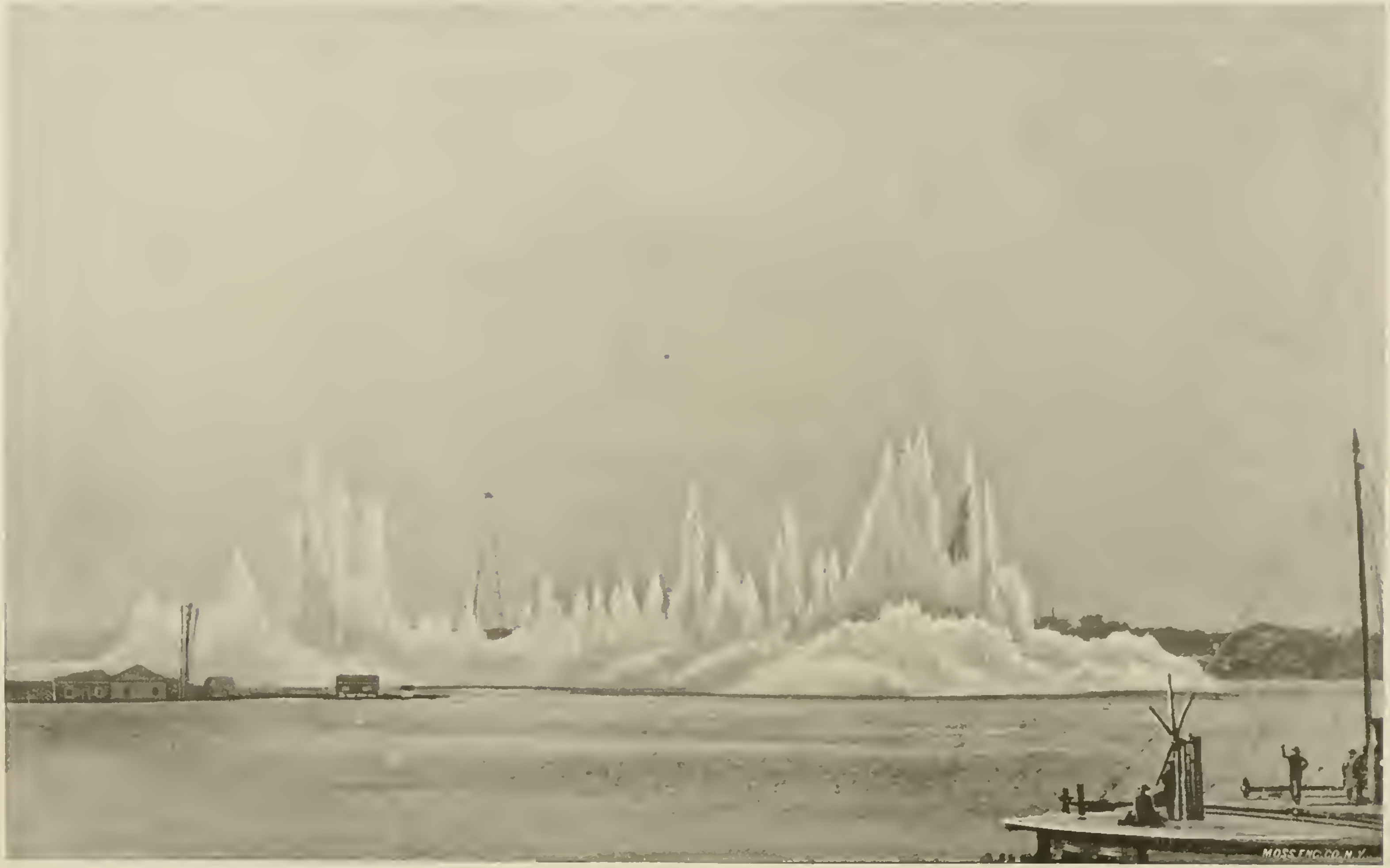

FLOOD ROCK EXPLOSION, OCTOBER 10, 1885.

LOCATION OF CAMERA 1,200 FEET WEST OF THE EXPLOSION. EXPLOSIVE USED 240,399 POUNDS OF RACKAROCK THE PRIMERS USED CONTAINED 42,331 POUNDS OF DYNAMITE No. 1, AND 240 POUNDS OF FULMINATE AREA OF EXPLOSION 9½ ACRES

FARROW'S

MILITARY ENCYCLOPEDIA

A DICTIONARY OF MILITARY KNOWLEDGE

ILLUSTRATED

WITH MAPS AND ABOUT THREE THOUSAND WOOD ENGRAVINGS

BY

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WEST POINT, NEW YORK

"What is obvious is not always known, and what is known is not always present."—JOHNSON.

COMPLETE IN THREE VOLUMES. VOLUME III.

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DEDICATED

TO THE

NATIONAL GUARDS OF AMERICA

In Appreciation of their Enterprise and Valor

AND AS A TRIBUTE OF HOMAGE

TO

GALLANT SOLDIERS.

PREFATORY NOTICE.

The design of this work is that of a Library of Military Knowledge for the People—not a mere collection of elaborate treatises in alphabetical order, but a work to be readily consulted as a Dictionary on every military subject on which people generally require some distinct information—no article being longer than is absolutely necessary. The several topics are not handled with a view to the technical instruction of those who have to make a special study of particular branches of military knowledge or art. The information given may be characterized in many instances as *non-professional*, embracing those points of the several subjects which every intelligent man or woman may have occasion to speak or think about. At the same time every effort is made that the statements, so far as they go, shall be precise and scientifically accurate.

Although about 30,000 subjects have been compiled from the various publications and records of the War Department, Foreign War Offices, and Military Works of reference, more than 5000 original articles have been prepared by specialists in America and abroad. While the Tactics, Ordnance, Gun Machinery, Implements, and Equipments of all ages and of all military powers have been fully described and illustrated under appropriate headings, a complete system of cross-references enables the military student to quickly locate several hundred articles pertaining to the general subject under investigation. Thus, under the article Magazine Gun will be found the following references: *Boch*, *Buffington*, *Bullard*, *Burgess*, *Burton*, *Chaffee-Reece*, *Clemmons*, *Colt*, *Dean*, *Elliott*, *Franklin*, *Hunt*, *Lee*, *Lewis-Rice*, *Miller*, *Remington*, *Russell*, *Spencer-Lee*, *Springfield-Jones*, *Tiesing*, *Trabue*, *Whitney*, and *Winchester Magazine Guns*. Under each of these articles are references to articles describing and illustrating all other arms of the respective classes. The Compiler has made special effort to set forth in detail the numerous decisions, rendered by the War Department and Tactical Department at West Point, on the tactical points raised and submitted from time to time by the Officers of the Army and National Guard. The descriptions and illustrations of more than 500 varieties of Gun Machinery, Steam Hammers, Cranes, etc., constitute a novel feature of the work to be appreciated by those wishing to investigate the subjects of construction, testing, etc.

The original plan has been strictly adhered to throughout; and if, as the work proceeded, there has been any change in the method or quality of the execution, it may at least be affirmed that the change has not been for the worse. After some experience, it became easier to find the person specially qualified to write a particular kind of article, and thus the circle of contributors became widened, and the distribution of the work more specialized. It was also seen to be desirable, in regard to certain classes of subjects, to admit a rather ampler selection of heads. This has been effected without increasing the scale of the work, not so much by less full treatment of the subjects, as by increased care in condensing the statements and omitting everything superfluous. A great quantity of matter pertaining to Foreign Armies has been introduced in this work, so as to enable the military student to compare the organization, arms, etc., of all armies with those of his own service. The Encyclopedia contains also descriptions of ancient armor, and of arms, lately in use, which have become obsolete, as it may be of some interest to follow the changes which have taken place in the mode and means of fighting from the earliest period down to the present time. The insertion of veterinary terms and of remedies for the common complaints of horses will be found useful under conditions where a Veterinary Surgeon is not available, as is often the case in detached parties of Cavalry. A description of all tools and machines found commonly in workshops may prove acceptable to Departmental Officers on their first joining Government Manufacturing Establishments.

Of the Sciences, the least adapted to encyclopedic treatment is Mathematics. All terms of common occurrence in Gunnery, Reconnoissance, etc., however, have been introduced, and a brief exposition of the subjects given, as far as could be done in an elementary way. Natural Philosophy has received ample attention, and all the leading doctrines and facts of general interest will be found under their appropriate heads, treated in a popular way, and divested as far as possible of the technicalities of mathematics. Chemistry, some knowledge of which is becoming daily more indispensable in all departments of military life, receives a comparatively large space. Prominence has been given to those points of the subject that have either a direct practical military bearing or a special scientific interest. During the progress of the work, several changes in the nomenclature and notation of the Science have come into general use; these have been duly noted under the appropriate headings. The new and far-reaching doctrines of the Correlation of Forces and the Conservation of Energy have produced vast changes in the nomenclature and classification of the various sections of Military Physics; while the more complete investigations into the phenomena and laws of light, heat, motion, and electricity have created virtually new sections, which must find a place in any adequate survey of scientific progress. Mechanical invention has, indeed, so kept pace with the progress of Military Science and the Art of War, that in almost every department of Physics improved machines and processes have to be described, as well as new discoveries and altered points of view. The manufacture of gunpowder and high explosives is a signal instance of the extent to which in our day scientific discovery is indebted to appropriate machinery and instruments of observation and analysis. These extensive changes in Physics involve corresponding changes in the method of their exposition. The scientific department of the work is consequently treated in all its branches in the most effulgent manner, and over 1000 very fine engravings are used for the purpose of illustration.

True to its projected plan as a LIBRARY OF MILITARY KNOWLEDGE FOR THE PEOPLE, this Encyclopedia will be found to be especially rich in notices of miscellaneous military matters. Some of the subjects introduced might perhaps be considered beneath the dignity of a book aspiring to a more severely scientific character; but all of them are, if not instructive, at least curious or entertaining, and likely to occur in the course of reading or conversation. During the progress of the work, the Compiler has received numerous assurances from parents as to how highly it was prized, even though only partly issued, by their sons at Military Schools, as a repertory of the kind of things they are constantly in search of and often puzzling their elders about. This use of the Encyclopedia has been steadily kept in view; and it is gratifying to learn that it is found efficiently to serve the purpose intended.

In conclusion, the Compiler asks the indulgence of Military Critics wherever errors or discrepancies have crept into this work, and begs to acknowledge the valuable help obtained from the works of many authors, both military and scientific, through the courtesy of Messrs. John Wiley & Sons and Mr. D. Van Nostrand, publishers, and the assistance he has received from various friends. To General Stephen V. Benét, Chief of Ordnance, United States Army, he is especially indebted for courteous assistance in the preparation of the work. To economize in space and to avoid crowding up the text, the name of the author from whom information has been derived has not been inserted after each quotation; but a list of all works which have been consulted, and from which extractions have been made, will be found at the commencement of each volume.

It is intended, with the view of meeting the changes which are constantly taking place in the *matériel* of armies, new processes, military inventions, etc., to issue a Supplement at suitable intervals, containing all alterations and additions.

UNITED STATES MILITARY ACADEMY,
West Point, New York, 1885.

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ABBREVIATIONS OF MODERN TERMS, PHRASES AND TITLES EMPLOYED IN FARROW'S MILITARY ENCYCLOPEDIA.

A.A.S. (*Academiæ Americanæ Socius.*) Member of the American Academy.
A.B. (*Artium Baccalaureus.*) Bachelor of Arts.
A.B.C.F.M. American Board of Commissioners for Foreign Missions.
Abp. Archbishop.
A.C. (*Ante Christum.*) Before Christ.
A. D. (*Anno Domini.*) In the year of our Lord.
Æt. (*Ætatis.*) Of age; aged.
Al. Alabama.
A.M. (*Artium Magister.*) Master of Arts; (*Ante Meridiem*) Before noon; (*Anno Mundi*) In the year of the world.
An. (*Anno.*) In the year.
Apr. April.
A.R. (*Anno Regni.*) In the year of the reign.
Ark. Arkansas.
A.U.C. (*Anno Urbis Conditæ.*) In the year from the foundation of the city.
Aug. August.
Avoir. Avoirdupois.
B. Book; (*b.*) Born.
B.A. Bachelor of Arts.
Bal. Balance.
Bart. Baronet.
Bbl. Barrel.
B.C. Before Christ.
B.C.L. Bachelor of Civil Law.
B.D. Bachelor of Divinity.
Bd. Bound.
Bds. Bound in boards.
Benj. Benjamin.
Bk. Book.
B.L. Bachelor of Laws; Breech-loading.
B.L.R. Breech-loading rifled.
Bp. Bishop.
Brig.-Gen. Brigadier-General.
C., or *Cap.* (*Caput.*) Chapter.
Cal. California.
Cam., or *Camb.* Cambridge.
Caps. Capitals.
Capt. Captain.
C.B. Companion of the Bath.
C.C.P. Court of Common Pleas.
C.E. Civil Engineer.
Cent. (*Centum.*) A hundred.
C.J. Chief Justice.
C.O. Commanding officer.
Co. Company.
Col. Colonel; Colorado.
Com. Commodore.
Conn., or *Ct.* Connecticut.
Cor. Corinthian.
Cor. Sec. Corresponding Secretary.
Crim. Con. Criminal Conversation; Adultery.
Ct. Cent.
Cts. Cents.
Cwt. Hundredweight.
D., or *d.* Penny, *or* pence.
Dan. Daniel.
D.A.Q.M.G. Deputy Assistant Quartermaster-General.
D.C. District of Columbia.
D.C.L. Doctor of Civil Law.
D.D. (*Divinitatis Doctor.*) Doctor of Divinity.
Dea. Deacon.
Dec. December.
Del. Delaware.
Dep. Deputy.
Dept. Department.
Deut. Deuteronomy.
Deft., or *dft.* Defendant.
Dist. District.
Dist. Atty. District Attorney.
ditto, or *do.* The same.
D.M. Doctor of Music.
Dols. ($) Dollars.
Doz. Dozen.
Dr. Doctor; Debtor; Dram.
D.V. (*Deo Volente.*) God willing.
Dwt. Pennyweight.
E. East.
Ed. Edition; Editor.
Edw. Edward.
E.g., or *e.g.* (*exempli gratia.*) For example.
Eliz. Elizabeth.
E.N.E. East-North-East.
Eph. Ephesians.
Esq. Esquire.
et. al. (*et alii.*) And others.
etc., or *&c.* (*et cætera.*) And so forth.
et seq. (*et sequentia.*) And what follows.
Exod. Exodus.
Expl. Explanation.
Ez. Ezra.
Ezek. Ezekiel.
Fahr. Fahrenheit.
Feb. February.
F.G. Fine grain; Field-gun.
Fl., or *Flor.* Florida.
Fred. Frederic.
F.R.S. Fellow of the Royal Society.
F.S. Field-service.
Ft. Foot, *or* feet.
Fur. Furlong.
Ga. Georgia.
G.B. Great Britain.
G.C. Good conduct.
G.C.B. Grand Cross of the Bath.
Gen. General; Genesis.
Geo. George; Georgia.
Gov. Governor.
Gov.-Gen. Governor-General.
G.S. General service.
G.S.W. General service wagon.
H., or *h.* Hour.
Hab. Habakkuk.
H.B.M. His, *or* Her, Britannic Majesty.
H.C. House of Commons.
Heb. Hebrews.
Hhd. Hogshead.
H.L. House of Lords.
H.M. His, *or* Her, Majesty.
H.M.S. His, *or* Her, Majesty's Ship, *or* Service.
Hon. Honorable.
Hos. Hosea.
H.R. House of Representatives.
H.R.H. His, or Her, Royal Highness.
Hund. Hundred.
I., or *Isl.* Island.
Ib., *Ibid.* (*Ibidem.*) In the same place.
Id. (*Idem.*) The same.
i.e. (*id est.*) That is.
I.H.S. (*Jesus Hominum Salvator.*) Jesus the Saviour of men.
Ill. Illinois.
In. Inches.
Incog. (*Incognito.*) Unknown.
Ind. Indiana.
I.N.R.I. (*Jesus Nazarenus, Rex Judæorum.*) Jesus of Nazareth, King of the Jews.
Inst. Instant (the current month).
Io. Iowa.
i.q. (*idem quod.*) The same as.
Is. Isaiah.
It. Italics.
J. Justice; Judge.
Jan. January.
Jas. James.
Jer. Jeremiah.
Jno. John.
Jona. Jonathan.
Jos. Joseph.
Josh. Joshua.
J.P. Justice of the Peace.
Jr., or *Jun.* Junior.
Judg. Judges.
Jul. July.
Kan. Kansas.
K.B. Knight of the Bath; King's Bench.
K.C.B. Knight Commander of the Bath.
Ken., or *Ky.* Kentucky.
K.G. Knight of the Garter.
K.G.C. Knight of the Grand Cross.
Ki. Kings.
Knt., or *Kt.* Knight.
L., or *lb.* Pound (weight).
L., *l.*, or £. Pound sterling.
La. Louisiana.
Lat. Latitude.
L.G. Large grain.
L.I. Long Island.
Lieut. Lieutenant.
LL.B. Bachelor of Laws.
LL.D. Doctor of Laws.
L.L.R. Line of least resistance.
L.S. Land service.
M., or *m.* Masculine.
M.A. Master of Arts; Military Academy.
Maj. Major.
Mar. March.
Mass. Massachusetts.
Matt. Matthew.
M.C. Member of Congress.
M.D. Doctor of Medicine.
Md. Maryland.
Mdlle., or *Mlle.* Mademoiselle.
M.E. Mechanical Engineer.
Me. Maine.
Mem. Memorandum.
Messrs. Gentlemen.
Meth. Methodist.
Mich. Michigan.
Min., or *min.* Minute, *or* minutes.
Minn. Minnesota.
Miss. Mississippi.
M.L. Muzzle-loading.
M.L.R. Muzzle-loading rifled.
MM. Messieurs.
Mme. Madame.
Mo. Missouri; Month.
Mons. Monsieur.
Mos., or *mos.* Months.
M.P. Member of Parliament.
M.P.P. Member of Provincial Parliament.
Mr. Master, *or* Mister.
Mrs. Mistress, *or* Missis.
M.S. Sacred to the Memory.
MSS. Manuscripts.
Mt. Mount, *or* Mountain.
M.T. Mountain train.
Mus D. Doctor of Music.
N., or *n.* North; Noun; Neuter.
N.A. North America.
Nath. Nathaniel
N.B. New Brunswick; (*Nota bene*) Note well, *or* take notice.
N.C. North Carolina; Non-commissioned.
N.C.O. Non-commissioned Officer.
N.E. North-East; New England.
Neb. Nebraska
N.F. Newfoundland.
N.H. New Hampshire.
N.J. New Jersey.
N.L. North Latitude.
N.N.E. North North-East.
N.N.W. North-North-West.
No. (*Numero.*) Number.
Non seq. (*Non sequitur.*) It does not follow.
Nos. Numbers.
Nov. November.
N.P. Notary Public; New pattern.
N.S. Nova Scotia; The New Style (since 1752).
N.T. New Testament.
N.W. North-West.
N.Y. New York.
O. Ohio.
Ob. (*Obiit.*) Died.
Ob., or *Obdt.* Obedient.
Oct. October.
O.P. Old Pattern.
Or. Oregon.
O.S. Old Style.
O.T. Old Testament.
Oxf., or *Oxon.* (*Oxonia.*) Oxford.
Oz. Ounce, *or* ounces.
P., or *p.* Page; Rebble.

Pa., or *Penn.* Pennsylvania.
Parl. Parliament.
Pd. Paid.
P.E.I. Prince Edward Island.
Per cent. (*Per centum.*) By the hundred.
Ph.D. (*Philosophiæ Doctor.*) Doctor of Philosophy.
Phil. Philippians.
Phila. Philadelphia.
Pinx., or *Pxt.* (*Pinxit.*) Placed after the painter's name on pictures: as, "Turner *pxt.*"
Pk. Peck.
Pl. Plural.
Plff. Plaintiff.
P.M. Postmaster; Past Master; (*Post Meridiem*) Afternoon.
P.M.G. Postmaster-General.
P.O. Post-Office.
pp. Pages.
P.P.C. (*Pour Prendre Congé.*) To take leave.
Pr., or P. (*Per.*) By the.
Pres. President.
Prof. Professor.
Pro tem. (*Pro tempore.*) For the time being.
Prov. Proverbs; Province.
Prox. (*Proximo.*) Next (the next month).
P.S. (*Post Scriptum.*) Postcript.
Ps. Psalm, or Psalms.
Pt. Pint.
Pub Doc. Public Documents.
Pwt. Pennyweight.
Q., or *Qu.* Query; Question; Queen.
Q.B. Queen's Bench.
Q.C. Queen's Council.
Q.E.D. (*Quod Erat Demonstrandum.*) Which was to be demonstrated.
Q.M. Quartermaster.
Q.M.G. Quartermaster-General.
Qr. Quarter (28 pounds); Farthing; Quire.
Qt. Quart; Quantity.
Qv. (*Quod vide.*) Which see.
R. (*Rex*) King; (*Regina*) Queen.
R.A. Royal Academy, or Academician; Rear-Admiral; Right Ascension; Royal Artillery.
R.C.D. Royal Carriage Department.
R.E. Royal Engineers.
Rec. Sec. Recording Secretary.
Rev. Revelation; Reverend.
R.F.G. Rifle fine grain.
R.G.F. Royal gun factory.
R.I. Rhode Island.
R.L. Royal Laboratory.
R.L.G. Rifle large grain.
R.M.A. Royal Military Academy.
R.N. Royal Navy.
Rom. Roman; Romans.
Rom. Cath. Roman Catholic.
R.R. Railroad.
Rt. Hon. Right Honorable.
Rt. Rev. Right Reverend.
S. South; Signor; Shilling.
S.A. South America; Small arms.
S.A.A. Small-arm ammunition.
S. Afr. South Africa.
Sat. Saturday.
S.B. Smooth-bore.
S.C. South Carolina; Scrap-carriage.
Sc., or *Sculp.* (*Sculpsit.*) Placed after the engraver's name on a picture.
Sch., or *Schr* Schooner.
Scil., or *Sc.* (*Scilicet.*) To wit; namely.
Script. Scripture.
S.E. South-East.
Sec. Secretary; Section.
Sen. Senate; Senator; Senior.
Sep., or *Sept.* September.
Serg. Sergeant.
Serv., or *Servt.* Servant.
S.J. Society of Jesus.
S.J.C. Supreme Judicial Court.
S. Lat. South Latitude.
Sld. Sailed.
Sm. Samuel.
S.M.I. (*Sa Majesté Impériale.*) His, *or* Her, Imperial Majesty.
S.O. Staff Officer.
Soc. Society.
Sq. Square.
Sq. ft. Square feet.
Sq. in. Square inches.
Sq. m. Square miles.
Sr. Sir, *or* Senior.
SS., or *ss.* (*Scilicet.*) Namely.
S.S. Sea-service; Sunday-school.
S.S.E. South-South-East.
S.S.W. South-South-West.
St. Saint; Street.
Stat. Statute.
S.T.D. (*Sacræ Theologiæ Doctor.*) Doctor of Divinity.
Sun., or *Sund.* Sunday.
Supt. Superintendent.
S.W. South-West.
Ten., or *Tenn.* Tennessee.
Tex. Texas.
Th., or *Thurs.* Thursday.
Theo. Theodore.
Tr. Translation; Transpose; Treasurer; Trustee.
Tu., or *Tues.* Tuesday.
Ult. (*Ultimo.*) Last, *or* Pertaining to the last month.
U.S. United States.
U.S.A. United States of America; United States Army.
U.S.M. United States Mail; United States Marine.
U.S.M.A. United States Military Academy.
U.S.N. United States Navy.
U.S.V. United States Volunteers.
U.T. Utah Territory.
Va. Virginia.
V.C. Victoria Cross.
Vice-Pres. Vice-President.
Vid. (*Vide.*) See.
Vis., or *Visc.* Viscount.
Viz. (*Videlicet.*) Namely; to wit.
V.n. Verb neuter.
Voc. Vocative.
Vol. Volume.
V.P. Vice-President.
V.R. (*Victoria Regina.*) Queen Victoria.
Vs. (*Versus.*) Against.
Vt. Vermont.
W. Week; West.
Wash. Washington.
Wed. Wednesday.
W.I. West India; West Indies.
W. Lon. West Longitude.
Wm. William.
W.M. Worshipful Master.
W.N.W. West-North-West.
W.S.W. West-South-West.
Wt. Weight.
Xmas. Christmas.
Y. Year.
Yd. Yard.
Yr. Your.
Zach. Zachary.
Zech. Zechariah.
Zeph. Zephaniah.

FOREIGN WORDS AND PHRASES EMPLOYED IN FARROW'S MILITARY ENCYCLOPEDIA.

Ab ante. (L.) Before; previously.
A bas. (Fr.) Down.
Ab extra. (L.) From the outside.
Ab initio. (L.) From the beginning.
Ab origine. (L.) From the origin.
Ab ovo usque ad mala. (L.) From the egg to the apples; from first to last. Roman banquets began with eggs, and ended with apples.
Ab urbe conditâ. (L.) From the foundation of the city.
A compte. (Fr.) On account.
Ad infinitum. (L.) To infinity.
Ad interim. (L.) In the mean while.
Ad libitum. (L.) At one's pleasure.
Ad nauseam. (L.) To disgust; till disgust is excited.
Ad patres. (L.) To his fathers; *i.e.*, dead.
Ad referendum. (L.) Till further consideration.
Ad valorem. (L.) According to; upon the value.
Affaire d'amour. (Fr.) An intrigue; a love-affair.
Affaire d'honneur. (Fr.) An affair of honor; *i.e.*, a duel.
A fortiori. (L.) With stronger reason.
A gusto. (Ital.) To one's heart's content.
A la bonne heure. (Fr.) In happy time; at a good hour.
A la Françoise. (Fr.) In the French manner.
A la mode. (Fr.) In fashion; fashionable.
A l'Anglaise. (Fr.) In the English manner.
Al fresco. (Ital.) In the open air.
Alias. (L.) Otherwise; *e.g.*, Jones, *alias* the Count Johannes.
Alibi. (L.) Elsewhere. A legal defense by which the defendant attempts to show that he was absent at the time and from the place of the commission of the crime.
Allons. (Fr.) Come on; let us go.
Alma mater. (L.) A nourishing mother. A name frequently applied by students to their college.
A l'outrance. (Fr.) To the uttermost; the last extremity.
Alter ego. (L.) A second self.
Alumnus. (L.) A foster-child; a pupil. The graduates of American colleges are often called *alumni*.
Amende honorable. (Fr.) To make the *amende honorable* is to make a suitable apology for and confession of one's offense.
Amor patriæ. (L.) Love of country; patriotism.
Amour propre. (Fr.) Self-esteem.
Ancien régime. (Fr.) The old government; the French monarchy before the Revolution.
Anno Domini. (L.) In the year of our Lord.
Anno mundi. (L.) In the year of the world.
Annus mirabilis. (L.) The wonderful year.
Ante bellum. (L.) Before the war.
Ante meridiem. (L.) Before noon.
A posteriori. (L.) From the latter; the cause from the effect.
A priori. (L.) From the former; the effect from the cause.
A propos. (Fr.) Appositely; seasonably; in regard to.
Argumentum ad hominem. (L.) An argument to the man; *i.e.*, personal.
Audi alteram partem. (L.) Hear the other part; both sides.
Au fait. (Fr.) Skilled; accomplished; competent.
Au fond. (Fr.) To the bottom; thoroughly.
Au revoir. (Fr.) Good-by, till we meet again.
Auto da fé. (Sp.) An act of faith; *i.e.*, burning heretics.
Aux armes. (Fr.) To arms.
A votre santé. (Fr.) To your health.
Bas bleu. (Fr.) A bluestocking; a literary woman.
Beau idéal. (Fr.) Ideal beauty. The absolute beauty which exists only in the mind.
Beau monde. (Fr.) The gay world; the world of fashion.

Bel esprit. (Fr.) A fine mind; wit.
Ben trovato. (Ital.) Well found: "a happy thought."
Bête noir. (Fr.) A scarecrow; a bugbear.
Billet-doux. (Fr.) A love-letter; a "sweet" note.
Bizarre. (Fr.) Strange; eccentric; fanciful.
Blasé. (Fr.) One who has seen and enjoyed everything, and upon whom pleasure palls, is called *blasé*.
Bona fide. (L.) In good faith; genuine; actual.
Bon-gré, mal-gré. (Fr.) With a good or ill grace; willy-nilly.
Bonhomie. (Fr.) Simple, unaffected good-nature.
Bon-jour. (Fr.) Good-day; good-morning.
Bon-mot. (Fr.) A good word, *i.e.*, a witty saying.
Ceteris paribus. (L.) Other things being equal.
Canaille. (Fr.) The rabble; the common multitude.
Carte blanche. (Fr.) Blank sheet of paper. To give a person *carte blanche* is to give him an unconditional discretion.
Casus belli. (L.) A case of war; an act which justifies war.
Cedant arma togæ. (L.) Let arms yield to the gown; *i.e.*, military to civil power.
Cela va sans dire. (Fr.) That goes without saying; follows as a matter of course and necessarily.
Chacun à son goût. (Fr.) Every man to his taste.
Châteaux en Espagne. (Fr.) Castles in Spain; air castles.
Chef d'œuvre. (Fr.) A masterpiece; an unequaled work.
Che sarà, sarà. (Ital.) What is to be, will be.
Chevalier d'industrie. (Fr.) An adventurer; one who lives by his wits.
Chronique scandaleuse. (Fr.) A record of scandals.
Cicerone. (Ital.) A person who acts as guide to sight-seers.
Comme il faut. (Fr.) Neatly; properly; rightly; in "good form."
Compagnon de voyage. (Fr.) Companion of one's travels.
Compos mentis. (L.) Sane; of sound mind.
Con amore. (Ital.) Earnestly; zealously.
Con spirito. (Ital.) In a spirited manner.
Corps Diplomatique. (Fr.) The foreign ambassadors.
Corpus delicti. (L.) The body of the offense.
Coup d'état. (Fr.) A bold stroke in politics.
Coup de grâce. (Fr.) A stroke of mercy; a final blow.
Coup de main. (Fr.) A bold, swift understanding.
Coup d'œil. (Fr.) A swift glance of the eye.
Coûte qu'il coûte. (Fr.) Let it cost what it may.
Cui bono. (L.) To what (for whose) good.
Cum grano salis. (L.) With a grain of salt; not unqualifiedly.
Currente calamo. (L.) Rapidly and fluently.
Da capo. (Ital.) From the beginning.
De bonne grâce. (Fr.) Readily; with good will.
Début. (Fr.) One's first appearance in society, or on the stage.
De facto. (L.) Actual; in fact.
De gustibus non est disputandum. (L.) There is no disputing about tastes.
De jure. (L.) Rightfully; lawfully; lawful.
De mortuis nil nisi bonum. (L.) Say nothing but good of the dead.
Dénouement. (Fr.) The catastrophe of a plot.
De novo. (L.) Anew; over again; afresh.
Deo volente. (L.) If it please God.
Dernier ressort. (Fr.) The last resource.
De trop. (Fr.) In the way; too much.
Dieu et mon droit. (Fr.) God and my right.
Distingué. (Fr.) Distinguished in manner.
Distrait. (Fr.) Preoccupied; absent-minded.
Divide et impera. (L.) Divide and govern.
Dolce far niente. (Ital.) Sweet do-nothing; luxurious idleness.
Double entente. (Fr.) Double meaning; obscenity in disguise. (Often erroneously written *double entendre*.)
Douceur. (Fr.) Sweetness; compensation; a gratuity.
Dramatis personæ. (L.) The characters of a drama.
Dulce domum. (L.) Sweet home.
Dum vivimus, vivamus. (L.) While we live, let us live; enjoy life to the full
Éclat. (Fr.) Splendor; distinction; brilliancy.
Élan. (Fr.) A spring; fire; dash; impetuosity.
Embarras de richesses. (Fr.) Embarrassment of riches; excess of anything.
Embonpoint. (Fr.) Plumpness of figure.
Empressement. (Fr.) Enthusiasm; eagerness.
En famille. (Fr.) In family; by themselves.
Enfant gâté. (Fr.) A spoiled child.
Enfant terrible. (Fr.) A terrible child; making ill-timed remarks.
En grande toilette. (Fr.) In full dress; toilet.
En masse. (Fr.) In a body.
En rapport. (Fr.) In communication.
En règle. (Fr.) As it should be; in rule.
En revanche. (Fr.) To make up for it.
En route. (Fr.) On one's way.
En suite. (Fr.) In company together.
Entente cordiale. (Fr.) A cordial understanding.
Entourage. (Fr.) Surroundings; adjuncts.
Entre nous. (Fr.) Between ourselves.
E pluribus unum. (L.) One of many. Motto of the United States.
Ergo. (L.) Therefore.
Esprit de corps. (Fr.) The spirit of the body; a feeling for the honor and interest of an organization.
Esprit fort. (Fr.) A skeptic; a free-thinker.
Et cætera. (L.) And the rest; etc.
Ex cathedrâ. (L.) From the chair; with authority.
Excelsior. (L.) Higher.
Exeunt omnes. (L.) They all go out.
Ex nihilo nihil fit. (L.) From nothing, nothing comes.
Ex officio. (L.) By virtue of his office.
Ex parte. (L.) From a part; one-sided.
Ex post facto. (L) After the deed is done.
Ex tempore. (L.) Off-hand.
Facile princeps. (L.) Easily the chief.
Facilis est descensus Averni. (L.) The descent into hell is easy.
Fait accompli. (Fr.) An accomplished fact.
Faux pas. (Fr.) A false step; a mistake.
Fecit. (L.) He, *or* she, made. This word is put after an artist's name on a picture.
Felo de se. (L.) A felon of himself; a suicide.
Femme de chambre. (Fr.) A chamber-maid.
Femme sole. (Fr.) An unmarried woman.
Festina lente. (L.) Make haste slowly.
Fête champêtre. (Fr.) A rural party; a party in the open air.
Feuilleton. (Fr.) A small leaf. The bottoms of the pages in French newspapers are so called, being given up to light literature.
Fiat justitia, ruat cœlum. (L.) Let justice be done, though the heavens fall.
Finis coronat opus. (L.) The end crowns the work.
Flagrante delicto. (L.) In the act.
Fugit hora. (L.) The hour flies.
Gamin. (Fr.) A street-urchin.
Garçon. (Fr.) A waiter.
Garde du corps. (Fr.) A body-guard.
Garde mobile. (Fr.) Troops liable for general service.
Gasconnade. (Fr.) Boasting; bragging.
Gaucherie. (Fr.) Awkwardness; clumsiness.
Gendarme. (Fr.) An armed policeman.
Genius loci. (L.) The genius of the place.
Gentilhomme. (Fr.) A gentleman; nobleman.
Genus homo. (L.) The human race.
Gloria in excelsis. (L.) Glory to God in the highest.
Gloria Patri. (L.) Glory to the Father.
Grand siècle. (Fr.) A great century.
Grossièreté. (Fr.) Grossness; rudeness.
Habeas corpus. (L.) You may have the body.
Hauteur. (Fr.) Haughtiness; loftiness.
Hic et ubique. (L.) Here and everywhere.
Hic jacet. (L.) Here lies.
Homme d'état. (Fr.) A statesman.
Honi soit qui mal y pense. (Fr.) Shame to him who evil thinks.
Horribile dictu. (L.) Horrible to say.
Hors de combat. (Fr.) Out of condition to fight.
Hôtel de ville. (Fr.) A town-hall.
Ibidem. (L.) In the same place.
Ich dien. (Ger.) I serve. (Motto of the Prince of Wales.)
Ici on parle Français. (Fr.) French spoken here.
Idem sonans. (L.) Sounding the same.
Id est. (L.) That is; i.e.
Ignis fatuus. (L.) A foolish fire; a delusion.
Ignobile vulgus. (L.) The ignoble crowd.
Ignotum per ignotius. (L.) The unknown by something more unknown.
Imprimis. (L.) In the first place.
In articulo mortis. (L.) At the point of death.
Index expurgatorius. (L.) A purging index; a list of works prohibited to be read.
In embryo. (L.) In the rudiments.
In esse. (L.) Actual; in existence.
In extremis. (L.) At the point of death.
In flagrante delicto. (L.) In the very act.
Infra dignitatem. (L.) Beneath one's dignity.
In futuro. (L.) In the future.
In hoc signo vinces. (L.) In this sign thou shalt conquer.
In loco. (L.) In place; on the spot.
In medias res. (L.) In the middle of a subject.
In pace. (L.) In peace.
In perpetuum. (L.) Forever.
In propriâ personâ. (L.) In one's own person.
In re. (L.) In the thing; in the matter of.
In rem. (L.) Against the thing
In seculâ seculorum. (L.) For ages of ages.
Instanter. (L.) Instantly.
In statu quo. (L.) In the state in which it was.
Inter alia. (L.) Among other things.
Inter nos. (L.) Between ourselves.
Inter se. (L.) Among themselves.
In toto. (L.) Entirely; wholly.
In transitu. (L.) In the passage; on the way.
In vino veritas. (L.) In wine there is truth.
Ipse dixit. (L.) He said it himself.
Ipso facto. (L.) By the fact itself.
Je ne sais quoi. (Fr.) I know not what.
Jeu de mots. (Fr.) A play upon words.
Jour de fête. (Fr.) A saint's day; a festival.
Jubilante Deo. (L.) Be joyful to God.
Jupiter tonans. (L.) Jupiter the thunderer.
Jure divino. (L.) By divine law.
Jure humano. (L.) By human law.
Jus civile. (L.) The civil law.
Jus gentium. (L.) The law of nations.
Juste milieu. (Fr.) The golden mean.
Labor omnia vincit. (L.) Labor conquers all things.
Laissez faire. (Fr.) Let things alone.
Lapsus linguæ. (L.) A slip of the tongue.
Lares et penates. (L.) The household gods.
Laus Deo. (L.) Praise be to God.
L'avenir. (Fr.) The future.
Le beau monde. (Fr.) The world of fashion.
Lèse majesté. (Fr.) High treason.
Lex loci. (L.) The law of the place.
Lex scripta. (L.) The written law.
Lex talionis. (L.) The law of retaliation.
Literatim. (L.) Letter for letter.
Littérateur. (Fr.) A literary man.
Locus sigilli. (L.) The place of the seal.
Ma chère. (Fr.) My dear.
Ma foi. (Fr.) My faith; upon my faith.
Magnum bonum. (L.) A great good.
Maison de ville. (Fr.) The town-house.
Maître d'hôtel. (Fr.) A house-steward.
Major domo. (Ital.) A chief steward.
Maladie du pays. (Fr.) Home sickness.
Matériel. (F.) Opposed to personnel.
Mater familias. (L.) The mother of a family.

Mauvaise honte. (Fr.) Bashfulness.
Maximum. (L.) The greatest possible.
Me judice. (L.) In my judgment.
Memento mori (L.) Remember death.
Memorabilia. (L.) Things deserving to be remembered.
Mens sana in corpore sano. (L.) A sound mind in a sound body.
Meum et tuum. (L.) Mine and thine.
Mirabile dictu. (L.) Wonderful to tell.
Mise en scène. (Fr.) Putting on the stage.
Modus operandi. (L.) The method of operating
Mon ami. (Fr.) My friend.
Mot d'ordre. (Fr.) The password; countersign.
Multum in parvo. (L.) Much in little.
Nemine contradicente. (L.) No one contradicting.
Ne plus ultra. (L.) Nothing more beyond; the utmost.
Nil admirari. (L.) To wonder at nothing.
Nil desperandum. (L.) We must not despair.
Ni l'un ni l'autre. (Fr.) Neither the one nor the other.
N'importe. (Fr.) It does not matter.
Nisi prius. (L.) Unless before.
Noblesse oblige. (Fr.) Nobility obliges; noble must act nobly.
Nolens volens. (L.) Willy-nilly.
Noli me tangere. (L.) Don't touch me; hands off.
Nolle prosequi. (L.) To abandon prosecution.
Nom de guerre. (Fr.) A war-name.
Nom de plume. (Fr.) Pen-name; name assumed by an author.
Non compos mentis. (L.) Not in one's right mind.
Non est inventus. (L.) He has not been found.
Non multa, sed multum. (L.) Not many things, but much.
Nota bene. (L.) Mark well.
Nous avons changé tout cela. (Fr.) We have changed all that.
Nous verrons. (Fr.) We shall see.
Odium theologicum. (L.) Theological hatred.
Olla podrida. (Sp.) A mixture.
Omnia vincit amor. (L.) Love conquers all things.
On dit. (Fr.) They say; people say.
Onus probandi. (L.) The burden of proof.
Oro pro nobis. (L.) Pray for us.
O tempora! O mores! (L.) Oh, the times! Oh, the manners!
Otium cum dignitate. (L.) Ease with dignity.
Outré. (Fr.) Extravagant; extreme.
Par excellence. (Fr.) By way of eminence; in the highest degree.
Par hasard (Fr.) By chance
Pari passu. (L.) With equal step.
Parvenu. (Fr.) An upstart; a rich snob.
Pater familias. (L.) The father of a family.
Pater patriæ. (L.) The father of his country.
Pax vobiscum. (L.) Peace be with you.
Peccavi. (L.) I have sinned.
Pendente lite. (L.) While the suit is pending.
Per annum. (L.) By the year.
Per capita. (L.) By the head; on each person.
Per contra. (L.) On the other hand.
Per diem. (L.) By the day; every day.
Per se. (L.) By itself.
Personnel. (Fr.) The staff; persons in any service.
Petitio principii. (L.) Begging the question.
Petite. (Fr.) Small; little.
Pièce de résistance. (Fr.) A joint of meat.
Pinxit. (L.) He, *or* she, painted it.
Pis aller. (Fr.) A last expedient.
Plebs. (L.) The common people.
Poeta nascitur, non fit. (L.) A poet is born, not made.
Point d'appui. (Fr.) Point of support.
Posse comitatus. (L.) The power of the country; the force that may be summoned by the Sheriff.
Poste restante. (Fr.) To be left till called for.
Post meridiem. (L.) Afternoon.
Post mortem. (L.) After death.
Post obitum. (L.) After death.
Pourparler. (Fr.) A consultation.
Pour prendre congé. (Fr.) To take leave.
Précieuse. (Fr.) A bluestocking; a conceited woman.
Preux chevalier. (Fr.) A gallant gentleman.
Prima donna. (Ital.) The first lady; the principal female singer in an Italian opera.
Primâ facie. (L.) On the first face; at first sight.
Primus inter pares. (L.) First among his peers.
Pro bono publico. (L.) For the public good.
Procès verbal. (Fr.) Verbal process; the taking of testimony in writing.
Pro et con. (L.) For and against.
Pro formâ. (L.) For the sake of form.
Pro patriâ. (L.) For one's country.
Pro tempore. (L.) For the time.
Punica fides. (L.) Punic faith; *i.e.*, treachery.
Quantum sufficit. (L.) As much as is sufficient.
Quelque chose. (Fr.) As if.
Quid nunc? (L.) What now? A gossip.
Quid pro quo. (L.) An equivalent.
Qui vive. (Fr.) Who goes there?
Quod erat demonstrandum. (L.) Which was to be demonstrated.
Quondam. (L.) At one time; once.
Rara avis. (L.) A rare bird.
Rechauffé. (Fr.) Warmed over; stale.
Recherché. (Fr.) Choice; elegant.
Redacteur. (Fr.) An editor.
Redivivus. (L.) Restored to life.
Reductio ad absurdum. (L.) Reduction to an absurdity.
Rentes. (Fr.) Public funds; national securities.
Requiescat in pace. (L.) May he, *or* she, rest in peace.
Res gestæ. (L.) Things done.
Resurgam. (L.) I shall rise again.
Revenons à nos moutons. (Fr.) Let us return to our sheep; come back to the subject.
Robe de chambre. (Fr.) A dressing-gown.
Roué. (Fr.) A rake.
Rouge et noir. (Fr.) Red and black (a game).
Sanctum sanctorum. (L.) The holy of holies.
Sang froid. (Fr.) Cold blood; self-possession.
Sans culottes. (Fr.) Without breeches; red republicans.
Sartor resartus (L.) The tailor patched.
Sauve qui peut. (Fr.) Save himself who can.
Savoir-faire. (Fr.) Knowing how to do things.
Savoir-vivre. (Fr.) Knowledge of the world.
Semper idem. (L.) Always the same.
Semper paratus. (L.) Always prepared.
Sequitur. (L.) It follows.
Seriatim. (L.) In order.
Sic itur ad astra. (L.) Thus men go to the stars.
Sic semper tyrannis. (L.) Thus always with tyrants. The motto of Virginia.
Sic transit gloria mundi. (L.) So passes the glory of the world.
Similia similibus curantur. (L.) Like is cured by like.
Sine die. (L.) Without a day.
Sine qua non. (L.) Without which, not; an indispensable condition.
Soi disant. (Fr.) Self-styled.
Spirituel. (Fr.) Witty.
Status quo. (L.) The state in which; the former state.
Stet. (L.) Let it stand.
Suaviter in modo, fortiter in re. (L.) Gently in manner, bravely in action.
Sub rosâ. (L.) Under the rose; secretly.
Sui generis. (L.) Of its own kind.
Summum bonum. (L.) The supreme good.
Tableau vivant. (Fr.) A living picture.
Table d'hôte. (Fr.) A public ordinary; dinner at a fixed price.
Tabula rasa. (L.) A smooth tablet; a blank.
Tant mieux. (Fr.) So much the better.
Tant pis. (Fr.) So much the worse.
Te Deum laudamus. (L.) Thee, God, we praise.
Tempora mutantur, et nos mutamur in illis. (L.) Times change, and we change with them.
Tempus fugit. (L.) Time flies.
Terra firma. (L.) Solid earth.
Terra incognita. (L.) An unknown country.
Tête-à-tête. (Fr.) Head to head; in private conversation.
Tiers état. (Fr.) The third estate; *i.e.*, the commons.
Totidem verbis. (L.) In just so many words.
Tour de force. (Fr.) A turn of strength.
Tout ensemble. (Fr.) The whole taken together.
Tout le monde. (Fr.) Everybody.
Trottoir. (Fr.) The pavement.
Tu quoque, Brute! (L.) Thou, too, Brutus.
Ubi libertas, ibi patria. (L.) Where liberty is, there is my country.
Ubi supra. (L.) As mentioned above.
Ultima Thule. (L.) Uttermost Thule; the end of the earth.
Usque ad nauseam. (L.) Till it was, *or* is, absolutely sickening.
Utile dulci. (L.) The useful with the sweet.
Ut infra. (L.) As below.
Ut supra. (L.) As above.
Vade mecum. (L.) Go with me; a companion.
Væ victis. (L.) Woe to the vanquished.
Vale. (L.) Farewell.
Valet de chambre. (Fr.) A servant.
Veni, vide, vici. (L.) I came, I saw, I conquered.
Verbatim et literatim. (L.) Word for word; letter for letter.
Verbum sat sapienti. (L.) A word to the wise is sufficient.
Viâ. (L.) By way of.
Vide. (L.) See.
Videlicet. (L.) Namely.
Vinculum matrimonii. (L.) The bond of matrimony.
Vis à vis. (Fr.) Face to face.
Vis inertiæ. (L.) The force of inactivity.
Vis viva. (L.) Living force.
Virâ voce. (L.) By the living voice.
Vive la bagatelle. (Fr.) Success to trifles.
Vive la Reine. (Fr.) Long live the Queen.
Vive l'Empereur. (Fr.) Long live the Emperor.
Vive le Roi. (Fr.) Long live the King.
Voilà. (Fr.) See there; behold.
Vox, et præterea nihil. (L.) A voice, and nothing more.
Vox populi, vox Dei. (L.) The voice of the people is the voice of God.

INDEX OF MATTERS NOT HAVING SPECIAL ARTICLES.

At the close of Volume III. will be found an Index of Subjects not having Special Articles. It has not been thought necessary to repeat in this Index the titles of the many thousand articles composing the body of the work. A person consulting the Encyclopedia is supposed, in the first instance, to look for the subject he is in quest of in its proper alphabetical place. If it is not to be found there, or by a *cross-reference*, by turning to the Index he is likely to get a reference to it under another name, or as coming in for notice in connection with some other subject. It frequently happens that subjects, having articles of their own, are further noticed under other heads; and where it seemed of importance, a reference is given in the Index to this additional information. The title of the article referred to is printed in *italics;* and when the article is of considerable length, the page is given in which the information is to be found.

CONTINUED REVISION.

The process of revising Farrow's Military Encyclopedia is constantly carried on, thus keeping up the information to the latest possible date. These revisions and additions will be supplied every few years in the shape of Supplements. A few blank pages are inserted at the close of each volume for the purpose of noting the reference to the various articles in the Supplements, which would naturally find alphabetical arrangement in the respective volumes.

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SABANDER.—The familiar of Shah-bander, an Eastern title for Captain or Governor of a post.

SABANTINES.—Steel coverings for the feet. The term is frequently applied to slippers and clogs also.

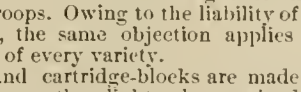
SABARCANE.—The Malays, and also the savages of Borneo, discharge their arrows and light darts through a long tube, called the *sabarcane*, by applying the tube to their lips and blowing through it. In this manner, they strike objects at great distances, with great force, and with astonishing precision of aim.

SABBATONS.—A round-toed armed covering for the feet, worn during a part of the Sixteenth Century.

SABLE.—One of the tinctures in Heraldry, implying black. In heraldic engravings it is represented by perpendicular and horizontal lines crossing each other.

SABOT.—*Sabots* are circular blocks of wood, fastened with tin straps to hollow projectiles for smooth-bore guns. Their object is to prevent the projectile from turning in the bore and bringing the fuse in contact with the charge of the piece. The diameter of the sabot corresponds to that of the projectile; it has a shallow dish-shaped cavity for the projectile to rest in, and is always attached to the side opposite the fuse-hole. When the piece is fired, the fragments of the sabot fly a short distance from the muzzle; consequently it is dangerous to use this kind of ammunition when firing over the heads of our own troops. Owing to the liability of premature explosions, the same objection applies to hollow projectiles of every variety.

Sabots and cartridge-blocks are made of poplar, bass-wood, or other light, close-grained wood; it must be well seasoned and should be clear of knots and splits. The assistant saws the scantling to the proper length for a sabot, roughs it out, and marks its center. The turner puts it in a lathe and turns, first, the exterior and grooves, and then the cavity for the projectile. The holes for the handles are bored with a bit, and countersunk on the inside to receive the knot on the end of the cord. Distance between them, for shells is 1.5 inch; for canisters, 2.3 inches. Length of cord for handles, for shells



12 inches; for canisters, 20 inches; diameter of cord, .15 inch. The cartridge blocks and sabots for shot and spherical case-shot for guns have one groove, (*a*). Sabots for gun-canisters and mountain-howitzer shells, spherical case-shot, and canister have two grooves, (*b*). All the grooves are .3 inch wide and .15 inch deep. They are .8 inch apart, from center to center, for guns, and .5 for the howitzer. The corners and bottom of the grooves are slightly rounded. The dimensions of finished sabots and blocks are verified with appropriate gauges. One man can make 350 sabots for 12-pounder gun, or 300 sabots for howitzer, or 600 cartridge-blocks, small charge, or 700 cartridge-blocks, large charge.

In siege and garrison service, sabots are required for the 8-inch canisters, for siege-howitzer, and all shells and spherical case-shot for smooth-bore guns. For canisters and the smaller guns, the sabots are turned in a lathe; for the larger calibers they are sawed from thick pine or poplar planks, and the cavity cut in a lathe; or the cavity is first cut by a tool of the proper curvature, and the sabot afterward sawed out with a circular saw. One man can make 350 sabots for a 10-inch columbiad in 10 hours; or 400 sabots for an 8-inch columbiad.

In positions where the pieces of sabots might prove dangerous to our own troops, as in firing over their heads when making an attack, sabots made of thick shavings of soft wood or pasteboard are used. For this purpose select black-walnut, pine, or fir, not too dry, and as free as possible from knots. Pieces of the proper length and width are dressed out, and by means of a coarse plane, shavings are cut .06 inch in thickness. Each shaving is rolled in a circle on a cylinder of iron, in which a longitudinal groove is cut. One end is thinned down, moistened and inserted in the groove, and the shaving is rolled on the cylinder, the smooth side turned outward; one man turns the cylinder by a crank, making three revolutions, the other holds the shaving so as to roll it evenly on itself, pulling it tight.

The different turns are then tacked together, the tacks being riveted on the inside against the iron cylinder; the end is thinned down with a rasp, and the sabot taken from the cylinder is immersed in a warm bath of thin glue. Pasteboard may be used instead of shavings of wood. The sabot is attached to the shell by means of four pieces of tape 1 inch wide. Each piece is folded around the sabot, and the ends sewed together; the seam is turned on the inside of the sabot, and is made fast to it by tacks, the four pieces of tape being attached to the sabot at the extremities of two diameters perpendicular to each other. The sabot is laid down on the table and the shell placed in it, the fuse-hole down; the ends of the tape are then drawn together and tied on top of the shell with a piece of strong twine. See *Field and*

Mountain Ammunition, Siege and Garrison Ammunition, and *Stand of Ammunition.*

SABRE.—A heavy sword, with which cavalry and dragoons are armed. The back is thick, that a blow may carry the more force, and also to render the weapon useful in the rough thrust of the cavalry charge. A saber is occasionally curved at the point, in the form of a cimeter. See *Hand-arms.*

SABRE EXERCISE.—When performing this exercise, the squad should be armed only with the saber, and placed in single rank. The object of the moulinets is to give suppleness to the wrist, which increases the dexterity and confidence of the men. Each lesson is begun and ended with the moulinets, executed with a quickness proportioned to the progress of the men, remembering that force is less necessary than skill. In teaching the saber exercise on foot, special reference must be had to its application when mounted. To this end, recruits are not to lean to one side, which would derange their seats on horseback; nor direct the blade so as to strike the hand, closed, six inches from the body, and as high as the elbow, fingers toward the body, little finger nearer than the thumb (position of the bridle-hand); at the same time place the right hand in tierce in front of and a little higher than the right hip, thumb extended on the back of the gripe, little finger by the side of the others, the point of the saber inclined to the left, and two feet higher than the hand, which grasps the saber without constraint. To return to the *carry*, the Instructor commands; 1. *Carry*. 2. SABER. At the command *saber*, the recruits resume the position of the soldier, and come to the *carry*. The saber exercise is taught in the following order, and by the following commands, all the movements being executed from *guard*. 1. *Left*, 2. MOULINET. Extend the arm obliquely to the left and front to its full length, the hand in tierce and as high as the eyes, the point of the saber to the front, and a little higher than the hilt. (Two.) Lower the blade, edge to the front, and make rapidly a circle around the hand, to the left of and near the horse's neck, the blade pass-

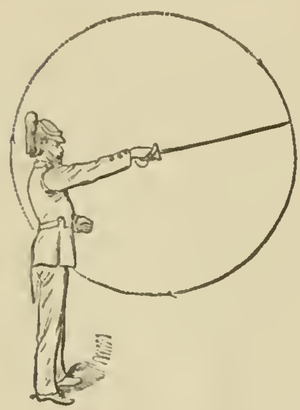


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

head or haunches of the horse, or the knees of the rider. All cuts, when not executed by motions, are terminated by a half moulinet, so as to bring the saber to the position of *guard.* The thrust requires less force, and its result is more prompt, sure and decisive than the cut. The saber is held in the full grasp, and in all motions in the saber exercise, except *right point* and *rear point*, the thumb is extended along the back of the gripe, and pressed against the guard. During the first lessons the Instructor takes care to rest the men from time to time, and to always give his explanations when the squad is at a *carry*, only keeping the arm extended long enough to correct faults.

The files being opened to at least three yards' interval, and the sabers at a *carry*, the Instructor commands: *Guard.* Carry the right foot about two feet to the right, heels on the same line: place the left ing close to the left elbow; return to the first position. (THREE.) Resume the guard, Fig. 1. 1. *Right*, 2. MOULINET. Extend the arm to the front to its full length, the hand in quarte, and as high as the eyes, the point to the front, and a little higher than the hilt. (Two.) Lower the blade, edge to the front, make rapidly a circle around the hand, to the right of and near the horse's neck, the blade passing close to the right elbow; return to the first position. (THREE.) Resume the guard, Fig. 2. To combine the execution of the preceding moulinets. 1. *Left and right* (or, *right and left*), 2. MOULINET. Execute the left moulinet; turn the wrist without pausing, and then execute the right moulinet. 1. *Rear*, 2. MOULINET. Raise the arm to the right and rear to its full extent, the point of the saber upward, the edge to the right, the body slightly turned to the right. (Two.) Begin by moving the point of the saber toward the left, and describe a circle in rear. (Three.) Resume the guard, Fig. 3. In executing the moulinets, the right arm is kept as steady as possible in position, the saber being controlled by motions of the wrist and hand. When the men execute the moulinets well, the Instructor requires them to execute several in succession without pausing, until the command *guard*. 1. *Tierce*, 2. Point. Raise the hand in tierce as high as the eye, throw back the right shoulder, carrying the elbow to the rear, the point of the saber to the front, the edge upward. (Two.) Thrust to the front, extending the arm to its full length, edge up. (Three.) Resume the guard, Fig. 4. 1. *Quarte*, 2. Point. Lower the hand in quarte near the right hip, the point a little higher than the wrist. (Two.) Thrust to the front, extending the arm to its full length. Three.) Resume the guard, Fig. 5. 1. *Left*, 2. Point. Turn the head and shoulders to the left, draw back the hand in tierce toward the right and near the right shoulder, the hand at the height of the neck, the edge of the blade upward, the point to the left and as high as the hand. (Two.) Thrust to the left, extending the arm to its full length. (Three.) Resume the guard, Fig. 6. 1. *Right*, 2. Point. Turn the head to the right, carry the hand in quarte near the left breast, the edge of the blade upward, the point to the right and as high as the hand. (Two.) Thrust to the right, extending the arm to its full length. (Three.) Resume the guard, Fig. 7. 1. *Rear*, 2. Point. Turn the head and shoulders to the right and rear, bring the hand in quarte near the left breast, the point to the rear and as high as the hand, the edge upward. (Two.) Thrust to the rear, extending the arm to its full length. (Three.) Resume the guard, Fig. 8. 1. *Against infantry*, 2. *Left*, 3. Point. Same as left point, except the point is downward. (Two.) Thrust down in tierce. (Three.) Return to the position of guard, Fig. 9. *Against infantry*, 2. *Right*, 3. Point. Same as quarte point turning the head and shoulders to the right, inclining the point downward. (Two.) Thrust in quarte. (Three.) Resume the guard, Fig. 10. 1. *Against infantry*, 2. *Front*, 3. Point. Bend well down to the right, extend the right arm well downward, the hand in rear

Fig. 7.

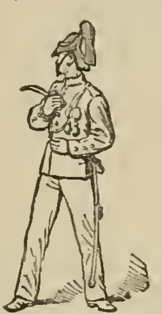


Fig. 8.

Fig. 9.

Fig. 10.

Fig. 11.

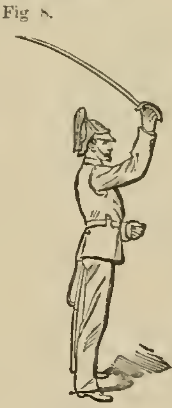


Fig. 12.

Fig. 13.

of the thigh, the back of the saber upward. (Two.) Thrust forward. (Three.) Resume the guard, Fig. 11. 1. *Front*, 2. Cut. Raise the saber, the arm half extended, the hand in front of the right shoulder, and and a little higher than the head, the edge upward, the point to the rear, and higher than the hand. (Two.) Cut, extending the arm to its full length. (Three.) Resume the guard, Fig. 12. The first position of *front cut* is the position of *raise saber*. Being at *raise saber*, to *carry saber*, the Instructor commands: 1. *Carry*, 2. Saber. 1. *Left*, 2. Cut. Turn the head and shoulders to the left, raise the saber, the arm extended to the right, the hand in quarte and as high as the head, the point higher than the hand. (Two.) Cut diagonally to the left. (Three.) Resume the guard, Fig. 13. 1. *Right*, 2. Cut. Turn the head to the right, carry the hand opposite the left breast, the point of the saber upward, the edge to the left. (Two.) Extend the arm quickly to its full length, and give a back-handed cut horizontally. (Three.) Resume the guard, Fig. 14. The *left* and *right cuts* are used against infantry, inclining the body forward, and cutting at the required angle. 1. *Rear*, 2. Cut. Throw the right shoulder well back, and execute the first motion of *right cut*. (Two.) Extend the arm quickly to its full length, and give a back-handed cut horizontally to the rear. (Three.) Resume the guard, Fig. 15. 1. *Left in quarte and tierce*, 2. Cut. Execute the first motion of *left cut*. (Two.) Execute the second motion of *left cut*. (Three.) Turn the hand in tierce, and cut horizontally. (Four.) Resume the guard. 1. *Right in tierce and quarte*, 2. Cut. Execute the first motion of *right cut*. (Two.) Execute the second motion of *right cut*. (Three.) Turn the hand in quarte, and cut horizontally. (Four.) Resume the guard. 1. *Rear in tierce and quarte*, 2. Cut. Execute second motion of *rear cut*. (Three.) Turn the hand in quarte, and cut horizontally. (Four.) Resume the guard. *Tierce*, 2. Parry. Carry the hand quickly a little to the right, point of the saber as high as the eyes, and opposite the right shoulder, edge to the right. (Two.) Resume the guard. 1. *Quarte*, 2. Parry. Turn the hand in quarte, and carry it opposite the left breast, edge of the blade to the left, point to the front, as high as the eyes, and a little to the left of the left shoulder. (Two.) Resume the guard. 1. *Left*, 2. PARRY. Raise the hand above and six inches in front of the eyes, the elbow somewhat bent, edge of the blade to the left, point downward, and parry the blow aimed at the left side. (Two.) Resume the guard. 1. *Left head*, 2. PARRY. Raise the saber quickly above the head, the right arm vertical, edge upward, point to the left and twelve inches below the guard. (Two.) Resume the guard. 1. *Right head*, 2. PARRY. Raise the saber quickly above the head, edge up, point to the left and higher than the hand, the right forearm nearly vertical. (Two.) Resume the guard. 1. *Against infantry*, 2. *Left*, 3. PARRY. Turn the head and shoulders to the left, raise the saber, the arm extended upward to the front and left, the hand in tierce, back of the blade to the front, point upward. (Two.) Describe a circle quickly on the left, from front to rear, parallel to the horse's neck, the arm extended; turn aside the bayonet with the back of the blade, bringing the hand, still in tierce, above the left shoulder. (THREE.) Resume the guard. Fig. 16. 1. *Against infantry*, 2. *Right*, 3. PARRY. Turn the head to the right, throwing back the right shoulder, raise the saber, the arm extending upward to the right and rear, the hand in tierce, edge of the blade to the left, point upward. (Two.) Describe a

Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

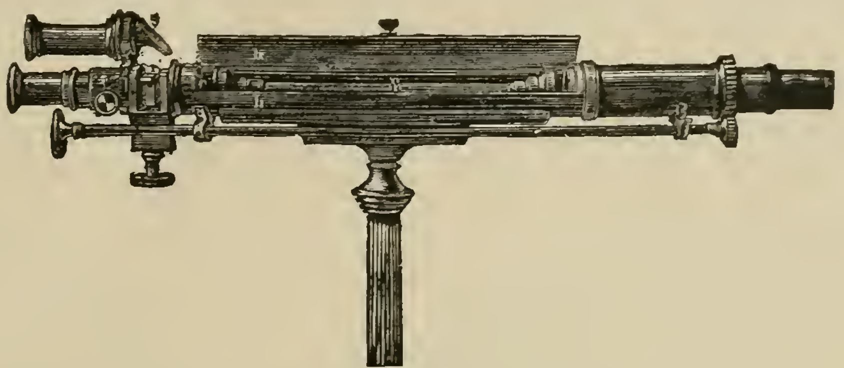
circle quickly on the right from the rear to front, the arm extended; turn aside the bayonet with the back of the blade, bringing the hand as high as the head, point upward. (THREE.) Resume the guard. Fig. 17. When the recruits begin to execute correctly the above cuts, thrusts, and parries, the Instructor requires them to make application of them by combined motions, such as: 1. *In tierce point and front*, 2. CUT. 1. *In quarte point and front*, 2. CUT. 1. *Left point and right* (or *left*), 2. CUT. 1. *Right point and left* (or *right*), 2. CUT. 1. *Rear point and rear*, 2. CUT. 1. *Against infantry, right point and right*, 2. CUT. 1. *Against infantry, left point and left*, 2. CUT.

Thrusts are preferable to cuts, as wounds made by cuts are generally trifling compared with those made by thrusts. Great attention must be paid to the position and balance of the body, as, by too great an exertion in giving a cut or thrust, a man may be thrown or so unsettled in his seat as to lose the advantage of his skill; he must depend upon his parries, and not trust to avoiding the attack of the enemy by turning or drawing back his body. In giving a forward thrust or cut, with the horse in rapid motion, very little force is required, as the impetus of the horse makes it effective. Choose the point of attack, and avoid if possible attacks made upon the left rear; in the latter case a change of position can alone place a man upon an equality with his opponent. This relative change may be effected by making a sudden halt, allowing an adversary to pass, or by turning quickly to the left about, bringing him on the right. If a man cannot do this, he is forced to keep on the defensive, being unable to make effective blows, and must crowd up to his opponent, whose cuts would otherwise tell.

In meeting an enemy on the left front, a man should turn sharply to the left on his own ground, bringing his right arm in position to act upon the enemy's left. In meeting him on the right front, press quickly on, and by a sharp turn to the right gain his left rear. If pursued, keep an adversary on the right rear; when attacked by more than one, try to keep them either to the right or to the left, but, should they succeed in placing themselves on each side, press close to the one on the left, and endeavor to keep the one on the right at a distance. The lance is parried like the saber. A man must close upon his enemy at once, and try to gain his right rear, where he is least able to attack or to defend himself; the same is true if he be armed with the bow and arrow. In pursuit, always approach at the right rear. When opposed to infantry, endeavor to meet an opponent on the right. See *Cuts*, *Fencing*, *Guard*, *Moulinets*, *Parry* and *Points*.

SABRETACHE.—A useless square accouterment which dangles against the legs of officers in some cavalry regiments. It purports to be a pocket for the conveyance of dispatches, etc., but probably is never used. The sabertache is hung by smaller ornamental belts from the sword-belt, and is itself covered with gold brocade, the emblems of the regiment and other devices.

SACCHARIMETER.—An apparatus based upon the rotary power of liquids, for analyzing saccharine substances. The instrument, as shown in the drawing, is made by Messrs. Richards & Co., New York, and is used by the United States Government in the Subsistence Department, and in the Custom House Laboratories. The principle of this instrument is not the amplitude of the rotation of the plane of polarization, but that of *compensation;* that is to say, a second active substance is used, acting in the opposite direction from that analyzed, and whose thickness can be altered until the contrary action of the two substances completely neutralize each other. Instead of measuring the deviation of the plane of polarization, the thickness is measured which the plate of quartz must have in order to obtain perfect compensation. The apparatus consists of three parts —a tube containing the liquid to be analysed, a polarizer, and an analyser. In making the analysis of raw sugar, before issuing to troops, a normal weight of 16.471 grains of sugar is taken, dissolved in water, and the solution made up to 100 cubic centimeters, with which a tube 20 centimeters in length is filled, and the number indicated by the vernier read off, when the *primitive tint* has been obtained. This number being 42, for example, it is concluded that the amount of crystallisable sugar in the solution is 42 per cent. of that which the solution of sugar-candy contained, and, therefore, 16.471 grains $\times \frac{42}{100}$, or



Saccharimeter.

6.918 grains. This result is only valid when the sugar is not mixed with uncrystallisable sugar, or some other left-handed substance.

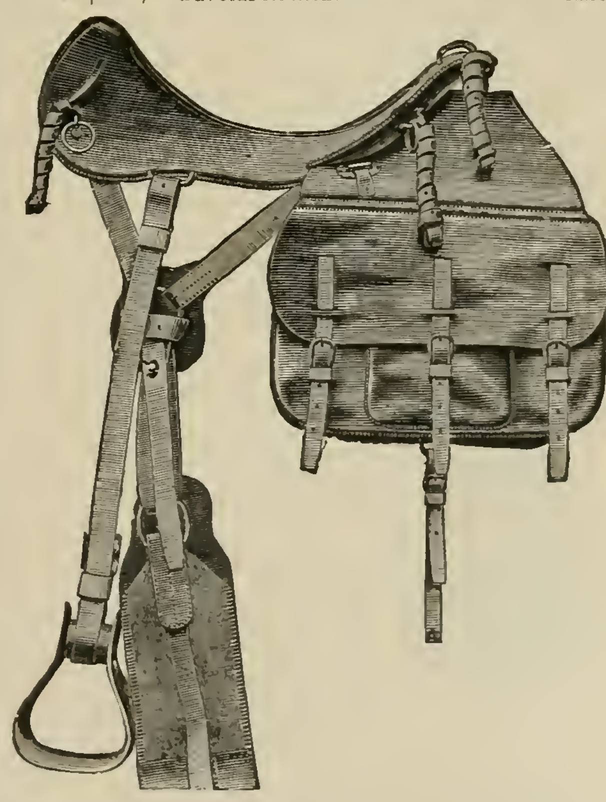
SACHEM.—A chief of a tribe of the American Indians; a Sagamore.

SACK.—An expression used when a town has been taken by storm and given up to pillage.

SACKRAMENTUM MILITARE.—The oath formerly taken by the Roman soldiers when they were enrolled. This oath was pronounced at the head of the Legion, in an audible voice, by a soldier who was chosen by the Tribune for that purpose. He thereby pledged himself before the gods to expose his life for the good and safety of the Republic, to obey his Superior Officers, and never to absent himself without leave. The aggregate of the Legion assented to the oath without going through the formal declaration of it.

SACRED BATTALION.—A band of infantry composed of 300 young Thebans, united in strict friendship and affection, who were engaged, under a particular oath, never to fly, but to defend each other to the last drop of their blood. At the famous battle of Leuctra, in which the Spartans were signally defeated by Epaminondas, the Sacred Battalion was commanded by Pelopidas, and mainly contributed to the success of the day.

SADDLE.—1. The seat which is put upon a horse for the accommodation of the rider. In the earlier ages the Romans used neither saddles nor stirrups. They can be traced back as far as the year 304, where we find accounts of their being made of leather. Every country has its own saddles in great variety. Those employed in the military service are made plain and strong, consisting of the following principal parts: The *saddle-tree*, including *pommel*, *seat*, and *cantle*; the *stirrups*; *stirrup-leathers*; the *girth*; the *girth-straps*; *surcingle*; the *coat-straps*; and frequently the *saddle-bags*. It is as difficult to describe and clearly define the very peculiar and superior lines of a saddle as those of a clipper yacht. An expert may in either case approve of them, but the real proof of excellence is the *trial*. The word saddle comes direct from the Spanish *silla* (*chair*). This term is still in use in that language, "The chair of the horse." While every one is ready to pronounce a chair in common use comfortable or otherwise, few would know how to proportion even a common household chair to give the maximum of comfort. But they would know several points of discomfort to avoid.



Starting from this point, we are first taught by experience to avoid all *padding*. The so-called English, or padded saddle, is unfit for common use. The padding hardens, shifts, and demands constant care and repairs; it absorbs sweat, remains damp, becomes mouldy, moth-eaten and rotten; forms hard lumps and *inevitably* makes sore backs. If the *seat* be padded, while it feels comfortable to a novice, it will *inevitably* produce chafing, tenderness of the skin, and not unfrequently piles. The seat should be as hard and smooth as possible. The slightest motion of the body *ventilates* the seat and keeps it cool, and avoids friction. The first effect of the hard seat is to sore the muscles, which is soonest relieved by frequent riding. A chafe can only be cured by abstaining from riding.

The saddle should be as light as is consistent with strength, and the pressure of the whole and each part of the rider should be distributed over the middle of the horse's back, which is constructed in such a manner as to admit of a certain amount of elastic action. The shape of the seat should be such as to allow the rider to sit well down into it, and balance himself in every position of the animal. The most graceful rider is the bareback rider. That saddle which enables one to approach nearest the bareback seat is by far the best.

In the mounted branch of the English service, the pattern saddle is termed *universal*. In a battery of artillery there are three descriptions of saddles, viz.: the *universal*, the *drivers*, and the *luggage*. The weight of the universal saddle is 28 pounds 2¼ ounces complete. Besides these, there are *pack saddles* suitable for the transport of military stores and mountain artillery, which in mountainous countries can only be carried by beasts of burden. The weight of this pack saddle is 27 pounds, and is known in the service as *saddle pack, general service*.

2. A command, directing that the saddle be placed on the horse's back, executed as follows: The saddle being at hand, the stirrups, girth, and surcingle crossed over the seat, and blanket folded and laid upon them, the Instructor commands: SADDLE.

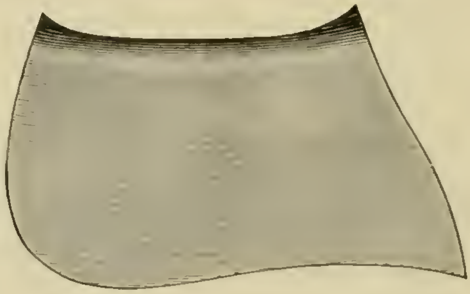
Place the blanket on the horse as previously explained; sieze the pommel with the left hand, and the cantle with the right, and place the saddle on the horse's back, well forward on the withers, bringing it from the direction of the croup in order not to frighten him: let down the girth and right stirrup, pass by the head of the horse to the off side, see that the stirrup and girth are properly adjusted, and the blanket smooth, return by the front to the near side. Take the girth-straps with the right hand, reach under the horse for the girth with the left, pass the end of the strap through the ring from below, and through the upper ring from the inside; sieze the end of the strap with the left hand, turn the right side to the horse, place the right hand on the strap near the upper ring, and press well down. Retain the end of the strap with the left hand, and pass the right between the strap and side of the horse, to smooth the hair and wrinkles of the skin; resieze the strap with the right hand, and pass the end through the buckle with the left, and buckle tight; pass the surcingle over the saddle, buckling it less tightly than the girth, and let down the left stirrup.

3. In pontooning, a *saddle* forms part of the superstructure of the bridge. It consists of a frame of timber placed centrally over the axis of the pontoon, and secured to it by lashings. See *McClellan Saddle, Mexican Saddle, Pack Saddle*, and *Whitman Saddle*.

SADDLE-BAGS.—Bags, usually of leather, united by straps, for transportation on horseback, one bag being placed on each side. A pair of saddle-bags should always accompany the saddle. The drawing represents a very suitable style, manufactured especially for scouting purposes, and furnished with a small assortment of instruments and necessities for the march. In the United States service, saddle-bags are issued to the cavalry as a portion of the horse equipments.

SADDLE-BLANKET.—A blanket which is used under the saddle. This blanket, after being shaken, is folded into six thicknesses, as follows: Hold it well up by two corners, the longway up and down, and double it lengthwise, the double corner in the right, the folded corner in the left hand; let go with the right hand, and seize the folded edge, the back of the hand to the body, just below the left hand; slip the left hand down the folded edge, and seize it near the other end; raise the left hand, extend the arms horizontally, the middle of the folded edge under the chin; then fold again in three equal parts, by first closing the left arm over the breast, and then the right, which is brought under the left and grasps the corner thus folded; reverse the blanket, bringing it in front of the body, and even the folds; hold the blanket between the chin and neck, slip the hands half-way down, and there grasp the blanket: let the upper part fall forward: the hands then hold the folded blanket, thus doubled, by each new upper corner, the right hand at the portion which will go towards the croup; the left hand at the part which will go over the withers; then flirt the outer part of the blanket over the right forearm. This is the position in which the blanket is held just before placing it on the horse. To put on the blanket, approach the horse on the near (left) side, with the blanket folded and held as above prescribed; place it on his back, sliding it once or twice from front to rear to smooth the hair, and carefully remove any locks of the mane; pass the buckle end of the surcingle over the middle of the blanket, and buckle it on the near side, a little below the edge of the blanket. The blanket should lie well up on the withers, and extend down equally on the sides.

SADDLE CLOTH.—In the military service, a cloth of regulation pattern placed under the saddle. It is used in particular as an absorbent of perspiration, thus adding to the horse's comfort, on the same principle as woolen underwear does to man's in summer. It also preserves the saddle. It is, therefore, necessary that it should be made of the best material. In



the United States Army, the saddle-cloth is prescribed as follows:

For General Staff Officers, and Officers of the Staff Corps: Dark blue cloth, of sufficient length to cover the saddle and holsters, and one foot ten inches in depth, with an edging of gold lace one inch wide.

For all other Officers.—Dark blue felt, according to pattern; is worn under the saddle and trimmed around the edges with cloth one and one-half inches wide, color as follows: Infantry, sky-blue. Artillery, scarlet. Cavalry, yellow.

The drawing shows the government pattern, the cloth being twenty-five inches on the back line. See *Housing*.

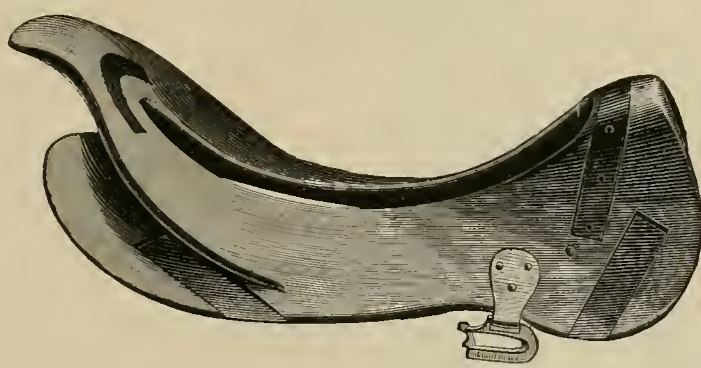
SADDLER.—One whose occupation is to make and repair saddles. Each company of cavalry in the United States Service is allowed one saddler. Saddlers are also employed in the Cavalry Service of European countries.

SADDLER CORPORAL.—In the British Service, a Non-commissioned Officer who has charge of the saddlers in the Household Cavalry.

SADDLER SERGEANT.—A Sergeant in the Cavalry who has charge of the saddlers. In the United States Army, Saddler Sergeants are Non-commissioned Staff Officers, one in each cavalry regiment.

SADDLE-TREE.—The frame of a saddle. Upon the good qualities of the *saddle-tree* will depend the prominent merits of the saddle. Shape, weight, smoothness, and regular bearing surface are the prominent considerations in connection with the saddle-tree. A noticeable objection to most saddle-trees at present constructed, is the raw-hide covering. The Indian and Mexican, having no skilled mechanics in wood or iron, and to whom raw-hides were worthless, made use of them, not only to cover up their rudely made saddle-frames, but to hold them together. In imitating, American work has frequently degraded into seaming together refuse hide, to cover up the rudest and most imperfect work. Raw-hide adds weight and expense, without producing any good effect. In wetting and shrinking, it will either warp the tree or crack, and one crack either on the upper or lower side will ruin the tree.

The Whitman saddle-tree, an invention of an officer of long cavalry experience, is a near approach to perfection, and can be depended on for practical results as well as to meet theoretical views. It is at present used by the United States cavalry, and is highly commended by foreign army officers, and urged by them for adoption in their respective countries. Its great advantage over all other wooden saddle-trees is the carefully adjusted bearing surface and seat. By use of machinery the two sides of this tree are made absolutely equal, a fact never before accomplished. It will be readily understood how soon the placing of any substance, say a penny, under one side of the saddle, would produce sore back. And yet any saddle-tree made by the old, careless process is likely, almost sure, to have greater irregularities at some points in its bearing surface.



SAEGMULLER SOLAR ATTACHMENT.—An apparatus consisting essentially of a small telescope and level; the telescope being mounted in standards, in which it can be elevated or depressed. The standard revolves around an axis, called the polar axis, which is fastened to the telescope axis of the transit instrument. The telescope, called the "solar telescope," can thus be moved in altitude and azimuth. It is provided with shade-glasses to subdue the glare of the sun, as well as a prism to observe with greater ease when the declination is very far north. Two pointers attached to the telescope to approximately set the instrument are so adjusted that when the shadow of the one is thrown on the other the sun will appear in the field of view. The drawing (page 8) shows the solar attachment fixed to an engineer's transit. Its adjustments are simple, and two in number:—

First. Attach the "polar axis" to the main telescope axis in the center at right angles to the line of collimation. The base of this axis is then provided with the three adjusting-screws for this purpose; by means of the level on the solar telescope this condition can be readily and accurately tested.

Second. Point the transit telescope—which instrument we assume to be in adjustment—exactly horizontal and bisect any distant object. The transit level will then be in the middle of the scale. Point the "solar telescope" also horizontally by observing the same object and adjust it, level to read Zero, for which purpose the adjusting-screws are provided.

In using the attachment, first take the declination of the sun as given in the Nautical Almanac for the given day, and correct it for refraction and hourly change. The correction for refraction is equal to the refraction of the sun in altitude, multiplied by the cosine of the angle $Z\ S\ P$. The meridianal refraction may be used as an approximation when the sun is not very near the horizon. Incline the *transit telescope* until this amount is indicated by its vertical arc. If the declination of the sun is north, depress it; if south, elevate it. Without disturbing the position of the transit telescope, bring the solar telescope to a horizontal position by means of its level. The two telescopes will then form an angle which equals the amount of the declination, and the inclination of the solar telescope to its vertical axis will be equal to the polar distance of the sun.

Without disturbing the *relative* positions of the two telescopes, incline them and set the vernier to the co-latitude of the place. By moving the transit and the solar attachment around their respective *vertical* axes, the image of the sun will be brought into the field of the solar telescope, and after accurately bisecting it the *transit telescope must be in the meridian, and the compass-needle indicates its deviation at that place.* The vertical axis of the solar attachment will then point to the pole, the apparatus being in fact a small equatorial. Time and azimuth are calculated from an observed altitude of the sun by solving the spherical triangle formed by the sun, the pole, and the zenith of the place. The three sides, $S\ P$, $P\ Z$, $Z\ S$, complements of the declination, latitude, and altitude, are given; we hence deduce, $S\ P\ Z$, the hour angle, from apparent noon, and, $P\ Z\ S$, the azimuth of the sun. The solar attachment solves the same spherical triangle by construction, for the second process brings the vertical axis of the solar telescope to the required distance, $Z\ P$, from the zenith, while the first brings it to the required distance, $S\ P$, from the sun. If the two telescopes, both being in position—one in the meridian, and the other pointing to the sun—are now turned on their *horizontal* axes, the vertical remaining undisturbed, until each is level, the angle between their directions (found by sighting on a distant object) is, $S\ P\ Z$, the time from apparent noon. This gives an easy observation for the correction of timepiece, &c., which is reliable to within a few seconds. See *Engineer's Transit* and *Solar Attachment.*

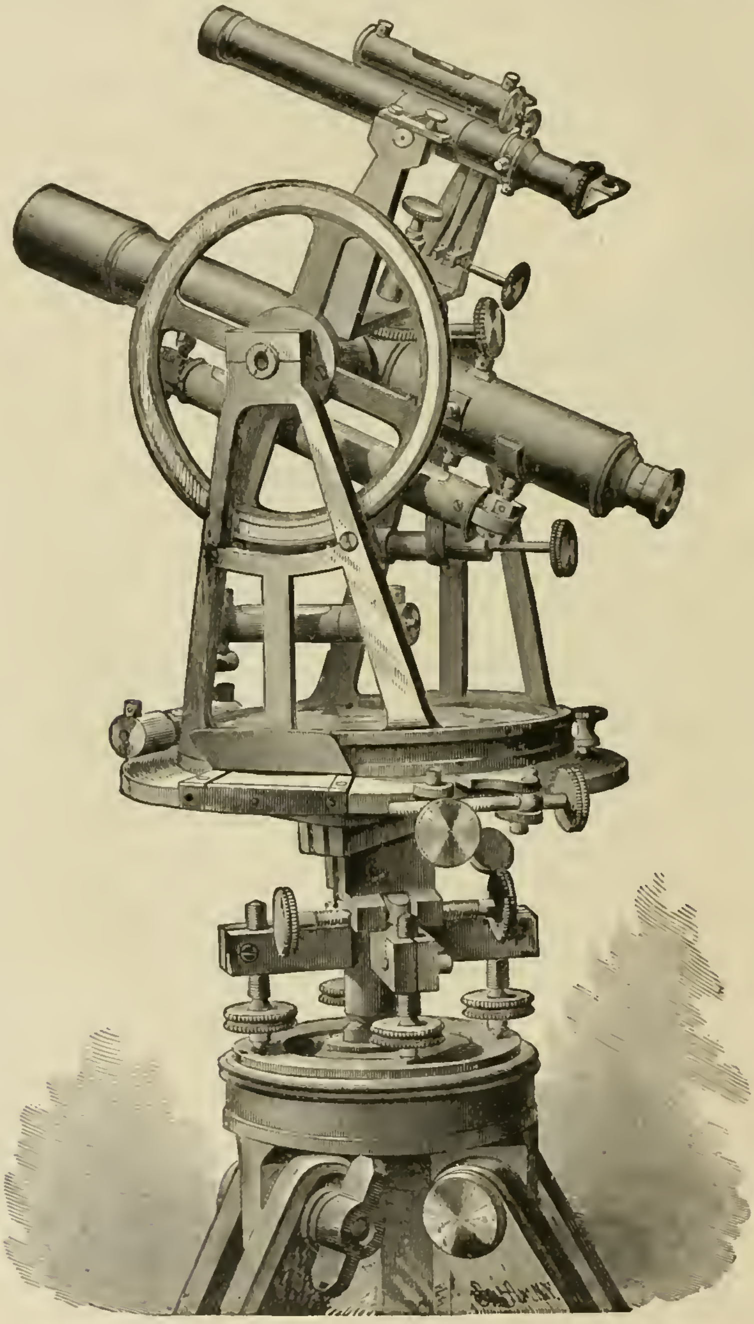
SAFE-CONDUCT.—A passport granted, on honor, to a foe enabling him to pass where it would otherwise be impossible for him to travel with impunity. All intercourse between the territories occupied by belligerent armies, whether by traffic, by letter, by travel, or in any other way ceases. This is the general rule, to be observed without special proclamation. Exceptions to this rule, whether by safe-conduct, or permission to trade on a small or large scale, or by exchanging mails, or by travel from one territory into the other, can take place only according to agreement approved by the Government, or by the highest military authority. Contraventions of this rule are highly punishable. Ambassadors, and all other diplomatic agents of neutral powers, accredited to the enemy, may receive safe-conducts through the territories occupied by the belligerants, unless there are military reasons to the contrary, and unless they may reach the place of their destination conveniently by another route. It implies no international affront if the safe-conduct is declined. Such passes are usually given by the supreme authority of the State, and not by subordinate officers.

SAFEGUARD.—A protection granted to persons or property in foreign parts by the Commanding General, or by other Commanders within the limits of their command. Safeguards are usually given to protect hospitals, public establishments, establishments of religion, charity, or instruction, museums, depositories of the arts, mills, post-offices, and other institutions of public benefit; also to the individuals whom it may be to the interest of the Army to respect. paper delivered to the party whose person, family, house and property it is designed to protect.

The following is a form of the safeguard:

By authority of —— ——.

A safeguard is hereby granted to [A. B —— ; *stating precisely the place, nature, and description of the person, property, or building.*] All officers and soldiers belonging to the Army of the United States are therefore commanded to respect this safeguard,



Saegmuller Solar Attachment.

A safeguard may consist of one or more men of fidelity and firmness, generally non-effective Non-commissioned Officers, furnished with a paper setting out clearly the protection and exemptions it is intended to secure, signed by the Commander giving it, and his Staff Officer; or it may consist of such a

and to afford, if necessary, protection to [*the person, family, or property of —— ——, as the case may be.*]

Given at Headquarters, the —— day of ——

A. B ——

C. D —— *Major General, Commanding-in-Chief.*

Adjutant General.

Whosoever, belonging to the Armies of the United States in foreign parts, or at any place within the United States or their Territories during rebellion against the supreme authority of the United States, forces a safeguard, shall suffer death. [Fifty-seventh Article of War.] See *Articles of War*, and *Field-service*.

SAFETY-FUSE.—This species of fuse invented by Messrs. Bickford for use in the Cornish mines, and now generally employed in the chief mining districts, consists of a hollow cord of spun yarn or hemp, tarred on the outside to render it waterproof, and filled with tightly-rammed gunpowder. This fuse ignites steadily at the rate of about 2 feet per minute, so that the time of the explosion can be easily regulated. The use of this contrivance has contributed to prevent those accidents arising from premature explosions, formerly of very common occurrence in mines. The fuse-tube is sometimes made of gutta-percha. See *Fuse*.

SAFETY-LAMP. — It has been long known that when marsh-gas or light carbureted hydrogen, which is frequently disengaged in large quantities from mines, is mixed with seven or eight times its volume of atmospheric air, it becomes highly explosive, taking fire at the approach of a light, and burning with a pale blue flame. Moreover, this gas in exploding renders ten times its bulk of atmospheric air unfit for respiration, and the *choke-damp* thus produced is often as fatal to miners as the primary explosion. With the view of discovering some means of preventing these exceedingly dangerous results, Davy instituted those important observations on flame which led him to the invention of the safety-lamp. He found that when two vessels filled with a gaseous explosive mixture are connected by a narrow tube, and the contents of one fired, the flame is not communicated to the other, provided the diameter of the tube, its length, and the conducting power for heat of its material, bear certain proportions to each other; the flame being extinguished by cooling, and its transmission rendered impossible. In this experiment, high conducting power and diminished diameter compensate for diminution in length; and to such an extent may this shortening of length be carried, that metallic gauze, which may be looked upon as a series of very short square tubes arranged side by side, completely arrests the passage of flame in explosive mixtures. The following are Davy's directions regarding the structure of his lamp: "The apertures in the gauze should not be greater than $\frac{1}{22}$ of an inch square. As the fire-damp is not influenced by ignited wire, the thickness of the wire is not of importance; but wire from $\frac{1}{40}$th to $\frac{1}{60}$th of an inch in diameter is the most convenient. Iron-wire and brass-wire gauze of the required degree of fineness, are made for sieves by all wire-workers, but iron-wire gauze is to be preferred; when of the proper degree of thickness, it can neither melt nor burn, and the coat of black rust which soon forms upon it superficially defends the interior from the action of the air. The cage or cylinder should be made of double joinings, the gauze being folded over so as to leave no apertures. When it is cylindrical it should not be more than two inches in diameter; for in larger cylinders the combustion of the fire-damp renders the top inconveniently hot, and a double top is always a proper precaution, fixed at the distance of half or three-quarters of an inch above the first top. The gauze cylinder should be fastened to the lamp by a screw of four or five turns, and fitted to the screw by a tight ring. All joinings should be made with hard solder; and the security depends upon the circumstance that no aperture exists in the apparatus larger than in the wire gauze." The cylinder is protected by three external, strong, upright wires, which meet at the top; and to their point of junction a ring is attached, by which the lamp is suspended. The oil is supplied to the interior by a pipe projecting from the cylinder, and the wick is trimmed by a wire bent at the upper end, and passed through the bottom of the lamp, so that the gause need not be removed for this process. When a lighted lamp of this kind is introduced into an explosive mixture of air and fire-damp, the flame is seen to gradually enlarge as the proportion of light carbureted hydrogen increases, until at length it fills the entire gauze cylinder. Whenever this pale enlarged flame is seen, the miners should depart to a place of safety, for although no explosion can occur while the gauze is sound, yet at that high temperature the metal becomes rapidly oxidized, and might easily break; and a single aperture of sufficient size would then occasion a destructive explosion. In a strong current of air, the heated gas may be blown through the apertures of the gauze before its temperature is sufficiently reduced to prevent an explosion; but such a contingency may be guarded against by placing a screen between the draught and the lamp. It was in the year 1815 that Sir Humphry Davy presented his first communication to the Royal Society respecting his discovery of the safety-lamp; and at the meeting held on Jan. 11, 1816, the lamp, as shown in Fig. 1, was exhibited. Sir Humphry Davy's claim as an original discoverer was immediately challenged by various persons, among whom may be especially noticed the late Dr. Reid Clanny, of Newcastle, and the great engineer, George Stephenson. Clanny's safety-lamp, shown in Fig. 2, was based on the principle of forcing in air through water by bellows; but the machine was ponderous and complicated, and required a boy to work it; moreover, he had been anticipated by Hum-

Fig. 1.

Fig. 2.

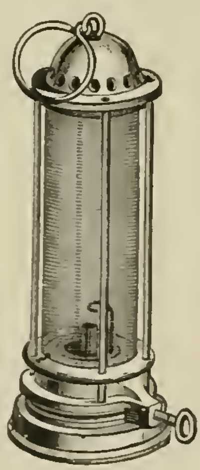
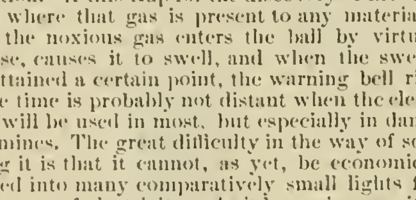


Fig. 3.

boldt in 1796. Stephenson's lamp is shown in Fig 3. In the French and Belgian collieries, Mueseler's lamp is in almost universal use. It consists of a glass cylinder immediately around the flame, and of the wire gauze above. An internal metal chimney opening a short distance above the flame creates a strong upward draught, which causes the feed air to pass briskly down from the wire gauze, and so keeps the glass cool and insures thorough combustion. Mueseler's lamp is also used in a few English collieries; but modifications of Davy's, Stephenson's, and in a less degree of Clanny's later lamp are still in general use in England, the best kinds of each having their wire-gauze covers secured by patent lever locks. In the catalogue of the collection of scientific apparatus shown at South Kensington in 1876, there is given an interesting table, with remarks, of the different forms of safety-lamps which either are or have been in use. It was compiled by the North of England Institute of Mining Engineers. Closely connected in its objects with the safety-lamp is a most ingenious invention pattented by Mr. Ansell of Her Majesty's mint. Its object is to determine, by a simple application of the law of osmotic force, the presence of any light carbureted hydrogen in mines. Mr. Ansell gives two or three forms to his apparatus, of which the following is the most simple: A thin India-rubber ball is filled with atmospheric air, and is placed on a stand under a lever which slightly presses its upper surface. This lever is connected with a spring, which it liberates when, from any cause, the lever is raised; and the liberation of the spring sets a bell in vibration. If this trap for the discovery of fire-damp is set where that gas is present to any material extent, the noxious gas enters the ball by virtue of osmose, causes it to swell, and when the swelling has attained a certain point, the warning bell rings.

The time is probably not distant when the electric light will be used in most, but especially in dangerous, mines. The great difficulty in the way of so applying it is that it cannot, as yet, be economically divided into many comparatively small lights from one source of electricity. As it burns *in vacuo* it can be rendered perfectly safe in an explosive mixture of fire-damp and air. Some twenty years since Mr. Holmes, the well-known electrician, invented a miner's electric lamp in which the light—equal to that of an ordinary candle—was produced by a small portable galvanic battery. Its cost was estimated at between £3 and £4. More recently MM. Dumas and Benoit have constructed a lamp the light of which is produced by a current of electricity from a Rhumkorff coil passing through a Geissler's vacuum tube. The tube, however, really contains a highly rarefied gas such as carbonic acid, and the light has only the character of a rich phosphorescent glow. Neither of these, nor any other form of an electric light, has as yet come into practical use in mining operations.

SAFETY LOCK. A lock so constructed as to guard against all accidental discharges of the piece. There



have been, from time to time, numberless patents for safety apparatus, but all have fallen far short of absolute safety, inasmuch as such safeties had to be removed by the thumb before firing, or in reality, only safeties at the will of the user. In the Scott locks of recent manufacture, a block-safety always interposes itself automatically between the hammer and striker before the hammer is half way to full-cock. By this new invention, the gun is always safe from the light pull of a lock jarring off in closing the breech action or the sear sticking through rust, or letting the gun fall. Should the lock go off in any possible way other than by the pull of the trigger, the hammer will be intercepted and blocked by a bar, as is shown in the drawing, and no discharge can take place. It is readily seen how the hammer with projecting lump, B, having been jarred off at full-cock, is caught by the safety-block, A, before it reaches the striker, E.

SAFETY REDOUBT.—In enclosed works a place of retreat, into which the troops may retire in safety after a vigorous defense of the main work, will remove the fears of the garrison for the consequences of a successful attack of the enemy, and will inspire them with confidence to hold out to the last moment. This interior work, which may very properly be termed the *keep*, can only be applied to works of large interior capacity. It may be formed of earth, or consist simply of a space enclosed by a defensive stockade, or palisading. In either case it should be about four feet higher than the main work, to prevent the enemy from obtaining a plunging fire in it from the parapet of the main work. The best arrangement for the keep is the construction termed the *block-house*. This work is made of heavy timber, either squared on two sides or four; the pieces which form the sides of the block-house are either laid horizontally, and halved together at the ends, like an ordinary log-house, or else they are placed vertically, side by side, and connected at top by a cap-sill. The sides are arranged with loop-hole defences, and the top is formed by laying heavy logs, side by side, of the same thickness as those used for the sides, and covering them with earth to the depth of three feet.

With regard to the details of the construction, the timber for the sides should be twelve inches thick, to resist an attack of musketry, and to resist field-pieces two feet, in which case the sides are formed of two thicknesses of twelve-inch timber. If the timber is placed upright, each piece should be let into a mortise in the cap-sill; and every fourth piece of the top, at least, should be notched on the cap-sill, to prevent the sides from spreading out.

The plan must conform to its object generally; it may be square or rectangular. If flank defenses are required, its plan may be that of a cross. The interior height should not be less than nine feet, to allow an ample room for loading the musket; this height will require that the timber of the sides shall be twelve feet long, in order to be firmly set in the earth. Sometimes a ground-sill is placed under the uprights, but this is seldom necessary. The width may be only twelve feet in some cases, but it is better to allow twenty feet; this will admit of a camp bed of boards on each side, six and a half feet wide, and a free space of seven feet. If cannon are to be used for the defense, the width must be at least twenty-four feet; this will allow eighteen feet for the service of the gun, which is generally ample, and six feet for a defense of musketry on the opposite side. A greater width than twenty-four feet cannot well be allowed, because the bearing would be too great between the sides for twelve-inch timber; and even for a width of sixteen feet it would be well to support the top pieces by placing a *girder* under them resting on *shores*. See *Keep* and *Redoubt*.

SAFETY STOP.—A device to prevent the accidental discharge of a gun. Usually a flat spring catches against the rear of the hammer and locks it against the nipple: when the spring is pressed against the stock, the hammer is free to be cocked.

SAGAIE. A dart or javelin used by the inhabitants of Madagascar. Also written *Zagie*.

SAGAMORE.—The head of a tribe among the American Indians, generally used as synonymous with *Sachem*. Some writers distinguish between them, making the *Sachem* a chief of the first rank, and a *Sagamore* one of the second.

SAGITTARII.—In the Roman Army, under the Emperors, young men armed with bows and arrows, who, together with the *Funditores*, were generally sent out to skirmish before the main body. They constituted no part of the *Velites*, but seem to have succeeded them at the time when the Socii was admitted into the Roman legions; for, at that period, the *Velites* were discontinued.

SAGUM.—An ancient military garment or cloak, made of wool, without sleeves, fastened by a girdle around the waist, and a buckle. It was worn by the Romans, Greeks, and Gauls. The Generals alone wore the *Paludamentum*, and all the Roman soldiers, even the Centurions and Tribunes, used the *Sagum*.

SAIKYR.—In the Middle Ages, a species of cannon smaller than the demi-culverin, much employed in sieges. Like the falcon, it derived its name from a species of hawk. See *Saker*.

SAINT MICHAEL.—The Order of Saint Michael was instituted in 1469 by Louis XII. in honor of the great services done to France by that Archangel at the siege of Orleans, where he is supposed to have appeared at the head of the French troops, disputing the passage of a bridge, and to have repulsed the attack of the English, whose affairs ever after declined in that Kingdom. The Order is a rich collar, with the image of that Saint pendent thereto, with the inscription, *Immensi tremor oceani*.

SAINT PETERSBURG CONVENTION.—A convention signed in December, 1868, in that city by all the European powers except Bavaria, and the United States of America, for interdicting the use of all explosive bullets in time of war.

SAINT REMY SYSTEM OF FORTIFICATION.—The enciente in this system is composed of isolated forts well covered by ravelins, counterguards and lunettes. Each fort contains a barrack for the garrison. The great defect is, that the loss of one fort deprives the collateral ones of flanking defence on half their perimeters.

SAJI MUTTEE.—An Indian term for carbonate of soda. It is found in many parts of India on the surface of the soil as a carbonate or sulphate of soda, in the proportion of 50 per cent. of the former to 10 or 15 of the latter. By washing, heating, and evaporation, the sulphate is converted into a sulphuret of sodium, which, by further heating and exposure to the atmosphere, is changed into carbonate of soda. In its crude state it is commonly used in India in clearing off the old coat of paint from gun-carriages previous to applying the new one, and for removing grease, etc.

SAKER.—An ancient 4-or 5-pounder of 13 feet, weighing from 2500 to 2800 pounds. According to Tartaglia, the *Sacre*, in 1546 was a 12-pounder of 9 feet, and weighing 2150 pounds. It was similar to the *Aspec*, but longer.

SALADE.—In ancient armor, a kind of bascinet, but projecting much behind the head, and having a movable visor. It was introduced in the reign of Henry VI. It is also written *sallet*.

SALADIN.—1. The original term for the coat of arms; so called because the Christians who conquered Palestine assumed it in imitation of the Turks, whose Chief was at that time Saladin. 2. The name given by the western writers to SALAH-ED-DIN YUSSUF IBN AYUB, the Sultan of Egypt and Syria, and the founder of the Ayubite Dynasty in those countries. As the great Moslem hero of the third crusade, and the beau ideal of Moslem chivalry, he is one of the most interesting characters presented to us by the history of that period. He belonged to the Kurdish tribe of Ravad, and was born at Tekreit (a town of the Tigris, of which his father Ayub was *Kutwal* or Governor under the Seljuks) in 1137. Following the example of his father and uncle, he entered the service of Noureddin, Prince of Syria, and accompanied his uncle in his various expeditions to Egypt in command of Noureddin's army. Saladin was at this time much addicted to wine and gambling, and it was not till at the head of a small detachment of the Syrian army he was beleaguered in Alexandria by the combined Christians of Palestine and Egyptians that he gave indications of possessing the qualities requisite for a Great Captain. On the death of his uncle Shirkoh, Saladin became Grand-Vizier of the Fatimite Caliph, and received the title of *El-melek-el-nasr*, "The Victorious Prince"; but the Christians of Syria and Palestine, alarmed at the elevation of a Syrian Emir to supreme power in Egypt, made a combined and vigorous attack on the new Vizier. Saladin foiled them at Damietta, and transferred the contest to Palestine, taking several fortresses, and defeating his assaillants near Gaza; but about the same time his newborn power was exposed to a still more formidable danger from his master, Noureddin, whose jealousy of the talents and ambition of his able young Lieutenant required all the skill and wariness at Saladin's command to allay. On Noureddin's death in 1174, Saladin began a struggle with his successor, which ended in his establishing himself as the Sultan of Egypt and Syria, a title which was confirmed to him by the Caliph of Bagdad.

SALEETAH.—An Indian term for a bag containing a soldier's bedding, &c. on the march. Saleetahs are also used in packing the compotent parts of tents. They are made of gunny cloth.

SALE OF STORES.—The President is authorized to cause to be sold unserviceable ordnance or stores of any kind, but the inspection or survey of unserviceable stores should be made by an Inspector General, or such other officer or officers as the Secretary of War may appoint for that purpose; and the sale should be made under such rules and regulations as may be prescribed by the Secretary of War. In all cases where lands have been, or shall hereafter be, conveyed to or for the United States, for forts, arsenals, dock-yards, light-houses, or any like purpose, or in payment of debts due to the United States, which are not used, or necessary for the purposes for which they were purchased, or other authorized purpose, it is lawful for the President of the United States to cause the same to be sold, for the best price to be obtained, and to convey the same to the purchaser by grant or otherwise.

SALIENT.—In Heraldry, that attitude of a lion or other beast, differing but slightly from *rampant*. He is supposed to be in the act of springing on his prey, and both paws are elevated. Two animals *counter-salient* are represented as leaping in opposite directions.

In a fortification, that which points outward from the interior of any work. For example, the central angle of a bastion, pointing toward the enemy, is a salient angle.

SALIENT ORDER OF BATTLE.—An order of battle, the front of the army being formed on a salient or outward angle. This formation is seldom resorted to, as it presents many disadvantages. Certain attacks of necessity assume the salient form, not to await the enemy, but for immediate attack, provision being made by reinforcing the head of the attack, for insuring and following up its successes, and by feints carried on elsewhere to weaken the resistance. On the defensive, the salient order can be resorted to, without entailing a defeat, if the wings can be strongly protected by obstacles, and the open of the triangle placed in such a manner as to deprive the cross-fire of the enemy's artillery of its full effect. Masses of cavalry may operate, however, with great effect from the apex of a salient order.

SALIENT PLACES OF ARMS.—In fortification, that part of the covered-way which is opposite a salient of a bastion or demi-lune.

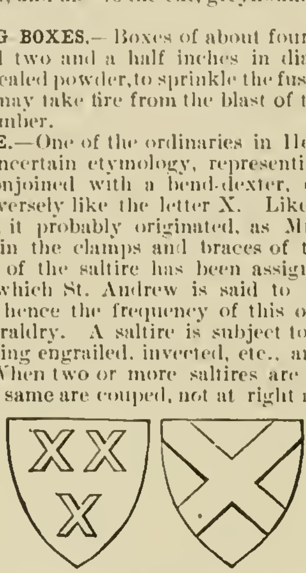
SALLY.—A sudden offensive movement by the garrison of a fortified place, directed against the troops or works of the besiegers.

SALLY-PORT.—A gate or passage by which the garrison of a fortress may make a sally or sudden attack on the besiegers. The name is applied to the postern leading from under the rampart into the ditch; but its more modern application is to a cutting through the glacis, by which a sally may be made from the covered-way. When not employed, sally-ports are closed by massive gates of timber and iron.

SALTANT.—In Heraldry, in a leading position, or springing forward; applied especially to the squirrel, weasel, rat, and also to the cat, greyhound, monkey, etc.

SALTING BOXES.—Boxes of about four inches altitude and two and a half inches in diameter, for holding mealed powder, to sprinkle the fuses of shells that they may take fire from the blast of the powder in the chamber.

SALTIRE.—One of the ordinaries in Heraldry, its name of uncertain etymology, representing a bend-sinister conjoined with a bend-dexter, or a cross placed traversely like the letter X. Like the other ordinaries, it probably originated, as Mr. Planché suggests, in the clamps and braces of the shield. The form of the saltire has been assigned to the cross on which St. Andrew is said to have been crucified; hence the frequency of this ordinary in Scotch Heraldry. A saltire is subject to the variations of being engrailed, invected, etc., and may be *couped*. When two or more saltires are borne in a shield, the same are couped, not at right angles, but

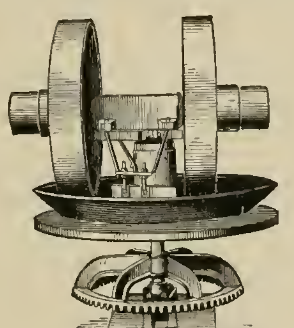


Saltire.

horizontally; and as they are always so treated, it is considered superfluous to blazon them as couped. Charges disposed in the form of a saltire are described as placed *saltireways*, or *in saltire*. The former term is more properly applied to two long charges, as swords or keys, placed across one another (in which case the rule is, that the sword in bend-sinister should be uppermost, unless otherwise blazoned); and the latter to five charges placed two, one, and two. See *Heraldry*.

SALTPETER.—The saltpeter, or niter, which is employed in the manufacture of gunpowder, and is the principal ingredient therein, is a natural production found in various parts of the world, but chiefly in the East Indies, Ceylon, and in Asia Minor. In the condition, however, in which it is imported it always contains a large quantity of earthy matter and other impurities, such as chloride of sodium, magnesia, and other salts, that have to be eliminated before the saltpeter is fit to be used in making gunpowder. Efflorescent salts are sometimes present, but the quantity being small, they are comparatively innoxious and do not weaken the powder, but only slightly impede the rapidity of deflagration. The refining of the saltpeter, therefore, is for the purpose of removing the before-named impurities and all earthy matters which may be present, and is affected by boiling and skimming the grough or impure saltpeter in large open boilers, and afterwards drawing off the liquor and straining it through canvas bags. The *modus operandi* is as follows: About 40 cwts. of salpeter in its crude state are put into an open copper boiler capable of containing 500 gallons; about 270 gallons of water are added to this, or about .66 of water to 1 of saltpeter, and these are allowed to stand all night; in the morning a fire is lighted under the boiler, and in about two hours afterwards they will be found to have reached a temperature of 300° Fahr., and will be boiling freely. During ebullition, and by constant stirring, the light matter—containing many impurities—rises to the surface, and is skimmed off; as soon as the scum ceases to rise, cold water is freely dashed on the surface of the boiling liquid to precipitate the chlorides that would otherwise be retained on the surface by the ebullition. After boiling until the solution of the nitrous salts is effected, the fire is allowed to go out; when all the ebullition has ceased, the foul salts and chlorides—being the heaviest—are precipitated, and, as the boiler is provided with a false bottom perforated with holes, the foul salts and other impurities pass through the perforations and remain at the real bottom of the boiler. In about an hour after the fire has been extinguished, the temperature of the solution will have fallen to about 220° Fahr., or sufficiently to allow of a syphon being introduced, the end of which is kept 1″ from the false bottom of the boiler, so as not to disturb the foul salts. The liquor is now drawn off by means of this syphon into a filter or trough, the bottom of which is fitted with four or five gun-metal taps, communicating with suspended Dowlas canvas filtering bags, of the shape of an inverted cone. If crystals form on these filtering bags, and prevent the liquor from passing freely through, hot water is poured over them to keep the canvas open, a constant supply of hot water for the purpose being obtained from a vessel provided with a flexible pipe, having a finely-pierced rose head, the whole being fixed in close proximity to the filtering trough, ready for use whenever required. When all the liquor has passed through the filtering bags, it is run into a shallow trough or cooler, which is about 12′ long by 6′ wide by 1′ deep, and is lined with sheet copper and placed by the side of a washing vat. The liquor in the cooler is now agitated by a wooden rake until the temperature is reduced to about 180° Fahr., at which temperature the mother-water separates from the saltpeter held in solution; when it falls below 180°, a large number of very minute crystals are formed, and these are collected and thrown on to a wire-cloth drainer, fixed at an angle immediately above the cooler, so that the strainings or liquor may run back again into the cooler; and the saltpeter, when sufficiently drained, is raked into the washing vat, which also is furnished with a false bottom, covered with fine copper wire-cloth. When the whole charge is in the washing vat, it receives three washings; in the first and second, pure water is freely sprinkled over the saltpeter from a rose-ended pipe, and after being allowed to stand for about fifteen minutes, the liquor—being very rich in mother-water and saltpeter—is run off into crystallizing pans by means of a tap at the bottom of washing vat. In the third washing, the vat is filled with cold water, and the liquor, after standing for about half an hour, is drawn off in the same manner; but as it now only contains a small quantity of saltpeter, it is not run into the crystallizing pans, but is collected in an underground tank for future use. The saltpeter obtained by the above process is almost perfectly pure, and has the appearance of snow. It is now placed in stone bins, perforated with small holes in the ends and sides, where it is allowed to drain. When placed in these bins the saltpeter contains from seven to twelve per cent. of water, but during the time it remains in them about six or seven per cent. is drained off. It is now fit for making gunpowder if used immediately; but if a supply be required for storage or transport, it is better to evaporate the remaining water, and this is done by drying it in a hot chamber in the following manner. The saltpeter is spread out about 2″ thick on shallow trays made of sheet copper, and placed on racks in the hot chamber, which is heated up to about 260° Fahr. by means of a flue underneath the floor. The saltpeter, while in the hot chamber, is stirred once or twice, and it is found that from four to six hours is sufficient to evaporate the remaining moisture. It is now taken out of the hot chamber and emptied into shallow trays, where it is allowed to cool; it is then put into barrels and sent into store.

By the above process about three-fourths of the saltpeter is crystallized, the remaining portion being held in solution by the mother-water that remains in the large cooler. When this has cooled down to within 7° or 8° of the temperature of the atmosphere, large crystals are formed, and adhere to the sides and bottom of the cooler; these are collected and put with the grough into the next charge of the boiler; all the mother-liquor is also collected in the underground tank, whence it is pumped into another boiler, where it is evaporated to a fourth of its original quantity; it is then drawn off by means of a syphon, passed through filtering bags, and collected in a receiver, whence it is run off into copper pans holding about thirty-six gallons each, and there allowed to crystallize. Though the crystals obtained in this manner are pure, still they contain cavities wherein the mother-water is enclosed, and it is found that the simplest and best plan is to use them in the next charge as grough. Over the foul salts and impurities left in the bottom of the evaporating pan hot water is poured, and the whole well stirred in order to extract any saltpeter that may remain; after being allowed to settle for a short time, this solution is also drawn off and passed through the filtering bags, previous to its being run into the crystallizing pans before mentioned. Should the filtering bags become clogged or full of impurities, they are removed and placed in larger bags hung in a cleaning apparatus, where they, together with the bags in which the saltpeter is imported, are well washed by having hot water run through them, and this water—containing a small percentage of niter—is also collected in the mother-liquor tank. The bag cleanser is also used



for washing the skimmings and foreign salts, etc., taken from the copper boiler; the residue from this is generally sold for manure, together with the refuse from the evaporating pans. The water from the various washings and drainings is all conveyed by gutters under the floor to the underground tank, whence it is pumped into the copper boiler as required, and used instead of pure water in the next charge; and as it contains a small percentage of saltpeter, a less quantity of grough is required to give the requisite proportions. To test the saltpeter, dissolve a small quantity in a test tube or phial with distilled water, add a few drops each of nitric acid and nitrate of silver. If the solution remains clear, the saltpeter is pure; but if a milkiness appears, it indicates the presence of a chloride, and this is generally the chloride of sodium. The saltpeter—if used immediately after being purified—is so fine as to require no further reduction of its particles before mixing; but if it has been dried for storage it must, like the sulphur, be reduced to a very fine powder. They are each ground separately in a small machine somewhat similar in character to a mortar mill. The machine consists of one pair of edge rollers or runners, travelling round a strong circular cast-iron bed, and revolving at the same time on their own axis. The speed of these rollers is eight revolutions per minute round the bed, and they are each 4' in diameter, and weigh 30 cwt. Each one travels on a different path, one being near to the inside curb or "cheese," as it is technically called, whilst the other one is further away from the center, and nearer to the outer curb. A shaft or spindle common to both rollers passes through their centers, and between them is a crosshead fixed on a vertical shaft that is driven by means of level gearing, the pinion being secured on the main horizontal driving shaft underneath the machine, whilst the vertical shaft or spindle, upon which the large bevel wheel is fixed, passes through the crosshead, this latter being provided with suitable brass bushes in order to allow the rollers to rise or fall according to the thickness of the material under them. The material to be ground—whether saltpeter or sulphur—is spread evenly over the bed of the machine to a thickness of about 1".05 or 2"; the rollers are then set in motion, and a very short time suffices to complete the operation of grinding. The material, when sufficiently ground, is shovelled from the bed into tubs and these are emptied into a hopper placed above a sifting reel, which is similar in all respects to the charcoal reel. As this reel revolves, certain projections provided on the shaft strike against similar projections on the bottom of the trough that conveys the material from the hopper to the reel, and as this trough is slung under the hopper it is thus made to vibrate, and so causes the material to be shaken gradually from the hopper into the reel. The ingredients are now weighed out very accurately, in the proportions of 15 of saltpeter to 3 of charcoal and 2 of sulphur, and as about 50 lb. of this mixture constitutes a charge for the incorporating mill, the quantities are—saltpeter, 37½ lb.; charcoal 7½ lb., and sulphur, 5 lb. These are placed separately in small bags, and taken to the mixing machine. See *Gunpowder*.

SALUTE.—A salute with cannon is a certain number of guns fired in succession with blank cartridges, in honor of some person, to celebrate an event, or to show respect to the flag of a country. The rapidity with which the pieces are discharged depends upon their caliber. Field-guns should have intervals of five seconds between discharges; siege-guns, eight; and guns of heavier caliber, ten. The minimum number of pieces with which salutes can be fired is two for field, four for siege, and six for all sea-coast guns. Mortars, as a rule, are not used for saluting purposes.

Personages entitled to salutes, if *passing* a military post, as also foreign ships-of-war, are saluted with guns of heavy caliber, the most suitable being the 10-inch smooth-bore. When troops are drawn up for the reception of a dignitary, and it is practicable to have a battery of field-guns on the ground, a salute from it should form part of the ceremony; otherwise guns in position are used. The national salute, and minute-guns upon funeral occasions, are, when praticable, fired from heavy pieces.

The pieces used for a salute should, if possible, be of the same or equivalent caliber; and when the number on the front of a work admits of it, the entire number required, and two or three over, should be loaded and made ready previous to commencing the salute; the detachments are then dispensed with, and a single cannoneer at each piece discharges it at the proper time. When the number of pieces is insufficient for the entire salute, as many as possible should be used, so as to avoid frequent reloadings. The pieces are numbered from right to left—*one, two, three*, and so on—and each detachment or the cannoneer, as the case may be, is made to clearly understand the number of the piece. To insure regularity of intervals, the officer in charge of the firing should habituate himself to uniformity in giving the commands to fire.

At the proper moment the officer in charge commands: *Number one*, FIRE, and observing the proper interval, *Number two*, FIRE, and so on to the left piece, when he returns to the first and repeats the same commands until the entire number required for the salute is discharged. In giving the command *fire*, he looks towards the piece to be fired, and gives it in such a pronounced manner, accompanied by a signal with his sword, as to be unmistakable. Immediately after each piece is discharged it is reloaded and made *ready*. The cartridges are withdrawn from the pieces that remain loaded at the conclusion of the salute. See *International Salute*, *National Salute*, *Official Courtesies*, *Personal Salutes*, and *Salvo*.

SALUTES.—Movements of the hand previous to addressing and subsequent to being addressed by a superior. To execute the authorized salute without arms, the Instructor commands: 1. *Right* (or *left*) *hand*, 2. SALUTE. Raise the right hand smartly, pointing in the same direction as the right foot, the palm of the hand down, the thumb close to the forefinger, the arm extended, and horizontal. (Two.) Bring the hand around till the point of the thumb and side of the forefinger touch the lower edge of the cap or visor, at the same time turn the head a little to the left, look towards the person to be saluted, and retain this position till the salute is acknowledged. (THREE.) Bring back the hand and arm to the position of the first motion, at the same time cast the eyes to the front. (FOUR.) Drop the arm quickly by the side.

Officers salute (without swords) as follows: (*First motion.*) Raise the right hand till the tips of the fingers touch the visor opposite the right eye, the thumb closed, the fingers and hand extended in prolongation of the forearm, the elbow down. (*Second motion.*) Lower the hand briskly and to the right till the point of the fingers are at the height of the shoulder and in front of it, the elbow advancing slightly; the hand and fingers still extended in prolongation of the forearm. (*Third motion.*) Drop the hand by the side. In rendering honors with troops, officers execute the first motion of the salute at the command *present*, the second motion at the command *arms*. The sword is returned to the *carry* at the command, 1. *Carry*, 2. ARMS.

The Sergeants salute (with arms) is executed as follows: Being at a carry, raise the left hand and arm horizontally to the front, palm of the hand down, the fingers extended. (Two.) Bend the left elbow, carrying the hand around till the forefinger strikes the piece in the hollow of the right shoulder, retaining it there till the salute is acknowledged. (THREE.) Return to the position of the first motion. (FOUR.) Drop the left hand by the side.

SALUTING COLOR.—An ordinary camp color, distinguished by a transverse red cross; or when the facings are red, by a transverse blue cross.

SALVO.—Concentrated fire from a greater or less number of pieces of artillery. Against a body of men, a salvo is generally useless, as the moral effect is greater in proportion to the area over which devastation is spread; but with fortifications, the case is otherwise. For the purpose of breaching, the simultaneous concussion of a number of cannon-balls on masonry, or even earth-work, produces a very destructive result. At Almeida, after the French had fired a few salvos of 65 guns, the castle sunk in a shapeless mass. The effect of a salvo of modern artillery, with its enormous steel shot, against iron-plated ramparts, has never yet been tried in actual war. The concentrated fire of a ship's broadside forms a powerful salvo.

Salvos, corresponding to volleys of musketry, are frequently fired by way of salutes over the graves of officers at the time of burial.

The order designating a funeral escort prescribes whether the fire shall be three volleys of musketry or three salvos of artillery. See *Salute*.

SAMBUQUE.—An ancient musical instrument of the wind kind, resembling a flute. It was also the name of an ancient engine of war used by Marcellus in besieging Syracuse. Plutarch relates that two ships were required to carry it. A minute description of this engine may be seen in Polybius.

SAND BAG REVETMENT.—Sand-bags are sometimes used for revetments when other materials cannot be procured; though their object, in most cases, is to repair damages done by the enemy's fire. They are made of canvas, or a good quality of gunny-cloth, sewed with cotton twine with lock-stitch; the bag, when empty, is 2 feet 8 inches long and 1 foot 4 inches wide. When filled and laid they occupy a space of 6 by 10 by 24 inches, and contain 0.85 of a cubic foot of sand, weighing very nearly 85 pounds. Thirty-two make a cubic yard.

The bags are laid as headers and stretchers, either in the English or Flemish bonds. They should not be more than three-fourths full when laid; if full they do not lay well, and are more liable to burst on becoming wet, or under great pressure. When time is of importance, the bags need not be tied, but the throat is given a twist and turned under the end of the bag as it is laid. To prevent decay, they should be payed with coal-tar before being filled or before being laid; this, furthermore, renders them the less liable to take fire when dry. One hundred and forty-four sand-bags, laid as above, makes ten superficial yards of revetment. Sand-bag reveting requires less anchoring to make it stand than any other. If the reveting is kept wet, the sand will not so readily escape through rents, nor will the bags take fire from the blast of the pieces; this, however, hastens their decay. From six to ten months, depending upon usage, is the duration of reveting made of sand-bags. When used near the muzzle of the piece in the revetment of embrasures, they soon wear away, from the blast of the piece, unless well protected. See *Revetment*.

SAND BAGS.—Canvas bags, in military constructions which are filled with sand or earth, and form a ready means for extemporizing a parapet or traverse against the enemy's fire; they are likewise used for protecting the head of a trench, or tamping the charge in a mine.

The sand-bag, for the revetment of batteries, when empty and laid flat, is 2 feet 8 inches long, and 1 foot 4 inches wide; those used in the construction of the trenches are 2 feet long and 12 inches wide. See *Mines*, *Revetment*, and *Sand-bag Revetment*.

SAND BLAST.—A method of engraving, cutting, and boring glass, stone, metal, or any other hard substances, by the percussive force of a rapid stream of sharp sand driven against them by artificial means. The process was invented by General Benj. C. B. Tilghman, of Philadelphia, who took out a patent for it in October, 1870. In the world of nature the abrading power of sand, when driven by air or water against hard substances, has long been recognized, and General Tilghman's invention was merely an application of this principle to the mechanical arts. The means of propulsion may be supplied either by an air or a steam blast, the former being produced by a boiler at high pressure, and the latter by a fan revolving with a great velocity. In either case the abrading material, which is usually a common hard sand, although small granules of iron or crushed quartz are occasionally used, is directed by a tube upon the object to be cut or engraved, the latter being so adjusted by means of slides that each part in succession can be brought under the action of the cutting particles. The engraving of the surface of glass with ornamental figures, etc., may by this process be very easily accomplished, simply by laying upon it patterns of the desired objects cut out of some resistant medium in the manner of stencils. The sand, of course, does not touch the protected parts, but indents those which are uncovered, until the result sought for is attained. Another method very commonly used is to cut the proposed pattern in sheet copper or brass, which is then placed over the glass, a brush of melted beeswax being drawn over the whole. The stencil is then raised, and the pattern left in exposed glass may then be operated upon by the blast. The ornamentation of glass in colors may also be performed by the sand-blast, for as the ordinary colored glass of commerce is mere window glass, with a thin layer of color on one side only, the use of the stenciled pattern as before will entirely remove the color from the exposed parts and leave it where protected. By the use of a photographed coating of gelatine upon glass (the well-known gelatine process in photography) very beautiful reproductions of line engravings may be made upon the glass at a small cost. The sand-blast has also been used successfully in the cutting of ornaments and inscriptions upon stone. Iron stencils are sometimes used for the purpose, but the most satisfactory material is found to be sheet rubber of about 1-16th of an inch in thickness. This is cemented upon the stone, and a movable jet pipe is caused to traverse the surface of the latter until the exposed portions have been sufficiently abraded. The wear upon the rubber itself is wonderfully slight, and the same stencil may be used over and over again. Another use to which the sand-blast has been successfully put is in turning blocks of stone and metal into circular and other forms in the lathe. Balcony pilasters, etc., have in this way been finished in a few hours which would have needed as many days to be cut out by hand. Upon wood the action of the sand-blast is not so satisfactory, being slow and tedious, and the only way in which it can be utilized on this material is in cutting out the large block type used in printing posters. The foregoing are only a few of the ways in which the sand-blast has manifested its usefulness, but as the invention is still in its infancy it is impossible to say what applications in the arsenal and workshop may not be found for it in the future. From its first appearance the sand-blast has attracted much attention both at home and abroad, many foreign patents have been taken out, and the use of the process is gradually spreading.

SAND-CRACK.—A splitting or fracture of the horny fibers of the horse's hoof, extending usually from above downward; when reaching to the quick it causes lameness, and in all cases it constitutes unsoundness. Horses with thin, weak, brittle feet, spoilt by much rasping, and rattled on the hard roads, furnish the majority of cases. The horn must be thinned for an eighth of an inch on either side of the crack, across the upper and lower ends of the crack, to prevent its extension, the firing-iron should be drawn, making a line nearly through the horny crust. The opening may further be held together by winding round the foot several yards of waxed string, or fine iron wire. Except in very bad cases, slow work on soft land may be permitted, but road work is very injurious. The growth of healthy horn is promoted by applying round the coronet, at intervals of 10 days, some mild blistering liniment.

SANDHURST ROYAL MILITARY COLLEGE.—In 1802 it was determined to institute a College for the training of military officers, in which professional education should be grafted on the groundwork of general instruction. The College was opened at Great Marlow; but, in 1812, it was transferred to a handsome stone building at Sandhurst. Up to 1862 this was devoted to the education of boys from the age of 13 upward. In that year, however, the system was changed; the course limited to one year immediately before entering the army, and the subjects of instruction confined to the higher mathematics, modern languages, and military science. Entrance was on the nomination of the Commander-in-Chief; and the payment by the Cadet's parent or guardian varies from £100 to *nil*, according to the circumstances and rank of the parent. Those for whom no payment is made must be orphans, and are styled "Queen's Cadets." Under the purchase system, all first commissions in the Cavalry and Infantry of the Line, which were granted without purchase, and not to men from the ranks, were given to Cadets from the Royal Military College, who competed for these prizes, and obtained them in order of merit. The abolition of purchase in 1871 brought about a radical change. The students are no longer boys intending to become officers, but Sub-lieutenants, who, having passed by competition for the army, spend a year at Sandhurst in acquiring the theoretical part of the war science. To be confirmed in the army as Lieutenant, the officer must pass creditably out of Sandhurst, and then serve a year on probation with a regiment. It cannot be doubted that this change of system must tend, as years go on, to secure for the army a great body of scientific officers. The Staff College is a separate Institution, about 2 miles distant. The estimated charge for the Royal Military College for 1878-79 was £36,281, of which about £5,000 is covered by the payments for the students.

SAND-SHOT.—Small cast-iron balls, such as grape, canister, or case, cast in sand. Larger balls are cast in iron moulds. This nature of shot varies in weight from 4 pounds to 1½ ounces.

SANFORD TARGET.—A canvas target possessing all the essentials of the Wimbledon target, but having a simpler mechanism, based on the principle of a window with upper and lower sashes, made to balance themselves, so that when one is pulled down the other is proportionately and simultaneously elevated. The frame work of this target is made of wood, and by increasing or diminishing the length of these frames, any class target can be erected at will, provided the length of the pit is sufficient. The pit should be at least eight feet long by six feet wide at the top, and seven feet deep for a second or third-class target. The framework of the target has two legs, which are secured to the sash by passing through staples fastened thereon. With this target a ricochet is signalled by waving the red flag three times in front of the target; otherwise, the marking and signalling are the same as when using the Wimbleton target.

SANGIAC.—A situation or appointment of dignity in Turkey. The Sangiacs are Governors of towns or Cantons, and take rank immediately after the *Beglerbegs*. The name is also applied to the banner which he is authorized to display, and has been mistaken for Saint Jacques.

SANITARY.—Having reference to measures for securing health. Within the last twenty years increased means have been adopted to reduce the state of mortality amongst the soldiery. During the Crimean war, the casualties were large at first, but from sanitary measures being taken, the number of deaths per 1,000 men was greatly reduced. In England, up to 1853, the mortality per 1,000 amongst the soldiery was 17.5, whereas that of the male population amounted to 19.2. The great mortality was in those days amongst the Foot Guards, and appears to have arisen in a great measure from want of proper sanitary arrangements. But a great improvement of late years has taken place in the health of the soldier; his barracks are better ventilated, his comforts and amusements are greater, and indeed all the measures adopted to keep him in health are more numerous than they formerly were. In 1874 the strength of the army in Great Britain was about 90,000; the average rate of mortality during that year was 8¾ per 1,000; this was a higher death rate than in 1873, which is accounted for in the higher death rate among the general population in 1874. The report from which the above information is gained observes that "no doubt the rate of admission and death in 1874 was also somewhat raised by the circumstance that many invalids from abroad, instead of being sent to Netley, joined their depots, and the records of their admission and deaths were not always kept distinct from those of the other soldiers."

SANITARY REPORT.—A report made yearly, or oftener, by Army Surgeons. The Report usually embraces the following subjects:

GARRISON—PERSONEL.

1. Present strength—mean strength, composition

and changes during the year, transient troops and the destination.

2. Civil employes and servants.

3. Women, children, and servants.

QUARTERS.

4. Barracks—Geographical and physical site, material, capacity, character, special features, etc.

5. Dormitories—superficial area and cubic air-space per man, ventilation.

6. Dormitories—warming and lighting, natural and artificial.

7. Dormitories—bedding, bunks, material, single, double, or superimposed.

8. Dormitories—fixtures for clothing, arms, seating, police.

9. Barrack offices, clothing and provision rooms, cellars, coal sheds.

10. Kitchens and company bakeries.

11. Mess-rooms, mess-furniture, quantity, condition, and material. Separate for N. C. O.'s.

12. Bath-rooms, lavatories, and facilities for ablution.

13. Married soldiers' quarters—relative site, number of sets, material, usual number of occupants to each room.

14. Officers' Quarters—Number of sets—material and character. Bathing and water facilities, condition and sufficiency.

15. Guard-house—Site, suitability, character, material, internal construction and arrangement, ventilation, warming, lighting, police, facilities afforded for cleanliness of inmates, minimum, maximum, and average occupancy by prisoners.

FOOD.

16. Rations—quality, quantity, variety, suitability for seasons and geographical situations, deficiencies, portions from which company savings are made.

17. Fresh Meat—kind, quality, mode of procuring, issuing, inspecting, preserving, and how often issued to troops.

18. Facilities for marketing for officers.

19. Extra supplies kept by Sub. Dept. for sale to officers—quality, sufficiency, and variety. Deficiencies, if any.

20. Extra vegetables, pickles, and other articles of food, game and fish—amount and how obtained.

21. Cooking—how often, by whom and when inspected, and hours for serving meals.

22. Gardens—post or company, how cultivated, disposition of produce.

23. Cows kept by companies—number of each.

24. Post-bakery—character, capacity, condition, and management.

25. Water-supply—Whence and how obtained, distributed, kept for use, quality and quantity. If well-water is used, give means for protection against sewage and drainage.

26. Ice—how obtained and preserved, quantity qualtity, allowance, and months of issue.

27. Store-houses—capacity and suitability for preserving rations.

28. Fuel—kind, quality, quantity, and suitability to climate and season.

CLOTHING.

29. Quality, condition, appropriateness for season and locality, especially in regard to blankets, boots, shoes, socks, and hats.

EMPLOYMENT.

30. Character and amount of martial and fatigue duties.

POLICE.

31. Personal habits, temperance, cleanliness, and bearing of men.

32. Sinks, latrines, privies, urinals, and water-closets—relative situation to barracks and quarters, condition, facilities for flushing, emptying, or how contents disposed of.

33. Drainage and Sewage—extent and character, natural and artificial, general and special, effects or defects.

34. Stables—relative site of cavalry, quartermasters, and others for the accommodation of officers private horses. Capacity, condition, and material. Police and disposal of manure.

35. Cow-pens, mule-corrals—relative position and police.

36. Are pigs or chickens kept for the benefit of the soldiers' mess?

37. Regulations governing the keeping of dogs at post and precautions against danger of hydrophobia.

38. Police—general, of post, how, when, and by whom done. Police—special, nature, whitewashing of fences, facilities, frequency. Police of yards and out-buildings attached to officers' quarters.

39. Recreation—facilities for boating, hunting, fishing, swimming, skating, games of strength and dexterity, ten-pins, billiards, base ball, cricket, theatricals, music, etc.

40. Post School—Site, capacity, and suitability, number of teachers and pupils, attendance by enlisted men, heating, ventilation, water-closets for pupils, etc. Divine service—facilities for attendance on.

41. Post or Company Libraries—number and the character of volumes, facilities afforded men for reading.

42. Recruits—physique and character.

43. Nature and frequency of punishment, effects on health and morals of soldiers.

HOSPITAL AND SANITARY.

44. Hospital buildings—site, relative position, condition, and suitability.

45. Hospital grounds—extent, cultivation, drainage, shade.

46. Heating, shading, lighting, ventilation, and protection from lightning.

47. Hospital wards—capacity, superficial area and air-space per bed, average occupation of each ward, isolation ward for the treatment of contagious diseases.

48. Hospital wards—fixtures and furniture.

49. Hospital kitchen and laundry—position, furniture, fixtures, and condition.

50. Hospital mess-room—fixtures and furniture.

51. Hospital offices, dispensary, store-rooms—fixtures, furniture, suitability, cellars, coal-sheds, out-buildings, condition, and use.

52. Hospital post-mortem room—the situation, fixtures, furniture, and condition.

53. Hospital lavatories—bath-extent, convenience, water-supply, drainage, etc.

54. Hospital water-closets, sinks, urinals—site and drainage.

55. Hospital drainage and sewage—separate or connected with other systems.

56. Hospital police and hospital grounds and vicinage.

57. Hospital diet—how cooked, inspected, served, and difference from diet-table.

58. Hospital garden—size, how cultivated, amount and variety of produce.

59. Cows, chickens, milk, butter, eggs, kept and raised for hospital.

60. Ice—how supplied to hospital, amount, and months issued.

61. How and when are purchases made from hospital fund, and its monthly average.

62. Hospital stewards—name, length of service, general and special character.

63. Attendants—names, length of service, character and discipline.

64. Officers, facilities for treatment of, in hospital.

65. Hours of sick-call, winter and summer

66. Percentage of sick to command, ditto of mortality to sick.

67. Aggregate number of days' service lost to Government by sickness of soldiers during year.

68. Cleanliness of patients on admission, discipline.

69. Nursing—how and by whom performed, night service.

70. Occupation and amusements of convalescents, reading matter, games, etc.

71. Prevalent diseases at post and vicinity.

72. Nature and amount of diseases amongst women, children, civil employés, camp followers at post, number and cause of deaths, and number of births at post during year.

73. Diseases, if any, of local origin.

74. Diseases supposed to be checked by hygienic measures.

75. Hospital supplies—whence obtained, quality, and condition in which received and kept.

76. Instruments—hospital and personal, condition.

77. Amount, nature, and condition of hospital bedding.

78. Amount, nature, and condition of the hospital clothing.

79. Amount and condition of hospital appliances.

80. Hospital Library—number of volumes, condition, and conveniences for preservation.

81. Hospital records, blanks, condition, supply, completeness; files of orders, condition.

82. Average monthlytemperature—extremes,wind, moisture.

83. Means of subduing fire at post, and special at hospital.

84. Means for transportation of sick and wounded —ambulances, stretchers.

85. Hospital tents—extra number, how kept, condition, and use.

86. Interments—how conducted, post cemetery—area, care, and condition.

87. Inhabitants of surrounding country, the Indian tribes, etc.

88. Sanitary measures recommended at the post—copies marked and appended herewith.

89. Extra sanitary measures enforced in hospital.

90. Miscellaneous facts and general recommendations.

SANJAK.—A Turkish word signifying "a standard," employed to denote a subdivision of an *Eyalet*, because the ruler of such a subdivision, called *Sanjak Beg*, is entitled to carry in war a standard of one horse-tail. The Sanjak is frequently called *Liva*, and its ruler a *Mirmiram*.

SANJAK-SHERIF.—The sacred banner of the Mohammedans. See *Flag of the Prophet*.

SANSCULOTTES.—The name given in scorn, at the beginning of the French Revolution, by the Court Party to the democratic "Proletaires" of Paris. The latter accepted this superfine reproach with sardonic pride, and the term soon became the distinctive appellation of a "Good Patriot," more especially as such a one often made a point of showing his contempt for the rich by neglecting his apparel, and cultivating rough and cynical manners. As the Noblesse prided itself on an illustrious pedigree, so the genuine child of the Revolution boasted that he was come of a long line of—noteless Sansculottes; that his "Ancient but ignoble blood had crept through scoundrels ever since the flood"

Toward the close of the Convention the name, connected as it had been with all the sanguinary excesses of the period, naturally fell into bad odor, and soon after totally disappeared: nor do the French appear to wish that its memory should be preserved, for they have not given it a place in their encyclopedias.

SAP.—In military engineering, the narrow ditch or trench, by which approach is made from the foremost parallel toward the glacis or covert-way of a besieged place. The sap is usually made by four sappers, the leading man of whom rolls a large gabion before him, and excavates as he progresses, filling smaller gabions with the earth dug out, and erecting them on one or both sides to form a parapet. The other sappers widen and deepen the sap, throwing more earth on to the parapet. A sap is considered to advance in average ground about eight feet per hour. From the nearness of the enemy's works, running a sap is an extremely dangerous operation. When possible,therefore, it is carried on at night: in any case, the sappers are relieved at least every hour. When a sap is enlarged to the dimensions of a trench, it bears that name. See *Double Sap*, *Half-double Sap*, *Flying Sap* and *Full Sap*.

SAP-FAGOTS.—Short fascines of straight brushwood at least one inch in diameter, used in regular approaches. Sap-fagots are two feet and nine inches long, and five inches in diameter. The center stake should be from one and one-half to two inches in diameter, and project nine inches beyond one end of the sap-fagot; this projecting portion is sharpened, to enable the sap-fagot to be planted firmly in the ground in an upright position.

SAPPER.—1. The name given to a private soldier in the Corps of Royal Engineers. The name of the Corps was formerly Royal Sappers and Miners. The pay of the sapper is £20 10s. 7½d. a year, with extra pay when at work: the number of such men for 1877-8 was 2,952. Only men of good character, already adepts in a mechanical trade, are eligible for this service, which is very popular, as an intelligent sapper frequently passes into some situation in civil life for which his practical military training specially fits him. Many sappers are excellent surveyors, photographers, and draughtsmen. 2. There is attached to the Corps of Engineers. United States Army, a company of sappers, miners, and pontoniers, called engineer soldiers. The company is composed of Sergeants or master workmen, Corporals or overseers, musicians, privates of the first-class or artificers, and privates of the second class or laborers. The said engineer company is subject to the Rules and Articles of War, is recruited in the same manner and with the same limitation, and is entitled to the same provisions, allowances, and benefits as are allowed to other troops constituting the present military peace establishment. The company is officered by officers of the Corps of Engineers, it performs all the duties of sappers, miners, and pontoniers, and aids in giving practical instructions in those branches at the Military Academy; and is under the orders of the Chief Engineer, liable to serve by detachments in overseeing and aiding laborers upon fortifications or any other works under the Engineer Department, and in supervising the finished fortifications, as fort-keepers, and preventing injury and applying repairs. In marches near an enemy, every column should have with its advance a guard detachment of sappers, furnished with tools to open the way or repair the road. It would be well if these sappers, as suggested by General Dembinski, were mounted, in order rapidly to regain the advance guard, after having finished their work.

SAPPING.—A mode of making trenches by continually advancing the head of the trench when the execution of common trench-work or the flying sap would expose the workmen to a close fire of musketry, before they could obtain cover.

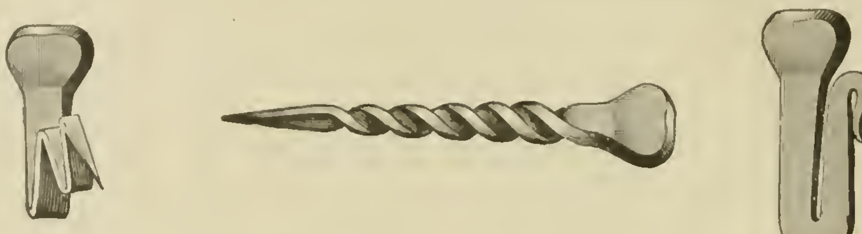
SAP-ROLLER.—A large gabion, 7½ feet in length, and 4½ feet exterior diameter. It requires for its construction 15 stakes, each from 1¼ inches to 2 inches in diameter. After it is completed, it is stuffed compactly with fascines 7½ feet long. The sap-roller is sometimes made of two concentric gabions, the diameter of the smaller being 2½ feet, and the space between the two compactly stuffed with fascines. The use of the sap-roller is to protect the squad of sappers, in their approach, from the fire of the place.

SAP-SHIELD.—A steel plate mounted on wheels for the purpose of giving cover to the sapper in a single sap, should the earth thrown up by him not be of sufficient thickness to give him shelter. The shield used in the English service is that invented by Sergeant Major Knight, R.E.

SARACEN'S HEAD.—A not unfrequent bearing in

Heraldry. It is represented as the head of an old man with a savage countenance.

SARANAC HORSE NAIL.—A nail of American manufacture which has attained a remarkable degree of success. The nail is much used by the United States Government, with satisfactory reports on it from officers in the field. The principles and effects of hand-made nails are fully retained in its process of manufacture, and insure for it a pre-eminence for toughness, strength, freedom from flaws, and beauty and superiority of finish. Being hammered at nearly welding heat, it is firmer and tougher, maintaining the stiffness and ductility without deteriorating, but rather improving the quality of the iron, producing absolute freedom from any tendency to sliver in driving, a cause of lameness and injury to so many horses. The drawings show how these nails may be twisted and bent when cold. The machinery or "mills" by which these nails are made are of very peculiar construction, and to the unmechanical mind seem complicated, but their operations are easily understood. The nail is forged (or hammered) hot, the machine making about 700 revolutions per minute, each eleven forming one nail. Thus it will be seen that about 65 nails are forged per minute. From the forging machines the nails are placed in tumblers for polishing, into which a strong current of air is forced, blowing all dust, etc., therefrom, and the product leaving in a remarkably bright form. The nails are then put through finishing-machines, by which the points are rolled out and trimmed cold. There are five of these machines in operation, known as Woodford's patent. The process of manufacture embraces the principles and effects of the old method of forging by hand, avoiding all straining of the iron, while the finish is very superior.



SARBACANE.—A blow-pipe, or long tube of wood or metal, through which poisoned arrows were shot by blowing with the mouth.

SARCELED.—A term in Heraldry, signifying a cut through the middle.

SARDAR.—In the East Indies, a chief or leader.

SARDINIAN HUTS.—Wooden huts made by many English officers in the Crimea and by the Sardinians for their men. They were 14 feet 3 inches long and 7 feet 1 inch wide in the clear; they could contain 6 infantry soldiers, and were found very comfortable.

SARISSA.—A Macedonian pike, a formidable weapon either for attack or defense, about 24 feet in length. The sarissa was borne by the *oplitai* of the Romans, and the other heavily armed troops. Also written *Sarisse.*

SARRAZINE.—An old name for a rough portcullis.

SARRE.—When artillery was first invented, a name given to a long gun, of smaller dimensions than the *Bombarde.*

SASH.—In the British Service the sash is a military distinction, worn on duty or parade by Officers and Non-commissioned Officers. For the former it is crimson silk; for the latter, crimson cotton. By officers it is worn over the left shoulder, and by Non-commissioned Officers it is worn over the right shoulder. There are no sashes in cavalry regiments. The sashes for the Austrian army are of crimson and gold; the Prussian army, black silk and silver; the Hanoverians wear yellow silk; the Portuguese, crimson silk with blue tassels, and the French have their sashes made of three colors, white, pink and a light blue, to correspond with the national flag. Sashes are generally worn around the waist, and were originally invented for the convenience and ease of wounded officers, as they might by such means be carried off the field with the assistance of two men.

SATELLITES.—Certain armed men, of whom mention is often made in the history of Phillip Augustus, King of France. The Satellites of Phillip Augustus were men selected from the militia of the country, who fought on foot and on horseback. The servants or batmen who attended the Military Knights when they went into action were likewise called Satellites, and fought in their defense mounted or on foot.

SATRAP.—In the ancient Persian Monarchy the Governor of a Province, whose power—so long as he enjoyed the favor of the King—was almost absolute. He levied taxes at his pleasure, and could ape the tyranny of his Great Master without let or hindrance. When the Monarchy of Cyrus began to decline, some of the Satraps threw off their slight allegiance, and founded independent Kingdoms or Sultanates of their own, the most famous of which in very ancient times was the Mithridatic Kingdom of Pontus.

SATURN.—In Heraldry, the black color in blazoning arms; sable.

SAUCISSON.—A fascine of more than the ordinary length; but the principal application of the term is to the apparatus for firing a military mine. This consists of a long bag or pipe of linen, cloth, or leather, from about 1 inch to 1½ inches in diameter, and charged with gunpowder. One end is laid in the mine to be exploded; the other is conducted through the galleries to a place where the engineers can fire it in safety. The electric spark is now preferred to the saucisson. See *Blasting* and *Mines.*

SAUL.—A tree well known in India, especially in the North-west Provinces. It is used in the construction of parts of gun-carriages. The wood is strong, tough, coarse-grained, and fibrous, not easily worked, and when dressed has a hard horny surface, and the fibers appear to be interlaced with each other. A cubic foot of the unseasoned wood weighs from 68 to 72 lbs. This tree grows also in Assam and Burmah.

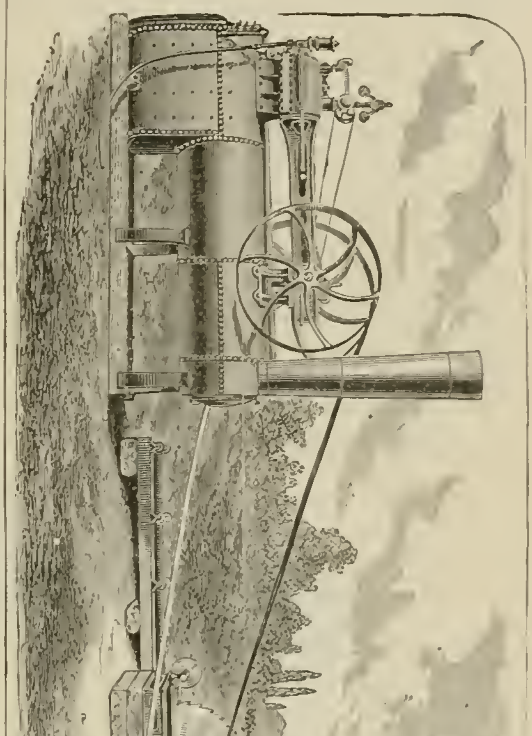
SAVAGES.—In Heraldry, *Savages* or *Wild Men* are of frequent occurrence as supporters. They are represented naked, and also, particularly in the later Heraldry, are usually wreathed about the head and the middle with laurel, and often furnished with a club in the exterior hand. Savages are especially prevalent in the Heraldry of Scotland. In more than one of the Douglass seals of the first half of the 15th century, the shield is borne in one hand by a single Savage, who acts as sole supporter.

SAVING-BANKS.—In 1842 an Act was passed for establishing military saving-banks in connection with the Regimental Pay Departments of the English Army. Another Act was passed in 1859, affording greater facilities to the frugal soldier. The proceedings of these banks in the first four years present the following figures:

	Deposits in Year.	Withdrawals in Year.
1859	£70,736	£64,497
1860	163,491	116,393
1861	167,136	149,090
1862	152,203	164,775

The figures have fluctuated through causes not stated in the Parliamentary Returns, being about the same in 1871 as in 1861, after being much lower in some of the intervening years, and much higher in 1866. The number of accounts open in the latest years was about 14,500, including those of many army charitable funds. By means of such banks the soldier can profitably deposit his money under Government security to the extent annually of £30, the whole deposit being confined to £200, inclusive of interest. Interest at the rate of £3 15s. per cent. per annum is paid; no interest is allowed on other parts of a pound than 6s. 8d. and 13s. 4d., nor on sums that have not remained on deposit one month. In the United States Army the soldier deposits with the Paymaster.

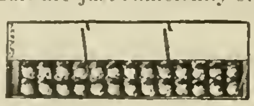
SAW MILL.—As troops are frequently called upon to construct their own quarters, and to assist in the erection of the buildings at newly established posts, it becomes necessary to investigate the construction and full operation of the saw mill, the proper management of which is essential in order to supply suitable timbers to the carpenters. Portable saw mills are variously designed with a view to lightness and fewness of parts. The Watertown Circular Saw Mill is much used in the United States, and will serve to illustrate the points which should be observed by all those entrusted with the management of a mill. The drawing represents the mill set up with an ordinary traction or agricultural engine. It will be noticed that the center frame, which is made of wood or of iron, is very solid and substantial. It can be very readily taken apart, when convenience in shipping is an object. The saw arbor is very heavy, with forged collars and a nut to hold the saw. The saw and pin holes are of standard size, so that a saw can be supplied by any saw manufacturer, with the certainty of its fitting. The arbor runs in long bearings, lined with anti-friction metal, and readily adjustible in any direction. At the same time the saw can be given any lead desired. The driving pulley can be placed within the frame, or on the outside as preferred. The feed is extremely simple. A belt passes loosely over a cone pully on the saw arbor, and a corresponding pulley on a parallel shaft, which has on its outer end a small friction roller. A pinion in the feed shaft engages the rack, and a lever is so arranged that a motion in one direction tightens the belt and feeds the log up to the saw, while a motion in the opposite direction presses the friction roll against the rim of a large flange pulley, connected by belting to the saw arbor, and gives a rapid return to the carriage. The carriage is made of Norway pine, six inches square, well seasoned, and securely and heavily stayed with wrought-iron. It is made in sections of twelve feet, and is shod with heavy V-shaped iron. It runs on chilled rollers, with babbitted boxes. The ratchet wheel upon the connecting shaft is so divided that each cog will set the log $\frac{1}{4}$ inch. The ratchet wheel is actuated by a set lever and four pawls of unequal lengths, which divide each cog in the ratchet in four parts, so the log may be moved, if required, $\frac{1}{16}$ inch by one movement of the set lever. Bolted to the head-block is a half circle, (called a "set circle,") in which are holes drilled at equal distances apart throughout its entire length. To these holes is fitted a pin to which is attached a cast-iron block having four sides, each side of which is at a different distance from the center of the pin. The sides of this block are marked as follows: $\frac{1}{16}$, $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$. Now, if the pin is put into the *first* hole in the set circle, with the side of the block marked $\frac{1}{16}$ towards the set lever, by bringing the lever against the block the log will move $\frac{1}{16}$ of an inch; if the pin is turned around, so the lever strikes the side marked $\frac{1}{8}$, the log will move $\frac{1}{8}$ inch, and so of all the sides. Putting the pin in the second hole, the log will move $\frac{1}{2}$ inch; third hole $\frac{3}{4}$ inch, and so of all the holes in the circle. Of course



the thickness of the stuff to be sawed can be varied $\frac{1}{16}$ of an inch in each hole of the circle if required. There is also a scale on each side of the head-block that can be used if desired. Knees slide directly upon the head-blocks, and are connected by gears with the set rod, which extends nearly the whole length of the carriage. The following points may be noted in connection with the mill: 1st. The friction feed and gig-works will slip instead of breaking in case of accident. 2d. A single lever controls all the movements of the carriage. 3d. The feed lever can be operated *outside* of the carriage—enabling *one man* to do both setting and feeding, thus doing all the work that *two men* perform in mills of other make. 4th. The set is exceedingly accurate and reliable. The last board is as perfect as the rest. 5th. Both ends of the log are set equally and at once, by a single lever. Or the head-block may be disconnected, and either end be set independently of the other, if preferred. 6th. The mill is reversible, and can be set up either right or left hand, adapting it to any mill site, without the expense, annoyance, and liability to error in setting.

SAWYER PROJECTILES.—The Sawyer projectile has upon its sides six rectangular flanges or ribs to fit into corresponding grooves of the bore. To soften the contact with the surface of the bore, the entire surface of the projectile is covered with a coating of led and brass foil. The soft metal at the corner of the base is made thicker than at the sides to admit of being expanded into the grooves, and thereby closing the windage. In the latest pattern of Sawyer projectiles the flanges are omitted, and the projectiles are made to take the grooves by the expansion of the soft metal at the base, which is peculiarly shaped for this purpose.

The Sawyer canister-shot consists of a casing of malleable iron, in one piece, in the form of a hollow cylinder, having one end closed by a head cast therewith, through which head is forced one or more small holes, through which a portion of the gas occasioned by the explosion of the charge of powder enters, driving forward the small iron balls and disengaging the metal cover placed in the forward end of the casting to hold the contents in position till fired. The casting has cut through its walls one or more series of oblique slits, the end of each slit slightly overlapping the end of the next slit in the same series, thus nearly severing the casting into two or more sections; said sections being held only by the narrow bars of metal between the contiguous ends of two slits; which bars are just sufficiently strong to with-



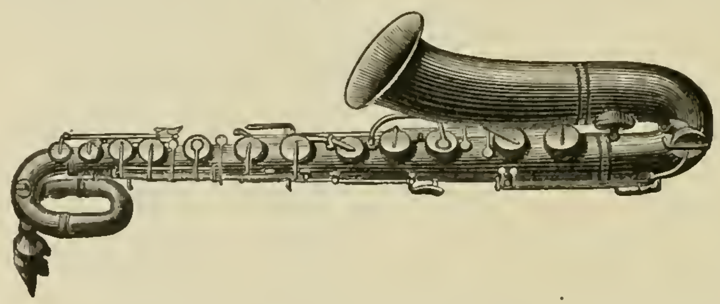
stand the ordinary shock of handling and transportation, but not strong enough to resist the shock of the explosion of the charge of powder in the gun; so that when the shot is discharged from a gun the cover is stripped from the mouth of the casing, and the casing is broken into two or more sections, from which the small shot are more readily and completely discharged than they would be if the casing remained intact, and each of said sections of the shell serve as a solid shot, doing greater execution than could be done were the shell to remain in one piece. See *Canister-shot, Expanding Projectiles*, and *Projectiles*.

SAXE.—A sort of Roman *gladius*, with a grooved blade, and very sharp on one side. Frequently called *Scramasaxe*.

SAXE SYSTEM OF FORTIFICATION.—In this system wood is substituted for masonry. The body of the place consists of an earthen cavalier, inside of which wooden barracks are constructed. This is surrounded by an enciente of small bastions. A third enciente is formed by large ravelins, the rampart of which is pierced with long embrasures for the defense of the main ditch. A fourth enciente of narrow counter-guards is constructed with wood and earth, and it has also embrasures through which guns mounted on rafts can be fired. A lunette, with retired flanks, defends the ditch, and a covered-way surmounts the whole. At about 3,000 paces from the center of the fortress, a continuous line of redans (36 in number) and curtains forms an advanced enciente. The redans contain solid towers of masonry, 25 feet high, several of which the besieger must take before he can open the trench. The immense quantity of wood required, and the rapid decay, are rather against this system.

SAXON.—A German powder-horn, about 12½ inches in length, invented at the close of the 16th century.

SAXOPHONE.—A brass musical instrument with a single reed and a clarionet mouth-piece. The body of the instrument is a parabolic cone of brass provided with a set of keys. Although these instruments are not a new invention, they have been comparatively unknown in this country until the past few years.



An instrument capable of such beautiful effects should not be left unnoticed by the military bands. They are by no means difficult to play, being considered by most musicians easier to master than a clarionet. Two of them, the B♭ Soprano and E♭ Alto, or where it is possible a full quartette, add immeasurably to the production of that class of music so very difficult to interpret satisfactorily with brass bands—overtures, and operatic selections. They have only to become better known to be considered a necessity in all leading bands.

SAYETTES.—A name given to arrows in the twelfth century, according to the Chronicles of Saint Denis.

SCABBARD.—The objects of the scabbard are to carry the sword and protect the blade from injury. Scabbards are generally secured to a belt, which passes over one of the shoulders, or around the waist of the wearer. For foot-troops, scabbards are made of leather, mounted with metal to protect them from wear. For scabbards for mounted troops, leather has not sufficient stiffness and strength, and steel is used in the place of it. The principal objections to metal scabbards are that they are heavy, dull the edge of the blade, and make considerable noise in striking against the equipments of the horse and rider. In certain parts of Asia these objections are overcome by making the scabbards of wood, covered with leather or rawhide. See *Hand-arms*.

SCALADE.—A furious attack upon a wall or rampart, contrary to form, and with no regularity, frequently carried on with ladders, to insult the wall by open force.

SCALE.—A line or rule of a definite length divided into a given number of equal parts, and used for the purpose of measuring other linear magnitudes. In map or plan drawing, the scale expresses the relation which the dimensions of the map bear to the natural features of the ground; this relation is frequently expressed by a representative fraction. For example, the representative fraction of a map on a scale of 1 inch to a mile is $\frac{1}{63360}$, that is, one inch on the map is equal to 63,360 inches (one mile) on the ground; in other words, the map represents all features on the ground 63,360 times smaller than their natural size. The following is the rule given for finding the fraction of a given scale. Reduce the number of yards in a mile into inches; divide the number found by the number of inches on which the scale is made, and the dividend will be the number of inches represented by one mile.

All countries have adopted special scales for their various classes of maps and plans; the following are those in use in the English Ordnance Survey:

Natural Scale.	Inches to 1 Mile.	Remarks.
$\frac{1}{500}$	126.720	Plans of towns.
$\frac{1}{528}$	120	Ditto.
$\frac{1}{1000}$	63.36	Ditto.
$\frac{1}{1056}$	60	Ditto.
$\frac{1}{1760}$	36	Special maps.
$\frac{1}{2376}$	26.6	Ditto.
$\frac{1}{2500}$	25.344	Parish Plans. Cadastral survey.
$\frac{1}{2640}$	24	Special maps.
$\frac{1}{5280}$	12	Ditto.
$\frac{1}{10560}$	6	County maps. Reconnoissances.
$\frac{1}{12672}$	5	Indexes.
$\frac{1}{15840}$	4	Special maps.
$\frac{1}{21120}$	3	Indexes. Reconnoissances of roads.
$\frac{1}{31680}$	2	Special maps.
$\frac{1}{63360}$	1	General map of the United Kingdom.
$\frac{1}{253440}$	0.25	Special maps (4 miles to an inch).
$\frac{1}{316800}$	0.2	Ditto (5 miles to an inch).
$\frac{1}{633600}$	0.1	Index map (10 miles to an inch).
$\frac{1}{1900800}$	0.03	Special maps, etc., (30 miles to an inch).

The best scales for field surveys are 2, 4, and 8 inches to a mile; for an index plan, 2 and 3 inches to a mile. Continental nations indicate the scale upon which a map is drawn, by the fraction that any linear distance measured thereon is of the actual distance on the ground. The principal scales used for military maps in Europe are as follows:

Austria ... ... $\frac{1}{14400}$ = 4·4 inches to the mile.
$\frac{1}{28800}$ = 2·2 " "
$\frac{1}{86400}$ = 0.733 inch "
Belgium ... ... $\frac{1}{20000}$ = 3.168 inches "
$\frac{1}{40000}$ = 1.584 inch "
$\frac{1}{80000}$ = 0.792 " "
Denmark ... ... $\frac{1}{20000}$ and $\frac{1}{500000}$
$\frac{1}{160000}$ = 0.396 " "
France ... ... $\frac{1}{80000}$ and $\frac{1}{400000}$
$\frac{1}{320000}$ = 0.198 " "
Germany ... ... $\frac{1}{25000}$ = 2.534 inches "
$\frac{1}{50000}$ = 1·268 inch "
$\frac{1}{100000}$ = 0.634 " "
$\frac{1}{80000}$ and $\frac{1}{200000}$ "
Holland ... ... $\frac{1}{25000}$ and $\frac{1}{50000}$. "
Italy ... . $\frac{1}{86000}$ and $\frac{1}{50000}$ and $\frac{1}{250000}$.
Russia ... . $\frac{1}{84000}$ = 0.754 inch to the mile.
$\frac{1}{126000}$ = 0.508 " "
Spain ... ... $\frac{1}{60000}$ = 1.056 " "
$\frac{1}{100000}$.
Sweden and Norway $\frac{1}{20000}$ and $\frac{1}{100000}$ and $\frac{1}{1000000}$.
Switzerland ... ... $\frac{1}{25000}$ and $\frac{1}{50000}$.

By dividing 63,360 (number of inches in a mile) by the denominator of the fraction of the scale, the number of inches it is to the English mile will be found. Thus—

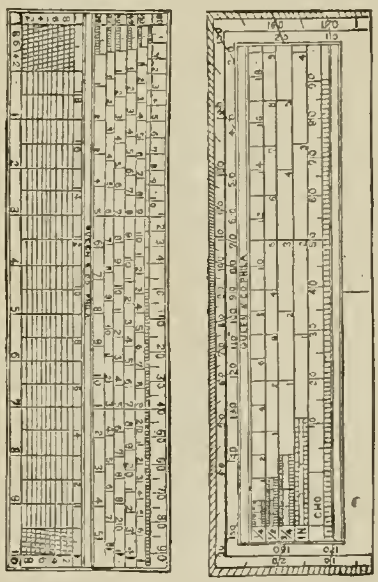
$$\frac{63360}{86400} = 0·733,$$

or the scale of $\frac{1}{86400}$ is equal to
0·733 inch to the mile.

A *scale of shade*, the invention of Colonel Scott, R. E., has been introduced into the service, and is used as a guide in determining the thickness and distance apart of each hachure for different angles and slopes. This scale is engraved for convenience on the back of a protractor, and is graduated for 35°, 25°, 15°, 10°, 7°, 5°, 3°, and 2°.

The term *scale* is also applied to a mathematical instrument consisting of an assemblage of lines engraved on a rule of wood or ivory, by means of which certain proportional dimensions or proportions are obtained by means of compasses. The principal are the *plain scale*, the *diagonal scale*, and *Gunter's scale*.

The *diagonal scale* is a mathematical instrument which is used when minute parts of a measurement are required, such as the tenth or hundredth part of



an inch. The formation of this scale is thus described in Heather, on "Mathematical Instruments":—"Draw eleven parallel equidistant lines; divide the upper of these lines into equal parts of the intended length of the primary divisions, and through each of these divisions draw perpendicular lines, cutting all the eleven parallels, and number them 1, 2, 3, etc., commencing from the second. Subdivide the first of these primary divisions into ten equal parts, both upon the highest and lowest line of the eleven parallel lines, and let these subdivisions be reckoned in the opposite direction to the primary divisions, as in the simply divided scales. Draw the diagonal lines from the tenth subdivision below to the ninth above, and so on, until a line from the first below joins the zero point above. Then, since these diagonal lines are all parallel and equidistant, the distance between any two of them in succession, measured upon any of the eleven parallel lines which they intersect, is the same as this distance measured upon the highest or lowest of these lines, that is, as one of the subdivisions; but the distance between the perpendicular, which passes through the zero point, and the diagonal through the same point, being nothing on the highest line, and equal to one of the subdivisions on the lowest, is equal to one-tenth of a subdivision on the second line, two-tenths on the third, and so on; so that this, and consequently each of the other diagonal lines, as it reaches each successive parallel, separates further from the perpendicular through the zero point by one-tenth of a subdivision, or one-hundredth of a primary division."

Gunter's scale is a flat brass rule, usually 2 feet in length, and about 1½ inch broad, having on one side equal parts, rhombs, chords, etc., as on the other plane scale, and on the other, the logarithms of these numbers; hence the lines on this side are called the logarithmic lines.

The term *scale* is also given to a graduated steel or wooden bar attached to guns, and known as the *tangent-scale.*

The *tangent-scale* attached to S. B. ordnance is a rod of metal or wood, made to slide perpendicularly in a groove at the breech, having engraved upon it the actual lengths of the tangents to the different angles of elevation. The object of the tangent-scale is to give elevation to a piece of ordnance beyond what the line of metal affords.

In rifled guns the tangent-scales, of which there are two attached to each gun, do not rise in a vertical plane, as in smooth-bore ordnance, but are set at an angle to the left from the vertical, to compensate for the lateral deviation caused by the right-handed rifling. They each consist of a rectangular steel bar, on which is engraved all information for the successful discharge and laying of the gun, such as the range, length of fuse, nature of charge, etc. On the top of the scale a tangent-sight is attached, which has a cross-head with a sliding-leaf and a clamping screw, by means of which the deflection caused by the wind blowing across the range, or one wheel being higher than another, can be met. This is known as the *deflection-scale.* This scale is graduated to 30′ on each side of the cross-head, each 30′ being divided into three spaces of 10′ each. By the aid of this scale, as shown above, compensation can be made to the right or left for the deflection of the shot by wind or inequality of the ground on which the carriage may be standing. This scale must not be mistaken for the scale for *permanent deflection* caused by the rifling of the gun. This deflection is met by the position of the tangent-scale or sight.

SCALE-ARMOR.—That armor of the Middle Ages, which consisted of small plates of steel riveted together in a manner resembling the scales of a fish. From the small size of the plates, it possessed considerable pliability, and was therefore a favorite protection for the neck, in the form of a curtain hanging from the helmet. Scale-armor is now obsolete, except, perhaps, among some Eastern Potentates.

SCALET.—An ancient name given to a lifting-jack. It was chiefly used in extricating wheels from deep ruts and soft ground.

SCALING.—Scaling a piece of artillery is flashing off a very small quantity of powder to clean out the bore; about one-twelfth of the shot's weight. The practice of scaling is now discontinued.

SCALING-LADDERS. When a place is badly guarded, all parts are accessible with ladders, but it is sometimes best to choose the highest walls for the escalade, as the enemy will probably, from a feeling of security, be less vigilant at such parts of the body of the place. Thus, at the siege of Badajoz in 1812, the English escaladed the highest walls in the city, and penetrated into the interior, while the attack directed upon breaches in the lower walls, although vigorously made, was repulsed. When it is considered how slow a process it is to bring up ladders to the counterscarp, in order to descend by them into the ditch, then to cross the ditch, and to rear the ladders against the escarp, and to mount them, it is evident that success will, in a great measure, depend upon the number of men that can mount at the same moment; in other words, upon the number of ladders. A ladder beyond a certain length becomes unwieldy, and the rearing of it difficult. The distance from the foot of the ladders to the wall should be at least equal to one-fourth of their height. If the distance be greater, the ladders are easily broken under the weight of the men mounting them; if much less, they will be so erect that the soldiers, as they ascend, must be continually in danger of falling headlong down. The scaling-ladders introduced by Sir Charles Pasley are in pieces of 12′ 8″ and 7′ 6″ in length, fitting into each other with strong double iron sockets, and tied by stout ropes. These can be arranged for any length, and quickly adjusted. Ladders made of long spars are awkward to carry; especially if there be any narrow sharp turnings in approaching the point of escalade; nor can long sound spars be always procured. It is desirable that ladders should be made of a light, tough wood; teak wood is too heavy. If a guy-rope be attached to each side of the ladder, they greatly assist in adjusting it and fixing it against the wall; the men told off for the guy-ropes should stand close to the wall, within the slope of the ladder; and these guy-ropes should be fixed at 5 or 6 feet below the top of the ladder, to prevent their being cut by the enemy on the wall. The total lengths of the ladders should exceed the height to be escaladed by 3 or 4 feet, in order that the men may step easily off the ladders on to the parapet or wall. Many failures have occurred from ladders being too short. It is desirable to have a pair of stout lifting bars, 3 or 4 feet long, with hooks, for each ladder. When an escalade is to take place, be sure to practice the men intended for the service thoroughly in carrying, in fixing, in ascending, and descending the ladders; descending, for going down a counterscarp; ascending, for getting up an escarp. Always use as many ladders as possible. If there be a counterscarp to descend, leave half the ladders there, while the other half are used against the escarp, that no time may be lost. Ascend the ladders together, on as large a front as possible. When an escalade is opposed by an enemy, take care that a good firing-party covers the escalade, with especial directions to fire upon any work that may flank the ladders. Avoid night attacks, except under peculiar circumstances: the example of gallant men is lost at night, whilst timidity is infectious. Make all arrangements under cover of darkness, but assault at day-break.

SCALLOP —This term, more commonly written *escalop,* signifies, in Heraldry, a species of shell. It has been considered the badge of a pilgrim, and a symbol of the Apostle St. James the Greater, who is usually represented in the garb of a pilgrim.

SCALPING.—A custom among the Indian warriors of North America, resorted to as a token of victory over an enemy. It is accomplished by grasping the hair above the top of the head, raising it with the skin to which it is attached, and quickly cutting the latter loose. Scalping *alone* is not fatal.

SCARF.—In Heraldry, a small ecclesiastical banner suspended from the top of a crozier.

SCARP.—The side of the ditch adjacent to the parapet. When the ditch of a fortress is dry, the scarp is usually faced with mason-work, to render it difficult of ascent; and behind this facing (*revêtement*) there are often passages or casemates for a defense. In temporary fortifications, the *revêtement* is sometimes of wood; while in field-works, palisades at the foot, or fraises on the *berme* or edge of the ditch, are held sufficient. The scarp is always made at as large an angle as the nature of the soil will allow; the design being to offer the greatest possible obstacle to an assailant. See *Counterscarp.*

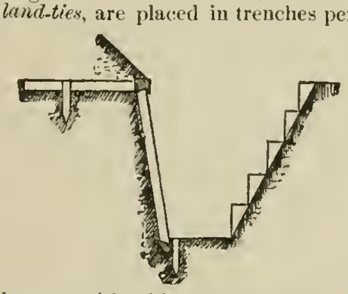
SCARPE.—In Heraldry, a diminutive of the bend sinister, being half the breadth of that ordinary.

SCARP GALLERY.—Galleries used to sweep the ditch with their fires are either scarp or counterscarp galleries, according to the position which they occupy. The usual method of building such a gallery is to excavate the earth behind the scarp or counter carp, as the case may be, until there is room to place the frame, if there is one to be used, or until there is room to accommodate the men who are to occupy the gallery. This excavation is then closed in front by a stockade built along the line of the scarp or counterscarp; it is closed overhead by a bomb-proof roof, the top of which is the parapet, in the case of a scarp gallery, and the glacis or natural surface of the ground, if a counterscarp gallery.

The arrangements of loop-holes, dimensions, etc., are all similar in kind and character to those for caponières. The entrance to a scarp gallery is by a covered passage; the same might be used for a counterscarp gallery; generally, the entrance to the latter is by openings into the ditch, at the ends of the gallery, which openings can be closed by bullet-proof doors. Counterscarp galleries are used at the salients of a work; scarp galleries at the re-entrants. These galleries should not be placed in positions where they would be exposed to artillery-fire. If there was any danger of exposure to this fire, and it was necessary to use one of these defenses, it is plain that the counterscarp gallery is to be preferred.

A scarp gallery, either for musketry or for one or two pieces of cannon, may be constructed to procure a flank fire in ditches with dead angles. These galleries may be made in all respects like a double caponière; the bottom of the gallery being sunk low enough to allow the greater portion of the ditch to be swept. As the top of the gallery must support that portion of the parapet of the work above, it must be firmly shored by strong timber. The rear of the gallery must be open, and there should also be an escape for smoke at the berme of the parapet above the gallery. A construction of a like character may be used to form a blind for one or two guns which it may be particularly desirable to place under cover from an enemy's artillery. The sides of the blind may be farther secured by placing against them either gabions or sand bags. See *Counterscarp Gallery* and *Gallery*.

SCARP REVETMENT.—This revetment is serviceable where the foot of the scarp is subject to wash, as in a wet ditch. It is formed of a frame-work of heavy timber, and is used chiefly for important field forts. A piece, termed a *cap*, is imbedded in a trench made along the line of the berme; and other pieces, termed *land-ties*, are placed in trenches perpendicu-



lar to the cap, with which they are connected by a dovetail joint; they are about 8 or 10 feet apart. Cross-pieces are halved into the land-ties near their extremities, and two square piles, about 5 feet long, are driven in the angles between the land-ties and the cross-pieces; inclined pieces, serving as supports to the cap, are mortised into its under-side at intervals of 8 or 10 feet. These supports usually receive a slope of ten perpendicular to one base; they rest on a *ground-sill* at the bottom of the ditch, to which they are mortised, this still being held firm by square piles.

Behind this frame-work, thick plank, or a heavy scantling is placed side by side, having the same slope as the supports; or else a rabate may be made in the cap and ground-sills, and the scantling be let in between these two pieces, serving as a support to the cap. This is the more difficult construction, but it is the better, since, should the heavy supports be cut away, the cap will still be retained in its place. Scarp revetments are sometimes formed by laying heavy timber in a horizontal position; but this method is bad, as it enables the enemy to gain a foothold by thrusting their bayonets between the joints. The length of the land-ties should be at least equal to two-thirds the depth of the ditch. The counterscarp is seldom reveted. A frame-work similar to that for the scarp might be used, and thick boards, laid horizontally, be substituted for the inclined scantling.

When a scarp revetment is made, the excavation of the ditch must be conducted in a different manner from that already explained. In this case, after the cap-sill and land-ties are laid, the excavation is continued to the bottom of the ditch, by removing only earth enough to allow the frame-work to be put up. A scaffolding of plank is then raised in the ditch on which the earth, that remains to be excavated, is thrown, and from there on the berme. See *Revetment.*

SCARP WALL.—To give strength and durability, the faces of the ditch are revetted with walls of masonry which sustain the pressure of the earth, protect them from the effects of the weather, and by their height and steepness present an additional obstacle to an open assault. The wall of masonry towards the rampart rises to the level of the foot of the exterior slope of the parapet, sustaining the pressure of rampart and parapet, and is called *scarp wall* or *scarp revetment;* the face of it towards the ditch, the *scarp.* The top of the scarp wall is finished by a course of broad, flat stones called the *coping*, which project beyond its face, and, serving as a *larmier* or a *drip*, protects it from the effects of the rain-water that runs from the parapet upon the coping.

Scarp walls are of three kinds: first, the ordinary retaining walls, strengthened by counterforts supporting directly the earth of the rampart; second, the same with relieving arches; and third, detached, wholly or in part, from the rampart. A scarp wall 30 feet high is usually admitted as a sufficient protection in all dry ditches against an escalade. That scarps over 30 feet high have been scaled is too true; but the success was owing to a want of ordinary precautions on the part of the assailed, and to the garrison not being of suitable strength to guard all points efficiently.

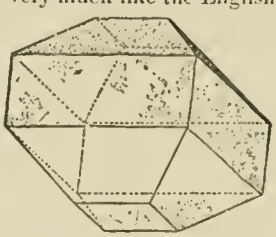
That heavy assaults upon comparatively weak field-works have been repulsed with great slaughter, we have also plentiful records of in our own and European contests. But in these cases the numerical strength of the contending parties under fire was nearly equal, and the defense of the most vigorous character, so that any shelter, however slight, would have inclined the balance on the side of the assailed. These are extreme cases, upon which it would be very unsound to base any rules for practice. As the object of all fortifications is to supply the place of numerical weakness on the part of the defense, the safer practice would seem to be to do this by placing such an obstacle in the way of an open assault that but a few men, promptly availing themselves of it, might frustrate long enough the attempt of the assailant to give time to gather sufficient force at the point assailed to render the attack abortive. When they act as retaining walls, to hold up the excavated side of the ditch towards the rampart, the rampart itself, and the parapet, they should receive a thickness and form of profile adapted to this end.

In the scarp walls of Vauban and Cormontaigne, and in many of the more modern fortifications of Europe, the scarp walls are built solid, with counterforts on their back, of the forms and the dimensions adopted by Vauban. This engineer gave his scarps a batir of $\frac{5}{1}$. Cormontaigne, finding that the faces of these walls were soon injured by the weather, adopted a batir of $\frac{6}{1}$. This for the same reason was increased by some to $\frac{12}{1}$, by others to $\frac{20}{1}$; and, in our climate, where the action of the weather on masonry is very injurious, our engineers have varied their batir from $\frac{24}{1}$ to $\frac{48}{1}$. Although no ordinary scarp walls can resist breaching, and have to be covered by earthen masks to screen them from the distant fire of the assailed, they should be so constructed as to render breaching a difficult operation;

limiting the breach made to the part of the wall actually destroyed by the assailant's projectiles. To give greater efficacy to the resistance offered to breaching, and to prevent such breach from taking a very gentle slope when formed, it has been proposed by some to back the wall and counterforts by a variety of pisé work, or with beton with but little lime in it, and of several feet in thickness. Others have proposed, for the same purpose, to connect the end of the counterforts by vertical arches, and to fill the cells thus formed either with pisé, or with this poor beton. See *Counterscarp Wall*.

SCEPTER.—Originally a staff or walking-stick, and hence in course of time, also a weapon of assault and of defense. At a very early period the privilege of carrying it came to be connected with the idea of authority and station. Both in the Old Testament and in Homer, the most solemn oaths are sworn by the scepter, and Homer speaks of the scepter as an attribute of Kings, Princes, and Leaders of Tribes. According to Homer, the scepter descended from father to son, and might be committed to any one to denote the transfer of authority. Among the Persians, whole classes of persons vested with authority, including Eunuchs, were distinguished as the "Scepter-bearing Classes." The scepter was in very early times a truncheon pierced with gold or silver studs. Ovid speaks of it as enriched with gems, and made of precious metal or ivory. The scepter of the Kings of Rome, which was afterwards borne by the Consuls, was of ivory and surmounted by an eagle. While no other ensign of sovereignty is of the same antiquity as the scepter, it has kept its place as a symbol of royal authority through the Middle Ages down to the present time. There has been considerable variety in its form; the scepter of the Kings of France of the first race was a gold rod as tall as the King himself.

SCHAGHTICOKE POWDER. A polyhedral powder, constructed very much like the English. The drawing shows the shape of the grain.



It is granulated from properly compressed ordinary press-cake in the following way: The cake is placed on a movable table or form, which is made to pass between two pairs of rollers. A set or comb of stationary cutters meets the cake on its passage and marks a series of grooves on its surface. By turning the cake half-way round, it is marked out into squares on a second passage. This process applied to the reverse face gives it a similar character, and determines the planes of fracture along which the cake will brake up to form the grains.

As tests in an 8-inch rifle in 1876, the following results were obtained: the density of the powder being 1.784 and the granulation 74:

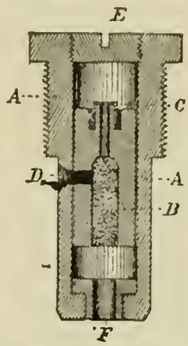
Nature of gun.	Kind of powder.	Weight of charge.	Weight of projectile.	Velocity.	Pressure.
8-inch rifle	Polyhedral. Laflin & Rand.	*Lbs.* 35	*Lbs.* 180	*Feet.* 1,360	*Lbs.* 37,500

See *Gunpowder*.

SCHAIFE.—In the Middle Ages, a term applied to a quiver or bundle of arrows.

SCHEITER SYSTEM OF FORTIFICATION.—This system borrows from Castriotto the detached bastions, gives to them a fausse-braye, as well as to the enciente, and surrounds the place by a double covered-way. All the counterguards consist of two walls 18 feet thick, 50 feet apart, with a roof of timber and earth; the interior space is divided by a floor into two stories, affording ample room for two tiers of guns.

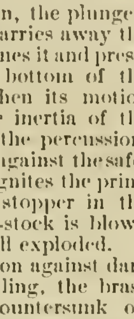
SCHENKLE PERCUSSION FUSE. This fuse consists of a metal fuse-stock, *A*, inclosing a movable core-piece or steel plunger, *B*, bearing a musket-cap, *C*. The plunger, primed and capped, is held in place by a screw or pin, *D*, which passes through a hole in the side of the stock and plunger. A safety-cap, *E*, is screwed into the top of the fuse-stock, and its bottom is closed by a cork or leather stopper, *F*.



When the projectile is set in motion, the plunger, by its inertia, carries away the pin which confines it and presses against the bottom of the fuse-stock. When its motion is arrested, the inertia of the plunger causes the percussion-cap to impinge against the safety-cap, which ignites the priming, when the stopper in the bottom of fuse-stock is blown out and the shell exploded.

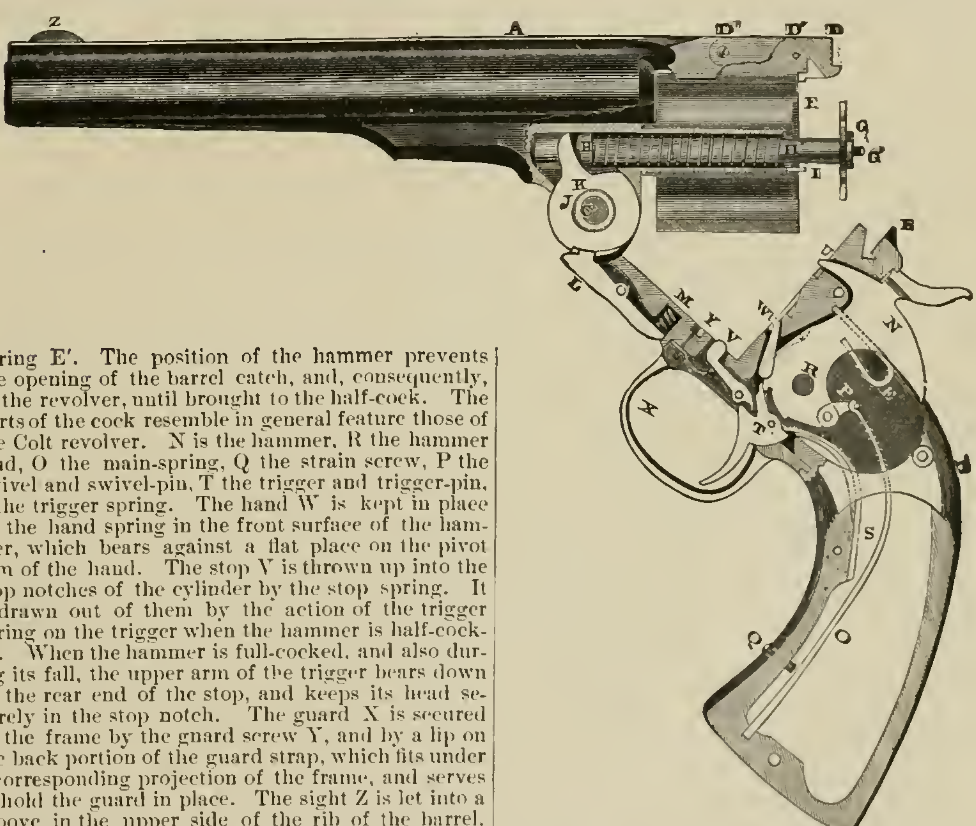
As a precaution against danger while handling, the brass safety-cap is countersunk on one end and flat on the other. It is kept with the countersunk end down except when loading; while this end is down, should the plunger become loose, the percussion-cap is prevented from coming in contact with the hard surface of the safety-cap, but on being turned end for end a plane surface is opposed to the percussion-cap, upon which it might strike. There is a slit cut in the top of the fuse-stock and cap, which is designed for the entrance of the fuse-wrench. See *Fuse*.

SCHENKLE PROJECTILE.—This projectile, which is shown in the drawing, is composed of a cast-iron body (*a*), the posterior portion of which is a cone. The expanding portion is a *papier maché* sabot or ring (*b*), which is expanded into the rifling of the bore by being forced on the cone by the action of the charge. On issuing from the bore the wad is blown to pieces, leaving the projectile unencumbered in its flight. A great difficulty has been found in practice in always getting a proper quality of material for the sabot, and in consequence, these projectiles have not been found to be reliable. See *Expanding Projectiles* and *Sabot*.



SCHIAVONE.—A sword having a basket hilt, used by the Doge's Guards in the sixteenth and seventeenth centuries. They were not known in Scotland until the eighteenth century.

SCHOFIELD SMITH AND WESSON REVOLVER.—The principal changes in this revolver, now used in the United States Army, from the original Smith and Wesson revolver, are in the extractor, the cylinder catch, and the barrel catch. By referring to the sectional drawing, the operation of the parts may be readily understood. A is the barrel joined to the frame B by the joint screw C. Under and behind the barrel projects the base pin upon which the cylinder F revolves. This is kept in its place on its pivot by the inner hook of the cylinder-catch D″, and is held down by the cylinder-catch cam D′, the upper part of the middle portion of which is cut away and allows the catch to rise when the cam is turned to a certain position. The base pin is hollow, and contains the extractor stem H, made in two parts, which screw together. Between the head of the stem and the bottom of the hole of the cylinder is confined the extractor spring H′, which is compressed when the extractor moves out. The extractor G is recessed into the face of the cylinder. The ratchet by which the cylinder is revolved, is cut in the face of the extractor, and the extractor stud G′ forms a rear bearing for the cylinder on the frame when the revolver is closed. The steady-pin I keeps the extractor exactly in place when it is down. The lifter J moves upon the friction collar K under the influence of the pawl L; the pawl is pressed against the lifter by the pawl spring M; the lifter is moved by the pawl in one direction only, and is therefore free to follow the motion of the extractor spring. In closing the revolver, the outer hook of the cylinder catch presses back the barrel catch E, and engages it under the influence of the barrel catch



spring E′. The position of the hammer prevents the opening of the barrel catch, and, consequently, of the revolver, until brought to the half-cock. The parts of the cock resemble in general feature those of the Colt revolver. N is the hammer, R the hammer stud, O the main-spring, Q the strain screw, P the swivel and swivel-pin, T the trigger and trigger-pin, S the trigger spring. The hand W is kept in place by the hand spring in the front surface of the hammer, which bears against a flat place on the pivot arm of the hand. The stop V is thrown up into the stop notches of the cylinder by the stop spring. It is drawn out of them by the action of the trigger spring on the trigger when the hammer is half-cocked. When the hammer is full-cocked, and also during its fall, the upper arm of the trigger bears down on the rear end of the stop, and keeps its head securely in the stop notch. The guard X is secured to the frame by the guard screw Y, and by a lip on the back portion of the guard strap, which fits under a corresponding projection of the frame, and serves to hold the guard in place. The sight Z is let into a groove in the upper side of the rib of the barrel. The recoil plate U receives the bearing of the cartridge head at the time of the fire. The following table gives the principal dimensions, weights, etc., of the revolver:

DIMENSIONS.

Total length	12″.5
Length of barrel	7″.5
Diameter of bore	0″.45
Grooves, number of	6
Grooves, twist of, uniform	1 turn in 16″—left-handed
Grooves, depth, uniform	0″.005

WEIGHTS.

Total weight	2.31 lbs.
Weight of powder charge (service)	28 grs.
Weight of bullet	230 grs.

The powder charge and weight of ball have been lightened to adapt the cartridge to the Schofield Smith and Wesson revolver. See *Smith and Wesson Revolver*.

SCHONSTEDT FUSE.—This fuse is very similar in its action to the Prussian, but has the advantage of acting both as an ordinary fuse and as an explosive one, and in having neither fulminating powder nor sulphuric acid in its construction. The case is made of a mixture of lead and tin, and the bottom part of it is made thick enough to allow the cutting of a side channel, which enters the central one near its end. The breaker is similar to the one in the Prussian fuse. A tube of glass open at both ends, and wrapped so as to fit, as in the Prussian fuse, takes the place of the closed tube. The side-channel is filled with ordinary fuse-composition, and the space around the thimble with a composition which burns out in two seconds. The glass tube is filled with fine powder, and a strand of quick-match, the lower end of which last is inserted in the mouth of the side-channel, where it enters the central one. When the shell is fired the quick composition takes fire, and being consumed in two seconds, sets fire to that in the side-channel, at the same time that it leaves the breaker unsupported. This upsets by the shock of striking, and the flame in the side-channel communicating with the powder and the quick-match in the broken glass tube, explodes the shell. In case the explosive apparatus does not act, the shell acts like one with a time fuse, and explodes when the side-channel composition burns out. See *Fuse*.

SCHOOL-MASTER.—In the English Army, the School-master is a Non-commissioned Officer of the first class, ranking next to a Sergeant Major. His pay varies with the length of service, rising gradually from 4s. a day on appointment, to 8s. a day after long service. He has an advantage over other Non-commissioned Officers in quarters and certain allowances. To become an Army School-master, it is necessary either to be a Certificated School-master, or to have served the apprenticeship as a Pupil-teacher, and to pass through a course of training for one year at the Normal School in the Royal Military

Asylum, Chelsea. After the completion of the training, the candidate is required to enlist as a common soldier for ten years' general service, whereupon he is immediately promoted to the rank of School-master. A few of the most deserving School-masters are promoted to Sub-inspectors of Schools, when they rank as Lieutenants, having 10s. a day for pay. The duties of the School-master are to teach the soldiers and their children the rudiments of general knowledge, to examine the girls' school, and to deliver lectures to the soldiers. There were in 1874, 180 Army School-masters, besides 13 Sub-inspectors.

SCHOOL MISTRESS. A person attached to each English Regiment or Corps for the purpose of instructing the daughters of soldiers and their sons under eight years old in the rudiments of English and in plain needlework. She must be a Certificated School-mistress, or a Pupil-teacher who has served her apprenticeship. After admission to the service, she is specially trained for six months at one of the four training institutions. This training is at the expense of the Government. The salary of a School-mistress varies from £30 a year in the third class to £50 a year in the first class. Proper provision is made for the quarters and supplies of the School-mistress, whose somewhat anomalous position among rough men calls for the most circumspect behavior. The annual charge (1873-74) for Army School-mistresses amounted, for 161, to the sum of £5,362.

SCHOOL OF GUNNERY.—A School established at Shoeburyness for the purpose of giving practical instruction to Officers and men of the artillery, and for carrying out the experiments connected with their branch of the service. This School consists of a Commandant and a Brigade Major, with 6 Instructors in Gunnery and 2 Superintendents of Experiments. Officers, Non-commissioned Officers, as well as squads of men selected from brigades of artillery, are sent thither from Woolwich for instruction in gunnery and the use of military machines, etc. The course of instruction at this establishment is divided into a *long* and *short* course. The *long course* is an annual course of instruction for Officers and Non-commissioned Officers of the Royal Artillery, partly carried out at Woolwich, and partly at Shoeburyness. One Officer is selected from every brigade at home and abroad, and 2 or 3 Non-commissioned Officers from a home brigade; they assemble at Woolwich on February 1, and go first through the manufacturing departments of the Woolwich Arsenal for 2 months. They then go to Shoeburyness, and remain there 9 months, during which time they complete a course of gunnery, signaling, bridging, etc. At the end of this period, they have to be examined, and certificates are given according to their qualifications. Officers obtaining a first-class certificate are eligible for the appointment of Instructors, and Non-commissioned Officers for that of Assistant Instructors. The *short course* is a similar course, but only lasts 2, 3, or 4 months, and is formed as circumstances allow, but at no specified time. It is usually composed of 2 or 3 Non-commissioned Officers from each or several home brigades. This course is usually confined to gun exercises and the uses of the various kinds of ammunition.

SCHOOL OF MILITARY ENGINEERING.—A school formed at Chatham for the special training of Officers of the Royal Engineers, after they have passed through the Academy at Woolwich, and also for the men and recruits of the Corps. This School consists of a Commandant, a Brigade Major, 2 Discipline Officers, and 11 Officer Instructors in construction, surveying, field-fortification, telegraphy, etc. Officers of the cavalry and infantry are permitted to attend the classes of instruction given at Chatham in flag-signaling, surveying, etc. A branch of this School has been established on board her Majesty's ship *Hood*, in the Medway, for the training of Engineers in submarine or torpedo duties. The men forming the torpedo companies are selected, on the completion of their course of instruction in field-works, from the depot companies of the School of Military Engineering, where, later on, extensive and practical knowledge of electricity in its application to the ignition of mines is imparted to them.

SCHOOL OF MUSIC.—The School at Kneller Hall, near Hounslow, for the training of the Band-masters and Musicians. Men showing musical talent and abilities, and desirous of being trained as Band-masters and Musicians, may offer themselves as candidates to this School on the recommendation of Band Committees, and are admitted into it under certain conditions.

SCHOOLS OF INSTRUCTION.—Establishments for the education of the officers of the Regular English Army and of the Auxiliary Forces in the advanced branches of their profession. To give officers an opportunity of going through the course carried on at these Schools, they are detached in turn from their regiments. Schools have been established in all the large garrison towns of the United Kingdom, and specially for the Auxiliary Forces, at Glasgow, London, Manchester, and Dublin, where they are placed under Garrison Instructors. In India, similar means of instruction are given to officers, and for this purpose Garrison Instructors are appointed to each of the principal cantonments or districts.

The Royal Hibernian Military School, which is situated at Dublin, Ireland, is for the maintenance, education, and training of boys for purposes of enlistment and service in the Army. The children to be admitted into the Institution must be free from mental or bodily defect or infirmity. They must be the children of a Non-commissioned Officer or Soldier in her Majesty's regular forces, or of a Non-commissioned Officer or Soldier deceased or discharged from the service. Children to be admitted must not be under 7 nor above 12 years of age. In the selection of boys for admittance, a preference in general is given:—Firstly, to orphans; Secondly, to all those whose fathers have been killed or have died in the foreign or home service: Thirdly, to those who have lost their mothers, and whose fathers are absent on duty abroad; Fourthly, to those whose fathers are ordered abroad on foreign service, or whose parents have other children to maintain.

SCHOOLS OF MUSKETRY.—When the introduction of the Minié rifle in the French service, and the subsequent arming of the British troops with the still more delicate Enfield rifle in 1851, brought the accuracy of a soldier's fire to be an important consideration in estimating his value (which with the old musket was not the case, as it was proverbial that the bullet never hit the point aimed at, however carefully), the English Government at once saw the necessity of providing instruction in the manipulation of the rifle. Accordingly, Instructors of Musketry were attached to the troops, one to each regiment; and a School was established at Hythe in 1854, under the late General Hay, where lessons on the theory of the arm, and practice in its actual employment, were the sole occupation of the day. Officers and promising men were sent there in great number, and soon became instructors to their comrades, so that the shooting of the whole army soon rose in a surprising degree. Whereas, before the establishment of this School, the English stood low in the scale of shooting, the competitions held during recent years at Wimbledon have demonstrated that no nation can hardly excel them as marksmen. The formation of the Volunteer Corps, in 1859, led to a greatly increased demand for musketry instruction, which the Government met by forming a second School of Musketry at Fleetwood (now abandoned), where the troops and volunteers of Scotland, Ireland, and the northern English counties found the necessary teaching. The Hythe School is superintended by a Commandant and Inspector General of Musketry Instruction, with subordinate Instructors. The

Inspector General is responsible also for the instruction throughout the regiments all over the world, and to him the musketry returns from each regiment are sent annually. See *Musketry Instruction.*

SCHULTZ CHRONOSCOPE.—This instrument, invented by Captain Schultz, of the French Artillery, is designed for the measuring of very short intervals of time. By means of it, periods varying from thirty seconds to the one-five thousandth part of a second

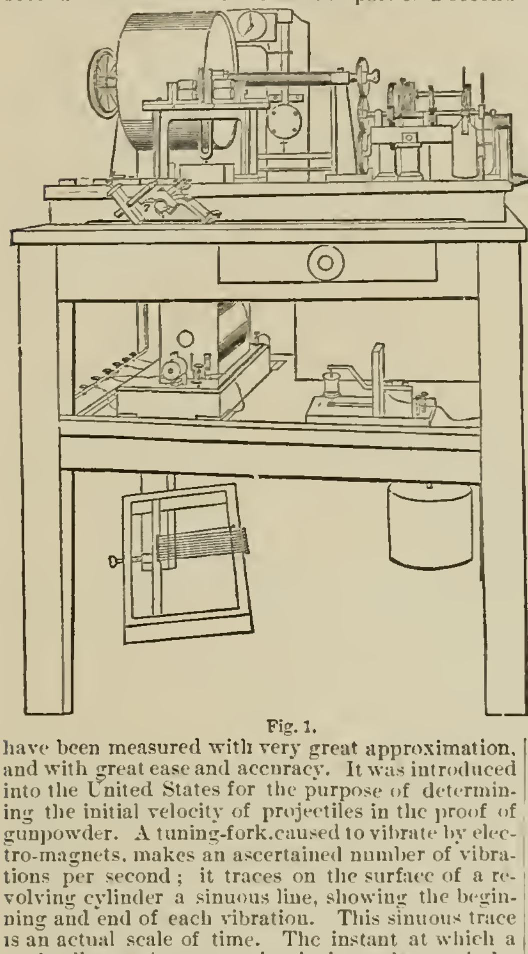


Fig. 1.

have been measured with very great approximation, and with great ease and accuracy. It was introduced into the United States for the purpose of determining the initial velocity of projectiles in the proof of gunpowder. A tuning-fork, caused to vibrate by electro-magnets, makes an ascertained number of vibrations per second; it traces on the surface of a revolving cylinder a sinuous line, showing the beginning and end of each vibration. This sinuous trace is an actual scale of time. The instant at which a projectile reaches any point in its trajectory is by the application of electricity marked upon the cylinder beside the scale of time. The number of vibrations comprehended between any two consecutive marks, is an exact measurement of the time elapsing between the instants at which the projectile occupied the corresponding positions in its trajectory. The measurement of time depends on the equality of duration of the vibrations made by the fork; the number of these vibrations in the unit of time is fixed by the construction of the fork.

The principal parts of the machine, Fig. 1, are the *cylinder*, *vibrating fork*, *electro-magnets*, the *wheel-work*, and the *electric interrupter*, *Ruhmkorff coil*, *pendulum*, and *micrometer*, and while experimenting, the *galvanic batteries* and *targets*. The cylinder has a double motion of rotation and translation, given by means of a weight acting on a system of clock-work. These motions can also be given separately by hand. The silvered face of the cylinder is covered with a thin coating of lamp-black, which is removed by the trace and spark, exposing the surface in strong contrast to the blackened parts. The vibrating fork stands immediately in front of the cylinder; on each side of it is an electro-magnet to originate, sustain, and equalize the amplitude of the vibrations. The left branch of the fork is armed with a flexible quill-point, which, by an eccentric roller, can be made to touch the cylinder at pleasure, and thus make the traces upon it. The interrupter is the mechanism by which the current for the fork's electro-magnets is made and broken. The "Russell Interrupter" is now used in the United States with the machine. In the Schultz chronoscope at West Point the detached mercury interrupter has been replaced by a light metallic spring, which is pressed against the tuning-fork on the inner side of the prong, making the fork its own interrupter when the electrical current is passed through it. The sparks indicating the time of rupture of the targets are produced by means of the Ruhmkorff coil. To use the coil, the primary wire is connected with a battery and the targets, the secondary wire with the instrument. One end of the latter wire is brought through a glass tube close to the cylinder, just over the fork; the other end is connected with the bed-plate and hence with the cylinder. By this arrangement, when the primary current is broken by rupturing the target wire, a secondary current is induced, and a spark is projected from the end in the glass tube to the face of the cylinder. The pendulum is used to determine the exact number of vibrations or "*tarage*" of the fork in a second of time, a matter of the greatest importance. It is connected with an ordinary clock-work, and should be regulated to beat half seconds with accuracy. To determine the number of the fork's vibrations, the Ruhmkorff coil is put in connection no longer with the targets, but with the pendulum, which is so arranged that, at every double beat, the current is broken and a spark made on the cylinder, marking each second of time. As the cylinder can run for thirty seconds, the number of vibrations sought can be obtained with close approximation by dividing the entire number of vibrations registered on the cylinder by the number of seconds. The micrometer serves to divide a vibration on the cylinder into very small parts for close reading. A double vibration of ordinary length may then be divided by it into 2,000 parts, and as each of the former is about the one-two hundred and fiftieth of a second, the reading of the micrometer may approximate to the one-five hundredth portion of a second of time. The vibrations made by the fork are recorded on the cylinder in the form of a sinuous line, Fig. 2, making the scale of time. The middle line, *a*, traced by the fork when at rest, is of great importance, as it divides the sinuous line, and gives the exact points of the origin and end of each vibration. Even when not in the middle, no error can occur when double vibrations are counted. To determine the value of the interval between two sparks, the number of double vibrations is then counted. Where both sparks fall immediately opposite to the intersections of the two lines, the value will be summed up in entire double vibrations, as in Fig. 2, *x* and *y* then being the sparks. Where one or both of the sparks do not fall opposite an intersection, the value of the interval is easily found. Two galvanic batteries are used, one connected with the interrupter, the other with the Ruhmkorff coil. In working the instruments it is essential that the current pass through only one target at a time, there being but one coil and battery,

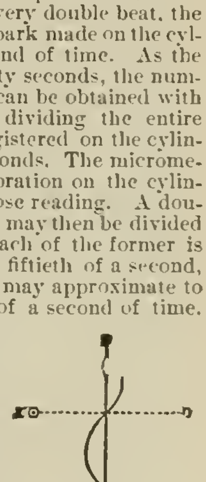


Fig. 2.

no matter how many targets may be used. After the first target is ruptured the current must be transferred to the succeeding one before the projectile reaches it, and so on throughout the series. There are different arrangements by which this may be effected.

The cylinder is coated by revolving it over the flame of an oil lamp. The operator, standing in front of the instrument, releases the translating screw, pushes the cylinder to the right, clamps it to the wheel-work, and throws the translating screw into gear again. He then sets the point of the quill, at the extremity of the fork, very lightly against the face of the cylinder, and releases the brake to the wheel-work. While rotating the cylinder is moved toward the left by the translating screw, and receives the trace of the middle line in the form of a helix. This done, the quill is raised, and the cylinder pushed to the right, as before. The quill is again set with its point exactly on the middle line, the translating screw thrown into gear, the circuit of the battery and the interrupter closed, and the spring on the interrupter moved by the adjusting screw till the proper vibration of the fork is obtained. At this point the caution "Ready" is given, the circuit of the battery and the Ruhmkorff coil promptly closed, and the cylinder started rotating, when the command "Fire" is given. As soon as the report is heard, the machine is stopped by the brake, both currents opened and interrupted, the quill point removed, and the cylinder detached from the wheel-work; the operator then counts the result. The vibrations of the fork are known to be isochronal for the same fork, when their amplitude is constant and are in no way affected by the motions of other parts of the machine. The "*tarage*" of the fork should be verified occasionally, and should always be taken when from any cause it may be supposed to have varied. To insure the greatest accuracy, it should be taken before each series of experiments. The limit to the precision of the machine depends upon the greater or less instantaneousness in the production of the spark; but the construction of the targets acts as a remedy, requiring, as they do, but one coil and one battery, whatever may be their number. See *Chronoscope*, *Galvanic Battery*, and *Russell Interrupter*.

SCHULTZE POWDER.—Captain Schultze, of the Prussian army, in the course of his investigations some twenty years ago into the properties of gun-cotton, with the view of determining its fitness for military purposes—a duty to which he was assigned by the War Department—was led to propose a substitute for gun-cotton, and prepared a new explosive, which he claimed, after numerous and extensive trials, possessed great advantages in many ways over both gunpowder and gun-cotton. The process of manufacture is as follows: Wood is sawed with fine saws into thin veneers across the grain; these are cut into small cubes by means of a machine for the purpose. In this state it much resembles sawdust. The best woods are those generally used for gunpowder—the alder and buckthorn. They are preserved in water till used, that they may retain their toughness. The grains are first passed through several processes by which the acids and all soluble substances are removed, when they are ready for the acids. Nitric acid of 1.48 to 1.50 is mixed with sulphuric acid, specific gravity 1.84, in the proportion of 40 parts by weight of the former to 109 of the latter, and set aside to cool. Six parts of the prepared wood are gradually added to 100 parts of the acids, stirring the whole constantly for two to three hours. A portion of the nitric acid combines with the wood, the sulphuric acid unites with the water, and the nitric acid is thus retained in its original strength. The grains are next placed in a centrifugal drying-machine, which removes the surplus acid, and is then washed for a considerable time in cool running water. It is boiled in a weak solution of carbonate of soda, and again washed in running water and dried. The grains are now heated with saltpeter, or baryta nitrate, as is preferred for most varieties. They are now dried at a temperature of 90° to 112° Fahr. for 12 to 18 hours, when they are ready for use.

It is manufactured in England and used in considerable quantities for sporting purposes, but has not been found to fill the requirements for military uses. It gives less recoil, smoke, and dirt than gunpowder. See *Gunpowder*.

SCHULTZ WIRE GUN.—The successful test in France of a 6-inch wire gun on the Schultz plan has given such an impetus to the development of this mode of construction that not only the French naval authorities have decided to push experiments in this direction on a large scale, but also English manufacturers have made, and are making, rapid strides in the development of systems involving the use of steel in this form.

Referring to the 34-centimeter gun, it may be here stated that wire 0.118 inch in diameter, to the extent of 43 layers, is wound round the body, giving a wire thickness of about 4.42 inches, the exterior being covered by a cast-iron jacket to protect the wire. The breaking strain of the wire is reported at 200 kilometers per millimeter, and it is put on under a tension of about one-third its ultimate strength. Longitudinal strength is given by 12 steel rods of about 7¼ inches in diameter, passing from the trunnion-ring to the breech-block receptacle, and secured at each end by suitable nuts. One statement gives the charge at 440 pounds, with a 900-pound projectile; another as 330 pounds powder and a 990-pound projectile.

The 24-centimeter guns—cast-iron bodies—are all unlined except one, which has a short steel tube. Thirty-five layers of wire about 0."8 thick from breech to center of trunnion-ring, and 16 layers from thence to about half the length of the chase, complete the wire wrapping. A jacket of copper over all, of 8 millimeters thickness, is superimposed over the wire. The breech-blocks are steel, and are secured as in the case of the 34-centimeter gun.

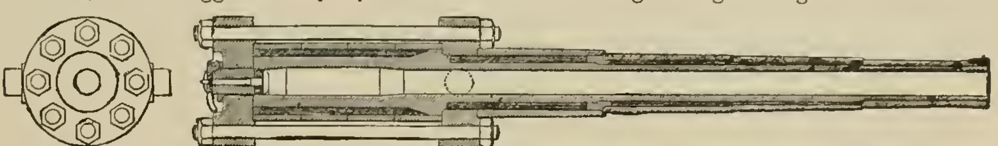
The following table gives some of the principal dimensions of these guns, and other data:

Kind.	Weight.	Caliber.	Chamber.		Length of bore.	Breech-piece.		Charge.	Projectile	Velocity (estimated.)
			Length.	Diameter.		Length.	Diameter.			
	Tons.	Inch's	Inch's	Inch's	Inch's	Inch's	Inch's	Pounds.	Pounds.	Feet.
34............c. m...	50	13.4	60.23	14.56	354	189	59	440	935	....
24............c. m...	18	9.44	56.30	11.4	269.25	....	....	176	352	2,362
10............c. m...	1.3	3.93	19.15	4.9	81.4	....	....	16.72	33	....

It will be seen by computation that Captain Schultz has an extraordinary excess of longitudinal strength, amounting—taking steel rods at 100,000 pounds per square inch—in tensile strength to over 50,000,000 pounds. The pressures on the bottom of the chamber or face of the fermeture would only be about 6,000,000 pounds, taking the gas pressures at 40,000 pounds per square inch. This ratio of resistance to pressures to be withstood, even if somewhat abnormal, seems excessive, and although it is necessary to keep, in providing for the strains, within the elastic limits of the metal used, yet even then we have a larger reserve than seems at all necessary. It results in an unnecessarily cumbersome and also weighty structure. The diameter of the breech-block is stated to be 59 inches; and it is estimated approximatively that the walls do not exceed nine-tenths of a caliber in thickness, if they attain that limit.

Referring to a 9-inch construction on the Shultz plan, represented in the drawing below, the following brief remarks may be made regarding its general features:

Assuming 40,000 pounds pressure as normal strain, and placing the tensile strength—attainable in good quality steel rods—at 100,000 pounds per square inch, it results, approximatively, that we have a ratio of strength to resist the stress on the face of the fermeture as at least six to one. The strains would have to be largely abnormal to reach the elastic limit of the rods, or, say, 80,000 pounds gas pressure per square inch, allowing 40,000 pounds per square inch as the statical pressure at which permanent set will take place. That solidity which insures the maximum of rigidity appertaining to undivided constructions is, however, wanting in this construction, and hence we have to contend with a tendency to a spring in the bolts, which is aggravated by repeated straining, and a vibrating action which will possibly sooner or later result in a tendency at each discharge to cause a transient play between the divisions of the gun, causing a slight momentary separation between the fermeture and the gas-check.



The advantage of separation of strains would be almost altogether lost if we attempted to screw the fermeture partly in the breech-block and partly into the body of the gun. This presumed possible disadvantage, however, can be fully met, it is believed, by the introduction of the De Bange gas-check—a check now adopted in the French land service, even up to the highest calibers (24 centimeters), both for pure steel and cast-iron and steel constructions. This is a check of extreme simplicity, cheap, light, readily applied, sufficiently durable, is replacable; is standard in the French army; is being developed at Woolwich, starting from 28-pounder guns, in which it has proved a success; and it requires no gas seat or enlargement of the chamber of bore to receive it. Its advantages in the construction under consideration are, that it *finds its seat* in firing not necessarily at one point, but that it has a tolerance in this regard, and hence can perform its functions under a play which cannot be successfully allowed for in the seating of the Broadwell ring, now universally used in obturation. This latter, however, can undoubtedly be used, but it is apparent that if desirable to experiment with the De Bange plan it can be readily and inexpensively tested in any construction, which is evidently designed for the Broadwell ring and the French fermeture, advantage being taken to test the former system prior to the application of the metallic gas-check obturation. It is proper, however, to state here that some objections have been raised regarding the De Bange check by the French naval authorities; the principal imperfections alleged being deterioration of the checks by repeated firings, and by time and climatic influences; and also a liability of the stem of the "mushroom head," between which latter and the face of the screw fermeture the check works. The difficulties of securing a central fire may be increased, but it is not seen but that by increasing the diameter of the *queue* of the roundellen, or "mushroom head", that objection and also that of liability to breaking of the *queue* can be satisfactorily met. The general principle that a great advantage cannot long remain subordinate to increased difficulties in securing other desideratums will soon vindicate itself by invention affording a solution of the difficulties surrounding the problem. These imperfections, if they prominently exist, are of such a nature as to be easily overcome; and we are sustained in this belief by the fact of the universal application of this mode of obturation in the French land service, and the successful experiments with it in Great Britain.

The model presented has thirty calibers of length; eight steel rods 5 inches in diameter, to support the breech-block; the steel tube—fluid compressed—and the wire to be wound and fastened after any well known good plan for securing the ends: and the gun finished after any of the common modes of jacketing or hooping. Its weight should not exceed 18 tons. One of the advantages of this rod system, it will be seen, is that the rods can be replaced when their elasticity is gone, *and as long as the body of the gun is intact, the gun is repairable.* The number of rods in this mode of construction should not, it would seem, be less than four; but the minimum number which can be used to the best advantage will give us greater stiffness in the system, and the number for this reason should be made but few, due regard being had to the demands in dimensioning and fastening the other parts of the construction. In the Schultz system it will be seen that cast iron, as well as steel bodies, are contemplated; and in such a system only can cast-iron without tubing be tolerated even for secondary purposes.

If the division of strains with wiring or fretting can make it available, yet inferiority in strength and reliability, besides other objections, *must result*, and we have but at best a make-shift construction. The cast-iron, besides, is more subject to deterioration by the action of the powder, and such guns present less endurance (about, say, one to three) than the others of the *same system* having steel barrels. Nothing but economy and facility of construction warrant any efforts to further contemplate experiments looking to its use. The current opinion in French army circles, is that the Schultz construction is the best elaborated, and that which has the greatest power for endurance at the present writing. It is regarded as perfectly rational in theory, and experiments, as far as made, give weight to its claims.

Before closing this discussion on the Schultz Wire Gun, with its peculiar feature of separate and independent provisions for both the tangential strain and the longitudinal breech strain, it is to be remarked that the advantages of the introduction of the latter principle in gun construction cannot be overlooked, and that every consideration warrants, if not demands, deep inquiry into the feasibility of its practical introduction in a system otherwise well digested to meet the other important requirements of maturely planned models. Increased strength must follow, and we would have, in the satisfactory introduction of this feature, an additional guarantee of the safe admission of much greater strains than can be borne by ordinary constructions in which no provision is found for the separation of the two forces which now act together at the breech to rupture the best constructed guns. See *Ordnance*, *Tubage*, and *Wire Guns*.

SCHUWALOW GUN.—A gun named after the inventor, a Russian General. It differed from a common gun in having an oval bore; the greater diameter lay in a horizontal direction; it had also a long cylindrical chamber.

SCIMITER.—A description of sword used among Eastern nations. It is considerably curved, and has its edge on the convex side. Being usually of high temper, and its shape favorable to incision, it forms an admirable cutting instrument, but is powerless as a thrusting weapon. The Scimiter is not, however, any match for the bayonet. Also written *Cimeter* and *Scimitar*.

SCLOPETTE – SCLOPOS.—A name given to the early hand-culverins, such as were in use at the end of the 14th Century. See *Escopette*.

SCONCE.—In fortification the term applied to any small redoubt or fort, detached from the main works for some local object, as the defense of a pass or ford, etc. The word is not now often used.

SCOPETIN.—A term formerly applied to a rifleman who was armed with the escopette.

SCORE.—In the United States Service, each soldier is provided with a target score-book, and is assisted and encouraged to keep a correct record of every shot fired, marking on the diagram the point struck by each shot. In stating the score made at any time, the percentage of the maximum possible is given, and this is taken of not less than five consecutive shots. The target-record is kept at each post by the Instructor of Musketry, and every shot fired is entered in it, with the name of the party who fired it, and also the range and score. In making the monthly report of the progress of his company in the practice of musketry, the Captain transmits along with it the target-record of the best firing made during the month, if any firing has been done. If the score-book is carefully kept a fund of valuable information, as regards the allowance to be made for a given wind, temperature, or quantity of moisture in the air, will be treasured up and form a useful guide for the future practice. The value of the record will depend greatly upon the care and minuteness with which the entries are made.

The following table arranged by N. P. Phister, U. S. Army, may be advantageously used to find the percentage of three scores when their aggregate is known:

Rule 1. Look in vertical column of index figures for the first figure of the aggregate, the percentage will be found in the same horizontal line and under the index figure corresponding to the second figure of the aggregate. Rule 2. To find percentage of six scores. Divide aggregate by two and take percentage from table. If the aggregate is an odd number,

2	26.67	28.	29.33	30.67	32.	33.33	34.67	36.	37.33	38.67
	0	1	2	3	4	5	6	7	8	9
3	40.	41.33	42.67	44.	45.33	46.67	48.	49.33	50.67	52.
4	53.33	54.67	56.	57.33	58.67	60.	61.33	62.67	64.	65.33
5	66.67	68.	69.33	70.67	72.	73.33	74.67	76.	77.33	78.67
6	80.	81.33	82.67	84.	85.33	86.67	88.	89.33	90.67	92.
7	93.33	94.67	96.	97.33	98.67	100				

divide the next lower number by two—take percentage from table and add $66\frac{2}{3}$. The figures for scores between 20 and 30 are put above indices for convenience.

The following table, prepared by Lieutenant Henry A. Reed, U. S. Army, is used for finding the number of points allowance for drift and wind to be made on the rear sight of the service rifle with the new service ammunition, (70 grains powder, 500 grains bullet).

WIND FROM—	RANGE—YARDS.									
	100	200	300	400	500	600	700	800	900	1000
XII. or VI. o'clock	0	0	0	0	0	0	0	0	0	0
XII½, V½, VI½, or XI½ o'clock	$\frac{1}{12}$	$\frac{1}{4}$	$\frac{1}{2}$	1	$1\frac{3}{8}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{1}{4}$	$5\frac{1}{2}$
I., V., VII., or XI. o'clock	$\frac{1}{8}$	$\frac{1}{2}$	1	2	$2\frac{3}{4}$	$3\frac{3}{4}$	5	$6\frac{1}{2}$	$8\frac{1}{2}$	11
I½, IV½, VII½, or X½ o'clock	$\frac{1}{6}$	$\frac{3}{4}$	$1\frac{1}{2}$	$2\frac{3}{4}$	$4\frac{1}{8}$	$5\frac{5}{8}$	$7\frac{1}{2}$	$9\frac{3}{4}$	$12\frac{3}{4}$	$16\frac{1}{2}$
II., IV., VIII., or X. o'clock	$\frac{1}{4}$	1	2	$3\frac{1}{3}$	5	$6\frac{1}{2}$	9	$11\frac{1}{4}$	15	19
II½ to III½ or VIII½ to IX½ o'clock.	$\frac{1}{3}$	$1\frac{1}{8}$	$2\frac{1}{4}$	$3\frac{3}{4}$	$5\frac{1}{2}$	$7\frac{1}{2}$	10	13	17	22
Drift:—Inches	1	3	5	8	17	16	22	28	36	43
Value of a point—inches	6	11	17	22	28	33	38	42	48	53

Multiply the velocity of the wind in miles per hour, by the number at the intersection of horizontal and vertical columns giving wind direction and range respectively; then apply the drift as follows:—Add if wind is from left; substract if from right. Divide the result by the value of a point and the quotient is the required number of points deviation.

EXAMPLE:—The rifleman is to fire at 600 yards; wind blowing from 4 o'clock, velocity 10 miles; $10 \times 6\frac{1}{2} = 65$; $65 - 16 = 49$; $49 \div 33 =$ about $1\frac{1}{2}$. The sight should be moved a point and a half right.

Move the slide *against* the wind except when with a wind from the right, the product of wind velocity by number in table is less than the drift.

SCORING.—When large charges are used, the rush of gas over the projectile produces what is termed *scoring* or *erosion* of the bore.


SCOTLAND
Towns upwards of 100,000 inhabitants shown thus
from 50,000 to 100,000
from 10,000 to 50,000
below 10,000
County Towns underlined
SCALE OF MILES
0 10 20 30 40 50
Railroads
Heights of Mountains in Feet
ATLANTIC
OCEAN
NORTH CHANNEL
IRELAND
ENGLAND
ARGYLE
PERTH
FIFE
STIRLING
LANARK
EDINBURGH
HADDINGTON
BERWICK
PEEBLES
SELKIRK
ROXBURGH
DUMFRIES
KIRKCUDBRIGHT
WIGTOWN
AYR
RENFREW
LINLITHGOW
ISLAY
JURA
ARRAN
CANTYRE
FIRTH OF CLYDE
FIRTH OF FORTH
SOLWAY FIRTH
LUCE BAY
Glasgow
Edinburgh
Paisley
Perth
St. Andrews
Stirling
Ayr
Dumfries
Carlisle
Londonderry
Belfast
Kilbrennan Sound
Sound of Jura
Mull of Galloway
Mull of Cantyre
Mull of Oe
Malin Hd.
Longitude West
of Greenwich
7
5
4
3
2
55
56


HEBRIDES OR WESTERN ISLANDS
LEWIS
HARRIS
NORTH UIST
SOUTH UIST
BARRA I.
SKYE
NORTH MINCH
LITTLE MINCH
SUTHERLAND
CAITHNESS
ROSS
PART OF CROMARTY
INVERNESS
NAIRN
ELGIN
BANFF
ABERDEEN
KINCARDINE
GRAMPIAN MOUNTAINS
MORAY FIRTH
SHETLAND ISLANDS
ORKNEY ISLANDS
British Miles
Butt of Lewis
Stornoway
Cape Wrath
Pentland Firth
Dunnet Hd.
Duncansby Hd.
Thurso
Wick
Ullapool
Dingwall
Cromarty
Dornoch
Tain
Inverness
Nairn
Forres
Elgin
Banff
Fraserburgh
Peterhead
Aberdeen
Stonehaven
Inverury
Portree
Kirkwall
Lerwick
Culloden 1746
Caledonian Canal
Loch Ness
Fort Augustus
Ben Nevis
Tarbat Ness
Lossiemouth
Buckie
Cullen
Portsoy
Macduff
Kinnaird Hd.

SCORPION.—1. A very ancient Egyptian weapon, roughly made from bronze or iron, and very much resembling an Indian whip-goad. 2. An ancient gun whose dolphins represented the scorpion.

SCORPION CATAPULT.—An ancient form of the catapult. It is described by Heron, Philon, and Vitruvius. One of these machines was recently made for the collection of arms of Napoleon III.

SCOTLAND.—The Royal Arms of Scotland, are—Or, a lion rampant gules, armed and langued azure, within a double tressure flory counterflory of fleur-de-lis of the second. Supporters—Two unicorns argent armed, maned, and unguled, or gorged with open crowns, with chains affixed thereto, and reflexed over the back of the last. Crest—A lion sejant affronté gules crowned, or holding in the dexter paw a sword, and in the sinister a scepter, both erect proper. The lion is first seen on the seal of Alexander II., and the tressure on that of Alexander III. The unicorn supporters do not appear on any of the royal seals of Scotland till the time of Queen Mary, on whose first great seal (1550) they are represented as chained and gorged with crowns. They were, however, sculptured on Melrose Abbey as early as 1805. In 1603, in consequence of the union of the crowns of England and Scotland, the Scottish Arms came to be quartered with those of England and Ireland, while one of the English lions

Royal Arms of Scotland, previous to the Union.

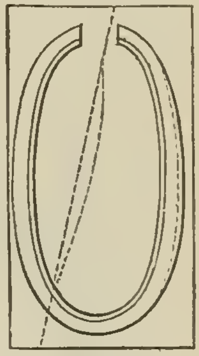
was adopted as a supporter. Precedence was, however, given within Scotland to the Scottish ensigns, which occupied the first and fourth quarters, and the unicorn also obtained the place of honor, being dexter supporter. From about the time of Charles I. to 1707, it became the practice to represent the unicorn as not merely gorged with an open crown, but crowned with an imperial crown. The treaty of union of 1707 declared that the ensigns of the United Kingdom should be in future such as Her Majesty should appoint "on all flags, banners, standards and ensigns, both on sea and land;" the same mode of marshaling being adopted in England and Scotland. But Art. 24 has been supposed to leave room for a different mode of marshaling on the seals in use in matters relating exclusively to Scotland, and on the great and other seals of Scotland. Since, as well as before the union, precedence has been given to Scotland. The question of the proper marshaling of the royal arms within Scotland was raised in 1853 by a petition to the Queen by the magistrates of Brechin; a reference was made by the home office in the first instance to Garter King-at-arms, and Garter's report was transmitted to the office of the Lord Lyon, where it was returned with observations by the Lyon Depute, who considered Scotland entitled to a precedence on the judicial seals of the country; and his views have since continued to be acted on.

SCOTS GRAYS.—The second regiment of dragoons in the British service. They are considered a superior body of cavalry, and bear as their motto, "Second to None."

SCOTT MAGAZINE-GUN.—A breech-loading small-arm having a fixed chamber closed by a movable barrel, which rotates about an axis parallel to the axis of the barrel. The gun is opened by cocking the hammer, releasing the barrel-catch, and allowing the barrel to revolve on an axis parallel to and beneath it, until the chamber comes opposite to the magazine. It swings aside the magazine-lid as it passes over the mouth of the magazine, and is automatically loaded by the action of the magazine-spring. By reversing the action of the barrel, the barrel-catch springs into place and holds it shut. The gun has a sliding extractor moving in a spiral cam recess on the axis during the revolution of the barrel. There is no ejection—the shell readily drops out as the gun is opened.

The magazine lies in the butt-stock, is charged from in front, and is closed by a sliding lid, which is kept in place by the action of a suitable spring.

SCOTT PROJECTILE. The shell devised by Commander Scott, of the British Navy, for firing molten iron, is shown in the drawing. It has three ribs cast upon it, which fit grooves so constructed as to center it in the bore of the gun when fired. The interior of this shell is lined with loam to prevent the heat of the charge from entering through to the bursting charge. It is supposed to be broken and its contents diffused on striking the object. See *Studded Projectiles*.



SCOTT SYSTEM OF RIFLING.—In this method the bore is rifled with narrow, shallow grooves, deeper on the driving than the loading-side. The projectile is one iron casting, having ribs almost triangular in section, extending the full length of the cylindrical body, and set to the angle of the rifling. In cross-section the ribs give a deep bearing-surface on the driving side. By shallowing the loading-side of the groove, the ribs rest on inclined planes, so that the projectile, when forced into its seat, has a natural tendency to slip round so as to cling to the driving-side before the gun is fired, to start easily, and to mount into the centring position the moment it begins to move out. Less windage is given to the ribs on the projectile than to its body, so that it rests upon its projections, and its body does not touch the bore at all. The ribs almost fill up the grooves, and check the escape of the gas, with its consequent erosion of the bore, and unequal action on the projectile. While by striking the curve of the cross-section of the groove and of the rib with two different radii, the latter is driven up into the center of the bore at once, causing the axes of the projectile and of the bore to coincide. In this system there are three grooves for the nine-ton guns and under; five grooves for twelve and eighteen-ton guns and upwards. The grooves are of the same size for all guns. Width, 0.8 inch; depth, 0.125 inch. This system has not as yet been generally adopted by any nation. See *System of Rifling*.

SCOUR.—A term very frequently used to express the act of discharging ordnance or musketry, rapidly and heavily, for the purpose of dislodging an enemy. Hence, to scour the rampart, or the covered-way. The term likewise signifies to clear, to drive away; as to scour the seas; also to run about in a loose desultory manner; as, to scour the country. *To scour a line*, is to flank it, so as to see directly along it, that a musket ball entering at one end may fly to the other, leaving no place of security.

SCOUT.—A person sent out in the front or on the flank of an army to observe the force and movements of the enemy. He should be a keen observer, and withal fleet of foot, or well mounted.

Scouts or single soldiers, if disguised in the dress of the country, or in the uniform of the army hostile to their own, employed in obtaining information, if found within or lurking about the lines of the captor, are treated as spies, and suffer death.

SCOUT-MASTER GENERAL.—A person formerly so called, under whose direction all the scouts and army messengers were placed.

SCRAMASAXE.—A dagger or cutlass about twenty inches in length, used by the early Frank soldiers. This weapon has been frequently found in the tombs of warriors laid side by side with the long *Spatha*. It was hollowed, so as to have two channels on each face, one of them being on each side of the central ridge of the blade; and these channels were filled with poison. The etymology of the word is as follows:—*Saxe* means knife, and *Scrama* may be derived from the word *Scamata*, a line traced on the sand between two Greek combatants; or from *Scaran* to shear, from which the German *Schere*, scissors, is derived.

SCRAPER.—An implement in use to scrape the residue of powder from the bores of mortars and howitzers, and to remove it from the piece. It consists of a handle of iron, having a scraper at one end, and a spoon for collecting dirt at the other, both being made of steel.

SCRAP-METAL.—A term applied to fragments of any kind of metal which are only of use for remelting. Copper and brass scrap consist of the turnings from the lathe, and all the useless and worn pieces, whether old or new. They are readily remelted. Scrap-tin consists of the clippings and fragments of tinned iron and worn-out tinned vessels; these are frequently dipped into hydrochloric acid, to dissolve off the tin-coating from the iron; and the muriate of tin so formed is of commercial value for dyeing purposes. Scrap-iron consists of any waste pieces of iron, although the term is usually held to mean malleable iron only; and for many purposes it is particularly valuable, as it is found that a greater strength can be obtained by welding small fragments of iron together, than is found in large masses, the fiber being much more twisted and interwoven, from the mingling of pieces in every imaginable direction.

SCRATCH-BRUSH.—A cylindrical bundle of fine steel or brass wire tightly bound in the center, with the ends projecting at both extremities so as to form a stiff brush for cleaning and scratching metals preparatory to gilding or silvering, or, as in the case of small-arms, preparatory to the browning them. As well as the shape above described, there is another, in which the steel wire is fastened in long lengths on leather or cloth, and in this form is known as *scratch card*.

SCREW DRIVER.—An appendage for turning screws in or out of their places. It has an end like a blunt chisel, which enters the nick or slit in the screw-head. The screw-driver for taking apart and re-assembling fire-arms is composed of two blades of steel, one of which turns on a pivot, passing through the other, or it may have an additional pivoted arm. The larger arm has a perforation at one end fitting the square of the "cone" or nipple, for the purpose of unscrewing the nipple from its seat. Fig. 1. represents the screw-driver, model 1870, used in the United States Army. A is the *large blade*, B the *small blade*, C the *rivet*. In taking apart the lock, the *notch* (D) should be clamped over the main-spring and used as a spring vise. Fig. 2. represents the combination screw-driver, which it is proposed to issue in the United States as soon as the present supply of appendages is exhausted. A is the *small screw-driver*.

Fig. 1.

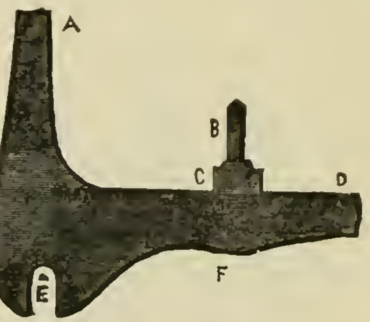


Fig. 2.

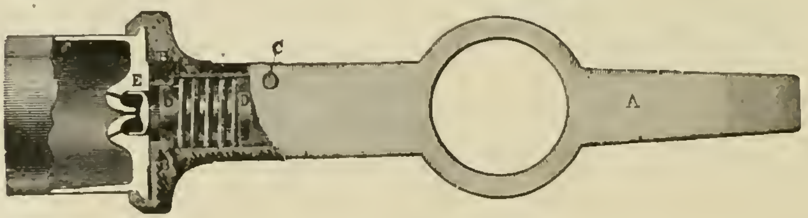


Fig. 3.

B is the *punch* to be used in removing the band springs. C is the *shoulder*, which is used to drive out the tumbler, in order to remove the hammer. To do this, after removing the tumbler screw, insert the punch (B) into the tumbler cavity, bring the shoulder (C) to bear evenly on the tumbler, and drive it out by hammering at the *point* (F). In so doing, the sides of the shoulder must be parallel with the sides of the square, to avoid striking on the hammer. D is the *large screw-driver*. E is the substitute for the *spring vise*, to be used in dismounting and assembling the lock. Bring the hammer to the full-cock notch; put the notch (E) over both branches of the main-spring; uncock the hammer, unhook the swivel, and remove the main-spring. Care must be taken to keep the spring in the notch in order to re-assemble the lock without a spring vise. The guard, butt-plate, and side screw-heads have concave slits for which the screw-driver is adapted. This lessens the danger of the stock being marred by accident in letting the screw-driver slip out of the slit. By keeping the screw threads well oiled, there will be no difficulty in taking out or replacing the screws.

A handy combination tool much used in military service is represented in Fig. 3. It consists of a screw-driver, A, combined with a capper, D, and hand-shell extractor, B, which is applied to the head of a shell, E. The capper is operated by pressure brought to bear when, A, is turned about the pivot, C.

SCREWED-IN SIGHT.—A variety of trunnion sight. The sight is made of steel and has a steel leaf, dove-tailed into its top. It is screwed into a hole above the trunnion. The leaf is hog-backed in shape, and its rear face is roughened to prevent the reflection of the light interfering with the *laying* of the gun.

SCREW-MACHINES.—Screws were little known or used before 1836, being rudely made by hand with imperfect tools. The head was forged or swedged up by a blacksmith; the thread and nick were formed by the use of hand dies and hack screws. In 1836, American ingenuity was directed to the subject, and the old hand tools were associated in machines having the capacity of imparting to each tool its proper motion. The swedge hammer became the heading machine, receiving the end of a coil of wire and regularly cutting the required length for a blank, which then received such a blow as to "set up" one end of the wire to form the head—the operation continuing automatically until the whole coil was made into blanks. These blanks were then handled individually and presented to organized machines, first for shaving the head, then for nicking, and lastly for cutting the thread. The above constitutes the second era in this manufacture; and such machinery, partly automatic, was all that was in use before 1846. Then a third era ensued, and an entire revolution was effected by constituting the machines entirely automatic. The blanks are by this system supplied in mass by the operator, the machine separating and handling each blank respectively as the nature of the operation demands, and producing with wonderful rapidity, regularity, and perfection. Chief among the inventors and constructors of this machinery was General Thomas W. Harvey, widely known for inventive genius in many directions. After him, perfecting and developing, were Sloan, Whipple, Rogers, and others; while the leading mind that organized this intricate business into probably the most successful manufacturing interest in this country was the late William G. Angell, of Providence, R. I., President of the American Screw Company. General Harvey was the first inventor of the partly automatic and of the entirely automatic machines. It is noticeable that though he produced gimlet-pointed

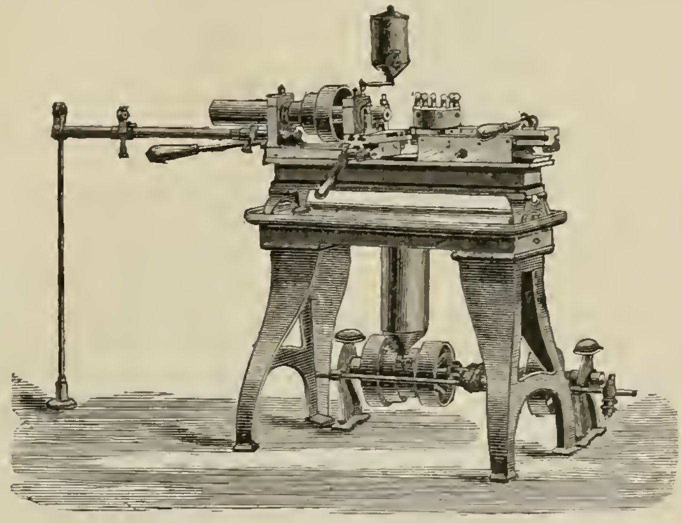


Fig. 1.

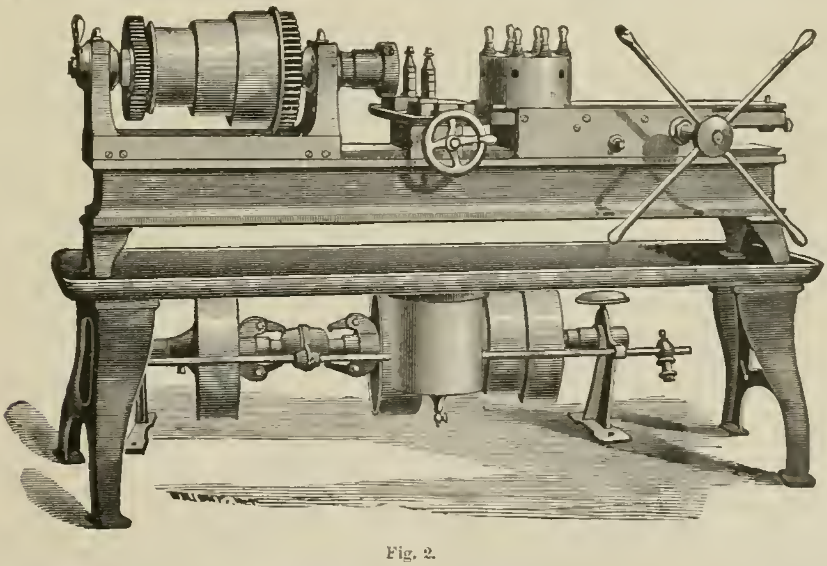


Fig. 2.

screws in 1836, it was not till 1846 that any considerable market was found for them. His son, Hayward A. Harvey, of Orange, N. J., likewise a skillful inventor in many departments, has made important improvements in the automatic machines, and this American invention is now in use throughout the world wherever screws are made. It is estimated that the consumption of screws throughout the world is not far from 100,000 gross per day—about 100 tons; and about 500 tons of iron are required for the daily production of machine and wood screws.

A light screw-machine, provided with the Parkhurst wire-feed attachment, made by the Pratt and Whitney Company, United States, and used to a great extent in arsenals, is shown in Fig. 1. On this machine every operation (except slotting the head), in the production of screws from wire or rod, is performed successively, without removal of the work from the chuck, stopping of the machine, or change of tools. The turret of the machine is self-rotating and self-fastening. One leg of the machine is arranged to swivel to accommodate itself to unevenness in the floor, with set-screws for adjustment. The wire-feeding device is simple in construction and efficient in operation. It is not liable to derangement, and is operated by the movement of a hand-lever. It feeds the wire forward to a length regulated by an adjustable gauge-stop held in the turret, and the same movement that brings the wire foreward closes the jaws of the chuck, holding the wire firmly. The reverse movement opens the jaws to receive another length. These movements are performed instantaneously without stopping the machine, so that the use of the device results in a great saving of time. It may be used on all sizes of machines, and is adapted to rods up to 1¼ inches diameter. Collets, for holding rods in the chuck, are provided in various sizes. The cone of this machine, usually carries a belt 1½ inches wide, and the countershaft has a speed of 310 revolutions.

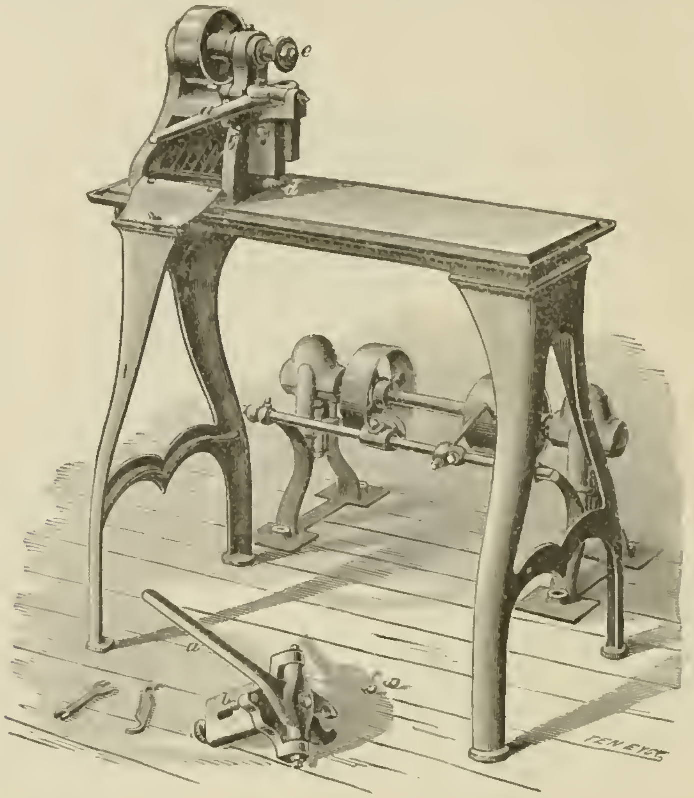


Fig. 3.

A very heavy screw-machine, having back-gears, adapted to the production of screws and studs from the rod of 1½ inches and smaller diameter, is represented in Fig. 2. It has an automatic feeding apparatus, with self-operating stop-motion, attached to the turret-slide. This is operative the entire length of the machine, and may be adjusted to feet as desired. The cone carries a 4-inch belt. The relative capacities of the machines of these and intermediate sizes is shown in the above table:

Size.	Diameter of hole through spindle.	Largest diameter wire-feed apparatus will take.	Diameter of hole in revolving head.	Length that can be milled.	Weight, with countershaft.
0	$\frac{5}{8}$ inch.	$\frac{1}{4}$ inch.	$\frac{7}{16}$ inch.	2 inch.	350 lbs.
1	$\frac{3}{4}$ inch.	$\frac{3}{8}$ inch.	$\frac{9}{16}$ inch.	2½ inch.	400 lbs.
2	$\frac{15}{16}$ inch.	$\frac{9}{16}$ inch.	$\frac{11}{16}$ inch.	3½ inch.	780 lbs.
3	$1\frac{5}{16}$ inch.	$\frac{15}{16}$ inch.	1 inch.	5½ inch.	1,225 lbs.
4	$1\frac{9}{16}$ inch.	1¼ inch.	1½ inch.	8½ inch.	2,200 lbs.

In the plain screw-slotting machine, the screw, held in a chuck mounted on a slide, is raised, by means of a hand-lever, pinion, and rack, to the cutter revolving in the spindle for simply sinking a nick in the head. This vertical slide has a movement of 4 inches, which may be limited by a screw and check-nuts. A rod, arranged to pass up through the chuck as it descends with the slide to starting point, pushes the screw out of the chuck, so as to be caught by the table. For slotting across screw-heads, and for light milling cuts, a cross-slide with traverse of 3 inches, operated by hand-lever, is added to the vertical slide. Fig. 3. shows the slotting-machine usually employed in the arsenal. It will be observed that it is very simple and is well adapted for slotting studs and screws expeditiously. Duplicate bushings, suitable for the different sizes of screws, can be fitted to the clamping jaws. The machine contains a closet, in which is a rack for holding the various sizes of cutters, and also furnishing a place for the bushings, wrenches, etc. Countershaft should run 160 turns per minute. Tight and loose pulleys 6 inches diameter, $2\frac{1}{2}$ inches face. Weight of entire machine, with countershaft, 370 lbs.

Quite an expensive machine is often used by gun-makers and others for slotting the heads of screws.

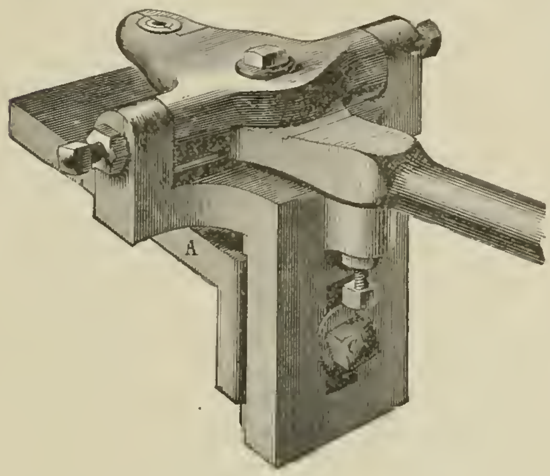


Fig. 4.

The device shown in Fig. 4, which can be attached to any ordinary hand-lathe, is believed to be more efficient for the purpose than any machine heretofore made. An active boy can slot from ten to fifteen thousand screws per day. A single bolt fastens the platform, A, of this apparatus to the bed of a hand-lathe, the long lever projecting in front at a right angle with the bed. An arbor carrying a circular cutter is held in the centers of the lathe. The long lever is moved horizontally to open the jaws for inserting and removing the screws, and downward to bring the screws to be slotted against the saw. A stop screw governs the downward motion, and thus regulates the depth of slot in the screw head. The working part of the apparatus can be raised or lowered on the platform front by means of a bolt provided for the purpose.

SCREW-THREAD GAGE.—A gage for giving the proper bevel to the edges of screw-cutting tools. For the general purpose of bolts and nuts there are three different forms of thread now in use. These are the ordinary sharp V, the Whitworth, and the U. S. Standard forms.

The sharp V-thread has its surfaces inclined to each other at an angle of 60°. A section of this thread is therefore an equilateral triangle, each side of which is equal to the pitch of the screw, and the depth of the thread, measured perpendicularly to the axis of the bolt, will be expressed by the formula—

$$d=p \cos 30^\circ=.866\,p$$

in which p represents the pitch, d the depth of the thread, and 30° half the angle included between the thread surfaces. The effective diameter of the bolt is expressed by the formula—

$$d=\mathrm{D}-2\times .866\,p=\mathrm{D}-1.732\,p$$

in which D and d represent the *nominal* and *effective* diameters respectively.

The Whitworth thread has its plane sides inclined to each other at an angle of 55°, with the angle formed by these surfaces, at both the periphery and root of the thread, so rounded that the depth of the finished thread is two-thirds the depth of a V-thread, having its surface inclined at an angle of 55°. In this form of thread the depth is readily determined by the formula—

$$o=\tfrac{2}{3}\times\frac{p}{2\tan 27^\circ\,30'}=.65\,p$$

and the diameter of the effective section of the bolt by—

$$d=\mathrm{D}-2\times .65\,p=\mathrm{D}-1.3\,p.$$

The U. S. Standard thread is simply the ordinary V-thread with surface inclined at an angle of 60°, and with the angles cut off at the top and filled in at the bottom to the extent of one-eighth of the depth of the V-thread each, so that the depth of the thread is three-fourths that of the ordinary V-form, and is expressed by the formula—

$$o=\tfrac{3}{4}\,p\cos 30^\circ=65\,p.$$

The effective diameter will then be—

$$d=\mathrm{D}-2\times .65\,p=\mathrm{D}-1.3\,p.$$

Collecting the results for the effective diameters of bolts having threads of the different forms, we have—

"V"	form,	$d=\mathrm{D}-1.732\,p$
Whitworth	"	$d=\mathrm{D}-1.3\,p$
U. S. Standard	"	$d=\mathrm{D}-1.3\,p$

With equal pitches it appears, therefore, that the maximum effective diameter of bolt is insured when threads of Whitworth or U. S. Standard forms are used, while the usual V-form insures the minimum effective diameter.

SCROLL-IRONS.—Iron brackets attached underneath the frame sides of the body, or the futchells of the fore-carriage in all carts and wagons where springs are used, to which these latter are connected by means of single bolts in front and double bolts and shackles in rear.

SCURVY.—A disease which is characterized by depraved conditions of the blood. In consequence of this morbid state of the blood, there is a debility of the system at large, with a tendency to congestion, hemorrhage, etc., in various parts of the body, and especially in the gums. It is a disease that has probably existed from the earliest times, but the first distinct account of it is contained in the history of the Crusade of Louis IX., in the 13th century, against the Saracens of Egypt, during which the French army suffered greatly from it. In the 16th century it prevailed endemically in various parts of the north of Europe, and it seems only to have abated about a century ago. It was in badly fed armies, in besieged cities, and on board ship, that its ravages were most appalling, and it is believed that more soldiers perished from scurvy alone than from all other causes combined, whether by sickness, tempest, or battle. Whole companies were prostrated by this scourge.

Scurvy so closely resembles purpura in its general symptoms that it will besufficient for us to refer to that disease, and here merely to indicate the leading points of difference between the two diseases, which, notwithstanding their similarity, are essentially different. Scurvy is caused by a privation, for a considerable time, of fresh succulent vegetables, while purpura often makes its appearance when there has been no deficiency of this food, or special abstinence from it. Scurvy is most commou in winter or the early spring, while summer and autumn are the seasons for purpura. In scurvy the gums are invariably swelled and spongy, and bleed readily; in purpura this is not necessarily the case. In scurvy there is extreme debility and depression of spirits, venesection and mercury do positive harm, while a cure is rapidly effected by the adminstration of lemon-juice or of fresh fruits and vegetables; whereas in purpura there is very little or no mental or bodily depression ; venesection and mercury often give relief, while no marked and certain relief follows the administration of the lemon-juice and fruits that are all powerful in scurvy.

Although the virtues of lemon-juice in scurvy were known as far back as 1636, when John Woodhall, Master in Surgery, published *The Surgeon's Mate, or Military and Domestic Medicine*, this invaluable medicine was not made an essential element of diet till1795. The effect of this official act maybe estimated from the following numbers: In 1780 the number of cases of scurvy received into Hasler Hospital (a purely naval hospital) was 1457, while in 1806 there was only one case, and in 1807 only one case Many Naval Surgeons of the present day have never seen a case of the disease. The potato posseses almost equally great antiscorbutic properties, and, fortunately potatoes when cooked are as active as when taken raw. The late Dr. Baly, to whom we are indebted for this discovery, states " that in several prisons the occurrence of scurvy has wholly ceased on the addition of a few pounds of potatoes being made for the weekly dietary." The salutary action of potatoes is probably owing to their containing a considerable amount of tartaric acid, partly in combination with potash and lime, and partly free. In addition to the dietetic treatment, which should include easily digested animal food, potatoes, such ripe fruits as can be procured, and an abundance of lemonade, little further need be prescribed. If necessary all constipation must be relieved by mild laxatives, such as rhubarb and castor-oil ; the appetite may be stimulated by bitter tonics, and opiates given to procure rest in case of pain or obstinate wakefulness. When the gums are very troublesome, the solutions of tannin, chloride of lime, or of nitrate of silver, may be applied to them. For an excellent account of this disease, the reader is referred to the article "Scurvy" by Dr. Budd, in *The Library of Practical Medicine.*

SCUTUM. A Roman buckler made of wood, the parts being joined together with little plates of iron, and the whole covered with a bull's hide. In the middle was an *umbo*, or boss of iron, which jutted out, and was useful to glance off stones, darts, etc. The *scuta*, in general, were four feet long, and different in size from the *clypei*, which were less and quite round.

SCYTHE KNIFE.—A modified form of the *war-scythe*. It is single-edged, and has the point curving from the edge to the back. The point is double-edged, and at the base of the blade there is a hook or spur. See *Glaive*.

SCZAROCH.—A shell adopted by the Russians. It is either a percussion or time shell and a shot, the latter of which ricochets beyond the point of explosion of the bursting charge. The shell portion is a simple iron cylinder, to one end of which is secured, by a thin sheet of lead, a spherical shot. On leaving the gun, the combined projectile acts like an ordinary elongated shell; but as soon as the explosion of the charge takes place, the cylinder flies in pieces, while the shot, impelled by the additional velocity and by reason of its form, ricochets for hundreds of feet ahead. In firing at batteries,the double effect of this projectile comes into excellent use, as the shell might be exploded among the guns, while the ball would strike far in the rear among the reserve troops; or while the shell might burst in the front rank of an advancing line, the ball would continue plowing its way through several succeeding ranks.

SEA COAST AND GARRISON CARRIAGES.—Prior to the introduction of heavy charges and elongated projectiles for use in heavy guns, the chassis was of sufficient length that the recoil of the top-carriage should be absorbed by its friction on the chassis-rails before the entire length of the latter had been traversed ; but of late years, when the improvement in powder has been such as to render it a practicable thing to fire heavy charges with projectiles weighing two or three times the weight of a round shot of the same caliber, the increase in the recoil has become so great as to render it imperatively necessary to resort to other means by which it may be controlled within the limits of the chassis-rails. Different methods of more or less merit have been from time to time proposed. That of multiplied friction of numerous plates, or the compressor, as it was called, seemed for a time to find most favor throughout Europe until Captain Fraser, of the English Navy, proposed the hydraulic buffer,and showed its successful practical operation, when soon after it was adopted by Krupp in the construction of his heavy carriages for Russia and Germany, since which time it has been generally adopted by every nation for heavy carriages to be usedin the land service, France, perhaps, excepted. Its simplicity and economy of construction, its efficiency, and its automatic operations are the features which commend it to general favor.

A hollow cylinder fastened to the chassis, abutting the middle of the rear transom, a piston-rod secured to the top-carriage and working in this cylinder, with four holes in the piston-head for the passage of the fluid which partly fills the cylinder, compose the essential parts of the hydraulic buffer as it has been universally adopted. In some carriages made by Krupp for the German Navy the cylinder,instead of being placed on the rear part of the chassis,against the rear transom, has been placed in front so that the piston-rod will be gradually pulled out of the cylinder instead of being thrust in, as is usually the case. It was supposed that for naval carriages there might be some advantages in this arrangement which did not apply to land carriages, whereas the greater expense that necessarily attends its construction,and the greater difficulty of preventing leakage around the piston, has operated to prevent the adoption of this arrangement for other carriages. The cost of the hydraulic buffer, as well as the weight added to the carriage, is less than those of the pneumatic buffer by about one-third.

United States.—In this service the carriages are designated as *barbette*, *casemate*, and *flank-defense*, carriages, according to the portion of a work in which they are mounted. Formerly nearly all sea-cost carriages were made of wood; but in consequence of great difficulty of preserving this material from decay, especially when exposed to the dampness of casemates, it has been determined to replace it by wrought-iron ; and strong, cheap, and manageable carriages have been devised and tested for this service. The principal feature in the construction of the new carriages, is a peculiar combination of boiler-plate and roller-beams, which gives, with requisite lightness, great strength and stiffness to the important parts. All sea-coast carriages are composed of the *gun-carriage* and the *chassis*. The purpose of the gun-carriage being to support the piece,it should be so constructed that the piece can be elevated or depressed in aiming,and run into and out of battery, in firing. The term "in batery," as applied to sea-coast guns, refers to the position which the piece occupies when it is ready to be fired ; in casemate pieces the muzzle must be in the throat of the embrasure, and in barbette pieces, directly over the superior slope of the parapet.

The gun-carriage is composed of two *cheeks*, held together by two plates of boiler iron called the *front* and *rear transoms*. Each cheek is formed of two pieces of boiler iron cut to a triangular shape, separated at the edges by interposing the vertical portion or web of a T-shaped bar. The horizontal branches project over each side to form a double rim, which gives stiffness to the cheeks. Flat bars of iron are also placed between the plates at suitable intervals to stiffen the cheeks in the direction in which the weight and recoil of the piece bear upon them. All these parts are held together by screw bolts.

The motion of the carriage to and from battery is regulated by a pair of *maneuvring wheels* which work on an eccentric axletree, placed underneath and a little in front of the center of the trunnions. The 13 and 15-in. carriages have two pairs of these wheels. When it becomes necessary to check the recoil of the gun-carriage, the wheels are thrown out of gear by means of a handspike, and the forward part of the carriage moves on sliding friction. When it is necessary to move to battery, the wheels are thrown into gear and the carriage moves on rolling friction.

All sea-coast cannon having no preponderance are elevated and depressed by a lever, (or other suitable contrivance,) the point of which works in a ratchet cut in the breech of the piece. The fulcrum is made of cast-iron and rests on the rear transom of the gun-carriage. It has several notches for adjusting the position of the elevating lever. This apparatus is exceedingly simple, and affords the means of changing the elevation with ease and rapidity. The piece is pointed, 1st, by two fixed sights, one attached to the breech and the other to a lug between the trunnions; 2d, by a brass graduated arc attached to the breech, parallel to the ratchet, and a pointer attached to the fulcrum. By the fixed sights the piece is brought in line with the object, and the arc and pointer mark the elevation necessary to strike it.

The chassis is the movable railway along which the gun-carriage moves to and from battery. It is composed of two wrought-iron rails inclined 3° to the horizon and united by transoms; there are certain diagonal braces to give stiffness to the chassis.

center of the front transom, as with an equal space it affords a greater horizontal field of fire, or affords a better opportunity to use heavy traverses of earth to protect the pieces from an enfilading fire.

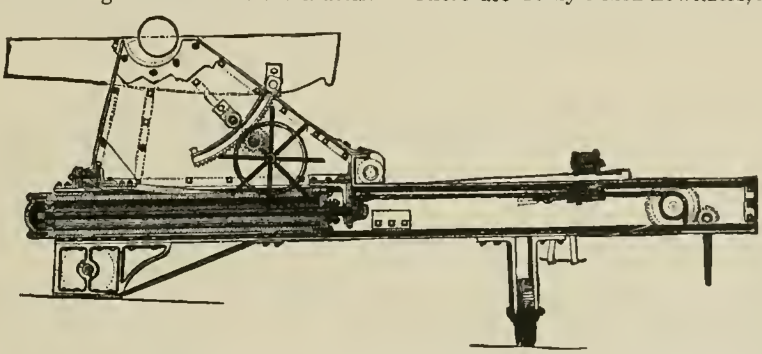
The carriages are at present maneuvred by handspikes applied to holes in the circumference of the traverse and maneuvring wheels. This mode is defective, inasmuch as power is wasted by continually overcoming the inertia of the gun and carriage when the handspikes are readjusted. It is proposed to supersede this by the continuous motion produced by cranks, and the experiments that have been made indicate that the heaviest pieces may be moved with much greater ease than heretofore.

Much attention is now being paid towards obtaining a more effective cover for barbette guns and the men that work them. It is understood that several plans to this end are under consideration by the Engineer Department, and among them are fixed and revolving turrets, the latter similar to those used on the monitors, except that they are to be moved by man rather than steam power.

The sea-coast carriages of the present system are:

The 15-inch Rodman gun, . . .	Barbette.
" 10-inch " " . . .	"
" 8-inch " " . . .	"
" 13-inch " " . . .	Casemate.
" 10-inch " "	"
" 8-inch " "	"
" 24-pdr. flank defense howitzer,	

There are many 8-inch howitzers, and 42 and 32-



For the 10-inch and smaller carriages, the chassis-rails are single beams of rolled iron, 15 inches deep; for all calibers above, the rails are made of long rectangular pieces of boiler plate and T-iron, in a similar manner to that of the cheeks of the gun-carriage. That the carriage may be moved horizontally in the operation of aiming the piece, the chassis is supported on traverse-wheels, which roll on circular plates of iron, fastened to a bed of solid masonry, called the *traverse-circles.*

The motion of the gun-carriage is checked front and rear, by pieces of iron bolted to the top of the rails, called *hurters* and *counter-hurters*; and it is prevented from slipping off sideways by *friction rollers* and *guides*, which are bolted to the cheeks and transoms.

The pintle is the central piece around which the chassis is traversed. It is formed of a stout cylinder of wrought-iron inserted in a block of stone, if the battery be a fixed one, or it is secured to cross pieces of timber bolted to a platform firmly imbedded in the ground, if it be of temporary nature. In casemate batteries the pintle is placed immediately under the throat of the embrasure, and the chassis is connected with it by a stout strap of iron, called the *tongue.* The muzzle of the piece when in battery, is situated in the throat of the embrasure—a position which, taken in connection with that of the pintle, gives the greatest horizontal field of fire. The center pintle carriage, or the one in which the pintle is in the center of the chassis, is preferable for barbette batteries to the one in which the pintle is in the

pdr. guns of the old system mounted in sea-coast batteries, but they are being replaced by those of larger caliber as fast as they can be provided by the private founders.

Germany.—The heavy carriages for both the land and sea-services are made, not in government shops under the direction of its own officers, but are furnished by private parties who have granted to them in their contracts a wide latitude both as to the kind of material to be used as well as other matters of detail; they are not obliged to follow a given model or produce constructions which shall be nearly alike. The result is that the carriages constructed by different contractors are widely different from each other, though they may be intended for the same purpose and even for the same gun. An expression of opinion was heard in opposition to this system of procuring supplies, as it tended, or was so believed, to make the carriages in some cases heavier than were needed to perform the work required of them.

Some of the carriages built by Krupp for the Navy have the cylinder for the hydraulic buffer placed on the front part of the chassis, so that the strain brought on the piston-rod shall be one of tension instead of compression. This disposition of the cylinder was suggested under the belief that in a ship's carriage, which is subjected to violent motions from the waves of the sea, the regular action of the carriage would be less interfered with when so constructed than when arranged in the ordinary way.

In carriages for the land-service these reasons do not obtain, and as this arrangement of the cylinder involves a greater cost of the carriage, and it is more difficult to prevent the loss of the fluid by leaking around the piston-rod where it passes through the head of the cylinder, this mode of construction has not been adopted.

The parties who have heretofore furnished nearly all of the heavy carriages are Krupp, of Essen, and Gruson, of Buckau, near Magdeburg. For a full description of these carriages see *Gruson Sea-coast Carriage* and *Krupp Sea-coast Carriages*.

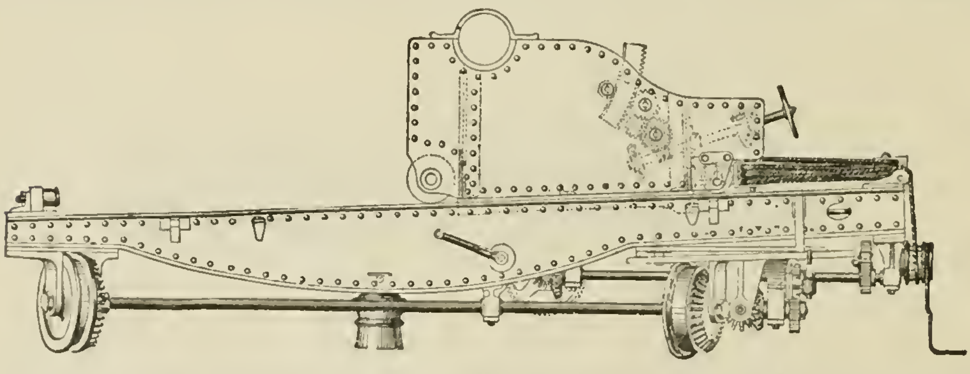
England.—The English carriages are made principally at the Royal Carriage Department, at Woolwich, but some are built from time to time by contract, by outside parties. Several different kinds of carriages are constructed to meet the varied wants of service in forts erected at so widely remote periods of time, but the differences are rather in details than in principle, and a general description covering the whole, with a brief notice of some of the principal variations, will suffice to give a very clear idea of their main characteristics.

The top-carriage is composed of two cheeks connected together by a vertical and a bottom transom, the attachment of the latter being strengthened by two knee-stays. Each cheek is made of a wrought-iron frame from 3½ to 4 inches thick, forged to the required shape, and planed on both sides. The plates, from .375 inch to .75 inch thick, and corresponding in general form to the frame, project beyond, both in front and rear, thus forming recesses for the truck-wheels, and are riveted to the frame, an inside brace being inserted between the plates where the vertical transom comes against them. The top and bottom surfaces of the cheeks are planed, the top being horizontal and the ends vertical when the carriage is on its chassis.

A metal trunnion-bed is made fast in each trunnion-hole by countersunk screws, and cap-squares are held in place by two feather-keys, which are attached to the cheeks by small chains. The bottom transom is a plate from .875 to 1 inch thick, is secured to the bottom of the cheeks by screws with countersunk heads, and is planed where it comes in contact with the cheeks and rails, that it may have even bearing-surfaces and guides of angle-iron are riveted to the lower side, to keep the carriage straight on the chassis. The vertical transom is a plate of .625 inch thickness, riveted along the lower edge and sides to an angle-iron frame, which is bolted to the cheeks and bottom transom. The upper edge is cut out in a curve, to allow the gun to turn on its trunnions freely without striking it. The knee-stays are riveted to the bottom transom, near its rear edge, and are bolted to the cheeks, one to each cheek.

The truck-wheels are between the plates of the cheek. The front wheels have axles from 2 to 2½ inches in diameter, and rest in gun-metal bearings secured to the cheek by two screws, which act as feathers in slots in the head of the axle, and prevent it from turning round in its bearing. The axle is put in from the outer side, and keyed in place. The axles of the rear wheels are eccentric, and are secured in the cheeks by what are called drop-plates. By taking out the rear bolt of the drop-plate, and turning it upward around the front bolt as a pivot, the axle is freed. The axles are joined by a "connecting-bar," in which are two holes to take the end of an iron hand-spike, so that the bar may be turned and both truck-wheels may be thrown in or out of gear at the same time. The inner end of each axle is made hexagonal, to receive a handspike socket in case the connecting-bar should be damaged. To prevent the rear-wheels from coming into play when the carriage recoils, a stop is riveted on the inside of each cheek.

The elevating apparatus consists of two wrought-iron circular racks pivoted to the gun and passing between the two plates of each cheek. The teeth are cut on the rear and convex edge, and work in the teeth of a pinion fixed to a spindle fastened in the cheek. On the concave edge a groove is cut, in which a friction-roller runs and keeps it engaged in the teeth of the pinion, and also prevents it moving sideways. The axles of the pinion and friction-roller pass through gun-metal bearings in the cheek; that of the latter is secured by a nut, and the former has upon it a capstan-head and clamp-screw for holding the gun in any desired position. The capstan-head has holes in the periphery for the end of an iron lever by which it is turned. By turning this head the gun is elevated or depressed, for the head has feathers which enter slots in the spindle,



so that any motion to the head is communicated to the spindle, and by the spindle to the pinion and rack. The clamp-screw binds the pinion and prevents it from moving.

The thread of the spindle in the right cheek is left-handed, so that the gun is held clamped by turning the clamping lever to the rear. For the 10-inch and larger carriages, and for the 9-inch of future construction, the gearing of the elevating apparatus is somewhat different. The pinion which engages the teeth of the rack is driven by a worm and wheel, with one or two intermediate pinions. The worm and wheel are placed on the inside of the cheek and held in place by two journal-boxes and caps bolted to the side of the cheek. To the rear journal-box a hinged clutch is screwed by a steel pin, and kept in place by a swivel-key. To throw the worm out of gear with the worm-wheel, open the clutch, turn the worm-shaft and draw it to the rear until the collar on it is in rear of the clutch; replace the clutch, and the shaft is held with the worm out of gear. On carriages of the most recent manufacture the worm-shaft is inclined upward to the rear. The hand-wheel for turning this shaft is in all carriages just in rear of the end of the cheek.

A front and rear eye-bolt for tackle is bolted to each cheek and a buffer-block of elm is bolted to the front transom. A loop for the priming-wire is attached to the right cheek.

The recoil of the gun is controlled in all carriages for the land-service by the hydraulic buffer. It consists of a wrought-iron lap-welded cylinder, with cast-iron cover-cap and flange, and wrought-iron piston-head and rod, a packing-gland and emptying-cock of brass. The cylinder is 77.375 inches long in the clear, and 8.07 inches in diameter, and holds 12 gallons 5 pints. The cap closes up the rear end, being screwed on. The flange is screwed on the front end, and the cover is bolted to the flange. Both the flange and cover are flat on top, to allow the top-carriage to pass over them without striking.

The chasses vary in height according to the use for which they are intended, whether in casemates or open batteries. The former have an imaginary pivot in front, the chassis being prevented from recoiling and guided in its motion by the traverse-wheels, which have in their periphery a deep groove for the traverse-circle to fit into. The chassis for open batteries are divided into three classes: the first has the pintle in front, and, like the casemate, it is imaginary; the second, the pintle is in the center, and the third has the pintle in rear of the center. The height of the chassis at the front end is 32.5 inches. When increased height is to be given, it is done by putting in a knee-stay bolster.

For the 7 and 9-inch guns the chassis-rails are rolled each in one beam 10 inches deep and 5½ in width of flange, bent round in front, and planed on the upper and lower surfaces and sides of the flanges. The front transom is a plate 1 inch thick, riveted along the sides and top to a frame of angle-iron. It is let slightly into the rails. A top plate is riveted to the front end of the chassis, and has an oblong hole in its length to give access to the nuts below it. The rear transom is a 7-inch beam, the flanges being 4 inches. It is fastened to the rails by a knee-plate bolted to it and the web of the rail. The traverse-forks are of wrought-iron, with a flange or knee to strengthen it to resist the thrust of the recoil.

The front forks are secured to a truck-plate 1 inch thick, bolted to the chassis-rail. The rear forks are riveted to a connecting-plate, which is fastened to the truck-plate, and these are bolted to the rails, wrought-iron bolsters being used to give the slope of 4°. A front bottom plate, .875 inch thick, joins the rails near their middle, and a rear bottom plate is bolted to the underside of the rear ends of the rails and the rear transom.

A diagonal brace of 1-inch plate, with a center piece and four arms like the letter X, is bolted to the underside of the chassis, and its center to the front bottom plate. The bent ends of the rails where they come together in front are joined by a connecting-plate which is bolted to the web of the two rails.

The traverse-wheels are of wrought-iron, having brass bushings. They are cylindrical, with a deep groove turned in the face to fit over the traverse-circle. The rear traverse-wheels have only one flange and on the front side. The journals of the traverse-wheels are steel, and are secured by a nut on the inner side. India-rubber hurters and counterhurters are provided. Eye-bolts for the tackle are bolted on each rail, one in front and one in rear; and a fifth is placed in the middle of the rear edge of the bottom plate, for use in transporting the chassis. Axle-tree bands to receive an axle for transporting the chassis are riveted to the front bottom plate.

The 9-inch chassis is provided with gear for traversing and running the gun from battery, the same arrangement serving for either purpose by disconnecting by a shipper the parts not required. The gear is worked by the crank-handles on either side of the rear end of the chassis.

A brass bevel-wheel is screwed fast to each of the rear traverse-wheels. An inclined shaft, with a capstan and spur-wheel on the rear and a bevel-wheel on the front end, extends from the rear end of the chassis down to two horizontal shafts running across the chassis just in rear of the traverse-wheels. These two shafts have a bevel-wheel on each end; one engages with this inclined shaft, and the other with the brass wheel attached to the traverse-wheels. Motion is given to the inclined shaft by means of two crank-handles on a shaft running across the rear end of the chassis with a bevel-piston on it, and is communicated by the horizontal shafts to the traverse-wheels.

The inclined shaft can be thrown out of gear with the shafts communicating with the traverse-wheels. If then the fall be made fast to the top-carriage, and passed around the capstan, the top-carriage may be run back from battery by turning the crank-handles.

In center-pintle carriages, in which the front and rear traverse-wheels are of the same size, the chassis is traversed by communicating motion to one front and one rear wheel. This is done by means of a long shaft running under the left side of the chassis, and having pinions on it to engage in the wheels made fast to the traverse-wheels. Motion is given to this long shaft by means of a short inclined shaft, as already described.

In chasses having the pintle nearer the rear end, the front wheels, being much the larger, are chosen as those to which motion is to be communicated. This is done by a long shaft running under the chassis. It is driven, as already mentioned, except in this case the cross-shaft is placed under the chassis-rails, instead of in rear of the rear transom.

The rails of the 10-inch chassis are built beams, fish bellied in shape, in order to get the required strength with the least amount of material. Two plates ¾-inch thick, cut to the required shape, are riveted to two T-pieces 6¾ inches wide. The webs come together at their front ends, but have an inner brace between them at the rear ends. The upper T is straight; the under one is bent to correspond to the plates. The depth at the front is 6½ inches, 11½ at the rear, and 18 inches in the middle. The 10-inch chassis, increased in height, is the same, except wrought-iron knee-bolsters are put in to give the required height. The rails of the 11-inch chassis have a depth of 18 inches in the middle, and a width of 6¾ inches.

The 35-ton gun-carriage differs from the preceding in some of the details. The cheek-plates are about .75 inch thick. The cheeks are joined together by a bottom transom of boiler-plate extending the entire length of the carriage, and two vertical transoms, each strengthened by angle-iron riveted to it around the sides and bottom. The elevating apparatus is worked by a wheel outside of the cheeks.

The truck-wheels of the top-carriage are thrown in gear by means of a hydraulic jack, which acts on a crank on the eccentric axle.

The front transom of the chassis is made fish-bellied, with the view of getting as much room as possible in rear of it for the piston, and the hurters, five in number, made of India rubber, are made fast to it. The counter-hurters are placed on the inside of the rail. The piston is placed as far to the front as possible. The cylinder for the hydraulic buffer is a wrought-iron lap-welded ⅜-inch tube, about .31 inch thick when bored out. The holes in the piston-head are .6 inch in diameter. The recoil usually varies less than 2 inches in length, and only 4 inches when the extreme charges are used.

France.—The top-carriage is made in the usual way, with two plates of boiler-iron more than a half inch in thickness, riveted together with a thick iron frame between them. The trunnion beds in the top of the cheeks are provided with cap-squares like those for the field-carriage.

The cheeks are connected to each other by transoms, the front one being of good cast-iron, and very heavy. The others are of rolled iron plates, the bottom one being very wide and curved downward between the cheeks. It is stiffened by iron bars riveted to it, the front end being re-enforced by a 6-inch trough-beam curved to fit it.

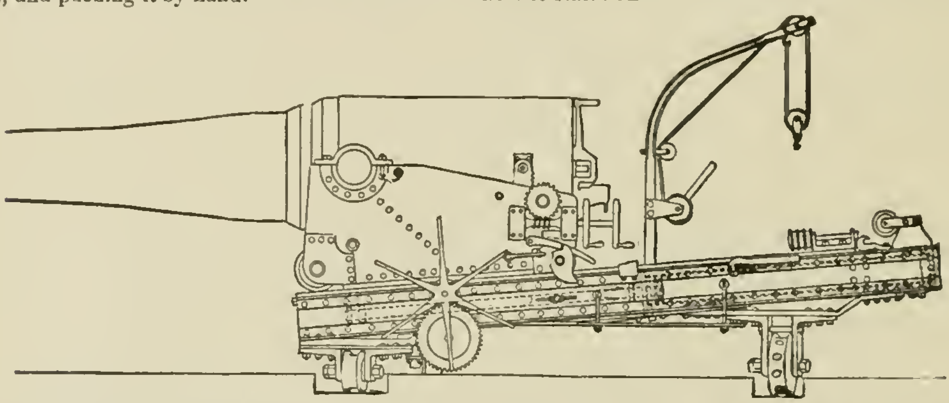
The elevating apparatus consists of a bar-link chain passing underneath the breech of the piece, which has a preponderance, and made to wind on an axle made fast to each one of the cheeks, and is turned by means of a rim-wheel on their outer face. By turning the wheels in one direction the chain is unwound from the axles, thereby made longer between the cheeks, the breech is lowered, and the angle of elevation of the gun increased. By turning the wheels in the opposite direction, the chain is drawn up, the breech raised, and the elevation of the gun is diminished. The top-carriage is provided with four truck-wheels for running the gun into battery. They are placed in the front and rear of the cheeks, between the plates. The rear ones are on eccentric axles, by which they can be thrown in gear at pleasure, and when thrown in, the rear end of the carriage is raised more than an inch from the rail, and the whole weight is brought on the four truck-wheels.

The handspike sockets on the eccentric axles are made of wrought iron as a matter of economy instead of bronze. Two iron rings are made fast to the front face of the cheeks for the purpose of attaching the hooks of pulley-blocks, by which to haul the gun into battery if for any reason it fails to run in when the truck-wheels are thrown in gear; ordinarily this will be sufficient, giving the gun a start, and pushing it by hand.

ing the handle in the opposite direction the pressure is relieved. A lug or stop is bolted to the side of the chassis-rail, and when the gun recoils, the handle, striking this lug, turns the screw, increases the compression on the friction-bars, and adds to the friction with which the carriage commenced to move back.

The chassis is composed of two solid rolled-iron beams, connected by front, rear, middle, and bottom transoms. In the smaller carriages for the 32 and 42 pounder guns the two rails are in one piece, bent in the arc of a circle in front. In the carriage for the 10.75-inch gun, the top of the rail is about 7 inches wide. It is about a foot deep, and the web is about an inch thick. The inclination of the chassis for sea-coast carriages is 4°. The pintle-transom is composed of three wide plates, laid one upon the other and firmly riveted together. The front transom is of cast-iron, very heavy; the middle of it rises some distance above the top of the chassis, and is rounded for a belaying-post, the breeching passing around it to check the recoil in case the brake should be disabled or get out of order. A spring-buffer is made fast to the rear side, against which the top-carriage strikes when running into battery too quickly.

The bottom transom covers the rear part of the chassis and forms a convenient flooring for the gunners to stand on.



The top-carriage for casemate guns is sometimes made of wood, it being protected from the weather in the casemates; and for the barbette carriages cast iron is sometimes used.

To check the recoil a compressor or friction brake is applied. It is composed of several long flat iron bars placed on their edges between the rails of the chassis, and parallel to them, one-half of the number on the right and the other half on the left of the middle line between the rails. These bars are fastened at each end on a bolt, so that they can move freely within narrow limits to or from each other, but cannot move in the direction of their length. Between these flat bars there are interposed short plates, suspended by notches on the front and rear edges from transoms of the top-carriage, just behind the front truck-wheels. These short plates are pressed forcibly together by means of a screw, which runs from one cheek-plate to the other through bronze boxes secured in them. On the screw are two nuts, which bear against the short plates and are prevented from turning with the screw, so they must move in the direction of the length of the screw toward one or the other end, depending upon the direction it is turned. The screw is prevented from moving lengthwise by means of a key at each end. The left end of the screw, where it projects through the cheek-plate, is cut into numerous teeth, like a cog-wheel, to receive a strong lever-handle, which can be thus put on in a great many different positions. By moving this handle to the front when the lever is below the screw the nuts are brought to bear on the short plates, and press them against the long friction-bars. By turning the handle in the opposite direction the pressure

Between the rails and parallel to them are sixteen friction-bars about ⅝ inch thick, placed on edge, and between the middle line of the chassis and the rail, eight in each group. They are fastened at each end to the chassis by two bolts, as already described.

On the inside of the rails, near the rear end, the counter-hurters are placed. They are made of India rubber, with a wooden face for the top-carriage to strike against.

The traverse-wheels, instead of being under the chassis as is usual, are very low and placed on the outside of the rails, the curved traverse-forks being bolted to the outside of the rails. This gives greater stability to the carriage, which for a ship's carriage is a matter of importance.

Concentric with the rear traverse-circle, and a little below its level, there is a second circle made of bronze, with recesses cut in it to engage the teeth of a large wheel, by means of which the lateral traverse of the carriage is given. In the rear of the chassis the crank is placed which operates this wheel through a system of wheels and pinions, so that two men can traverse the gun with ease.

The carriage is a very heavy and expensive one, weighing from 18 to 20 tons, and costing $10,000.

Sweden.—The cheeks of the top-carriage, instead of being formed of two plates of boiler-iron riveted together with an iron frame between them, as usual, are made each of a single plate of iron 1½ inches thick, cut to the required shape. The journals for the truck-wheels are formed by boring holes in the cheek-plates at the proper places, and re-enforcing them by circular iron plates 1 inch thick, fastened to the cheek-plate by four bolts each. The transom, which is usually vertical, has in this carriage an inclination of 45° with the vertical, sloping down from the trunnion-beds to the rear.

The elevating apparatus, placed on each side of the carriage, consists of a worm on the outside of the cheeks, operating a wheel and pinion, the latter playing in a rack attached to the breech of the gun. The rails are built beams, the web being a plain flat plate 1 inch in thickness, to which is riveted on either side at top and bottom a piece of angle-iron, forming a double T-rail, which is further strengthened by riveting to the angle-irons a flat bar on top and bottom.

The recoil is checked by a hydraulic buffer, constructed after the English pattern. The gun being a breech-loader, the carriage is so constructed that the gun shall be returned by the force of the recoil into the position in battery, in the same way as has been described in speaking of the German carriages. The traverse-wheels are like those used generally in Europe.

The carriage is traversed by means of a crank at the rear end of the chassis, the crank operating an endless screw and wheel, which turns the traverse-wheels. See *German Naval Carriage, Gruson Sea-coast Carriage, Hydraulic Gun-carriage, Krupp Sea-coast Carriages, Moncrieff Depression Carriages, Muzzle-pivoting Carriages*, and *Turret Carriage.*

SEA-COAST ARTILLERY.—Sea-coast defenses are intended to protect the entrances of rivers and harbors, to defend military establishments and points of commercial importance, to oppose the landing of an enemy on any part of the coast, and to prevent the approach of his vessels, either for aggressive purposes or for taking the soundings, observations, etc. The efficiency of the guns depends on their caliber, combined with facility of maneuvre, or rapidity of fire. As sea-coast cannon generally occupy permanent positions, the weight of the piece and projectile is not a serious objection to an increase of caliber, provided the proper mechanical facilities are supplied for moving them with celerity. Projectiles of 10-inch caliber are handled by two men. Those of 15-inch caliber require the aid of machinery to lift them quickly to the muzzle of the piece. It is proposed to mount special cannon of very large caliber at certain points commanding the entrance to the most important harbors. The intention in such cases is that the projectile shall contain powder enough to constitute a *mine*, and destroy an enemy's vessel at a single shot. As the fire of such pieces is necessarily slow, and the speed of steam vessels very great, it is evident that success depends on the certainty with which a single shot strikes the object. A system of obstructions, like rafts or torpedoes, should therefore be combined with them. A 20-inch gun has been made and mounted in accordance with this idea, for the defense of the New York Harbor. It weighs 117,000 lbs., carries a solid shot weighing 1,080 lbs., with a charge of 100 lbs. of powder. The most effective projectiles that can be brought to bear against wooden ships are shells and hot shot. The destructive superiority of the former was well attested in the Crimean war, and particularly in the naval engagement of Sinope, when the entire Turkish fleet was destroyed by Russian shells in about one hour's time. In the sea-fight between the Kearsarge and Alabama, the victory of the former was won by the great destructive power of its 11-inch shells. Modern mechanical skill has succeeded in covering vessels of war with plates of wrought-iron which are proof against shells and solid projectiles of less caliber than 8 inches. Rifle projectiles of a less caliber have the power to penetrate such plates, but they do not make the irregular holes and produce the shattering effects of larger round shot; holes that cannot be plugged, and injuries that cannot be repaired in action. Sea-coast cannon comprise *guns, columbiads, howitzers* and *mortars*. The solid shot pieces of the United States sea-coast service are the 32-pdr. and 42-pdr. guns, and the 8-inch, 10-inch, 13-inch, and 15-inch columbiads and Rodman guns.

It has been found that, 1st, no fort now built can keep out a large fleet without channel obstructions; 2d, a partial obstruction of the channel is not sufficient; 3d, no fleet can pass a battery if kept under fire of heavy guns by proper obstructions. It has, therefore, become necessary that sea-coast defenses shall consist of: 1st. Forts and land batteries; 2d. Floating batteries; 3d. Passive obstructions; 4th. Submarine mines. These may be used singly, but the most effective defense is made by combining them according to circumstances. The introduction of steam vessels of war, and their protection by armor plates, have necessitated great change in the construction and armament of sea-coast forts. The best temporary fortifications are made of earth, with large masses, as parapets, traverses, etc., for covering the guns. A better covering in the form of iron turrets has been proposed, as reveting the masonry of casemates with armor has not been found to give good results. Vessels of war, or floating batteries propelled by steam, are necessary for the complete defense of some harbors. If the channel be unobstructed, steam vessels can run past shore batteries, however well the latter may be armed and served. On the other hand, should there exist passive obstructions, the vessels have not the endurance and power to effect much damage to land defenses. The most effective channel obstructions are submarine mines. The object, then, of the obstructions used in connection with batteries is, 1st, to detain attacking vessels under the fire of the guns; and, 2d, to not only delay the advance of vessels, but to assist in injuring them. The obstructions must, therefore, be within range of the shore or floating batteries. The passive obstructions may rest on the bottom of the channel, as dams, sunken vessels, or masses of stone; or they may be floating, as rafts, booms, chains, or ropes. The active obstructions are the mines, in the form of torpedoes; these may be stationary or movable; the use and application of the latter belong properly to the Navy, and of the former to the Army, which employs them as auxiliary to the shore batteries. The mines adopted by the U. S. Engineers are constructed to be self-acting, exploding by contact, or to be exploded by electricity, the firing being in the hands of an operator on shore. The mines are laid in lines of many groups; the guns of the batteries can be trained upon any group, and be fired by electricity by the operator controlling the mines. The two explosions can thus be made simultaneous, and a vessel attacked both above and below water at the same time.

The armament of sea-coast batteries depends on their importance and on the depth and width of the channel to be defended. Deep channels, permitting the entrance of large vessels, and wide channels, requiring long ranges, should be defended by pieces of the largest caliber. When smooth-bored and rifled pieces are combined in the same work, the power of the piece will indicate the point at which it should be placed to render it most effective; those faces which bear directly on the channel may be armed with smooth-bored guns, and those which enfilade the channel, with rifled pieces. Each work must be provided also with light cannon and machine-guns for its own protection, and to oppose the landing of troops. The depth and width at different points of the body of water to be defended being known, and also the draft, armor and armament of the war-ships of the different foreign powers, the construction and armament of the necessary works of defense can be determined. No armored vessel can attack a work successfully if the latter be properly situated and armed with the same number of guns, each of which shall be capable of racking or penetrating her armor. As vessels, however, can keep in motion, and can pass by and out of range of shore batteries in a given time, the chance of their being disabled will be in direct proportion to the number of guns employed against them: this number should, therefore, be as great as circumstances will permit. The distance of the vessel, the direction in which moving, rate of speed, her size, and the time of flight of the projectile, are all elements to be considered. For the purpose of bombardment, sea-coast smooth-bored mortars are effective at about two and one-half miles, and rifled guns at five miles. The size of the object to be struck renders such fire of more value from ship-board, though land batteries would interfere very seriously with a fleet anchored at such distances. Long range gives comparative immunity to forts, but not to ships; the latter can, by selecting their position, sometimes bring a larger number of guns to bear upon a given point than can a battery. On the other hand, the guns in a battery are fired from stationary platforms, and the ranges would generally be known; the battery does not present so good an object as a vessel, unless it be on a level with the water; and if an earth-work, it is little affected by the projectiles. For rifled guns, the maximum effective range for accuracy has been placed at 4,000 yards. This, however, cannot be relied upon for penetration, even though at this distance the power of the projectile may not be too much diminished, since the actual piercing depends upon the angle which the axis of the projectile makes with the plane of the armor; 1,600 to 2,000 yards must for this purpose be at present considered the maximum effective range.

A projectile capable of piercing an armored vessel makes a hole larger than its own diameter, and the back of the plate is usually bulged, cracked, and carried away; the wood backing is torn, splintered, and racked for several feet around, making immediate repair impossible. The machinery of the vessel is always below the water-line, but if it can be reached by a shot, the result may be most disastrous. In firing, then, at a vessel's broadside, aim to strike at the water-line about opposite the machinery; if the projectile strike the water, it will either penetrate to the hull below the water-line, or rebound and strike above it. With a turreted ship, the most vulnerable part is the lowest circumference of the turret; shot striking at that line will jam the turret and impede or prevent the use of the guns within it. The ports of vessels are also points which can be fired at to great advantage. *Shot* or special *shells* will always be employed against the armor of war ships. Which shall be used will depend upon the construction of the vessel and the thickness of its armor. *Common shells* should be used when firing at a port, or at the crew when exposed, and also against wooden ships. *Grape* and *canister* can be employed only against landing parties, or against the ports when a vessel approaches sufficiently near to the battery. They can also be used against the rigging and wooden masts of ships. *Direct fire* is the only one that can be used to advantage against the sides of armored vessels. Against wooden ships it should be always used when the surface of the water is rough.

Against all unarmored vessels, ricochet fire is the most effective, and to secure the flattened ricochet, batteries should be placed as low as possible. The inaccuracy of the oblong projectile and the loss of velocity of a spherical one, with this fire, renders its employment useless against armored vessels. At all distances not exceeding 2,000 yards, the ricochet of projectiles from the 15-inch gun is extremely formidable.

This fire can be employed to advantage by iron-clads against low batteries, particularly when the size of the port will not permit sufficient elevation being given for the range required. A work elevated 50 feet above the water deprives the enemy of ricochet.

Shells of almost any size falling under a high angle will pass through the deck of any wooden vessel; against iron-clads, however, shells of large caliber only would be of value. Such a projectile would penetrate at least one deck of an armored ship; its effect on the vessel's bottom would then depend upon the number of decks of iron through which it would have to pass. A shell should not burst till after it has entered the vessel, when its action would probably be most destructive.

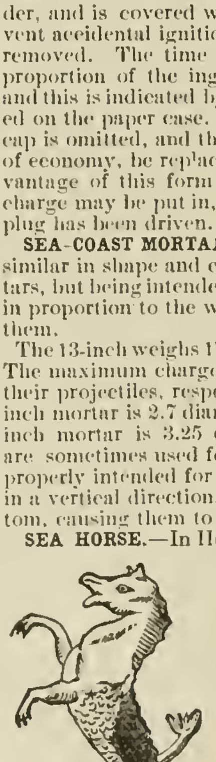
It is by no means easy to direct vertical fire upon ships with a sufficient accuracy to produce the desired effect, even when a large number of them forms a target of considerable size. This fire is effective when it is desirable to prevent an enemy from occupying certain anchorage, as no fleet nor vessel can remain under well directed fire from heavy mortars. A battery of one hundred such pieces will keep at bay all the iron-clads that can maneuver or anchor within their range. See *Columbiads*, *Ordnance*, *Rodman Gun*, and *Submarine Mines*.

SEA COAST FUSE.—This fuse is principally distinguished from the mortar-fuse by its having a metal cap, constructed to prevent the burning composition from being extinguished when the projectile strikes against water. It is composed of a *brass plug*, which is firmly driven into the fuse-hole of the projectile; a *paper-fuse* inserted into the plug, with the fingers, immediately before loading the piece; and a *water-cap*, screwed into the plug after the paper-fuse has been inserted. The water-cap is perforated with a crooked channel, which is filled with mealed powder; the mealed powder communicates fire to the paper-fuse, and the angles of the channel break the force of the water. The top of the cap has a recess which is filled with a priming of mealed powder, and is covered with a disk of sheet lead to prevent accidental ignition; before loading, this disk is removed. The time of burning is regulated by the proportion of the ingredients of the composition; and this is indicated by the number of seconds marked on the paper case. In firing over land, the water-cap is omitted, and the brass plug may, for the sake of economy, be replaced by a wooden one. One advantage of this form of fuse is, that the bursting-charge may be put in, or be taken out, after the fuse-plug has been driven. See *Fuse* and *Mortar-fuse*

SEA-COAST MORTAR.—The sea-coast mortars are similar in shape and construction to the siege mortars, but being intended for greater range, are heavier in proportion to the weight of the projectiles used in them.

The 13-inch weighs 17,120 lbs.; the 10-inch, 7,300 lbs. The maximum charge is one-tenth of the weight of their projectiles, respectively. The bore of the 13-inch mortar is 2.7 diameters in length: that of the 10-inch mortar is 3.25 diameters. Sea-coast mortars are sometimes used for siege purposes, but they are properly intended for striking the decks of vessels in a vertical direction, hence penetrating to the bottom, causing them to sink. See *Mortar*.

SEA HORSE.—In Heraldry, a fabulous animal, consisting of the upper part of a horse with webbed feet, united to the tail of a fish. A scalloped fin is carried down the back. The arms of the town of Cambridge are supported by two sea-horses, proper finned and maned or.

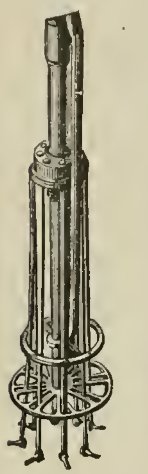


Sea-horse.

SEA LION.—In Heraldry, a monster consisting of the upper part of the lion combined with the tail of a fish.

SEAR.—The pivoted piece in a gun-lock, which enters the notches of the tumbler to hold the hammer at full or half-cock, and is released by pulling the trigger in the act of firing. The *half-cock* notch is made so deep that the sear cannot be withdrawn by the trigger. The *sear-spring* causes the sear to catch in the notch of the tumbler.

SEARCHER.—An instrument used in the inspection of cannon. It consists of a long staff of wood, fitted with a head of eight steel points, as shown in the drawing. The points are arranged at equal intervals around the head, and attached with a tendency to spring out and increase their diameter; this tendency is restrained by a hoop of iron embracing them, and capable of being worked in and out on the head of a rod extending along the staff.



The searcher is used for detecting the presence of small cracks or flaws. To use the instrument the hoop is pushed out on the head, thus contracting the points; it is then introduced in the gun to the bottom of the bore, and the hoop being pulled back allows the points to spring out and take against the surface of the bore. The searcher is then also slowly withdrawn, turning it at the same time; if one of the points catches, its distance from the muzzle is measured on the staff, and its position on the bore noted, and marked on the exterior of the gun. The size and figure of the cavity is then determined by taking an impression of it in wax. See *Inspection of Ordnance.*

SEASONED TROOPS.—Troops that have been accustomed to climate, and are not so liable to become the victims of any endemical disorder as raw men unavoidably are.

SEAT OF THE CHARGE.—The *form* of that part of the bore of a fire-arm which contains the powder, will have an effect on the force of the charge, and the strength of the piece to resist it. The points to be considered as most likely to affect the force of the powder, are, the form of the surface, and its extent compared to the enclosed volume. In the first place, to obtain the full force of a charge, its form should be such that its inflammation will be nearly completed before the gas begins to escape through the windage, and the projectile is sensibly moved from its place; in other words, the length of the space occupied by the charge should be nearly equal to its diameter; in the second place, as the tension depends much upon the heat evolved by the combustion, the absorbing surface should be a minimum compared to the volume.

The charges with which solid projectiles are generally fired being greater than ⅓ of their weight, the cartridge occupies a space, the length of which is greater than the diameter; and in cannon, therefore, which fire solid projectiles; the form of the seat of the charge is simply the bore prolonged; this arrangement, when compared with the chamber, makes the absorbing surface of the metal a minimum, and reduces the length of the charge so that its inflammation will be as complete as possible, before the gas escapes and the projectile is moved.

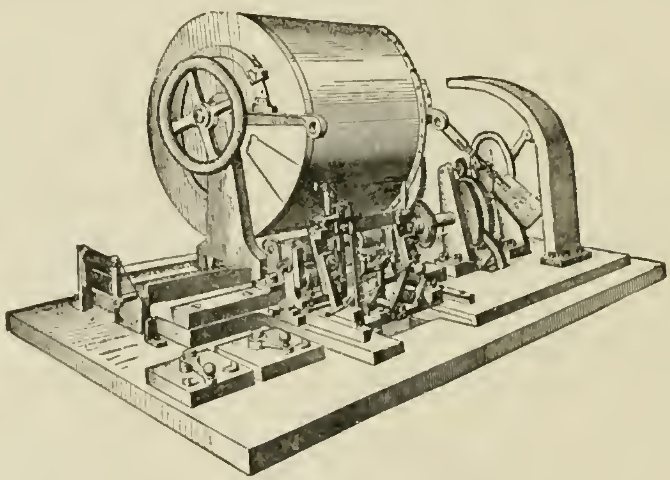
To give additional strength to the breech, and to prevent the angle formed by the plane of the bottom and sides of the bore from becoming a receptacle for dirt, and burning fragments of the cartridge-bag, it is rounded with the arc of a circle whose radius is one-fourth the diameter of the bore at this point. Instead of its being a plane bottom, it is sometimes made hemispherical, tangent to the surface of the bore. In all cannon of the most recent model, the bottom of the bore is a semi-ellipsoid. This is thought to fulfil the condition of strength more fully than the hemisphere. When a light piece is used to throw a projectile of large diameter and great weight, the effect of the recoil can only be diminished by employing a small charge of powder. If such a charge were made into a cartridge of a form to fit the bore, its length would be less than its diameter, and being ignited at the top, a considerable portion of the gas generated in the first instants of inflammation, would pass through the windage, and a part of the force of the charge would be lost. To obviate this defect, to give the cartridge a more manageable form in loading, and to make the surface a minimum, as regards the volume, the diameter of this portion of the bore is reduced so as to form a *chamber.*

SEAT OF WAR.—The country in which a war is being carried on.

SEBERT AND MARCEL-DEPREZ CHRONOGRAPH.—This new chronograph retains the principle modifications introduced into the Schultz chronograph, as shown in the drawing. For example, the new mode of supporting the vibrating fork, the arrangement by which it is made to mark only at the moment desired, and, finally, the employment of Marcel-Deprez electro-magnetic registers. The principal modifications which distinguish it from the latter apparatus are the following: The cylinder designed to receive the registration is much longer, so as to admit of placing in a single row the 20 Marcel-Deprez registers, designed to signal the entire movement of the 10 pistons of the apparatus called manometric balances. The great length rendering more difficult the displacement of the cylinder with reference to its axis it is left stationary, and the fork and the connector-registers, designed for measuring phenomena whose duration exceeds that of a revolution of the cylinder, are mounted on a moveable slide. This slide is moved by an endless chain, operated by a wheel-work with which it can be connected at will by a special gearing, which also can be worked automatically at the moment of firing.

In order to extend the duration of the rotation of the cylinder as long as may be necessary, it is provided with a motor-wheel work similar to those which are employed in the Hughes' telegraph-printers, and which permit the motor-weights to be wound up during the motion without interrupting the movement. The arrangement giving the means of utilizing the apparatus for experiments of long duration, as, for instance, the observation of the law of the movement of a projectile over the whole extent of its trajectory, during the lapse of several seconds, the cylinder is furnished with a regulator, so arranged as to cause the velocity of rotation at the circumference to vary within very extended limits from 0.50 to 15 meters (1.64 to 49.213 feet) per second, and the means of regulating this velocity is assured, even during the working, by employing a regulator with movable fans arranged so that it can be adjusted under all circumstances. A velocity indicator was added to the apparatus, which shows at each instant the approximate velocity acquired by the revolving cylinder, which gives the means, by operating on the regulator, of bringing the velocity to the proper rate, according to the nature of the experiment in view, and of not causing the firing until the moment when it is certain that the apparatus is brought under the conditions required. The arrangements applied last of all to the Schultz chronograph for the readings is retained; that is to say, the employment of a stationery microscope mounted on the slide and of a graduated scale on the cylinder; but, in order to increase the precision of the measures, this scale was traced on a disk furnished with a toothed gearing with a micrometric endless screw, the head of which is furnished with a graduated roller movable before a vernier. Finally, in order to facilitate the employment of electric currents both for the working of the registers and for setting in motion the fork and the divers automatic attachments applied to the apparatus, there is annexed to the chronograph a special switch board by which all the necessary combinations of currents are easily effected, and the number of the battery elements, according to circumstances, grouped on each register. The switch board is provided with an apparatus for communicating fire, by which the relative retardation of this communication of fire is regulated at will at the moment of setting in motion the slide which contains the registers, and at the moment when the pen of the fork rests on the cylinder: it is furnished also with a special apparatus, designed to produce a simultaneous rupture of the currents which animate the 20 registers placed before the cylinder, in the case of experiments with the manometric balance with 10 pistons.

The drawing represents a front perspective view of the arrangement given to the Schultz modified chronograph when ready for work with a single-connector register. In this case the handle is pushed down which engages the screw attached to the cylinder, which is displaced longitudinally by a movement proportional to its movement of rotation. The pen of the register then traces on its surface a continuous helicoidal curve by the side of sinusoidal tracing of the fork, which is also developed helically. The examination of this drawing makes easily recognizable the principal modifications which have been made to the original arrangement of the Schultz chronograph. The organs for setting in motion, and those for regulating the velocity have not received any modifications: but the fork, and its system of support, have been lowered by making, for this purpose, a lodgment in the table, so as to leave more available space for the registers which permits, in case of need, of placing before the cylinder two rows, one above the other, each composed of 10 registers, simply disconnectors. When connector-registers are employed, these registers, are placed on a small special support, near the fork. When simply disconnector-registers are employed for registering a phenomenon whose duration is less than that of a revolution of the cylinder, in which case the cylinder is allowed to turn in its place, it is necessary to prevent the tracings of the diapason from overlaying each other by being made during more than one consecutive turn; this result is obtained by mounting the fork on a movable jointed base so that the pen of the cylnder can be brought nearer or farther at will, without interrupting the vibrations of the fork. The movement of the base, besides, is directed by means of a handle, acting on a joint in the form of a knee, so that with a simple movement from right to left, or *vice versa*, of this handle there is a corresponding double movement from rear to front, then from front to rear of the fork.



The position of the pen is also regulated so that in this movement it rests lightly on the cylinder when it reaches its extreme position in front, so that it is sufficient to give to the handle a complete movement, in one direction or the other, in order that the pen may trace on the cylinder in motion some undulations, which suffice to show the velocity of the latter at this precise moment. The number of these vibrations, also, may be increased or diminished according to greater, or less, rapidity with which the movement is executed. It is evident that with this arrangement the exact velocity of the cylinder can be ascertained at the precise moment of the production of a phenomenon by moving the handle of the fork at the same moment that this phenomenon is produced, that is to say, in the case of the experiments in which we are at present engaged, at the same moment that the inflammation of the powder is produced. In order that the observer may avoid giving this movement to the fork too soon or too late, this latter case occurring, for instance, when he gives the order to fire and there is delay in executing the command, an arrangement is added to the apparatus which causes the displacement of the fork, automatically, at the very moment of the firing. This addition is seen in the drawing; it consists, on the one hand, in the employment of a caoutchouc spring, capable of a variable tension, and which draws the handle of the fork constantly towards the left; and, on the other hand, of a special electro-magnet, placed at the other extremity of the stroke, and whose attraction retains, in ordinary circumstances, the lever of the handle, which is furnished for this purpose with a small armature of soft iron. The electro-magnet is traversed by a special circuit which is interrupted at the moment of firing, either by the traction on the firing lanyard, if the fire is communicated in the usual manner, or by the working of the conjunctor for communicating fire, if electricity is employed for the inflammation of the priming. The handle of the fork is then loosed at the very moment when the inflammation takes place, and the tension of the caoutchouc spring that draws it may be regulated in such a manner as to take into account the functional retardation of the apparatus for communicating fire. So that the tracing of the vibrations may be protracted till the precise moment when the signals to be registered are produced. See *Chronograph*, *Drop-chronograph*, and *Marcel-Deprez Register*.

SECONDARY BASES.—As an army advances, other bases, termed secondary are commonly assumed, to enable the army to have its supplies at hand. These bases, which should present the same qualities as do the original base, are usually established by detached bodies of troops, or by the re-enforcements sent forward, so that the army will not be delayed in its onward movement. The importance of establishing secondary bases increases in proportion as the army removes from its primitive base. Napoleon's long line of operations in the Russian campaign, 1812, required such bases to provide for the safety of his army. A study of this campaign cannot fail to be instructive as illustrating the immense difficulties to be overcome in conducting a campaign at a great distance from the primitive source of supplies and re-enforcements. The Tennessee river, being navigable, formed a secondary base for General Sherman in his Atlanta campaign. Chattanooga—the principal point on this river, being also on the line of railroad from Louisville to Atlanta, the main source of supply for his large army of 100,000 men—was the principal depot of supplies and the most important point of this line or base.

A power which is master of the sea, is enabled to assume a base at pleasure and still have a strong point of support. This fact was illustrated during our late war, when General McClellan, in 1862, assumed his base at the White House on York river. After his line of communication was cut by General Lee, McClellan changed his base to the James river without any risk of failing to find a strong support. Later,also General Grant changed his base from the Potomac to the James river. General Scott, from the same cause, was able to select Vera Cruz as his base during the Mexican war. England from her superiority on the sea, would have great advantages in this respect.

The length of the base of operations should be in proportion to the distance that an army may be required to operate from it. If the base is too contracted, the different roads leading to the objective point will be very much resrticted, which would greatly facilitate any movement of the enemy to separate the army from its base.

SECOND COVERED WAY.—In fortification,that beyond the second ditch. This ditch is made on the outside of the glacis, when the ground is low and there is plenty of water.

SECONDING.—A temporary retirement to which Officers of Royal Artillery and Royal Engineers are subjected when they accept civil employment under the Crown. After six months of such employment the officer is *seconded*, by which he loses military pay, but retains his rank, seniority, and promotion in his Corps. After being seconded for ten years he must elect to return to military duty, or to retire altogether.

SECRECY.—In military economy this quality is peculiarly requisite. It signifies fidelity to any secret; taciturnity inviolate; close silence. Officers in particular, should be well aware of the importance of it, as the divulging of what has been confidentially intrusted to them, especially upon expeditions, might render the whole project abortive. The slightest deviation from it is very justly considered a breach of honor, as scandalous conduct unbecoming an officer and a gentleman. In all official matters the person so offending is liable to the severest punishment and penalty.

SECRETARY.—The Chiefs of the Executive Departments of the United States Government, forming the Cabinet, are termed Secretaries, except in the case of the Post-office Department and the Department of Justice. They are the Secretary of State, whose charge is the foreign relations of the Government; the Secretary of the Treasury, who has charge of the national finances, including the customs revenue; the Secretary of War,who has in charge the U. S. Army and controls its disposition—under the direction of the President, who is Commander-in-Chief of the Army and Navy—and who has charge of all forts and all military movements; the Secretary of the Navy, who bears a similar relation to the naval force; and the Secretary of the Interior, in whose charge are the Indian tribes, Government lands, pensions, the Patent Office, and Bureau of Education. These officials are appointed by the President and confirmed by the Senate. They report annually, and as much oftener as required, to the President, who lays their reports before Congress. The salary of each of the Heads of Departments is $8,000 per annum. Each is subject to removal by the President, whenever in the judgment of the latter the interest of the Government shall so demand. During the administration of President Johnson the power of removal was taken from him by what was known as the Tenure of Office Act, which was applied in the case of Secretary of War Stanton, whom the President had removed from office. The difficulty resulted in the impeachment of the President and his acquittal; when Secretary Stanton resigned. See *Minister*.

SECRETARY AT WAR.—Formerly a high officer of the British Ministry, who had the control of all the financial arrangements of the Army,and who was the responsible medium for parliamentary supervision in military affairs. In the time of the Tudors, the war business of the country appears to have been transacted by the Department of the Secretary of State. The formation of a War Office proper took place about 1620. The office rose in importance as the Army increased; but was limited to financial authority, neither the Commander-in-Chief nor Master General of the Ordnance being subject to it. At length, during the Russian war the evils of this divided authority led to the creation of a Secretary of State for War, to control all the military departments. The Secretaryship-at-War was merged in this superior office in 1855, and although for some years preserved technically a separate appointment held by the Secretary of State, was abolished by Act of Parliament in 1863.

SECRETARY OF LEGATION—The title of the Second Diplomatic Official accompanying full missions to Foreign Courts, and who fulfills the duty of the Minister in his absence. Such Officials are sent by the United States to the Courts of Great Britain, Russia, France, Spain, Germany, Austria-Hungary, Italy, Japan, China, Mexico, Brazil, and Turkey; at the last-named Court, supplying all the functions of Consul General. The Foreign Countries having Secretaries of Legation at Washington are: Argentine Republic, Austria-Hungary, Belgium, Brazil, Chili, Colombia, France, Great Britain, Hayti,Mexico, Peru, Russia, Spain, Sweden and Norway,Turkey, China, Japan.

SECRETARY OF STATE.—An ancient and important office in the government of England. The oldest record of its existence is in the reign of Henry III., when John Maunsell is described as "Secretarius Noster." Prior to the restoration, the holder of this office was generally styled the "King's Chief" or "Principal Secretary;" he had the custody of the King's signet, and discharged his duties with the assistance of four clerks. Two Secretaries are said to have been first appointed toward the close of the reign of Henry VIII. The office, always one of influence, gradually grew in importance. On the union of 1707, Anne added a third Secretary of State for Scotland, which office, however, was done away with. In the reign of George III. there were at first but two Secretaries; for a time there was a third for America, but his office was abolished by statute in 1782. While the Secretaries were two in number, both equally directed home affairs; to one of them were committed the foreign affairs of the Northern to the other of the Southern Department. Irish affairs belonged to the province of the elder Secretary.

There are now five principal Secretaries of State who are respectively appointed for the Home Affairs, the Foreign Affairs, War, the Colonies, and India. They are all appointed by the Sovereign by the mere delivery of the seals of office, without patent, and are always members of the Privy Council and of the Cabinet. Though each has his own Department, he is considered capable of discharging the duties of the others; a member of the House of Commons, if removed from one Secretaryship to another, does not thereby vacate his seat.

The Secretary of State for the Home Department has the charge of the maintenance of the internal peace of the United Kingdom, the security of the laws, and the administration of justice, so far as the royal prerogative is involved in it. He directs the disposal and employment of the regular troops at home, and provides for the suppression of riots. The militia, yeomanry, and volunteers are entirely under his control. He has the ultimate supervision of all that relates to prisons and criminals; and numerous statutory powers have been given him regarding police, sanitary-matters, the regulation of labor, etc.

The Secretary of State for Foreign Affairs is the responsible adviser of the Crown in all communications between the Government and Foreign Powers. He negotiates treaties, either directly with the Foreign Ministers resident in the country, or through the British Ministers abroad. It is his duty to inquire into the complaints of British Subjects residing in foreign countries, to give them protection and to demand redress for their grievances. The Foreign Secretary recommends to the Sovereign all Ambassadors, Ministers, and Consuls, to represent the country abroad. He grants passports to British subjects and naturalized foreigners.

The Secretary for the Colonial Department has the supervision of the laws and customs of the Colonies, watches over their interests, directs their government, apportions the troops necessary for their defense or police, appoints the Governors of the Colonies, and sanctions or disallows the measures of the Colonial Governments: rarely, however, prescribing measures for their adoption.

Each of these four Secretaries of State is assisted by two Under Secretaries of State nominated by himself; one usually permanent, while the other is dependent on the administration in power.

The Secretary of State for India, whose office dates from the abolition in 1858, of the double government of India by the Court of East India Directors and Board of Control, has the same control over the government of India which was formerly exercised by these bodies, and countersigns all warrants and orders under the sign-manual relating to India. He is assisted by an Under Secretary who is also a Member of the Legislature, and loses office with the Cabinet, and by a permanent Under Secretary and Assistant Secretary, as also by a Council of fifteen members, over whom he presides. Every order sent to India must be signed by the Secretary, and all dispatches from governments and presidencies in India must be addressed to the Secretary.

There is also Chief Secretary for Ireland, resident in Dublin, except during the sitting of Parliament, and under the authority of the Lord Lieutenant. His office resembles that of a Secretary of State, but he is generally called Secretary to the Lord Lieutenant. He is assisted by an Under Secretary.

The Secretary of State for War (see SECRETARY AT WAR) has the superintendence of all matters connected with the Army, assisted by the Commander-in-Chief, and is responsible for the amount of the military establishment. He prepares for the royal signature and countersigns commissions in the Army, and recommends to the Sovereign for the Order of Knighthood of the Bath.

SECRETARY OF WAR.—The principal officer of the Executive Department of War. Mr. Attorney General Wirt, in an opinion, dated January 25, 1821, says, the Secretary of War "does not compose a part of the Army, and has no duties to perform in the field." The duties assigned by law for the Secretary of War are the following: 1. The Act creating the new Department (*Act* Aug. 7, 1789) gives to the Secretary, besides the custody of records, books, and papers of the old Department, the record of military commissions, the care of warlike stores and other duties clearly ministerial. 2. Section 5, *Act* March 3, 1813, continued in force by the 9th section of the *Act* of April 24, 1816, delegates jointly to the President and Secretary of War the power to make regulations better defining and describing the respective powers and duties of Staff Officers. 3. Articles of War intrust the Secretary of War with muster-rolls and returns, and give him authority over the forms of such papers, and to require stated returns. 4. Articles of War authorize him to grant discharges to Non-commissioned Officers and soldiers, and make him the medium in passing proceedings of certain Courts-Martial, and the organ of the President's orders thereon. 5. Another Article of War charges the Secretary with receiving accounts of the effects of deceased officers and soldiers. 6. *Act* May 18, 1826, Section 1, respecting clothing, etc., charges certain duties upon the Quartermaster General "under the direction of the Secretary of War." 7. Several *Acts* authorize the Secretary to purchase sites for Arsenals. 8. The Ordnance Department and its *matériel* are made subject to the Secretary by the *Act* February 8, 1815. 9. Under the *Act* March 2, 1803, Section 1, the Secretary of War is authorized to give direction to the State Adjutants General, in order "to produce uniformity" in returns, and to lay abstracts of the same, etc. 10. The Secretary shall lay before Congress on the 1st of February in each year a statement of the appropriations of the preceding year showing the amount appropriated, and the balance remaining unexpended on the 31st of December preceding. He shall estimate the probable demands which may remain on each appropriation, and the balance shall be deducted from the estimates of his Department for the service of the current year; (*Act* May 1, 1820.) 11. He shall render annually accounts exhibiting the sums expended out of such estimates, together with such information connected therewith as may be deemed proper; (*Act* May 1, 1820.) 12. The Secretary of War shall cause to be collected and transmitted to him at the seat of Government all flags, standards, and colors, as may be taken by the Army of the United States from their enemies; (*Act* April 18, 1814.) 13. The Secretary may employ for the office of the War Department one chief clerk, and such other clerks as may be authorized by law; (*Acts* April 20, 1818, and May 26, 1824.) 14. The Secretary of War may furnish to persons who design to emigrate to Oregon, California, or New Mexico, such arms and ammunition as may be needed to arm them for the expedition at the actual cost of such arms and ammunition; (*Resolution* March, 2, 1849.) 15. All purchases and contracts for supplies or services for the military service of the United States, shall be made by or under the Secretary of War; (*Act* July 16, 1798.) 16. He shall annually lay before Congress a statement of all contracts, with full details; (*Act* April 21, 1808.)

Not one of the numerous Acts of Congress relative to the War Department gives him authority to command troops. His lawful duties are all purely administrative, and "as he does not compose a part of the Army," the President, in the exercise of his office of Commander-in-Chief, can of course only use the military hierarchy created by Congress. The English, from whom our system is borrowed, opposed to centralization of authority as adverse to freedom, have judiciously recognized the fact, in practice as well as in theory, that the War Department is not of such a nature that it can be directed as other Departments of the Cabinet, or even be made to work by the simple play of constitutional changes in the Ministry. They have consequently separated the *action* of the public force from the *direction* of all financial matters. But as the safety of the State depends upon the stability of its military institutions, the steadfastness of the means at work, and the skilful direction of all details, the Minister of War, who is changed by every triumph of opposite opinion, is not a military officer, and not charged with military authority. The permanent military institutions of the country do not depend upon him. The Army does not look to him for nominations to office, discipline, or military control. He is simply the great provider, the superintendent of accounts, the financier, the interpreter of the plans of the Cabinet for exterior and politico-military operations. He is aided by Under Secretaries, who do not go out of office with the Cabinet, and who are charged with the administration and payments for the *matériel*. The Commander-in-Chief, on the contrary, is the conservator of discipline, the center of nominations, the life-spring which animates and directs the Army, the source of orders, the regulator of tactics. He occupies himself with improvements of all kinds, and with the destination of *matériel*. It is to him that the Minister of State for War has recourse when he communicates to Parliament or the Cabinet the condition of the Army, details of organization, and other military information. Military finance and support of armies are thus left with the Secretary of War, while command, discipline, and improvements are regulated by the Commander-in-Chief. The Minister of War thus follows the fortunes of a Cabinet without the military institutions of the country being in any manner affected by any party changes. Practice in the United States has widely diverged from this theory.

SECRET PATROLS.—Secret patrols consist of a few men, and are generally sent out on the flanks, sometimes in the rear of the enemy's army. They have frequently to go far, and be long gone, to make the necessary observations; and of all the duties of Light Cavalry, therefore, this is the most difficult to perform. Many of the rules laid down for other patrols, are likewise applicable here. A patrol of this kind marches without advance or rear-guard. Only one man must be detached to look over the country from the hill-tops. The high roads must be avoided as much as possible, and the patrol march by by-roads, deep valleys, etc., etc. A guide on horseback will be of great service to such a patrol; but he is to be paid for it, and well treated. The patrol, to feed, must go off the road into a thicket or wood, and a look-out be set from a tree. If anything hostile approach, the patrol must escape unperceived and seek out another place of concealment, until it may continue its march without danger. A fire can rarely be lighted—never without being very careful to hide it: but it is better to do without one. An inhabitant who meets with the patrol at night, must remain with it until the march is resumed. Should a secret patrol, in spite of all these precautions, be discovered by the enemy, it must fly. But, as soon as the enemy gives up the pursuit, it must make a renewed attempt to get, by roundabout ways, to where it is to execute its commission. A well-informed and clever officer is required for this kind of duty; one who speaks the language of the country, and has a knowledge of the customs, habits, hopes, and fears of the inhabitants. The leader of a patrol should always be able to answer the following questions about the roads he has passed over:

As to whether they are rocky, sandy, or boggy?

How many streams were passed; their distance from one another: their breadth, depth, and strength of current?

The character of their banks; whether steep, miry, etc.?

Whether fordable at every season for Cavalry, Infantry, or Artillery, etc.?

How many bridges span them; whether of wood or stone, massive or slight?

How many villages there are on the road; their names; and the distances from one to the other?

Whether the road runs much through woods, or at some distance from them; the woods, of what size and kind, etc.? See *Patrols* and *Side Patrols*.

SECRET SERVICE.—Under the U. S. Government, a Department or Bureau, not created by law, nor recognized by specific appropriation for its cost. Its duties are not defined, and vary with the occasion which may create them. During the War of the Rebellion the service was extended: its Chief was a soldier with the rank of a Brigadier General of Volunteers, and its power and authority—under the Government—were practically unlimited. This service is, since the close of the War, represented by the Bureau of Special Agents of the Revenue Department of the U. S. Treasury. These Officials are charged with the investigation of suspected frauds in the collection of the revenue, either through fraudulent invoices, undervaluation, or false appraisement. They are authorized to inspect invoices and other records in the various Custom-houses; and to investigate the books of mercantile houses, and require them to be brought into Court for examination, on suspicion of any fraudulent importation of goods.

SECTION. 1. A certain proportion of a battalion or company, when it is told off for military movements and evolutions. 2. If a plane pass through work in any direction, the cut made by it is a section; if the cut be vertical and perpendicular to the face of the work, it is a ground-plan: thus, when the foundation of a house appears just above the ground, it shows the ground-plan of the building.

SECTION CUTTER.—A cutting instrument for making thin sections for microscopic examination. The

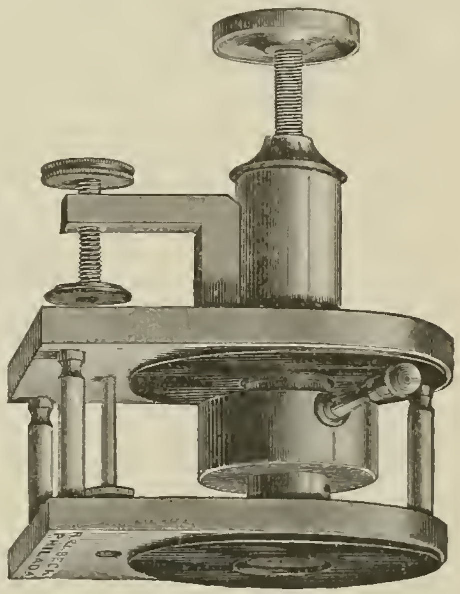


Fig. 1.

drawings show two forms of the instrument. Fig. 1, represents Walmsley's adaptation of Dr. Bevan Lewis's ether-spray microtome.

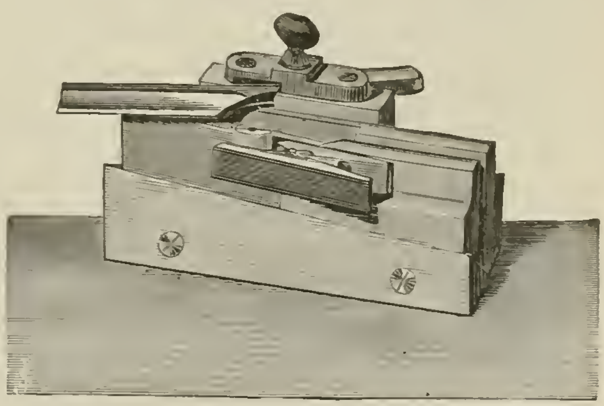


Fig. 2.

This form is largely in use by our leading Histologists, and by the Medical Department of the Army. To the excellent section instrument, of the Army Medical Museum pattern, a second table, with glass top, is added, through which a brass-topped tube, with condensing chamber beneath, is advanced by the same micrometer screw. Some thickened gum-water being put upon the top of this tube, a piece of tissue, say a portion of spinal column from a freshly-killed animal, may be placed in it, and the nozzle of the freezing atomizer having been introduced into the tube beneath, the tissue will be solidly frozen in from one to three minutes. Ether may be used, but rhigolene is much better; a considerable portion of it will be condensed in the chamber, and can be drawn off by the tube, shown in the illustration, for further use. The knife should be kept cold by being placed on a block of ice before using. The instrument is made in two sizes, with tubes of 1 inch and 1½ inches diameter. Fig. 2 shows the instrument after the pattern of M. Rivet, in brass, and furnished with a micrometer screw and knife.

SECTION LINER.—An instrument for indicating sections of objects in fortification and architectural drawings, for drawing screw-threads, laying out the spaces for brick work, letterings on drawings, and in all cases where narrow spaced parallel lines are needed. With it a person of moderate ability or practice can produce an effect of great uniformity and neatness in sectional drawings, almost, or quite equal to the engine-dividing of engravings. The instrument consists of a ruler, covered on the underside with an India-rubber cloth, a triangle with a clamping-screw, passing through near one of its edges and a plate, with the necessary arrangement for producing a movement over equal spaces. The several parts are placed together as represented in the engraving, Fig. 1., there being a little spring beneath the front edge of the top plate, which presses against one edge of the ruler, while the triangle is clamped against the other edge. The ruler may be placed upon the paper in any desired position, the India-rubber cloth underneath keeping it there with great security; and it thus acts as a guide for the triangle which can be moved along over equal steps by alternately pressing down the ivory button and letting it spring back. This movement is produced by the action of a little pawl upon the ruler, which is always to be kept pretty sharp, so that it will take a quick and certain hold. The length of the steps taken, or the distance between the lines drawn, is regulated by the screw above the spring, the distance moved over each time being greater as the spring is allowed to have more play. By changing the clamping-screw on the triangle, any edge can be placed against the ruler. Fig. 2. represents a sample of work done with Bergner's Section Liner.

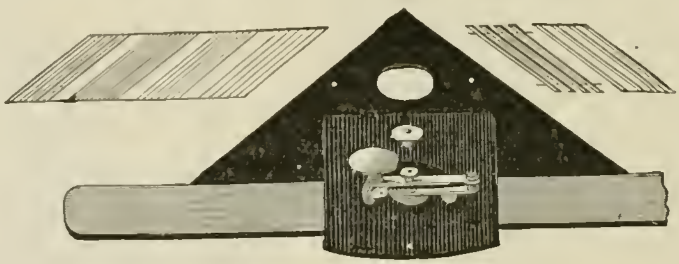


Fig. 1.

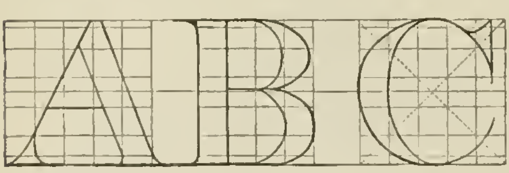


Fig. 2.

SECTOGRAPH.—A scale for use with a contoured map or plan, which enables the Surveyor to make a section of the ground with the least possible expenditure of time and labor. The contours on the map furnish the data, and enable the Surveyor to produce the required sections. It is, as stated by the designer, Lieutenant Tressider, R.E., a means of giving to a map the advantages of a model without its defects.

SECTOR OF EXPLOSION.—At the moment that a gun is fired, there is a sort of spherical sector of fire formed in front of the piece, whose extremity presses against the bottom of the bore, while the external portion of it terminates in the air, which this sector compresses and drives in every direction; the air thus forming a support, the sector reacts with its full force upon the bottom of the bore and causes the recoil of the piece.

SECTOR WITHOUT FIRE.—The star and bastioned forts were devised to remedy the defects of *sectors without fire*, and of the *dead spaces*, found in redoubts. A sector without fire is the name given to that space exterior to a work which is not defended by the direct fire of the adjacent faces. The space is included between lines drawn through a salient, perpendicular to the faces.

SECURE ARMS.—A position in the Manual of Arms, executed as follows: The Instructor commands. 1. *Secure*, 2. ARMS. Advance the piece slightly with the right hand, the barrel turning to the right; grasp the piece with the left hand, the forearm horizontal, and turn the barrel to the front, at the same time change the grasp of the right hand to the lower band, the barrel vertical. (Two.) Drop the muzzle to the front, the guard under the right arm, the hand supported against the hip, the thumb on the rammer; drop the left hand by the side.

1. *Carry*, 2. ARMS. Grasp the piece with the left hand, back down, midway between the upper and lower bands; resume the carry with the right hand, the barrel turning to the right. (Two.) Drop the left hand by the side. See *Manual of Arms*, Fig. 11.

SECURE PIECE.—A command, in artillery, directing that the piece be moved in battery, the muzzle depressed, the tompion inserted in the muzzle, and the vent-cover placed on the vent.

SECUTEUR.—A gladiator who was armed with a helmet, shield, and sword, or leaden club, and who fought with the *Retiaire*.

SEDAN CHAIR.—A portable covered vehicle for carrying a single person, borne on two poles by two men. The name is derived from the town of Sedan, in France, where this species of conveyance is said to have been invented. It is said that the Duke of Buckingham was in the practice of using one in the reign of James I., a proceeding which gave general offense, it being made matter of public remark that this royal favorite used his fellow countrymen to do the work of beasts. The general introduction of sedan chairs into England dates from 1634, about the same period that hackney coaches came into use. Sedan chairs were largely used during the greater part of last century, being found very well adapted for transporting persons, in full dress, to public and private entertainments. Not only were there numerous public conveyances of this kind in London and all considerable towns, but the owner of every large mansion had his private sedan handsomely fitted up. In Edinburgh, a century ago, sedan chairs were far more numerous than hackney coaches, and were almost all in the hands of Highlanders. Sedans are now seldom seen except for the transport of the sick, in the field.

SEDENTARY TROOPS.—The bodies of troops that remain at home to garrison towns, fortresses, etc., after the active Army and the Reserve have left the country. By the new English mobilization scheme a large force, including a few regular regiments and the garrison artillery, forms the garrison or sedentary Army of the country. It is divided into 13 separate commands, and will in time of war have to watch and defend the coasts.

SEDITION.—A general name given to such offenses against the State as fall short of treason. In the law of England it is not a strictly technical word. Writing, publishing, or uttering words tending to excite subjects to insurrection, though not urging them to rebellion or a total subversion of the Government, come under this denomination. There are various English statutes directed against particular acts of sedition, such as seditious libels, and seditious meetings and assemblies, which are punishable as misdemeanors. Act 36, George III., directed against all seditious practices and attempts pending to high treason, is extended to Ireland by 11 Vict., and additional provisions are added to it. By this latter Act the compassing or devising, either to depose the Queen; to levy war against the Queen, for the purpose of changing her Majesty's measures, or constraining or overawing Parliament; or to move any foreigner to invade the Queen's dominions, is made felony, punishable by transportation for life, or for a period not less than seven years, and that notwithstanding the facts should amount to treason.

In Scotland sedition is distinguished from leasing-making in so far as the object of the latter is to disparage the private character of the Sovereign, while the former crime is directed against the order and tranquility of the State. The punishment of sedition formerly arbitrary, is now restricted to fine and imprisonment.

SEGBANS.—Horsemen among the Turks who have care of the baggage belonging to cavalry regiments.

SEGMENT-SHELL.—An elongated projectile invented by Sir William Amstrong. The first iron body is coated with lead, and contains a number of segments of iron in successive rings, leaving a hollow cylinder in the center for the bursting-charge. The charge bursts on impact or by a time-fuse, and scatters the segments in all directions. It may be used as case-shot by arranging the fuse to explode the shell on leaving the muzzle. The object originally of introducing the segment-shell was that it might, by its construction, take the place of common shell, which, it was found, did not break up into sufficiently small pieces. Then it was hoped that it would act as Shrapnel, but again it was observed that, from the bad shape of the segments, it did not fly forward with sufficient velocity, and it scattered too much. Again, fired with a time-fuse, it was not reliable as to bursting at the exact moment required; so it was not considered efficient as Shrapnel, and contained too small a charge of powder to make it useful as a common shell against buildings, field-works, etc.

SEJANT.—Sejant, or Assis, in Heraldry, is the term of blazon applied to a beast in his usual sitting posture. A lion borne in full face, with his forepaws extended sideways, is blazoned sejant affronté, as in the crest of Scotland.

SELECTION.—The act of choosing and taking from among a number. In the British Army, selection according to merit is the system observed in promoting officers from a lower to a higher grade. In the United States all officers select their quarters according to rank.

SELF-CONSUMING CARTRIDGE.—The original cartridge of the needle-gun and of the chassepôt; it is made of a linen or silk envelope and the explosive composition is situated in the center of the powder. Experience has shown that no cartridge can be trusted to consume entirely in the barrel, under all circumstances, as the metal conveys the heat away so rapidly that often the thin paper in contact with it is untouched from the combustion of the powder. This cartridge therefore leaves in the chamber a mass of débris, paper, caoutchouc, copper, and dirt. In order to counteract this, the chamber has to be made a little larger than is necessary; hence, frequent missfires. The grease with which the cartridge is covered gets decomposed, and remains useless, if it does not penetrate through the paper and attack the powder, so that after twenty rounds the dirt in the rifle is solidified, accuracy is lost, and firing is stopped from the impossibility of loading. The cartridge is besides very liable to get damp, on account of the paste it contains, and it is quickly damaged in magazines. The chassepôt (as modified by Major Gras) and the German needle-gun (Mauser) now fire a metallic cartridge.

SELF-DEFENSE.—In law, defense of ones' person or property from an injury. A person upon whom violence is inflicted may defend himself by so much counter-violence as is necessary for his protection and no more. If assaulted by blows, he may defend himself by blows. A man may defend himself, even to the extent of his committing homicide, to prevent any violent crime, whose perpetration would constitute a felony. He may retnrn force with force in defense of his person or property against an attempt at forcible felony; and he need not retreat, but may even follow his assailant. When there is no threatened or intended felony, a man may defend himself in a mutual fight caused by any sudden quarrel, or where without a mutual fight the assailant attempts or commits an assault and battery; and the assailed person, where an attempt to strike him is made and the assailant is near enough to be able to strike him, need not wait to be struck first.

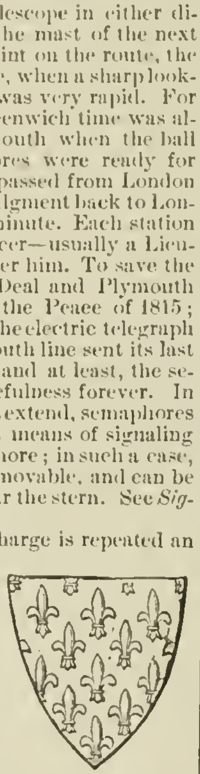
SELF-DENYING ORDINANCE.— A measure carried through Parliament in 1645 by the influence of Cromwell and the Independents, with the view of removing Essex and the Presbyterians from the command of the Army. It was on motion of a fanatic of the name of Zouch Tate, who on the ground that "there is but one way of ending so many evils, which is, that every one of us freely renounce himself," proposed, that "No member of either House shall, during this war, enjoy or execute any office or command civil or military, and that an ordinance be brought in accordingly." The ordinance, which was clearly intended to take all the executive power out of the hands of the more moderate politicians, and form an army independant of Parliament, was the subject of violent and protracted debate, but eventually passed in both Houses, and became law. The consequence was that Essex, Warwick, Manchester, and others gave in their resignations, and the conduct of the war was intrusted to Fairfax; Cromwell, to whom, as a member of the Lower House, the self-denying ordinance extended, as much as to Essex and the rest, had the duration of his commission prolonged by the Commons on account of his invaluable services as a leader of cavalry, and by his brilliant achievements soon surpassed his Commander in reputation.

SELICTAR.—A Turkish saber formerly much used.

SELLING OUT.—The permission formerly given to an Officer in the English Army, on retiring from the service, to sell his commission for the stipulated sum laid down by the Regulations. Since the non-purchase system has been established, this sanction is only granted to those Officers who entered the service previous to 1871, in which year the purchase of commissions was abolished. Officers who were in the service prior to that year receive the value of their commissions from the Army Purchase Commissioners.

SEMAPHORE.—The name applied to the system of telegraphy in use before the application of the electric current. Semaphores were first established by the French in 1794, as a plan for conveying intelligence from the capital to the armies on the frontier. In the following year, Lord George Murray introduced them in England; and by their means the Board of Admiralty were placed within a few minutes of Deal, Portsmouth, or Plymouth. These semaphores consisted of towers built at intervals of from 5 to 10 miles on commanding sites. On the top of each tower was the telegraph apparatus, which at first comprised 6 shutters arranged in 2 frames, by the opening and shutting of which, in various combinations, 63 distinct signals could be formed. In 1816 Sir Home Popham substituted a mast with 2 arms, similar to many of the present railway signals. The arms were worked from within the tower by winches in the look-out room, where a powerful telescope in either direction constantly commanded the mast of the next station. If a fog set in at any point on the route, the message was delayed; otherwise, when a sharp look-out was kept, the transmission was very rapid. For instance, the hour of one by Greenwich time was always communicated to Portsmouth when the ball fell at Greenwich; the semaphores were ready for the message, and it commonly passed from London to Portsmouth and the acknowledgment back to London within three-quarters of a minute. Each station was in the charge of a Naval Officer—usually a Lieutenant with one or two men under him. To save the cost of this Establishment, the Deal and Plymouth lines fell into disuse soon after the Peace of 1815; and the superior advantages of the electric telegraph being incontestable, the Portsmouth line sent its last message Dec. 31, 1847, and, on land at least, the semaphore closed its career of usefulness forever. In calm weather, when flags will not extend, semaphores are employed on board ship as a means of signaling from vessel to vessel, or to the shore; in such a case, the post containing the arms is movable, and can be readily shipped or unshipped near the stern. See *Signals*.

SEME.—In Heraldry, when a charge is repeated an indefinite number of times so as to produce the appearance of a pattern, then the term *semé* (sometimes *aspersed* or *powdered*) is applied to it. When a field is semé, it is treated as if it were cut out of a larger extent of surface, some of the charges being divided by the outline of the shield. The term *crusilly* denotes semé of cross crosslets, and *billetty* semé of billets.



Seme.

SEMISPATA.—A Frankish dagger or scramasaxe, having a single edge and several grooves on the back of the blade. Its length, including the haft, is about 24 inches.

SEMI STEEL.—If, in the operation of puddling, or in decarbonizing cast-iron, the process be stopped at a particular time, determined by indications given by the metal to an experienced eye, an iron is then obtained of greater hardness and strength than ordinary iron to which the name of semi-steel, or puddled steel, has been applied. The principal difficulty in its manufacture is that of obtaining uniformity in the product, homogeneity, and solidity throughout the entire mass. It is much improved by reheating and hammering under a heavy hammer, but it has not been found a very reliable material for even cannon of small caliber. See *Puddled Steel* and *Steel*.

SENATE.—The Upper House of Congress; composed of twice as many members as there are States in the Union, the two members from each State being elected by the respective State Legislatures, to hold office for six years. The Senators are held to represent the local sovereignty of their respective States. All Bills in Congress must pass both Houses to become laws; though the same may originate in either House. Of special functions, the Senate possesses that of ratifying treaties with foreign powers; of confirming the nominations to office made by the President, and of sitting as a High Court of Impeachment in case of the trial of public officials. The different States have each an Upper House corresponding in its duties and powers with the United States Senate.

SENESCHAL.—In the origin of the office, probably an attendant of the servile class who had the superintendence of the household of the Frankish Kings. In the course of time, however, the Seneschalship rose to be a position of dignity, held no longer by persons of servile race, but by Military Commanders, who were also invested with judicial authority. The Lieutenants of the great Feudatories often took the title of Seneschal. A similar office in England and Scotland was designated Steward, but is rendered into Latin as *Senescallus*.

SENIORITY.—Priority given to a regiment or an officer; it has reference to the date of the raising of the former or the date of commission of the latter.

SENTENCE.—The judgment of a Court-Martial in allotting the punishment of a convicted soldier. The punishment to be awarded is arrived at by the votes of every Member of the Court. Before deciding as to the quantity, the Court should settle as to the nature of punishment. In all cases the opinion of the majority should be absolute, but when the votes are equal, the more lenient sentence should be given. No sentence of death can be passed unless two-thirds of the Members of the Court concur therein.

SENTINEL—SENTRY.—A private soldier, marine, or sailor posted at a point of trust, with the duty of watching the approach of an enemy or any person suspected of hostile intentions. Sentries mount guard over depots of arms, the tents of Commanding Officers, etc. During the night each sentry is intrusted with the "word," or the countersign; and no person, however exalted in position, may attempt to approach or pass him without giving that as a signal. In such case the sentry is bound to arrest the intruder, and, if necessary, to shoot him. It has happened before now that the Commander-in-Chief of an army has been a prisoner in the hands of one of his own sentries. When an army is in the field the sentries are its eyes, for they guard the approaches in every direction some distance in front of the main body of troops. In the event of attack they give the alarm and retire slowly on their supports. There is usually an agreement, tacit or expressed, between Commanders that their outlying sentries shall not fire upon one another as such, would only be productive of useless bloodshed. Under martial law death is the penalty to any sentry for sleeping on guard.

SENTRY-BOX.—A place of shelter for a sentry in bad weather or against the effects of the sun. It is made either of masonry or wood.

SEPADAR.—An East Indian term for an officer of the rank of Brigadier General.

SEPAHI.—An East Indian term given a feudatory chief, or military tenant.

SEPOY.—A term corrupted from the Indian word *sepahi*, a soldier. This word sepahi, in its more familiar form of *spahee*, is known in most Eastern armies; and is itself derived from *sip*, a bow and arrow, the ordinary armament of an Indian soldier in ancient times. The word sepoy now denotes a native Hindu soldier in the British Army in India. The present sepoy force numbers about 140,000 men. See *East India Army*.

SEPTEMBRISERS—SEPTEMBRISTS.—A name given to the frantic executioners in what are known as the "September Massacres" in Paris. The causes of this ferocious outburst were twofold—mad fear of domestic traitors and of foreign despots. The news came pouring into Paris, ever more and more maddening, of Prussian and Austrian hordes marching victorious over the frontiers; insolent Royalists obtruding themselves in the van of the invading armies and breathing threatenings and slaughter; while the numerous *Aristocrates* (*i.e.*, favorers of the King and

Court) were believed to be making preparations to receive them in Paris. At the very same moment broke out the Royalist Insurrection in *La Vendée*, rendering France still further delirious, whereupon Danton, "Minister of Justice," got a decree passed, August 28, 1792, ordering domiciliary visits for the arrest of all suspected persons, and for the seizure of arms of which patriotic France stood very much in need. Upward of 2,000 stands of arms were got in this way, and 400 head of new prisoners. On the morning of Sep. 2 the news of the capture of Verdun by the Prussians arrived. The mingled rage and panic of the people cannot be described. All the bells in Paris were set a-clanging; men and women hurried in myriads to the *Champ de Mars* to get themselves enrolled as volunteers. Danton entered the Legislature—"The black brows clouded, the colossus figure tramping heavy, grim energy looking from all features of the rugged man"—and made that famous speech, ending: "*Pour les vaincre, pour les atterrer que faut-il? De l'audace, encore de l'audace et toujours de l'audace.*" The effect was electrical. He obtained from the assembly a decree condemning to death all "Who refused to march to the frontiers or to take up arms." But patriotism against foreigners was not enough. Were not the traitors at home deserving of death? Marat thought so: multitudes of ardent frantic men and women shared his conviction; but it is not proved that either Marat or Danton formally ordered the massacres, or, indeed, that anybody ordered them. They were rather only the spontaneous outburst of patriotic insanity, beholding aristocratic treachery and plots everywhere. Priests, Swiss soldiers, aged and infirm paupers, and women, both reputable and disreputable, and criminals, were mercilessly cut down or shot. From Sunday afternoon till Thursday evening the wild butchery went on at the Bicêtre, the Abbaye, the Convent of the Carmelites, the Conciergerie du Palais, the Grand Châtelet, St. Firmin, La Force, and the Salpêtrière. One gathers a glimpse of the savage sincerity of the Septembrisers when one reads that the gold rings, watches, money, etc., found on the persons of the massacred were all religiously brought to the town-hall; not a single thing was stolen or furtively appropriated.

SERAKHUR.—In the East Indies, a Non-commissioned Officer who is employed in the artillery. The title answers to that of *Sergeant*. In the naval service, the *Serang* is a similar person, and answers to the title of *Boatswain*.

SERASKIER—SERIASKER.—The name given by the Turks to every General having the command of a separate army, and, particularly, to the Commander-in-Chief or the Minister of War. The Seraskier, in the latter sense, possesses most extensive authority, being subordinate only to the Sultan and Grand Vizier; he is selected by the Monarch from among the Pashas of two or three tails.

SERDANS.—Colonels in the Turkish Service.

SERENADE.—Originally the music performed in a calm night. Serenading has been chiefly practiced in Spain and Italy. It is very common among the students of the German Universities to assemble at night under the window of a favorite Professor, and give him a musical tribute. A piece of music characterized by the soft repose which is supposed to be in harmony with the stillness of the night, is called a serenade, or sometimes a *nottorno*. It is a common practice in the Army to serenade Officers visiting or returning to Military Posts and Head-quarters.

SERGE.—A quilted cloth, made of woollen, and manufactured in many Counties of England, especially in Devonshire. Serge was used very recently in the manufacture of gun-cartridges, but it has been superseded by silk cloth. White serge is used for lining the panels of saddles.

SERGEANT ARMORER.—A skilled mechanic attached to regiments of infantry and cavalry, for the purpose of repairing and keeping the arms in order.

SERGEANT-AT-ARMS.—Formerly a sort of body-guard attendant upon the person of the Sovereign or of the Lord High Steward when sitting in judgment on a traitor. They numbered about thirty. The functions of this body have long ceased.

The Houses of Lords and Commons have each a Sergeant-at-Arms, both of whom execute the commands of the House to which they belong, as regards the apprehension or custody of all persons committed by order of Parliament. The office is generally held by a military man, who is very seldom under the rank of a Field Officer.

SERGEANT D'ARMES.—Philip Augustus, fearing to be assassinated on the instigation of the Sheik of the Mountain, during his stay in Palestine, organized for the protection of his own person, a corps of *Sergeants d'Armes*, consisting of gentlemen, whom he armed with bronze war-clubs and bows and arrows. It was their duty to accompany him everywhere.

SERGEANT INSTRUCTORS.—In the British Army, Sergeants who assist in the instruction of fencing, gunnery, and musketry.

Sergeant Instructor in Fencing.—A Sergeant attached to each cavalry regiment, to instruct the officers and men in the art of fencing.

Sergeant Instructor in Gunnery.—A Sergeant appointed to assist the Gunnery Instructor, attached to each brigade of artillery.

Sergeant Instructor of Musketry.—A Sergeant attached to each line regiment, and two to the Engineers, whose duty it is to assist the Instructor of Musketry in teaching the use of small-arms.

SERGEANT MAJOR.—The senior Non-commissioned Officer in a regiment. His duties are of a very important nature, as will be realized when it is considered that he is the Adjutant's right-hand man. In him should be embodied all that is manly, soldier-like, and zealous. His duties are so manifold that for the proper performance of them he should be the smartest and most intelligent man in the regiment, and his example and conduct such as shall cause him to be esteemed and respected by every soldier in it. Besides the Sergeant Major of a regiment, there are *Troop Sergeants Major* in the cavalry, and *Battery Sergeants Major* in the artillery.

SERGEANT MASTER TAILOR.—A Non-commissioned Officer who oversees the tailoring of a regiment. He is taken from the soldier tailors instructed at the Royal Army Clothing Depot at Pimlico; it is not, however, necessary that he should be educated at the above depot, as a civilian tailor on enlistment, after undergoing the prescribed examination in his trade at the Royal Army Clothing Depot, can be appointed.

SERGEANTRY.—A tenure by which all lands were held in the feudal times in England. After the Conquest the forfeited lands were parcelled out by William to his adherents upon condition of the performance of services of a military character. The military tenants of the Crown were, however, of two descriptions: some held merely *Per Servitium Militare*, by Knight-service; others held *Per Sergentiam*, by Grand Sergeantry, a higher tenure, which involved attendance on the King not merely in war, but in his Court at the three festivals of the year, and at other times when summoned. Although the word Baron, in its more extended sense, was applied to both classes of Crown Tenants, yet it was only those holding by Grand Sergeantry whose tenure was said to be *Per Baroniam*. In its earliest stage the distinction between the greater nobility and lesser nobility or gentry in England was, that the former held by Grand Sergeantry, and the latter by Knight-service only. In theory, lands held by Sergeantry became gradually extinct before the abolition of military holdings. Considerable misapprehension on the part of Dugdale and later writers has arisen from a double use of the word *Serviens*, or Sergeant, which is sometimes applied to a tenant either by Grand Sergeantry or Knight-service who had not taken on himself the obligations attendant on knighthood.

The term *Petty Sergeantry* was applied to a species of socage tenure in which the services stipulated for bore some relation to war, but were not required to be executed personally by the tenant, or to be performed to the person of the King, as the payment of rent in spurs or arrows.

SERGEANTS.—Non-commissioned Officers of the Army and Marines in the grade next above Corporal. They are selected from the steadiest among the Corporals, and their duties are to overlook the soldiers in barracks, and assist the Officers in all ways in the field. They also command small bodies of men as guards, escorts, etc. Every company has four Sergeants, of whom the senior is the First Sergeant. A superior class are the Staff Sergeants, as the Quartermaster Sergeant, Armorer Sergeant, Hospital Sergeant; and above them all is the Sergeant Major. The daily pay of a Sergeant varies from 1s. 1d. in the Infantry, to 2s. 11d. in the Horse Artillery. In ancient times the rank of Sergeant was considerably more exalted. In the 12th century the Sergeants were gentlemen of less than knightly rank, serving on horseback. Later, the Sergeants-at-Arms were the Royal Body Guard of gentlemen armed *cap-à-pie*. Also written *Serjeant*.

SERPENTEAU.—A round iron circle, with small spikes, and squibs attached to them. It is frequently used in the attack and defense of a breach. It likewise means a fusee, which is filled with gunpowder and bent in such a manner, that when it takes fire, it obtains a circular and rapid motion, and throws out sparks of light in various directions.

SERPENTIN.—A sort of small *lin-stock* employed to hold the match when applied to the cannon.

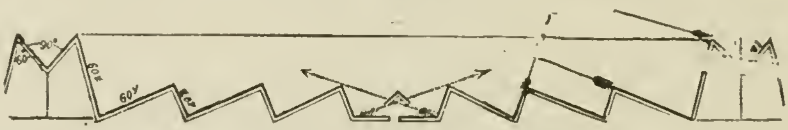
SERPENTINE.—A very ancient wall-piece, with a match-lock, carrying an 8-ounce leaden ball, with a charge of 4 ounces of powder. Its length was 6 or 7 feet, and weighed from one to two hundred-weight.

SERPENTIX.—The cock of the very ancient match-lock, also the lock itself. The term is also applied to an ancient 24-pounder gun, of 13 feet, weighing 4360 pounds, whose dolphins represented the figures of serpents.

SERPENTS.—Small rocket-cases charged with composition, consisting of two parts of charcoal and sixteen parts of mealed powder. The case is made by rolling a rectangle of paper No. 4 with the hand-rolling board, and choking it at one end. The cases are driven $\frac{2}{3}$ their length, giving each ladleful of the composition three blows with the mallet. The case is choked over the composition, and the remainder of it is nearly filled with mealed powder, upon which a small paper wad is placed. A clay head is then driven on it, and the end of the case turned down to secure it. The other end is primed with priming paste, or a small strand of quick-match. See *Compositions* and *Fireworks*.

SERRA FUSE.—This fuse originally consisted of a cast-iron case with a flat head, which was screwed into the eye of the shell to receive the fuse proper, which was made of bronze and was screwed into the case when required, having for that purpose a square head. The end of the iron fuse-plug projected slightly into the shell, and was hollowed out and notched, in order to receive a priming to render the explosion of the charge more certain. The fuse was filled with meal powder, compactly and regularly driven. It was designed for use with Shrapnel shot, and each caliber had three lengths, corresponding to the three most important distances, and differing in the time of burning, $\frac{1}{5}$ of a second in the 12-pounder, and one second in the 24-pounder, so that for the former piece, the fuses would burn 2″, $2\frac{1}{5}$″, and $3\frac{3}{5}$″, and for the latter piece, $2\frac{2}{5}$″, $3\frac{2}{5}$″, and $4\frac{3}{5}$″. The hole in the fuse-plug was kept closed with a tow wad, until just before inserting the fuse. It was found to be an improvement, when the plug or case was made of bronze, instead of cast-iron. This fuse has undergone many improvements. The plug has been made smaller, with no screw on its exterior, which was instead made slightly conical, and was driven into the fuse-hole, like an ordinary wooden fuse. Instead of iron; it was made of a mixture of tin, lead, and zinc, one part of each. In this manner, it could be applied to any shell without the trouble and expense of cutting a screw in the eye, and consequently could be used with the shells already manufactured, without any change. See *Fuse*.

SERRATED LINE.—A line principally used in place of a straight curtain between two advanced works, which are too far apart to protect each other and the space between them. When the ground between the advanced works is level, or nearly so, the branches of the crémaillère form salient and re-entering angles, which are on the same right lines. The long branches alternate from the middle point, where either a salient or re-entering angle is formed; the latter is preferable, as it is stronger, and may be arranged with flanks and a curtain, which will be better situated for defense than the two faces forming a salient angle. See *Lines*.



Plan of a Cremaillere Line between two salient Priest-caps.

SERRE DEMI-FILE.—That rank in a French battalion which determines the half of its depth, and which marches before the demi-file. Thus a battalion standing six deep, has its *serre demi-file* in the third rank, which determines its depth.

SERRE FILE.—The last rank of a battalion, by which its depth is ascertained, and which always forms its rear. When ranks are doubled, the battalion resumes its natural formation by means of the *serre-files*. *Serre-file* literally signifies a "bringer up."

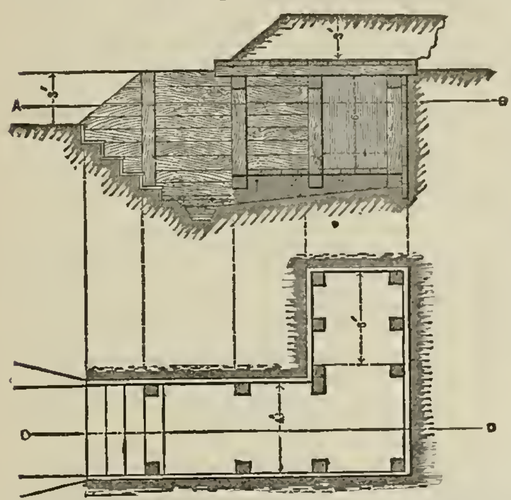
SERVANS D'ARMES.—Persons who belonged to the third class of the Order of Malta. They were not Noblemen, although they wore both the sword and cross. Also called Chevaliers Servans.

SERVANTS.—In the British Service soldiers are taken from the ranks for the purpose of waiting upon Officers. This privilege of having a soldier servant is not granted on Indian service, or where a Colonial allowance is granted in lieu of servants. Each *Infantry* Regimental Officer is allowed to have *one* soldier to attend on him: Field Officers and Adjutants keeping horses for regimental purposes, as well as all *Cavalry* Officers when present at Head-quarters or employed on duty, *two* each. In the United States Service, Officers are not permitted to employ soldiers as servants.

SERVICE.—In a military sense, the art of serving the State in war. All studies, acts, and efforts of the profession of arms have this end in view. To belong to the Army and to belong to the land service, are the same thing. In a more restricted sense, service is the performance of military duty. In its general sense, service embraces all details of the military art. But in its restricted sense, actual service is the exercise of military functions.

SERVICE MAGAZINE.—The size of a service magazine will depend upon the number of rounds it is desirable to have ready for immediate use; usually, twenty rounds for sea-coast guns, and from fifty to one hundred for those of smaller caliber, will be sufficient. The capacity of the magazine to hold this amount or any other that may be fixed upon will be determined by the rules given in the article Storage Magazine. When the magazine is to hold barrels, it should be 6½ feet high and 7½ feet wide; this will accommodate four tiers of three rows, leaving a passage-way of 30 inches. The length will depend upon the number of barrels, and this will be governed by the number and caliber of pieces to be provided for; generally, 15 feet will be ample. The magazine is usually constructed of coffer-work or gabions.

Magazines of this kind are sometimes built in the adjacent traverses if there be any; generally under the parapet, near the guns; and often under the barbettes. It may be entirely above the ground, or be partly or wholly under the ground, as shown in the drawing, where the magazine or passage-way are lined with wooden frames. The frames are made of timbers or scantlings of the proper dimensions,



each frame consisting of two uprights, called stanchions, a ground-sill, and a cap. The frames are then placed upright, about three feet apart, and in the position which they are to occupy. Their tops and sides are then planked over; this planking is called the sheeting. The bottom of the excavation is sloped from the sides to the middle, and from the rear to the front, to allow all water leaking through the magazine to collect in a shallow trench made along the middle line, and to run off into a drain prepared to receive it, or into a dry well dug near the entrance. The ground-sills are then floored with boards. Great care must be taken to make the top water-tight, before the earth is placed upon it. This done, it is covered with several feet of earth depending upon the degree of exposure to which it is subjected. The plane, and horizontal section of themagazine and entrance, made by the plane, A B; and the elevation, and section by the vertical plane, C D, are shown in the drawing. The entrance to the magazine should be closed by a stout door, and the approach to it should be protected by a splinter-proof. If field-artillery is employed to defend the work, the limber boxes are taken off and placed within the magazines. See *Powder Magazine* and *Storage Magazine*.

SESSION.—The actual sitting of a Court, Council, etc., or the actual assembly of the members of such a body for the transaction of business. Hence, also the time, period, or the term during which a Court, Council, and the like, meet daily for business; or the space of time between the first meeting and prorogation or adjournment.

SETENDY.—A term commonly applied to the Militia in the East Indies.

SET OF THE ARM.—An expression for the *lead* and *hollow of the arm* of an axletree, when taken together.

SETTER.—In gunnery, a wooden instrument, the mouth of which is slightly hollowed out; it is used with the aid of a mallet to set the fuse into common and diaphragm shells. Mallets and setters are issued with garrison S.B. guns, and form part of a set of fuse implements.

SETTING UP DRILL.—Exercises devised for the *setting up* of recruits and soldiers of non-military appearance. The exercises constituting the Setting Up Drill in the United States are four in number and are executed as follows: The Instructor commands:

1. *First*, 2. Exercise.—Bring the hands to the front till the little fingers meet nails downward, arms horizontal. (Two.) Raise the hands in a circular direction over the head, the ends of the fingers touching, and pointing downward so as to touch the top of the forage-cap, thumbs pointing to the rear, the shoulders kept down, elbows pressed back. (Three.) Extend the arms upward to the full length, the palms of the hands touching; then force them obliquely back, and gradually let them fall to the position of the soldier.

1. *Second*, 2. Exercise.—Raise the arms from the sides, extended to their full length, until the hands meet above the head, palms of the hands to the front, fingers pointing upward, thumbs locked, right thumb in front, the shoulders pressed back. (Two.) Bend over till the hands, if possible,can touch the ground, keeping the arms and knees straight. (Three.) Resume the position of the soldier.

1. *Third*, 2. Exercise – Extend the arms horizontally to the front, the palms of the hands touching. (Two.) Throw the arms extended, well to the rear, inclining slightly downward; at the same time raise the body upon the toes. (Three.) Resume the position of the soldier. The first and second motions of this exercise should be continued by the commands, *one, two—one, two*, till the recruits, if possible, are able to touch the hands behind the back.

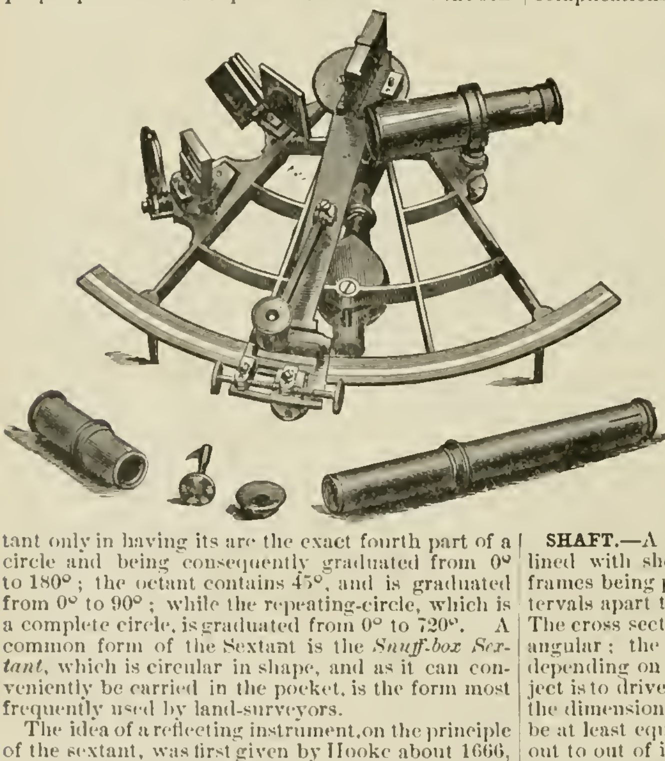
1. *Fourth*, 2. Exercise.—Raise the arms laterally until horizontal, palms of the hands upward. (Two.) Swing the arms circularly, upward and backward, from front to rear. (Three.) Resume the position of the soldier. As soon as the recruits understand the various exercises, they are continued without dwelling upon the numbers, the Instructor prefacing the exercise by the command *continue the motion*, and giving the command *three*, for the conclusion. See *Gymnastics*.

SEVERUS WALL.—A rampart of stone built by the Roman Emperor Severus in Britain, 208 A. D., between the Tyne and the Solway. On the first subjugation of Britain by the Romans, a line of forts had been constructed by Agricola extending from the Forth at Edinburgh to the Clyde at Dunbarton. The Emperor Hadrian, on visiting Britain, 120 A. D., threw up for the protection of the Roman Province a wall of turf extending across the narrowest part of the island, between Tyne and Solway. Twenty years later Antoninus Pius, whose Lieutenant Lollius Urbicus, had gained fresh advantages over the northern tribes, endeavored to check the inroads of the Caledonians by erecting another rampart of earth between the Forth and Clyde, connecting Agricola's line forts. But after a vain struggle of 60 years, the Romans found it necessary to abandon the whole district between the walls, and Septimius Severus built a strong rampart of stone immediately to the north of the wall of Hadrian. Toward the close of the 4th century, Theodosius, for a brief period, reasserted the Roman dominion over the district between the walls of Antonine and Severus, which, in honor of the Emperor Valens, obtained the name of Valentia. But this newly-established Province was soon lost, and it was not long before the Romans finally abandoned Britain. Many remains of the Roman walls are yet to be traced.

SEVIR.—A term applied to a Captain of Cavalry among the Romans.

SEXTANT.—An instrument used for measuring the angular distance of objects by means of reflection. The principle of its construction depends upon the theorem, that *if a ray of light suffer double reflection the angle between the original ray and its direction after the second reflection is double that of the angle made by the reflecting surfaces.* It is a brass sector of a circle in outline; the sector being the sixth part of a complete circle, for which reason the instrument is called a sextant. The drawing shows the essentials of its construction. The instrument is capable of very general application, but its chief use is on board ship to observe the altitude of the sun, the lunar distances, etc., in order to determine the latitude and longtitude. For this purpose it is necessary to have stained glasses interposed between the mirrors, to reduce the sun's brightness. These glasses (generally three in number) are hinged on the side, so that they may be interposed or not at pleasure.

The sextant is liable to three chief errors of adjustment; 1° if the index-glass be not perpendicular to the plane of the instrument; 2° if the horizon-glass be not perpendicular to the plane of the instrument; and 3° if, when the mirrors are parallel, the index does not point accurately to 0°; this last is called the *index-error*, and is either allowed for, or is remedied by the means of a screw. The first two errors are also frequently remedied by the means of screws working against a spring, but in the best instruments the maker himself fixes the glasses in their proper position. The quadrant differs from the sex-



tant only in having its arc the exact fourth part of a circle and being consequently graduated from 0° to 180°; the octant contains 45°, and is graduated from 0° to 90°; while the repeating-circle, which is a complete circle, is graduated from 0° to 720°. A common form of the Sextant is the *Snuff-box Sextant*, which is circular in shape, and as it can conveniently be carried in the pocket, is the form most frequently used by land-surveyors.

The idea of a reflecting instrument, on the principle of the sextant, was first given by Hooke about 1666, but the first instrument deserving the name was invented by John Hadley early in the spring of 1730 and a second, and much improved form of it, was made by him a short time afterwards Hally, at a meeting of the Royal Society, claimed for Newton the priority of invention; and in Oct., 1730, a Philadelphian, named Godfrey, also asserted his claim as the original inventor, but that learned body decided that Newton's claim was unsupported by even probable evidence, and that Hadley's and Godfrey's inventions were both original, but that the second form (which is almost the same as the common sextant now employed) of Hadley's instrument was far superior to his first form and also to Godfrey's. See *Engineer's Transit.*

SEYMENY BASSY.—An appellation given to the Lieutenant General of Janissaries in the Turkish Service.

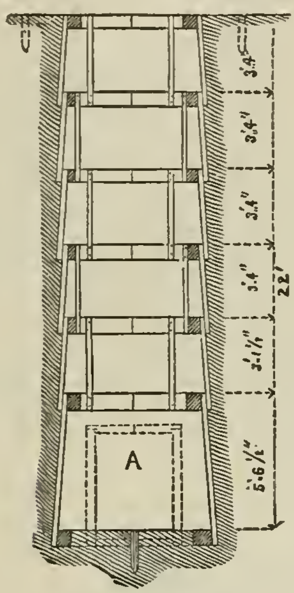
SEYMOUR HORSE-SHOE.—This shoe, a recent invention, possesses several advantages over most shoes, and is specially adapted for campaign and rough service. The nails required to hold the shoe in position are very small, and three on a side are amply sufficient. The heads of the nails being also well driven into the countersink are fully protected from disturbing forces, by being at the bottom of the corrugations. The shoe is ready to nail on when it leaves the factory, and requires no work whatever except in the special cases of suiting the exact shape of certain hoofs. It possesses the very great advantage of permitting the *frog to get to the ground*, in order that it may assert itself, keep in a good condition, and fulfill its natural and proper functions of keeping the heels well spread, defending the wall from concussion, and thereby lessening the liability to diseases and complications of the feet, legs, and shoulders. Very many of the troubles incident to the limbs of horses are due to *high-heel calks*; keeping the frog from the ground and thereby depriving it of the exercise it should have to keep it healthy and in good order. Another feature of advantage in this shoe is, that it is admirably adapted for use on "interfering" horses. No part ever projects beyond the hoof. See *Horse-shoeing.*

SHABRACK.—A Hungarian term, generally used among Cavalry Officers, to signify the cloth furniture of a troop-horse. Also written *Shabraque.*

SHACKLE.—In artillery material, the iron ring attached to a triangle gin, from which the block and tackle are suspended. It is fastened to the upper part of the prypole and cheeks by means of a bolt called the "shackle bolt." The term is also given to the ring at the end of the shaft of an anchor.

SHAFT.—A vertical pit made in the earth and well lined with sheeting to keep the soil from caving in, frames being placed horizontally and at suitable intervals apart to sustain the pressure on the sheeting. The cross sections of shafts are either square or rectangular; the dimensions of the sides of the section depending on the object of the shaft. When the object is to drive a gallery from the bottom of the shaft, the dimensions of the shaft-frames, in the clear, must be at least equal to that of the gallery, measured from out to out of its sheeting. A shaft sunk for establishing a mine-chamber simply, should usually be of the least dimensions; which, to allow the miner to work with facility, are at least 3 ft. by 2 ft. in the clear. Two kinds of frames are usually requisite in sinking shafts, a *top frame*, formed of four pieces, halved to fit each other, which, when put together, have the same dimensions in the clear as the shaft; each piece projecting beyond the sides, or having an *over length* of 1½ to 2 ft. and a *side frame* which also consists of four pieces of smaller scantling than the top frame, halved at the ends to fit; its dimensions from out to out being the same as of the top frame in the clear. In very loose soil it may be necessary to use a temporary frame, termed an *auxiliary frame.* This is somewhat larger in the clear than the ordinary shaft-frame, and is used only for a temporary purpose in setting the ordinary frame. The opposite pieces of each frame are marked with a saw-cut, termed a *score*, at their middle, on the upper side. The scores serve to fix the position which the frame should occupy when laid. The scantling for top frames is usually 6 in. square; that of side and auxiliary frames $4\frac{1}{2}$ in. for a shaft over $4\frac{1}{2}$ ft. in the clear. For smaller shafts the scantling may be of smaller dimensions.

To construct a shaft in a loose soil, there will be

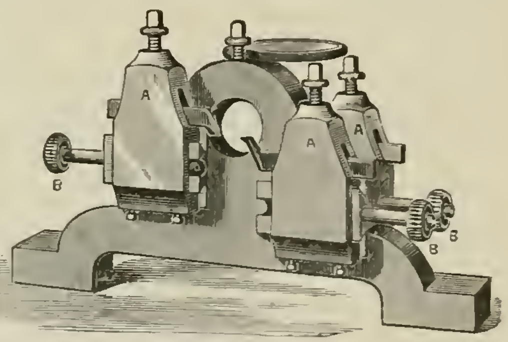


Vertical Section of Shaft showing the Frames and Gallery A at bottom of Shaft.

required a top frame; five side frames for the intervals above estimated; two for the remaining lower portion of the shaft; one auxiliary frame; four battens for each interval, each of the length of the interval added to the thickness of the shaft-frame; from twelve to twenty square pickets about 18 inches long; with the machinery and mining tools requisite for the operation. The work is laid out by first driving a picket to mark the axis of the shaft, and two others which, with the first, should be in the vertical plane containing the axis of the gallery. A level bed is then made for the top frame; the pieces of which are accurately laid and confined by pickets, one at the end of each piece; care being taken to drive the two pickets of each piece at the same time, so that their true position may be kept. Other pickets may be driven temporarily on the outside of the frame, at the angular points. After the frame is laid the accuracy of its position is tested by seeing whether the distances from the center of the central picket to the interior angular points, or, in other words the *semi-diagonals* of the figure, are equal; if they are the position is correct. The excavation is next commenced, and, if the crumbling of the soil does not interfere, may be carried as far as the position of the first frame below the top frame; the sheeting boards, inserted between the sides of the excavation and the exterior of the top frame, being gradually advanced with the excavation. Having reached its place, the first side frame is hung by four battens, two being nailed to each piece of the opposite sides of the top frame, and also to the two corresponding pieces of the side frame, the halvings of which are turned upwards; after these pieces are adjusted by their scores, and securely fixed by the battens, the other pieces are laid on them, with the halvings down, and secured by nails. This frame being fixed, the ends of the sheeting of the next interval may be inserted between it and the sheeting of the first interval, and the excavation continued. The soil now becoming troublesome by its crumbling, measures must be taken to retain it firmly until the second frame is laid. For this purpose the auxiliary frame is introduced, and hung midway in the interval, as the ordinary frames. The sheeting which, thus far, has been gradually advanced with the excavation, is also inclined outwards at bottom, to gain room for the auxiliary frame, by wedges inserted between the boards of the two intervals. After the auxiliary frame is fixed, the excavation and sheeting are carried on to the end of the interval, the next frame is hung, and the sheeting for the new interval introduced. The auxiliary frame is now removed and placed in the next position it is to occupy, as soon as reached by the excavation. The work proceeds in this order until the shaft is completed; then a picket is driven in the bottom to make the central point. A sketch made to a suitable scale, should be in hand for immediate reference in conducting such works. This is more particularly necessary for gallery work, the sketches for which should be very accurately drawn, referenced, and numbered; as they serve not only for reference to guide the miner, but to determine the positions and dimensions of some of the important portions. See *Auxiliary Frame*, *Gallery*, *Shaft Intervals*, and *Shafts à la Boule*.

SHAFTED.—In Heraldry, borne on a shaft. This term is applied to a spear-head.

SHAFTING ATTACHMENT.—A useful device employed in the armory. When used in connection with the usual form of lathe, it makes a convenient arrangement for turning a large amount of shafting,



and does not lessen the value of the lathe for general or other special work, as it can be easily removed.

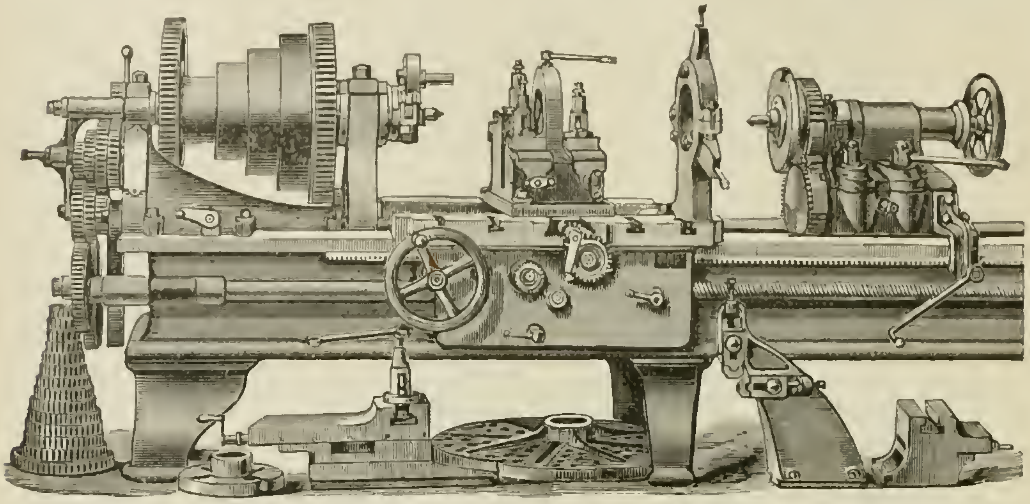
It consists of a *heavy arch piece* bolted on to the rest or carriage, carrying *three turning-tools*, two on the front and one on the back of the shaft, and having a hole bored out in the upper part of the arch to receive bushes for steadying the shaft while turning, or to hold fluted rings for finishing the shaft.

The first tool on the front takes off the first chip, and the tool on the back turns the shaft to its proper size.

After it passes through the bush the water-polishing tool finishes the shaft, leaving it *perfectly round and smooth*. The drawing represents the attachment as made by the Pond Machine Co., and used in the United States armories and factories. Each tool-holder, A, is adjustable by a screw, B, operating the tool block. See *Lathe*.

SHAFTING-LATHE.—A lathe much used in all armories for turning rods for shafting. The shaft is usually held between two tail-centers and is dressed off longitudinally by a series of annular cutters secured to a slide rest. The shaft may be rotated, in which case the cutters in the annular holder will be modified to suit the direction of cut.

The drawing shows a shafting-lathe, swinging 28 inches over shears; 21 inches over rest-carriage; the cone has four changes for $3\frac{1}{4}$-inch belt; double geared; steel spindles; metal boxes; dead spindle clamped by adjustable conical binder; hand movement of the carriage by a balance-wheel attached in wrought-iron rack on bed; reverse feed motion to apron attached to rest-carriage; independent-geared friction feed; compound tool-rest; cross feed; self-oiling slides to carriage; slide block for turning pulleys; turning and screw-cutting feeds cannot be engaged at the same time; large and small face plates;



screw and screw-gearing, with standard and traverse rests; counter-shaft, hangers, pulleys, 20 × 8 inches, to run 75 turns per minute, with 10½ feet bed, to turn a 6 feet shaft; the weight is about 5500 pounds. See *Lathe*.

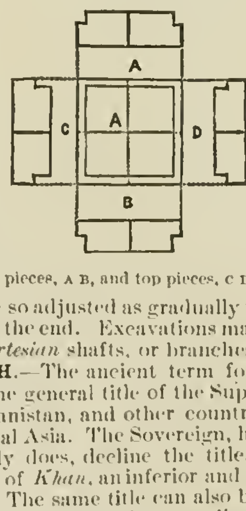
SHAFT INTERVALS.—The term *interval*, both in shafts and galleries, expresses the distance between two adjacent frames added to the thickness of the scantling of one frame, and measured in the direction of the axis of the shaft, etc. With scantling and sheeting of the usual dimensions, the interval should not be greater than 3½ ft. Having given the depth of a shaft, and the height of a gallery to lead from the bottom of the shaft, we may estimate the shaft interval as follows: take the height of the gallery frame, estimating from the top of its ground sill to the top of the cap sill; the thickness of the top sheeting; and the thickness of the shaft frame; two inches for free space between the gallery frame and the shaft frame next above it, to introduce the top sheeting, and add them into one sum; subtract this sum from the total depth of the shaft, and divide the remainder into any convenient number of equal or unequal intervals, each not greater than 3½ feet, for the shaft interval required. See *Shaft*.

SHAFT-IRONS. Rectangular bands or brackets of iron, fastened to the lower surface of the splinter-bar, by means of which the shafts are attached to it.

SHAFTS.—The thills of a carriage, attached to the splinter-bar. The chief point of strain on the shafts, both vertically and horizontally, is by the splinter-bar; here, therefore, their sectional dimensions should be the greatest, tapering off vertically and horizontally both towards foot and point. The shaft sockets or crutches are liable to severe straining pressures in directions *opposite* to the *traction*, as well as to transverse pressures. Their form and mode of union with the axletree-bed or futchells must be specially designed to withstand these strains.

SHAFTS A LA BOULE.—These shafts are lined with frames made of plank, as shown in the drawing. This kind of shaft can only be used with advantage in favorable soil, on account of the difficulty of introducing the frames sufficiently near each other: they are commonly placed one foot apart, as shown in drawing. Large gabions, 6 ft. long, and from 3 ft. 6 in. to 4 ft. in diameter, are sometimes used for lining of shafts, near the surface, smaller gabions being introduced as the work is proceeded with

For the purposes of quickly establishing small camoutlets and fougasses, a boring-apparatus has been resorted to, the diameter of the boring-tool being 4 in. This machine is worked like ordinary tools of this kind. The chamber is charged by inserting powder in cylindrical cartridges of somewhat less diameter than the shaft, which are well pressed forward. If a large charge is requisite the end of the shaft can be enlarged by a tool with a joint, which will admit



Plan A, under pieces, A B, and top pieces, C D, of shaft case.

the tool to be so adjusted as gradually to increase the excavation at the end. Excavations made in this way are termed *artesian* shafts, or branches. See *Shaft*.

SHAG BUSH.—The ancient term for a hand-gun.

SHAH.—The general title of the Supreme Ruler in Persia, Afghanistan, and other countries of Southern and Central Asia. The Sovereign, however, may, and frequently does, decline the title, assuming in its place that of *Khan*, an inferior and more common appellation. The same title can also be assumed by any of the Shah's son, and upon all the Princes of the Blood the cognomen *Shah-zadeh* is bestowed.

SHAMBRIE.—A long thong of leather, made fast to the end of a cane or stick, for the purpose of animating a horse, or of punishing him if he refuses to obey the rider.

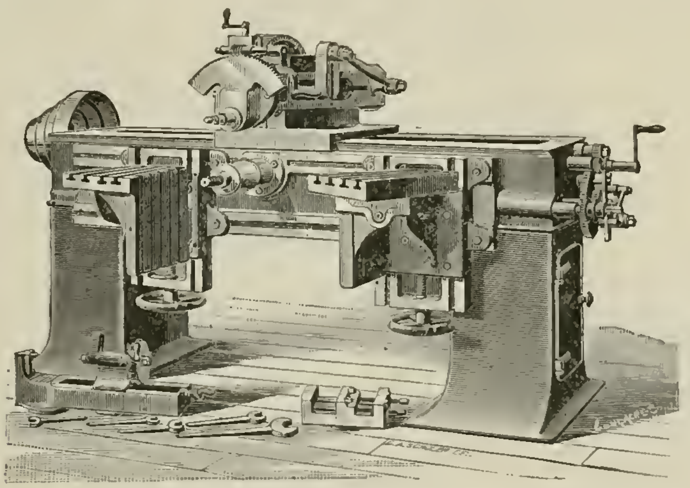
SHAM DAMN.—A very inferior quality of iron used in the manufacture of cheap guns.

SHAMROCK.—A national emblem of Ireland, a leaf with three leaflets, or a plant having such leaves, sometimes supposed to be the wood sorrel, but more generally believed to be some species of clover, or perhaps some common plant of some of the nearly allied genera, as the bird's-foot trefoil, or the black medick. It is not improbable that the name has a sort of general reference to plants with trifoliolate leaves, and that a more exact determination of the species may be as difficult as the attainment of botanical accuracy in regard to the emblematic thistle of Scotland.

The small-leaved clover *(trifolium repens)* has had superstitious respect attached to it from early times. According to the elder Pliny no serpent will touch it. It is said to have been first assumed as the Badge of Ireland from the circumstance that St. Patrick made use of it to illustrate the Doctrine of the Trinity. See *Trefoil.*

SHANK.—A large ladle to contain molten metals; it is worked by a straight bar at one end, and a cross-bar with handles, called the *crutch,* at the other end, by which it is tipped to pour out the metal. Shanks are made of various sizes, from those handled by two men to those containing several tons, and slung from a crane. Nasmyth, of Manchester, England, has added to the pivot of the large crane-ladle a tangent-screw and worm-wheel, by which it may be gradually tilted by a man standing directly in front and at any convenient distance.

SHAPING MACHINE.—A metal planing-machine in which the object is dogged to a table with vertical and horizontal adjustment, or to a mandrel, and the tool above it has a reciprocating motion. The machine, in various sizes, is adopted for a variety of work in the arsenal. In the 14-inch machine, shown in the drawing, the cutter-bar has an adjustable stroke of 14 inches, or any less distance, is 30 inches long, and has a bearing upon the saddle of 28½ by 8 inches.



By means of an eccentric, in combination with a slide, the tool has a nearly uniform cutting stroke, and, as a resultant, a quick return and consequent saving of time in doing work. The saddle-slide that holds the cutter-bar is fed longitudinally by a screw extending from end to end of the machine. The tool-head on the cutter-bar has an automatic angular feed, the degree of the angle determined by a graduated disc. It has also a circular feed, designed for planing the inner arcs of circles. The machine has also an independent, automatic, circular feed, which will feed the entire circle, a device that greatly increases the capabilities of the tool. A spindle with two cones accompanies this circular feed. The base of the vise is grduated, and has a cross movement of 3 inches, by means of a crank-wrench. The vise can be readily removed, so that both platens may be used to support long pieces. The platens are gibbed to the vertical ways so that no dirt can fall between them and the ways when the bolts are loosened. The slides and surfaces are carefully fitted by scraping. The speed of the countershaft, having 14 by 4-inch tight and loose pulleys, is 220 revolutions per minute. The traverse of the saddle-slide on the bed is 50 inches. Weight of the machine, 5,100 pounds. See *Column Shaper* and *Planing-machine.*

SHARP-SHOOTERS.—An old term applied in the army to riflemen. It is now appropriated to naval use, to the men stationed in the top to annoy those on the deck of an enemy's vessel.

SHARPS RIFLE.—This gun belongs to that system in which a fixed chamber is closed by a bolt, by direct action, and in which the lock is concealed. The receiver has a slot in its upper surface for the purpose of loading the chamber or filling the magazine. It is bored through at rear for the reception of the breech-bolt, which is composed of two principal parts, viz: The body and the locking-tube. The bolt is locked by lugs on the locking-tube, turning in corresponding cuts in the receiver. The bolt carries on its upper surface the extractor, which is of the ordinary spring-hook pattern, and in its axis the firing-pin, which extends the whole length of the bolt. The spiral form of the face of the locking-tube, and of the shoulder of the bolt, is such as to cam the bolt up against the head of the cartridge when the bolt is locked.

On the rear face of the locking-tube are two spiral surfaces, which bear against corresponding surfaces of the firing-pin. When the handle is turned down to lock the bolt, the firing-pin spring is compressed between the shoulders on the pin, and nut on the extreme rear of the bolt. On withdrawing the nose of the sear, the firing-pin, under the influence of its spring, moves forward and explodes the cartridge. The shell is ejected by the ejector-pin, which strikes against the lever of the carrier, when the bolt is withdrawn, and is driven forward against the lower side of the head of the shell, while the extractor is pulling on the upper. The firing-pin spring and rear of bolt are protected by a thin shell. The bolt is prevented from being drawn completely out of the receiver by the lever of the carrier and by a key striking on the upper surface of the extractor.

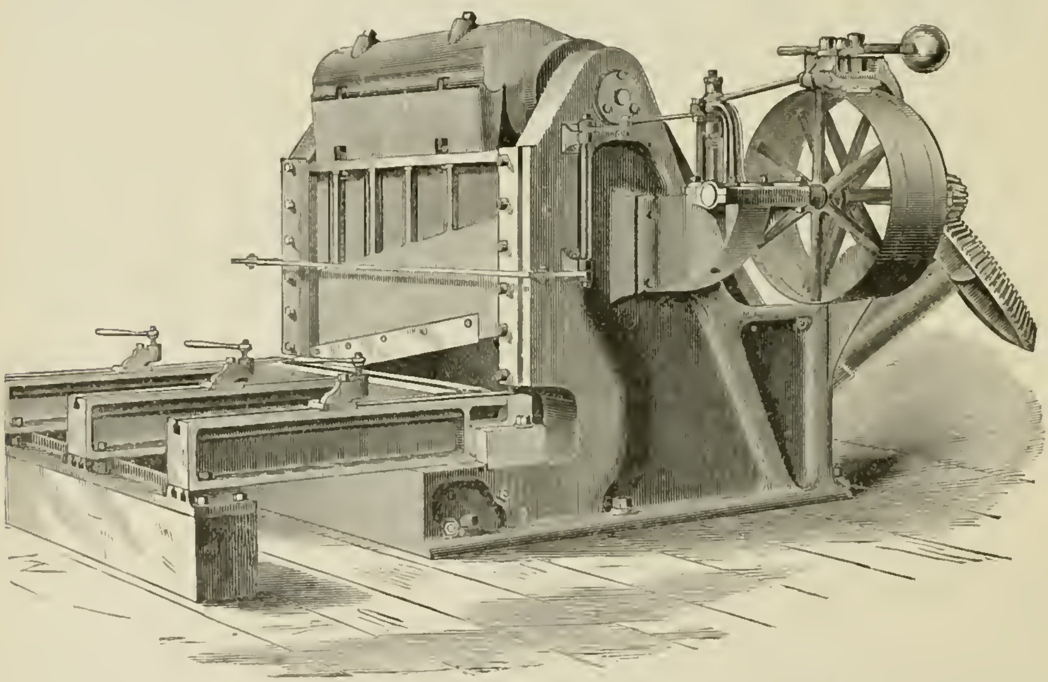
The magazine is in the tip-stock. When the breech-bolt is withdrawn the projection in which the ejector-pin is situated, strikes the lever of the carrier, tipping the latter up in a position oblique to the axis of the bore, bringing the point of the cartridge nearly opposite the center of the chamber. The carrier is held in this position by a pin and spring. When the bolt is closed the cartridge is driven in the chamber, while a projection on the bolt strikes the lever, causing the front of the carrier to descend opposite the mouth of the magazine to receive another cartridge. The carrier is of such thickness at its front as not to uncover the magazine-tube completely when the former rises. Cartridges are thus prevented from escaping from the magazine except when the carrier is in position to receive them. No magazine cut-off is applied to this gun; consequently it can only be used as a single-loader when the magazine is empty.

As a magazine-gun, 3 motions are necessary to operate it, viz.:opened, closed, fired. As a single-loader, 4 motions are necessary, viz.: opened, loaded, closed, fired.

This gun carries 9 cartridges in the magazine, 1 in the carrier, and 1 in the chamber. See *Magazine-gun.*

SHEARING MACHINE.—A machine variously designed, and indispensable in the construction of ordnance, iron carriages, and also armor. The drawing shows the most improved machine of this class, and is made by Wm. Sellers & Co. In designing it, the wants of modern war constructions have been kept in view. The plate clamped to its place can be sheared with exceeding exactness, either in trimming the edge of long plates or cutting off plates five feet wide and under, to lengths. The driving device is new and very efficient. The blade being at all times under the control of the operator, can be made to cut to any fixed point in its length and then stopped or raised. It is provided with an automatic adjustment to its belt-shifting motion, gauging the length of its stroke. It makes the down stroke, immediately reascends, and stops up, to wait for the readjustment of the plate. A hand rod in front of the machine is convenient to shift the belts and start the cut.

The machine is so constructed as to have its strains all within itself, and is not in any great measure de-



pendent upon stone foundations for its rigidity, other than the proper maintaining of the structure in the level position. The vertical slide is arranged to receive curved blades, and the bed-plate, to which the lower blade is attached, is capable of ready removal, to receive a curved bed-plate with a shear-blade bent to match the curve of the upper blade.

The machine as represented is used for trimming edges of long plates, or cutting off to length plates 5 feet wide. It will shear wrought-iron plates of one inch thick. The upper blade is guided vertically in the frame of the machine, and driven down by a pitman as wide as the blade is long; this pitman receiving its motion from a long rocking-shaft above it. The driving-arm or lever of the machine is a rack segment engaging with the teeth of a spiral pinion which is driven by a bevel-wheel and pinion and open and crossed belt, after the manner of planing-machines. The cutting-blade is adjustable in length of stroke, returning at double the speed of its down stroke. Countershaft has 24-inch pulleys, 7-inch face, 272 revolutions per minute.

Another variety of the machine is a very efficient tool for cutting bar-iron. There is a rest provided on which the bar, resting at the required point of cut, can be pushed under the blades when open without stopping the machine, while, as in all shearing and punching-machines, a very convenient stop-motion is provided.

The following are the capacities of the machines, in ordinary use:

Shearing-machine, 26 inches over-reach, will shear plates $\frac{15}{16}$ inch thick.

Shearing-machine, 23$\frac{3}{4}$ inches over-reach, will shear plates 1$\frac{1}{2}$ inches thick.

Bar shearing-machine is capable of cutting iron 6 inches by 1$\frac{1}{2}$ inches.

Plate shearing-machine, having 12 inches stroke, making cut 60 inches long, capable of shearing 1 inch iron plate, over-reach for edges of long plate 7 inches, will cut across plates 5 feet wide at any point of their length.

Lever-shear for angles, will cut 6 inches by 6 inches by 1$\frac{1}{2}$ inches angles square without spoiling the crop end.

Very frequently punching and shearing-machines are combined. The shear is intended for cutting plate-iron of usual thickness, while the punching side has its dies so arranged in a holder as to permit the punching of flanges which are as small as 12 inches in diameter; the punching being done from the outside or marked side; and flanges turned out on end of flues can be punched vertically. The holes in the dies are made larger than the punches by the following formula, expressing the diameter and thickness in sixteenths of an inch. The diameter of the die hole =diameter of punch, plus $\frac{2}{10}$ the thicknes of the plate $(D = d + 0.2t)$. Thus, for iron plate $\frac{6}{16}$ of an inch thick, the diameter of the punch being $\frac{13}{16}$ of an inch, the diameter of the die hole will be 14.2 sixteenths of an inch, say $\frac{7}{8}$ inch. The method of making the die hole larger produces a taper hole in the plate, but allows the punching to be done with less consumption of power and, it is said, with less strain on the plate. To run these machines efficiently, the fast and loose pulley on the machine should make at least 120 revolutions per minute; this will punch 12 holes to the minute; if a faster speed is admissible on the work, the speed of pulleys can be increased. By means of an independent stop motion, one stroke can be made at a time on either side of the machine without stopping the machine itself, or interrupting the work being done on the other side. In this respect it is as convenient as two entirely distinct machines. See *Angle Shearing-machine*, *Lever Shearing-machine* and *Power-shears*.

SHEARS.—The elemental form of a pair of shears consists in two spars fastened together near the top,

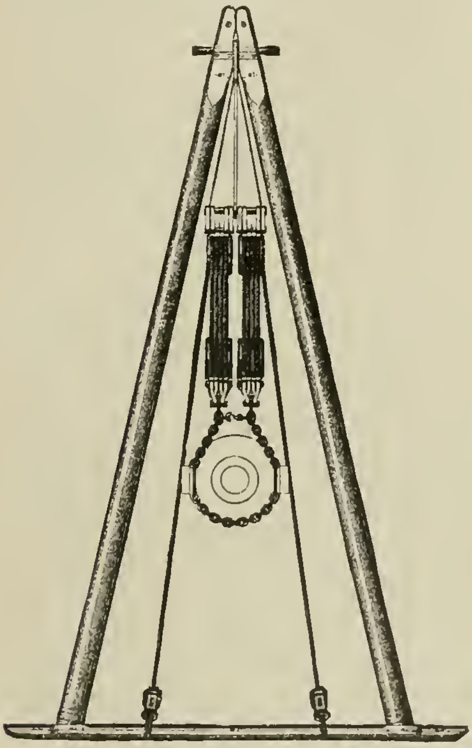


Fig. 1.

with a pully at the point of junction, and held by a rope, fastened to any convenient object, in such a position that the weight lifted hangs nearly between the spars. This forms an easily improvised crane. An apparatus of this kind, of great height and strength, is useful for masting vessels. In the principal dock-yards there are tall permanent shears, mounted either on the side of the masting-dock or on a floating shear-hulk.

Shears are much used for lifting guns and heavy weights over the face of a wall or cliff, or in other situations where the gun could not be used for want of a footing for the pry-hole. The proper dimensions of the spars are given in the table in the next column;

The upper and lower ends are respectively called the *head* and *heel*, and the part where the lashing is applied is termed the *cross*. The stores necessary to equip a pair of shears are: Two *single blocks*, two *double blocks*, one *double block*, one *treble block*, one *snatch block; main-tackle fall*, 100 fathoms 3 to 5-inch Manila rope; *guys*, 50 fathoms 3 to 6-inch Manila rope; *head lashing*, 10 fathoms 3 to 4-inch Manila rope; *heel lashing* (two each), 10 fathoms 3 to 4 inch Manila rope; also *contingencies* (two each), 50 fathoms 3 to 4-inch Manila rope; *main tackle*, one fathom 6-inch Manila rope; *snatch block*, 6 feet 4-inch Manila rope; *holdfasts* (six) each made of 1 fathom 4-inch Manila rope; *contingencies* (six), each made of a half fathom

Weight.	Diameter.	Length.
Tons.	Inches.	Feet.
2	Head 6 to 9 heel.	20 to 30
5	" 10 to 14 "	30 to 40
12 and upwards.	" 14 to 20 "	30 to 45

of 4-inch Manila rope; *spun-yarn* for mousing, stops, etc., one ball of 100 fathoms; two *cleats* for heels, to prevent the lashing from slipping up, made by cutting lengthwise, diagonally, a piece of 6 by 6-inch scantling 2 feet long; twelve *stakes* for holdfasts for guys, 6 feet by 6 feet by 8 inches; four *stakes* for heel-posts, and two *shoes* for heels, 6-inch plank, 15 feet by 15 feet.

To rig the shears, lay the heads of the spars on a trestle about three feet high, the right leg above the left, so that they cross at about twice their thickness from the ends, with the heels in their proper positions. Take a good piece of 3½ or 4-inch rope well stretched, middle it, and make fast to the shear-leg, below the cross; with one end pass the requisite number of figure-of-eight turns around both spars, having each turn well taut, and hitch the end to the upper part of the shear-leg; with the other end pass riding-turns around both legs, filling up the intervals between the first turns; come up with the hitch of the first end, and pass frapping-turns around all parts of the lashing between the shears; finish with a square knot, and stop the ends back with a good spun-yarn stop; if necessary tighten up with wedges. Lay the middle of the back guy in the cross; bring the left-hand end up around the right leg and over the head of the left leg; then carry the right-hand end around under both legs; let it cross over the left-hand end, and seize them together with spun-yarn. Make a bowline knot in the end of the fore-guy and slip it over the head of both legs. Lay the middle of the main-tackle strap under the cross above the fore guy; bring the ends up over the cross; hook the upper block to them under the cross before the fore-guy, *and mouse it*, taking care that the splice comes in the middle of the strap and that the fall leads to the rear.

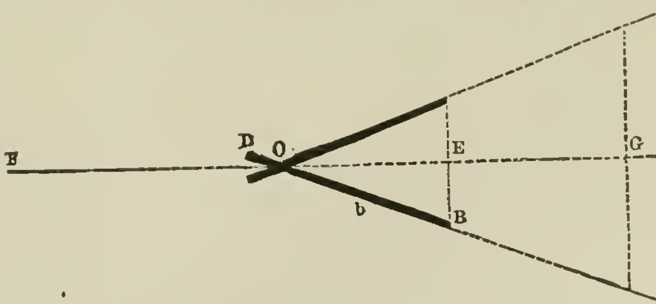


Fig. 2.

Then drive the heel-posts on each side of the heels about a foot toward the head, and one foot outside; lay the shoes under the heels; make a timber-hitch around the inner posts with the heel-lashings; pass three times over the legs below the cleats, and hitch the lashings to the outer posts. Drive four holdfasts for each back-guy as follows; Two on each side the line of the legs prolonged, three feet apart, and two six feet in rear of these. Lay the ends of the guy straps over the front stakes; connect each pair of front and rear stakes with a strap twisted up taut to insure the strain being distributed properly. Drive two holdfasts for the fore-guy, one in the rear of the others in the prolongation of the axis of the shears. Hook the upper blocks of the guy-tackles to a bowline in the end of the guys, and the single block to the guy-strap, and *mouse them all*. Ordinarily the fore-guy can be worked without a tackle, belaying it over the holdfasts, first taking a round turn over the one next the shears.

If not too heavy, the shears may be made by lifting the head and hauling on the guy-tackles, slacking the heel lashings as required, and tending the fore-guy carefully to prevent the shears falling over towards the rear. When raised, hook the snatch-block to a strap placed below the cleat on either leg. If the shears are too heavy to raise in this way, bring both guys together at the heels; form a crutch by lashing together two poles (or use the legs of the garrison gin); place the guys in this crutch; pass the end of a small rope over *both* guys, in *front* of the crutch, down *under* the lashing, and take a rolling-hitch with it around *one* of the guys, in *rear* of the crutch; haul the rope well taut, and secure it to the lower end of the crutch leg. Raise the crutch with an inclination of one-sixth to the front, and heave up the shears by the guy-tackles. When the crutch ceases to act, slack it to the ground by means of the small rope.

The inclination or the *rake* of the shears should not exceed 20 degrees, or four-elevenths of their height, and each leg should have about one-half this inclination. In this position the strain on the guys will never exceed one half the weight. Allowance of seven or eight degrees, or one foot in eight, should be made for the stretch of the guys. The diagram (Fig. 2.) will serve as a guide in placing shears, holdfasts, etc.

Make A B = $\frac{1}{6}$ C E;
C D = 2 *a b*;
E F, E G = at least 2 A C.

When the locality will not admit of rigging the shears in position as described, they may be raised from the foot of the wall or cliff by means of a gin or lighter shears in the following manner:—Pass the shear lashing and attach the front-guy; lash a stout spar across the legs about two feet above the center of gravity, giving the heels the proper spread; fasten a small rope to each heel to serve as guys; hook the gin tackle to a strap firmly attached to the middle of the cross-spar, and heave away, *tending the guys carefully*. As the head of the shears comes above the crest of the wall, put on the back-guys and main-tackle strap, and hook on the tackle; *mouse all hooks;* raise the shears, place the heels on the shoes, pass the heel lashings, set up the guys, and lower the gin to the ground by means of its tackle, leaving the spar in position.

When the garrison or casemate gin is used as shears, the pry-pole is replaced by a parting block of the same diameter. The guys are attached as follows: Middle the rope for the back-guys; push the bight through the clevis from below and slip it around both legs; haul the ends back tight and lay them over the head of the gin to the rear, each part lying between the nearest leg and the parting block, taking care to place canvas under the ropes to prevent chafing. The fore-guy is hitched around the clevis bolt. A single back-guy may be used, formed of a tackle of the same size as the gin tackle, hooked into a strap applied as described for the guy-ropes. In this case particular care must be taken to bring the axis of the shears in the vertical plane containing the holdfast and the center of gravity of the weight to be lifted. The shears are lowered by slacking the guys and heel-ropes, or by using small shears. When no capstan is available, a windlass may be improvised as follows:

Nail a strong cleat on the lower side of each leg, three feet from the heel, butt-end down; lay a round spar a little more than one-third the length of the shears across the legs, one foot above the butt of the cleats, and pass a strong lashing, frapping it loosely between the spar and legs, taking care to have the lashings of equal length, *grease the spar under the lashing*; pass a strap around each end of the spar, put one end through the other, take a round turn around the spar, and put a hand-spike through the free end, to be used as a lever to turn the windlass. The straps should be nailed to the spar to prevent slipping. Additional levers may be applied in the same manner if required. The windlass is chocked by allowing the ends of two hand-spikes (or more) to touch the ground. No person should be permitted to stand or pass under the shears while a weight is being raised. The shears proposed by the Ordnance Department to be furnished for hoisting a 15-inch gun are represented in Fig. 1. See *Cranes*, *Gin*, and *Mechanical Maneuvers*.

SHEAR STEEL.—Blistered or natural steel refined by piling thin bars into faggots, and then rolling or hammering them into the bars after they have been brought to a welding heat in a reverberatory furnace. The quality is improved by a repetition of this process, and the steel is accordingly known by the names *half shear*, *single shear*, and *double shear;* or 1 *mark*, 2 *marks*, and 3 *marks*. See *Blistered Steel*, *Natural Steel*, and *Steel*.

SHEATHE.—To put into a sheathe, a case, or scabbard; to inclose or cover with a sheath or case. *To sheathe the sword*, means to put an end to war or enmity, or to make peace.

SHEETING.—A term applied to the coarse hempen cloth used for making tarpaulins.

SHEIK.—A title of reverence, applied chiefly to a learned man, or a reputed Saint, but also used sometimes as an ordinary title of respect, like the European Mr., Herr, etc., before the name. It is, however, only given to a Moslem. The Sheik Al-Islam is the Chief Mufti of Mohammedanism at Constantinople; a title supposed to have been first assumed by Mohammed II. at his Conquest of Constantinople in 1453, when this place became the Seat of his Empire. The Sheik of Mecca, by virtue of his supposed descent from the Prophet, levies a kind of tribute on all the pilgrims to the Kaaba. The term is also applied to heads of Mohammedan Monasteries, and to the higher order of religious preachers. Sheik Al-Gebal (ancient of the mountain) is the name of the Prince of the Assassins, or those Ishmaelites of Irak, who undertook to assassinate all those whom their chief would pronounce to be his enemies.

SHELL.—A term applied to the semicircular hilts, such as the Spanish rapiers have, which protected one side of the hand.

SHELL-BULLET.—A bullet made of lead, hollow, and oblong, with the pointed end formed like the nipple of a gun, snd pierced to communicate with the interior space, which is filled with powder. A common percussion-cap is placed on the end, and the bullet is then sent home with a concave rammer-head. Fired from a rifle, the bullet goes point foremost, and at the impact explodes the cap and the powder in the bullet, igniting any powder it may come in contact with, or setting fire to any inflammable material. Caissons or ammunition-wagons of any kind may in this way be destroyed.

SHELL-FOUGASSES.—Shells may be buried singly, or in small heaps, and be made to burst either under the ground, or on its surface. If they are to burst under the earth, they must be sufficiently charged to produce a crater, through which the pieces are projected. If they are to burst on the surface, the requisite quantity of powder to produce a crater and throw out the shells must be lodged under them, while these latter need only have a sufficient charge to burst them. In all cases a box is used, divided into two parts by a partition. The shells are placed in the upper part; their fuses project through the partition, and extend from $\frac{1}{2}$ to 1 inch below it. In the lower part, the hose only is placed when the shells are intended to produce their own crater; but powder sufficient to produce the crater is introduced when they are intended to burst on the surface of the ground. The effects produced by common and shell-fougasses are very limited, and only destructive near to their craters, consequently they should not be exploded until the enemy is above them. The following table gives the charges and craters of loaded shells for fougasses:

Description of Shell.	Full Charge of the Shell.		Depth at which the full Charge Produces a Crater	
	lbs.	oz.		
Caliber, 5½	1	0	2′	0″
" 8	2	9	2	10
" 10	5	0	3	6
" 13	11	0	4	7

See *Fougasses.*

SHELL-GAUGE.—An instrument for verifying the thickness of hollow projectiles. It is provided with a set of removable curved arms, each corresponding to a particular variety of shell, which screw into a socket on the leg of the calipers, are inserted within the fuse-hole of the shell. The thickness of the wall is measured between the points of the arm and leg. An arc is so graduated as to show the proper thickness for each caliber, and any deviation beyond certain limits causes the rejection of the shell. It is customary, in the inspection of a shell, when determining thickness of the metal, to take three points at least, on the great circle at right angles to the fuse-hole; also one at the fuse-hole, and one at the bottom. The instrument shown in Fig. 1, is employed to determine the thickness of the shell at all points except at and opposite the fuse-hole. Fig. 2. shows the gauge for the thickness opposite the fuse-hole. See *Calipers, Inspection of Projectiles,* and *Shells.*

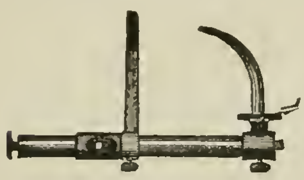


Fig. 1.

Fig. 2.

SHELL-HOOKS.—For mortar and other heavy shells which cannot easily be handled, *shell-hooks* are used. These consist of two bent iron arms connected by a pivot; one end of each is bent inwards to enter the ear of the shell, whilst the other ends are joined to a handspike ring, by two small rings.

A handspike being run through the large ring, and the lower ends of the arms adjusted to the ears of the shell, these ends approach each other, taking hold of the shell as soon as the handspike is raised.

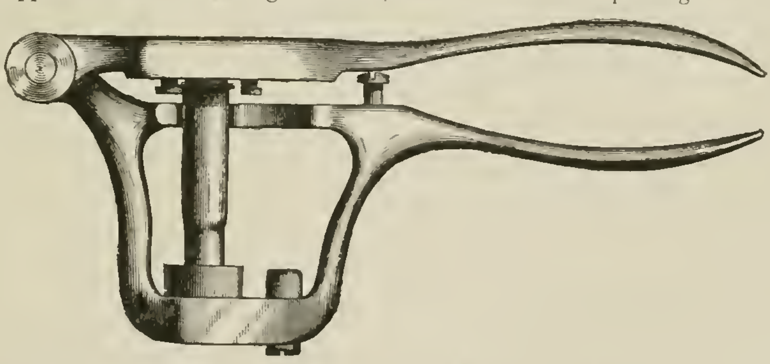
SHELL-IMPLEMENTS.—For transportation, shells are carried uncharged. For charging them, two men and the following implements, in addition, are required, viz.: One set of *powder-measures*, one *funnel*, one *fuse-mallet*, one *fuse-setter*, one *rasp*, two *grummet-wads*, two *wipers*, one *budge-barrel*, together with a supply of fuse-plugs and tow. The fuse-plugs are of wood, and the tow is to stop the fuse-holes until the shells are to be taken to the piece. The shells should be well cleansed on the outside from rust and dirt. This is done at the filling-room of the service magazine. The shells for the howitzer should be strapped to sabots, in which case the loading would be greatly facilitated.

SHELL-JACKET.—A common term for an undress military jacket.

SHELL PLUG-SCREW.—An iron or a hard wooden screw with a handle, used to extract the corks or wooden plugs with which the fuse-holes are stopped. The handle is usually in the shape of a ring about 2 inches in diameter.

SHELL-REDUCER.—An implement for reducing the mouths of cartridge-shells, in order that the bullets may fit very snugly, when loading. The drawing shows a very effective *shell-reducer*, which also performs the office of a shell-expander. After cleaning the shells thoroughly, hold the instrument in the right hand, open far enough to allow the shell to be entered sideways into its seat, catching the flange under the hook of the top piece and entering the open end of the shell into the die; then press the handles together.

This will reduce the shell at the mouth. By opening the handles the shell will be withdrawn from the die; and as it then may be a little too small it can be brought to the exact size of the bullet by the repetition of the same process, using the plug instead of the die. With new shells it will generally be quite sufficient to use the expanding tool only. It is best to always oil the shells slightly on the outside and inside of the mouth, before reducing or expanding them.



SHELLS.—Vessels of metal, containing gunpowder or other explosive compound, so arranged that it shall explode at a certain point, and spread destruction around by the forcible dispersion of its fragments. The invention of this murderous missile cannot be accurately traced. Shells were employed in 1480 A. D. by the Sultan of Gujerat, and by the Turks at the siege of Rhodes, in 1522. The Spaniards and Dutch both used them during the War of Dutch Independence; and they appear to have been generally adopted by about 1634. As shells required mortars for their projection, they were not used in naval warfare until the French constructed special bomb-ves-

	Shell.								Spherical case-shot.			Remarks.
	For S. C. guns.		For mortars.				Field-guns and howitzers.					
	10-inch.	8-inch.	13-inch.	10-inch.	8-inch.	24-p'ndr.	24-p'ndr.	12-p'ndr.	8-inch.	24-pounder.	12-pounder.	
Diameter	9.87	7.88	12.87	9.87	7.88	5.68	5.68	4.52	7.88	5.68	4.52	The 8-inch mortar shell is used in the 8-inch siege howitzer. The 15-inch shell is 14.85 inches in diameter; it has ears at the extremities of the diameter at right angles to the fuse-hole. Thickness, 2.5 inches. The fuse-holes of shells and spherical case-shot for the fuse-plug taper 0.15 inch to 1 inch.
Thickness of side and bottom — True	2	1.5	2.5	1.6	1.25	0.9	0.9	0.7	0.7	0.55	0.45	
Thickness of side and bottom — Greatest	2.1	1.58	2.65	1.7	1.33	0.95	0.95	9.74	0.725	0.575	0.475	
Thickness of side and bottom — Least	1.9	1.42	2.35	1.5	1.17	0.85	0.85	0.66	0.625	0.525	0.425	
Thickness at fuse-hole	3	2.25	2.6	1.6	1.25	1.35	1.35	1.05	1.5	1.1	0.9	
Depth of recess for fuse	....	....	....	....	....	....	....	....	0.4	0.4	0.4	
Diameter of fuse-hole — Exterior	1.45	1.338	1.8	1.75	1.3	0.9	0.9	0.9	1.62	1.62	1.62	
Diameter of fuse-hole — Interior	1	1	1.25	1.51	1.113	0.698	0.743	0.743	0.75	0.75	0.75	
Distance between ears	6	5	7	6	5	....	....	....	....	....	....	
Weight	102	50	218	88	41	16.8	16.8	8.34	30.36	12.32	6.22	

sels in 1681; but since that period, shell-guns, being cannon of large bore, have been introduced, and shells are now employed by all ships of war.

Until within a few years, every shell was a hollow sphere of cast-iron, varying in thickness from half an in. to 2 in., and in diameter from 5½ in. to 13 inches. The sphere had a fuse-hole (like a bung-hole) an inch across, through which the charge was inserted, consisting of pieces of metal and powder to burst the shell. The hole was plugged by a fuse, which was a tube of slow-burning powder, timed to communicate fire to the charge after the lapse of a certain number of seconds. This fuse might either be kindled by hand the moment before the mortar was fired, or its ignition might be effected by the act of firing itself. The Shrapnel shell, introduced by Colonel Shrapnel of the Royal Artillery, in the year 1808, contained a number of bullets, and being fired at bodies of men, it was timed to explode about 100 yards before reaching them, when the shell burst, and the bullets with the fragments continued their course, diverging continually as they went, until they reached object in a death-cloud. The *concussion shell*, or *percussion shell*, is one in which the charge is fired by the detonation of a cap on striking an object. If sufficiently delicate to explode on touching a soft object, and at the same time not to be exploded by the resistance of the air to its rapid flight, this form of shell is the most certain in execution.

Since the introduction of rifled ordnance, the shell has become the commonest form of projectile. It has ceased to be spherical, and is usually in the shape of an elongated bolt. Several rival shells at present divide public favor, and compete for adoption into war-service. Without noticing the numerous varieties which are in course of trial, the following are well known competitors: The *Armstrong* shell is a pointed bolt of iron (usually percussion), containing an inner "segment shell," made up of 49 segments of cast-iron. Seven of these segments form a circle, or ring, and 7 circles give the necessary length. A coating of lead affords a soft medium for fitting into the grooves of the gun. The shell thus made somewhat resembles a bottle without a neck. The necessary bursting charge having been inserted, the rear end is plugged with lead, the fuse is screwed into the front, and the shell is ready for action. This projectile has a great and accurate range, and its segments cannot fail, on explosion, to do a great damage. The principal drawback has been found in the lead-casing, which is often thrown off in parts soon after the shell leaves the gun, and which thus falls among the foremost ranks of the army using it, sometimes inflicting severe wounds. The *Whitworth* shell is an elongated hexagonal bolt of iron or steel, cast in one piece, and with a bursting charge at the rear end. It explodes on percussion; but the space allowed for the burster is deemed insufficient to produce the full effect which the length and correctness of the weapon's range give cause to expect. The *Lancaster* shell is oval, to fit the bore of the *Lancaster* gun. *Martin's* shell is charged with molten iron, which sets on fire all combustible matter on which it can be thrown. The *Diaphragm* shell, invented by Colonel Boxer, R. A., has an iron division or diaphragm to separate the powder in the shell from any balls or slugs, in order that the friction of the latter may not prematurely cause the powder to explode. A six-pounder diaphragm shell contains 30 carbine-balls, an eight-inch shell, 322 musket-balls. The *Palliser* shell, which is now employed in the British Service, is chiefly remarkable for the hardness imparted to its fire-point by a process of "chilling" during casting. This gives it a great power of penetration into iron plates, etc.

The table in preceding column gives the particulars of the shell, used in the United States Service. See *Carcass, Case-shot, Grenade, Hollow Projectiles, Hotchkiss Shells,* and *Projectiles.*

SHELTER-PITS.—Pits made for the protection of skirmishers. The men make these for themselves.

In most instances it is only necessary to improve a natural cover. These pits may be constructed in ordinary soil in from 3 to 5 minutes. The depth need not be uniform, but should be about ten inches where the man's body will be, and about six inches in other parts. See *Rifle-pit.*

SHELTERS.—1. In a military sense, all those structures which protect the troops in the field. There are many means resorted to for this purpose. When without cover of any description, a shelter may be frequently made by selecting several small trees or bushes, cutting away the lower branches and draw-

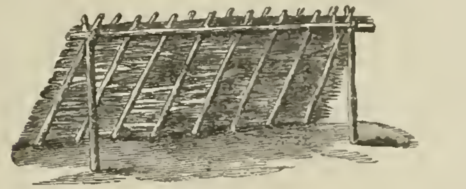


Fig. 1.

ing together and interlacing the upper ones. Others, if needed, may be added—loose grass and twigs being thrown over all. A still more substantial shelter may be made, if the material is at hand, by sinking two forked uprights, as in Fig. 1, placing a horizontal pole across them, inclining a number of shorter poles and closely interlacing small twigs, grasses or reeds. A very simple shelter may be formed by placing the several poles in a semi-circle, and binding the small ends together with a rope or thong and covering this frame with canvas, blankets, hides or brush. It is preferable to the foregoing, having its sides covered.

In very many localities, bark is a most suitable and convenient article for use in the construction of shelters. The Australians strip the bark very rapidly in the following manner: Two rings are cut around the tree; the one as high as can be reached, the other low down. A vertical slit is then made, and the whole piece forced off with axes, &c. In spring the bark comes off readiest from the sunny side of the tree. A large sheet of bark is exceedingly heavy. It is flattened, as it lies upon the ground, by weighting it with large stones, and allowing it to dry, partially at least, in that position. Straw walls of the following kind are very effective as shelters, and they have the advantage of requiring a minimum of string (or substitute for string) in their manufacture. The straw, or herbage of almost any description, is simply nipped between two pair of long sticks, which are respectively tied together at the two ends, and at a sufficient number of intermediate places. The whole is neatly squared and trimmed. A few of these would help in finishing the roof or walls of a house. They can be made movable, so as to suit the wind, shade, and aspect. Even the hut door can be made on this

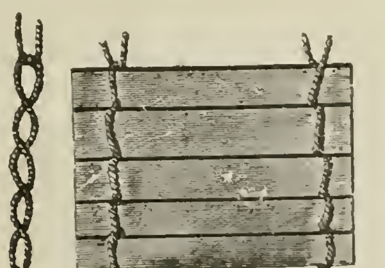


Fig. 2.

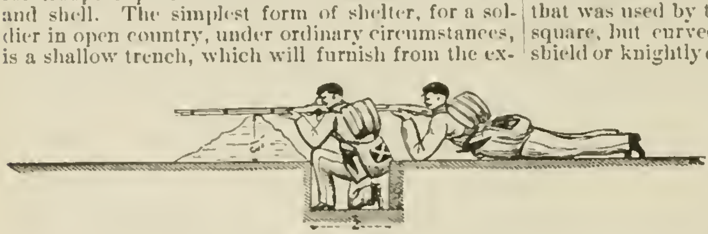
principle. In building log-huts, four poles are planted in the ground to correspond to the four corners: against these, logs are piled one above another; they are so deeply notched where they cross one another, that the adjacent sides are firmly dovetailed together. When the walls are entirely completed, the doors and windows are all chopped out, and the spaces between the logs well caulked with moss, &c., or the log-cabin will be little better than a log-cage. The Malay hitch, shown in Fig. 2, affords a simple way of attaching together wisps of straw, rods, laths, reeds, planks, poles, or any thing of the kind, into a secure and flexible mat; the sails used in the far East are made in this way, and the movable decks are made of bamboos joined together with a similar but rather more complicated stitch. Soldiers might be trained to a great deal of hutting practice in a very inexpensive way if they were drilled at putting together huts whose roofs and walls are made of planks lashed together by this simple hitch, and whose supports were short scaffolding-poles planted in deep holes dug without spades or any thing but the hand and a small stick. The poles, and planks, and cords might be used over and over again for an indefinite time. Further, bedsteads could be made in a similar way by short cross-planks lashed together, and resting on a framework of horizontal poles lashed to uprights planted in the ground. The soldier's bedding would not be injured when being used on these bedsteads, in the way it would be if it laid on the bare ground. Many kinds of designs and experiments in hutting could be practised without expense in this simple way. Few travellers have habitually made snow houses, except Sir J. Franklin's party, and that of Dr. Rae. Great praises are bestowed on the comfort of snow houses by travellers, but skill and practice are required in building them. The mode of erection of these dome-shaped buildings is as follows: It is to be understood that the hard, compact, underlying snow is necessary for the bottom of the hut; and that the looser textured, upper layer of snow is used to build the house. First, select and mark out the circular plot on which the hut is to be raised. Then, cut out with knives deep slices of snow, six inches wide, three feet long, and of a depth equal to that of the layer of loose snow, say one or two feet. These slices are curved, so as to form a circular ring when placed on their edges, and of a size to make the first row of snow-bricks for the house. Other slices are cut for the succeeding rows; and, when the roof has to be made, the snow-bricks are cut with the necessary double curvature. A conical plug fills up the center. Loose snow is then heaped over the house, to fill up crevices. Lastly, a doorway is cut out with knives; also a window, which is glazed with a sheet of the purest ice at hand. For the inside accommodation, there is a pillar or two, to support the lamps. Underground huts are used in all quarters of the globe. The experience of the British troops encamped before Sebastopol tells strongly in their favor, as the habitations during an inclement season. The timely adoption of them was the salvation of the British Army. They are, essentially, nothing else than holes in the ground, roofed over. The shape and size of the hole correspond to that of the roof it may be possible to procure for it; its depth is no greater than requisite. If the roof have a pitch of 2 feet in the middle, the depth of the hole need not exceed 4½ feet. In the Crimea, the holes were rectangular, and roofed like huts. Where there is a steep hill-side, an underground hut is very easily contrived; because branches laid over its top have sufficient pitch to throw off the rain, without having recourse to any uprights, etc.

2. A good defense of a field-work is greatly aided by shelters, arranged for the men and the stores, so that the men can rest in them, and the stores can be kept safe from the enemy's fire. The shelters generally used are known as bomb-proofs and splinter-proofs, which differ from each other only in capacity and strength. Bomb-proofs must be strong enough to resist the effects both of the impact and of the explosion of the projectiles which strike them. They should be roomy, and when used by the men, should be well ventilated. Splinter-proofs are so placed that they are not exposed to the impact of projectiles.

They are liable to be struck by fragments of shells or splinters knocked off by the impact of a projectile, and are therefore made only strong enough to resist the effects of the flying fragments and splinters produced by shells bursting, or by projectiles striking near them. Bomb-proofs may be built during the construction of the parapets, or after the parapets are finished. The latter is the more usual method. The position in a field-work occupied by a bomb-proof depends upon the size of the work, the kind of trace, degree of exposure of the interior of the work, the convenience of the position, etc. Hence, bomb-proofs are sometimes placed under the parapet; sometimes in the gorge of a half-closed work; sometimes in the middle of the parade, etc.; the position being determined by the circumstances of each case.

Ingress and egress of the men who use the bomb-proof may be facilitated by cutting some steps into the side of the trench. The part of the bomb-proof resting against the side of the trench should be revetted by a covering of plank, fascines, or other suitable material, to keep the shelter dry, and to make it more comfortable. Guard beds should be constructed, when the bomb-proof is wide enough, so that the men can lie down at full length; if not wide enough, benches can be made which will allow the men to assume easy positions. Shelters which are not exposed to the impact of the projectiles of the enemy, need not be so strong as the bomb-proof. It will be sufficient if they are proof against the splinters and fragments of shells produced by the enemy's fire. Shelters of this kind are usually constructed in inclined positions, and they are made by placing strong timbers, or bars of railroad iron, in an inclined position against the surface to be protected, and in juxtaposition, and then covering them with earth sufficient to make the interior safe against the fragments which may strike the shelter. No absolute rule, or set of rules, can be made which will apply to all cases in practice. Each particular work must be considered by itself and in connection with its surroundings. Interior arrangements, extremely necessary in one particular work, might be useless in another; the position occupied by these arrangements in one work might be the very worst places for them in a work of another kind, or in a work situated in a different locality. See *Bomb-proof Shelters*, *Hut*, *Splinter-proof Shelters*, and *Tent*.

SHELTER TRENCHES.—Trenches constructed usually in the presence of the enemy, to provide cover for troops exposed in the field to the action of shot and shell. The simplest form of shelter, for a soldier in open country, under ordinary circumstances, is a shallow trench, which will furnish from the excavation, sufficient earth, when heaped upon the side towards the enemy, to screen the soldier in the trench from the enemy's view. A log laid in front of the trench and the earth thrown over and against it, adds materially to the protection afforded by the shelter. Having arrived on the line (not necessarily straight, but being determined by features of the ground, so as to secure all natural cover), the men either stack or ground arms, and begin to throw the earth to the front (using both hands if necessary) so as to form a parapet from 16 to 20 inches high. All available turf, logs, or rocks should be used as a revetment to the interior slope of the parapet.



One rank kneeling in trench, and file-closers lying down in rear.

When the trench has been made 2 feet wide and 15 inches deep it will afford excellent cover for one rank kneeling in it, and file-closers lying down in rear. If the trench be made 4½ feet wide, it will afford cover for two ranks kneeling inside of it; if it be 7 feet wide, it will allow the men to lie down in it.

The main object of these trenches is to afford cover from the fire of the enemy until the proper moment for advancing against him. They should, therefore, offer no impediment to a forward movement, and troops should be able to march straight over them when necessary. When the trenches form a long line, at every 100 yards or so, to enable the artillery, cavalry, etc., to pass, slight ramps should be formed or intervals left in the trenches, which may at these places be made to overlap.

In about one hour's time, a soldier can make his trench (5 feet wide), to 18 inches throughout and raise the parapet to a corresponding height. This will allow him to take a kneeling position when firing. In from two to three hour's time, the trench can be enlarged to a width of 8 feet, and the earth excavated thrown upon the mound, raising it to a height of 3 feet with a thickness of about 4 feet. A trench of these dimensions allows the soldier to occupy a standing position when firing, and it approximates to the form of trench to be constructed finally, when the position is to be held. See *Hasty Intrenchments*.

SHERLOCK EQUIPMENT.—This consists of a knapsack, two haversacks, two canteens, with waist-belt and straps over the shoulder to support the knapsack, etc.

The knapsack is made of rubber cloth, with a light, square frame of wood to preserve its shape, 11 by 11 inches and 4 inches deep. On the sides are two little pouches containing square canteens.

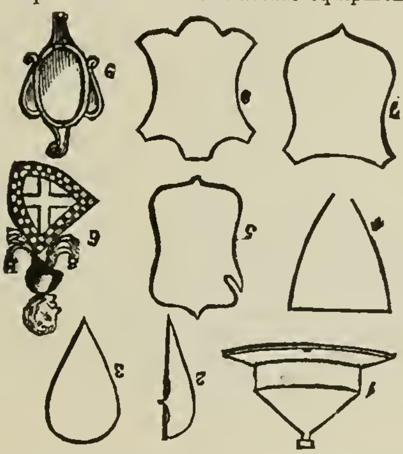
Haversacks are two little sacks suspended on each side of the body under the arms, and attached to a brace-yoke by hooks.

The waist-belt behind is a broad piece of leather, fitting across small of back and supporting bottom of the knapsack. The blanket is rolled and suspended to the bottom of the knapsack.

Straps to waist-belt terminate in brass hooks, adjustable to any size by means of leather keepers.

SHIELD.—A piece of defensive armour, borne upon the left arm, to ward of the strokes of the sword and of missiles. It has been constantly used from ancient times through the Middle Ages, till the invention of firearms rendered it useless. The large shield worn by the Greeks and Romans was circular, and often ornamented with devices. Another form of shield that was used by the Roman heavy-armed infantry, square, but curved to encircle the body. The early shield or knightly escutcheon of the Middle Ages was circular in outline, and convex, with a boss in the center; the body generally of wood, and the rim of metal (No. 1). In the 11th century, a form came into use which has been compared to a boy's kite (No. 2), and is said, with some probability, to have been brought by the Normans from Sicily. It was on all of the shields of this shape that armorial designs were first represented. These shields were in reality curved like the Roman *scutum;* but after Heraldry began to be systematised, we generally find them represented on seals, monuments, etc., as flattened, in order to let the whole armoral design be seen. In the 13th century this long and tapering form began to give place to the pear-shape (No. 3), and a triangular or heater-shape (No. 4). During the 14th century, these new forms became more generally prevalent, and the heater-shape, which was perhaps most frequently represented on armorial seals, began to approach more to an inverted equilateral arch. The same variety of forms, with some modifications, continued during the 15th century, a tendency appearing in all representations of the heater-shaped shield to give it more breadth below. A notch was often taken out in the dexter chief for the reception of the lance, in which case the shield was said to be *à bouche* (No. 5). Subsequent to the middle of the 14th century, when the shield came to be depicted as surmounted by the helmet and crest, the shield is often represented *couché* that is, pendent from the corner (No. 6), an arrangement said to have originated in the practice of competitors hanging up their shields prior to a tournament, where, according to De la Colombière if they were to fight on horseback, they suspended from the sinister chief, and if on foot, by the dexter chief. A square shield denoted a knight-banneret. Shields of arms were often represented as suspended from the *guige*, or shield-belt, which was worn by the knights to sustain the shield, and secure it to their persons.

After the introduction of firearms made shields no longer a part of the warrior's actual equipment, the



Shields.

form of the shields on which armorial bearings were depicted, on seals, monuments, brasses, etc., varied greatly in form, and generally speaking became gradually more tasteless, fanciful, and unmeaning (Nos. 7, 8, 9). A tendency has, however, been shown in recent Heraldry to recur to the artistic forms prevalent in the 14th and 15th centuries.

In early times, shields of the form which generally prevailed at the period. were exhibited on the seals and monuments of ladies; but about the 15th century, the practice began, which afterwards became usual of unmarried ladies and widows (the Sovereign excepted) bearing their arms on a lozenge instead of a shield.

The heraldic insignia of towns, corporations, etc., as well as individuals, are placed on shields. The bearing of Merchants' Marks in a shield was prohibited by the heralds of the 16th century under severe penalties, and yet not a few instances are to be found on monumental brasses of these devices being placed on shields.

SHIFTING-PLANK.—This is usually a piece of $2\frac{1}{4}$ inch plank, 1 foot wide, 5 feet 7 inches long, and beveled at both ends on opposite sides. It is used principally for shifting pieces from one carriage to another.

SHINGLING-MILL.—A rolling-mill or forge, where puddled-iron is hammered to remove the dross, compact the grain, and turn out malleable-iron.

SHOEBURYNESS.—A locality in the County of Essex in England, where Ordnance Experiments are carried out. As far back as 1842, ground was set apart at Shoeburyness as ranges for use and practice of artillery. Since then it has become a School of Gunnery for the regiment of artillery, where two courses of instruction are carried out, viz., the *long* and *short course*. Detachments of the volunteer artillery are sent yearly to Shoeburyness for a training lasting a fortnight.

SHOOTING.—Shooting, with an intent to wound, is felony in the law of England, and punishable with penal servitude for life. The offense consists in the shooting at another, or drawing a trigger, or in any other manner attempting to discharge loaded arms. It is not, however, an offense unless there was a possibility of injuring some person; the intent must not only exist, but the relative situation of the parties must be such that serious injury might have ensued. The extent of the actual wound is immaterial.

SHOOTING-IRON.—A term sometimes applied to a firearm.

SHOP.—An Egyptian iron weapon about six inches in length. Sometimes known as *Khop.*

SHORT-ROLLER.—This roller is formed like the *long-roller*, but is only one foot long. It is used in positions where the long-roller can not act, as between the cheeks of a carriage, in placing the gun in its trunnion-beds, or removing it from them.

SHORT SERVICE.—A period of six years and not less than three, which soldiers must serve in the English Army under the colors. By a recent order from the Horse Guards, recruits enlisting for short service into all regiments but cavalry may do so up to the age of thirty.

SHOT.—This term is applied to all solid projectiles fired from any sort of firearms; those for cannon and carronades being of iron, those for small-arms of lead. The latter are known as bullets and small-shot. The shot used for guns at present vary from the 3-pounder, for boat and mountain artillery, to the 13-in. shot, which weigh about 300 pounds as a shell, or 700 lbs. as an elongated bolt. Generally, shot are cast. There are simple practical rules for calculating the weight of *spherical* shot from the diameter, and *vice versa*, which are often useful in reading of artillery actions. Given the diameter in inches, to find the weight in pounds:—Cube the diameter, and multiply the result by 14; reject the two right hand figures: those remaining will give the weight in pounds. Given the weight in pounds, to find the diameter in inches:—Multiply the cube-root of the weight by 1.923, and the result is the diameter of the shot in inches.

Small-shot are of various sizes, from swan-shot, nearly as large as peas, to dust-shot, and made by dropping molten lead through a colander in rapid motion from a considerable height into water. The lead falls in small globular drops. The holes in the colander vary in size according to the denomination of the shot, No. 0 requires holes $\frac{1}{50}$ in. in diameter, No. 9, $\frac{1}{360}$ inch. The colanders are iron hemispheres, 10 inches in diameter, and coated within with the *cream* or scum which is taken off the molten metal. A small portion of arsenic is melted with the lead, and the fusion in the colanders is maintained by those vessels being surrounded by burning charcoal. The discovery of the advantage attending a long fall was made in England toward the end of the last century. Previously the shot had dropped from the colanders at once into the water. The lead was then so soft that the shot were flattened by the water. The fall through the air enables the lead to cool and harden before taking its plunge. The smaller sizes require less fall than the larger—100 feet suffices for sizes Nos. 4 to 9—the larger sorts demand 150 feet. The highest shot tower is at Villach, in Carinthia, where there is a fall of 249 feet. After cooling, shot are sifted in successive sieves to separate the sizes. Misshapen shot are found by their inability to roll; and finally, the whole are polished by rotary motion in small octagonal boxes, into which a little plumbago has been thrown. See *Bar-shot, Bullet, Projectiles,* and *Solid Shot.*

SHOT BOTTOM.—The block of wood attached to spherical shot and shell to steady them in their passage through the bore of the gun, and to keep the fuse in the axis of the bore when being loaded. The bottom was fastened at one time by tin straps; at another with an adhesive composition. Both methods have been superseded in England by General Boxer's mode, viz.: by attaching the bottom or sabot to the projectile by means of a copper rivet driven through the center of the wood into a small undercut cavity in the shot; the shape of the hole and the malleability of the metal causing the sabot to cleave most closely to the shot or shell.

SHOT-GARLANDS.—Stands on which shot and shell are piled; they are used to retain shot placed on defences, and are made either of iron or wood. Hitherto, garlands have been made of cast-iron and of a square pattern, but they are ordered to be used up and replaced by wrought iron of a rectangular form. They preserve the shot from deterioration, and it is usual to place a tier of unserviceable shot under the serviceable pile.

SHOT GAUGES.—Instruments used for ascertaining the measurement of spherical projectiles. They are simply iron rings with metal handles, and of varying dimensions, for determining the diameter of the shot or shell. Only one high gauge for each caliber is issued. The projectiles should pass in all directions through the high gauge, but must not pass through the low gauge. Ring gauges will also be used for rifled projectiles as well. Low and high gauges are issued to fire-masters and inspectors of warlike stores and store stations. See *Iron Cylinder-gauge.*

SHOT-GUN.—A smooth-bore firearm used for short range shooting. Shot-guns are frequently made double-barreled, and of late years the breech-loading principle has been extensively introduced. Some breech-loaders are provided with interchangeable rifle and shot barrels. The drawing represents the American Arms Company's semi-hammerless single-gun, which combines all the advantages of the hammerless without the *danger* of the self-cocking principle. The extractor is made to allow the shell to be pushed altogether *home* in loading, avoiding any strain on the gun in closing. To cock the gun, press down the little lever on the side. The lockplate is easily removed to get at and oil the lock. Its construction is such that no water or dirt can penetrate to the lock. See *Baker Gun* and *Parker Gun.*

SHOT-LINES.—These lines are intended to be used in connection with a gun or mortar and a projectile, to effect the communication between the shore and stranded vessel, or, in certain cases, between vessels at sea. They should be made of the very best materials. The English method of faking has been adopted in the United States, in laying up these lines for firing. Rockets may be used instead of a gun and projectile for carrying the line.

It is found necessary during firing to have some method of taking up the lines rapidly, and, at the same time, one that would keep them from becoming entangled. A light reel is designed for this purpose which answers all the requirements. This simple contrivance consists of a frame, reel, and crank of wood, and of two wire pins. The frame is dovetailed together, and has four small D-rings attached to it by bits of leather. These rings engage with the snap-hooks of the carrying-braces. The reel is composed of an arbor, carrying cross-pieces at each end. The arbor is retained in the frame by the wire pins.

A strip of leather passes over the extremities of the cross-pieces at each end to keep the radial arms from catching in the line when winding it up. See *Life-saving Rockets.*

SHOT METAL.—An alloy of lead 56 parts, and arsenic 1-part. Used for making small shot.

SHOT POUCH.—A receptacle for small shot, carried on the person. It is usually made of fine leather, the mouth-piece being provided with a measure, having an adjustable cut-off to determine the quantity of the charge. The pouch is sometimes adapted for carrying charged cartridges. It has two receptacles, united behind by a strap and buckle, and communicating with a common mouth-piece, which has a gate permitting the escape of one cartridge at a time.

SHOT-TABLE.—The device for insuring the equal shrinkage of shot in all directions while cooling. It has an annularly grooved surface with a conoidal central projection, and turns on an upright spindle. The hollow spherical mold is placed thereon after the cast is made, and rotated until the casting is cool enough to be removed.

SHOT-TOWER.—A lofty tower for making shot by dropping from its summit melted lead, which cools in the descent, and is received into a cistern of water or other liquid.

SHOULDER.—That portion of the axle-tree body immediately contiguous to the arm. Also, the upper part of the blade of a sword.

SHOULDER ANGLE.—In fortification, that angle formed by the meeting of face and flank of a bastion.

SHOULDER-BELT.—A very wide belt worn over the shoulder for various purposes. The belt is usually crossed from the right shoulder, and supports the cartridge-box, or other articles of equipment. In some armies the sword is suspended from the shoulder-belt. See *Belt* and *Sword-belt.*

SHOULDER-KNOTS.—The ornamental knots of gold cord on cloth of the same color as the facings of the arm to which the officer, wearing them, belongs. The insignia of rank and number of regiment or corps are embroidered on the cloth ground. The prescribed patterns for the United States Army, are as follows:

For Officers of the Adjutant General's and Inspector General's Departments, and for Aides-de-Camp to General Officers.—Of gold cord, Russian pattern, on dark blue cloth ground; insignia of rank and letters of corps or designation of regiment embroidered on the cloth ground, according to pattern; an aiguillette of gold cord is to be worn with the right shoulder-knot, according to pattern.

The aiguillette, instead of being permanently attached to the shoulder-knot, may be made separate, so as to be attached to the coat underneath the knot by means of a strap or a tongue passing through the lower fastening of the knot.

For Officers of other Staff Corps.—Same as above described, without the aiguillette.

For Officers of the Signal Corps.—Same as above described, without the aiguillette. The distinctive insignia will be according to the pattern deposited in the office of the Chief Signal Officer.

Whenever the full-dress coat is worn by officers on duty, the prescribed epaulettes or shoulder-knots are attached. Letters are embroidered on the shoulder-knots in old English.

For the Engineer Corps.—A silver turreted castle of metal one and four-tenth inches in width by nine-tenths of an inch in height.

For the Ordnance Department .—A shell and flame in silver embroidery one and four-tenths inches in width by nine-tenths of an inch in height.

For Officers of Cavalry, Artillery, and Infantry.—

For a Major.—Two gold embroidered leaves, one at each end of the pad.

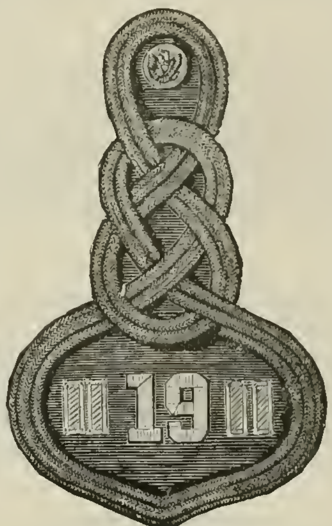
For a Captain.—Two silver embroidered bars at each end of the pad.

For a First Lieutenant.—One silver embroidered bar at each end of the pad.

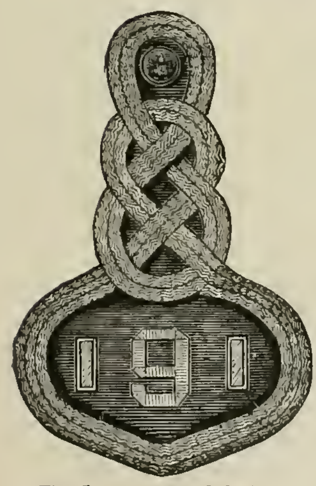
For a Second Lieutenant, or an Additional Second Lieutenant.—Plain. The above insignia are the *same* as prescribed for the shoulder-straps. See *Epaulettes.*

SHOULDER-STRAPS.—Narrow straps, 1$\frac{3}{8}$ inches wide by 4 inches long, bordered with an embroidery of gold $\frac{1}{4}$-inch wide. They are worn on the shoulders of Commissioned Officers, and are indicative of rank. They are prescribed as follows in the United States Army :

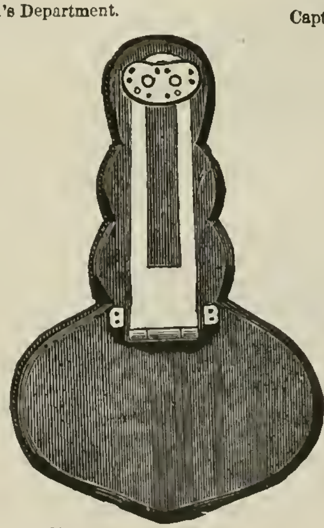
Colonel Inspector General's Department.



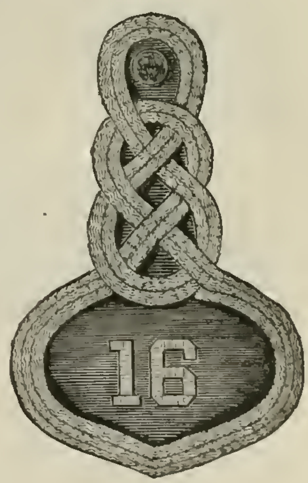
Captain 19th Infantry.



First Lieutenant 9th Infantry.



Shoulder-knot Fastening.



Second Lieutenant 16th Infantry.

Of the same pattern as for the Staff Corps, but on cloth of the same color as the facings of their arm, with insignia of rank and number of regiment embroidered on the cloth ground, according to pattern.

For Regimental Adjutants.—Of same pattern as for other officers of their arm, but having aiguillettes attached.

The insignia of rank on the shoulder-knots is as follows :

For a Colonel.—A silver embroidered eagle at the center of the pad.

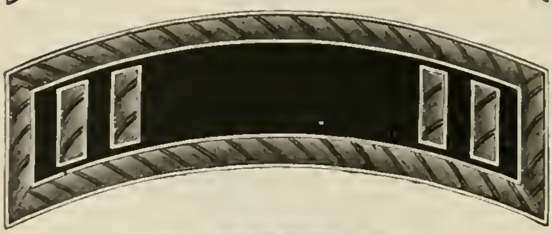
For a Lieutenant Colonel.—Two silver embroidered leaves one at each end of the pad.

For the General of the Army.—Dark blue cloth, one and three-eighths inches wide by four inches long, bordered with an embroidery of gold one-fourth of an inch wide; two silver-embroidered stars of five rays each, and gold-embroidered "Arms of the United States" between them.

For Lieutenant General.—The same as for the General, except that there will be three silver-embroidered stars of five rays, one star on the center of the strap, and one on each side, equidistant between the center and outer edge of the strap, the center star to be the largest.

For a Major General.—The same as for the Lieutenant General, except that there will be two stars instead of three; the center of each star to be one inch from the outer edge of the gold embroidery on the ends of the strap; both stars of the same size.

For a Brigadier General.—The same as for a Major General, except that there will be one star instead



of two; the center of the star to be equidistant from the outer edge of the embroidery on the ends of the strap.

For a Colonel.—The same size as for a Major General, and bordered in like manner with an embroidery of gold; a silver-embroidered spread eagle is on the center of the strap, two inches between the tips of the wings, having in the right talon an olive branch, and in the left a bundle of arrows; an escutcheon on the breast, as represented in the "Arms of the United States." Cloth of the strap as follows: For the General Staff and Staff Corps, dark blue: Artillery, scarlet; Infantry, sky-blue; Cavalry, yellow.

For a Lieutenant Colonel.—The same as for Colonel, according to corps, omitting the eagle, and introducing a silver embroidered leaf at each end, each leaf extending seven-eighths of an inch from the end border of the strap.

For a Major.—The same as for a Colonel, according to corps, omitting the eagle, and introducing a gold-embroidered leaf at each end, each leaf extending seven-eighths of an inch from the end border of the strap.

For a Captain.—The same as for a Colonel, according to corps, omitting the eagle, and introducing at each end two silver-embroidered bars of the same width as the border, placed parallel to the ends of the strap, at a distance between them and from the border equal to the width of the border.

For a First Lieutenant.—The same as for a Colonel, according to corps, omitting the eagle, and introducing at each end one silver-embroidered bar of the same width as the border, placed parallel to the ends of the strap, at a distance from the border equal to its width.

For a Second Lieutenant, or an Additional Second Lieutenant.—The same as for a Colonel, according to corps, omitting the eagle.

For Chaplains.—A shoulder-strap of black velvet, with a shepherd's crook of frosted silver on the center of the strap, may be worn.

Officers serving in the field may dispense with prominent marks likely to attract the fire of sharp-shooters; but all officers must wear the prescribed shoulder-strap, to indicate their rank. It is worn whenever the epaulette or shoulder-knot is dispensed with.

SHOWER.—A term often applied to gold-rain, small stars of slowly burning composition, etc., constituting the decoration of a rocket or shell, and which produce the effect of a shower of fire in falling.

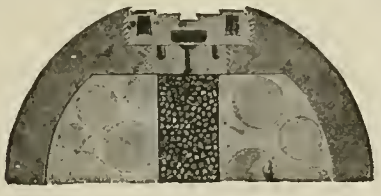
SHRAPNEL.—Thin-sided shells, in which also are placed, besides the bursting-charge of powder, a number of small balls embedded in sulphur. They are cast in the same manner as ordinary shell, excepting that their sides are made thinner to allow for a greater number of balls. The charge of powder is quite small, being only sufficient to rupture the case and liberate the balls.

The thickness of the metal should be such that it will resist the explosion of the charge within the bore of the gun, but open readily with a small bursting-charge. The bursting-charge should be merely sufficient to open the shell without affecting the flight of the bullets. A spherical shell of this class has a less thickness of metal than a common shell, viz., about one-tenth of its diameter, and its weight when empty is about half that of a solid shot of similar diameter.

To fill a shrapnel a funnel is screwed into the fuse-hole, and the case filled with the requisite number of balls. A round, hollow steel mandrel, made slightly tapering towards the lower end, which is rounded off, and having a score cut on either side throughout its length, to admit of a free passage for the melted sulphur to the interior of the shrapnel, is driven and worked through the fuse-hole to the bottom of the case. The projectile is thoroughly warmed, generally in warm water, to prevent the cold metal from solidifying the sulphur before it has filled all the interstices.

It is then filled with melted sulphur, and as soon as the sulphur is set, the mandrel is withdrawn: this is accomplished by first heating it from the interior by the insertion of a hot rod, when it is readily removed. The funnel is also removed, and the magazine formed by the mandrel is cleaned, and the fuse-hole carefully tapped out. In this magazine is deposited the charge of powder, where it is protected against all injury from the movement of the balls. By this arrangement the quantity of powder required to open the shrapnel is very small, and the bullets are prevented from striking by their inertia against the sides of case and cracking when the piece is fired.

Lead being much more dense than iron, the shrapnel is, when loaded, nearly as heavy as a solid shot of the same caliber for the lighter guns. A shell of this class, is in fact, simply a canister-shot adapted to long range. The rupture may be made to take place



at any point of its flight; and in this respect it is superior to canister and grape, which begin to separate the moment they leave the piece. See *Boxer Shrapnel Shell*, *Case-shot*, *Projectiles*, and *Rifle-shrapnel*.

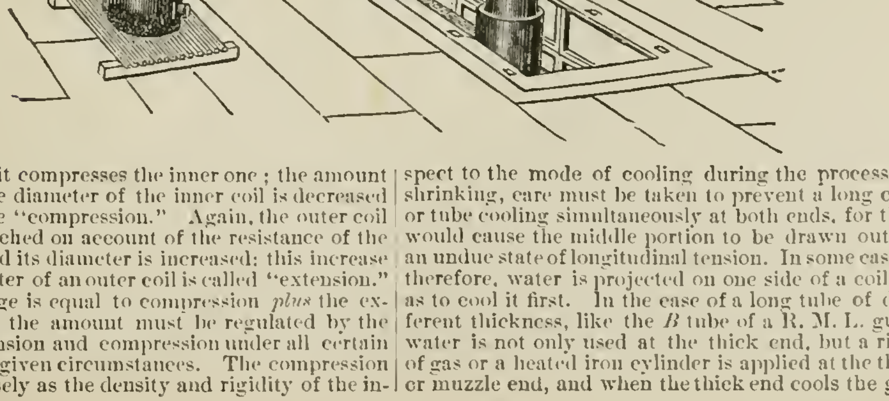
SHRAPNEL FUSE.—The French, in the affair of Traktir, made good use of shrapnel with a fuse of the following description: It was made of hard wood having three channels parallel to its axis. These were filled to different heights with composition, corresponding thus to three different bursting distances. Each of these channels was provided with a tin tube in which the composition was placed. The longest channel was always left open. The other two were closed with a covering of leather, over which was placed, for the shorter column, a disk of rose-colored paper, for the other, one of blue. On these paper coverings were marked the distances at which the columns would cause explosion. These distances were also placed on the face of the fuse near the top of the channels. The fuse was capped with a rondelle of fringed paper, over which was placed a plain rondelle of parchment with a piece of tape attached, by means of which the fuse was uncapped. The composition in the three channels burned in $1\frac{1}{2}''$, $2\frac{1}{2}''$ and $3\frac{1}{2}''$. It was proposed to modify this fuse by adding a fourth column, intended to burst the shell at only 250 yards' distance, but at this short distance, canister shot will do quite as well, if not better, than shrapnel.

SHRINKING.—In the construction of built-up guns, the inside diameter of the outer tube when cold must be rather smaller than the outside diameter of the inner tube: this difference in the diameter is called the "shrinkage." While the outer coil is cooling and contracting it compresses the inner one; the amount by which the diameter of the inner coil is decreased is termed the "compression." Again, the outer coil itself is stretched on account of the resistance of the inner one, and its diameter is increased; this increase in the diameter of an outer coil is called "extension." The shrinkage is equal to compression *plus* the extension, and the amount must be regulated by the known extension and compression under all certain stresses and given circumstances. The compression varies inversely as the density and rigidity of the interior mass; the first layer of coils will therefore undergo more compression than the second, and the second more than the third, and so on. Shrinking is employed not only as an easy and efficient mode of binding the successive coils of a built-up gun firmly together, but also for regulating as far as possible the tension of the several layers, so that each and all may contribute fairly to the strength of the gun.

The operation of shrinking is very simple; the outer coil is expanded by heat until it is sufficiently large to fit easily over the inner coil or tube (if a large mass, such as the jacket of a Fraser gun, by means of a wood fire, for which the tube itself forms a flue; if a small mass, such as a coil, in a reverberatory furnace at a low temperature or by means of gas). It is then raised up by a traveling crane overhead and dropped over the part on to which it is to be shrunk, which is placed vertically in a pit ready to receive it, as in the drawing.

The heat required in shrinking is not very great. Wrought-iron on being heated from 62° F. (the ordinary temperature) to 212°, expands linearly about $\frac{1}{1000}$th part of its length; that is to say, if a ring of iron 1,000 inches in circumference were put into a vat of boiling water it would increase to 1,001 inches; and according to Dulong and Petit, the co-efficient of expansion, which is constant up to 212°, increases more and more from that point upward, so that if the iron ring were raised 150° higher still (*i. e.*, to 362°) its circumference would be more than 1,002 inches. No coil is ever shrunk on with so great a shrinkage as the $\frac{2}{1000}$th part of its circumference or diameter, for it would be strained beyond its elastic limit. Allowing, therefore, a good working margin, it is only necessary to raise a coil to about 500° F., though in point of fact coils are often raised to a higher degree of temperature than this in some parts, on account of the mode of heating employed. Were a coil plunged in molten lead or boiling oil (600° F.) it would be uniformly and sufficiently expanded for all the practical purposes of shrinking, but as shrinkings do not take place in large numbers or at regular times, the improvised fire or ordinary furnace is the more economical mode, and answers the purpose very well.

Heating a coil beyond the required amount is of no consequence provided it is not raised to such a degree of temperature that scales would form; and in all cases the interior must be swept clean of ashes, etc., when it is withdrawn from the fire. With respect to the mode of cooling during the process of shrinking, care must be taken to prevent a long coil or tube cooling simultaneously at both ends, for this would cause the middle portion to be drawn out to an undue state of longitudinal tension. In some cases, therefore, water is projected on one side of a coil so as to cool it first. In the case of a long tube of different thickness, like the *B* tube of a R. M. L. gun, water is not only used at the thick end, but a ring of gas or a heated iron cylinder is applied at the thinner muzzle end, and when the thick end cools the gas



or cylinder is withdrawn from the muzzle and the ring of water raised upward slowly to cool the remainder of the tube gradually.

SHUNT RIFLING.—This is one of Sir William Armstrongs systems of rifling, and combines both the *centering* and the *compressing* systems. As the inventor deemed it important to prevent the shot from moving laterally, by direct pressure on its sides, instead of by allowing it to center itself, as in the *centrical* system; and, as the expansion system did not meet his views, his ingenious resort was to arrange the rifling so that the shot runs home easily, and is then *shunted*, or switched off, or turned a little in the gun, so that, when it comes out, a shallower position of the groove will nip it, and prevent its lateral movement. The driving-side of groove near the muzzle is made shallow. The projectiles have soft copper studs, which fit easily with a windage of .025 inch into the deep portion of the groove; when the gun is loaded, the studs travel down this deep part until they reach about the middle of the bore, where they meet with an incline, by which they are *shunted* into a narrow part of the groove, of the same depth, down which they travel to the chamber. On discharge the studs bear against the other side of the groove, until they come to the incline, up which they travel, the studs being thereby compressed. With this compression they pass through the remaining part of the bore. There are three grooves with a uniform pitch of one turn in 40 calibers, the edges being angular. This system embraces the theories of centering the projectile and its retardation, the latter of which is now conceded to be a disadvantage. The Russians have a "Shunt system" borrowed from Armstrong's, but differing in details. American guns, on similar principles, have been made experimentally. There is only a minute difference between the diameters of the bore and projectile.

SHUTERNAUL. In the East Indies, a sort of arquebuse, which is fixed upon the back of a camel.

SIBLEY TENT.—A tent of peculiar construction, in the center of which a fire can be made, and all its occupants sleep with their feet to the fire. It is conical, light, easily pitched, erected on a tripod holding but a single pole, and will comfortably accommodate twelve soldiers with their accouterments. Where means of transportation admit of tents being used, this tent is very handy and satisfactory. The tent is still much used in the United States Service. See *Tent*.

SICK AND HURT.—A Board so called, to which the agents, commissaries, etc., belonging to the several military hospitals in Great Britain, were responsible.

SICK CALL.—A military call which is sounded on the drum, bugle, or trumpet, whereby the sick men are warned to attend the hospital.

SICK FLAG.—The yellow quarantine flag hoisted to prevent communication; whence the term of Yellow Flag and Yellow Admirals. There are two others, one with a black-ball, the other with a square in the center, denoting plague or actual diseases.

SICK LEAVE.—A leave of absence granted to officers and military subordinates in consequence of any sickness or disability. In the United States Service, leaves of absence on account of sickness are not granted to go beyond the limits of the Military Department within which they are stationed, unless the certificate of the Medical Officer shall explicitly state that a greater change is necessary to save life, or prevent *permanent* disability. Nor are sick-leaves to go beyond the Department limits given in any case, except of an immediate urgency, without the previous sanction of the War Department.

Commanders of Geographical Departments and Divisions are authorized to grant leaves of absence, on account of sickness, subject to the limits fixed by the General Regulations of the Army for ordinary leaves. The application must be accompanied by Surgeon's certificate of disability. Leaves not are granted unless they originate at the post of duty of the applicant. No application for *extension* of sick-leave will be granted from the Head-quarters of the Army, or the War Department, unless such extension shall have been approved by the Department or Division Commander. On the expiration of a leave of absence on account of any sickness, if the party be able to travel (without endangering his ultimate cure), he will forthwith proceed to his post, although his disability may not have been removed. Exceptions to this general rule must be made in each case by the War Department.

When an officer is prevented by sickness from joining his station, he transmits the prescribed medical certificates, monthly, to the Commanding Officer of his post, and regiment or corps, and to the Adjutant General—all through Department Head-quarters; and when he cannot procure the certificate of a Medical Officer of the Army, he substitutes his own certificate, on honor, as to his condition, the certificate to embrace a full statement of his case. The certificates, when approved by the Department Commander and forwarded to the Adjutant General of the Army, will be sufficient authority for his absence until he is able to travel to his post. If the Officer's certificate is not satisfactory, he will be informed; if satisfactory, the Adjutant General will furnish him, for the advice of the Pay Department and to secure his pay, an official letter of acceptance. Whenever an officer has been absent on account of sickness for one year, he may be examined by a Medical Board and the case specially reported to the President.

When an officer is absent under an accepted certificate of disability, he will be entitled to the same pay as if an order had been issued granting him leave of absence on account of disability.

The following is the form of medical certificate, given by the Medical Officer:

————, of the———Regiment of——, having applied for a certificate on which to ground an application for leave of absence, I do hereby certify that I have carefully examined this officer and find that—[*Here the nature of the disease, wound, or disability is to be fully stated, and the period during which the officer has suffered under its effects*], and that, in consequence thereof, he is, in my opinion, unfit for duty, and not able to travel without endangering his ultimate cure. I further declare my belief that he will not be able to resume his duties in a less period than—[*Here state candidly and explicitly the opinion as to the period which will probably elapse before the officer will be able to resume his duties. When there is no reason to expect a recovery, or when the prospect of recovery is distant or uncertain, or when a change of climate is recommended, it must be so stated.*] Dated at ——, this——day of—— ———— ————

[Signature of the Medical Officer.]

SICKLEGHAR.—An Indian term. A native of India employed in arsenals for cleaning metal work.

SICK REPORT BOOK.—A book in which the names of any of the men who are sick in a company, troop, etc., are entered, also the names of their diseases, and probable cause of same. This book is signed by one of the Company Officers to which the men belong and the attending Surgeon. On the next page is the form of the monthly report of sick and wounded to be made out in duplicate; one copy to be sent to the Medical Director, and the other to the Surgeon General direct. Separate reports are to be made in every case for white and colored troops.

SIDE BARS.—1. The longitudinal side-pieces of a traveling-forge or a battery-wagon. 2. Two plates which unite the *pommel* and *cantle* of a saddle. In some saddles they are of steel, and give elasticity to the seat, which is suspended from the *pommel* and *cantle*.

SIDE BONES.—Enlargements situated above the horse's heels, resulting from the conversion into bone of the elastic lateral cartilages. They occur mostly in heavy draught horses with upright pasterns, causing much stiffness, but, unless when of rapid growth, little lameness. They are treated at first by cold ap-

Station: ————————————————, *Month:* ————————, 18

Mean strength of the command: Officers,——; Enlisted men,——; Total strength,——.

Tabular list of diseases. (Here enter only those diseases of which there are cases, the nomenclature and order of the statistical nosology (Revised Army Regulations, Form 42) being strictly observed.)	Remaining under treatment from last month.	Taken sick or wounded during the month.	Total to be accounted for.	Returned to duty.	Transferred to another hospital or command.	Discharged for disability.	Deserted while under treatment.	Died.	Remaining under treatment.
Total......................									

VACCINATION REPORT FOR THE MONTH.	During the month.	No. of cases	During the month.	No. of cases
	Vaccinated successfully..........	....	Re-vaccinated successfully......	....
	" unsuccessfully......	....	" unsuccessfully..	....

plied continually, until heat and tenderness are removed, when blistering or firing must be resorted to.

SIDE-LINES.—Fetters for horses, or other animals, when turned out to graze. They are similar in their construction to *hobbles*; but instead of being placed on both front or on both hind-legs they are attached to a fore and hind-leg on the same side. An animal bearing *side-lines* can gallop, though with labor, to a short distance, should he scent a wild beast approaching him; but, hobbles will not permit him to move at all rapidly. In anticipation of such dangers, *side-lines* would be preferable. They should be issued to troops of at least three sizes (the length of chain being about 18, 24, and 30 inches) to suit the different sized animals and the emergencies requiring their use. The pattern, used by the United States cavalry, is composed of leglets of leather fastened by a steel-wire snap, connected by a chain, $\frac{3}{16}$-inch iron link. As with hobbles, it would be better to have the side-lines constructed of steel, with a locked connecting-chain. See *Hobble*.

SIDE PATROLS.—Side patrols are placed as shown in Fig. 1. The two men in A must not only from time to time communicate with the advanced guard —that is to say, one of them incline to the left until he can see it—but the other, when there is a height near, even at a thousand yards' distance, must ride to the top of it and look over. When attacked, side patrols behave as advanced and rear-guards; they meet the enemy, and do not suffer him to come too near the column. When the side patrol meets with a wood in the direction of its march, the disposition is altered, as shown in Fig. 2. The officer detaches, the Sergeant's troop to the right, the Corporal and four men to the left, and himself remains with his men in the center. The Sergeant sends two men to the skirts of the wood; these must look at the tracks, and one of them occasionally rides to the top of a height, if any be near; the remainder divide themselves to the left of these two men, at such a distance that they can keep one another in sight. The Corporal divides his men in the same manner, between the right flank of the column and the officer's troop. If the officer perceive that these two lines are not extensive enough to cover the ground toward his troop, he detaches a sufficient number of men to the right and left, to form a perfect line, which line must be careful never to pass the head of the column. The Non-commissioned Officers endeavor to keep all their men in the same line with the officer's division. All this should be done quietly, without hurry or fuss, and will be so done, wherever the men have been previously instructed in their duty. To see men unnecessarily galloping and fatiguing their horses on such occasions, from mere want of instruction, and without doing any more good than if at a walk, really excites one's pity.

Patrols of discovery consist generally of a considerable force, so as to be enabled to defend themselves against small parties or patrols of the enemy, and are sent for the purpose of ascertaining whether a certain place is in the enemy's possession, whether he is on the move against us, or whether a certain district is occupied by him. Such a patrol usually has three men for an advanced and two for its rear-guard, and, if necessary, sends one man to its right, and another to the left, along its heights. As not only the safety of the patrol frequently, but the very object for which it is sent, depends upon its not being seen by the enemy, it is of the utmost importance to impress well upon the men in the front. that they are not to be satisfied with merely looking out before them, but to examine closely the tracks along the cross-roads, ascend the hills with caution, etc If this be well done, the patrol will sometimes have a chance of making prisoners. A patrol which sees the enemy advancing towards it with not too strong a force, must conceal itself, and at the proper moment attack him vigorously; whereby he will be thrown into confusion, fly, and perhaps lose some prisoners. When the enemy is too strong, the patrol avoids him, and, if circumstances permit, continues its march, and endeavors to carry out the object for which it was sent. A patrol must never enter a village or wood, which has not been examined: but this is to be so managed as not to delay the patrol.

For, it must be borne in mind, that the officer who sent it out has calculated the time of its return; should it not come back at that time, he may get apprehensive, and send another one out to look for it; whereby both men and horses will be unnecessarily fatigued.

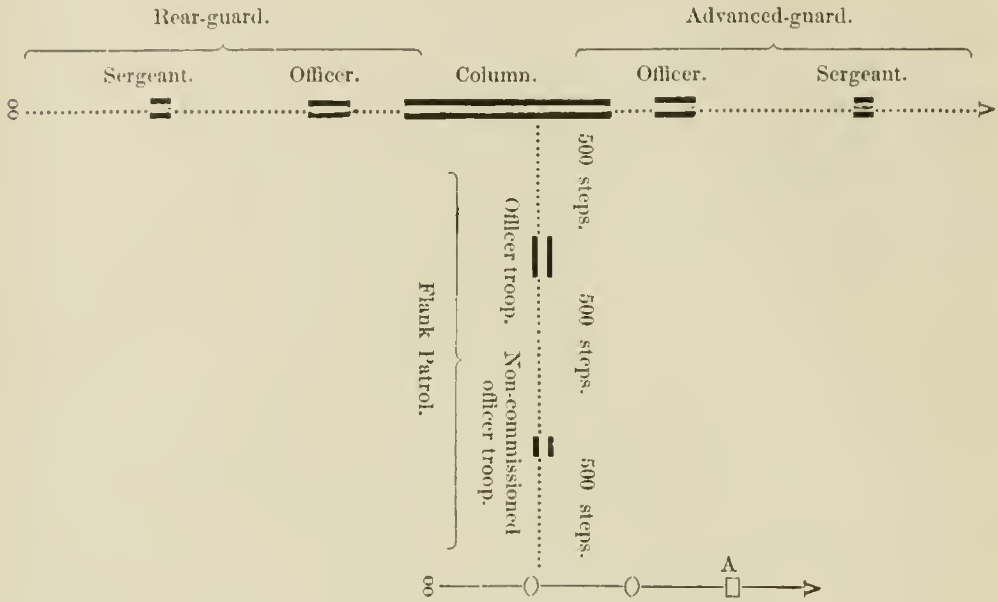


Fig. 1.

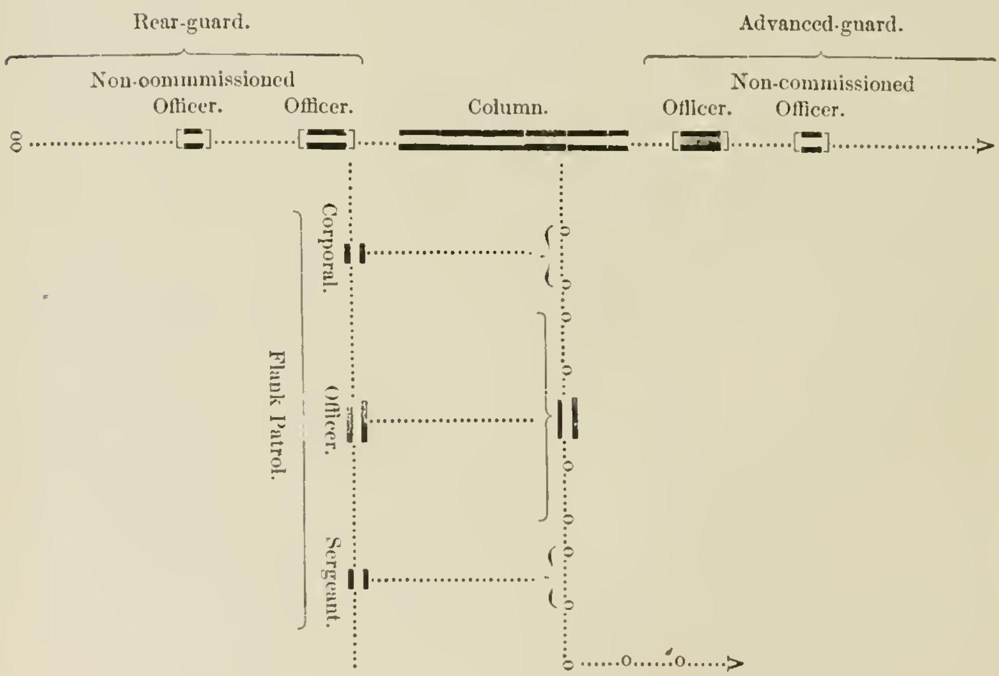


Fig. 2.

In passing, at night, any village which the enemy may have occupied, the patrol is to halt about five or six hundred yards from it. When no vedettes of the enemy are visible, a few men are sent to the right and left, who approach stealthily, to ascertain if the entrances to the village are occupied by troops, and to try and pick up an inhabitant, whom they may bring back with them. If nothing can be learned in this way, the patrol cautiously moves on.

When a patrol is ordered to ascertain, by night, whether a village is occupied, and how, three of the best mounted men are picked out for the lead; eight others follow at a distance of twenty-four yards; and the remainder of the patrol, at a hundred yards. The enemy's vedettes are then approached without noise, and as soon as one challenges, the three men in advance bear down on him at full speed, to take him prisoner. Should they not succeed, they with the other eight must make a dash at the guard, to bring off a prisoner, with whom they retire. The alarm will be given in the village to a certainty, and the sounding of trumpets or beating of drums, will enable the patrol to judge by what kind of troops it is occupied. If a patrol go so far as to be obliged to feed, it must never stop to do so in a village, but always in an open country under some trees, and, while halting for this purpose, must never omit to throw out vedettes. The horses must be watered and fed by detachments—never *all* at the same time—so as to guard against surprise. Provisions and forage, if it be necessary to get them out of villages, must be brought out by the inhabitants. On such occasions, as on all others, the inhabitants are to be treated with kindness; any attempt to rob or ill-treat them, must be promptly and most severely punished. But the object had in view by the patrol, and the direction of its route, must be carefully concealed from them. Guides that are sent home, must, if possible, be deceived, by the patrol's marching in a false direction, until they are out of sight. If information about the road be wanted, the inquiry must embrace several roads, that the true one may not be suspected. See *Patrols* and *Secret Patrols*.

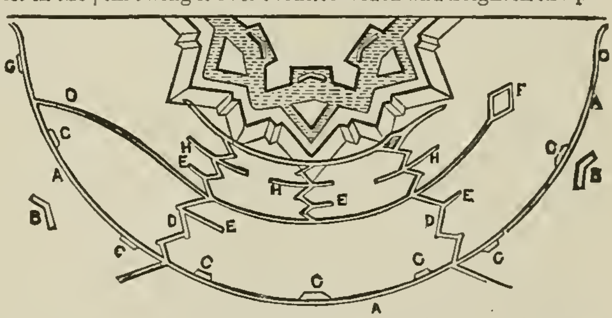
SIDE-RIB.—The rod at the side of a carbine to which the sling is fastened.

SIDE-SCREW.—One of the screws by which the lockplate is secured to the stock. They pass through the stock, and are held by the side-screw plate or by side-screw washers.

SIDE-TACKLE.—A purchase hooking into an eye-bolt on a naval gun-carriage and an eye-bolt in the ship's side, and serving to train the gun to point forward or abaft the beam, and to run it out of the port. Each carriage has side-tackle on each side.

SIEGE.—The sitting of an army before a hostile town or fortress with the intention of capturing it. With certain elements, the success of a siege is beyond a doubt; the result being merely a question of time. These elements are: first, the force of the besiegers shall be sufficient to overcome the besieged in actual combat, man to man. If this be not the case, the besieged, by a sortie, might destroy the opposing works, and drive away the besiegers. The second element is, that the place must be invested; so that no provisions, reinforcements, or other aliment of war can enter. The third element is, that the besiegers be undisturbed from without. For this it is essential that there shall not be a hostile army in the neighborhood; or, if there be, that the operations of the besiegers be protected by a covering army able to cope with the enemy's force in the field. The ancients executed gigantic works to produce these effects. To complete the investment, they built a high and strong wall around the whole fortress; and to render themselves secure from without, they built a similar wall facing outwards, beyond their own position. The first was circumvallation, the second contravallation. It was thus that Cæsar fortified himself while besieging Alexia, and maintained 60,000 men within his ring. In modern warfare, it is considered preferable to establish strong posts here and there round the place, and merely sentries and vedettes between.

Let us now assume that a fortress of great strength has to be reduced, and that the force of the enemy in the vicinity has been either subdued or held in check by a covering army. By rapid movements, the place is at once invested on all sides. This step constitutes merely a blockade; and if time be of little importance, is a sufficient operation, for hunger must sooner or later cause the fortress to surrender; but if more energetic measures are required, the actual siege must be prosecuted. Advantage is taken of any hidden ground to establish the park of artillery and the Engineer's park; or if there be none, these parks have to be placed out of range. The besieging force is now encamped just beyond the reach of the guns of the fortress; and their object is to get over the intervening ground and into the works without being torn to pieces by the concentrated fire of the numerous pieces which the defenders can bring to bear on every part. With this view, the place is approached by a series of zigzag trenches so pointed that they cannot be enfiladed by any guns in the fortress. In order to accommodate the forces necessary to protect the workers, the trenches at certain intervals are cut laterally for a great length, partly encircling the place, and affording safe room for a large force with ample battering material. These are called *parallels*, and they are generally three in number. The distance of the first parallel will increase as small-arms become more deadly; but with the old smooth-bore muskets it was usual to break ground at 600 yards from the covered-way of the fortress, while at Sebastopol ground was broken at 2,000 yards, and in the Siege of Paris by the Germans the lines were begun at least 4 miles from the city. The locality of the parallel being decided on, a strong body of men is sent to the spot soon after nightfall. The attention of the garrison is distracted by false alarms in other directions. Half the men are armed cap-à-pie, and lie down before the proposed parallel; while the other half, bearing each a pick and shovel, and two empty gabions, prepare for work. Each man deposits the gabions where the parapet of the trench should be. He then digs down behind them, filling the gabions with the earth dug out; and, after they are filled, throwing it over them to widen and heighten the parapet.



Before daylight the working-party is expected to have formed sufficient cover to conceal themselves and the troops protecting them. During the day, they—being concealed from the garrison—widen and complete their parallel, making it of dimensions sufficient to allow of wagons and bodies of troops with guns passing along. During the same night, other parties will have been at work at zigzags of approach from the depots out of range to the first parallel, which zigzags will be probably not less than 1,000 yards in length. Usually the defenders will not expend ammunition on the first parallel, for its extent (often several miles) will render the probability of doing material damage extremely small. For this reason also, the dimensions of the parapet and its solidity are of far less importance in the first parallel than in the more advanced works of attack. The first parallel, AAA, being completed, the engineers select points near its extremities, at which they erect breast-works, BB, to cover bodies of cavalry, who are kept at hand to resist sorties from the garrison. The length of the parallel is usually made sufficient to embrace all the works of two bastions at least. Sites are then chosen for batteries, CC, which are built up of fascines, gabions, sandbags, and earth. They are placed at points in the parallel formed by the prolongation of the several faces of the bastions, ravelins and other works of the fortress, which faces the batteries are severally intended to enfilade by a ricochet fire. Other batteries will be formed for a vertical fire of mortars and shell-guns By these means it is hoped that the traverses on the hostile ramparts will be destroyed, the guns dismounted, and the defenders dispersed, before the final approaches bring the assailants to the covered-way. The sappers will now commence their advance toward the points, or salient angles, of the two bastions to be attacked. If, however, the trench were cut straight toward the fortress, its guns could easily destroy the workmen and enfilade the approach. To prevent this, it is cut in short zigzags—as at D—the direction always being to a point a few yards beyond the outmost flanking-works of the garrison. The side of each trench nearer the fortress is protected by gabions and sandbags, as in the case of the parallel. At intervals, short spurs of trench, incipient parallels, are cut, as at E, to contain small-arms-men, who act as guards to the sappers. The second parallel is about 300 yards from the enemy's works,and has to be more strongly formed than the first. It often terminates in a redoubt, F, to hold some light artillery and a strong force of infantry, who could assail any sortie in flank; or it may run into the first parallel, as G, giving easier access for troops than through the zigzags The second parallel is revetted with sandbags, in which the loopholes are left for musketry. After passing the second parallel, the angles of all the zigzags become more acute,to prevent enfilading. At about 150 yards, certain demi-parallels, H, are cut, and armed with howitzer batteries, to clear the covered-way, while riflemen also act from it. The third parallel is at the foot of the glacis. Thence the place, after being sufficiently battered, is taken by a storming-party, who make their way over the glacis, or the covered-way is topped by the double-sap, which is a safer plan for the army generally, though much more deadly to the sappers. When the crest of the covered-way has thus been reached, batteries of heavy artillery will be there established, for the purpose of breaching the walls of the ravelin and bastion; while at the same time miners will first seek to destroy the defender's counter-mines (which would otherwise be likely to send these batteries into the air), and then will excavate a tunnel to the ditch, at the foot of the counterscarp. If the breach becomes practicable, a storming-party will emerge from this tunnel or gallery, and seek to carry the opposite work by hard fighting. If inner works still subsist, which would tear assailants to pieces, the double sap may be still continued across the ditch, if a dry ditch, right up the breach, that counter-batteries may be formed. If the ditch be wet, means must be adopted for a causeway or a bridge. By these means, however obstinate may be the defense, if the besieging force be sufficiently strong, and aid do not arrive from without, the ultimate success of the attack becomes certain. Vauban raised attack to a superiority above defense, first by the introduction of the ricochet fire, which sweeps a whole line: and secondly, by originating parallels. Before his time the whole attack was conducted by zigzag approaches; in which the troops actually in front could be but few, and were therefore unable to withstand strong sorties of the garrison, who, in consequence, frequently broke out and destroyed the works of the besiegers, rendering a siege an operation of a most uncertain character. See *Besiege*.

SIEGE AND GARRISON AMMUNITION.—Ammunition for siege and garrison service consists of cartridges of sizes varying according to circumstances, and the following projectiles, viz: *Shot* for 15, 10, and 8-inch columbiads (model 1861). *Shells* for 15, 10, and 8-inch columbiads, 13, 10, and 8-inch mortars; also the Coehorns and 8-inch siege-howitzer. *Spherical case-shot* and *canister* for 10 and 8-inch columbiads, and 8-inch siege-howitzer. The shells and spherical case-shot (except for the 8-inch siege-howitzer) are attached to sabots; the other projectiles are not strapped.

Canisters are made and filled like the canisters for field-service, except their dimensions, and. instead of being attached to a sabot, the lower end of the cylinder is slit with longitudinal cuts, .5 inch long and from .25 to .38 inch apart according to the caliber. The strips thus formed are turned down over a cast-iron bottom plate .5 inch thick. The cover for these canisters is of sheet-iron, .1 inch thick; it has a handle 3.75 inches long by 1.72 inch wide,made of iron wire No. 9, fastened to the cover by a strap of sheet-iron 2 inches long, 1.75 inch wide, secured by two rivets .15 inch thick. Canisters for 8-inch siege-howitzer are attached to sabots made to conform to the bore.

A stand of grape consists of 9 shot, placed together by means of 2 cast-iron plates, 2 rings, and 1 bolt and nut. The square of the nut is 2 diameters of the bolt; and its thickness 1 diameter. The head of the bolt is countersunk flush with the bottom of the lower plate, which has a slot to prevent the bolt from turning when the nut is screwed on. Each plate has on the inside 3 beds for the shot,of a depth equal to half the thickness of the plate. They are made in the form of a spherical segment,the curvature of which is the same as that of the shot; their centers are on equidistant radii, midway between the edge of the bolt-hole and that of the plate. In the upper plate are 2 holes .25 inch diameter placed opposite to each other at .5 inch from the edge of the plate to receive a rope handle. For the 8-inch siege-howitzer the stand of grape must be attached to a sabot as for canisters. The sabot may be fastened to the lower plate with screws, or the bolt may be made long enough to pass through it, or else the sabot may be inserted into the piece separately from the stand of grape.

The following implements are required for filling shells:—1 *pair of shell-hooks;* 1 *handspike;* 2 *hand-hammers;* 2 *scrapers*, (pieces of sword-blade); 2 *tow-hooks;* 2 *pairs of pincers; rags;* 1 *chisel* and 1 *mallet*, to clean the shells and break up any hard substances that may be found in the interior; 2 *searchers*, for sounding cavities; *shell-gauges;* 1 *grate*, to dry the shells on; 1 *fuse-saw;* 1 *gimlet;* a *ring of rope*, or a *hollow block;* 1 *funnel; powder-measures;* 1 *tub* or a *vessel* for powder; 2 *baskets*, for the composition and fuses; 1 *rasp;* 1 *fuse-setter;* 1 *mallet;* 1 *fuse-reamer*. The shells are cleaned inside and out, gauged, and examined that they have no defects that would cause their rejection; that the fuse-hole is not defaced; if there be water in the cavity,the shell is dried by gentle heat and cooled slowly.

To fill shells for guns or howitzers.—A helper places the shell on the block or ring of rope, the fuse-hole uppermost; inserts the fuse-plug and drives it in till the top is flush with the surface of shell. The principal reams out the hole to its proper size,the helper holding the shell to prevent it from turning. The helper inserts the pipe of the funnel in the fuse-plug, and the principal pours in the powder and closes the hole with a wad of dry tow rammed in securely,leaving a portion of it projecting out. When cylinders of rock fire or other combustibles are used, they are inserted before the fuse-plug is driven.

To fill mortar-shells.—The shells are generally filled and the fuses driven in the battery-magazines as they are required. The helper places the shell on a ring of rope and inserts the pipe of the funnel in the fuse-hole; the principal pours in the bursting-charge, introduces the cylinders of rock-fire and pushes them aside with a small stick, that they may not be in the way of the fuse when driven in. He then inserts the fuse, which should enter to within half an inch of the top, and with a mallet and fuse-setter drives it so that the end of the fuse shall project not more than .2 inch. The fuse is cut to the proper length, according to the range, before it is driven into the shell, by resting it in a groove made in a block to

Summary of the Ammunition for siege, garrison, and sea-coast services.—

	Smooth-bore guns.			Howitzers.	Mortars.					Rifled guns.								Rifled mortars.		Remarks.
	8-inch.	10-inch.	15-inch.	8-inch.	8-inch.	10-inch.	10-inch.	13-inch.	Coehorn.	30-pounder.	4.5-inch.	8-inch.	10-inch.	12-inch.	300-pounder.	200-pounder.	100-pounder.	8-inch.	10-inch.	
Charge of powder, maximum........lbs	15	28	120	4	2.25	4	12	20	0.5	3.25	3.2	35	70	120	25	16	10			For canister use.
Height of charge........................ in	9	11	26	6						8.5	7.5	23	32	35	11	12.5	11.25			Lead bullets, or slugs, 11 to the
Diameter of cartridge.................... do	7.25	9.2	14	4.2						3.75	4	7.25	9.125	11	9.35	7	5.5			pound.
Cartridge-bag { Length............... do	18	21	37	14						12.75	14	35	40	57.15	23.5	22	19.5			
Cartridge-bag { Width...... .... do	7	9	12	7.6						12.75	12.75	24	30	35	16	12.5	10			
Cartridge-bag { Pieces............... No	4	4	4							2	2	2	2	2	2	2	2			
Cartridge-bag { Diameter, bottom in	8.8	10.2	15	5.2						4.75	5.5	8.25	10.2	13	10.35	8	7			Parrott projectile for 300-pdr.
Sabot...... ...... { Height............... do	1.9	2	2.37	4																Parrott projectile for 200-pdr.
Sabot...... ...... { Diameter........... do	7.5	9.6	14.62	7.7																Parrott projectile for 100-pdr.
Straps, two for each. { Length............... do	23.5	29.2	52.5																	Parrott projectile for 30-pdr.
Straps, two for each. { Width............... do	0.75	1	1.25																	Hotchkiss pro'tile for 4.5-inch.
Canister......... { Length............... do				25.1																Butler projectile for 4.5-inch.
Canister......... { Height.............. do				8.6																Dyer projectile for 4.5-inch.
Canister......... { Interior diameter. do				7.8																
Canister......... { Number of shot... do				48																
Canister......... { Weight.............. lbs				53.5																
Shell.............. { To fill mor'r-pow. do	1.75	3	13.5	2.5	2.5	4.75	4.75	8.50	5	1.25	1				14	5	4.75 3.25			Long shell. Short shell.
Shell.............. { To blow mor.-pow oz	5	9	16	4	4	5	5	10	15											
Grape .... { Rock-fire..................																				
Grape .... { Plate . { Diameter in		7.85																		
Grape .... { Plate . { Thickness do		6																		
Grape .... { Ring, diameter.... do		6·55																		Grape should not be used in rifled cannon.
Grape .... { Bolt .. { Length... do		14.7																		
Grape .... { Bolt .. { Diameter do		6																		
Grape .... { Weight.............. lbs		75.5																		
Wad, junk...... { Diameter .... do	7.8	9.75																		
Wad, junk...... { Height................ do	8.5	16.5																		
Wad, junk...... { Weight, finished.. lbs																				
Wad, junk...... { Junk.................. do																				
Wad, junk...... { Strands of hemp.. No																				
Charge for 20-inch guns................ lbs																				200 pounds mammoth powder.
Height of charge for 20-inch guns. in																				16.5 inches.

receive it and to hold it steady, the saw running in a cut made for it; or the fuse may be bored through to the composition with a gimlet, at the proper length.

To fire 12-pounder shells from mortars of a large caliber.—This kind of fire is intended only for short distances, as in the defense of a breach, and supersedes the use of the stone mortar. Take a strong tub or half-barrel, provided with two strong rope handles, add a second bottom on the outside, bringing it flush with the ends of the staves to which it is nailed. To this bottom nail another, made of a single piece of wide 2-inch plank of a sufficient length to support the ends of the staves. A block of light, dry wood, of the diameter and length of the bore, is attached to the bottom of the barrel or tub by nails, and the lower end of the block which goes next to the charge is covered with sheet-iron. The fuses of the shells are cut, driven, uncapped, and the shells placed in the barrel, the fuses turned down. When the bottom tier is finished a second one is laid, and so on to the last, which is covered over with hay, which is rammed in to keep the projectiles in place. The charge of powder is put in the mortar, the proper elevation and direction are given, and the barrel or tub, loaded, is raised by the handles, the block wiped clean and introduced into the bore and set home. See *Ammunition*, *Cartridge-bags*, *Sabot*, *Strapped Ammunition*, and *Wads*.

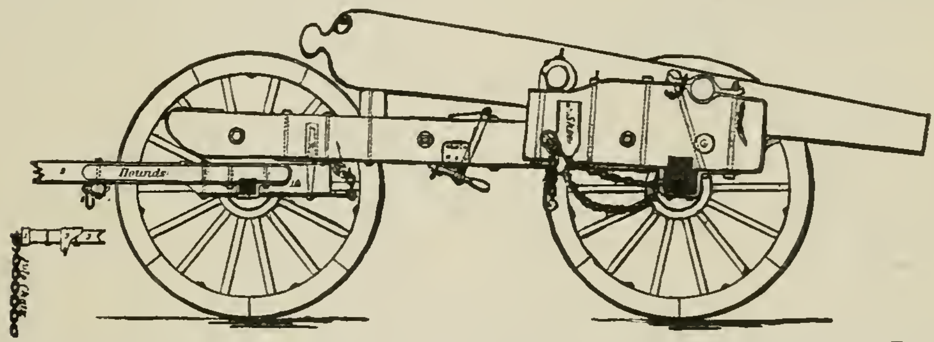
SIEGE-ARTILLERY.—In siege operations, the use of different kinds of cannon and projectiles, and of various kinds of fire, depends upon the end to be attained and the relative positions of the besieger's guns and the works to be attacked. The position to be occupied by the siege-batteries is determined by the object to be accomplished by each battery, by the nature of the ground and of the attack, and by the power of the besieger's artillery as compared with that of the besieged. In the Franco-German War of 1870, siege-batteries were constructed at distances of 4,000 yards and more, in order to drive the besieged from his outworks and to engage his artillery with such effect that a second and nearer position should be tenable. At this limit, which was the extreme range, was reached oftener than had been expected; the Germans have since introduced pieces sufficiently powerful to attain a range of 9,300 yards with 40° of elevation. With these the enemy's artillery can be engaged, with decisive results, up to 5,000 yards, his works enfiladed up to 5,500 yards, and bombarded beyond 8,000 yards. Breaching-batteries were formerly established about forty yards from the point to be breached, but in recent years the distance has been as great as 4,000 yards. Siege cannon are employed: 1st. To destroy all buildings and *matériel*, and to keep down the fire of the work so as to facilitate the establishment of the lines and batteries of attack. 2d. To dismount the artillery and to destroy its cover. 3d. To form breaches. 4th. To silence Infantry fire, effect lodgments, and clear terrepleins. 5th. To defend the batteries against sorties, and to drive from their position troops that prevent or delay the progress of the siege-works. 6th. To prevent the enemy from repairing damages, and to cover and support the assaulting columns. *In the defense*: 1st. To prevent the establishment of lines and batteries of attack, and to counteract and silence the fire of the enemy's batteries. 2d. To destroy established works, to dismount the enemy's artillery, to interrupt communication between different parts of his works, and to retard the progress of his works. 3d. To drive the enemy from outworks he may have captured, to cover and support sorties, and to prevent the enemy from following too closely the troops returning from a sortie. The fire of the besieged will be, at least for a time, more powerful than that of the enemy.

In the attack, solid shot are used principally for dismounting artillery and forming breaches, and *in the defense*, for dismounting artillery and against the head of a sap; but even for these purposes they are not necessary, and they are being replaced generally by shells, except when the latter have not the power to do the required work. Shells with large bursting charges and using time or percussion-fuses, which depend upon the object fired at, are employed more generally than any other projectiles in siege operations. This fire should from its nature be massed on distinct portions of the object. In shell fire from guns, the percussion-fuse is the best. Shells may be employed for breaching and demolishing masonry, for destroying buildings, earthworks, etc., for dismounting artillery, and for injuring the *personnel* of the enemy. In breaching, a special battering-shell may be used to destroy the face of a revetment, etc., and thus allow the common shell, with its larger bursting charge, to be employed. Shells striking masonry and bursting on impact, produce but little effect; when fired without fuses they will explode, but not before some penetration has been accomplished. For dismounting artillery, the fire should be enfilading, as a direct fire is comparatively harmless. Howitzer-fire is employed for bombarding purposes, for destroying *matériel* and penetrating the roofs of bomb-proofs and magazines, and for breaching or demolition when indirect fire has to be employed. In the latter case, the maximum charge or one closely approximating to it must be employed, though the charge and elevation must within limits be adjusted to suit the range and conditions of fire; the shell must clear the intervening obstacle, and yet strike the wall at the proper point. Shrapnel, being of value against animate objects only, cannot be employed by the besiegers to so great an extent as by the besieged. It is of little effect against troops behind earthworks unless they can be enfiladed, but will generally be used against working parties, sorties, etc., and at points where the enemy may be expected to expose himself during day or night. It is used to silence temporarily the enemy's fire by driving off the gunners; in this case, its effect is greatest when fired from mortars. This fire should be distributed over the whole extent of the object fired at, and it should preferably be parallel or oblique to some line of the work. Grape and canister are of use only to repel sorties and to clear the parapets of men when the range permits. Canister is used at ranges within 600 yards. Machine-guns also would be employed for these purposes.

When the end is to be accomplished by range, accuracy, or hard hitting, or when shrapnel is used, the direct fire is employed. If the point to be reached be behind a protecting mass, the direct fire must be curved, and reduced charges and preferably shells must be used. This allows projectiles to be thrown into a work close at hand, and renders it possible to form a breach at a point concealed from view. The principal use of the ricochet fire is to enfilade the terrepleins of the faces, curtains, etc., and render them untenable, at the same time injuring or destroying the unprotected *matériel*. By this fire certain lines of the work would be taken in reverse. Ricochet fire can be used only when the works of the besiegers have not approached sufficiently near to interfere with the rebounds of the projectile. *In the attack*, and also *in the defense*, the importance of vertical fire cannot be overestimated, and too much care cannot be taken to render it effective. For this fire, shells from smooth-bored mortars have generally been used; but large shells and shrapnel with heavy bursting charges are now being introduced, thrown from rifled mortars, howitzers, and even guns. Although this fire is not effective in dismounting cannon and forming breaches, it is of the greatest value in reaching parts sheltered from direct and ricochet fires, in destroying magazines, barracks, bomb-proofs, and the masses of troops. In this way the enemy's positions can be thoroughly searched, and the fire of his artillery be diminished or even for the time suppressed, the latter requiring, however, a continuous fire from a large number of pieces. There is no time when the besiegers or even the besieged may not employ this fire, but on account of the limited extent of the besieged work it can be used to more advantage by the besiegers; they may be able to advance their works of attack without permanently silencing the artillery of the enemy, and light mortars can be placed in the most advanced works. The moral effect produced by vertical fire is far greater in proportion to its destructive effect than that of any other kind of fire. See *Ordnance; Siege-gun*, and *Siege-mortar*.

SIEGE-CARRIAGES.—The greatly improved facilities of late years for transporting heavy guns by railways, steamers, etc., have rendered it practicable to use for siege purposes guns which would have been regarded a few years ago as entirely beyond the range of possibility for such uses. At that time, a gun throwing a 30-pound projectile was the largest siege-gun to be found in any service, while now it would be difficult to fix a limit to the size of the guns that may be used against besieged places. The gun-carriage must of necessity conform to the gun for which it is constructed, and we see now constructed for siege purposes carriages which differ in no material point from those made for garrison and seacoast defense, so less clearly have the distinctions between the different classes of guns been defined.

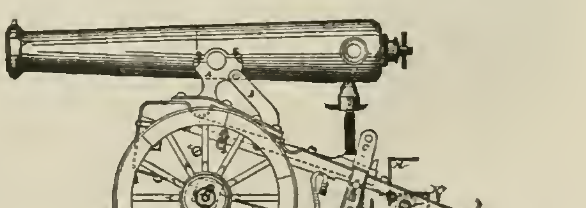
United States.—In this Service the siege-carriages are the 24-pounder and 8-inch howitzer-carriage; the 18-pdr. smooth; 30-pdr. rifle; 12-pdr. smooth, 4½-in. rifle; mortar-wagon; limber; and mortar-bed.



The construction of the siege-gun carriage is similar, in most of its details, to the field-gun carriage. It differs, however, in the greater strength of the parts, and in the mode of attaching to the limber, and by the absence of the parts used for carrying the implements. The position of the trunnion-beds is often such that when the carriage is limbered up, the weight of the piece is thrown too much on the rear wheels for convenience of transportation; another set of trunnions is therefore formed at the rear end of the cheeks, by enlarging the heads of the cheek-bolts, and the piece is shifted to them in transportation. They are called the "*traveling trunnions*." The breech of the piece rests in a groove formed in a block of wood, called the "*bolster*" and the elevating screw is disposed of by reversing it in its nut. To prevent it from unscrewing by the motion of the carriage, one of the handles is then slipped through a leather loop attached to the under side of the stock.

The same kind of limber is used for all siege-carriages. It is composed of a *fork*, the *pole*, the *axletree*, the *pintle*, the *hounds*, the *splinter-bar*, and also the *friction-circle*. The fork then constitutes the main part of this carriage, and to it are attached the pintle, the pole, the splinter-bar, the axle-tree, and the friction-circle. As the carriage is not subjected to the shock of firing, the axle-tree is not imbedded in wood to give it stiffness, as in the gun-carriage. The pintle is placed far enough in rear of the center of the axle-tree to enable the weight of the stock of the gun-carriage to act as a counterpoise to the pole, and give it steadiness when the carriage is in motion. The friction-circle acts as a sweep-bar for the *shoe* of the trail when the limber turns around its pintle. The attachment of the two carriages is secured by a lashing *chain and hook*. See *Siege-mortar Wagon*.

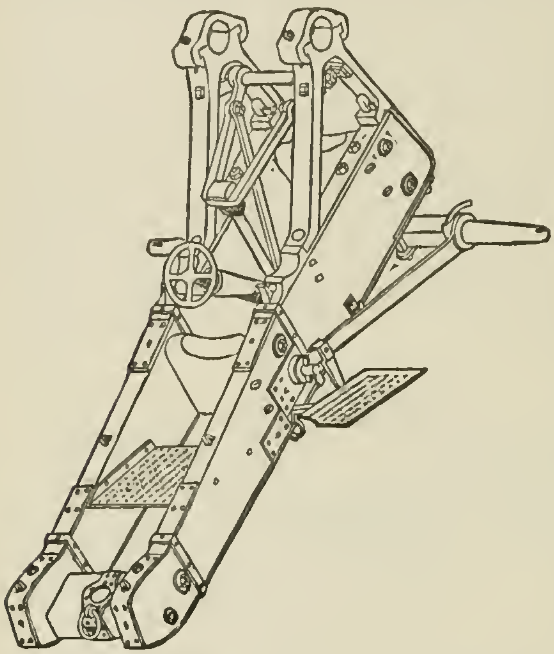
Austria.—With the view of affording greater protection to the gunners serving siege-guns, a modification has recently been made in the siege-carriage. This change consists in raising the gun about a foot and a half higher above the ground than in the old carriage. No new constructions have been made, but, to gain the proposed advantages of this new improvement at the least expense, it was determined to alter the old carriages on hand by adding to the height of the cheeks. This has been done by making a strong forged-iron frame which fits closely in the trunnion-bed of the old carriage, and has a trunnion-bed in its upper face. This iron frame is firmly bolted to the top of the cheeks of the old carriage, leaving it in all other respects unchanged. The frame is made in two parts, held very firmly together by a bolt. The elevating apparatus, instead of having a stationary female screw, has one attached to the movable elevating-quoin of wood resting between the cheeks, to which its front end is hinged by a bolt passing through the cheeks, so as to turn freely around it. The rear end of this quoin is held by another cross-bolt running through the two iron uprights *c* on the outside of the cheeks. There are three holes for this bolt in the cheeks and iron plates so that the position of the quoin may be shifted according to the elevation desired, affording a ready means of giving very different degrees of elevation to the gun, at the same time using only a short elevating-screw, by raising or lowering the seat of the female screw. Two separate female screws are attached to the elevating-quoin, so as to accommodate guns of different lengths, which may be mounted in turn on the same carriage, thus having only one carriage for the siege-gun and rifled howitzer. An iron



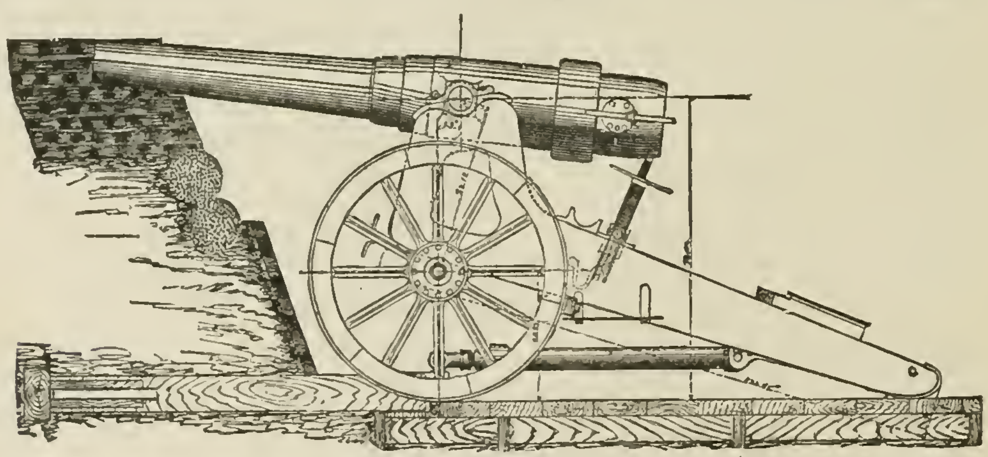
step, M, for the gunner is placed above the middle transom, and when not in use can be turned over in the position of M¹. This style of carriage is used for the 12-centimeter and 15-centimeter siege-guns and 12-centimeter howitzer. The axis of the piece is 62 inches above the ground. The carriage will admit of an elevation of 34° and depression of 17°. It weighs 3,540 pounds for the 15-centimeter (6-inch) gun, and 2,850 pounds for the 12-centimeter ($4\frac{3}{4}$-inch) gun. A wheel weighs 320 pounds. The width of track is 48.4 inches.

Height of the trunnions..................	72 inches.
Weight of the carriage with wheels...	2,750 pounds.
Width of track..............................	65 inches.

Germany.—The Prussian siege-carriage resembles much in its general appearance that just described. It is a wooden carriage of old pattern, well ironed with a strong wrought-iron frame firmly keyed and bolted to the cheeks, to support the gun, raising it high above the platform. The cap-squares are made



with projections which fit over lugs on the trunnion-beds, and are kept in place by an eye-pin. The elevating apparatus consists of one long screw with a wheel-handle, working in a female screw with long arms terminating in trunnions which fit in beds on top of the trail. The lower end of the screw turns in a collar secured to an upright on which the breech of the gun rests. The head of the upright is supported by two rods which turn on a cross-bolt just under



Prussian 15 centimeter Carriage.

the trunnions, and its foot by rods which are hinged to the first supporting-rods. The screw has an inclined position, and rises when the gun is depressed in rear of the breech. The gun may be elevated 31° and depressed 10°. The axle is iron, and is supported at the shoulders by two strong supports which connect it with the trail. Steps are provided, one between the sides of the trail for the gunner to stand on while pointing, and one on the side to enable him to mount on the carriage.

The Krupp siege-carriage for the 21-centimeter (8.26-inch) gun is made of wrought-iron and consists of a top-carriage and chassis, with a hydraulic buffer to check the recoil. The top-carriage is essentially the same as his carriage for sea-coast guns. The gun can be elevated from 6° depression to 26° elevation. The chassis differs in some minor particulars; it has an inclination of 4°; the rails are rolled each in a single piece; the front traverse-wheels are omitted; and the chassis has a bolster on the front transom, which rests on the pintle-plate, the pintle entering the bolster. The crane and hydraulic buffer are similar to those used in the sea-coast carriages. The traverse-wheels have the face hollowed out so as to fit over the traverse-circle (which is not flat but semi-circular in cross-section), and have holes in the face to receive the end of a truck-handspike to traverse the carriage. On the outer side of the rails, toward the front end, there is bolted to each rail a lifting apparatus, consisting of a screw worked by a wheel and worm, and an iron stirrup to receive a strong axle provided with a pair of large iron wheels, used in transporting the gun and carriage. The axle has a square body. The wheels have bronze felloes, shaped thus ⌴ and cast in sections; the spokes are iron rods.

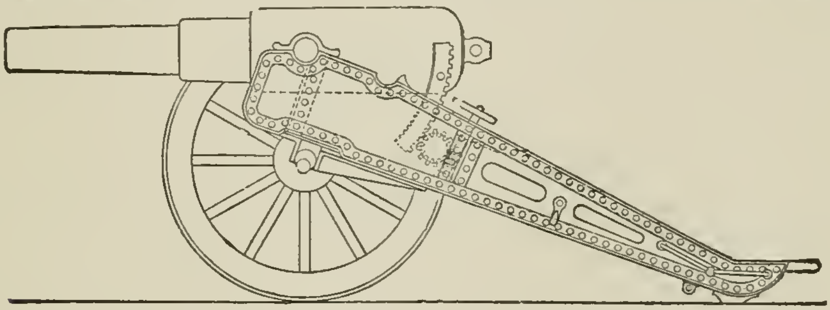
To prepare the carriage for transportation the top-carriage is run back nearly to the counter-hurters, the chassis is raised from off the pintle by means of the lifting apparatus, the transport-axle is secured in the axle-stirrup on top of the rails, and the transport-wheels are put on. These are 80 inches in diameter and have a 7 in. tread. The traverse-wheels are then removed, and the rear end of the chassis is raised and secured to the limber. The traverse-wheels may be then carried in another wagon to lighten the load of the gun and carriage. The crane is removed and secured against the side of the carriage. A shoe is provided to lock the wheel in going down hill. The platform is made of oak timbers bolted together. The cast-iron pintle-block and the traverse-circle are bolted to the platform. For transportation the platform is taken to pieces, and may be carried in an ordinary baggage-wagon. To establish the gun in battery, the ground is first leveled and rammed until it be firm, the platform is laid and the pintle-block and traverse-circle are bolted down: the gun is brought over the platform, the front bolster over the pintle, and the chassis supported by the lifting apparatus ; the transport-wheels and axle are removed, the traverse-wheels are put in place ; the limber is removed, and the chassis lowered in place.

	Pounds.
Weight of top-carriage	2,033
Weight of chassis	3,810
Weight of the gun limbered up	18,000
Weight of platform complete	4,586

The 15-centimeter (6-inch) carriage is made of wrought iron, except the wheels, which are of wood, with bronze nave-boxes. The cheeks, which are unusually high, the center of the trunnion-beds being 6 feet above the platform, and are made of boiler-plate, strengthened with angle-irons riveted all around the edge ; the cheeks continued to the rear, parallel to each other, and joined by transoms, form the trail. The traveling-trunnion-beds are placed on the trail, bringing the center of gravity of the gun, when it is on the road for transportation, as low as possible. The elevating apparatus consists of a single-screw with a rim-wheel handle, and a female screw with projecting arms terminating in trunnions which fit in journal-boxes in the sides of the trail. In order to obtain a great range of elevations without increasing inconveniently the length of the screw, two sets of journal-boxes are provided ; one on the top, the other in the sides of the trail. The carriage admits of elevations up to 35° and depressions down to 5°, with a screw of moderate length. The striking peculiarity of this carriage is the application of the hydraulic buffer for checking the recoil in carriages of this kind, by which means the recoil is controlled within the limits of about one yard. The cylinder of the buffer is placed under the middle line of the carriage, between the cheeks, to which its rear end is fastened by a cross-head, at a distance from the rear end of the trail of about one-third its entire length, and may be elevated or lowered within narrow limits. The piston-rod is fastened by a pivot-bolt to a timber anchored in the parapet, and can be moved vertically as well as horizontally to accommodate different positions of the carriage. An ordinary wagon-brake is provided to control the motion of the carriage down hill. It acts on the tread of the tire, and the pressure is applied by means of a screw attached to a cross-head on the front ends of the cheeks. Two iron brackets are fastened to the outside of each cheek, opposite the breech of the gun, for a step or platform for the gunners to stand on while loading the gun. The platform provided is the ordinary siege platform, laid down horizontally instead of sloping up to the rear end. Weight of carriage, 4,068 pounds; height of wheels, 62 inches.

Russia.—The Russian carriage is in most respects like the mortar-carriage, consisting of a top-carriage mounted on a wooden chassis. The cheeks of the top-carriage are made of a single thickness of boiler-plate about ½-inch thick for the 24-pounder-gun, strengthened by angle-irons riveted to it around its outer edge. The trunnion-plates are riveted to the cheeks. The transoms, six in number, are wrought-iron sleeves over the bolts which pass through the cheeks, and are held by nuts on the outside. The two rear bolts hold two iron stirrups, to which is attached a wooden block in which is placed the female screw for giving the elevation of the gun. The axle, which is large, with a square body, is placed close to the front edge of the cheeks. This is put in all carriages, whether used in garrisons or for siege purposes, though of use only for the latter. The wheels are made entirely of wrought-iron. The spokes, eight in number, are cut from two wide bars about one inch in thickness, leaving the bar at their middle uncut. The two pieces are placed, the one on the other, at right angles to each other, and firmly riveted together; an additional piece is riveted on each side, and a hole is bored through the four thicknesses which constitute the nave. There are no proper felloes, but the tire is in two pieces, each a complete hoop, the one shrunk on over the other. The tenons of the spokes extend through only the inner thickness. Holes are drilled through the tire, at regular intervals, for truck-handspikes. The chassis is composed of two wooden rails connected with transoms, just like that for the mortar-carriage, and rests on the platform without traverse-wheels or other mode of traversing than handspikes or snatch-blocks.

England.—The English siege-carriage is made like the field-carriage. The trail-plates have parts cut out so as to lighten them, and are riveted to the inner side of the angle-iron frame. The elevating apparatus is composed of a circular rack attached to the breech of the gun, worked by a pinion on the inside of the right cheek, a friction-wheel holding the rack against the pinion, which is worked by an endless screw with a wheel-handle projecting above the top



of the trail. The endless screw is inclosed in an iron box on the outside of the right cheek. The elevations that can be given are embraced between 35° elevation and 5° depression. An iron box is provided in the trail to carry the circular rack when the gun is in the traveling-trunnions. The lock-shoe and chain are on the left of the carriage. The limber is formed entirely of iron.

	40-pounder.	64-pounder.
Weight of carriage	2,744 lbs.	3,416 lbs
Weight of limber	1,246 "	1,246 "
Width of track		62 inches.

See *Krupp Sea-coast Carriages, Moncrieff Depression Carriages, Platforms,* and *Sea-coast and Garrison Carriages.*

SIEGE-GUN.—A siege-gun is constructed to throw a solid projectile with the highest practicable velocity, in order to penetrate the masonry of revetments, and to lessen the curvature of the projectile's flight, thereby increasing its chances of hitting objects but slightly raised from the ground. Rifled guns having been found to fulfill these conditions more fully than smooth-bored guns, they have entirely superseded the latter for siege purposes. A siege-gun, properly so called, is one that can be mounted on a siege-carriage which serves both for the purposes of transportation and for firing. Very large guns, as the 10-inch columbiad and the 8 and 10-inch rifle-guns were used in the siege operations of the late war, but they are not technically siege-guns, for no suitable carriages have been yet provided for their transportation over common roads. Whenever railroad or water communications will permit them to be transported, the largest guns may be employed in siege operations with great effect. The two siege-guns now in use in the United States, are the 4½-inche and the 30-pdr. rifles.

The 4½-inch rifle-gun is made of cast-iron, cooled from the exterior; the great length and small size of the bore rendering the water-cooling process impracticable. Its form is similar to that of the 3-inch field-gun. The principal weight and dimensions of this gun are as follows, viz.:

Designation.	No.	Lbs.	Inch.
Caliber	....	.. ....	4.5
Length of piece	....	....	133.
Maximum diameter	....	....	15.6
Minimum diameter	....	....	9.
Length of bore (calibers)	26.5	....	....
Number of grooves	9.	....	....
Width of grooves	....	....	0.97
Width of lands	....	....	0.6
Depth of grooves	....	....	0.075
Windage	....	....	0.05
Initial velocity (feet)	1280	....	....
Charge (cannon powder)	....	3.25	....
Solid shot	....	35.5	....
Shell (unfilled)	....	25.	....
Weight of piece	....	3570	....
Preponderance	....	300	....
Carriage and limber	....	3650	....
Piece, carri'e, limb'r & imple'ts	....	7400	....
Horses to transp't (good roads)	8.	....	....
" " (inferior roads)	10.	....	....

This piece is mounted on the 12-pounder carriage, slightly modified and represented in the article *Siege Carriages*. The gun, on its platform, admits of 9° 30′ elevation and 10° 30′ depression. On level ground it admits of 12° elevation and 10° depression. By digging a trench for the trail to run in, a still greater elevation may be obtained.

The 30-pounder rifle-gun is made of cast-iron reinforced, after the plan of Captain Parrott, with a band of wrought-iron. Its bore is 4.2 inches in diameter, and its length about 28 diameters. Its weight is 4,-200 lbs., and it is carried on the 18-pounder siege-carriage. The weight of its projectile and charge of powder are the same as for the 4½-inch gun. It has no preponderance, and has been found to be a very accurate and reliable gun in service. See *Ordnance* and *Siege-Carriages*.

SIEGE-GUN BATTERIES.—Experience has shown that the 4½-inch siege-gun can readily accompany an army in the field and with almost the same facility as the 12-pounder. Its great range, power, and accuracy endow it with many advantage when used as a heavy field-piece, and it should form a portion of the artillery of every army organized for campaign purposes. For this service the pieces are organized into batteries of four or six guns each, and equipped after the manner of light field batteries. Each piece is furnished with two caissons of the usual pattern, having, however, only two partitions in each half-chest; these are parallel to and 4.5 inches from each side—the outer spaces for projectiles, the inner for cartridges. This arrangement allows 16 rounds for each chest, 48 per caisson, and 96 per gun. A tray in each chest serves to carry pouches, primers, and the fuses. One spare wheel is carried for the caissons of each two pieces. Caissons not carrying spare wheels, carry picket-ropes and forage. A picket-rope should be in sections; each section long enough to accommodate the horses of one piece and its two caissons, together with a proportional share of spare and other horses. This requires each section to be 35 yards long. The ends of the ropes should be provided with hooks; these, besides enabling them to be used more conveniently as picket-ropes, allow of their being used as drag-ropes for extricating carriages from any difficult places on the march. Light-artillery harness is used, but, owing to the weight of the pole, breast-hooks of extra strength are provided for the wheel-horses. The swing team being attached to lead-bars, wheel-traces are required for it.

The implements for the piece are as follows: Six *handspikes;* small ends under sweep-bar, resting on axle, large ends resting on splinter-bar, and secured by a leather strap passing from the hounds, through loops on the handspikes, to buckles on the fork; or by a rope passed through rings on the handspikes and around through staples of the hounds and fork. One *short-roller;* on the stock between theglunette bolts; secured by a rope passing through a hole in the axis of the roller and fastened to the stock. One *trace-rope;* two half-hitches in the middle around the cascable; the ends turned around the maneuvering bolts, and crossing to take up the slack. This secures the piece from sliding on its carriage. The sponge and rammer-heads are upon the same staff, which is cut to the shortest practicable length. Two sponges and rammers are allowed to each piece, and, together with one worm for each two pieces, are carried upon the sides of the piece, secured with two stout leather straps buckled around the chase and the body of the gun. The service of the piece, so far as sponging and ramming are concerned, is similar to that for light field-pieces. The sponge-bucket is carried in the same manner as for light field-pieces. One fuse-wrench, one fuse-gauge, one fuse-knife, one fuse-reamer, and one pair of gunner's pincers for each piece are carried in the trays of the limber chests of the caisson. A cartridge-pouch is used instead of a pass-box, and is carried by No. 4 suspended from the left shoulder to the right side.

Large and heavy horses, particularly for wheel-teams are used for the guns. Except where the roads are unusually good, ten are allowed to each piece. Each horse, both for piece and caissons, is provided with a nose-bag, carried as for a light field battery, and one watering-bucket is allowed for each pair of horses, carried—those for the pieces on hooks attached to the rear axle; those for caissons as in light artillery. One lifting-jack for each two pieces is carried on one of the caissons belonging to these pieces. The lifting-jack weighs 160 pounds, and is carried on a caisson having no spare wheel. Each caisson is supplied with axes, shovels, picks, paulines, etc., as for a light field battery. Two hundred rounds of ammunition are allowed for each piece, and that not contained in the caissons is carried in transportation-wagons. One spare gun-carriage, with limber complete, drawn by six horses, accompanies each battery. Three spare poles for the limber of the piece, ironed and fitted ready for insertion, are carried on the spare carriage. Each battery is furnished with a battery-wagon and forge. The spare carriage, battery-wagon, forge, ammunition, and baggage-wagons form a train, and, on the march, usually accompany the light-artillery train. The cannoneers carry their equipments and march by the side of the piece' as in a light field battery. In place of the shoe (which is entirely useless) a stout rope, attached to the ring-bolt of the lock-chain, is substituted. This rope is passed around the felly with two or three turns, is held by a cannoneer walking by the side of the piece. In this manner he is enabled to let the wheel go as it approaches the bottom of a descent.

The battery-wagon herein mentioned is that furnished from the arsenals; but,being cumbersome and quite unsuitable for field service, it is better to utilize its body and limber-chest by placing them on the running gear of the army transportation-wagon. The limber-chest can be attached to the front part of the wagon-body by strong iron brackets, and serves as a seat for the driver. A similar chest can be placed in like manner, on the rear end in place of the forage-rack. In the front chest is carried all the carriage-maker's outfit, and in the rear one that of the saddler. On the middle of each side of the body may be attached a small chest for horse medicines, or for such other small articles as may be required of easy access. When the wagon is thus arranged it is as easily drawn by four horses as the other by six, and one driver, using double lines, is sufficient. The arrangement for attaching the draught-horses to siege-gun carriages being similar to that for the army transportation-wagon, the harness used with the latter will answer for the former. A driver is required for each pair of horses, as in light field-artillery.

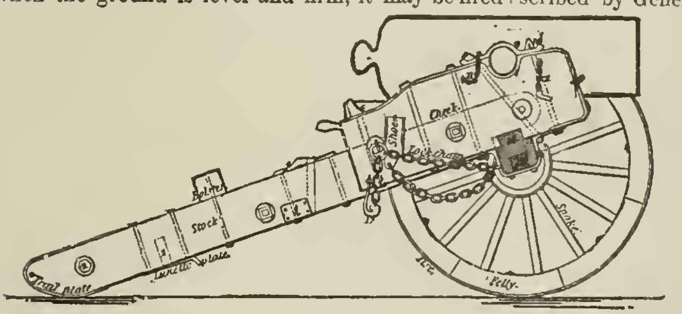
SIEGE-HOWITZER.—The *siege-howitzer* is principally employed for a *ricochet* firing, and for the purpose of battering the earth and fragments of masonry which are left standing after the fire of the breaching guns has ceased.

The following table shows the principal weights and dimensions of the 8-inch United States Service howitzer:

Designation.	No.	Lbs.	Inch.
Caliber			8.
Weight		2,600.	
Length			60.
Diameter (maximum)			17.5
Diameter (minimum)			15.
Length of bore (calibers)	5.81		
Windage			9.12
Charge (cannon powder)		4.	
Shell (empty)		45.	
Preponderance		380.	
Weight of piece, carriage, limber, and implements		6,660.	
Horses to transport	8.		

The bursting charge of the shell is one pound, and the charge to blow out the fuse-plug is four ounces. The howitzer on its platform admits of 13 degrees elevation and 10 degrees depression.

In works, it is fired from a wooden platform; but when the ground is level and firm, it may be fired without. It is used chiefly in field-works for flank defense.



The size of the trunnions and the distance between the rimbases are made the same as in the 24-pounder gun, that it may fit the 24-pounder siege-carriage, in which case a *quoin* is used for elevating instead of the ordinary screw. It would be an improvement in the working of this piece were it without preponderance. It has the advantage over the old siege-howitzer that the projectile always rests in contact with the powder, however small the charge, and the consequence is that the ranges are greater for the smaller charges.

This piece fires mortar-shells, spherical-case, grape and canister shot. By taking off the wheels of the carriage, and reversing the piece in its trunnions, and supporting the whole with strong timbers, this piece may be used as a mortar, in which capacity it gives very long ranges. As it is sometimes fired over the heads of men in the advanced trenches, no sabot or cartridge-block should be used in it except for canister. See *Siege-gun*.

SIEGE-MORTAR.—Siege-mortars comprise the *common mortars* and *Coehorn mortar*. The stone mortar was formerly used for siege purposes, but is now laid aside. The common siege-mortars are of two sizes, the 8 and 10-inch, so called from the diameters of their bores. They have no preponderance, and elevation and depression are effected by a lever the point of which acts in a ratchet cast on the breech. The fulcrum of this lever is attached to the rear transom of the mortar-bed. The chamber is elliptical as in the siege-howitzer, and for the reason given in the description of that piece, all the new mortars give longer ranges than the old ones. The bores of these mortars are about two diameters long,and the weight about 22 times that of the projectiles, respectively. To prevent the primers from pulling out of the vent, there should also be a grooved pulley attached to the *clevis-lug* for the lanyard to pass over. The vertical field of fire lies between 30° and 60°. The angle at which mortars are often fired is 45°. This gives very nearly the maximum range for a given charge of powder. The exterior form of the siege-mortars is cylindrical; consequently the natural line of sight is parallel to the axis of the bore,—a position of great convenience in aiming. The line of sight should be permanently marked on the piece while it is in the boring-mill.

Siege-mortars are used to attain those portions of a work,by vertical fire,which are defended against the direct and ricochet fires of guns and howitzers, such as the covered-way, the ditch with its communications,and the roofs of magazines,casemates, etc. The projectile principally used in mortars is the shell, which for the 8-inch weighs 44 lbs., and for the 10-inch 88 lbs. General Bormann, of the Belgian Army, some years ago proposed to convert the 10-inch mortar-shell into a spherical case-shot by filling it with balls about the size of 12-pdr. canister-shot, and a bursting-charge sufficient to rupture the shell; the fuse to be timed so that the projectile would burst about 50 feet from the ground. The effect of such projectiles at the siege of Petersburgh is thus described by General Abbott, the Commander of the siege-batteries: "This battle was probably the first in which spherical case-shot from heavy mortars was used. The expedient of putting the thirty 12-pdr. canister-shot under the bursting-charge of the 10-inch shells was of great utility,their fire keeping quiet the most dreaded flanking batteries of the enemy's line." From its lightness,and consequent mobility,the 8-inch mortar may be usefully employed in reaching an enemy sheltered by temporary field-works. See *Eight-inch Siege-mortar Mortar*, *Siege-gun*, and *Ten-inch Siege-mortar*.

SIEGE-MORTAR WAGON.—The mortar-wagon is employed to transport siege projectiles, mortars and their beds, and spare guns. It is composed of a limber and a body. The body consists of two middle-rails, united so as to form the stock, and two side-rails. These pieces rest upon the axle-tree, and are strongly connected together by cross-pieces of wood and straps of iron. At the rear of the body is placed a windlass, which aids in the mounting of guns and mortars. Stakes are placed around the sides of the body, to sustain the side and end boards which are used in transporting projectiles.

The lightness of the mortar, and the high angle under which it is fired, render it unsafe to be fired from a carriage; it is therefore, mounted on a bed, which rests directly on a platform. The siege-mortar-bed is made of wrought-iron. The different parts are the cheeks and the two transoms which connect the cheeks together. There are two projections at the end of each cheek, underneath which the handspikes are placed for moving the bed in aiming; also one maneuvring-bolt, for the same purpose. The sea-coast mortar-beds have an eccentric truck-wheel for facility of maneuver. To insure accuracy of fire with heavy guns and mortars, it is absolutely necessary that their carriages and beds should rest upon solid and substantial platforms. The platforms for siege-pieces, being transported with an army, should have the greatest lightness compatible with strength to endure the shocks of long-continued firing.

SIEGE–TRAIN.—The men, guns, and material collected together for the conduct of a siege. The following shows the proportion of *personnel* and *matériel* of a siege-train of 105 pieces.

55 rifled 64-pdrs. } on traveling-carriages
20 rifled 40-pdrs. } with siege-limbers ;
30 rifled 8-inch howitzers on traveling-carriages.

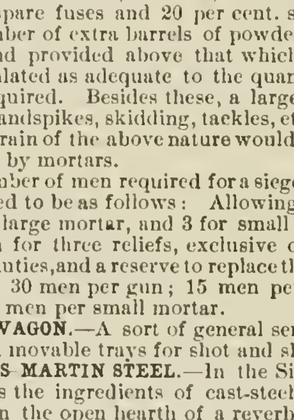
The number of rounds per gun, as well as the charges to be employed, varies according as these are intended for direct, ricochet, or curved fire. Ten per cent. spare fuses and 20 per cent. spare tubes, and a number of extra barrels of powder, should be allowed and provided above that which may have been calculated as adequate to the quantity of projectiles required. Besides these, a large proportion of guns, handspikes, skidding, tackles, etc., are provided. A train of the above nature would be also supplemented by mortars.

The number of men required for a siege equipment is computed to be as follows : Allowing 10 men per gun, 5 for large mortar, and 3 for small mortar, the proportion for three reliefs, exclusive of magazine and store duties, and a reserve to replace the casualties would be : 30 men per gun ; 15 men per large mortar; and 9 men per small mortar.

SIEGE WAGON.—A sort of general service-wagon fitted with movable trays for shot and shell.

SIEMENS-MARTIN STEEL.—In the Siemens-Martin process the ingredients of cast-steel are melted together on the open hearth of a reverberatory furnace of special construction, and a certain proportion of manganese necessary to make a sound and practically malleable steel added. The usual plant consists of a gas-producer, regenerators, furnace, auxiliary reverberatory furnace, with ingot-molds, etc.

The gas-producer, shown in the drawing, is a large chamber of triangular section, capable of holding



several tons of fuel. The charging is effected through a hopper at the charging-hole, A. The coal travels slowly down the inclined wall, B, becoming gradually heated, and parting with its volatile matters until it reaches the narrowest part of the grate. The combustion here goes on slowly, the small amount of carbonic oxide produced being immediately decomposed by the thick column of incandescent fuel above so that the contents of the chamber are gradually converted into inflammable gas, chiefly carbonic oxide, which, diluted with the nitrogen of the air remaining after combustion, is subsequently employed as fuel. The gas evolved from the producer passes through the valve, G, into the stack, H, whence it issues at a temperature of about 200°. In traversing the horizontal pipe, P, it loses one-half its heat so that its density is sufficiently increased in the descending pipe to establish a continuous draught from the gas-producer towards the furnace without the use of a special chimney.

The regenerators are placed under the furnace, and are four in number, two for the air and two for gas. They consist of vaults built in the foundation, which are filled up with fire-brick closely stacked, so that a large number of small rectangular openings are left between them, forming chambers for the blast and gases to circulate. They are worked in pairs, two being heated by the waste flame, while the others are giving up their heat to the cold air and gases ; owing to the large amount of surface presented by the bricks, the absorption of the surplus heat is effected with comparative rapidity, and the temperature of the current escaping to the chimney is reduced to the boiling point of water : they all communicate with the furnace at one end, and at the other end they are fitted with valves by the reversal of which they communicate either with the chimney carrying off the products of combustion which have parted with their heat to the bricks, or with the pipes of air and gas to which they give up their heat, thus raising the temperature of the blast and the fuel to a very high point before they enter the furnace. As soon as the brick-work has attained the proper temperature in two of the chambers, the current is turned into the adjoining pair by reversing the valves, and the heat accumulated in the brick-work is abstracted by cold air passing through one and gas through the other until the second pair is heated, and so on the process being kept up continuously notwithstanding the intermittent action of the regenerators. The bed of the furnace is flat, and is made of fine sand consolidated by pressure and strong heating, and supported on cast-iron plates, which are kept cool by a circulation of air underneath. The bed has a slight inclination towards the tap hole, which is generally placed in the middle of the furnace at the back. The furnace has a bridge at each end, which becomes alternately the fire-bridge and flue-bridge. There are three or four working-doors on the front, which are used for charging. The casting trough or ladle, and ingot, are worked in much the same manner as in the Bessemer plant, except that the ladle is attached to the furnace, and the ingot-molds are arranged on a revolving platform, by means of which they are brought successively under the ladle.

The materials for charging are pig-iron, steel, and wrought-iron scrap, and spiegeleisen or ferro-manganese. The proportions of the different material charged are determined by the requirements of the steel to be made. The charges weigh from 2 to 8 tons depending on the size of the furnace. All the materials are heated to a bright red in the auxiliary furnace. The pig is charged first and is soon melted, as soon as it arrives at a white heat, the wrought-iron or steel is added in charges of about 200 pounds at a time, each charge being raised to a white heat by exposure to the stream of gases at the flue-bridge before being immersed in the bath. After two or three additions, ebullition commences and continues till the carbon is wholly removed from the pig. The exact condition of the metal is ascertained from small proofs taken from the charge after each addition of iron towards the end of the operation. These are run into a small ingot-mold, and when cooled to the proper heat, hammered into a plate about ⅜-in. thick, and 5 in. wide. When the decarbonization is completely effected, these proofs will bend double cold, and show a fracture quite fibrous. A quantity of manganiferous pig, from 40 per cent to 10 per cent. of the charge, according to the desired hardness for the steel, is then added. When this is melted, the bath is stirred to insure homogeneity, and the final proof taken, which is treated in the same manner as the others, and gives reliable evidence of the state of the metal before pouring. This enables the quality to be adjusted to the degree of hardness required; should it be too soft, more pig is added; should it be too hard, waiting for a quarter of an hour will materially soften the material. When the metal is brought to the required condition, it is tapped off into ingot-molds.

In the Bessemer process the steel produced from a given charge of pig is less than the quantity of pig used by some 15 per cent, and to this extent any impurities are concentrated, and therefore proportionately greater in the finished product. In the Siemens-Martin process, on the other hand, the weight of the finished product is about equal to the pig-iron charged, the loss of the latter being made up by the reduction of the pure ores charged into the bath; and under these circumstances there is no such concentration of the original impurities of the pig. See *Bessemer Steel* and *Steel.*

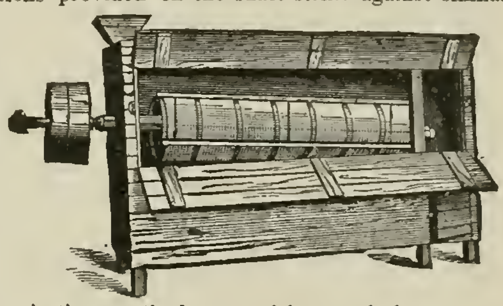
SIEMENS REGENERATIVE GAS-FURNACE.—A furnace much used in the making and melting of steel, and noted for its economical consumption of fuel. It consists of two parts: one of these contains the "Regenertors," or, as Dr. Percy calls them, the "Accumulators;" the other, which may be either quite near or more than 100 feet apart, contains the "Gas-producers" or source of the heat. In the regenerative portion, when the furnace is to be employed for the production of iron or steel, there is a melting-hearth or bed. Immediately below this hearth there are two pairs of arched chambers filled with fire-bricks placed sufficiently far apart to let air or gases pass freely between them, and at the same time expose a large surface to absorb heat. One pair of these chambers or regenerators communicates by separate flues with one end of the hearth, the other pair with the opposite end of it. Thus we have in duplicate, so to speak, a chamber through which gas and another through which air can be admitted. The furnace being in operation; while the gas and air are being admitted to the hearth through, say, the left pair of these chambers, the highly-heated products of combustion pass through the open brick-work of the corresponding pair on the right before reaching the chimney. What would pass up the chimney as waste heat in an ordinary furnace is thus absorbed by the bricks of the regenerators. After a given time—usually from 30 to 60 minutes—by means of suitable pipes and valves, the arrangement, or if we may so call it, the current, is reversed. Gas and air are now sent through the freshly-heated pair of regenerators, while the "waste heat" in turn passes into the other pair. In this way, by reversing the valves at intervals, hot currents of gas and air, in suitable proportions, are always reaching the hearth where combustion is effected at a very high temperature.

The advantages claimed for this furnace are:—1. Saving of fuel, amounting to 40 to 50 per cent. in the quantity, besides which inferior qualities of fuel, such as slack, coke-dust, lignite, and peat may be employed, producing a money saving in many instances amounting to 75 per cent. 2. Unlimited command of heat without intense chimney draught, owing to the principle of accumulation involved. 3. Great purity and gentleness of flame, which greatly diminishes the oxidation or deterioration of the material heated in the furnace and improves the quality of the produce. 4. Increased durability of the furnace and the perfect uniformity of the heat throughout the furnace. 5. Saving of space within the buildings and great cleanliness of operation, the fuel being converted into gas in the yard. 6. Complete and immediate command of the intensity of the heat and of the chemical nature of the flame, which may instantly be changed from a reducing to an oxidizing flame, or the reverse; thus tending to facilitate and improve all metallurgical operations. 7. No smoke from the stack, owing to the perfect combustion of the fuel, which renders this furnace beneficial to the public in all the large towns.

This furnace was, however, found at the time to be expensive in prime cost and somewhat costly in repairs. In the manufacture of ordnance continued changes in the direction of increased weight are often made. It thus becomes unadvisable to be hampered with an elaborate system of furnaces very difficult to adapt to ever-varying conditions. Under more stable conditions in the future, it may become desirable to revert to this system. See *Furnace.*

SIEVE.—A netted utensil for separating the smaller particles of substances from the grosser. In the manufacture of gunpowder, sieves are indispensable for separating the different sizes of grain. They are made of wire of different dimensions, and are known by the number of meshes to the linear inch.

SIFTING-REEL.—A machine employed in the manufacture of gunpowder. After the materials, whether saltpeter or sulphur, are ground they are shoveled into tubs and emptied into a hopper placed above a sifting-reel, which is similar in all respects to the charcoal-reel. As the reel revolves, certain projections provided on the shaft strike against similar



projections on the bottom of the trough that conveys the material from the hopper to the reel, and as this trough is slung under the hopper it is made to vibrate and cause the material to be shaken gradually from the hopper to the reel. The fine particles pass through a wire cloth of thirty-two meshes to the inch and fall into a bin provided; the coarse particles are thrown out at the end into another bin, whence they are taken and reground. See *Gunpowder*, *Saltpeter*, and *Sulphur.*

SIGHT.—1. The power of the eye for distinguishing objects far and near. In judging distances, good eyesight is most necessary; in fact defect in a soldier's vision renders him unable to shoot, and no recruit should be admitted into the Service if the power of his eyesight is not adequate to meet the demand made upon it consequent on the increased range of small-arms of the present day, the length of which is about 1,000 yards. This maximum range, or even an intermediate one, requires that the soldier who uses such weapons shall have a clear vision, and shall be able to judge correctly the distance of an object, the size of a man, in any position up to that extent of range. The Medical Officer who examines the recruit is able to judge of his fitness or otherwise for the Service as regards his eyesight, and is responsible that, before the recruit is admitted, he has undergone the proper examination and test.

Good eyesight recognises masses of troops at 1,700 yards. At 1,300 yards, infantry may be distinguished from cavalry, and the movements of troops may be seen, but the horses of cavalry are not quite distinct. A single individual may be seen at 1,100 yards, but his head does not appear as a round ball beyond 700 yards. At 600 yards, white cross-belts may be seen. At 500 yards, the face seems a light-colored spot; the uniform head, body, arms, and their movements, can be made out. At 250 yards, buttons may be seen, and officers distinguished from men. Officers with bright scabbards and men with fixed bayonets can be discovered, on a clear day, at a distance of 1,500 yards. 2. A small piece of metal, fixed or movable, on the breech, muzzle, center, or trunnion of a gun, or on the breech and the muzzle of a rifle, pistol, etc. by means of which a gun is levelled on the object to be struck. In smooth-bore guns, *quarter-sights* are cut on the upper quarter of the base ring, and numbered up to 3°.

Heavy smooth-bore ordnance are provided with *Millar sights*, which consist of a graduated tangent-scale at the breech, and a dispart sight in front of the second reinforce. A wooden tangent-scale is also used for elevation over the *clearance*-angle.

Heavy B. L. R. guns (Armstrong) are sighted with a *barrel-headed* and a *trunnion* sight on each side of the piece; the barrel-headed sight is held in a tangent-ring or in a socket according to the nature of the gun, the slots of the tangent-ring inclining to the left at an angle of 2° 16.′

A *barrel-headed sight* consists of a bar, elevating-nut, cross-head, two thumb-screws, and leaf. The whole is made of gun-metal, except the bar, which in most guns is made of steel. The bar is graduated on one side in degrees, on the other in yards. The degrees are divided into 6 parts of 10′ each, and any number of minutes up to 10′ each can be given. The cross-head is horizontal, and is graduated to give ½° of the deflection either to the right or left, and this ½° is also divided into three parts of 10′ each on both sides; at each end of the slide is a graduated nut divided into minutes up to 10,′ and these nuts are connected by a screw crossing the bar at right angles. A leaf with the sight-notch slides along the scale, and can be moved either right or left by either nut. These sights will become obsolete, on the guns to which they are attached being no longer required.

The *trunnion-sight* is of two kinds, viz., *drop-sight* and *screwed-in-sight*. Certain guns have the former, other guns the latter. The drop-sights consists of a gun-metal socket, collar, and pillar, and a steel leaf. The socket fits into the gun, the collar locks into the socket, and the pillar, at the top of which the leaf is screwed, fits into the collar. The *screwed-in* sight is made of steel, and has a steel leaf dove-tailed into its top and screwed into a hole above the trunnion. The leaf is hog-backed in shape, and its rear surface roughened to prevent the reflection of the light interfering with laying the gun.

The sights attached to heavy English M. L. R. guns are very similar to those of breech-loaders, with this difference, that, instead of the barrel-headed sight, they have a simple cross-head with sliding-leaf and clamping-screw attached to the *tangent-sight* bar, This sliding-leaf head gives 30′ deflection right or left, and is only for use when one wheel is higher than another, or to allow for wind or some other inaccuracy. They have also a trunnion fore-(drop) sight on each side of the gun, an hexagonal tangent-scale (graduated to 5°), and a dispart or fore-(drop) sight on top of the piece; the breech tangent-sights fit into sockets let into the side of the breech, and are inclined to the left, like those of a B. L. R. gun, but at different angles, the inclination of sight for the 7-inch gun being 3°, for the 8-inch 23′, for the 9-inch 44′, and for the 10-inch 1° 10′. The 64-pr. and 80-pr. converted guns are each provided with a breech and trunnion-sight on each side of the gun, but they have no top-sights; a wood side-scale is also supplied. The 64-pr. wedge-gun (Armstrong) has an *hexagonal brass sight* (tangent-scale), graduated to 5°, and a dispart or fore (drop) sight; the former on the top of the breech, the latter on the top of the trunnion-ring. The 40-pr. and 25.-pr. are side-sighted, having two tangent-sights and screw trunnion-sights of the usual pattern. The field-guns are sighted as follows: The 16-pr. is side-sighted, and has two tangent-sights set at 1° 50′ to the left, and two steel trunnion-sights screwed in. The tangent-sights have rectangular steel bars with gun-metal sliding-leaf heads, and are graduated with degree, yard, and fuse scales. The 9 and 7-pounders are central-sighted.

SIGHT-POUCH.—A long, slender case, used sometimes for carrying the breech-sight. It is suspended from the shoulder.

SIGNAL-ROCKET.—This rocket, designed specially for signalling has a cylindrical case of paper or metal, *a*, as shown in the drawing, attached to one extremity of a light wooden rod, *f*, and containing an inflammable composition, *b*, which, being fired, shoots the whole of the arrangement through the air, by the principle that an unbalanced reaction from the heated gases which issue from the openings in fireworks, gives them a motion in the opposite direction. The principal parts of a signal-rocket are: the case, *a*; the composition, *b*; the head, *c*; the decorations, *e*; and the stick, *f*.

The case is made by rolling stout paper covered on one side with paste around a *former*, and at the same time applying a pressure until all the layers adhere to each other. The vent is formed by choking one end of the case while wet, and wrapping it with twine. The paper case is covered outside with paste, and enclosed in a cylindrical case of tin, $1\frac{3}{16}$ inches in diameter and 9 inches long. The lower edges of the tin case are turned under slightly, to keep the paper case from going through.

A variety of compositions are employed for signal-rockets; the best can only be determined by trial, as it varies with the condition of the ingredients. The following proportions are used in the Naval Laboratory.

Niter	4 lbs. 8 oz.
Sulphur	1.2 oz
Charcoal	2 lbs.
Mealed powder	4 oz.

To increase the length and brilliancy of the trail, add steel or cast-iron filings.

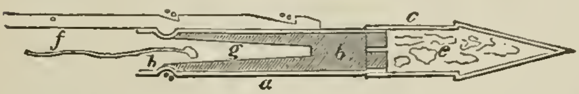
The case is placed in a bronze mold, which has a conical spindle attached to the center of its base to form the bore, *g*. This spindle is made of steel, $6\frac{1}{2}$ inches long, and goes up through the vent into the center of the case, having a hemispherical bottom to fit the choke, *h*. The composition is driven with a screw-press regulated to a pressure of about 5 tons. The first and second drifts are made hollow to fit over the spindle, and the third is solid. A small ladleful of pulverized clay is first put in and pressed down around the spindle, forming a bottom ¼-inch thick. The composition is next put in, a ladleful at a time, each one pressed down separately. The top of the case is closed with clay, which is one diameter thick, and perforated with a small hole for the passage of the flame from the burning composition to the head; through this hole a strand of quick-match is placed.

The rocket is primed by inserting one end of the strand of quick-match, about eight or ten inches long, through the vent into the bore, and coiling the remainder in the recess formed by the choke. A piece of paper is pasted over the end to protect it.

The head is formed by a tin cylinder $1\frac{3}{16}$ inches in diameter and $2\frac{1}{2}$ inches long, joined to a hollow tin cone $2\frac{1}{2}$ inches high, making the length of head 5 inches. The long tin case goes about ½ inch into the cylindrical part of the head, and a piece of paper is pasted over the joint. The object of the head is to contain the decorations, which are scattered through the air by the explosion which takes place when the rocket reaches the summit of its trajectory. The explosion is produced by a small charge of rocket composition, which is put into the head with the decorations. When the composition is consumed, the bursting-charge explodes the head and ignites the decorations, which, falling, produce a brilliant light that can be seen at a great distance.

Stars for decorations, are formed by driving the composition moistened with alcohol and gum arabic in solution in port-fire molds, or molding it in brass cylinders of the desired diameter. It is then cut into short lengths and dredged (sprinkled) with mealed powder. The gum arabic is intended to give such consistency to the stars that the explosion of the head of the rocket may not break them in pieces, thereby destroying the effect. The following is the white star composition:

Niter......	$3\frac{1}{2}$ oz.
Sulphur...	$1\frac{1}{2}$ oz.
Mealed powder...	$\frac{3}{4}$ oz.



The stick is a tapering piece of pine, about nine times the length of the case, and the large end is tied to the side of the case, so as to guide the rocket in its flight, as it has no rotary motion. The common center of gravity of the rocket and stick is a little below the former. The stick counteracts by the resistance of the air upon it and tendency to turn over, and so maintains the rocket, during its flight, as nearly as possible in the direction in which it is fired.

The object of having the cavity or bore in the interior of the rocket is, that a large surface of composition may be at once ignited when the rocket is fired, and so great a quantity of gas generated in the case that it cannot escape from the vent as quickly as formed, and it therefore exerts a pressure in every direction on the interior surface of the rocket. The pressures on the sides of the rocket mutually balance each other, but the pressure on the head is greater than that on the base, in consequence of the escape of gas from the vent; it is in this excess of pressure on the head over that on the base which causes the rocket to move forward, this being merely a similar action to the recoil of a gun. The force which produces motion in a rocket is therefore different from that which acts upon a projectile fired from a piece of ordnance; the former is a *constant* force producing accelerated motion in the rocket until the resistance of the air is equal to the force or the composition is consumed; while the latter may be considered merely as an impulsive force, which ceases to act upon the projectile when it has left the bore of the piece.

A few rockets are always kept mounted and ready for use. To fire a rocket, the stick is placed in a *trough*, or in a tube, as a guide; a musket-barrel will answer the purpose. The paper covering the bottom is torn off, exposing the priming. Holding the guide vertical or nearly so, a slow-match is applied to the priming, which ignites the composition. The inflamed gas issues violently from the bottom of the case as the rocket ascends.

The time of ascent is from 7 to 10 seconds, and they will attain a height of about 500 yards.

Under favorable circumstances a signal-rocket may be seen within a circuit of from 30 to 40 miles. In mounting rockets the stick is attached so that it will hang end down, when supported, close up alongside the bottom of the rocket. See table on page 86.

SIGNALS.—Signals are the means of transmitting intelligence to a greater or less distance by the agency of sight or hearing. Incomparably the most powerful medium yet known for this purpose is the electric current. Sound-signals are obviously but a short circuit. The electric current requires fixed apparatus establishing an actual communication between the two points; and is therefore inapplicable to the ordinary cases of ships interchanging signals with each other or with the shore; and, except under unusual circumstances, it would not apply to armies maneuvering in the field. For these purposes, so far as present knowledge extends, signals by sight or sound must always be the resort. The ancients seem to have elaborated a fair system of night-signals by torches for military purposes; but in naval affairs the ships sailed so close together that orders could be communicated by word of mouth, while the turning of a shield from right to left sufficed as sailing directions to the several lines. In modern times signaling between ships has become indispensable; but there is probably no department of practical science in which progress has been slower, and every so-called system of signals has been distinctly without any system whatever. In the time of James II. a signal could only be expressed by flags, in confusing number, hung in different parts of the vessel. By the beginning of the present century, thanks to Sir Home Popham and other inventors, the system had been adopted of hanging a number of flags under one another, each symbol or combination thus employed having an arbitrary conventional meaning attached to it. Alterations in the specific flags have been made from time to time, but essentially this is the system now in use. The flags are either square, triangular of the same length, or pendants which are pointed and longer. These are of black, white, red, blue, and yellow (in the Austrian Service alone green is added) in mass

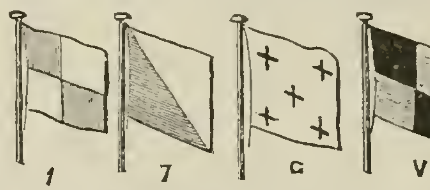


Fig. 1.

or in combination. Specimens of the flags in use are shown in Fig. 1. The signalmen find, however, that at a distance blue, red, and black are not readily distinguishable, nor yellow from white. It has consequently been the recent tendency, and apparently most justly, to reduce all the signs to black and white, singly or in combination, trusting to shape for the different signals. There are, however, disadvantages at

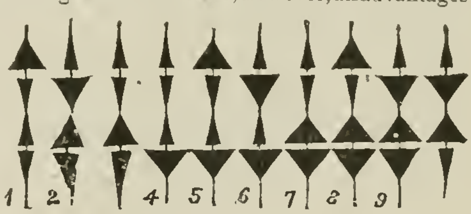


Fig. 2.—Cone System.

tending flags. In a still day they are difficult to read; or the wind may so blow that they will be only seen end on. At sea the motion of a ship will generally neutralize these drawbacks; but the case is otherwise on shore, and it may consequently occur that the ship can communicate to the land, but cannot get a reply. To obviate this, signals representing solid

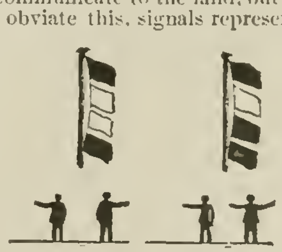


Fig. 3.

figures are sometimes employed. To fulfil their conditions they must appear the same in whatever lateral direction seen. But this limits the shapes to cylinders, cones, and the sphere, or the combinations of those figures; and as the total number of distinguishable signs is reduced, signaling becomes reduced from the word-signal to the telegraph. This distinction should be clearly understood, as much is involved in it. A word-signal, as in the present system, is where the whole word or message is sent up at once, and flies simultaneously; a telegraph signal is one in which the letters composing the word or numbers representing the signal are shown separately, and each is removed before another is shown. At sea the word system is best, for it involves no act of memory; and memory, even from signal to signal, is found difficult by signalmen in the turmoil of perhaps storm or fighting. On the other hand, the telegraph system involves far simpler apparatus, and the changes can be effected more rapidly. As regards the actual time required for a message, the word-system has the advantage in a message short enough for the whole to be shown at one time; but otherwise the difference

The following table shows the dimensions and weights of rockets and their ornaments :—

	Interior diameter of rockets.		
	.75-inch.	1-inch.	1.5-inch.
Height of rectangle for cases........inches...	10	11	13
Length of the finished case........do....	9.25	10.60	12.50
Interior diameter of the choke........do....	0.25	0.42	0.65
Exterior diameter of the case........do....	1.35	1.60	2
Spindle...... Height........do....	6.25	6.75	8.0
Spindle...... Diameter at base........do....	0.25	0.42	0.65
Spindle...... Diameter at top........do....	0.13	0.21	0.33
Nipple....... Diameter........do....	0.75	1.0	1.48
Nipple....... Height........do....	0.65	0.7	1.0
Diameter of cylinder and part of nipple........do....	0.75	1.0	1.48
Drifts...... Diameter. .do....	0.72	0.97	1.47
Drifts...... Length of cylindrical part........ 1st drift.....do....	9.65	10	12.75
Drifts...... Length of cylindrical part........ 2d drift.....do....	7.25	9	10
Drifts...... Length of cylindrical part........ 3d drift.....do....	4.5	5 25	7.60
Drifts...... Length of cylindrical part........ 4th drift....do....	2.5	3.0	4.0
Drifts...... Conical cavity. Dia'r at bott'm or base 1st drift.....do....	0.27	0.44	0.67
Drifts...... Conical cavity. Dia'r at bott'm or base 2d drift.....do....	0.24	0.36	0.64
Drifts...... Conical cavity. Dia'r at bott'm or base 3d drift.....do....	0.21	0.33	0.60
Drifts...... Conical cavity. Com'n dia'r at top........do....	0.14	0.23	0.33
Drifts...... Conical cavity. Length of........ 1st drift.....do....	6.75	7.5	8.50
Drifts...... Conical cavity. Length of........ 2d drift.....do....	4.25	5.0	6.0
Drifts...... Conical cavity. Length of........ 3d drift.....do....	3	3	4
Driving mallet........ Weight........pounds...	1.25	1.5	2.0
Driving mallet........ Length of handle........inches...	8	8	8
Charger........ Diameter........do....	2.25	2.75	3.5
Charger........ Length of cylinder........do....	2.5	2.20	2.85
Charger........ Whole length........do....	7	7.75	8.30
Height of the solid........do....	1.5	2.0	3.0
Composition for 100 rockets........pounds...	30	50	125
Clay in head........ounces...	0.75	1	1.25
Pot........ Rectangle....... Length........inches...	12.5	7.25	15
Pot........ Rectangle....... Height........do....	3.10	3.25	5
Pot........ Former dia'ter........do....	1.35	1.60	2.25
Pot........ Weight of pot.. Stars........ounces...	1	1.5	2
Pot........ Weight of pot.. Serpents........do....	1	1.5	3
Pot........ Weight of pot.. Gold rain........do....	1	1.75	2.5
Pot........ Bursting-charge........do....	0.5	1	1.25
Cone........ Conical former Height........inches...	3.25	3.75	4
Cone........ Conical former Diameter at base........do....	1.5	2.0	2.30
Cone........ Length of finished cone........do....	1.75	4	4.35
Stick........ Length........do....	80	84	96
Stick........ Thickness of large end........do....	0.6	0.66	0.8
Stick........ Thickness of small end........do....	0.35	4	0.5

	.75-inch rocket.		1-inch rocket.		1.5-inch rocket.	
	Number.	Weight.	Number.	Weight.	Number.	Weight.
		Grains.		*Grains.*		*Grains.*
Stars........	10	490	15	700	20	890
Gold rain........	10	490	15	700	20	870
Streamers........	8	685	12	1,025	18	1,575
Serpents........	3	525	4	850	8	1,350

is not material. If all advantages be balanced, it is probable that the telegraph system will eventually supersede the other entirely. Whether the word or the telegraph system be practiced, another question is, whether to spell each word, or to use numerals and a code. Under the latter principle about 14,000 of the words and sentences most commonly sent are arranged for easy reference in the signal-book. With the addition of 1 or 2 repeating symbols the 9 numerals and 0 give combinations 4 together to this number. A combination of figures is arbitrarily assigned to each expression; and the expression is communicated by representing those figures in their proper order. With the book of reference at hand, and an intelligent signalman, there can be no very great doubt of the superior rapidity of the "code." A code has also this further advantage, that, the signals representing things and not words, it can be made international, the same symbols representing the same idea in every language. It is then only necessary for universal signaling that each nation should concur in the meaning to be attached to the several signs. Many gentlemen of ability have devoted their attention of late years to the simplification of signals among whom conspicuous positions must be assigned to Colonel Grant, Colonel Bolton, Mr. Redl, and Captain Colomb, R. N. Their principal object has been so to simplify the telegraph system that signals may be made with any apparatus, or without apparatus at all. To accomplish this they have, to a great extent, abjured all color and resorted to form and motion. Among the form telegraphs there is the principle of the old semaphore, in which each letter or number is shown by the position of two arms. The arms are heavy, and involve mechanism; besides which they are not always clear on a ship in motion beyond a short distance. Very superior in visibility and simplicity is Redl's System of Cones. This consists of 4 cones fixed to a mast. The cones are collapsable, and are formed in a similar manner to umbrellas. Their usual condition is shut, and they can only be held open while a rope attached to each is pulled. With cones of 3 feet base, signaling is rapid and clear up to 5 miles, and the mast can be inserted at any place. The system is very simple: each cone represents a number, 1, 2, 3, or 4; then 1 and 4 shown represent 5; 2 and 4, 6; and so on, as in Fig. 2. This very elegant system can be applied in military or naval operations. But its chief beauty is that a person understanding it can make the same signals without the cones; for example, if a black flag represent an open cone, and a white flag a shut cone, a ship with 4 black and 3 white flags can make every signal. Again, the arm raised horizontally may represent the open cone; against the body, the shut cone; then two men standing on a cliff are as good as any signal-post—see Fig. 3. Or if one person only be present, he may represent an open cone by raising his arm with a handkerchief extended, and a shut cone by his arm without the handkerchief. He has only then to raise his arm four times in quick succession, with or without the handkerchief, to make the required signal. We have thus arrived at a universal system of the utmost simplicity, which in war, and especially during invasion, might be of inestimable benefit to the nation. The code of signals cannot be generally diffused by the Government. It only remains to apply the same system to night-signals. The old naval principle has been to hang dingy lanterns in various shapes—triangles, squares, crosses, etc. Besides requiring large bases to be at all visible, this has been found from the motion of a ship to be nearly useless. Redl's system has been applied by hanging four lanterns in a vertical line to represent the cones, and obscuring those which corresponded to shut cones. An improvement was found in introducing a red or green light in the middle, to show the relative positions of the four. The best night-signals are, however, flashing lights, as introduced by Colonel Bolton, and more elaborately by Captain Colomb, and adopted in the English Navy. This consists of a bright light, covered over by a shade, which shade, by mechanism can be lifted for any given time, exposing the light meanwhile. A flash of about half a second's duration is negative: a line of 1½ seconds, positive. Four exhibitions of the light then represent a symbol as in Redl's cones. It will be seen that this system produces results similar to Morse's electric telegraph. If the distance be within a mile or so, and the weather be still, a bugle will answer equally well, long and short notes representing the positive and negative cones. The fundamental principle of the foregoing system of universal telegraphy, applicable by night or by day, by sight or by sound is to employ two signals only—one positive and one negative—and to regulate their exhibition by periods of time. Heliography is now largely used for military signaling where there is plenty of sunshine. The heliograph is simply a mirror on a stand, capable of being swung horizontally as well as vertically, with a small hole in the mirror to look through, so as to direct it accurately. Two trained sappers with heliographs can easily flash signals to one another at a distance of 50 miles, and so communicate even without the help of a telescope. See *Semaphore*.

MARINE SIGNALS.

It is certainly very desirable to have in use a system of marine signals by which communications between vessels may be easily made, promptly read and clearly understood.

The systems now in general use in the merchant service perhaps answer well enough under favorable conditions of wind, weather and distance, that is to say, having a wind from the right direction strong enough to blow out the flags, with weather clear enough to enable you to distinguish colors, to recognize diagrams, or to discern outlines, and with moderate distances for maintaining communication. But to every one who is familiar with the meteorology of the sea, and the experience of the sailor, it is well known that signals which depend upon differences of color, upon diagrams, or upon outlines for correct interpretation, fall far short of the demands that are made upon them. Vessels are sometimes in sight of each other for many hours, separated by a distance of only one or two miles, yet they are entirely unable to express their wishes so as to be understood through such inadequate means. We herewith present the outlines of a new system of marine signals, designed by Mr. S. P. Griffin. With this system it is thought possible to communicate at distances so remote that distinctions in color are lost, diagrams are impossible to trace, and outlines are rendered obscure; or when color, or haze, or dimness of light intervenes to bring about similar results, without materially impairing the simple visibility of objects.

With this system, in order to convey intelligence clearly and rapidly between vessels, it is only necessary to be able to see the flags or other objects used in place of them, their combinations and their changes are so simple, and are so easily made, that errors in reading signals cannot very well occur.

There are three classes of marine signals; namely, day-signals, night-signals, and fog-signals. They address themselves to the eye and ear. Day-signals, as a rule, are made with flags, as these furnish the simplest, and probably the best, medium of communication whenever objects can be made out and vessels are beyond hailing distance; shirts, blankets, sails, barrels, in fact, any objects that can be readily discerned and handled, are useful for making signals, and there are a number of different plans of using these various objects, each of them possessing some merit For night-signals, lights at once suggest themselves as being the best. The plain white light can be substituted for flags in this system with entire success. Fog-signals are necessarily made by sounds; they may be used as day or night-signals also, but in practice, owing to their want of volume, they are not nearly so useful as flags or lights, and as they address the ear only, a sound-signal alphabet must be made for them —with the use of instruments that are capable of producing continuous sounds, like the bell, the trumpet, the horn, and the whistle, there need not be any trouble in transmitting intelligence, combinations of short and long sounds will satisfy any demand that can arise within the limits of hearing. As long as objects can be seen or sounds heard and we can control them, so long may signals be transmitted simplicity of arrangement is, of course, a consideration of great importance. Mr. B. F. Greene introduced a plan of signaling by measuring intervals of time between exhibitions. General A. J. Myer, Signal Officer of the Army, in speaking of it says, "thoroughly understood and skilfully used it will render intelligent communication and co-operation practicable under circumstances which have made them hitherto impossible." Undoubtedly Mr. Greene's plan of signaling is of great value, but it is not very well adapted to the requirements of the merchant service, a few simple objects, and two simple sounds without complex combinations seen or heard and understood at once, without the necessity of precise admeasurement of time intervals, are better. On board men-of-war, besides the ordinary instruments furnished to merchantmen, they have guns of suitable caliber, an abundance of pyrotechnic contrivances, and numerous officers to detail to look out and mark time.

Under this system, flag signals may be displayed from one, two, three or more places as may be agreed upon beforehand. As ships and barks are most engaged in over sea voyages, and are most given to the use of signals, the first arrangement will be for them, using their three masts as signal places and nine flags. It is not necessary that masts shall be used, or that brigs and schooners cannot be included in the first arrangement; masts are the best places, other things being equal, but two masts and a gaff, the fore and aft stays, the back stays, anywhere to show three separate and distinct hoists of flags at once will do. Let it be understood that signals must be read from forward aft, from aloft down, from starboard to port. The vessel that desires to signal, must first call attention by a hoist; let this hoist also indicate the number of places she means to use: in this first arrangement, it will be done by displaying three flags, one under the other. As soon as she is answered by a hoist of one flag, which means an affirmative, all right, go ahead. She will then hoist the signal for the international code letters, the alphabet, or numerals, as she chooses. An answer of two flags means, a negative do not understand, repeat. As this system of signaling is not intended to supersede other systems already in use, but to supply their deficiencies, it is well to conform to what is already known and practised as nearly as can be done; therefore, the alphabet and the signal dictionary of the "International commercial code of signals" will be adopted. The flags of that code as objects easy to discern may also be used. In clear weather, at moderate distances, colors, diagrams, and outlines may be used with good effect in signaling. But as soon as it is found impossible or difficult to make them out, resort may be had to this system, with the same flags, with the same letters, having the same meaning, the difference being that each letter requires a separate hoist or a combination of hoists. It may be desirable at times to be able to spell words, to construct sentences, wherefore an alphabet arranged for this system is given. The use of abbreviations in marine signals will greatly facilitate communication between vessels. In the formation of words certain letters may be understood, and in the construction of sentences whole words may be omitted. Some words and parts of sentences are so much used at sea that an allusion, however slight it may be, will indicate them without any danger of ambiguity. By writing the message to be transmitted by signals, an inspection of it will suffice to show the number of letters and of words that may be safely left out, and still convey to the eye and to the ear its full meaning. Communications by the use of numbers are easier and quicker than those by words and sentences, hence it is desirable to have a numeral signal dictionary. One can be easily made which will contain all that the exigencies of the sea requires. So may the names of vessels and places be arranged numerically in groups designated by their rig and their initial letters.

Object Signals.—First Arrangement for three signal places and nine flags, see Fig. 4, the flags are numbered in the Fig. merely for illustration. Attention signal indicating the number of places to be used, three flags one under the other in one hoist.

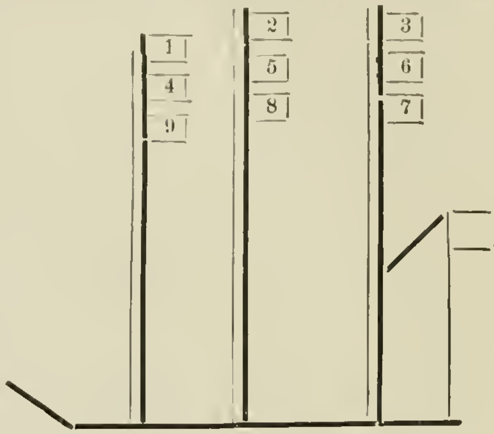


Fig. 4.—International Code Signals and Numerals.

B	Flag 1.	No. 1.	M	Flag	1 2 3.
C	" 2.	" 2.	N	"	1 2 4.
D	" 3.	" 3.	P	"	1 2 5.
F	" 1 2.	" 4.	Q	"	1 3 4.
G	" 1 3.	" 5.	R	"	1 3 6.
H	" 1 4.	" 6.	S	"	1 4 7.
J	" 2 3.	" 7.	T	"	2 3 5.
K	" 2 5.	" 8.	V	"	2 3 6.
L	" 3 6.	" 9.	W	"	2 5 8.

Second Arrangement for two signal plans using eight flags on two masts, or a mast and gaff, etc. Attention signal, indicating the number of places to be used, two flags, one under the other.

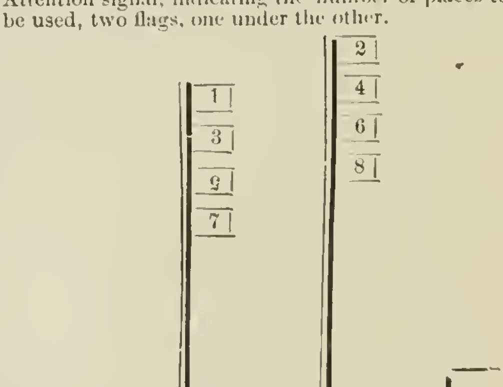


Fig. 5.—International Code Letters and Numerals.

B	Flag 1		T	Flag	1 2 3 4 6.
C	" 2.		V	"	1 3 5 7 2.
D	" 1 2.		W	"	1 2 4 6 8.
F	" 1 3.				
G	" 2 4.				
H	" 1 2 3.				
I	" 1 2 4.				

Numerals.

1	Flag 1.
2	" 2.

K " 1 3 5.
L " 2 4 6.
M " 1 2 3 4.
N " 1 2 3 5.
P " 1 2 4 6.
Q " 1 3 5 7.
R " 2 4 6 8.
S " 1 2 3 4 5.

3 " 1 2.
4 " 1 3.
5 " 2 4.
6 " 1 2 3.
7 " 1 2 4.
8 " 1 3 5.
9 " 2 4 6.

Third Arrangement for one signal place, using five flags on one mast, or on a gaff, etc. Attention signal indicating the number of places used, one flag.

Fig. 6.—International Code, Letters, and Numerals.

In practice there will not be any trouble experienced in reading signals with blank spaces in the hoists, for the blanks will be measured at once by the flags above and below them. In daylight, when a vessel desires to communicate with another by signals she can indicate her choice of any one of the three preceding arrangements as directed, and if she chooses to use the alphabet of this system, she indicates it by hoisting signal W. flags, 2, 5, 8, running the hoist up three times for the first arrangement. Fig. 6. By hoisting signal G, flags, 2, 4, running the hoist up twice for the second arrangement. By hoisting signal F., four flags, running it up once for the third arrangement. Or the numerals by five flags in one hoist, run up and down twice, immediately after attention and place signal is answered and hauled down. It is understood that the international code letters will be used unless expressed to the contrary as above written. Signals must be kept flying until they are answered.

Sound Signals.—A whistle, trumpet, horn, bell, or any other instrument that is capable of producing continuous sound may be used. One short and one long sound are all that are necessary. The length of the dash or line indicates the relative duration of sounds.

B.	No. 1.	North	— — —
C.	" 2.	South	— ——
D.	" 3.	East	—— —
F.	" 4.	West	— — ——
G.	" 5.	N. E.	— —— —
H.	" 6.	S. E.	— —— ——
J.	" 7.	N. W.	—— — ——
K.	" 8.	S. W.	—— —— —
L.	" 9.	N. N. E.	— — — ——
M.	E. N. E.		— — —— —
N.	E. S. E.		— —— — —
P.	S S. E.		—— — — —
Q.	S. S. W.		— — —— ——
R.	W. S. W.		— —— —— —
S.	W. N. W.		— —— — ——
T.	N. N. W.		—— — —— —
V.	Stopped		—— —— — —
W.	At Anchor		—— — — ——

A short sound is half the duration of a long sound, and may be indicated by the time it takes to count slowly one, two. A long one by counting slowly one, two, three, four; intervals between sounds of the same group will be indicated by one, two, and intervals between groups by one, two, three, four. With a little practice this plan of signaling can be successfully conducted; the man who operates the instrument to produce the sounds, say with the whistle, will very soon acquire correctness in his short and long sounds, and in his blanks or intervals. The attention signal, with the sound-producing instrument, will be five short sounds, thus — — — — —, the answering and affirmative signal one long sound, —— the negative signal, two long sounds, —— ——. It is understood that the international code of letters and definitions will be used unless the alphabet is desired by signal F, two short and one long sound, — — ——, repeated three times, or numerals by signal L, three short and one long sound — — — —— repeated three times. As compass fog-signals are of great importance at sea, and as it is customary on board steamers to sound the whistle during fogs, it will be easy to indicate the course by this arrangement, instead of making only an unintelligible noise. The signals stopped and at anchor are obviously of great use under circumstances of common occurrence in the experience of the navigator. Signals are given for sixteen compass courses only, as it is believed that they will be enough in practice: to give a signal for each of the remaining sixteen points would extend the length of it too much. Besides, if you are steering, say N. by E., make the north and N. N. E. signals alternately: if you are steering N. by E. half E., make the N. N. E. signal, it being within half a point of the course, and practically near enough to it and the same for the other courses for which no special signal is given.

RAILWAY SIGNALS.

In considering the means to be employed for directing and ensuring the safety of the traffic upon railways, it became evident that among other things some plan should be devised for giving instructions and information to drivers and guards of trains as to the state of the road in advance of them, or of the nearness of a preceding train, so that the speed and progress might be judiciously regulated; the plan ultimately adopted as most suitable was that of signals. These chiefly consist of variously shaped boards, painted a bright red color on one side to indicate danger, and in some cases green on the other to indicate caution; these boards are fastened to a pole or mast attached to a post in such a manner as to admit of their being turned round, raised and lowered, or otherwise altered in position so that in addition to representations by colors certain movements are executed. In most cases the engineers or the traffic managers arranged their particular system of signals, fixed or portable, without consideration of those used on other lines, and the natural result is that the forms and systems in use are considerably diversified; the first railways had signals placed only at the principal stations and junctions, the intermediate portions of line were regulated by policemen who had certain beats assigned to them, and who gave manual signals to the drivers as necessity demanded; danger was indicated by facing the approaching train and elevating both hands above the head; the go slow or caution signal was given by one hand similarly held and all right or the line clear by extending the right hand from the body horizontally. Red, green, or blue, and white flags were used in many instances in conjunction with and also instead of the manual signals; gradually station or home fixed signals were introduced throughout each railway, then distant or auxiliary signals worked by wires having their levers concentrated at one locality, frequently in a cabin or signal-box, for facilitating operation by the men in charge; this latter method has now to a great extent given place to a system of interlocking the mechanism for moving the points and signals, and especially at junctions and large stations: these inventions for locking prevent the possibility of an all-right signal being given when the road governed by that signal is fouled in consequence of a train being wholly upon it, or through its being intersected by a train passing from another road.

The most general form of signal is that of the semaphore; it is an imitation of, the old telegraphy systems, the first of which appears to have been invented by a Dr. Hooke in 1684, Fig. 7, and revised by a Rev. Mr. Gamble about 1795; it was then styled the radiated telegraph, Fig. 8; further improvements were made in the year 1804, and also in 1810 by Pasley, by Rear-Admiral Popham in 1816, Fig. 9, and by Pasley or Macdonald in 1822, when the system was termed the Universal Telegraph, Fig. 10; it was similar in detail to the French coast semaphore in use in 1803. The semaphore signals as used on the railways are constructed with arms upon both sides of a mast fixed upon a center-pin free to move up and down; those on the left-hand side, as seen when facing the signal, are as a rule to govern the left roads, and there are as many arms as roads or descriptions of trains to be regulated. It has been found desirable to further distinguish the arms by numbers or letters painted upon them, or by affixing pieces of shaped iron or board corresponding with the understood number or letter of the several roads.

Among the early attempts in signal construction, three may be noted as possessing some novelty. In 1838 a disc signal was in use at Vauxhall Bridge, Birmingham, the invention of a Dr. Church; it was connected to the points and stood about 5 ft. high; two discs, 2 ft. in diameter, were fixed on the top at right angles to each other, and surmounted by a lamp showing two red lights, one blue and one white; the discs were painted with colors to correspond. In 1842, C. Hall introduced a system on the Great Eastern line; the signal consisted of five leaves placed in the shape of a fan on a mast, and colored yellow, green, red, and white; each leaf indicated the time a train had passed it; a green post was fixed at the side of the line 100 yds. in advance of the signal, beyond which no train was to pass if the fan exhibited the red leaf; a green and white striped post was also fixed at one mile beyond the signal; and if the fan showed the seven or nine minute color when passed, the driver might put on moderate or full speed on reaching the striped post. These signals were in use several years. On the Greenwich Railway plain posts were fixed to each road at half a mile on either side of the junction, on reaching which the driver opened the engine whistle, and the switchman notified by hand-flags which train was to proceed on to the main line. The construction of self-acting, or rather train-actuated signals, has claimed the attention of a very large proportion of inventors of signals, but

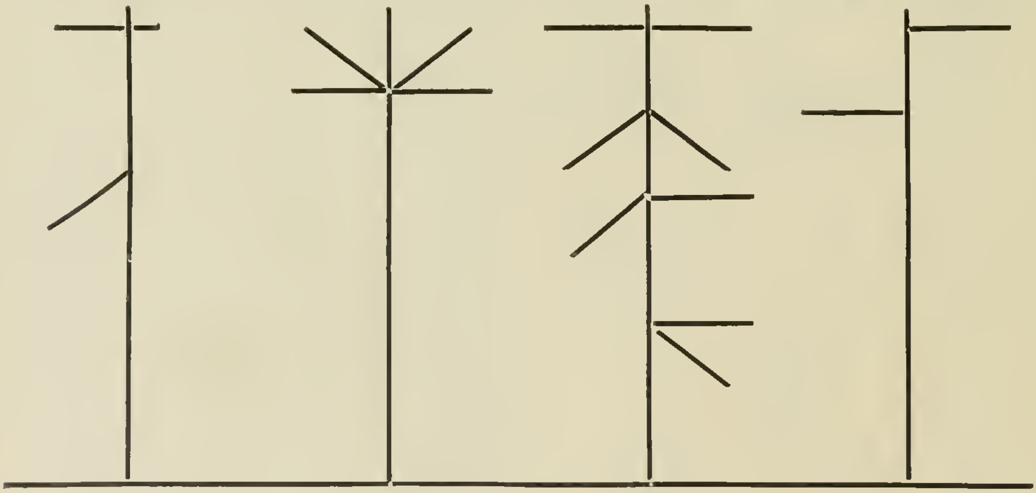


Fig. 7. Fig. 8. Fig. 9. Fig. 10.

very few systems have been tried, and many of those were found practically unreliable and therefore useless. Whitworth's signals were used on the Brighton line, at some of the tunnels on the Lancashire and Yorkshire, Whiston Bank, near Liverpool, and several other situations. In 1858 Baranowski obtained permission to test his automaton distant signal between Hackney and Kingsland, on the North London line. It was set to danger by the passing train pressing down a lever which actuated the mechanism of the signal; and when the train reached a distance of 1100 yds. it pressed down another lever, causing the danger signal previously set to be released. Although many hundreds of trains successfully worked it, its failure on one occasion is supposed to have caused an accident which led to its being removed. The Midland Company erected an indicator at Kegworth in 1863, showing the time a train had passed up to fifteen minutes. It was set in motion by a treadle being depressed by a passing train. At the expiration of fifteen minutes the pointer returned to zero. This signal was subsequently removed as unreliable. So soon as the few inventions at all trustworthy for locking signals and points had proved their advantages over previous systems, they were rapidly adopted by many of the railway companies.

A very satisfactory plan was introduced by R. C. Roper in 1869. The advantages of this system are, that the locking is accomplished without any moving bolts, cranks, or screws, the long bars on the point levers which effect the locking are in sight, and the operator can see which levers can be moved and which cannot. A bar is mounted on the point levers extending between the signal levers, dividing them into sets, and as respects each point lever in motion either way separating the single levers, which must precede the point levers in their movements from the others. The levers are all arranged in a frame in the usual way; one side of the frame is termed permission for main line, and the other permission for branch line. On each point lever is fixed a bar, the bar on one set being lower or higher than that on the other, extending as above described, and so coupled with the signal levers that if there be arranged on that side of the frame called permission for branch line all those signal levers and levers belonging to the main line, and on the opposite side of the frame those signal levers which belong to the branch line, all the signals will be then at danger. The bars on the point levers extend over the point levers in such a manner, that on either point being brought over to one side of the frame, the bar upon it rests against those signal levers which ought to be locked by it when in this position, and the signal levers which are ranged on other side of the frame are no longer locked by this lever. The side of the frame which gives permission to the main line gives danger to the branch, and the reverse; but in no case can the signal levers be moved before the point levers. A system invented by Wm. Bains, is in use at the somewhat complicated junction at Lindal Cote, it having a cross-over road running into both up and down main lines, two branch lines, on one side, and three lines on the other. There are catch-points on the up side, which have to be kept closed for the cross-over road and open for the catch-siding so that the main lines may not be fouled by traffic on the branch lines; these catch-points can only be opened for the cross-over road when the signals have been set to danger for the main lines and the branch lines on the opposite side; consequently nine points and seven signals have to mutually interlock with the one set of points. The levers are all centerd on the main shaft, and above this is a smaller shaft, which passes through a quadrant arc in the foot of each lever, thus allowing the required range of motion. On this shaft are loosely slipped a number of short tubes or rockers; these have cams upon them, which act against projecting tappets fixed one upon the bottom of each locking bar, and when the cam is held up under of one these tappets it prevents the bar from being pushed down, in which case the detent of that lever cannot be raised out of the quadrant notch. The practical result of this arrangement is, that before the lever has been moved ⅛-in. in the quadrant the locking of the second lever is perfectly effected; the pressure upon the several parts is very small and they do not require oiling.

The existing arrangements for working the traffic on the London Metropolitan Railway and at the Victoria and Cannon Street stations are good examples of the application of locking gear to signals and points, and the facilities for safety afforded thereby have been recognized by the English Board of Trade, and strong recommendations are embodied in the regulations issued by that Department that all railway companies should adopt such means for the prevention of accidents. See *Signal Tactics.*

SIGNAL SERVICE.—At the time of the organization of the Department of Meteorology of the Army Signal Office, there was no general system in operation for "Simultaneous Meteorology," and the one ever since in use was devised and carried into effect by General Myer, Chief Signal Officer. By this system the innovation was introduced of observing and reading off the instruments, "at the same moment of actual (not local) time." By this arrangement the Signal Office at Washington can call for and receive reports from all parts of the country, taken at each of the stations, at any hour of the day or night. Thus, the exact condition of the atmosphere over the whole field of inquiry is set down at a given instant, establishing the existence of conditions on which predictions may be and are fearlessly made. In November, 1871, a comparison of the tri-daily forecasts, or "probabilities," as they were styled, showed a verification of 69 per cent, which rose to 76.8 per cent by 1872. These results "afforded the best elucidation and the most complete demonstration of the law of storms and the movements of cyclones that had ever been obtained in any country." In 1872 and 1873 the expansion of the work of the Signal Office was very great; extending, through the cordial aid of agricultural societies, into a comprehensive Weather Bureau sustained in the interest of agriculture; and, through its connection with life-saving and signal-stations, becoming a most certain and effective agent for saving life and property endangered by storms on the sea. "Indication" and "Cautionary Signals," based upon three series of simultaneous weather-reports telegraphed to Washington daily, are issued from the office of the Chief Signal Officer three times each day, and are printed in all newspapers where it may be important to do so, and otherwise made public. The preparation of a graphic weather-map embodying the telegraphic data furnished to the Chief Signal Officer every eight hours, preserves an accurate picture of the existing aerial phenomena, and the conditions on which storm predictions are made. The "Farmers' Bulletins" are reprinted by the Signal Service Observers in many cities, and the telegraphic forecasts are circulated among many thousand subcenters in agricultural communities, and thence distributed among farmers. As the predictions cover twenty-four hours, and often hold good for twice that period, they reach the denser rural populations sometimes a day and a half and always as much as fourteen hours before the period to which they apply expires. The railroad system has co-operated in this service, and nearly all the railway companies distribute daily reports to the railway stations, without charge. Cautionary signals are of two kinds: 1. Those premonishing dangerous winds to blow from any direction. 2. Those premonishing off-shore winds, likely to drive vessels out to sea. The first distinctively termed the "Cautionary Signal," consists of a red flag with a black square in the center, for warning in the day-time, and a red light by night. The second, or "Cautionary Off-shore Signal," consists of a white flag with black square in the center shown above red flag with a square black center by day, or a white light shown above a red light by night, indicating that while the storm has not yet passed the station, and dangerous winds may yet be felt there, they will probably be from a northerly or westerly direction.

The *London Times* has said "the weather is by no means a subject which should be regarded merely as a matter of conversation for the multitudes of people who find it difficult to talk about any thing else. The subject is, in reality, one of great national importance; and of far more importance than many others which occupy the time and the thoughts of the public; and it is only neglected on account of the obscurity behind which the causes of weather changes have been hitherto concealed, and of the consequent apparent futility of discussing them. If any scientific investigation could bring the subject of weather changes within the region of actual knowledge, so that reasonable forecast might be made concerning them, it would at once become manifest that scarcely any other subject would vie with them in universality of interest. The power of foreseeing the weather of the next few days would do much, the power of foreseeing the weather of the next season would do almost everything, to take away from agriculture the uncertainty which is now its greatest hinderance; and a bad harvest season would then no longer, as at present, entail upon the nation a loss which must be estimated by millions." The accuracy attainable in foretelling the weather of at least the next few days, the forecasts being based upon local indications taken in connection with the general information furnished by the Signal Service, will agreeably surprise any one who will test the matter for himself. In our active, working life, who does not consult the weather, and what branch of every-day life and its varied pursuits is not influenced and affected by its changes? The practical application of weather knowledge to all classes of industry, to all professions, handicrafts, and processes of animal and vegetable life, is steadily increasing. Physicians and boards of health are enabled, from telegraphic weather reports, to detect dangerous atmospheric conditions, to investigate the origin and spread of diseases and epidemics, and to give timely warnings or hopeful encouragement, based on the knowledge of coming changes. The subtile, mysterious influence of the weather governs and controls us, and, because we pay so little attention to its changes, sends many of us to our long home. The important question, will it be clear or cloudy, warm or cold, rain or snow, on the morrow, involves so much of our health and comfort, as well as success, in nearly every practical walk of life, that all should be, as all may be, able to answer it for themselves. That a local, isolated observer, without instruments, but with some general knowledge of the elements of meteorology, and with the aid of telegraphic reports of weather conditions, especially to the westward, whence most of our weather comes, can foresee his own weather for the morrow, is beyond doubt. No farmer need suffer loss or damage from the coming rain; no merchant need risk his perishable cargo; no speculator his money, and no traveler his safety and comfort.

Weather prophecy, that covers a period of time in advance, and that specifies certain dates in the future upon which certain conditions are, or are even likely to prevail, is simply a delusion, and the alleged prophets should be regarded as materialized spooks and noisy cranks, who blow their horns, of greater or less dimensions, emitting sounds signifying nothing. Some of these manage, by extensive advertisement and an occasional chance hit, to attract the attention of the over credulous; but they sooner or later fade away and disappear from public attention. No man can, by any reasoning whatever, or upon any hypothesis, foretell the weather beyond a few days, or rarely a week in advance. Long range predictions, whether based on the position of the planets, the influence of the moon or of sun spots, or on the assumed law of periodicity, are unreliable, and amount simply to good, bad, or indifferent guess-work. It is not complimentary to the intelligence of the times, or the diffusion of knowledge, that the absurd vaticinations of the professional weather wizards should always be accepted with more or less credibility. Failures do not seem to have any effect upon the minds of the unthinking, while a chance success is heralded throughout the land, even by the press, whose business it should be to be intelligent. Arago, a French astronomer, said that no scientific man, who cared for his reputation, would venture upon a weather prediction. And yet the leading weather prophets of our time are men who base their predictions upon the occurrences of astronomical events; upon the theory that the planets exercise a controlling influence over the weather of our earth; that planetary perihelion and aphelion passages, oppositions, and conjunctions, produce changes and interruptions in the electric currents undulating between them, causing various grades of meteoric disturbances in our atmosphere.

The only reliable, as it is the only reasonable, system of forecasting the weather, is that of our Signal Service. But, while the Weather Bureau at Washington is making great progress in reducing meteorology to an exact science, the geographical areas for which predictions are made are too large, and entirely different weather may prevail in different portions of the same district. To say that local rains will occur on a given day in, for instance, the Ohio valley, is not altogether satisfactory to residents in different portions of the valley. To anticipate, by way of illustration of this: Suppose a storm is central over the western plains—weather generally travels in an easterly direction—the Signal Service announcement would be local rains for the upper Mississippi valley on the morrow, and on the next day for the Ohio valley. Now, those in different portions of either district, who have some knowledge of local signs and indications, can supplement this official announcement for their district, and determine for themselves whether the coming rain is or is not likely to reach their particular locality during the day. A little practice will enable the merchant or the farmer to read between the lines of the necessarily brief and sometimes misinterpreted government report with good results.

The Signal Service system is also employed in Great Britain and among other European nations. It consists in taking careful and simultaneous observations at a great number of representative points of the pressure and temperature of the atmosphere, the direction and velocity of the wind, the degree of moisture or saturation of the air, the cloudiness, etc., at each point. In our country, these observations, made several times each day, are promptly reported by telegraph to the central office at Washington, and there projected upon a map of the country, which then shows at a glance the distribution of sunshine and cloudiness, of warm and cold, of fair and foul weather at the time, just as the geographical map shows the distribution of mountains and valleys, plains and river courses, land and water. Our present weather science dates from the time of making simultaneous observations at numerous and widely scattered places, and the use of the telegraph in transmitting the results. Without the weather map, it would not be possible to predict weather for the various geographical divisions of the country from any central point, as is now done with great success. Without a knowledge of the principles of meteorology, the established laws and generalizations, weather reports are of little value in respect to making any deductions therefrom. There is no limit to the utility of such knowledge, and it is not difficult to acquire. There is nothing mysterious attaching to it. When once leading facts are mastered and borne in mind, there is a wonderful simplicity in meterology. There is an absorbing fascination in the constantly changing conditions, as revealed from day to day by the weather map. From the study of this map are made the forecasts for the various geographical, or rather meteorological districts, for short durations of time. These forecasts, or "Indications," are based upon established laws of storms.

The atmosphere which envelops our earth is the great factory in which all the meteorological phenomena occur. The ever varying pressure, temperature, and moisture of the air, are the three *keys* with which to unlock the weather mystery, which ceases to be a mystery when these principal elements constituting *weather* are understood. Moisture, manifesting itself in various ways, is perhaps the principal element to be considered in determining local weather changes. The air is never quite dry, and at times it is so full of moisture that a fall of rain is almost inevitable. Increasing heat increases the capacity of the air for holding moisture. Evaporation, or the conversion of visible water into invisible vapor, is constantly going on to a greater or less extent. A simple saucer full of water exposed to the open sky, and protected from interference, will, by the more or less rapid diminution of the quantity of water through evaporation, give indications of the weather. Dryness, or fair weather, is connected with a rapid rate of evaporation, and dampness, or wet weather, with a slow or more or less suspended rate of evaporation. Any intelligent, practical observer, can get satisfactory results in local weather predictions by simply watching the clouds and the varying humidity of the air, as indicated by two common thermometers suitably arranged and called a hygrometer.

The instruments should be perpendicularly secured on a piece of board about ten or twelve inches apart, and both should show the same temperature. Then cover the bulb of one of the thermometers with a wick leading into a small covered vessel, fastened to that side of the board and at some little distance from the bulb, containing preferably rain water. The readings of that thermometer, called the "wet bulb" will usually be found to be lower than those of the other. This is due to the water absorbed by the wick rising by capillary attraction to the end of the wick over the bulb and evaporating, causing cooler air around that bulb, and thus lowering the mercury in the tube. In dry weather evaporation goes on rapidly. In very damp weather evaporation is slow. When the air is thoroughly saturated with moisture, evaporation from the wick ceases, and the two thermometers read alike. That is to say, the moisture in the air, when thoroughly saturated, has the same effect upon the "dry bulb," as the water held by the wick has upon the "wet bulb." Should, for instance, the dry bulb read 60°, and the wet bulb 50°, the percentage of relative humidity would be 44 or low. By relative humidity, is meant the proportion of vapor in the air at any given time compared with what the air could contain at that time if thoroughly saturated. Saturation being expressed by 100, the above, it will be seen, would be low, less than one-half, indicating dry weather. On the other hand, should the dry bulb read 60°, and the wet bulb 58°, the percentage of humidity would be 88, or high. Should both read alike, care always being taken that the vessel is kept supplied with water and the wicking clean, the percentage of humidity would be 100—that is, the air would be quite thoroughly saturated with moisture. The greater the difference in the readings, the drier the air, and the less chance for rain.

But a knowledge of the mere percentage of existing moisture is not of so much practical importance to the farmer or others, whose business pursuits depend largely upon weather conditions, as the fact whether dampness is increasing and rain therefore probable, or whether the air is drying and fair weather likely to ensue. These facts are admirably indicated by the little instrument above described. The approaching or separating thermometers, taken in connection with the wind direction and local signs, together with the information furnished by the weather reports, should enable any one to satisfy himself as to his probable weather for at least a day or two in advance.

The air deposits a portion of its vapor on all bodies that are colder than itself, and the temperature at which such a deposit of moisture is made is called the dew point. The dew point may at all times be found by calculations with a set of factors.

The rule is: *Multiply the factor opposite the reading of the dry bulb into the difference of the dry and wet bulb thermometers, the reading of the dry bulb thermometer, less the product found, will be the dew point.*

TABLE OF FACTORS FOR COMPUTING THE DEW POINT.

Dry Bulb.	Factor.	Dry Bulb.	Factor.	Dry Bulb.	Factor.
20°	8.1	29°	4.6	38°	2.4
21	7.9	30	4.2	39° to 41°	2.3
22	7.6	31	3.7	42 to 45	2.2
23	7.3	32	3.3	46 to 50	2.1
24	6.9	33	3.0	51 to 56	2.0
25	6.5	34	2.8	57 to 64	1.9
26	6.1	35	2.6	65 to 73	1.8
27	5.6	36	2.5	74 to 86	1.7
28	5.1	37	2.4	87 to 90	1.6

EXAMPLE.

Suppose the dry bulb reads	65°
Wet bulb	59°
The difference	6°
Factor (from the table 65°)	1.8
Product	10.8
Dry bulb reading	65°
Less product	10°.8
Dew point	54°.2

Suppose the dry bulb reads 60.5°, and the wet bulb 60°. This would show that the air is very highly saturated, and, by reference to the Relative Humidity Table, it would be found that the percentage of humidity was 97. Rain could be expected, because the air contained nearly as much moisture as it was capable of sustaining. Computing the dew point, or temperature required to condense the vapor, in this case we find it to be 59.5°.

$(60.5°-60=.5°\times1.9=.95;\ 60.5-.95=59.5°+)$

That is to say, the temperature of the air in this case has to sink less than one degree, in order to produce rain.

As a guide to the probability of rain, the application of this method becomes interesting, and is generally found reliable.

If the mercury in both bulbs rises as the day advances, rain is likely, since the temperature of the air will naturally fall with the decline of the sun. In sultry weather clouds and other "signs" of rain may mislead us, but if we look at the evening sky and see there the fair weather red, as well as consult our hygrometer, and find there a considerable difference in the readings, we need not apprehend rain on the morrow. A rapid increase in the difference between the two thermometers in the morning foretells a fine day. An increasing difference between the temperature of the air and the temperature of the dew point, accompanied by the fall of the latter, is a certain sign of fair weather. But diminished heat and rising dew point foreshow rain. Fog and mist, resulting from the difference of temperature between the surface of the earth and the overlying strata of air *ascending*, is a sign of rain, as so much more vapor is being added to the amount already contained in the air. When the upper regions of the air are saturated with vapor, as indicated by *halos* around the sun or moon, it is a well-known sign of rain—the larger the halo the nearer the rain. Air saturated with vapor is much more transparent than dry air, and unusual clearness or transparency is therefore a sign of rain. Under such conditions distant objects are seen with greater distinctness, which is an indication of rain. *Lights* appear brighter and nearer before rain. The refracting power of the air becomes greater through the increasing aqueous vapor in it, and distant objects, especially over water, *loom*, or have an apparently increased elevation. On the other hand, when there is a deficiency of this vapor, and there are commingling strata of air of different temperatures, there is *haziness* indicating dry weather.

Clouds are simply aggregations of the particles of vapor in the air assuming well-defined forms and peculiarities. They appear and disappear, and assume their various shapes, according to the state of the atmosphere in respect to moisture, temperature, and movement. With their various forms all are acquainted by observation. Being merely packed particles of moisture, they are subject to temperature and wind, as the latter are governed by pressure, as we shall see further along. *Cirrus* clouds resemble locks of hair or feathers with parallel diverging fibers. They are the highest and least dense. They sometimes cover the sky as a mere transparent haze, and sometimes form themselves into collections of parallel threads, assuming an infinite variety of wavy fibrous shapes. They mostly consist of icy spicule or the frozen vapor of the upper regions. They are the first to make their appearance after a period of fair weather, and are the forerunners of coming foul weather. When the ends of these "cats' tails" curl and point *upward*, rain can be expected; when *downward*, fine weather. In the former case, a warm ascending current is attended by the decomposition of vapor preceding rain; in the latter, a cool descending current produces evaporation, and, consequently, fair weather. When these clouds sink and become denser, the result of increasing moisture in the upper air, they assume the appearance somewhat of carded cotton, and this change foretells rain.

Cumulus clouds are produced by warm currents of air ascending and expanding. They are associated with fine, warm summer weather. So long as these preserve their regularity and float along in their accustomed serenity, the existing fair weather is not likely to be interrupted. The volume of these sometimes majestic clouds is greater on warm, moist days, than when the weather is cold and dry, for evident reasons. When the edges or outlines of these clouds are sharp and well defined, it shows a dry atmosphere, and therefore presages fair weather. As all atmospheric disturbances are due to a disturbed equilibrium of the air, it is a sign of fair, normal weather, when the under surface of these massive and majestic clouds is uniform and level, showing that the equilibrium of the air strata upon which they float is unbroken.

Stratus is the extended, uninterrupted *sheet* of cloudiness that prevails in threatening, dismal, rainy weather. The hurrying *scud* cloud is a reliable sign of rain. When small clouds disappear, there will be no rain that day. If they increase in size, and unite, falling weather is at hand. The reason is plain. When the air is charged with electricity clouds are attracted to each other, and combinations are formed which result in showers, or heavy rains, according to the intensity of the conditions. When the electricity is passing off, or is diffused, clouds break up, and are dissolved. A "mackerel sky," which is a combination of *cirrus* and *cumulus* clouds, indicates fair weather for the day; but presages rain within a day or two after. The French have a proverb, "A dappled sky and a painted woman don't last long."

To produce rain, there must be a combination, in some form, of the upper and lower cloud formation —the icy vapor uniting with the vesicular. The *halo* around the moon shows the saturation of the upper regions of the sky—the descent of the icy *cirrus*. The larger and more complete, or better defined, the circle, the greater the degree of saturation. A warm south wind now bringing up the stately *cumulus*, rain results from the union of these two principal types of cloud, on the same principle that pouring ice in a glass tumbler, on a warm, moist summer day, will cause a deposit of water on the outside of the tumbler. The temperature to which the glass had been reduced by the ice at the moment the vapor of the surrounding air began to condense on its sides, is the *dew point*. In wide-spread rain storms, there are two or more layers or strata of clouds, the upper stretching out in advance of the lower, but merging into it over the region where rain is falling most copiously.

Suppose our locality is *e*, Fig. 1. The upper layer *b* has reached us, and we are beginning to see the approaching lower layer *a*. We can expect rain. If, now, an extended rain storm having set in, our locality is *d*, and there be breaks in the lower laye we cannot see the sky through them, because of the intervening upper layer. Our heaviest rain is probably yet to come. But if our locality were *c*, and breaks occurred in the clouds, we would be able to

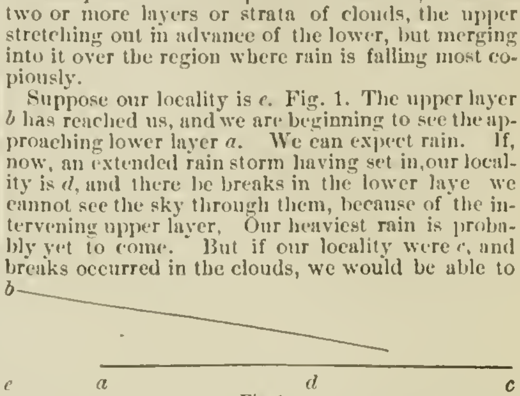


Fig. 1.

see the blue sky, the upper layer having passed beyond us; and we could expect an early end of the rain, and the return of fair weather. The character of the clouds, their combinations and movements, are important elements in forecasting all local weather. They are the effects of movements of aerial currents, and show, by their kind and changes, the pressure, temperature, and moisture at higher altitudes; and, by their movements, the prevailing currents of air, indicating whether the weather is likely to be warm or cold. If properly interpreted, clouds are sure indices of coming weather.

Rain is the vapor of the air condensed and precipitated This condensation is the result of a cooling of the air below the temperature of the dew point. This cooling takes place through radiation, the mingling of warm and cold masses of air, the opposition of winds of different temperatures, or any cause that produces condensation, either gradual or sudden. When variable winds prevail, light rains may generally be looked for. The amount of water received by the earth, from the clouds, is interesting and surprising. This amount can be very accurately ascertained by the usual rain-gauge. A rain-gauge may consist of a funnel-shaped collector and a cylinder, made of stout tin; the former securely fitting into the latter, as shown in the cut. It should be securelyplaced, with an exposure as clear as possible, and with the top of the funnel on a level. If the top of the funnel is ten inches in diameter, and the diameter of the cylinder about 3.16 inches, or the square root of 10 inches, the proportion between the cylinder and funnel will be as one is to ten; and ten inches of rain collected in the cylinder would equal one inch in the funnel, or one inch actual rain-fall. Fifteen inches in the cylinder would be one inch and a half actual rain-fall. One inch in the cylinder would equal *one-tenth of an inch* rain-fall. The length of the cylinder is immaterial; the longer the better, as it lessens the chance of overflow in case of specially heavy rains. The measuring rod—a thin, narrow strip of wood of the length of the cylinder—is graduated in inches and lengths of inches; and, when making an observation, the funnel is removed, the rod inserted in the cylinder, and the depth of water accurately noted; after which the water is emptied: and the funnel replaced Should the rod indicate a depth of twelve inches of water in the cylinder, the actual rainfall would be one inch and two-tenths. It is an easy matter to calculate how many *gallons* of water in the cylinder, the actual rain-fall would be one inch and two-tenths. It is an easy matter to calculate how many *gallons* of water fell during any rain storm, or any season, upon any given area of surface. As before stated, the amount will be found to be surprising.

Frosts should not take the farmer or the horticulturist by surprise. The probability of their occurrence can be known with almost as much certainty as the arrival of an express train. For practical use, one of the most important meteorological instruments is the common *hygrometer* by means of which can be ascertained at any time the *dew point*, and the approach of low temperature, or of frost, thus foreseen and provided against. If on a fair day, toward evening, the dry bulb, which would also be the temperature of the air, indicated 50° and the wet bulb 38°, the dew point at the time would be about 25°, and frost could of course be expected. If, on the other hand, the dry bulb were 50° and the wet bulb 48°, the dew point then would be about 46°, and no frost need be feared under the circumstances. The rule and table of factors for computing the dew point is given on page 93. The temperature of the air need not necessarily sink to 32° to produce frost, since plants and other good radiating bodies may become cooled by radiation considerably below the temperature of the surrounding air, and a heavy frost may occur when a thermometer above the surface indicates only 36° to 40°. A light frost may occur when the same thermometer indicates as high as 45°, or even 50°, of temperature. The formation of frost depends upon the dew point. Dew and frost, like rain and snow, are formed under the same circumstances, excepting the difference in temperature. Severe frosts, in their season, are found in the cooler, evaporating air attending the advance of areas of high barometer, and the approach of such areas may always be known by an intelligent reading of the weather reports.

The rule is, that *the force of the wind varies as the square of its velocity*. The force of a wind blowing at the rate of twelve miles per hour would, therefore, be just four times as great as that of a wind blowing six miles per hour, or .72 of a pound per square foot. The calculation can be carried on indefinitely. A wind blowing 24 miles per hour would exert a pressure four times as great as one blowing 12 miles per hour, or 2.88 lbs. Wind blowing 48 miles per hour would exert a pressure four times as great as one of 24 miles, or 11.52 lbs. 96 miles per hour, which would be a tremendous hurricane, would exert a pressure four times as great as 48 miles, or 46.02 pounds on every opposing *square foot* of surface. The Signal Service designates winds of 1 and 2 miles per hour as *light;* 3 to 5 miles, *gentle;* 6 to 15 miles, *fresh;* 16 to 25 miles, *brisk;* 26 to 40 miles, *high;* 41 to 60 miles, *gale;* 61 to 80 miles, *storm;* 81 to 150 miles, *hurricane*. The force of a wind blowing at the rate of 150 miles per hour would be equal to a pressure of 112.5 pounds per square foot.

The causes of winds are:

1. *Unequal atmospheric pressure* This creates motion in the air. With uniform pressure over any extent of country, there is very little, if any, motion or wind. The wind blows from regions where the pressure is greatest, to regions where it is least. Storms are areas of lowest pressure; therefore, the wind blows toward storms from all directions.

2. *Unequal specific gravity in the air.* This results from differences of temperature and humidity. Denser or colder air will flow toward regions where lighter or warmer air prevails, underrunning and displacing the latter. A storm is a concentration of heat, causing the air to expand, become lighter, and ascend. Cooler or colder air, according to the season, therefore, flows into the storm region to re-establish an equilibrium, and hence the change of temperature after a storm preceded by warm weather. The specific gravity of vapor is much less than that of dry air, and air, therefore, flows from dry to moist localities.

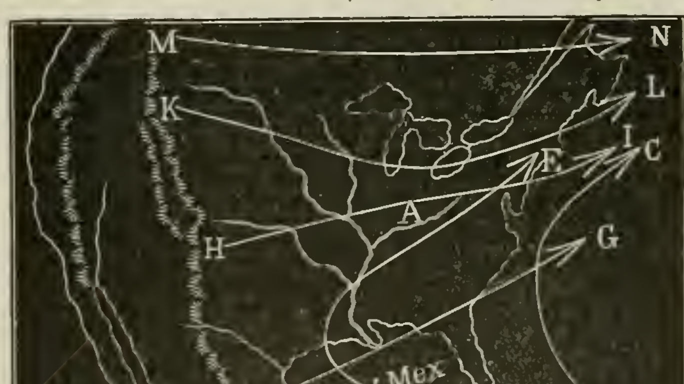


Fig. 2.

Wind is simply air in motion. Capricious as wind seems to be, it is nevertheless subject to definite laws. The *direction* of the wind is determined by the vane, and its *velocity* by an instrument called an *anemometer*. The indications of the latter are expressed in pounds of pressure per square foot of exposed surface. The pressure (in pounds per square foot) of wind velocities of from one to ten miles per hour is as follows:

Miles per hour.	Pressure per sq. ft.	Miles per hour.	Pressure per sq. ft.
1	.01 lbs.	6	.18 lbs.
2	.02	7	.24
3	.04	8	.32
4	.08	9	.40
5	.12	10	.50

The rotation of the earth has a relative effect upon the motion of the air. The velocity of the earth's rotation around its own axis every twenty-four hours is different in different parallels of latitude. At the equator the velocity eastward is 1036 miles per hour; in latitude 15°, 1000 miles; 30°, 887 miles; 45°, 732 miles; 60°, 518 miles; 75°, 268 miles; and at either pole nothing. There being but two primary motions of air, north and south—the other relative motions, due to the greater or less velocity or rotation of different parallels of latitude, will be readily understood. The *temperature* of the wind depends, of course, upon the quarter from which it blows and the distance it traverses from such quarter.

Each particle of the elastic air exerts a pressure upon those beneath it, and the weight and pressure of the entire mass upon the surface of the earth is recorded by the barometer. Atmospheric pressure varies as the motion, depth, density, moisture, and temperature of the atmosphere varies. Increasing or higher pressure means a flow of deeper, dryer and cooler air over a given region, as shown by the *rising* mercury in the barometer tube. Decreasing or lower pressure means a diminishing weight of the air, because it is then lighter, warmer, moister, and ascensive, and the mercury in the barometer tube sinks correspondingly. The term "area or *high* barometer," means a region of country over which there is an excess of air. The term "area or *low* barometer," means a region of country over which there is a deficiency of air. The former is, as a rule, attended by fair and the latter by foul weather. *Storms* are areas of *low* barometer, and as they approach our locality our barometer falls, that is, the mercury within the tube *sinks*, by reason of the influence of the coming storm, which draws the air toward its center, where it ascends. The fall of the mercury is according to the severity of the storm. If we happen to be in the path of the storm, our barometer will be lowest when the storm center passes over us. As the storm center passes by us, the barometer begins to rise, because there is a mass of air rushing over the locality after the depression or storm center, on the same principle that water seeks a level. Central areas of storms pursue paths across our country approximately shown in Fig. 2. If our locality is A (the Ohio valley), we are within influential distance of all storm centers taking the tracks, K L, H I, D E, and sometimes F G, and B C. B C, and D E, are West India cyclones, the latter out of their regular course.

When the barometer is reported lowest in a certain region, it means that there is a storm central there. When it is reported highest in a certain region, it means that that is the central region of the fair weather area. When the construction of the barometer—the difference between dry, cool, bracing and heavy, and moist warm, enervating and light air, as well as the fact that the atmosphere is forever seeking an equilibrium—that areas of low and areas of high barometer are constantly chasing and changing their relations to each other—is understood, this matter will be clear. It is a common mistake to say that the air is *heavy* in damp, wet weather, and *light* in fair, normal weather. The opposite is the case. Some of the effects of low barometer, or stormy weather, upon man and beast, have already been alluded to. When high takes the place of low, a grateful change is experienced, and the duration of the new condition can be approximately anticipated by reference to, and a study of, the weather reports. A high and steady barometer indicates, as a rule, dry, clear, fine weather. A low and fluctuating barometer indicates cloudy, windy, or wet weather. Changable weather is indicated by a quick rise, followed by a quick fall, in the barometer, or the reverse. Fair, still weather is the normal condition of the atmosphere just as health is the normal condition of living beings. Changes from this normal condition of the atmosphere are the results of forming, approaching, or passing disturbances. There is no uniformity or regularity in the intervals between these changes of conditions. The beginning, or first appearance, of a change can always be detected in the weather reports. The elements to be considered in any locality, in determining the immediate future of the weather, are atmospheric pressure, temperature, wind, moisture, the appearance of the sky, and (as announced by the telegraphic reports) the fact of precipitation elsewhere, whether in the form of rain or snow.

Areas of high barometer and areas of low barometer, are attended by their own system of winds circulating around them, towards and into the Low, and from and out of the High.

The direction of the wind is one of the main elements to be considered in weather predictions; and it can be known with reasonable certainty what winds will prevail, if it is known where the barometer reads highest, and where lowest, and this information the weather reports usually give. The rule is: "*Stand with your left hand toward the region where the barometer is lowest, and your right hand toward that where it is highest, and you will have your back to the direction from which the wind will blow during the day.*" Or, knowing the region of lowest pressure, and we stand *facing* it, our wind will blow from some point on our left to some point on our right. Not knowing the region of lowest pressure, if we stand *facing the wind*, the storm center will be on our right. Stand anywhere around the area facing the *center*, and the wind will be found to blow on your right side. Stand anywhere around the area of "Low," *facing the wind*, and the storm-center (*Low*) will be on your right side. The opposite holds good in the case of high. The former is a *cyclonic*, and the latter an *anti-cyclonic* system of winds. The lower clouds indicate the true direction of the wind better than the vane, since local surface winds may be diverted from the general direction by the topography of the earth or other obstructions. Air has primarily but two motions, northward and southward. But common observation shows us that the wind blows in every possible direction; and we have seen that there are two entirely opposite *systems* of circulation of air around areas of high and low barometer. The wind does not usually blow *directly* into a region of low, or out of a region of high, barometer; but is, in both cases, deflected toward the right; and this deflection is increased according to the size or extent of the area, whether of low or high pressure, around which the wind is blowing. Professor Ferrel has demonstrated that this deflection to the right is a mathematical necessity arising from the influence of the earth's daily rotation, causing every thing moving on its surface to deflect to the right in the northern hemisphere, and to the left in the southern hemisphere. The air, then, has a sinuous, spiral motion inward, toward the center of a region of low pressure, and at the center it flows upward from the surface. The friction of the earth's surface may retard this deflected or tangential motion of the air, and, in storms of great energy, the wind may be found to blow more nearly directly toward the center of the disturbance.

The wind, then, in any locality, may be expected to be—Easterly, when high is in the north, or low in the south. Southerly, when high is in the east, or low in the west. Westerly, when high is in the south, or low in the north. Northerly, when high is in the west, or low in the east.

By drawing lines upon a weather chart, or map, connecting the places where the barometer readings indicate equal pressure, we are enabled to definitely locate the position and extent of the areas of low and high barometer, and, with some practice and experience, to determine about when such areas, with their attendant weather, will reach and overlie our own locality. Such lines are called *isobars*. To locate an area of *low* barometer, seek out the places where the barometer reads the lowest, and encircle them, as far as possible, by an isobar. Take, for example, a report projected on the *Cincinnati Commercial Gazette's* weather map. At the time of that report, we find that, at Chicago, the barometer reads 29.77 inches; at Indianapolis, 29.74 inches, and at Louisville, 29.78. Now, simply trace a line representing approximately 29.80, from a point near Toledo to one west of Cincinnati, east of Louisville, thence around Louisville, on the south, and curving north-westward through Vincennes; thence slightly west of Chicago, and on, north-eastward, over Lake Michigan. You have here inclosed the region of lowest pressure on the map, which, in this case, however, is not the storm center, but the southern *extension*, or southern portion of the oval storm area, whose center is over the lake regions. Then trace a line for one-tenth of an inch higher pressure, or 29.90 inches, beginning west of Pittsburg; thence south-westwardly, keeping slightly north of Nashville and Memphis, passing *through* Little Rock; thence around Fort Gibson, and again north-eastward, passing slightly east of Keokuk and Davenport, describing a curve around the west of La Crosse, and running the line north-eastward again, beyond the limits of the map. This line incloses the usual barometric trough accompanying a storm movement, and generally lagging behind in the eastward movement of the storm.

If the map included and reports were had from British America, the northern portion of this storm area could be inclosed in a manner similar to that here shown. At Chattanooga and Vicksburg, it will be observed, the barometer reads over 30 inches. A line for 30 inches of pressure, drawn through Salisbury, Decatur, Grenada, and Alexandria, and leaving Chattanooga and Vicksburg east of that line, will show a portion of the western edge of an area of *high* barometer that preceded the storm movement above partly inclosed. High and low, like waves of a tempest-tossed ocean, follow each other across the country, their paths varying over higher or lower latitudes, according to the season of the year. On the map the increasing high barometer, with its colder northerly and north-westerly winds and clearing weather, is at once observed in the Missouri Valley.

It is the study of these areas of high and low barometer, as they succeed each other in their transit across the country, that is of importance. Predictions for the various geographical districts are based upon the result of such a study. Predicting the approach of a storm (*low* barometer), or a period of fair weather (*high* barometer) after a storm, is in this way comparatively easy. The *duration* of either condition depends upon its extent and rapidity of movement. The things to be considered are the position or location of the coming condition, its rate of progress, its probable path, and whether or not and *when* it will reach our own locality. Local signs will generally help to settle the last point.

Treating of storms and their causes, Professor Loomis says: "Storms are caused by a strong and extensive upward motion of the air, by which means its vapor is condensed by the cold of elevation. The atmosphere receives heat from the sun, and it loses heat by radiation. Only about one-fourth of the rays of the sun are absorbed in passing vertically through the atmosphere. The remaining three-fourths are absorbed by the earth's surface, by which means its temperature is raised, and heat is thence communicated to the air which rests upon the earth. The atmosphere thus receives its heat chiefly at the bottom, and, in consequence of radiation, loses it most rapidly at the top. Since the density of the air is diminished by an increase of heat, the atmosphere is in a state of unstable equilibrium, and the lower strata tend continually to rise and take the place of the upper. Such ascending currents are formed on every tranquil day. As the air ascends, it comes under diminished pressure and expands; and, as it expands, it cools at the rate of about 38 degrees for two miles of ascent. This ascending air carries with it the vapor which it contained at the earth's surface, and, if it rises high enough, the cold produced by expansion will condense a portion of this vapor into cloud. The height to which the air must ascend before it will become cold enough to form cloud, depends upon the difference between the dew point and the temperature of the air. If the dew point be ten degrees below the temperature of the air, cloud will begin to form when the ascending current has risen about 1500 feet."

After a period of fair weather, whose duration depends upon the dimensions and rate of movement of the area of high barometer causing it, the first indications of a storm are generally to be looked for in the western semicircle. These indications are condensation in the form of long threads of cirrus cloud formation, the ordinary cloud bank at night-fall, or the extensive and general condensation in which is formed the circle around the sun or moon. The formation of a storm center, or "area of low barometer," is due to moist, warm, and light air, having an ascensive motion. This moist rising air ascends into the upper regions, where the temperature is low, and, passing the dew point, its moisture is condensed and assumes the form of clouds; and the pressure of the air upon the barometer, or the surface of the earth, wherever this operation may be going on, is gradually lessened, and the mercury in the barometer tube sinks. Or, the warm, light, vaporized air may move high over the land, frequently over strata of dry cool air, in great volume, from the central meteorological zone, gradually sinking down and forming the germs of barometric fields of low pressure, which spread and develop into extensive storm areas. It is in such fields that the heat of the sun is concentrated and storm centers originated. The earth absorbing electricity from the air, electric disturbances of more or less violence, according to the intensity of the condition, are experienced. The absorbtion or withdrawal of electricity from the vaporized air produces sudden condensation, excessive precipitation, and a change of temperature. Wherever a storm is forming or approaching, the surface air within influential distance is attracted toward it. This movement begins first nearest the center of disturbance, each separate and individual particle of air being in turn attracted and set in motion, until the whole mass flows toward the storm center from all directions. Thus, if a storm is central in the Mississippi valley, the winds in the Ohio valley will be easterly, while in the Eastern States they may still be dominated by another system. As the storm progresses eastward and becomes central in the Ohio valley, the winds in the Eastern States will come under its influence and shift to easterly. When the storm has passed, a north-to-west wind is felt, and this follows up the disturbance, filling up the atmospheric depression and restoring normal weather. Storm areas are generally in the form of elongated ellipses, or are trough-like, much greater in length than in breadth. The shifting of the wind to the clearing-up quarter during the passage of a storm, whether through the north or the south points, will indicate to the observer whether the center of the disturbance is passing by on the south or north of his locality. If the wind sets in from the westward, having shifted through the *north* point, the depression is passing eastward, *south* of the observer; if through the *south* point, *north* of the observer.

An ordinary storm's path is generally in an eastward or north-eastward direction. The storm area extends from north to south, has more or less of an oval shape, moves eastward side foremost, its northern portion moving faster than the southern. Its diameter from north to south is of great and sometimes unknown length, while from east to west it is comparatively small. American storms are of a rotary character, they are progressive whirlwinds, moving forward in the line of an increasing spiral, and revolving from east to west in the northern, and from west to east in the southern hemisphere. An area of low barometer, wherever it may exist, is the place where opposing currents meet. The larger this area the longer the storm, and the more extensive the rain area. The rain area is under the slope of one current over the other. The size of areas of low barometer varies from a few square miles, as in local storms and tornadoes, to hundreds of miles square, as in extensive cyclones. The heaviest gales attend the most crowded isobars, or lines of equal pressure. These can always be traced on the weather map, and the approach of strong winds be anticipated. In severe storms, the wind is found to blow nearly toward the center of the disturbance. The more violent winds usually follow the rear of an advancing storm; those that precede the storm are apt to be most dangerous, by reason of being in the area of rain, fog, etc. The wind velocity is calculated from the relative pressures surrounding the central depression. If the central depression is considerably lower than surrounding pressures, it is evident that there will be a violent rush of air into this depression. If a storm-center were moving over a given place, and the atmospheric pressure there were unusually low, while at points one hundred and seventy miles distant the barometer read one inch higher, the wind velocity would be great enough to demolish houses and damage shipping. Cases of hurricanes, tornadoes, etc., are instances of these steep slopes or gradients. The steeper the gradient, that is to say, the nearer together the isobars are found to lie, the more dangerous the wind. In winter these slopes are more gradual, as the light, moist, warm, ascensive current climbs far over the other. In summer they are more steep, as the cold downward current, from its weight, banks up against the warm one.

Warmer weather is associated with a falling barometer, if the depression that induces the fall is to the west or north of your locality. As before stated, the air flows from regions of high to regions of low barometer. The weather report always announces where the barometer stands lowest. If the barometer is reported highest in the south and lowest in the north, your weather will be warm, but not as warm as it would be if there were no elevation of barometer in the south, because then the southerly air will not have traveled far. An excessively hot, dry summer, like that of 1881, is caused by the tracks of storms, or areas of low barometer, being invariably far to the north. Lows moving along extremely northern latitudes, will generally attract the southerly air toward them, and the succeeding Highs remain too far north to materially affect the weather in the interior of the country. The result is a high degree of temperature, and possibly serious drouths, since the moisture is carried over and beyond us without meeting opposing currents to condense and precipitate it in the form of frequently much needed rain. In that case we say: "All signs fail in dry weather."

The telegraph and the newspapers tell us of the effects of tornadoes; and the frequency of these recitals is probably due to the increasing facilities for gathering information, rather than the more frequent occurrence of tornadoes now than formerly. They are most frequent and severe between the 35th and 45th parallels of latitude, and between the Allegheny Mountains and Kansas and Nebraska, and they are of more common occurrence in the United States than in Europe. Theoretical meteorologists tell us that the tornado is a *column*, and the cyclone an extensive *body*, of gyrating air. Their destructive difference is due to the difference in their velocity of gyration. The important element of the tornado is its spiral movement, and this movement is inaugurated by a local mass of heated air, fed by moist surface currents ascending and forming a partial vacuum, into which the surrounding air is drawn, necessarily acquiring a gyratory motion. There being less resistance in the upper strata of air, this gyratory motion begins there first, and the well known trunk or *funnel* is there initiated and elongated downward, the main and most rapidly revolving mass being above ordinary obstacles on the earth. This column-like downward projection of the tornado cloud is not necessarily at all times visible. Distinguished meteorologists further tell us, that in the central area of the tornado the tendency of the air is spirally upward, as tourists ascend the Tower of Pisa. On the outside of this area, the tendency is downward, and the pressure increases. These opposite tendencies, therefore, produce a closing spiral at the earth end of the trunk, and an opening spiral at its conjunction with the cloud, giving it the shape of an inverted *cone*. This cone is assumed to be hollow, with quiet and rarified air along its center. Objects drawn into the vortex are raised and hurled outwardly from the ascending whirl. When at times a tremendous rain-fall, or "cloud burst," occurs, it is due to the weight of the water having become greater than the ascensive power of the air that held it in suspension.

The conditions that are favorable for the production or development of tornadoes, are an unusual elevation of temperature for the season, sultry and electric conditions of the atmosphere, a low barometer, and the conflict of opposing winds of different temperature. They are composed simply of northerly and southerly lateral currents acquiring a curving direction, the southerly one (in front) westward and inward, and the northerly one (in rear) eastward around and into the center, thus producing a whirl, on the southern side of which trees and other objects are blown toward the *east*, and on the northern side toward the *west*. The direction of movement of tornadoes, which happily are local and short lived, conform to the general law of all storms—that is, from left to right. The southerly current is the strongest, and covers the greatest area. The tornado is apt to occur immediately after the passage of the lowest barometer. The heated air in front, or on the east (sun rise) side of a vortex ascends, and in the rear the air descends, bringing with it the temperature of the upper regions. This downward sloping rush of colder air, coming in contact with the upward sloping flow of warmer air, the friction and electric action set in motion, produce the tornado, whose incipient formation is in the air above. Like a ravenous bird of prey it descends, striking the earth with an already established gyratory motion around its own center, and then, in accordance with the law of all storm movements, bounds and rebounds with greater or less velocity and destructive force, in a generally easterly direction. There is usually a black and somber cloud ranging perhaps less than a thousand feet above the surface, to which is imparted a gyratory motion, giving rise to a funnel shaped projection of the under surface of the cloud toward the earth, and this terrible funnel or trunk is more or less developed and destructive, according to the condition of the cloud and the character of the locality over which it is being dragged; now apparently fastening its enormous and powerful leech-like mouth upon a grove of trees or a row of buildings, then snatched away and lifted upward by some impulsive movement of its parent cloud only to sink again to surprise, throw into consternation, and, perhaps, lay in ruins some thriving town that may happen to lie in its path. It has its origin in the enormous electric tension caused by the friction of opposing atmospheric currents of different temperature: and electricity is undoubtedly the active agent producing the appalling effects of tornadoes. Except in a general way, tornadoes can not be predicted in advance. Their formation or approach may, however, be recognized by local indications. The most marked indications are a sultry, oppressive atmosphere, a peculiar stillness, and the appearance of fierce looking clouds approaching each other from opposite directions. It is the collision of these clouds, borne by opposite currents of air of different temperature, that causes the terrific whirl and the visible funnel shaped tornado cloud. Much has been written about means of escape from the tornado, but nothing that has been suggested appears thoroughly practicable. Cellars, caves or "dug-outs," it is claimed, will afford protection; but it is doubtful whether there is any way of escape, except, when possible, running away from its line of movement, and out of its influence. Fortunately tornadoes are short-lived, and their tracks are narrow.

Forecasting the weather by the Signal Service system, as has already been shown, is done by simply taking the atmospheric conditions throughout the country, locating the existing areas of low and high barometer, and estimating their probable direction and speed of movement, and announcing, on a basis of well established rules and scientific deductions, what changes in respect to pressure, temperature, wind, and weather are likely to occur in the various districts in consequence of such movement. Any one possessing some knowledge of natural forces, and understanding the nature of the weather, can, with the aid of weather reports, foretell, from an approaching condition, the character and probable duration of his own local weather. If the prediction based on this system is not fulfilled, there is good and sufficient cause for it. Unexpected changes sometimes occur; retarding, counteracting, or dissipating influences appear; so that, perhaps, entirely different weather may ensue. The mysterions force in nature, which we call a low barometer, sometimes performs wonderful freaks, and pursues apparently erratic paths. The Signal Service prediction of general and severe frosts for the North-west, the Lake Regions, and thence southward to Tennessee, on the 20th and 22nd of September, 1823, the mere announcement of which, more especially as it was emphasized by the injunction to "Give utmost publicity," had such a marked effect upon speculation in crops, especially corn, which was then in jeopardy, was a case in point. The prediction was based upon the appearance of a very high and threatening barometer; that is to say, an unusual accumulation of unseasonably cold air in the extreme North-west. No other prediction could have been made under the rules at the time, excepting, perhaps, that it might have been more conservative in tone. The reason for the non-fulfillment of the prediction, as afterward revealed, was simply the appearance of a new storm, whose place of origin was in the lower portion of the Ohio valley, and whose path was northward, but, being barred from making any *easterly* progress by a High overlying the North-east, it curved *westward* over the lake regions. In the meantime, the frost-threatening High in the North-west had pressed down over the regions west of the Mississippi river. The storm now curved *southward*, and fought its way through the eastern borders of the great body of cold air overlying the entire West, and traversing Iowa and the Lower Mississippi valley during the day, attended by heavy rains and violent north-west winds in its rear, returned almost to the place of its origin, thus describing a great loop, after which it slowly passed off north-easterly.

The effect of this unusual movement was to delay, counteract, and in a great measure *dissipate* the high barometer that threatened the frosts predicted. The country is divided into various meteorological districts, the extent and location of which may be recognized by their designations. Atmospheric waves of disturbance are generally first perceived in the Far West, and then usually move in an easterly direction with greater or less speed, covering successively districts, or portions of districts, according to the latitude along which the center of disturbance moves, and the enlarging or contracting area of the field of disturbance. If the barometer is very low at the center of the storm area, high winds and severe gales will prevail over an area of country of about two hundred miles radius during the winter months, and probably less than one hundred miles during the summer months. There is an old saying—

"If the glass falls low, prepare for a blow."

If an energetic storm center is located in Dakota or Minnesota, with a considerable extension of the storm area southward across the Missouri valley, the whole traveling eastward, the winds in the Ohio valley will be successively south-easterly, southerly, south-westerly, westerly, and north-westerly, as the depression in the north passes to the eastward of our meridian. The depression having passed into the North-east, or the St. Lawrence valley, an opposite condition, or area of high barometer, will follow, coming perhaps from over the Rocky Mountain regions, or perhaps from western British America. If from the latter, and it pursues the usual south-easterly path of high pressure areas, we can prepare for a change of temperature, possibly according to the season, a severe cold wave, and our winds will continue to shift around the compass in the regular way; that is, to north, north-east, east and south-east, when evidences of another depression will very likely again be seen in the reports from the Far West. In this case, we will have a period of fair weather, whose duration may be known by the character, extent and rate of movement of the high barometer causing it. If the wind is northerly and steady, and the sky becomes clear and bright, we need expect no change of weather until we see the fore-runners of the next storm, in the form of streaks of cloud appearing above the horizon of the western semicircle. In winter, the storm will follow the first appearance of these thin, hazy, feathery clouds in several days in spring and autumn generally in about one day. Now, if our barometer, or the pressure in our locality as shown by reports from neighbouring stations, is high and steady for some time, there is a surplus of air, the weather will be dry and fine, and no disturbance can take place. The passage of an area of high barometer over a given locality may occupy several days, or a week—occasionally longer—from the time that "first rise after low" (which foretells stronger blow) reaches the locality until the next rain. Or, if the high pressure was of rapid birth, and unsteady character, it may pass away or become dissipated very quickly. Weather waves may be likened to the waves of the ocean; sometimes grand in their proportions, and steady and regular in their movement; at other times choppy and uncertain. Storms, areas of *low barometer*, have a warm or hot area on their east side, with easterly or south-easterly winds, and a cool or cold area on their west side, with northerly or westerly winds. If a storm is central in the upper Mississippi valley, the highest temperature of the month may occur in the Ohio valley, while the lowest temperature of the month prevails in the Missouri valley. We may be sweltering in a moist atmosphere of 80° or 90° on the hot side of a storm, and in a dry be subjected, all unprepared perhaps, to the chilling winds and cold air following the storm. In this matter, at least, we can know what "a day may bring forth," and there is no excuse for our disregard of the changes that are inevitable: changes sometimes sudden, great, and fatal, bringing disease and suffering and death, results that may be avoided by proper precautions.

The Signal Service, then, is able to announce, with general accuracy, what the weather indications are, from day to day, in the various districts, by keeping itself well informed of the movements of low or high barometers, and the influences opposing, retarding, or modifying such movements. Storms traverse the country along higher or lower parallels, according to the season of the year, caused by the difference of the earth's position to the vertical rays of the sun. In winter and early spring, these storm paths lie along lower latitudes, and we look to the *south-west* for all indications. The lower the line of transit, the colder our winter; because the cold northerly air, in the rear of storms, preponderates. In the latter part of spring and early summer, these belts of condensation have moved further north, with the apparent motion of the sun; and we look to *west* for indications. In summer and autumn they are in the north: and the further north, the warmer our summer and longer our autumn: because the warm southerly air, in their *front*, preponderates. We then look to the *north-west* for indications. If a south-western Low appears, it is likely to travel eastward, or north-eastward, across the country, according to the most favorable conditions in its front. East and south-east to south-west winds, warmer, increasingly cloudy weather, and rain, will successively prevail over the regions in front, or on the east side, of its line of march; while north-east to west winds and much colder weather, with clearing rains, caused by the very cold winds under-running and changing the previous current, will follow as a belt of cloudiness, generally moving about *south-eastward* over the country. If this movement of the cool wave (advancing high barometer) is slow, and clearing weather does not set in as quickly as anticipated, it is because their is high pressure in the south opposing its progress. When a western low appears, it is likely to move in some easterly direction, attended by the same system of winds and weather. If a northwestern low appears, it is also likely to move eastward over, or north of, the Lake Region. Our warmmest weather, and periods of drouth, are in connection with storms passing by in the far north. Very often the conditions following a storm, in such case, do not reach us. Storm centers seek moist, warm regions, where the pressure gives way most readily; and the force of the wind in any locality depends mainly upon the rapidity with which the pressure is changing, decreasing in front, and increasing in rear, of the storm. The Signal Service predictions are reduced to the simple "determination of the path pursued by the central area of low pressure, and the rapidity with which this will extend its influence in any given direction."

Local intimations of the approach of a storm, even without instruments, are abundant, and easily read. In a period of bright, clear weather, when the atmosphere is in a normal state, we are under the condition of high pressure; and this can be distinguished very readily by our feelings alone. This fair, pleasant and agreeable condition gradually passes off with rising temperature, haziness, growing dampness, freshening southerly winds, and increasing cloud formation. There is a storm somewhere in the West, and its influence is slowly extending over us. The increase in temperature is a sure sign of an approaching storm. It shows that the central area of barometer has passed beyond us, and that the southerly current is again sinking to the surface, and warming up the earth and lower strata of air. More or less haziness may attend this change, which, counteracting the tendency to cloud formation, may prolong our fair weather. Then, as the storm or rain belt approaches, evaporation ceases—we feel the humidity of the air increasing, in consequence of the rising temperature and the prevailing wind. The barometer is gradually falling; the thready cirrus clouds appear; condensation increases; the wind freshens, blowing towards the coming storm; our feelings begin to tell us of the approaching change; the air begins to feel close and sultry; animals become restless; all substances affected by moisture show the change; odors are concentrated; fires do not burn brightly; water boils more rapidly; halos appear; distant lights are brighter, and sounds more distinct; there is a *foul* sunset, and rain is evidently at hand. High pressure, with its usual attendant, fair weather, has passed away, and low pressure, with its foul weather, prevails. Meanwhile, the weather map or weather reports will have kept us informed just where the Low was central, from time to time, and whether the center of the disturbance, or only the borders, and which borders, of its area were approaching our locality. When we consider the importance and utility of practical weather knowledge, it is surprising that a portion of the time and effort devoted in our schools and universities to acquiring a smattering of sciences that have little or no practical bearing upon the ordinary pursuits of life, is not applied to a study of those that have, prominent among which is meteorology—the science of the weather, the study of the atmosphere. The time when mere notions and superstitions respecting the weather had possession of men's minds has passed away.

The relative positions of the planets, the changes, phases, and appearance of the moon, the actions of the ground-hog, the beaver, or the intelligent pig, the gabbling of geese, and the migration of birds, all old-fashioned "signs," have been superseded by a steadily increasing knowledge of the laws governing the wonderful phenomena occurring in our atmosphere. Effects have been traced to their causes. Drouths or wet spells, excessive heat or cold, storms or sunshine, are susceptible of explanation, anticipation, and, therefore, preparation against their coming. The wind no longer blows where it listeth. We know whence it comes and whither it goes. The study of meteorology would soon place students in possession of inductive generalizations, that would give them an insight into the nature of the changes that are constantly taking place. The weather map—reports from different places of pressure, temperature, moisture, wind, and cloudiness, projected upon a map of the country, or even the common blackboard, is an object lesson second to none in point of interest and value. The Government furnishes these reports every eight hours. They could be multiplied for distribution among learners, for practical work in connection with the study of the subject, and for purposes of prediction of local changes. In connection with the study of the text-book, time and practice in locating the fields or areas of different weather, over the country, as shown by the reports, would soon enable the learner to comprehend the processes of nature, and the ever-moving weather conditions. Those of our readers wishing to pursue this interesting subject into further detail are referred to the excellent work—"*The Weather*," by S. S. Bassler, from which the substance of this article is taken.

The Signal Service, as at present organized in the United States, consists of one Chief Signal Officer, with the rank, pay and emoluments of a Brigadier General; ten Second Lieutenants, and 400 enlisted men. See *Field Telegraphy* and *Meteorology*.

SIGNAL TACTICS.—Sending messages by mounted men is always liable to accidents, and at times circumstances may preclude the possibility of doing so. During an action or the execution of movements in the presence of an enemy, orders can be sent with rapidity and silence, by night or by day, by means of signals, and in the same way communication can be maintained between parties on shore and on water.

The electric telegraph and telephone are, during war, constantly liable to interruptions, so it is essential to have the power of supplementing them by a system of signaling that is independent of elaborate apparatus; but very constant practice is necessary to enable one to transmit and receive messages accurately and quickly. A good signal-man must know several systems of signaling and different cipher systems, but for common work the General Service Code for the Army and Navy is used. Lieutenant Hugh T. Reed, U. S. Army, having had varied experience in teaching military signaling in the Army, has prepared a most valuable and concise text-book, conveniently arranged for the ordinary instruction in the elements of military signaling. In preparing this work he has endeavored to overcome the difficulties encountered in the past, by adopting the same company formation and system of maneuvering that is used in the other branches of the service, thus making the forms of drill for a squad or company of signalmen as nearly as possible like those in use for other troops. The substance of what follows is taken from this work.

GENERAL SERVICE CODE FOR THE ARMY AND NAVY.

The General Service Code, a code of two elements, is made by a certain combination of the two elementary signals "1" and "2" placed opposite to each letter of the alphabet and to each of the ten digits, the whole number opposite to each standing for that letter or digit. The elementary signal "3" is a pause signal used merely to denote the end of a word, sentence, etc. This code is used with the wand, flag, torch, telegraph and heliograph instruments. When used on telegraph instruments, seventeen words per minute is rapid sending by this code. Red and green lights may also be used with the General Service Code: the red indicating "one," the green "two," and both together "three."

A...... 22	H...... 122	O...... 21	V......1222
B......2112	I 1	P...... 1212	W 1121
C...... 121	J...... 1122	Q...... 1211	X......2122
D..... 222	K 2121	R...... 211	Y...... 111
E...... 12	L...... 221	S...... 212	Z 2222
F 2221	M...... 1221	T...... 2	
G 2211	N...... 11	U..... 112	
1......21112	4......22212	6......12222	8......11112
2......12221	5......22221	7......11222	9......11211
3......22122			0......22222

The following are a part of the conventional signals used with the General Service Code, to wit:

3— End of word. 33— End of sentence.

333— End of message. 22, 22, 22, 333— Cease signaling..

22, 22, 22, 3— Signal of assent: "Acknowledge," "I understand," or "Message is received." "I see your signals," etc.

121, 121, 121, 3— Repeat. 212121, 3— Error.

211, 211, 211, 3— Move a little to the right.

221, 221, 221, 3 – Move a little to the left.

The "call signal" is made by swinging the wand, flag, or torch, from right to left until acknowledged. a..after b..before c....can h..have n..not r...are t...the u....you ur.your w.word wi.with y.why

The signals "number 21" and "number 2121," mean "O. K.," and are often used in reply to messages.

The following four conventional signals are used with the General Service Code when the signals are made with the wand, flag, or torch, to wit:

The *first* precedes and the *second* terminates the body of the message; the *third* precedes numerals used in the message, and the *fourth* terminates them. To make these signals, being at *position*, the Instructor commands:

1. *Message*, 2. Follow.

Drop the wand in a vertical plane to the front 120°, then move it horizontally to right 90°, then vertically to the left 240°, then horizontally to the front around to the right 180°, then again to the left 240°, then horizontally to the front 90°, then up to *position*.

1. *Signature*, 2. Follow.

Make in same manner as for message follow, only reverse the movements, passing from right to left.

1. *Numerals*, 2. Follow.

Drop the wand in a vertical plane to the front 120°, then move it horizontally to the right 90°, then vertically to the left 240°, then horizontally to the front 90°, then up to *position wands*.

1. *Numerals*, 2. Ended.

Make in same manner as for numerals follow, only reverse the movements, passing from right to left.

Signal numbers are read thus:

THE LETTERS.

A...Twenty-two
B..Twenty-one—twelve
C..One—twenty-one
D...Two—twenty-two
E..................................... ....Twelve
F...................................Twenty-two-twenty-one
G...Twenty-two—eleven
etc., etc., etc.

THE NUMERALS.

1................................Twenty-one—one—twelve
2................................Twelve—two—twenty-one
3........................ Twenty-two—one—twenty-two
etc., etc., etc.

THE CONVENTIONAL SIGNS.

End of word..Three
End of sentence ....Thirty-three
End of message.........................Three-thirty-three
Acknowledge..
Twenty-two-twenty-two-twenty-two-three
Cease signaling ....
Twenty-two-twenty-two-twenty-two-three-thirty-three
Error. Twenty-one—twenty-one—twenty-one—three
Move to the right...
Two-eleven—two-eleven—two-eleven—three
etc., etc., etc.

21112, 12221, 22122, etc., when preceded by "numerals follow" and followed by "numerals ended," are numerals, while at other times they are conventional signals.

AMERICAN MORSE CODE FOR TELEGRAPH INSTRUMENTS.

The American Morse Code, the code of four elements, is made by a certain combination of four elementary signals, the dot (-), the dash(—), the long (——), and the space (an extra distance between certain dots), placed opposite to each letter of the alphabet and to each of the ten digits; the combination opposite to each standing for that letter or digit. This code is employed on telegraph and heliograph instruments.

A - —	H - - - -	O - -	V - - - —
B — - - -	I - -	P - - - - -	W - — —
C - - -	J — - — -	Q - - — -	X - — - -
D — - -	K — - —	R - - -	Y - - - -
E -	L ——	S - - -	Z - - - -
F - — -	M — —	T —	& - - - -
G — — -	N — -	U - - —	
1 - — — -	4 - - - - —	6 - - - - - -	8 — - - - -
9 - - — - -	5 — — —	7 — — - -	9 — - - —
3 - - - — -			0 ——

Period - - — — - - Interrogation — - - — -
Comma - — - — Exclamation — — — -
Semicolon - — - — -
Parenthesis - — - - — Italics — - - - —
Paragraph — — — —

EUROPEAN MORSE CODE FOR TELEGRAPH INSTRUMENTS.

The European Morse Code, a code of two elements, is made by a certain combination of the two elementary signals, the dot and the dash, placed opposite to each letter of the alphabet, and to each of the ten digits; the combination opposite to each standing for that letter or digit.

This code may be used on the heliograph instrument, and it may also be used with the wand, flag, or torch, by making a "1" for the "dot," a "2" for the "dash," and a "3" for the "pause signals."

A - —	I - -	Q — — - —	Y — - — —
B — - - -	J - — — —	R - — -	Z — — - -
C — - — -	K — - —	S - - -	ä - — - —
D — - -	L - — - -	T —	é - - — - -
E -	M — —	U - - —	ö — — — -
F - - — -	N — -	V - - - —	ü - - — —
G — — -	O — — —	W - — —	ch — — — —
H - - - -	P - — — -	X — - - —	
1 - — — — —	4 - - - - —	6 — - - - -	8 — — — - -
2 - - — — —	5 - - - - -	7 — — - - -	9 — — — — -
3 - - - — —			0 — — — — —

Period - - - - - - Interrogation - - — — - -
Comma - — - — - — Exclamation — — - - — —
Semicolon— - — - — - Quotation - — - - — —
Parenthesis — - — — - —
Apostrophe - — — — — -
Per cent — — — — — — —

THE ENGLISH SIGNAL CODE.

The code adopted by the British government, a code of two elements, is made by a combination of the two elementary signals "-" and "—" placed opposite to each letter of the alphabet and to each of the ten digits; the whole number opposite to each standing for that letter or digit. The elementary signals are termed "short" and "long" flashes, or "dots" and "dashes." At night signals are in all cases made by the obscuration and exposure of a single light; in daytime by flags or other apparatus.

TABLE OF SIGNAL CODES.

Alphabet.	General Service Code for Wand, Flag and Torch.	General Service Code for Heliograph and Telegraph Instruments.	American Morse Code for Heliograph and Telegraph Instruments.	European Morse Code for Telegraph and Heliograph Instruments	English Signal Code for Wand, Flag and Torch.	General Service Homographic Code for Lantern and Disk.
A	22	.. ..	- —	- —	- - - - -	11
B	2112	.. . . ..	— - - -	— - - -	- -	21
C	121	. .. .	- - -	— - — -	- —	31
D	222	.. .. ..	— - -	— - -	— -	41
E	12	. ..	-	-	- - —	51
F	2221	.. ..	- — -	- - — -	- — - -	12
G	2211	.. .. . .	— — -	— — -	- -	22
H	122	. .. ..	- - - -	- - - -	- - -	32
I	1	.	- -	- -	- - - -	42
J	1122	. . .. ..	— - — -	- — — —	- - - - -	52
K	2121	.. . .. .	— - —	— - —	- - - - - -	13
L	221	.. .. .	——	- — - -	- —	23
M	1221	. .. .. .	— —	— —	- - —	33
N	11	. .	— -	— -	- — -	43
O	21	.. .	- -	— — —	- - - —	53
P	1212	. .. . ..	- - - - -	- — — -	- - — - -	14
Q	1211	. .. . .	- - — -	— — - —	- - -	24
R	211	.. . .	- - -	- — -	- - - -	34
S	212	.. . ..	- - -	- - -	- - - - -	44
T	2	..	—	—	- - - - - -	54
U	112	. . ..	- - —	- - —	- - - - - - -	15
V	1222	. .. .	- - - —	- - - —	- —	16
W	1121	. . .. .	- — —	- — —	- - - -	25
X	2122	.. . .	- — - -	— - - —	- - — -	35
Y	111	. . .	- - - -	— - - — —	- - - - —	45
Z	2222	.. ..	- - - -	— — - -	- - - — - -	55
&	1111	. . . .	- - - -			
ing	2212	.. ..				
tion	1112	. . . ..				
ä				- — - —		
é				- - — - -		
ö				— — — -		
ü				- - — —		
ch				— — — —		
I	21112	.. . .	- — — -	- — — — —	-	1
II	12221	. .. .	- - — - -	- - — — —	- -	2
III	22122	.. ..	- - - — -	- - - — —	- - -	3
IV	22212	.. ..	- - - - —	- - - - —	- - - -	4
V	22221	.. ..	— — —	- - - - -	- - - - -	5
VI	12222	. .. .	- - - - - -	— - - - -	—	6
VII	11222	. . ..	— — - -	— — - - -	- —	7
VIII	11112	. . . . ..	— - - - -	— — — - -	— -	8
IX	11211	. . .. . .	— - - —	— — — — -	- - —	9
X	22222	.. ..	——	— — — — —	— - -	0

A or 5 - - - - -	I or 13 - - - -	Q or 21 - - -
B or 6 —	J or 14 - - - - -	R or 22 - - - -
C or 7 - —	K or 15 - - - - - -	S or 23 - - - - -
D or 8 — -	L or 16 - —	T or 24 - - - - - -
E or 9 - —	M or 17 - - —	U or 25 - - - - - - -
F or 10 - — - -	N or 18 - — -	V or 26 - - —
G or 11 - -	O or 19 - - - - —	W or 27 - - - —
H or 12 - - -	P or 20 - - — - -	X or 28 - - — -
Y or 29 - - - - —	Z or 30 - - - — - -	

1 -	3 - - -	5 - - - -	7 - —	9 - - —
2 - -	4 - - - -	6 —	8 — -	0 — - -

Preparative	- - - - - - - - - - - etc.
Wait	- - - -
General answer	— - — - — - — - etc.
Understood	-
Not understood	- -
Repeat or interrogative	- - — — - -
Spelling prefix	- — — -
Numeral	- - -
End of word	— — — — etc.
End of sentence	— — — — etc.
Pause	— — — — etc.

GENERAL SERVICE HOMOGRAPHIC CODE.

This, a code of ten elements, is made by certain combinations of the ten digits, placed in sets of two opposite to each letter of the alphabet, and in sets of one opposite to each of the ten digits; the whole number opposite to each standing for that letter or digit. The additional element (the 3 of the General Service Code.) is a *pause signal* used merely to denote the end of a word, sentence, etc.

A. . .11 F. . . .12 K. . .13 P. . . . 14 U. . .15 V. . .16
B. . .21 G. . . .22 L. . .23 Q. . . .24 W. .25
C. . .31 H. . . .32 M. . .33 R. . . .34 X. .35
D. . .41 I. . . .42 N. . .43 S. . . .44 Y. .45
E. . .51 J. . . .52 O. . .53 T. . . .54 Z. .55

1. . . . .1 3. . . . .3 5. . . . .5 7. . . . .7 9. . . .9
2. . . . .2 4. . . . .4 6. . . . .6 8. . . . .8 0. . . .0

Conventional, practical, and cipher signals, are the same as those used with the General Service Code; the disk (or lantern) in the right hand being used to make all except the *pause signal*, and to make it both disks should be used together. In ordering conventional signals, the Captain should precede each by the cautionary command, "*Code*"; thus—1. *Code*, 2 THREE; 1. *Code*, 2. REPEAT, etc. A *disk* is eighteen inches in diameter, made of canvas on a heavy wire fastened to a handle six inches long. The "*position*" and "*carry*" are same as for *lantern drill*, described hereafter.

Being at position, the Captain commands:

1. *Motion*, 2. ONE; or 1. *Figure*, 2. ONE.

Extend the right arm diagonally up to the right and immediately return it.

1. *Motion*, 2. TWO; or 1. *Figure*, 2. TWO.

Extend right arm to the right and return.

1. *Motion*, 2. THREE; or 1. *Figure* 2, THREE.

Extend right arm diagonally down to right and return.

1. *Motion*, 2. FOUR; or 1. *Figure*, 2. FOUR.

Extend left arm diagonally up to the left and return.

1. *Motion*, 2. FIVE; 1. *Figure*, 2. FIVE.

Extend left arm to the left and return.

1. *Motion*, 2. SIX; or 1. *Figure*, 2. SIX.

Extend the left arm diagonally down to the left and return.

1. *Motion*, 2. SEVEN; or 1. *Figure*, 2. SEVEN.

Extend both arms diagonally up on the sides and return.

1. *Motion*, 2. EIGHT; or 1. *Figure*, 2. EIGHT.

Extend arms to the right and left respectively and return.

1. *Motion*, 2. NINE; or 1. *Figure*, 2. NINE.

Extend arms diagonally down on the sides and return.

1. *Motion*, 2. TEN; or 1 *Figure*, 2. ZERO.

Extend both arms above the head, cover right disk with the left; and return.

On page 102 is a table of some of the signal codes at present used.

Numerals.—When numerals are made by the wand, flag, or torch, *without* the signals of "numerals follow" and "numerals ended," they are conventional signals, and have the meanings placed opposite to them, for the General Service Code, as follows:

1................Wait a moment.
2................Are you ready?
3................I am ready.
4................Use a short pole and small flag.
5................Use a long pole and large flag.
6................Work faster.
7................Did you understand?
8................Use white flag.
9................Use black flag.
0................Use red flag.

WAND DRILL.

In the position carry wands, the wand is in a vertical position in the right hand, resting in the hollow of the right shoulder, the arm nearly extended, the thumb and forefinger embracing the lower end of the wand; thumb against the thigh, the other fingers extended and joined in rear; the left hand by the side.

Being at a carry, the Instructor commands:

1. *Position*, 2. WANDS.

Bring the wand with the right hand vertically in front of the center of the body, the hand at the height of the breast; at the same time move the fingers in rear by the side of the forefinger, back of hand to the right.

Being in position, the Instructor commands:

1. *Motion*, 2. RIGHT.

Drop the wand in a vertical plane to the right by turning the right hand and forearm till the wand makes an angle of about 120° from the vertical, then instantly return it to the vertical.

1. *Motion*, 2. LEFT.

Make in the same manner to the left.

1, *Motion*, 2. FRONT.

Make in the same manner to the front.

Being in position, to make the "call signal," the Instructor commands:

1. *Swing*, 2. WANDS. 3. STAND.

Drop the wand in a vertical plane to the right, by turning the right hand and forearm, till the wand makes an angle of about 120° from the vertical—then pass it instantly in a vertical plane to a corresponding position on the left—back to right—left—and so continue, till the Instructor commands: 3. STAND, when position will be resumed.

Being in position, the Instructor commands:

1. *Carry*, 2. WANDS.

Resume the carry with the right hand.

To Rest.

Being at a *carry*, the Instructor commands:

1. *Squad*, 2. REST; or, 1. *In place*, 2. REST.

To resume the carry, he commands:

1. *Squad*, 2. ATTENTION.

There are two methods used in ordering letter signals; the first by numerals—the second by letters.

Examples by the first method.

Being at position wands, the Instructor commands:

1. *Number*, 2. ONE.

Make in same manner as *motion right.*

1. *Number*, 2. TWO.

Same as *motion left.*

1. *Number*, 2. THREE.

Same as *motion front.*

1. *Number*, 2. ONE.

Same as *motion right.*

1. *Number*, 2. TWO—TWELVE.

Make "two"—"one"—"two," without pausing.

1. *Number*, 2. THREE.

Same as *motion front.*

1. *Number*, 3. ELEVEN—TWENTY-ONE.

Make "one"—"one"—"two"—"one," without pausing.

1. *Number*, 2. TWELVE.

Make "one"—"two," without pausing.

1. *Number*, 2. TWO—TWENTY-ONE.

Make "two"—"two"—"one," without pausing.

1. *Number*, 2. THIRTY-THREE.

Make "three"—"three," without pausing.

Examples by the second method.

The Instructor commands:

1. *Letter*, 2. A.

Make "two"—"two" without pausing.

1. *Letter*, 2. B.

Make "two"—"one"—"one" —"two," without pausing.

1. *Letter*, 2. C.

Make "one"—"two"—"one," without pausing.

Etc. Etc. Etc.

A message to be signaled should be written thus:

"FORT HALE, D. T., December third.

"To C. O., Fort Randall:

"Indians are reported near you. X. Y."

or, when in the General Service Code, thus:

"2221, 21. 211, 2, 3, 122, 22, 221, 12, 3, 222, 3, 2, 3, 222, 12, 121, 12, 1221, 2112, 12, 211, 3, 2, 122, 1, 211, 222, 3,2, 21, 3, 121, 3, 21, 3, 2221, 21, 211, 2, 3, 211, 22, 11, 222, 22, 211, 211, 3,—1, 11,:222, 1, 22, 11, 212, 3, 22, 211, 12, 3, 211, 12, 1212, 21, 211, 2, 12, 222,3, 11, 12, 22, 211, 3, 111, 21, 112, 333,—2122, 3, 111, 333."

The signalman is ordered to *position wands;* the Instructor then orders the signals one at a time, giving the second after the first is signaled, and between "Fort Randall" and "Indians" he orders "*message follow*," and after "333," "*signature follow*" then "X" —"3"—"Y"—"333" "*carry wands.*"

Numerals are signaled in words or figures. When in figures, and in position, the Instructor commands:

1. *Numerals*, 2. FOLLOW.

Supposing the number to be 19, he next commands:
1. *Figure*, 2. ONE; or, 1. *Number*, 2. TWENTY-ONE—ONE—TWELVE.

Make "two"—"one"—"one"—"one"—"two, without pausing. 1. *Figure*, 2. NINE; or, 1. *Number*, 2. ELEVEN—TWO—ELEVEN.

Make "one" "one"—"two"—"one"—"one" without pausing.

The Instructor then commands:

1. *Numera's*, 2. ENDED.

When numerals in a message are to be signed *in figures*, the message is proceeded with as far as the numerals—then the signals for "*numerals follow*" is made—then the numerals—then the signal for "*numerals ended*," and then the message is proceeded with as before.

TO READ AND TO RECORD SIGNALS.

After a recruit has been taught to make signals, he should be instructed to read and record signals made by another person, and for this purpose two recruits are sent about 50 yards from a man making signals. One of the two sent out reads the signals of the man signaling, and calls them aloud, while his companion records them, either in letters or in signal numbers, as called. If the signals are called and recorded in signal numbers, it may be necessary to refer to the General Service Code to know their meaning.

Thus—1, 2, 3, 1, 212, 3, 1121, 12, 221, 21, 33, and by reference to the General Service Code, we find that they mean "It is well."

FLAGS ATTACHED TO POLES.

Pieces of sheeting or bunting, 1 to 2 feet square, tacked to poles 6 to 8 feet long, make good flags for short range signaling.

A squad or detachment, equipped with flags *attached to poles*, is drilled by similar commands and means as those used in wand drill in the position *carry flags*.

The pole (flag attached) is in the right hand; pole nearly vertical and resting in the hollow of the right shoulder; arm nearly extended; thumb and forefinger embracing the pole about 18 inches from the butt, the other fingers extended and joined in rear; the left hand by the side.

Being at a carry, the Instructor commands:

1. *Position*, 2. FLAGS.

Bring the pole with the right hand vertically in front of the center of the body, the hand at the height of the breast, and move the fingers in rear by the side of the forefinger, back of the hand in the front; at the same time grasp the pole with the left hand at the butt, the forearm horizontal and resting against the body. 1. *Carry*, 2. FLAGS. Resume the carry with the right hand; slip the left hand up the pole to the right shoulder, fingers extended and joined, the thumb close to the forefinger, back of the hand to the front, elbow close to the body. (Two.) Drop the left hand by the side.

MANUAL OF THE KIT.

The *case* is of canvas, and when open it is 4 feet long and 2 wide, with two rubber pouches for the torches and wormer; there are short straps to hold the three parts of staff in place; the two flags are folded and laid over the whole. The kit, rolled up, is fastened by three other straps. The *canteen*, of copper, holds a gallon. The *haversack*, of rubber, holds the small articles, shears, pliers, etc. A *telescope*, with ball and socket holder (carried in the haversack), completes the signalman's outfit. In the position *carry kits*, the kit is in the right hand, nearly vertical, the butt resting in the right hand; the arm hanging nearly at its full length, near the body; the thumb in front, the fingers closed together underneath and embracing the butt; the left hand by the side. 1. *Right shoulder*, 2. KITS. Being at a carry, raise the kit vertically with the right hand, grasp it with the left hand 4 inches below the middle strap, and raise this hand until it is at the height of the chin. (Two.) Raise the kit and place it on the right shoulder, the top elevated and inclined to the left. Slip the left hand over the kit on the shoulder. (Three). Drop the left hand by the side. 1. *Carry*, 2. KITS. Carry the butt slightly to the left and lower the kit with the right hand; grasp it with the left hand 4 inches below the middle strap, the hand at the height of the chin. (Two.) Resume the carry with the right hand. (Three.) Drop the left hand by the side. 1. *Kits*, 2. PORT. Being at a carry, throw the kit diagonally across the body, grasp it smartly at the same instant with both hands; the right at the lower, the left at the middle strap, the kit sloping upward, and crossing opposite the point of the left shoulder, the butt proportionately lower. The palm of the right hand is above, and that of the left is underneath the kit; elbows close to the body. 1. *Carry*, 2. KITS Resume the carry with the right hand. (Two.) Drop the left hand by the side. 1. *Sergeants*, 2. SALUTE. Being at a carry, raise the left hand and arm horizontally to the front, palm of the hand down, the fingers extended. (Two.) Bend the left elbow, carry the hand around till the forefinger strikes the kit in the hollow of the right shoulder, retaining it there until the salute is acknowledged. (THREE.) Return to the position of the first motion. (FOUR). Drop the left hand by the side. 1. *Order*, 2. KITS. Being at a carry, grasp the kit with the left hand immediately above the middle strap; let go with the right hand; lower the kit quickly with the left, regrasping it with the right above the middle strap; the hand at the height of the thigh; the butt about three inches from the ground; the left hand steadying the kit from the right. (Two.) Lower the kit gently to the ground near the right hand, drop the left hand by the side, elbow close to the body, the back of the hand to the right, the fingers extended and joined; the kit between the thumb and fingers, extended along the kit; the butt against the toe of the right foot; the kit vertical. *To Rest.* At an order kits, the Instructor commands: 1. *Squad*, 2, REST; or, 1, *In Place*, 2, REST. To resume the order, he commands: 1. *Squad*, 2. ATTENTION. 1. *Carry*, 2. KITS. Raise the kit vertically with the right hand; grasp it at the same time with the left, below the right; resume the carry with the right hand. (Two.) Drop the left hand by the side.

The kits should be habitually carried at the *right shoulder* during drill when marching. Signalmen equipped with the wand, the flag, or torch, salute as prescribed for Sergeants' salute with the kit.

The detachment with and without arms is maneuvered the same as a troop of cavalry, or a company of infantry, and when equipped with kits, movements herein prescribed are added.

Deployments.

By the flank.—Being formed in line, the Captain commands:

1. *Form signal line*, 2. *Guide center*, 3. MARCH, 4. *By the left* (or *right*) *flank take intervals*, 5. MARCH, 6. *Detachment*, 7. HALT. At the *second* command, the director (an experienced Sergeant previously designated) places himself quickly by the shortest line, 5 yards in front of the center of the detachment. At the *third* command, the director and rank march forward; the file-closers stand fast. The director and rank having marched 15 yards, the fourth command is given, at which they halt and face to the left when the rank does. At the *fifth* command, the left file steps off, and, conducted by the left guide on his left, marches in the prolongation of the former front of the detachment; the other men follow successively at the proper interval, each steadily in the trace of his predecessor; the director and file-closers maintain their relative positions. The movement is continued till all the intervals are taken. At the *seventh* command, all of the signalmen halt, face to the front, and align themselves to the right (the point of rest) without command. The Captain and guides take their posts. This formation is termed a *signal line*. In double rank, at the *third* command, the rear rank stands fast, then faces to the left with the front rank; at the *fifth* command, the left file of the rear rank steps off at the same time the left file of the front rank does, and marches parallel with him; the other men of the rear

rank follow successively, each man stepping off with his front-rank man.

The Posts of Officers and Sergeants in Signal Line.

The *Captain* is 15 yards in front of the center; as Instructor, he goes wherever his presence is necessary; the *First Sergeant* is on the right of, and 1 interval from the rank; the *Second Sergeant* is on the left of, and 1 interval from the rank; the *Lieutenants* and the *other Sergeants* are in the line of file-closers as in line. In double rank, the right and left guides are 1 interval from their flanks of the front rank; the file-closers are posted as in line. During drill with flags or torches, the file-closers and the right and left guides go wherever their services may be required. At the close of this drill, they resume their posts, by the command of the Captain: 1. *Guides*, 2. Posts.

By both flanks. Being in line, the Captain commands:

1. *Form signal line*, 2. *Guide center*, 3. March, 4. *By the right and left flanks take intervals*, 5. March. The *first*, *second*, and *third* commands are executed as explained by the flank. At the *fourth* command, the center file and those to the right face to the right, and those to the left face to the left. The men who have faced to the right are designated *right signalmen;* those who have faced to the left, *left signalmen.*

At the *fifth* command, the deployments by both flanks are executed as explained by the flank. When the center file has his interval, the First Lieutenant commands: 1. *Right signalmen*, 2. Halt: and when the rear signalman on the left has taken his interval, the Second Lieutenant commands: 1. *Left signalmen*, 2. Halt. The right and left signalmen face to the front after halting, and all align themselves on the center (the point of rest) without command.

When the deployments are made by one or both flanks from line on the march, the file-closers halt at the *third* command. In double rank, the rear rank halts at the *third* command. In signal line, the habitual *interval* between signalmen is 5 yards. In double rank, the habitual *distance* between ranks is 15 yards. For inspection of kits, intervals are two yards. In double rank, the distance between ranks is 5 yards. Greater or less than the habitual interval may be had by adding the words "*to* (so many) *yards*" between the words "*by the left* (or *right*, *flank*," and "*take intervals*," in the fourth command In double rank the front rank may be marched less than the habitual distance, by the fourth and fifth commands being given sooner. Two parts of staff are used at five-yard intervals, and the intervals should be increased 1 yard when an additional part of the staff is used. The *staff* is of hickory, 12 feet long, tapering from 1 inch at the butt to ½ inch at the tip, and is divided into three equal parts, which are provided with brass ferrules for joining the whole together. The first, or tip part, is that to which the flag is attached; the second, the one to which the torch is attached, is covered with the ferrule 6 inches long at its upper end, to protect it from the flames of the torch. Another, a larger part of staff, 4 feet long, is sometimes strapped on the outside of the kit, and then 12 feet of the staff may be used with the torch, and 16 feet with the flag.

The Assembly.

Being at a halt, the Captain commands: 1. *Form line*, 2. *Guide center*, 3. March, 4. *Assemble on right* (or *left*) *signalman*, 5. March. At the *third* command, the file-closers close to the rank. At the *fifth* command, the right file stands fast and at a *carry:* the others face to the right, close upon the right file, and form on his left in their order, face to the front, and come to a *carry*. The officers, guides and director, take posts in line. In double rank, at the *third* command the rear rank closes to the front rank and at the *fifth* command the right file of both ranks stand fast; the others all face to the right and close in as in single rank. The assembly on the center signalman is similarly executed, the center file stands fast at a *carry*. If marching to the front, the rank halts at third command. If marching to the rear, the detachment assembles as when marching in advance; the assembly completed, the detachment is faced about. In double rank, the front rank only, halts at the third command; if marching to the rear, the rear rank forms in front; the assembly completed, the detachment is faced about.

FLAG DRILL.

The ordinary *signal flags* are 4 feet square, of white bunting, with red centers 16 inches square, or red, with white centers, each flag having on one side strings or ties 6 inches long, sewed in couples 1 foot apart, for attaching flag to the staff.

Being in single line, kits at a carry or an order, the Captain commands:

1. *Unstrap*, 2. Kits.

Place the kit upon the ground with both hands, 12 inches in front of the toes, butt to the right; at the same time carry the right foot 3 inches to the rear; unswing the canteen without rising, and place it immediately to the left of the kit, nozzle to the front; unstrap and open the kit, and then take the position of the soldier.

1. *Attach*, 2. White (or Red) Flags.

Advance the left foot 9 inches, putting it under the kit; take out the parts of staff to be used (usually two), the largest first; pass the butt end to the left and rear, and connect them together; take out the flag designated and attach to the top of the staff, tying top signals first; the flag attached, pass the staff to the front with both hands, and place it on the ground, the butt resting on the kit in front of the feet, and then take the position of the soldier.

1. *Detachment*, 2. On Post, 3. March.

At the *second* command, place the left foot 1 yard to the front; take up the staff with both hands, the left at the butt, the right about 18 inches from the left, advance the right foot 1 yard.

At the *third* command, raise the staff to position (vertically) in front of the body; the left hand at the height of the waist: at the same time advance 2 yards further to the front, using the guide on the right.

Being on post at position flags, the Captain commands:

1. *Motion*, 2. Right.

Drop the flag in a vertical plane to the right, using both hands, till the staff makes an angle of about 120° from the vertical, then instantly return it to the vertical.

1. *Motion*, 2. Left.

Make in the same manner to the left.

1. *Motion*, 2. Front.

Make in the same manner to the front.

Being on post at position flags, to make the "call signal," the Captain commands:

1. *Swing*, 2. Flags, 3. Stand.

Drop the flag in a vertical plane to the right, using both hands, till the staff makes an angle of about 120° from the vertical; then pass it instantly in a vertical plane to a corresponding position on the left; back to the right—left—and so continue till the Captain commands: 3. Stand, when *position flags* will be resumed.

When at position flags, the Captain may order any signals he desires.

Being on post, the Captain commands:

1. *Down*, 2. Flags.

Step backward 3 yards; at the same time lower the flag and place it upon the ground; then stand erect.

To Rest.

Being at down flags, the Captain commands:

1. *Detachment*, 2. Rest: or, 1. *In place*, 2. Rest.

To resume attention, and post in rear of the kit, he commands:

1. *Detachment*, 2. Attention.

Being at attention in rear of the kit, to repack kits, the Captain commands: 1. *Repack*, 2. Kits. Advance the left foot 9 inches, putting it under the kit: pass the staff to the left and rear with both hands; return all the articles used to their proper places in the kit; strap up the kit, fastening the middle strap first; sling the canteen without rising; pick up the kit, and then take the position of *order kits*. The kits are brought to a *carry* and *right shoulder*, and the line assembled, as explained in the assembly. If the command *repack kits* be given when *on post*, hold the staff vertically in both hands; face about, and with guide left return to place in rear of the kit, halt, face about, and return all articles, etc., as just explained. Being on post, at position flags, to change from flag to torch drill, the Captain commands: 1. *Return*, 2. Flags. Hold the staff vertically in both hands, face about, and with guide left return to place in rear of kit, halt, face about, detach flag and return it and the top part of the staff to the kit; drop the other part on left side; leave the canteen and the kit open on the ground, and take the position of the soldier. When the flags are *down*, the command *return flags* is executed after the post in rear of the kit is taken. The commands for torch drill are executed as explained under that head.

TO OPEN STATION.

Being in double rank, to establish signal communication between the front and rear ranks, the Captain designates the senior Lieutenant (or Non-commissioned Officer) to take command of the rear rank. The Captain marches the front rank one hundred yards or more to the front, takes intervals, faces it about, unstraps kit, etc., to *attach flags* (or *torches*). The Lieutenant (or Sergeant) cautions the rear rank to stand fast; then gives the same commands as the Captain for taking intervals, etc., to *attach flags* (or *torches*). The Captain then commands: 1. *Front rank*, 2. Open, 3. Station. At the *second* command, the front rank marches *on post* and *swings flag* till the flags of the rear rank are seen; then *stands flag*; then acknowledges (22, 22, 22, 3); then makes the signals for "to A. B.," and the signal for "message follow;" then takes the position of *stand*, the Lieutenant, seeing the "call signal" of the front rank, commands: 1. *Rear rank*, 2. On post, 3. March, 4. Acknowledge; the rear rank makes 22, 22, 22, 3, then *down flag*, and is ready to receive messages from the front rank. Communication between any two stations is opened in a similar manner.

TO CLOSE STATION.

Being in double rank, in signal line, the ranks facing each other, to form line, the Captain commands: 1. *Front rank*, 2. Close, 3. Station, 4. Stand. At the *second* command, the front rank marches *on post*; at the *third*, *swings flag*, and as soon as *acknowledged* by the rear rank, the Captain commands: 4, Stand; and immediately after: 5. *Cease*, 6. Signaling, 7. *Repack*, 8. Kits, 9. *Carry*, 10. Kits, 11. About, 12. Face; and he also gives the commands for the *assembly*. The Lieutenant seeing the front rank "call," commands: 1. *Rear rank*, 2. On post, 3. March, 4. Acknowledge. 5. *Cease*, 6. Signaling, 7. *Repack*, 8. Kits, 9. *Carry*, 10. Kits; and causes the rear rank to execute the Captain's commands to assemble.

PRACTICAL SIGNALS.

Signal stations are generally on hill-tops, roofs of buildings, mast-heads of vessels, etc., and so far apart (from 1 to 30 miles) that it is necessary to use a telescope or marine-glass to read the motions of a signal flag or torch. There should always be at least two men to each signal-station, who have a practical knowledge of signals. Now, suppose there are two such men at each of two different stations, and those at the first station designated by A and B, and the two at the second by C and D, and it is desired to signal a message from the first to the second station. At the first station A takes his flag (or torch) and calls by waving it successively from right to left. B, seeing the flagman at the second station make 22, 22, 22, 3, commands A to "stand"—"acknowledge," which A does by first coming to "*position flag*," and then making 22, 22, 22, 3. B then calls off the message signal by signal, and A makes them, pausing for a second after each signal, after making the signature he makes 333, and puts his flag down. At the second station, when A's call is seen, C takes his flag and makes 22, 22, 22, 3, and puts it down. D reads A's signals and calls them off, one at a time, to C, who writes them down. If the message is received correctly and read, C acknowledges it by flagging 22, 22, 22, 3, and putting his flag down if the answer is not to be signaled at once. If the message is not received correctly or understood, C flags 121, 121, 121, 3, 22, 3, (repeat after), or 121, 121, 121, 3, 2112, 3, (repeat before), and the signals for a word in the message that is received. If none of the message is understood, C flags 121, 121, 121, 3, 22, 221, 221, 3, (repeat all) and then puts his flag down; at the first station. B, seeing C's flag, orders A to "*acknowledge*," and calls out the signals to be repeated. If A makes an error while flagging, he at once makes 212121, 3, and then the correct signals, beginning at the word or number in which the error was made. Communication between any two stations is conducted in a similar manner.

TORCH DRILL.

The *flying-torch* is of copper, 18 inches long and 1½ inches in diameter. It has two screw fastenings for attachment to the staff, and a place near the close end for filling it. The *foot-torch* is also of copper, 18 inches long and 2 inches in diameter. The flame shades and extinguishers for both are also of copper. Being in a signal line, kits at a carry or an order, the Captain commands: 1. *Unstrap*, 2. Kits. Place the kit upon the ground with both hands, 12 inches in front of the toes, but to the right; at the same time carry the right foot 3 inches to the rear; unsling the canteen without rising, and place it immediately to the left of the kit, nozzle to the front, unstrap and open the kit, and then take the position of the soldier. 3. *Prepare*, 4. Torches. Advance the left foot 9 inches, putting it under the kit, take out the torches; place them in front of the kit, foot-torch on the right, and both pointing to the front; take the canteen in the left hand, the funnel in the right, and fill the torches, the foot-torch first; return canteen and funnel—take out flame shades, remove extinguishers, put flame shades on the torches, and extinguishers in the haversack—then take the position of the soldier. 5. *Foot-torch*, 6. Place. Take the foot-torch in the right hand; march forward, guide right, 4 yards, halt, place it on the ground near the feet, wick to the front, and before rising take a match from the haversack and light the foot-torch—then stand erect, face about, and with guide left return to place in rear of the kit, halt and face about. 7. *Attach*, 8. Torches. Advance the left foot 9 inches, putting it under the kit; take out the parts of staff to be used (usually two), the larger first, pass the butt-ends to the left and rear, and connect them together; take the flying-torch in the right hand and fasten it to the top of the staff; the torch attached, pass the staff to the front with both hands and place it on the ground, the butt resting on the kit in front of the feet, and then take the position of the soldier. 9. *Detachment*, 10. On post, 11. March. At the *tenth* command, place the left foot 1 yard to the front; take up the staff with both hands, the left at the butt, the right about 18 inches from the left; advance the right foot 1 yard, and light the flying-torch at the flame of the foot-torch. At the *eleventh* command, raise the staff to a vertical position in front of the body; the left hand at the height of the waist; at the same time advancing 2 yards farther to the front, with the guide on the right.

TO RECEIVE A MESSAGE.

Being on post, the Captain commands:

1. *Down*, 2. Torches.

Step backwards 3 yards; at the same time lower the torch and place it upon the ground in rear of the foot-torch; step up on the right to the flying-torch and put the extinguisher on it: then stand erect near the flying-torch.

TO REST.

Being at down torches, the Captain commands: 1. *Detachment*, 2. Rest; or, 1. *In Place*, 2. Rest. 1. *Detachment*, 2. Attention. Remove the extinguisher, and take post in rear of the kit.

Being at attention, in rear of the kit, to repack kits, the Captain commands:

1. *Repack*, 2. Kits.

Take the canteen in the left hand to the right of the foot-torch; empty any turpentine both torches may contain into the canteen; sling the canteen; take foot-torch in the right hand; step backward 2 yards; take the staff in the left hand, hold it vertically, and return to the rear of the kit; return all articles to their proper places; strap up the kit, fastening the middle strap first; pick up the kit, and take position of *order kits*.

If the command *repack kits* be given when *on post*, first execute "*down torches*," and then above. Being on post, at position torches, to change from torch to flag drill, the Captain commands: 1. *Return*, 2. Torches. Execute what is prescribed for *down torches*, then what is prescribed for *repack kits*, except that the canteen is unslung and placed again at the left of the kit; the upper part of staff is dropped at the left side, and the kit left open upon the ground. The command *return torches* may be given from a *down*. The commands for *flag drill* are executed as explained under that head. Any signals that are made with the flag can be made with the torch, and by the same commands. If it be necessary for the man signaling to stop to fill a torch, or to stop for any other purpose, he will, at the end of a word, lower the flying-torch to the ground on his *left*, fill the torch requiring it, and then raise the flying-torch from his left and continue the message where he left off.

LANTERN DRILL.

As it is often impracticable to use torches, especially on board ship, lanterns may be used for night signaling at short ranges, and each signalman should use three, one a colored or more brilliant light than the other two, well fastened at his waist for a reference light, and the other lanterns held one in either hand against the breasts for the "*position*" or "*carry*," these two positions being the same with lanterns or disks. The General Service Code is used. Being in signal line, at position, the Captain commands: 1. *Motion*, 2. Right; or, 1. *Number* 2. One. Extend right arm to the right and immediately return it. 1. *Motion*, 2. Left; or, 1. Number, 2. Two. Extend the left arm to the left and immediately return it. 1. *Motion*, 2. Front; or, 1. *Number*, 2. Three. Extend both arms down and immediately return them. The conventional, practical, and cipher signals of the General Service Code are about the same as those used with the torch; the lantern in the right hand being used to make all except the pause signal, and to make it both lanterns should be used together. Lanterns may be used to make the signals of the General Service Homographic Code. A squad or detachment of signalmen equipped with lanterns and maneuvered by similar commands and means to those already explained. As the whole number opposite to a letter or digit should be made without a pause, the right and left motion must be combined in making it.

INSPECTION OF THE DETACHMENT.

The Captain deploys the signal line, and then commands: 1. *Officers and Non-commissioned Officers to the front*, 2. March, 3. Front. At the *second* command, the file-closers pass through their nearest intervals in the ranks, and they and the guides place themselves in their order, the Officers 10, and the Non-commissioned Officers 5 yards in front. All dress toward the point of rest. The Captain superintends the alignments, commands *front*, and then: 4. *Unstrap*, 5. Kits. Place the kit upon the ground with both hands, 12 inches in front of the toes, butt to the right; at the same time carry the right foot 3 inches to the rear; unsling the canteen without rising, and place it immediately to the left of the kit, the nozzle to the front; unstrap and open the kit, and then take the position of the soldier.

6. *Inspection*, 7. Kits. Advance the left foot 9 inches, putting it under the kit; take out the torches; remove extinguishers; put on flame-shades; place torches in front of the kit; foot-torch on the right, and 2 feet from flying-torch, both pointing to the front; lay the wormer, extinguishers, funnel, pliers, and shears between the torches; take out all parts of staff, pass the butt-ends to the left and rear, and connect them together, and lay the staff, on the ground; lay the white flag on the kit, strings from you; fold in the middle toward the strings; fold again in the same way; the flag on the front half of the kit; fold the red flag in the same manner, immediately in rear of white flag, with the strings to the front, the flags nearly covering the kit; take the staff in the left hand, stand erect, holding it vertically on the left side, left hand at the height of the breast, butt of staff against the left toe. The accouterments and dress of each soldier having been minutely inspected, the Captain commands: 8. *Open*, 9. Haversacks; and examines them. The Captain then commands: 10. *Repack*, 11. Kits. Advance the left foot 9 inches, putting it under the kit; pass the staff to the left and rear with both hands; return all articles used to their proper places; strap up the kit, fastening the middle strap first: sling the canteen without rising, pick up the kit and then take the position of *order kits*. The next commands are: 12. *Carry*, 13. Kits, 14. *Officers and Non-commissioned Officers to your posts*, 15. March. At the *fifteenth* command, the Officers and Non-commissioned Officers face about and return to their posts in rear.

An instrument called the heliograph, heliostadt, or sun-telegraph, constructed with small mirrors made to turn upon both a horizontal and vertical axis, mounted upon a tripod, so arranged as to reflect the sun's rays in any direction, and to make the flashes appear and disappear in rapid succession, is to a limited extent used in the Army; and by it messages may be transmitted much faster than with flags or torches, and it can be used at long ranges. It is manipulated by a key, similar to the electric telegraph instrument. Mirror signaling was first used by the North American Indians. There are several styles of heliographs used in the Army. The manner of using two kinds will be given in this place.. They are both mounted on tripods, and are quite portable. The following conventional signals may be used with both instruments.

"Call"........................A succession of flashes.
"Error"................ " "
"Adjust instrument"......5 flashes.
"G. A."........... ....Go ahead.
"G. S.".........................Go slower.

THE MANSE HELIOGRAPH.

The mirror turns on a vertical axis by a tangent-screw, and on a horizontal axis by a rod (with a thread on it) from the top of the mirror to the base or top of the stand of the tripod, which supports the whole. *To sight the instrument:* Place it, so that by turning the mirror vertically and horizontally when the sun shines upon it, the dark spot in the center of the mirror (or a piece of paper wetted and put on center), as seen by a person standing nearly in front of and looking into the mirror, is in a line with and covering the distant station; then put up a half-inch rod, so as to be in line with the spot and distant station, mark the place on the rod covered by the shadow of the spot. The rod usually has a sliding brass button to mark the shadow spot, and a disk of pasteboard made to slide along the rod, and upon which the reflection falls when the key of the instrument is not depressed, and when it is not wished that the reflection be thrown to the distant station. Then by moving the mirror either horizontally or vertically, without changing the position of the instrument, the signalman may always know that whenever the shadow of the center spot of the mirror covers the mark on the vertical rod, (usually from 2 to 20 feet distant from the instrument that the reflection of the sun is thrown on the distant station. And whenever the reflection of the sun from the distant station is seen, this reflection, the marked place on the rod, and center spot of the mirror, may be seen by looking into the mirror from the position chosen in setting it up.

THE GRUGAN HELIOGRAPH.

The "sun-mirror" has a hole at its center. The "flashing-mirror" has a disk at its center. Set the tripod firmly on the ground; clamp the bar to the tripod; clamp the *sun-mirror* to the bar, and turn up the sighting-rod. Ease the bar-clamp, and, sighting through the hole in the mirror, move the bar and raise or lower the sighting-rod until its disk accurately covers the distant station; then reclamp, being careful not to disarrange the alignment. Move the mirror by means of its slow-motion screws until the reflection of the hole in the mirror (shadow spot) falls upon the disk of the sighting-rod. The flash will then be visible at the distant station. *The shadow spot must be kept in the center of the disk while signalling.* Place the screen, clamped on its tripod, close to and in front of the sighting-disk, so as to intercept the flash *when the key is depressed* (obscuration system). Working the screen in the same manner as a telegraph key, will cause the flash to disappear and appear to the distant observer. The screen may be worked and the adjustment kept by a single operator.

TWO GRUGAN MIRRORS.

Set the tripod firmly on the ground; clamp the bar to the tripod; clamp both mirrors to the bar. Place the bar diagonally across the line of vision to the distant station; the *flashing-mirror* facing the distant station, the *sun-mirror* facing the sun. Stooping down, the head in rear of and near the flashing mirror, turn the *sun-mirror* by means of the slow-motion screws until the whole of the *flashing-mirror* is seen reflected in the sun-mirror, and the reflected disk and hole accurately cover each other. Still looking in the sun-mirror, turn the flashing-mirror (by its slow-motion screws) until the distant station is brought into position, which will be when the reflected disk, the hole, and the reflection of the distant station are accurately in line, or cover each other. Now, stepping behind the *sun-mirror*, throw upon the flashing mirror a full flash from the sun-mirror, and adjust the latter until the shadow spot falls upon the center of the disk. The flash will then be visible at the distant station. *The shadow spot must be kept in the center of the mirror-disk while signaling.* Place the screen, clamped on its tripod, so as to intercept the flash *when the key is depressed*, and in a convenient position for keeping the sun-mirror adjusted.

INTERNATIONAL SIGNALS.

The necessity for a uniform and comprehensive system of signaling at sea, and to shore stations on the coasts of the United States, and other countries, has led to the adoption of the "International Commercial Code of Signals," for their naval as well as for their merchant ships, by the following nations, to-wit:

United States,	Russia,	Spain,	Germany,
England,	Greece,	Portugal,	Holland,
France,	Italy,	Brazil,	Sweden,
Denmark,	Austria,	Belgium.	

Messages received at all telegraphic signal stations and life-saving stations in the United States will be transmitted and delivered to the adress on payment, either at the Station or at the place to which adressed, of the telegraphic charge. All messages received from or adressed to the War, Navy, Treasury, State, Interior, or other official department of Washington are telegraphed without charge.

Signal stations have been established at some of the most important points on the coast of the countries above named, at which the International Code is the *only* code recognized; and vessels of any nation, which make their names known by means of this code on passing these stations, are immediately reported.

Ship owners should see that their vessels are provided with the "International Commercial Code Signal Book" and the requisite number and kind of flags for signaling purposes according to this code. The flags represent 18 consonants, B, C, D, F, G, H, J, K, L, M, N, P, Q, R, S, T, V, W, each of which has its special flag or pennant of varied forms and colors. The day signals of this code are made by hoisting, in the same hoist, 1, 2, 3, or 4 of these flags; the meaning of any combination of flags in a hoist is given in the code book; some combinations stand for a whole sentence, some for single words, others for separate letters of the alphabet; hence, it is not difficult to establish communication, especially now that the meanings of a large number of combinations are translated into so many different written languages. Examples:

Combination.	Meaning (in English).
H. B	Want immediate assistance.
H. F	We are coming to your assistance.
H. W	Engine or machinery disabled.
K. P	Bar impassable.
M. F	Hold on until high water.
P. N	Want a steam tug.
B. P. W	Do you wish to be reported?

Cautionary Signals.

The U. S. War Department (through the Signal Bureau,) prescribes that the following "Cautionary Signals" be displayed, as occasion may require, at all active Signal and Display Stations of the Signal Service.

Cautionary Signal, *i. e.*, a square, red flag, with a square, black center by day, or a red light shown at night, calls for caution in view of an approaching storm, and is so "cautionary" with reference to winds blowing from any direction.

Cautionary Off-Shore Signal, *i.e.*, a white flag with black square in the center, shown above a red flag with black square in the center, by day, or a white light shown above a red light by night, is "cautionary" with reference to winds expected to blow from a northern or western direction or off-shore, at or near the place at which it may be.

SIGNALS ON THE WATER.

The United States Treasury Department published, Feb. 17, 1877, the following circular, to wit:

Every vessel of the mercantile marine navigated without complying with the instructions of this circular, will be liable to a penalty of $200, for which sum the vessel may be seized and proceeded against.

Rule 1. *Steam and Sailing Vessels.* Every steam-vessel which is under sail and not under steam, shall be considered a sail-vessel; and every steam-vessel which is under steam, whether under sail or not, shall be considered a steam-vessel.

Rule 2. Lights. The lights mentioned in the following rules, and no others, shall be carried in all weather between sunset and sunrise.

Rule 3. *Lights for Ocean-going Steamers and Steamers carrying Sail.* All ocean-going steamers, and steamers carrying sail, shall, when under way carry —(*a.*) At the foremast head, a bright white light, of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least 5 miles, and so constructed as to show a uniform and unbroken light over an arc of the horizon of 20 points of the compass, and so fixed as to throw the light 10 points on each side of the vessel, namely, from right ahead to 2 points abaft the beam on either side.

(*b.*) On the starboard side, a green light, of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least 2 miles and so constructed as to show a uniform and unbroken light over an arc of the horizon of 10 points of the compass, and so fixed as to throw the light from right ahead to 2 points abaft the beam on starboard side.

(*c.*) On the port side, a red light, of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least 2 miles, and so constructed as to show a uniform and unbroken light over an arc of the horizon of 10 points of the compass, and so fixed as to throw the light from right ahead to 2 points abaft the beam on her port side.

The green and red lights shall be fitted with inboard screens, projecting at least 3 feet forward from the lights, so as to prevent them from being seen across the bow.

RULE 4. *Lights for Towing-Steamers.* Steam-vessels, when towing other vessels, shall carry 2 bright white masthead lights, vertically, in addition to their side lights, so as to distinguish them from any other steam vessels. Each of these mast-head lights shall be of the same character and construction as the masthead lights described by Rule 3.

RULE 5. *Lights for Steamers not Ocean-going nor Carrying Sail.* All steam-vessels other than ocean-going steamers carrying sail, shall, when under way, carry on the starboard and port sides lights of the same character and construction and in the same position as are prescribed for side lights by Rule 3, except in the case provided in Rule 6.

RULE 6. *Lights for Steamers on the Mississippi River.* River steamers navigating waters flowing into the Gulf of Mexico and their tributaries, shall carry the following lights, namely: 1 red light on the outboard side of the port smoke-pipe, and one green light on the outboard side of the starboard smoke-pipe. Such lights shall show both forward and abeam on their respective sides.

RULE 7. *Lights for Coasting Steam-vessels, and Steam-vessels navigating Bays, Lakes, and Rivers.* All coasting steam-vessels, and steam-vessels other than ferry-boats, and vessels otherwise expressly provided for, navigating the bays, lakes, rivers, or other inland waters of the United States, except those mentioned in Rule 6, shall carry the red and green lights, as prescribed for ocean-going steamers, and, in addition thereto, a central range of 2 white lights, the after light being carried at an elevation of at least 15 feet above the light at the head of the vessel. The head light shall be so constructed as to show a good light through 20 points of the compass, namely, from right ahead to 2 points abaft the beam, on either side of the vessel, and the after light, so as to show all around the horizon.

The Lights for Ferry-boats shall be regulated by such rules as the Board of Supervising Inspectors of Steam-vessels shall prescribe, to wit:

Lights for Ferry-boats. The lights for ferry-boats with rudders on both ends, shall be such as, in the opinion of the supervising inspector of the district in which the boats are running, are best adopted to the character of the navigation and to the prevention of accidents by collision or otherwise.

Globe Lights. A globe light may be used in place of the torch mentioned in Rule 25, when the use of such torch would be likely to endanger the safety of vessel or cargo.

Fog-signals. It is recommended by the Board of Supervising Inspectors of Steam-vessels that, whenever there is a fog by day or night, sailing-vessels and every craft propelled by sails upon the ocean, lakes, and rivers, when on the starboard tack, shall sound, with intervals of not more than 2 minutes, *one* blast of the fog-horn; when on the port tack, *two* blasts; when with the wind free, *three* blasts; and that, when lying-to or at anchor, they shall sound the bell, with the same intervals.

Fog-horns. The selection of an instrument to be employed in making the fog-signals required by law must, in every case, be left to the master or owner of the vessels, it being only necessary that the Department shall so far regulate such selection that instruments not effective for the purpose shall be excluded. Any instrument or device for this purpose which produces a sound equivalent to that of a steam-whistle, will be considered sufficient for the the purposes of the law.

RULE 8. *Lights for Sailing-vessels.* Sail-vessels, under way or being towed, shall carry the same lights as steam-vessels under way, with the exception of the white masthead light, which they shall never carry. (See Rule 3, *b* and *c.*)

RULE 9. *Exceptional Lights for Small Sailing-vessels.* Whenever, as in case of small vessels during bad weather, the green and red lights cannot be fixed, these lights shall be kept on deck on their respective sides of the vessel, ready for instant exhibition, and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such a manner as to make them most visible, and so that the green light shall not be seen on the port side nor the red light on the starboard side. To make the use of these portable lights more certain and easy, they shall each be painted outside with the color of the light they respectively contain, and shall be provided with suitable screens.

RULE 10. *Lights for Steam-vessels and Sailing-vessels at Anchor.* All vessels, whether steam-vessels or sailing-vessels, when at anchor in roadsteads or fairways, shall, between sunset and sunrise, exhibit where it can best be seen, but at a height not exceeding 20 feet above the hull, a white light in a globular lantern of eight inches in diameter, and so constructed as to show a clear, uniform, and unbroken light, visible all around the horizon, and at a distance of at least one mile.

RULE 11. *Lights for Pilot-vessels.* Sailing pilot-vessels shall not carry the lights required for other sailing-vessels, but shall carry a white light at the masthead, visible all around the horizon, and shall also exhibit a flare-up light every fifteen minutes.

RULE 12. *Lights for Coal-boats, Trading-boats, Rafts, and all other like Craft.* Coal-boats, trading-boats, produce-boats, canal-boats, oyster-boats, fishing-boats; rafts, or other water-craft, navigating any bay, harbor, or river, by hand-power, horse-power, sail, or by the current of the river, or which shall be anchored or moored in or near the channel or fairway of any bay, harbor, or river, shall carry one or more good white lights, which shall be placed in such a manner as shall be prescribed by the Board of Supervising Inspectors of Steam-vessels.

RULE 13. *Light for Open Boats.* Open boats shall not be required to carry the side lights required for other vessels, but shall, if they do not carry such lights, carry a lantern having a green slide on one side, and a red slide on the other, and, on the approach of or to other vessels, such lanterns shall be exhibited in sufficient time to prevent collision, and in such a manner that the green light shall not be seen on the port side, nor the red light on the starboard side. Open boats, when at anchor or stationary, shall exhibit a bright, white light. They shall not, however, be prevented from using a flare-up, in addition, if considered expedient.

RULE 14. *Lights on Vessels of the United States Navy.* The exhibition of any light on board of any vessel-of-war of the United States may be suspended whenever, in the opinion of the Secretary of the Navy, the Commander-in-Chief of a squadron, or the Commander of a vessel acting singly, the special character of the service may require it.

RULE 15. *Fog Signals.* Whenever there is a fog or thick weather, whether by day or night, fog signals shall be used, as follows:

(*a.*) Steam vessels under way shall sound a steam-whistle placed before the funnel, not less than 8 feet from the deck, at intervals of not more than 1 minute.

(*b.*) Sail-vessels under way shall sound a fog horn at intervals of not more than 5 minutes.

(*c.*) Steam-vessels and sail-vessels, when not under way, shall sound a bell at intervals of not more than 5 minutes.

(*d.*) Coal-boats, trading-boats, produce-boats, canal-boats, oyster-boats, fishing-boats, rafts, or other water craft, navigating any bay, harbor, or river, by hand-power, horse-power, sail, or by the current of the river, or anchored or moored in or near the channel or fairway of any bay, harbor, or river, and not in any port, shall sound a fog-horn, or equivalent signal, which shall make a sound equal to a steam-whistle, at intervals of not more than 2 minutes.

RULE 16. *Sailing-Vessels.* If two sail-vessels are meeting end on, or nearly end on, so as to involve risk of collision, the helms of both shall be put to port, so that each may pass on the port side of the other.

RULE 17. When two sail-vessels are crossing, so as to involve risk of collision, then, if they have the wind on different sides, the vessel with the wind on the port side shall keep out of the way of the vessel with the wind on the starboard side, except in the case in which the vessel with the wind on the port side is close-hauled, and the other vessel free, in which case the latter vessel shall keep out of the way. But if they have the wind on the same side, or if one of them has the wind aft, the vessel which is to windward shall keep out of the way of the vessel which is to leeward.

RULE 18. *Steam-Vessel Meeting.* If two vessels under steam are meeting end on, or nearly end on, so as to involve risk of collision, the helms of both shall be put to port, so that each may pass on the port side of the other.

RULE 19. If two vessels under steam are crossing, so as to involve risk of collision, the vessel which has the other on her own starboard side shall keep out of the way of the other.

RULE 20. *Sail and Steam-Vessels Meeting.* If two vessels, one of which is a sail-vessel and the other a steam-vessel, are proceeding in such directions as to involve risk of collision, the steam-vessel shall keep out of the way of the sail-vessel.

RULE 21. *Steam-Vessel approaching another Vessel, or in a Fog.* Every steam-vessel, when approaching another vessel, so as to involve risk of collision, shall slacken her speed, or, if necessary, stop and reverse; and every steam-vessel shall, when in a fog, go at a moderate speed.

RULE 22. *Vessel overtaking another.* Every vessel overtaking another vessel shall keep out of the way of the last mentioned vessel.

RULE 23. Where, by Rules 17, 19, 20, and 22, one of two vessels shall keep out of the way, the other shall keep her course, subject to the qualifications of Rule 24.

RULE 24. *Special Instructions.* In construing and obeying these rules, due regard must be had to all dangers of navigation, and to any special circumstances which may exist in any particular case, rendering a departure from them necessary, in order to avoid immediate danger.

RULE. 25. *Sailing Vessels to be furnished with Signal-Lights, and to show Torches.* Collectors, or other chief officers of the customs, shall require all sail-vessels to be furnished with proper signal-lights; and every such vessel shall, on the approach of any steam-vessel during the night-time, show a lighted torch upon that point or quarter to which such steam vessel shall be approaching.

Conflicting Rules. Any directions heretofore given by this Department, conflicting with the above instructions, have been revoked.

Ciphers should be as simple as possible, with the object of not having a letter or end of a word appear twice by the same signal. Any cipher can be deciphered, but the time generally required to make out a cipher message often renders it useless to an enemy. The persons interested rearrange the code used by changing the signal characters, the one with another. A copy of the code thus arranged is furnished to at least one person at each signal station. The message is written out in the signal characters of the new code and signaled, character by character, or combination by combination, by a man at one station, and recorded at the other station, and then deciphered by the person knowing the code used.

Whenever the General Service Code is used, the signal for "*cipher follows*" must *always precede* a cipher message. To make the signal "cipher follows," drop the flag in a vertical plane to the front 120°, make three complete circles to the right, keeping the staff in the same inclined plane, then up to position flags. When the cipher part of the message is completed, make the signal "cipher ended" by a reverse movement.

There are a great many methods used in cipher signaling. Examples of a few methods will be given. A *signal disk* consists of two circular plates of cardboard or other material, fastened concentrically together, so that one may revolve on the other, or be clamped together in any position; the top plate is a little smaller than the other. Both plates are ruled from the center, and have thirty sub-divisions; in each of these spaces on the small disk is written, in a prearranged order, a "*letter of the alphabet*," "*end of word*," "*ing*," "*tion*," and "*and*," and in each space of the other disk is written, in a prearranged order, "*one combination*." The disks may be clamped in thirty different positions, thereby giving thirty codes of signals.

A *signal disk*, furnished by the Chief Signal Officer of the Army to commissioned officers under his instruction, may be used for transmitting messages with flags and torches in the General Service Code, by the following rules, to wit: Three front motions stand for end of message, while pause signals from the disk are used for end of word or sentence.

1st Case. Known: Adjustment letter and key number. Adjust the letter to the key number.

2nd Case. Known: Adjustment letter (when not preconcerted, R generally). Not known: Key number. Then place adjustment letter to coincide with any selected number for the key number, send number selected from the disk, followed by a pause signal from the disk (not the front motion), and go on with message.

3d Case. Not known: Adjustment letter and key number. Then send adjustment letter by code signals (as 2112 for B), followed by a front motion. Adjust the letter (B in this case) to some combination on the disk; send this combination, followed by a pause signal from the disk (not a front motion); go on with message.

4th Case. To change adjustment letter while sending message; Make two pause signals from disk; follow with combination which coincides with new adjustment letter as disk stands, then two more pause signals from disk, then change disk so that new adjustment letter stands opposite the key number; continue the message.

If a party of signalmen desire to communicate by signals with an unknown party on a distant station, equipped with signal flags and torches, and it is ascertained that the two parties do not use the same alphabetical codes, a code may be arranged if both know the method of "sixes." For convenience the stations will be designated by A and B respectively: A takes "*position*," C does the same. A swings his flag in a vertical plane to the right, back to the left, right, left, right, left, up to "*positon*" (which, by the General Service Code, is 121212.) C does the same. Both flags are then put down. A arranges a code, as explained in the last paragraph, and takes "*position*" again. C resumes "*position*. A makes six times the signal for "one"; a pause of six seconds; six times the signal for "two"; a pause of six seconds; six times the signal for "three," and puts his flag down. This is to indicate to C that the code contains two elements and a pause signal. C makes the same signals the same way, and puts his flag down. A takes up his flag and makes, in alphabetical order, the signal numbers of his code, with a pause of six seconds after each combination. At the end of the alphabet he makes "333" of his code, and puts his flag down. C, having previously written down the letters of the alphabet, records opposite to each in their order the signal numbers received. He then takes his flag and makes "22, 22, 22, 3" of the new code, and the signal numbers in the order he has received them. At the end of the alphabet he makes "33'? of the new code, and puts his flag down. If correct, A makes "22, 22, 22, 3" of the new code. If, in exchanging the alphabets, either A or C fails to make out one of the signals made by the other, the receiver at once makes a "stop" signal by waving his flag from side to side. The sender stops immediately, and makes "22, 22, 22, 3" of the new code, and the signal *preceding* that one questioned, and then continues. In like manner alphabets of any number of elements may be made and communication established. Communication may be established in a similar manner by parties using heliograph or telegraph instruments.

CIPHER SIGNALING BY TRANSPOSITION.

Take the message:

"We can hold out two days,"

and before signaling write it thus:

"days two out hold can we:"

or by another transposition, thus:

"ew nac dloh tuo owt syad,"

or by any other transposition agreed upon.

CIPHER SIGNALING BY ROUTE.

Take the sentence:

"We have driven all the Indians of this vicinity into their agencies."

Make three, four or more columns, thus:

	1	2	3	4
1	we	in	this	Friday
2	have	Indians	vicinity	came
3	driven	the	into	Jackson
4	all	of	their	agencies.

and write the message in regular order in these columns, one word under another in some columns, and one above another in the other columns, placing the corresponding words on the same horizontal lines; and if there are any places left in the last column, add unimportant words.

The message is signaled as it appears in the horizontal lines, thus:

"We in this Friday have Indians vicinity came driven the into Jackson all of their agencies."

Before the message is written in columns a *blind* (either the same or different word each time) may be written after the *fifth*, *tenth*, *fifteenth*, etc., words of the message, thus:

"We have driven all *wheat* of the Indians in *corn* this vicinity into their *have* agencies;" and now one more column or one more lines will be required, thus:

1	2	3	4
We	corn	this	up.
have	in	vicinity	going
driven	Indians	into	is
all	the	their	grain
wheat	of	have	agencies.

and the message to be signaled is:

"We corn this up have in vicinity going driven Indians into is all the their grain wheat of have agencies."

The number of columns and the order of using them, and where the blind words are to be placed, must be prearranged.

CIPHER SIGNALING BY SCALES.

Instead of using the disk as described in another place, the letters and numbers that are on the disk are written in two separate columns in the same order of succession as on the disk and by comparing the letters in the left hand column of the scale with the letters of the disk, it will be seen that they are the same and that the numbers opposite are the same also. The *letters* are written *once* and the *numbers twice*, one set immediately under another, so that by writing the letters on a slip of paper placed over the letters on the scale, this strip may be moved so that each and every number will come opposite to each and every letter, thereby having the same changes made with the disk. Hence it is immaterial which a person uses, a disk or a scale. A new scale is easier made than a disk.

......111	H......111
......112	A......112
......122	S......122
......121	Q......121
......1111	G......1111
......1112	D......1112
......1121	V......1121
......1122	M......1122
......1211	&......1211
......1212	E...... 1212
......1221	C...... 1221
......1222	X......1222
......2111	tion... 2111
......2112	ing....2112
......2121	end(3)2121
R 2122	2122
K 2211	2211
Z 2212	2212
U 2221	2221
Y......2222	2222
F......212	212
T......211	211
P......221	221
N 222	222
J 21	21
B 22	22
L 2	2
W......1	1
I 11	11
O......12	12

Select any letter on the scale for an *adjustment letter*, and any number on the scale for a *key number;* then, to use the scale, move the strip containing the letters up or down till the adjustment letter comes opposite to the key number selected, and a message may be sent on this key. When no adjustment letter is given "R" is understood. Example: Take the letter "R" as the adjustment letter, and "1212" as the key number, move the slip so that "R" is opposite to "1212."

To signal the adjustment letter and key number (sent after the signal for "cipher follow") make the General Service signal for the adjustment letter—then 3, by General Service Code—then a number from the *scale*—then 333, General Service Code, thus: Signal "1121, 3, 1122, 333," which means that the adjustment letter is "W" and the key number "1122." Move the strip to place "W" opposite "1122," and the key is set.

To signal a cipher message, with "R" to be the adjustment letter, station A calls C, C acknowledges by "22, 22, 22, 3." A signals the key number (any one he wishes to use) "2122," C makes "22, 22, 22, 3,—2122—333," A and C adjust their scales (or disks) by making the letter "R" coincide with "2122," and messages may now be exchanged. Example: To signal "Black Hills," A signals "22, 2, 112, 1221, 2211, 2121, 111, 11, 2, 2, 122, 2121."

To change the key *number* while sending a message, at the end of a sentence make "33, 111, 33," which shows that each adjustment letter is to be placed opposite to "111," the new key number. The receiving station will make "22, 22, 22, 3—111—333," and thus the key number may be changed often.

There should be preconcerted plans for changing both the adjustment letter and key number, given to the persons required to use them. These instructions should be committed to memory, then destroyed.

CIPHER SIGNALING BY SUBSTITUTION.

Make substitutions as follows;

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	U	Y
1	7	8	9	2	0	.	:	3	;	,	!	?	-	4	5	6

THE CYPHER TABLE.

	r	s	t	u	v	w	x	y	z	,	—	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
h	AA	AC	AF	AJ	AO	AU	A—	BH	BQ	B,	CJ	CV	DG	DU	EH	EX	FM	GC	GV	HN	IG	J	JX	KT	LQ	MO	NN	ON
i	AB	AE	AI	AN	AT	A,	BG	BP	BZ	CI	CU	DF	DT	EG	EW	FL	GB	GU	HM	IF	I—	JW	KS	LP	MN	NM	OM	PM
j	AD	AH	AM	AS	AZ	BF	BO	BY	CH	CT	DE	DS	EF	EV	FK	GA	GT	HL	IE	I,	JV	KR	LO	MM	NL	OL	PL	QK
k	AG	AL	AR	AY	BE	BN	BX	CG	CS	DD	DR	EE	EU	FJ	F—	GS	HK	ID	IZ	JU	KQ	LN	XL	NK	OK	PK	QJ	RH
l	AK	AQ	AX	BD	BM	BW	CF	CR	DC	DQ	ED	ET	FI	F,	GR	HJ	IC	IY	JT	KP	LM	MK	NJ	OJ	PJ	QI	RG	SD
m	AP	AW	BC	BL	BV	CE	CQ	DB	DP	EC	ES	FH	FZ	GQ	HI	IB	IX	JS	KO	LL	MJ	NI	OI	PI	QH	RF	SC	S,
n	AV	BB	BK	BU	CD	CP	DA	DO	EB	ER	FG	FY	GP	HH	IA	IW	JR	KN	LK	MI	NH	OH	PH	QG	RE	SB	SZ	TU
o	BA	BJ	BT	CC	CO	C—	DN	EA	EQ	FF	FX	GO	HG	H—	IV	JQ	KM	LJ	MH	NG	OG	PG	QF	RD	SA	SY	TT	UN
p	BI	BS	CB	CN	C,	DM	D—	EP	FE	FW	GN	HF	H,	IU	JP	KL	LI	MG	NF	OF	PF	QE	RC	R—	SX	TS	UM	VF
q	BR	CA	CM	CZ	DL	D,	EO	FD	FV	GM	HE	HZ	IT	JO	KK	LH	MF	NE	OE	PE	QD	RB	R,	SW	TR	UL	VE	VY
r	B—	CL	CY	DK	DZ	EN	FC	FU	GL	HD	HY	IS	JN	KJ	LG	ME	ND	OD	PD	QC	RA	RZ	SV	TQ	UK	VD	VX	WO
s	CK	CX	DJ	DY	EM	FB	FT	GK	HC	HX	IR	JM	KI	LF	MD	NC	OC	PC	QB	Q—	RY	SU	TP	UJ	VC	VW	WN	XD
t	CW	DI	DX	EL	FA	FS	GJ	HB	HW	IQ	JL	KH	LE	MC	NB	OB	PB	QA	Q,	RX	ST	TO	UI	VB	VV	WM	XC	XT
u	DH	DW	EK	E—	FR	GI	HA	HV	IP	JK	KG	LD	MB	NA	OA	PA	P—	QZ	RW	SS	TN	UH	VA	VU	WL	XB	XS	YG
v	DV	EJ	E,	FQ	GH	G—	HU	IO	JJ	KF	LC	MA	M—	N—	O—	P,	QY	RV	SR	TM	UG	U—	VT	WK	XA	XR	YF	YU
w	EI	EZ	FP	GG	G,	HT	IN	JI	KE	LB	L—	M,	N,	O,	PZ	QX	RU	SQ	TL	UF	U,	VS	WJ	W—	XQ	YE	YT	ZF
x	EY	FO	GF	GZ	HS	IM	JH	KD	LA	L,	MZ	NZ	OZ	PV	QW	RT	SP	TK	UE	UZ	VR	WI	W,	XP	YD	YS	ZE	ZR
y	FN	GE	GY	HR	IL	JG	KC	K—	LZ	MY	NY	OY	PX	QV	RS	SO	TJ	UD	UY	VQ	WH	WZ	XO	YC	YR	ZD	ZQ	,A
z	GD	GX	HQ	IK	JF	KB	K,	LY	MX	NX	OX	PW	QU	RR	SN	TI	UC	UX	VP	WG	WY	XN	YB	YQ	ZC	ZP	Z	,K
,	GW	HP	IJ	JE	KA	KZ	LX	MW	NW	OW	PV	QT	RQ	SM	TH	UB	UW	VO	WF	WX	XM	YA	YP	ZB	ZO	Z,	,J	,T
—	HO	II	JD	J—	KY	LW	MV	NV	OV	PU	QS	RP	SL	TG	UA	UV	VN	WE	WW	XL	X—	YO	ZA	ZN	ZZ	,I	,S	,—
a	IH	JC	J,	KX	LV	MU	NU	OU	PT	QR	RO	SK	TF	T—	UU	VM	WD	WV	XK	X,	YN	Y—	ZM	ZY	,H	,R	,,	—G
b	JB	JZ	KW	LU	MT	NT	OT	PS	QQ	RN	SJ	TE	T,	UT	VL	WC	WU	XJ	XZ	YM	Y,	ZL	ZX	,G	,Q	,Z	—F	—M
c	JY	KV	LT	MS	NS	OS	PR	QP	RM	SI	TD	TZ	US	VK	WB	WT	XI	XY	YL	YZ	ZK	ZW	,F	,P	,Y	—E	—L	—R
d	KU	LS	MR	NR	OR	PQ	QO	RL	SH	TC	TY	UR	VJ	WA	WS	XH	XX	YK	YY	ZJ	ZV	,E	,O	,X	—D	—K	—Q	—V
e	LR	MQ	NQ	OQ	PP	QN	RK	SG	TB	TX	UQ	VI	V—	WR	XG	XW	YJ	YX	ZI	ZU	,D	,N	,W	—C	—J	—P	—U	—Y
f	MP	NP	OP	PO	QM	RJ	SF	TA	TW	UP	VH	V,	WQ	XF	XV	YI	YW	ZH	ZT	,C	,M	,V	—B	—I	—O	—T	—X	—,
g	NO	OO	PN	QL	RI	SE	S—	TV	UO	VG	VZ	WP	XE	XU	YH	YV	ZG	ZS	,B	,I	,U	—A	—H	—N	—S	—W	—Z	——

Use the ordinary letters where no cipher is given When punctuation points are used to punctuate, they should be enclosed in parenthesis. Example:

W:2- t:2 92v3! w1s s38,(.) T:2 92v3! 1 s13-t w45!9 76(;) 75t w:2e t:2 92v3! w1s w2!!(,) T:2 92v3! 1 s13-t w1s :2(.)

By substitution, using a dictionary of any edition agreed upon, such as Webster's "Pocket Dictionary of the English Language." To encipher a message, find the first word of it in the dictionary, and substitute for it the word on the corresponding line one or more pages forward or back. Proceed in the same manner with the remaining words till the whole message is turned into cipher. To decipher a message one must know the dictionary used, and the number of pages turned. A different number of pages must be turned for each word of the message; thus, for the first word suppose one page is turned, for the second word two pages, for the third three pages, and so on to the end of the message. Geographical proper names may be substituted for tell-tale words.

Another method:—Select for a key-word a word of 6 or 7 letters that has no letter repeated in it; draw a square, divide it into 25 smaller squares, number them as shown in the diagram, and then, beginning at the upper left hand corner, and passing from

M	2 A	3 J (I,	4 E	5 S
8 T	9 Y	10 B	11 C	6 D
7 F	12 G	H	12 K	7 L
6 N	11 O	10 P	9 Q	8 R
5 U	4 V	3 W	2 X	1 Z

left to right, in each square write one letter, first the letters of the key-word (majesty) in their order, and then those of the alphabet, omitting all letters used in the key-word.

To encipher. Find each letter of the message in the diagram, see the number of its square, and substitute for it the letter in the square having the corresponding number; the letter in the center square having no number, it has no substitute.

The cipher may be written with the letters in groups.
Example: Majesty—key-word.
Message.................... *W e a t t a c k a t n o o n .*
Message enciphered....I v x r r x o g x r d c c d .

To decipher. Reverse the process of enciphering.

Another method. Select for a key number a number of seven or more figures; write the message, and, beginning at the first letter, put under it the key number, one figure under each letter in rotation, and repeat the key number till there is a figure under each letter. *To encipher.* Substitute for each letter of the message the letter of the alphabet that is a certain number from it, this number being determined by the figure under each letter of the message; when there is not the number of letters near the end of the alphabet indicated by the figure under any letter of the message, add on as many letters as may be required from the beginning of the alphabet in regular order; letters of the alphabet having o under them, have no substitutes.

The cipher may be written with the letters in groups.
Example: 4,631,870—key number.
Message.................. *W e a t t a c k a t n o o n .*
Key number.............4 6 3 1 8 7 0 4 6 3 1 8 7 0 .
Message enciphered...a k d u b h e o g w o w v n .

To decipher. Reverse the process of enciphering.

The Cipher Table is composed of 784 squares of equal size, with a combination of two characters in each square. Beginning at the upper left hand corner, the first diagonal passes through one square, the second through two, and the third three, and so on—the number of squares increasing one at a time to the twenty-eighth, and then decreasing one at a time to the fifty-fifth diagonal, which passes through the square in the lower right hand corner. There are twenty-eight characters used, *i. e.*, the letters of the alphabet, the comma, and dash, giving 28 times 28 combinations of two characters each. In the 1st square is (AA), in the 2d (AB), 3d (AC), etc., in the 28th (A—), 29th (BA), 30th (BB), 31st (BC), etc., and so on to the 784th, which has (— —). The twenty-eight characters are next placed in two series of squares with one character in each square: one series is arranged vertically, the other horizontally, so that the former will be to the left of, and the latter above the squares of the table: the two characters opposite to (AA) make the key—the first being the one in the vertical, and the second that in the horizontal series. HR is the key of the accompanying table. When the charecters in the series are placed in their natural order the key is termed *regular*, and when the characters are not so placed the key is *irregular*. See page 112.

RULES FOR USING THE CIPHER TABLE.

To encipher a message in the General Service Code, write it in words without punctuation marks; point it off into periods of two characters each, counting every letter and space between *consecutive words* as separate characters; set the key; then, beginning with the first group of the message, find the first character of it in the vertical series on the left, the second in the horizontal series at the top of the table; the two characters in the small square of the table at the intersection of the straight lines bounding the two in the vertical and horizontal series respectively, will be the first two characters of the message in cipher. Proceed in the same manner to find the corresponding ciphers for the other groups.

MESSAGE READY TO ENCIPHER

Key: HR.

Fl	*ag*	*.S*	*ta*	*ti*	*on*	*,e*	*ls*	*re*	*n,*	*A-*	*M-*	*Po*	*st*
,A	*dj*	*-F*	*or*	*t,*	*Ap*	*ac*	*he*	*-T*	*hr*	*ce*	*f*	*re*	*ig*
ht	*.w*	*ag*	*on*	*s,*	*fr*	*om*	*.H*	*ol*	*br*	*oo*	*k,*	*ha*	*ve*
,a	*rr*	*iv*	*ed*	*-C*	*or*	*p-*	*D-*						

MESSAOE ENCIPHERED.

Key: HR.

To deciper a message in the General Service Code. Point it off into groups of two characters each, counting every letter, (,), and (—), as separate characters; set the key; then, beginning with the first group of the enciphered message, find the two characters of it in one of the small squares of the table; the character in the vertical series on the left, and that in the horizontal series at the top of the table, will be the first and second letters, respectively, of the message. Proceed in the same manner to find the corresponding letters for the other groups.

MESSAGE READY TO DECIPHER.

Key: HR.

-B	*wv*	*hp*	*kh*	*rx*	*sa*	*ub*	*hj*	*p,*	*er*	*ro*	*es*	*ts*	*dj*
qt	*zv*	*vn*	*bu*	*iq*	*,,*	*T-*	*ex*	*jd*	*aa*	*xw*	*uw*	*me*	*gu*
af	*kz*	*wv*	*sa*	*hx*	*mp*	*rd*	*wf*	*qf*	*jb*	*sy*	*dd*	*cv*	*p,*
qt	*b-*	*At*	*xg*	*tg*	*ba*	*gn*	*ty*						

MESSAGE DECIPHERED.

Key: HR.

"Flag Station, eleven A. M.
"Post Adj. Fort Apache:
"Three freight wagons from Holbrook have arrived.
"Corp D."

A double cipher, or a cipher in a cipher, is one of very difficult solution. For instance, a message enciphered by one method may be itself enciphered by another method. See *Signals.*

SIGNAL TELESCOPE.—The telescope of the Signal Corps pattern has been determined by experience as the best for general uses. These telescopes are of about thirty powers. They have a focal length of twenty six inches. The tube is cased in leather, in place of wood or metal. The draw is of four joints, bronzed black, in order that there may be neither glitter to attrack the enemy, nor glare to disturb the eye of the observer. Leather caps are fitted over both eye and object-glasses, and the whole is supported by a strong leather strap, long enough to pass over the shoulder, and connecting the caps and glass in such way that there are no loose parts. This glass is strong and portable. It has power sufficient for any ordinary use, and is of a size to be conveniently handled. It is habitually worn slung over the shoulder, by the Signal-officer, wherever he may be, in the field. At permanent stations, the largest and most powerful glasses, mounted upon stands, and with accurate machinery, compasses, scales, etc., may be used. The varieties of pocket-glasses may be used at distances of from five to ten miles. A glass known as the carbineer-glass is not larger in diameter than the finger, and may be carried in the vest pocket.

Binocular-glasses (marine-glasses) have, with a low magnifying power, an extensive field of view, and give much light. They are for use in observation of extensive movements, where large tracts of country must be taken in one field of view, to find the tents of the enemy, his wagons, etc., or other objects to be afterward more closely examined with the telescope. They are employed on ship-board, or in boats, where the rolling motion interferes with the use of the telescope. They are used for observations to be made on horseback, or in hasty examinations made on foot or in trees, and generally for all observations not critical, or those to be made under circumstances where the telescope cannot be conveniently handled. The marine-glass ought to be held by both hands when in use; and to steady it, the arms should be kept close to the body. In following a moving object, to keep it in the field of view, the head ought to be turned with the glass. For reading signals at short ranges, as, say up to five miles, these glasses are better than the telescope. Signals have been frequently read with glasses of this description at the distance of ten miles.

Telescopes ought never to be allowed to fall into the hands of the enemy. Officers, on dangerous stations, should conceal their glasses when not in use. When a glass is to be hidden for precaution, the object lens, or one joint of the telescope, should be hidden separately from the body of the telescope. A single joint or one lens is so small an object, that it can be concealed almost beyond the possibility of discovery. If an officer is in danger of capture, and there are no means of concealment, the telescope-glasses should be shattered or rendered worthless rather than surrendered. To adjust a telescope to its proper focus, view with it some object with well-defined outlines, at a distance of about half a mile, lengthening or shortening the eye-glass joint until the object is seen with the sharpest distinctness. To adjust a glass at night, fix it upon some brilliant star. Glasses which are to be used in the field, should have plainly marked on one of the eye-glass slides a focus-mark, so that they may be adjusted at any time without an especial adjustment in every case. Telescopes, the object-glasses being equal in size, diminish light, as a general rule, in proportion as their magnifying power is great. The most powerful glasses are, therefore, to be used for minute observations on the clearest days, or when there is a strong light on the observed object. When the light is fading, or there is little light upon the observed object, the clearer view will be had with glasses of large field and low magnifying power. When telescopes are fitted with a double adjusting focus, the short focus is to be used when the light is dim, the long focus when strong.

The following is a simple method by which to estimate approximately the power of a telescope: When the object-glass of a horizontally placed telescope is turned toward the light, a luminous point or spot appears on the eye-glass. The diameter of this spot must be carefully measured. Measure then the diameter of the object-glass. The power of the glass is that number given as quotient when the diameter of the object-glass is divided by the diameter of the luminous spot. Thus if x = diameter of object-glass, and y = diameter of luminous spot, the Power $= \frac{x}{y}$. See *Telescope*.

SIGN LANGUAGE.—A pantomimic system of communicating ideas, extensively used by North American Indians. The range of its use is not exactly known, but it is common among all the tribes of the Plains and many of those beyond the Rocky Mountains. It is in one sense the Court language of the Indians, being the only means of communication between tribes not speaking a common dialect. The following signals will serve to show the nature of the method of communication: "*Who are you?*" is signaled by waving the right hand to the right and left several times in quick succession; "*We are friends*," by raising both hands and grasping the left with the right, as in shaking hands; "*We are enemies*," by closing the right hand and placing it against the forehead, or by waving a blanket (usually red) in the air. To say by signs "*that after a certain journey a good camp will be found, and that game may be found along the road*," first indicate the course of the sun, from its rising to the point at which it will appear on reaching the camp; then straddle one finger of the left hand with two fingers of the right, trotting them in imitation of the motions of pony and rider; then act as though halting, dismounting and tiring; then remount and proceed on the way; finally stop, bow the head, rest it on the hand and close the eyes in imitation of sleep. To intimate that "*such a one is dead*," place one hand over the other and then quickly slip it beneath (gone under); that "*such ones are husband and wife*," point to each and place the forefingers in contact throughout (meaning one); that "*such ones are brothers and sisters*," point to each and place two fingers in the mouth (meaning nourished at the same breast); that "*such ones are good friends*," point them out and fold the arms over the breast, etc. The various tribes are indicated by making the representation of some totem peculiar to each. The Comanches, or "Snakes," by a gliding motion, like a crawling snake. The Crows, by imitating the flapping of wings. The Sioux, or "Cut-throats," by drawing the hand across the throat. The Kiowas, or the "Prairie Men," by imitating the drinking of water. The Pawnees, or "Wolves," by placing the hands at the sides of the head, like the ears of a wolf. The Arapahoes, or "Smellers," by laying hold of the nose. The Utes, or "Dwellers among the Mountain Tops," by pointing upward. The Cheyennes or "Cut-arms," by drawing the hand across the arm, etc.

The Indians have a system of signaling by means of smokes during the day, and fires at night. The color (light or heavy), the volume (thin or dense), and the varying brilliancy of flame, are all significant signals. Every tribe jealously guards the secrets of its code of signals. Smokes may be raised several hundred feet in a vertical column by making a fire without very much blaze and piling on green boughs, grass, and weeds. By confining the smoke and permitting it to escape at intervals, puffs may be sent up at will. Owing to the very clear mountain air, the elevated "buttes" and mountain ridges may be seen at a great distance, and may serve the purpose of signal-stations. The Indian alphabet is very similar to ours, being made up of long and short lines. By spreading a blanket over the column of smoke and quickly displacing it, the length or shortness of the columns, as well as their frequency, may be regulated. See *Trail*.

SIGN-MANUAL.—The subscription of the Sovereign, which must be adhibited to all writs which have to pass the Privy Seal or Great Seal. When attached to a grant or warrant, it must be countersigned by one of the principal Secretaries of State, or by the Lords of the Treasury. The sign-manual, in practice, consists but of the initial of the Sovereign's name, with the letter R added, for *Rex* or *Regina*.

SILENCE.—To cause to cease firing by a vigorous cannonade. In an action, "To silence the fire" of the enemy's guns is to disable his artillery in such a way that he is unable to reply.

SILICON.—Next to carbon, silicon, or *silicum*, is the commonest and most abundant constituent of all cast-iron. Its effect is very similar to that of carbon and its tendency is to reduce the percentage of carbon. It is an element that is always present in every form of iron, although at times its quantity is very minute; the proportion of silicon being higher in the gray than in the white variety, and the greater the quantity of graphite in the crude iron, the larger the amount of silicon. The best common iron contains from one to one and one-fourth per cent. of silicon. Such iron has a smoother face than inferior pig, and when struck with a hammer rings: it is brittle and crystalline; whereas inferior pig contains only ½ or ⅜ of silicon, is rough on the face, breaks with less ease than the crystalline pig, and when struck sounds dead like lead, without ringing at all. Silicon exists in cast-iron sometimes combined and sometimes separate, and is derived from silica in the ore or in the fuel. Silica is a combination of silicon with oxygen; and when the latter is abstracted by the carbon at the high temperature of the blast-furnace, the silicon enters into combination with the iron. The presence of a large proportion of silicon in cast-iron is generally considered injurious to its quality. In refining iron the silicon is oxydized before the carbon, and in some cases the silicon is separated completely from the metal, existing only as traces. The time required to refine iron seems to depend upon the amount of silicon present in the pig: thus, gray iron requires much longer time than white, and when very silicious white iron or glazed gray-pig is used, it is almost impossible to refine it. See *Cast-iron*.

SILL.—In fortification, the inner end of an embrasure.

SILLADAR HORSE.—Indian irregular cavalry, raised and maintained on the principle of every man furnishing and maintaining his own horse, arms, equipments, etc., in return for his pay.

SILLON.—In fortification, a work raised in the middle of a ditch, to defend it when it is too wide. It has no particular form and is sometimes made with little bastions, half-moons, and redans, which are lower than the works of the place, but higher than the covered-way. It is frequently called an *envelope*.

SILURES.—A powerful people in Britain, inhabiting South Wales, who long offered a formidable resistance to the Romans, and were the only people in the Island who at a later time maintained their independence against the Saxons.

SILVER-RAIN.—The small cubes of a composition which emits a white light in burning; used as decorations for the pots of rockets, etc.

SILVER STICK.—The title given to a Field Officer of the Life Guards, when on duty at the Palace. The *Silver Stick* is in waiting for a week, during which period all reports are made through him to the *Gold Stick*, and orders from the *Gold Stick* pass through to the Brigade. In the absence of the *Gold Stick*, on levees and drawing-room days, he goes to the Royal Closet for the parole. See *Gold Stick*.

SIMULATION.—The vice of counterfeiting illness or defect, for the purpose of being invalided.

SINCH.—A strap whereby the loop on the end of the girth of a Spanish saddle is laced to the loop on the saddle. The Spaniards and Mexicans do not use a buckle, but pass a strap, rope, or raw-hide over and over around the loops and tuck the end in.

SINE DIE.—A term signifying "Without Day." When a Court or other body rise at the end of a session or term, they adjourn *Sine Die*. In law this does not preclude further proceedings by the same Court.

SINGLE COMBAT.—The "Holm-gang," or island duel of the old Norsemen. A great many quarrels were settled by single combat, when to guard against interference, the principals went alone to some small island (or holm), and there settled their quarrel by strength and skill. The idea is as old as war. In the Bible we read of Goliah challenging any Israelite to single strife. In the Iliad, Ajax challenges any opponent, and furthermore defies heaven. It was not uncommon in England, and was particularly invoked in charges of treason. The idea finds its modern and despicable expression in dueling.

SINGLE-STICK.—A cudgel used in fencing or fighting. Also, a game at cudgels, in which he who first brings blood from his adversary's head is pronounced victor.

SINISTER.—In Heraldry, the left-hand side of a shield. As shields are supposed to be carried in front of the person, the sinister side is that which covers the bearer's left side, and therefore lies to the spectator's right.

SINOPLE.—In Heraldry, a term meaning the same as *vert*. See *Vert*.

SIOBOOKATANA.—A Japanese saber having a long straight handle, but without any guard, quillons, or counterguard.

SIR.—A term originally corresponding to *Dominus* in Latin, and which has come, when appended to the Christian name and surname, to be the distinctive mark of knighthood. It was at one time the practice to use the same title in addressing the Clergy, a familiar instance being Sir Hugh Evans in the *Merry Wives of Windsor*. To so great an extent did this usage obtain, that a "Sir John" came to be a common sobriquet for a Priest. "Sir" was here a translation of *Dominus*, the term used for a Bachelor of Arts, originally in contradistinction from the *Magister*, or Master of Arts, but eventually extended to the Clergy without distinction. Used along with the Christian name and surname, "Sir" is now applied exclusively to Knights and Baronets. When standing alone, it is a common complimentary mode of address used without much consideration of rank or social status. "Sire" is another form of the same monosyllable, which has been adopted from France as a mode of addressing Royalty.

SITE.—The ground occupied by a work is denominated the *site*, or *plane of site*. The *command* is the height of the interior crest above the site; and the *relief* is the height of the same line above the bottom of the ditch. See *Field-fortification*.

SIXAIN.—In the Middle Ages, an order of battle, wherein six battalions being ranged in one line, the second and fifth were made to advance, to form the van-guard; the first and sixth to retire, to form the rear-guard; the third and fourth remaining on the spot, to form the corps or body of the battle.

SIX-SHOOTER.—A pistol with six barrels, or capable of firing six shots in quick succession; especially a six-barreled or six-chambered revolver.

SIZE.—In a military sense, to take the height of men for the purpose of placing them in military array, and of rendering their relative statures more effective.

SIZE ROLL.—In the British Service, a list containing the names of all the men belonging to a troop or company, with the height or stature of each specifically marked.

SKAIN—SKEAN.—A Celtic word which signifies a knife. It was a weapon in the shape of a small sword or knife, and was worn by the Irish in early times. Also written *Skeen*, and *Skeine*.

SKELETON.—A term applied to the diminished state of a regiment from casualties in the field or as the result of sickness.

The term is also applied, in conjunction with the word drill, to *skeleton-drill*, which is a method of instructing Officers and Non-commissioned Officers in drill, when a sufficient number of men cannot be collected to form a battalion in single rank. A skeleton battalion is formed of companies composed of two, four, or eight men each, representing, if there are two, the flanks of the company; if there are four, the flanks of half-companies; if there are eight, the flanks of sections. The intervals between the flanks are preserved by means of a piece of rope held at the ends to its full extent. By this means any set or number of maneuvers may be performed.

SKELP.—The rolled metal or welding of wrought-iron, from which certain gun-barrels are made. The skelp is passed between rollers, which first bend the plate longitudinally, and afterwards convert it into a tube. The tube is then heated to a welding heat, a mandrel is pushed into it, and it is passed through the welding rolls, which weed the edges and at the same time taper and lengthen the tube. The boring and turning are afterwards done in lathes. See *Gun-barrel*.

SKEW-BRIDGE.—A bridge placed obliquely so as to cross a road or river at an angle not a right angle. Such bridges, built of stone, are not easy of constuction, owing to the peculiar twisted forms which the voussoirs assume, and were scarcely ever used till the necessities of railway curves compelled their introduction. They are evidently a great improvement on the old-fashioned mode of twisting a road, first to the right and then to the left, in order to get the bridge at right angles to the place to be crossed. Since the introduction of iron girders as the support of bridges, skew-bridges have become easy of construction, and are now quite generally used.

SKID.—A rectangular beam of wood used extensively in all operations connected with the movements of heavy artillery. All blocks and skids should be sound, free from knots, and perfectly true in dimensions. When the edges become splintered and rounded by wear, they should be discarded, as with such it is impossible to erect safe and stable scaffolding and supports. They should not be painted; the thickness of each should be marked on both ends. In erecting a scaffold or other support, a level foundation is of the first consideration; the blocks should then be laid crossing each other in alternate tiers, and the weight supported should be made to bear equally upon all sides of the base.

The term skid is frequently employed to denote any timber which is used as a base to keep one object from resting on another. Thus, a row of cannon in store will be kept from the ground by skids.

The term is also applied to the drag which is put on the wheels of carriages in going up hills, to prevent rolling backward.

SKIDDING OF ORDNANCE.—All cannon should be placed, according to kinds and calibers, on skids of stone, iron, and wood. Permanent skids, made by building small square pillars of brick, about 18 inches high, with old railroad rails laid on the top of them, end to end, are best and cheapest. The ground selected should be hard, well-rammed, and covered with a layer of cinders or other suitable material to prevent any vegetation. *Guns and long howitzers* should rest on the skids in front of the base-ring and in rear of the muzzle; the axis is inclined at an angle of 4 or 5 degrees with the horizon, the muzzle lowest; the trunnions touching each other; or, if space be wanting for that arrangement, the trunnion of one piece may rest on the adjoining piece so that the axis of the trunnions is inclined about 45° with a horizontal line, the muzzle closed with a tompion or a plug of dry wood saturated with oil or grease; the vent down, stopped with a greased wooden plug or with putty or tallow. If circumstances require it, the pieces may be piled in two tiers, with skidding placed between them, exactly over those which rest on the ground, the muzzles of both tiers in the same direction and their axes preserving the same inclination. *Short howitzers and mortars* should rest upon thick planks or on good flagging, standing on their muzzles; the trunnions touching; the vents stopped. *Iron ordnance* should be covered on the exterior with a lacquer impervious to water; both the bore and the vent should be greased with a mixture of *oil* and *tallow* or of *tallow* and *beeswax* well melted together and boiled to expel the water. The lacquer should be renewed as often as required, and the grease at least once every year. The lacquer and grease should be applied in hot weather. The cannon should be frequently inspected, to see that moisture does not collect in the bore.

SKINNERS.—A name assumed by a predatory band in the Revolutionary War, who, professing allegiance to the American cause, but influenced by a desire to plunder, roamed over the "neutral ground" lying between the hostile armies, robbing those who refused to take the oath of fidelity.

SKIRMISH.—A slight fight in war; a light combat between detachments from armies which are yet at a considerable distance from each other, or between detached and small parties.

SKIRMISHERS.—Soldiers operating in loose array, two together—*i. e.*, front and rear, having a lateral distance of about six paces between the files. When the army advances, the ground in front, and for some distance on each flank, is usually covered by skirmishers, to prevent surprise. If cavalry come suddenly on them, they rush together, and form small squares, called rallying squares. Skirmishers fire independently at their own discretion; but the rule is, that one of the two men composing a file should always have his rifle loaded. Orders are communicated by the sound of bugle. The employment of skirmishers dates from the wars of the French Revolution, when France, assailed on all sides, supplied great numbers of conscripts, who, from the want of instruction and practice in discipline, were thrown out to fight in a loose order, where coherence and precision were not so much wanted as intelligence and courage. Skirmishers, to perform their work satisfactorily, must act together and with vigor, either to break the enemy's lines or to repulse, according to circumstances, the counter-attacks of the enemy: they must be maintained in a regular order, "order in disorder," as a foreign writer expresses it, and be regularly reinforced by the supports, which, being placed at a certain distance in rear, are always ready to advance and feed the first line when the time comes. To prepare for the final charge, by crushing the enemy with their fire, is the first aim of skirmishers; to support them when weakened, to push their line by successive bounds till they reach the enemy's positions, is the duty of supports. The reserve follows in rear, becoming in its turn supports, according to circumstances, ultimately joining the skirmishers in the last attack, assisting in penetrating the enemy's position, striking the final blow, and in pursuing the enemy with its fire.

SKIVER.—An old form of dirk used for stabbing purposes.

SKOTTEFER.—A name formerly applied to an archer.

SKULL CAP.—The small German bassinet, of the thirteenth century. It was worn over the *camail* and under the *heaume*.

SKY-ROCKET.—A species of fire-work composed of a mixture of niter, sulphur, and charcoal, tightly rammed in a stout paper case—which is caused to ascend when the compound is ignited at the lower end. It is provided with a stick which is attached to the case at one side. See *Rockets*.

SLAGS.—Fused compounds of silica in combination with lime, alumina, or other bases which result as secondary products from the reduction of metallic ores. More or less of the metal always remains in a slag; in the early days of iron-smelting the proportion of metal thus wasted was so great that some old slags have been profitably smelted in recent times.

Slags being silicates, are of the nature of glass, and externally have a glassy, crystallized, or stone-like character. Beautifully crystallized specimens are occasionally to be met with at smelting-works. They vary very much in color, and are sometimes so prettily veined and marbled, that attempts have been made to apply them to ornamental purposes. Millions of tons of slag are annually produced at the iron smelting-works of Great Britain, but almost the only use to which it has yet been successfully applied is in the making of square blocks or bricks for building purposes. The slag is run into molds, either as it issues from the blast-furnace, or after being re-melted; and it is found to be a very durable material. Broken slag is also used as a covering for roads, but its brittleness and sharpness are objectionable qualities for this purpose Several patents, beginning so far back as 1728, have been taken out for casting slag into articles of a more ornamental nature, but hitherto they have not been commercially successful.

In an archæological point of view, slags are interesting as pointing out the sites of ancient smelting-works, and as affording a clue to the primitive methods of obtaining the metals from their ores.

SLANT-FIRE.—A name applied to the fire when the shot strikes the interior slope of a parapet, *forming* with it a horizontal angle, not greater than 30°.

SLASH.—1. A term formerly employed to express the pieces of tape or worsted lace which were placed upon the arms of Non-commissioned Officers, in order to distinguish them from privates. 2. To strike violently and at random with an edged instrument; to lay about one indiscriminately with blows. 3. To cut in stripes or lines. Hence, the *slashed* sleeves and pockets, which are peculiar to the British Cavalry, when the officers or men wear long coats.

SLASHING.—In compliance with the principle that all houses, trees, brush-wood, etc., within range of the work, which could be used as a shelter and a place of concealment by the enemy's sharp-shooters should be removed, it is essential that the trees within six hundred yards of the work be cut down. As it is not practicable to remove immediately the trees from the spot, it is the custom to cut them down so that they shall form, while lying on the ground, an obstacle which may be used in the defence of the work. Trees cut down so as to fall in all directions, form what is known as a slashing. It is better, where the trees are intended to be used as an obstacle, that they be cut so as to fall towards the enemy; and, in the case of the smaller trees, which might be moved by several men, the trunks should not be cut entirely through, but only enough to allow the trees to fall. A thick and well arranged slashing forms an excellent obstruction to an enemy's free movements. It has the serious defect of being easily burned when dry. See *Abatis*.

SLAT-BAR.—The bar of a seige-howitzer limber between the splinter-bar and bolster, and connecting the futchels.

SLEEPER-RIFLE.—A breech-loading small-arm having a fixed chamber and a peculiar breech-mechanism. It is opened by pressing an eccentric lever on the right side of the butt-stock, and thus throwing out the spring-butt-plate, so as to release the rear end of the chamber-lever, and to allow it to be then thrown down by the spring included between it and the stock. By closing the chamber-lever until its rearmost end engages with the butt-plate, the forward end catches the cartridge, as would be done by a pair of tongs.

SLEEPERS.—Small joists of timber, which form a foundation for the platform of a battery, and upon which the boards for the flooring are laid. Also, the undermost timbers of a gun or mortar. Sleepers must pe well embedded in cuts or trenches, and firmly fixed or pinned into the earth, and then covered with blanks, and finally completed with ribands and rack-ashings on each side.

SLEETS. The parts of a mortar extending from the chamber to the trunnions, to strengthen that part.

SLEEVES.—Sleeves of flannel or serge, drawn over the coat-sleeves of the gunners and other cannoneers to prevent them from being soiled while loading the mortars.

SLEIGH.—A particular pattern of carriage used for the transport ot artillery in countries where much snow falls, such as in Canada. The carriages of the country are termed "sleds," and when artillery was sent to Canada in 1862, the sleds were found very useful and better adapted than the sleighs. The term *sleigh* is also given to the carriage on which heavy guns are moved when in store. The mode of moving this nature of carriage is by means of rollers being placed underneath the sleigh and worked by hand-spikes.

SLEWING.—To slew a gun or mortar, when, strictly speaking, is to turn it on its axis without moving it from the spot on which it rests. If the piece to be slewed rests on skids, a handspike is placed close to it on each skid, bevel up, and on that side of it towards which it is to be turned. This is then called "scotching" or "chocking."

SLIDE-REST.—An appendage to the turning-lathe, so contrived as to hold a tool firmly to the work, and while cutting a shaving from the bar in the lathe, the tool is slid gently along and the bar is turned quite true. There are two slides to the rest, by the separate or combined motions of which the tool can be made to act along or across the work with great accuracy; the attendance of a workman may even be dispensed with, by attaching a *star* to the wheel, and an iron *finger* to the end of the work in the lathe; as the work revolves, the finger will bear down one of the points of the star, the effect of which is the same as turning the screw-handle, by which the tool is so moved along the surface of the work.

SLIDING-CALIPERS.—An instrument used for measuring the specimens of metal to be tested. Its sliding-scale is divided into twentieths of an inch. A vernier is attached containing fifty divisions, which cover forty-nine divisions on the sliding-scale, and it reads to thousandths of an inch. It will measure space not exceeding two and a half inches, giving the result to the nearest one thousandths of an inch. The accuracy of its adjustment may be readily verified by pressing the points together gently, and noting whether the zero points coincide. If from the wearing of the steel points, or from other cause, the adjustment should become incorrect, it may be re-adjusted by turning the screw which forms one of the points.

When the instrument is designed for both outside and inside diameters, the vernier is then on the slide, which is moved along the scale. An attachment for communicating slow motion to the slide is also added. The scale is divided into fortieths of an inch. The vernier contains twenty-five divisions, which cover twenty-four divisions on the scale, and reads to thousandths of an inch. The extent of the scale which can be used by the vernier, when including the clamp, is 6 inches. In measuring an inside diameter it is necessary to add 0 2 inch to the reading of the instrument for the thickness of the measuring points. See *Calipers* and *Microscopic Gauge*.

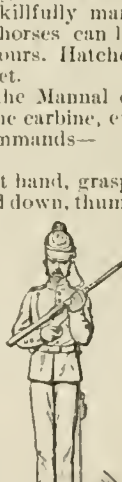
SLIDING-CARRIAGE.—The carriage mounted on a traversing platform and much used in coast batteries where rapidity of traversing is required, the objects fired at from such batteries being seldom stationary.

SLING.—1. A leather strap attached to a musket serving to support it across the soldier's back, as occasion may require. 2. A weapon much in use before the introduction of fire-arms, formed of a piece of leather, with a round hole in the middle, and two cords of about a yard in length. A round pebble being hung in the leather by the cords, the latter were held firmly in the right hand, and swung rapidly around. When the stone had attained great speed, one string was disengaged, on which the stone flew off at a tangent, its initial velocity being the same as it had at the last moment of revolution. This velocity gives far greater range and force than could be imparted in mere throwing. 3. A construction employed to hoist horses on board the ship. It is made of stout web, or double No. 1 canvas. It is 5 feet long and 2 feet wide, secured at each end by a stick of strong wood 2 inches in diameter. The sides are bound with strips of canvas doubled, thus making the edges four thicknesses. Loops of 4-inch rope are attached to each stick. The loop attached to one stick is 9 inches long; that attached to the other is 2 feet 11 inches, and has an iron eye—3 inches, inside measurement—fixed in the end. Breast and breech ropes (2-inch) 9 feet long are fixed to each side, and are tied together when the sling has been put under the horse. The slings should be tested by an excess of weight. A donkey-engine is used for hoisting. Five men are required to sling a horse quickly and well. One man holds the head guy, which is attached to a neck-collar; two men, one on each side of the horse, pass the sling under his belly; both then hold up the ends over his back, passing the long loop through the shorter one and hooking on the eye of the former to the lifting tackle, continuing to hold up the sling until the horse's legs leave the ground; another man stands at the breast and fastens the breast-rope, while the fifth stands at his rump and fastens the breech-rope. The officer superintending commands: HOIST AWAY. The first man slacks away at the guy-rope, holding it just sufficiently taut to keep the horse's head steady. When hoisting, no delay should be permitted; it should be done in the shortest time compatible with safety. At the commencement, after a certainty that all is right, it should be done rapidly to raise the horse off his feet and free him from surrounding objects before he has time to do any injury by kicking. After attaining the necessary height, he is carefully and steadily lowered to the deck. Care should be taken to have two or three careful and active men stationed to seize the horse and prevent his plunging until the slings are removed. While one holds him by the head stall, another rapidly unhooks the tackle purchase, and two others let loose the breech and breast-bands, or ropes. When the horses are to be lowered through a hatch to a deck below, the combings of the hatch, as well as stanchions about it, should be well padded. As an additional precaution, a head-collar should be provided, with a large pad on top to prevent injury should the horse strike his head against the deck beams when lighting on his feet. Everything being in readiness and skillfully managed, an average lot of one hundred horses can be hoisted on board in from two to three hours. Hatches for horses must be at least 10 by 10 feet.

SLING CARBINE.—A command in the Manual of Arms, when troops are armed with the carbine, executed as follows: The Instructor commands—

1. *Sling*, 2. CARBINE.

Throw the piece briskly into the left hand, grasping it at the rear-sight, back of the hand down, thumb along the groove, elbow close to the body, barrel to the rear, the muzzle pointing to the left and front, left hand as high as and opposite the shoulder; slip the swivel to the front with the right hand, and bear on the springs to open it; engage it in the ring and grasp the small of the stock with the right hand. (Two.) Let go with the left hand, dropping it by the side; lower the muzzle, passing the carbine behind the right hip, push the butt to the rear, and drop the right hand by the side. See *Manual of Arms* and *Unsling Carbine*.



SLING CART.—The contrivance used for moving pieces of heavy artillery, or other objects short distances. They are of two kinds: one, the garrison sling-cart for heaviest weights, is attached by its pole to a siege or a field-limber, and may be drawn by horses; the other, the hand sling-cart, is designed for moving lighter weights and siege-pieces to the trenches by hand. The siege-limber may also, in case of necessity, be used as a sling-cart. With the hand sling-cart, the weight is raised by first attaching to it a sling, and then applying to the sling the hook upon the rear of the axle, by raising the pole of the cart. The pole is used as a lever, the axle and wheels being the fulcrum. It may be used for any weights not exceeding 6,000 pounds. With the garrison sling-cart, the weight is raised by first attaching to it a sling, and then applying to the sling the hooks forming the lower part of a powerful screw passing up through the axle of the cart. Above the axle is the nut of the screw, provided with long handles. Power is applied to these handles and the screw is run up, thus raising the weight. This sling-cart is capable of carrying 20,000 pounds; but with such heavy weights the handles of the screw are difficult to turn. To overcome this difficulty, a modification has been made in the cart by substituting for the screw a hydraulic-jack.

Through the axle-body two vertical mortises are now cut each at a distance of twenty inches from the middle of the axle-body. Through these mortises slide two stout bars of iron, with hooks below for the sling-chain, and holes above for pins to support them as they are raised; the pins pass through the bars above the axle-body. A strong cross-bar connects the upper bars near their tops; under this the head of the jack is applied, the jack resting on the axle-body.

The efficiency of the wooden sling-cart has lately been much increased by the introduction of a new *hoisting apparatus*. This modification consists in the use: 1st, of a *hoisting bar*, composed of two parallel bars that pass through mortises in the axle and terminate in hooks—a cross-bar as a brace is welded immediately above the hooks; 2d, of a *hydraulic jack*; that stands on the axle over the mortise, for the old hoisting-screw; 3d, of an iron *cross-head* that slips over the hoisting-bar and rests on the head of the jack. The branches of the hoisting-bar are pierced with holes for movable pins. In using this apparatus the rings or chains by which the weight is slung are hooked to the lower ends of the hoisting-bar; pins are passed through those holes on each branch which appear immediately above the cross-head; the jack is worked and the weight is raised to the required height; a pin is placed in the lowest available hole of each branch, and the jack let down till the weight is born by the pins resting on the axle. If one lift of the jack be not sufficient, the operation is repeated as often as necessary.

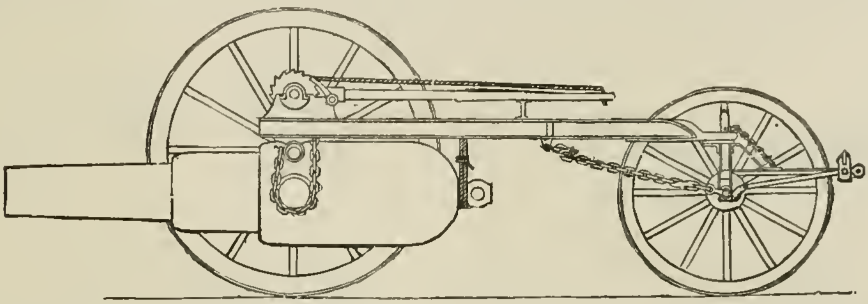
The English iron sling-cart is composed of a perch, two sides and two cross-pieces, two cheeks, an axle, and axle-body. The perch and sides are of girder-iron, and are connected by a cross-piece, also of girder-iron, riveted to them in front, and by the axle which is riveted to them in rear; also, by a stay of round-iron from the perch to each side.

The axle is arched, to give greater room under it, and has in the middle two lugs which receive the perch and rivets to secure it, also, a projecting piece at the shoulder for riveting it to the side. The cheeks are of T-iron, and are riveted to the sides; they support the windlass directly over the shoulders of the axle. The perch has a lunette by which the rear wheels are connected with the limber. A windlass of elm, cylindrical except at the ends, where it is octagonal, is provided with both ratchets and handspike sockets. It has a hook at its middle, to take an eye in the middle of the sling. Two similar hooks are on each end of the axle-bed, to take the ends of the sling. The handspikes are 80 inches long; two of them have 15 feet of a 2-inch rope made fast to the small end. The windlass is worked, in raising the load, from the rear of the wagon.

The limber is wholly of iron. The axle-body is built up by riveting two plates on the sides of the axle, with the pintle between them, and covered with a top-piece. The three futchells of T-iron are riveted to the axle-body, and bolted to the splinter-bar; this is made of plates, trough-shaped, and strengthened by a stay of round-iron at each end, connecting it to the axle-body. The wheels are wooden, with bronze nave-boxes and wrought-iron flanges. The principal weights and dimensions are as follows:—

Weight of sling-wagon..............	4,760 pounds.
Weight of sling-wagon wheel.....	777 pounds.
Diameter of sling-wagon wheel...	7 feet.
Diameter of limber-wheel..........	5 feet
Width of tire of wagon-wheel.....	6 inches.
Width of track.........................	71 inches.

See *Garrison Sling-cart*, *Hand Sling-cart*, and *Mechanical Maneuvers.*

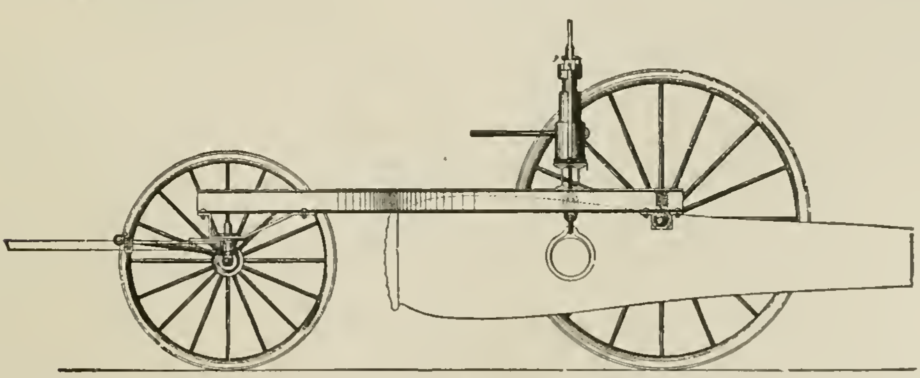


SLING-CHAIN.—A chain used in mechanical maneuvers, and for various purposes. It is composed of 69 *links*, 1 *ring* at one end, and 1 *hook* at the other. The links are made of .75-inch round-iron, and are 5 inches long. The ring is of 1-inch iron, and 6 inches diameter (exterior). Whole length of chain, 256.25 inches. The sling-chain is carried wound around the stock. It may be used for a lock-chain, the one provided with a shoe being dispensed with.

SLINGERS.—The common name for the men who used the sling. The inhabitants of the Balearic Islands were celebrated for their skill with this weapon. The Greeks, Romans, and Carthaginians, as well as the Germans, had each their regiments of slingers. The use of the sling has continued even among European armies until the 16th century, at which time they were employed to hurl grenades.

SLING-ROPE. A rope used in packing. It is usually a hand-laid Manila rope, one-half or three quarters of an inch in diameter and fifteen or sixteen feet long. See *Packing.*

SLING-WAGON.—The sling-wagon which is proposed as a substitute for the present sling-cart, is represented in the drawing which shows its construction, and the mode of using the hydraulic-jack for slinging the load. The body of the wagon is made of 6″ rolled-iron beams, simply and cheaply framed together. The bolster on which the jack stands and the load is supported is formed of two 6″ beams placed side by side, and is held in place by clamp-bolts, which admit of it being shifted at pleasure, so as to throw the weight of the load more or less on the front wheels, as circumstances may make it desirable. The wheels are steel, except a part of the nave, which is made of malleable cast-iron, the felloes being sheet-steel, and the spokes steel, rolled tapering and hollow, or + shaped in cross-section. The front axle is made so as to take a field-carriage wheel should it at any time be necessary.

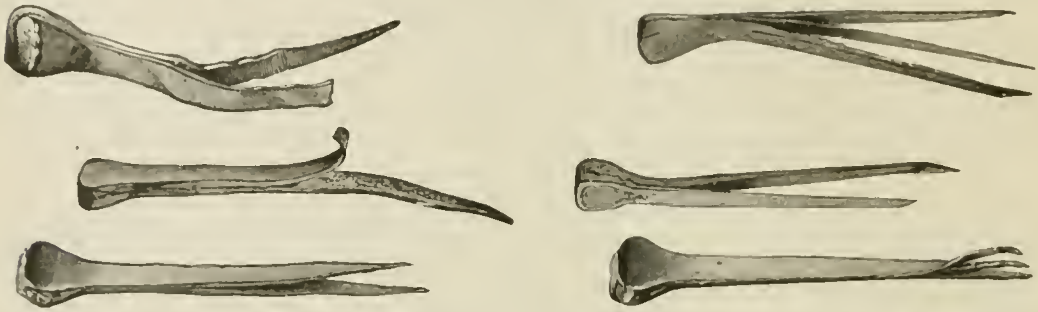


To use the hydraulic-jack in slinging the load, place the elevating-bar in position, the jack standing on the middle of the bolster and the cross-head resting on the head of the jack. Pass the trunnion-rings over the trunnions of the gun or the sling under the load to be carried, and hook the ends on the lower ends of the hoisting-bar. Insert the pins in the lowest holes that they will enter and commence pumping. When the load is raised sufficiently high, put in the pins in the lowest hole; let down the head of the jack until the weight is brought to rest on these pins. The jack may be removed or carried where it rests, ready for further use. The load can be carried suspended from the hoisting-bar as safely as if it were slung from the hooks on the screw. If the weight of the load to be transported be great, increase the strength of the front wheels and throw more of the weight upon them by carrying the bolster further forward. In this way a wagon for carrying a 15-inch gun can be constructed without making the wheels and exles excessively heavy. See *Mechanical Maneuvers* and *Sling-cart.*

SLIPPED.—In Heraldry, a term of blazon applied to a leaf, branch, or flower, which is represented with a stalk, and torn from the parent stem.

SLIPS.—Wrought-iron cylindrical cases about 4½ feet long by 2 feet 5 inches in diameter, in which the wood for gunpowder purposes is distilled; the cases are fitted with lids, and are made to fit into iron retorts, which are imbedded in masonry in such a manner that the heated air from the furnace shall circulate freely round them, and thus convey an equable heat to all parts of the retort throughout the operation of charring. In each slip there are two holes, which correspond with similar holes in the retort, and through which the gases from the wood pass off in the process of distillation. The charge of dhall stalk (the wood used in India) for a slip depends upon the size of the wood. If of large size, the slip will hold 150 lbs., medium 70 lbs., and small size 50 lbs.

SLIVERING. In farriery, the term applied to the longitudinal splitting of horse-shoe nails cut from *cold-rolled* iron. The compression of shearing holds the edges of such a nail together, and *slivering* does not show itself until the nail is driven into the hoof, when



the horny fibers cause the sections to separate. The drawing shows *slivered* nails, which were taken from horse's feet, in the American Service. These nails were all formed by the cold-rolling, punching, and shearing process, which was employed in America, until the introduction of the Putnam nail of *hot-forged* and *hammer-pointed* construction. See *Horse-shoe Nails*.

SLOPE ARMS.—A word of command, in the British Service, for placing the musket upon the shoulder with the butt advanced. In marches, soldiers are almost invariably permitted to slope arms.

SLOPE BLOCK.—In setting the ground sills of the frames in ascending or descending galleries, a small cubical block of wood, termed a *slope-block*, is used, the height of which is equal to the difference of level between the ground sills of an interval. To determine the height for any portion of a gallery where the intervals are equal, or nearly so, the difference of level or of reference of the two extremities of this portion must be divided by the number of intervals. Thus suppose that in the portion of a gallery from A to C, there is an ascent of 5 ft. or 60 in., and twelve intervals; the edge of the slope-block will, therefore, be $\frac{60}{12} = 5$ in. In a portion from C to D, if there is a fall of 4 feet 1 in. or 49 in., and thirteen nearly equal intervals, the edge of the slope-block will be 3 ft. 7 in. nearly. See *Gallery*.

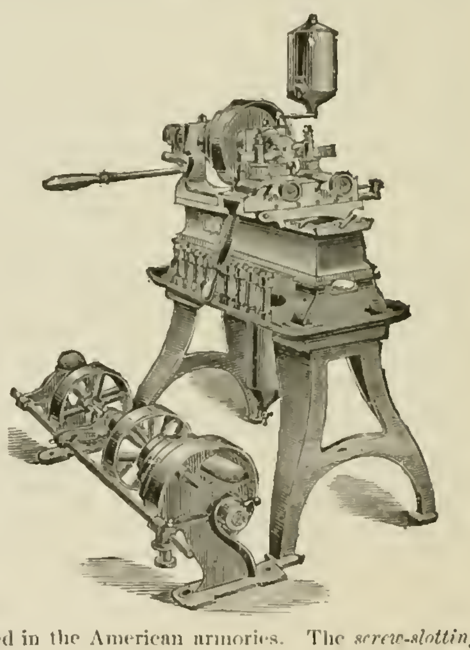
SLOPES.—In fortification, the inclination given to the earth in the formation of the ramparts and parapets, such as the *exterior* and *interior* slopes, and expressed usually by fractions in which the numerator represents the height and the denominator the base of the slope. Thus a slope described as $\frac{2}{1}$ (or verbally as two on one) is one in which the vertical height is twice the base; whilst that expressed by $\frac{1}{2}$ (or verbally as one on two) is, on the contrary, one in which the base is double the vertical height.

Slopes of hills or mountains are expressed in topography by vertical or horizontal *hachures*. Uphill at 15°, slopes are accessible for guns, but at that degree their fire would be useless; at 30°, it would be difficult for cavalry to ascend, and at 10° to charge; at 20°, infantry cannot ascend in order, but slopes are accessible for skirmishers at 45°, at 60° inaccessible for infantry. Downhill, they are suitable for attack or defense for infantry at 10°, artillery 4°, and cavalry not more than 5°.

SLOPING SWORDS. In the British Service, a position of the sword among cavalry, when the back of the blade rests on the hollow of the right shoulder, the hilt advanced.

SLOW TIME. The same as *common time*, by which troops on foot march at the rate of ninety steps per minute.

SLOTTING-MACHINE.—A machine much used in gun manufacture and mechanical engineering for the cutting of slots, or square grooves, in metal. It is of great importance, and many very ingenious inventions have been perfected for facilitating the process. The principle is, however, very simple, and is the same in all. It consists of a cutting-tool, or chisel, held very firmly in an arm, which is pressed down and raised alternately. The tool is thus made to pare off a thin portion of the metal each time it descends, until it has cut a slot of sufficient size. Water is continually thrown on to prevent the metal from becoming overheated by the friction. The drawing represents the Pratt and Whitney machine which is much



used in the American armories. The *screw-slotting machine* has a head carrying a cone-pulley of three grades, and the spindle has a longitudinal adjustment. In the plain machine the screw, held in a chuck mounted on a slide, is raised, by means of a hand-lever, pinion, and rack, to the cutter revolving in the spindle for simply sinking a nick in the head. See *Milling* and *Shaping-machine*.

SLOW MATCH.—Slow-match is a prepared rope which is used to keep and carry fire; it burns slowly with a firm, hard coal and is not easily extinguished. The materials required for slow-match are: *Hemp* or *flax rope* of three strands, slightly twisted, about 25 yards long, and of a uniform diameter of 0.6 inch; acetate of lead (sugar of lead), water. The utensils for preparing, are: 1 *kettle*; 1 *tub*; 2 *wooden spatulas*; *levers*; *twisting-winch*; *mats* or *hair-cloth*. Slow-match is prepared in two ways: 1. Boil the rope for 10 minutes in water holding in solution one twentieth of its weight of acetate of lead; remove it with spatulas into the tub; or let it remain in the cold solution until it is thoroughly saturated. First twist it over the kettle, and then, by attaching one end to the hook of a twisting-winch, twist it hard, keeping it stretched by means of a stick passed through a loop at the other end, at the same time rubbing it smartly, always in the same direction from the hook, with coarse mats, hair cloth, or cuttings of buff leather, until the diameter of the match is reduced 0.1 inch, and it has an uniform twist and hardness. Stretch it on poles or on a fence to dry, and put it up in neat coils, well secured. Match thus prepared burns 4 inches in an hour. 2. If sugar of lead cannot be procured, the rope may be simply leached. For this purpose it is put into a leach-tub and steeped in pure water for 12 hours; this water is then drawn off and replaced by lye prepared in a boiler, with a quantity of ashes equal to half the weight of the rope, to which 5 per cent of quicklime is added. This lye, with the ashes, is put, after being warmed, into the hopper of the tub, and then when it has run through and remained some time in the tub it is drawn off, heated again, and then poured back on the ashes. This operation is repeated several times in the course of 24 hours, which is the time required for the rope to be well leached. After being taken out and twisted with sticks, it is steeped for 5 minutes in hot water, being stirred at the same time, and the operation is finished as before. Match prepared in this manner burns 5 inches in an hour. Cotton rope, well twisted, forms a good match without any preparation. A slow-match may be made of strong paper by immersing it in a warm solution of niter, of about 1 pound to 2 gallons of water. When dry, roll each sheet separately, pressing it firmly, and pasting the last turn. A half-sheet thus prepared will keep fire for three hours. Slow-match weighs from 3 to 5 ounces to the yard.

Slow match is packed in tight casks or boxes. A cask 40 inches high, 24 inches diameter (weighing 60 pounds), contains 150 pounds of match. The casks and boxes should be marked with the kind and quantity of match, place and date of fabrication. Dimensions of a box to hold 200 pounds of hemp or 220 pounds cotton match; 44 inches long, 28 inches wide, 18 inches deep; weight, 87 pounds. It is made of boards 1 inch thick, ends $1\frac{1}{4}$ inch, and has corner-pieces of hard wood, 2.25 inches square. See *Fireworks*.

SLUE.—A term often used in mechanical maneuvers. To *slue* a piece or other object, *end for end*, is to turn it round, not allowing it to revolve on its longer axis. See *Mechanical Maneuvers*.

SLUG.—1. An extemporized leaden projectile formed by cutting bar or sheet lead into irregular masses; used in case of necessity as a substitute for balls or shot. 2. In breech-loading arms, which carry a bullet slightly larger than the bore of the barrel, the bullet, when forced to assume the sectional shape of the bore in the act of firing, is said to *slug* or to be *slugged*.

SLUGGED.—In breech-loading pieces, the bore consists of two separate parts, viz., the barrel, which is rifled, and the chamber immediately behind it, the bore of which is larger than that of the barrel. In this part, the charge and ball fit. When the ball is forced into the barrel by the ignited powder, it enters the grooves and becomes what is termed *slugged*.

SLUICE-GATE.—In fortification, a strong vertically sliding door, placed in a batterdeau, for regulating the flowing of the water in the ditch. Sluice gates are used besides for retaining and raising the water of a river or canal, and, when necessary, to give it vent.

SLUING TRUNNIONS.—*To slue the trunnions* is to turn the piece on its axis so as to bring the trunnions into any necessary position. This is done by first placing the piece on skids perpendicular to its axis. A fulcrum is placed near the trunnion to be raised; upon this a handspike or other lever is used, the piece, meanwhile, being chocked on the opposite side. Or a trunnion-loop may be passed around the trunnion to be raised, and a handspike or lever passed through it, with the butt-end resting on the top of the piece; the power is applied by lifting at the other end, the piece being chocked as before. Or, by passing the bight of a rope once or twice around the piece, and placing the butt of a handspike or lever through the bight, and bearing down or lifting up, using the piece as a fulcrum, the ends of the rope being held to prevent them from slipping. All three of these methods may be used at the same time. The skids should be well greased under the piece, as likewise should be the chocks. When the piece is of great weight, the hydraulic-jack or gin is advantageously used, provided the axes of the trunnions are not vertical. The former is placed under and the latter over the trunnion to be raised. When the axes of the trunnions are vertical, or nearly so, a rope is then passed around the upper one and hauled upon by means of tackle.

SLUR-BOW.—A species of cross-bow formerly used for discharging fire and arrows.

SMALL ARM BARRELS.—Barrels in the English Service for the conveyance and storage of small-arm cartridges. They are of three sizes, *half*, *quarter*, and *eighth*. The half-size is used for blank cartridges, and contains 2,000 rounds; the quarter for ball cartridges, 700 rounds of Snider or Martini-Henry ammunition; and the eighth for small supplies. The quarter-barrel is being superseded by boxes.

SMALL-ARM FACTORIES.—The establishments in which the small-arms of the service are made, viewed, and repaired. The English Government has a factory at Enfield, where the arms issued to the Regular and Auxiliary Army are made, the factory being able, when in full work, to turn out, daily, a thousand and upwards of complete arms, tested and ready for use; at Birmingham, the Government has also a large establishment for viewing the arms supplied by contract, and at Pimlico there is an establishment for repairing damaged arms, and for training Armorer Sergeants for detached service with regiments. All arms are made on the interchangeable system, so that the parts of any one rifle will fit the parts of any other when thrown promiscuously together.

SMALL-ARM PRACTICE.—Ammunition should only be expended in action; in defense of life or public property; in target practice or hunting; in the instruction of recruits; for authorized salutes, and for the subsistence of scouts and other civil employés when they are obliged to rely on their arms, to sustain life. In the United States, the Army is allowed at the rate of 20 ball-cartridges per man per month for target practice, and in the Cavalry service this number is divided between the carbine and revolver, at the discretion of the Commanding Officer. When not expended in target practice, the ammunition may, in the discretion of the Post Commander, be expended in hunting. This allowance need not be expended in each month, but may accumulate, not longer, however, than to the end of the fiscal year, and thus be used under the most favorable circumstances. That unexpended at the end of the fiscal year (June 30) is no longer available. Guards on being relieved should not necessarily discharge their pieces, but should withdraw the cartridges and replace them in the box. On the frontier, where hunting for large game is practicable, the men are encouraged to hunt and, for this purpose, Captains of companies may sell cartridges to their men in limited quantities, according to the supply on hand, and account for the sales and the money received with their quarterly returns of ordnance.

SMALL ARM PROJECTILES.—These projectiles, in great variety, are described under specific headings Only a few of the most prominent will be briefly noticed in this connection.

The bullet used in the United States Service, is derived from that of the *Carabine à tige*, chiefly, by making a conical cavity in its base. The shape of the first cavity employed, was that of a frustum of a cone; but this was found defective when used in the rifle-musket, inasmuch as it rendered the bullet too weak at the juncture of the two exterior surfaces. For arms with reduced charges of powder, as in the carbine and pistol, the large cavity is most suitable. A distinguishing feature of the musket-bullet is, that no patch of any kind is used in loading; in nearly all other modern bullets a greased patch of cloth, or paper, envelops them when placed in the bore.

The British bullet (sometimes known as the Pritchett bullet) has a perfectly smooth exterior. A conical plug of box-wood is inserted into the opening of the cavity, it is said, more for the purpose of preserving the form of the bullet in transportation than aiding in the expansion. The diameter and weight of this bullet are nearly the same as in the United States bullet.

Two distinct bullets are employed in the French Army. The first is heavy, and is intended to have great force and accuracy at long distances. It is used by troops armed with the *carabine à tige*, as the Chasseurs and Zouaves. The second bullet is light, and without much accuracy, describes a flattened trajectory, which increases the chances of hitting a line of men at the usual fighting distance. This bullet is used by troops of the line, who are not supposed to be skilful marksmen.

The Austrian bullet belongs to the class of solid expanding projectiles. In this particular case, expansion is effected by the crowding up of the disks, formed by cutting two deep grooves around the cylinder. A portion of the Austrian rifles (those carried by Non-commissioned Officers, and men of the third rank, who act as skirmishers) have a spindle attached to the breech-screw; the object of which is, not to aid in expanding the bullet, but to give it an invariable position with reference to the powder, and thereby secure uniformity of action.

The bullet used in the Swiss Service is solid, and is forced by a cloth patch tied around the grooves. The position of the bullet with reference to the powder is constant; this is determined by a notch on the ramrod—the notch being so arranged as to leave an interval between the powder and the bullet. The diameter of this bullet is much less than that of any other Service; and, in consequence of its lightness, it is fired with a larger proportional charge of powder. Within the usual range of small-arms, it is said to have a flatter trajectory, and a greater accuracy, than any other small-arm projectile; but at extreme ranges it loses its velocity very rapidly.

The proper charge of powder, for a small-arm, depends on the caliber, windage, length of the barrel, weight of the piece, and character of the projectile. The charge of the old smooth-bored musket was not far from one-third the weight of the projectile; this was necessary to make up for the loss of force by a great windage, and to give the round bullet the necessary momentum. When the elongated bullet was introduced, it became necessary to reduce the charge to prevent too severe recoil; besides, the mass of the bullet being increased, a diminished velocity sufficed to produce the same effect.

In the case of expanding bullets, too small a charge will be insufficient to force the lead into the grooves of the barrel; at the same time, it is shown by experience that, if the charge be increased beyond a certain point, the bullet is liable to be disfigured by *upsetting*, and its accuracy is diminished. *The proper charge for elongated expanding bullets varies from one-tenth to one-seventh the weight of the projectile.* See *Forcing* and *Projectiles*.

SMALL ARMS. The ancient small-arms might be classed as follows: 1st. *Hand-arms*, for close conflict. 2d. *Projectile-arms*, to attain an enemy at a distance. 3d. *Defensive-arms*, to protect the body. Hand-arms comprised the *war-club*, *battle-axe*, *pike*, *sword*, and *saber*. The *war-club* was a stout stick, the large end of which was armed with blades, or points of metal; that used by foot-soldiers was from 7 to 8 feet long, and weighed from 20 to 30 pounds. It was extensively used in the Middle Ages, and is still employed by certain oriental cavalry. The *battle-axe* was at first made of stone or bone, and afterward of metal. This weapon was much used by the Celts and Gauls, but principally by the Franks, who hurled it with great skill and effect against an enemy. The *pike* was generally employed both by infantry and cavalry. That for the infantry was very long, as in the case of the Macedonian lance, or the *sarissa*, the length of which was about 20 feet. In some countries this weapon continued to be used as late as the seventeenth century. The cavalry lance was shorter and lighter than the preceding; it is still used by certain kinds of cavalry.

The Roman *javelin* was a short pike, about 6½ feet long, which was thrown against the enemy. The *spontoon* or *half-pike*, was carried by French infantry officers as late as the time of Louis XV. The *halberd* and the musket, with its bayonet fixed, are pikes.

Swords and sabers have varied much in character with the manner of fighting of different nations; for instance, the Gauls and the Germans, who defended themselves with shields made of willow, or other light wood, made use of long and flexible swords, while the Greeks and Romans, who all wore breastplates and helmets of metal, used short and stout swords. The knights of the Middle Ages carried long and heavy swords, which they wielded with both hands.

The principal projectile-arms, before the invention of gunpowder, were the *sling*, *bow*, and *cross-bow*. The *sling* was formed of a leather cap suspended by two cords; a stone placed in the cap, a rapid rotary motion was communicated by the hand, one of the cords was set free, and the stone escaped in a tangential direction, and was thrown to a distance varying from 200 to 300 steps. The *bow* was formed of a piece of highly elastic wood, confined in a bent position by a strong cord attached to its extremities; it possessed the power of projecting arrows to long distances. This weapons played a very important part in all ancient warfare, and continued to be used by civilized nations to a comparatively late period. In the Middle Ages, it was said, that a skilful archer could fire twelve arrows in a minute, and strike a man at a distance of 100 yards. If certain English authors are to be believed, an archer who could not perform this feat, was disgraced. According to their statements, an arrow had sufficient force to penetrate an oak plank, two inches thick, at a distance of 200 yards. The *cross-bow* was a bow attached to a stock having a channel to guide the arrow. It is said to have been introduced into Europe from Asia, during the Crusades, by Richard Cœur de Lion, who armed the English troops with it. At present, the use of the bow is confined to the barbarous tribes only; the skill and dexterity with which it is managed by the Prairie Indians of this country, make it an exceedingly formidable weapon at short distances.

Armor, which was employed to protect the most exposed part of the body, naturally followed the introduction of offensive-arms. At first it was made of wood, the skins of certain animals, the scales of serpents, shells of turtles, etc., and subsequently of metallic plates, or of a cloth folded in layers. The body was also protected in the rear by movable obstacles, as shields, bucklers, etc. Among the Romans and Greeks, the infantry of the line wore the helmet, the breast-plate, a species of half-boot protected with iron, and the buckler; the cavalry, ordinarily, wore a cuirass formed of bands of leather, covered with plates of bronze. In the time of Charlemagne, coats of mail, formed of small chains, were much worn. These were followed by complete suits of metallic armor, which were worn until the introduction of fire-arms.

Portable fire-arms were invented about the middle of the fourteenth century. At first they consisted simply of a tube of iron or copper, fired from a stand or support. They were loaded with leaden balls, and were touched off by a lighted match held in the hand. They weighed from 25 to 75 pounds, and consequently two men were required to serve them. The difficulty of loading these weapons, and the uncertainty of their effects, as regards range and accuracy, prevented them from coming rapidly into use, and the cross-bow was for a long time retained as the principal projectile-weapon for infantry. Breech-loading small-arms, similar in principle to the cannon described elsewhere, were introduced about the same time, but they were soon thrown aside for want of strength and solidity. The difficulty of aiming hand-cannon, arising from their great weight, was in a measure overcome by making them shorter, and supporting them on a tripod, by means of the trunnions which rested in forks. The breech was terminated with a handle which was held in the right hand, while the match was applied with the left. Thus improved, this fire-arm was called the *arquebuse;* it was employed in sieges; and to defend important positions on the field of battle. The next improvement in the arquebuse, was to make it lighter, and enclose it in a piece of wood, called the *stock*, the butt of which was pressed against the left shoulder, while the right hand applied the match to the vent. It was still very heavy, and in aiming, the muzzle rested in the crotch of a fork placed in the ground. To give steadiness to the aim while applying the match to the priming, a species of lock was very soon devised, which consisted of a lever holding at its extremity a lighted match. In firing, the lever was pressed down with the finger until the lighted end of the match touched the priming. This apparatus, known as the *serpentine*, continued in use until it was replaced by the *wheel-lock*, which was invented in Nuremburg, in 1517. The wheel-lock consisted of a grooved wheel of steel, which acted through a half-revolution on a piece of alloy of iron and antimony, placed near a priming-charge of powder. The sparks thus evolved fell upon and ignited the priming-charge. The first pistol was a wheel-lock arquebuse, so small that it could be held and fired from the extended hand. It was invented in 1545, in Pistoia, a city of Tuscany; hence its name. The petronel was a wheel-lock arquebuse of large caliber and of lighter weight than its predecessors. To diminish the effect of the recoil, the butt of the stock was much curved, and had a broad base, which was pressed against the breastplate of the cuirass when the piece was fired. Two sizes of the petronel were used, one for infantry and one for cavalry. The musket was first introduced by the Spaniards, under Charles V. The original caliber of the musket was such that eight round bullets weighed a pound; the piece was, consequently, so heavy that it was necessary to fire it from a forked stick inserted in the ground. The size of the bore was finally reduced to eighteen bullets to the pound; and from this arm was derived the late smooth bore musket.

It is generally stated that the rifle was invented by Gaspard Zoller, of Vienna, and that it first made its appearance at target practice at Leipsic, in 1498. The first rifle grooves were made parallel to the axis of the bore, for the purpose of diminishing the friction of loading forced or tightly-fitting bullets. It was accidentally discovered, however, that spiral grooves gave greater accuracy to the flight of the projectile, but the science of the day was unable to assign a reason for this superiority, and the form, number, and twist of the grooves, depended on the caprice of individual gun-makers. About 1600, the rifle began to be used as a military weapon for firing spherical bullets. In 1729, it was found that good results could be attained by using oblong projectiles of elliptical form. The great difficulty, however, of loading the rifle, which was ordinarily accomplished by the blows of a mallet on a stout iron ramrod, prevented it from being generally used in regular warfare. The improvements which have been made in the last thirty years, principally by the officers of the French Army, have entirely overcome this difficulty, and rifles are now almost universally used in place of smooth-bored arms. The rifle has ever been a favorite weapon in this country, arising, doubtless, from the peculiar circumstances which surrounded its early settlers and pioneers, and on more than one occasion has it proved, in the hands of the irregular troops, a formidable weapon to its enemies. Until 1855, the mass of the American infantry was armed with smooth-bored muskets, but since that time it has been wholly armed with rifles. In spite of the advantages which fire-arms possessed, they, like the arms which preceded them, were not suited to resist the charge of cavalry. The bayonet, and firing in closed ranks, were unknown; the most skilful Captains of the age, however, sought to combine fire arms with pikes, in such a manner that one might afford protection to the other. The French Army was thus arranged in six ranks, four with muskets and two with pikes; on the introduction of the bayonet, it was reduced to four, and finally to three ranks. The bayonet derived its name from Bayonne, where it was first made, in 1640. At first it was formed of a steel blade attached to a handle of wood, which was inserted in the bore of the barrel, except in the operations of loading and firing. Thirty years afterward the wooden handle was replaced by a hollow socket, which fitted over the muzzle of the barrel; this change rendered the musket at all times a pike as well as a fire-arm, and led to the formation of modern infantry. The flint-lock was derived from the wheel-lock, by substituting flint for the alloy of iron and antimony, and a steel battery for the wheel. It was generally introduced into the French Army in 1680, and continued to be used in all military services, until about 1842, when it gave way to the percussion-lock. In proportion as fire-arms were improved, the rapidity of fire increased. In 1703, the loading of the musket was performed in twenty-six times and the fire of infantry was necessarily slow. In 1744, the employment of fine powder for priming was dispensed with, and the cartridge (said to have been the invention of Gustavus Adolphus) was adopted in its place. See *Care of Small-arms, Fabrication of Fire-arms, Fabrication of Swords and Sabers, Hand-arms, Inspection of Small-arms, Ordnance, Packing Small-arms, Portable Fire-arms, Royal Small-arms*, and *Springfield Rifle*.

SMALL-ARM VELOCIMETER.—The velocimeter may be very conveniently applied in studying the law of the recoil of a musket in order to estimate the accelerating forces developed in an arm of small caliber by the combustion of the powder. As it is important to diminish the weights set in motion, in order to obtain a greater amplitude of tracings, the barrel is separated from the stock, and the breech fermeture is replaced by a simple screw-plug, with a pin passing through it, which serves to ignite the cartridge

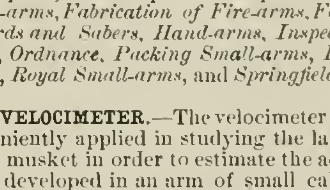


Fig. 1.

arranged for inflammation by electricity. The gun-barrel is clasped between two collars, Fig. 1., furnished with ears, which serve to guide it in the grooves of two metallic rules, secured parallel to each other on a wooden stand. These collars are formed each of two pieces insulated from the gun-barrel by an India-rubber ring and united by two screws, also insulated by means of an ivory washer; one of the ear-guides belongs to the upper piece and the other to the lower piece. The rear collar is furnished in addition with two friction springs, resting on the upper face of the guide-rules, and both secured on the upper piece; lastly, the two rules are in communication with the common circuit formed by the return wires of the registers. It results from this arrangement that, during the recoil movement of the piece, the electric circuit of these registers is each instant completed by the movable piece of the collar which bears the friction piece. The right rule has, also, fitted at a point suitably chosen, about a millimeter from the initial position of the spring, a rather small insulating tongue, which this friction piece encounters and passes over as soon as it is displaced; we thus obtain a simultaneous rupture of the currents of the registers, immediately followed by their reëstablishment; we then realize the conditions necessary for obtaining, at the very moment of the experiment, the measure of the functional retardations of each of these registers, as has been previously stated. The gun recoils freely in its slides, over a length of about 50 centimetres (19.685 inches); it then strikes a wooden hurter, which also slides on the rules, serving for guides, and which is held by means of two extended India-rubber thongs, placed symmetrically right and left, and which tend the more to deaden the effect of the shock. A toothed rack of brass, fixed between the slides, and whose obliquely-cut teeth give a hold to a pawl with a spring fixed in the buffer, serves to keep this latter in the extreme position to which it is brought by the shock, and prevents the gun-barrel from being sent back with violence to the front.

The ribbon, in the form of a tablet, designed to receive the tracings, is fixed directly on the gun-barrel; it has at its extremities two notches narrowed at the rear end, in which are engaged two large-headed pins fixed on the barrel. Above this tablet are placed two horizontal axes, turning, with a stiff friction, in their bearings, and which have, one the electrically-supplied vibrating fork, the other the registers. The fork is arranged as usual, but owing to the inconsiderable portion of the recoil of the gun, which corresponds with the passage of the ball through the bore, it must give a great number of vibrations if we wish to study, with sufficient precision, the law of the movement in this passage. A fork giving 2,000 simple vibrations per second is generally used; a fork with 3,000 vibrations is sometimes employed, but the setting of it in operation is very difficult. The electric registers are designed to give the velocity of the musket-ball. As this velocity, in consequence of the forcing of the ball, may be obtained by noting simply the moment of the rupture of a wire stretched before the muzzle and that of its arrival on a disjunctor target, it is usual to employ only two registers, one placed in the circuit of the wire at the muzzle, the other in the circuit of the target. In order to avoid any displacement of the gun at the moment of the inflammation, fire can be communicated to the cartridge electrically, as shown in Fig. 2. This result is obtained by transforming the primer of the cartridge into an electric primer. The ordinary primer is replaced by a sensitive composition contained in a small capsule, in the center of which is a small obturator-plug of brass, the rod of which passes through a very small ivory insulating ring. A small spiral of very fine platinum wire is soldered, one part to the plug, and the other to the edge of the metallic cap, and is imbedded in the sensitive composition. It suffices, then, to put the conductors of the firing battery in communication, one part with the rear end of the insulated plug, the other with the body of the gun, which itself communicates electrically with the cartridge and the cap, that by closing the current we may cause the incandescence of the wire and the inflammation of the primer and the charge. The communications are established by means of a small special connection at the extremity of a flexible cable, with two conductors, which end at the terminals of an insulating plane-table, on a column, placed on the side of the stand of the apparatus. The length of this flexible cable is sufficient to permit the free recoil of the gun. The terminals and the commutators, placed also on the stand of the apparatus, permit of establishing conveniently the circuits of the fork and the registers, of interrupting at will that of the former, and of reuniting in one common circuit the egress wires of the latter. We could replace electric ignition by a blow, causing the inflammation of a cap, by arranging the apparatus in such a manner that the shock might have no other effect than that of forcing the gun-barrel harder against a shoulder, limiting its movement towards the front; but with a fire-lock gun it would be more simple still to effect the inflammation of the cartridge by the application of some inflamed body; communicating the fire to a small quantity of priming-powder put in the vent, we would thus avoid all prejudicial disturbance before the leaving of the shot. See *Benton Thread Velocimeter* and *Velocimeter*.

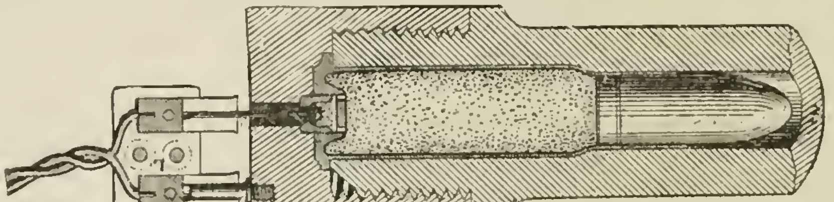


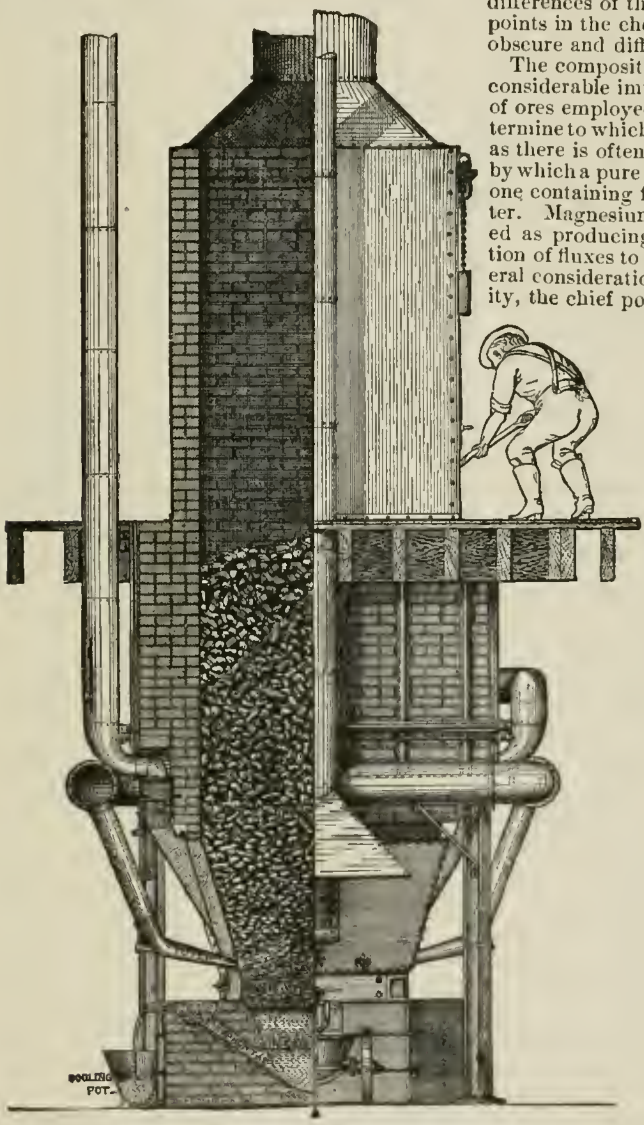
Fig. 2.

SMALL PICKETS.—An obstacle consisting of straight branches of tough wood cut into lengths of two and a half or three feet. They are driven into the ground in a quincunx order, about twelve inches apart, and project irregularly above it, not more than eighteen inches. Interlaced with cords, wires, grape-vines, brambles, prickly shrubs, etc., they form an excellent *entanglement*. See *Accessory Means of Defense*.

SMART MONEY.—In England, a sum paid by a recruit to free himself from his engagement. This is done in the presence of a Magistrate, and previous to attestation. The amount is 20s., which includes the enlisting shilling; the Enlisting Sergeant receives one-half (9s. 6d.), the remainder is credited to the public. A recruit cannot legally be attested until 24½ hours have elapsed from receipt of the enlisting shilling; he can claim 95½ hours' grace before attestation. If the enlister neglects to have him attested within 96 hours after enlistment, the engagement is void and the recruit free. Sundays, Christmas Day, and Good Friday, do not count as time against a recruit, but though he may, if he wishes, allow them to count; thus a recruit enlisted on Saturday night cannot be attested against his will on the following Monday, although, if willing, he may be attested.

SMELTING.—Smelting is the process by which iron or some other metal is reduced to the metallic state, and separated from the refractory substances with which it is combined in the ore. It consists in raising the ore to a high heat, in contact with carbon and a suitable *flux*, in the blast or smelting-furnace. The *flux* unites with the earthy matter of the ore, so forming a glassy substance called *slag* or *cinder*, and the carbon, as carbonic oxide, unites with the oxygen of the ore, setting the iron free; which, in turn, unites with a portion of the carbon, and forms a fusible compound called pig or cast-iron.

In practice, very few ores are ever found to contain earthy ingredients in proportions sufficient to form readily fusible slags alone, and it therefore becomes necessary to supply the deficiency. This may be done, either by mixing ores of dissimilar composition in such quantities as shall yield slags of the desired composition, or by the addition of calcareous or aluminous minerals not containing iron. The first of these methods is certainly to be preferred, as by it



the slag is formed without unnecessarily reducing the percentage of iron in the charge or burden, taken as a whole; whereas, the addition of fluxes increases the weight of material to be passed through the furnace for the same produce of metal; but it can only be carried out in localities having a large and varied command of minerals. Usually, therefore, a combination of both methods is used, the best mixture of ores obtainable being supplemented by the addition of earthy minerals.

The reduction of iron ores can be effected practically only by carbou or carbonic oxide. The principal flux employed in iron-smelting is carbonate of lime in the form of limestone. As a very high temperature is necessary to effect the reduction, the metal almost always combines with a greater or less proportion of the reducing agent, as well as of other elementary substances, such as the silicon, sulphur, and phosphorus, that may be present either in the ore, the fuel, or the flux; so that the ultimate result is never a pure metal, but is a compound of iron with carbon, silicon, sulphur, phosphorus and sometimes manganese, and occasionally traces of other baser elements, as titanium, etc. Small traces of foreign elements exert a very marked influence on the metal; and it is these small, and in many cases unnoticed, differences of the composition, that render so many points in the chemistry and practical working of iron obscure and difficult to be understood.

The composition of the limestone to be used is of considerable importance, and depends upon the kind of ores employed. Chemical analysis alone can determine to which class a particular limestone belongs, as there is often nothing in the external appearance by which a pure limestone may be distinguished from one containing forty or fifty per cent. of foreign matter. Magnesium limestone is especially to be avoided as producing a very refractory slag. The addition of fluxes to the blast-furnace is regulated by several considerations. When the ores are of good quality, the chief point to be considered is the production of the most fusible slag, with the smallest addition of non-ferriferous matters; this is more especially the case with charcoal-furnaces. When mineral fuel is used, however, it is necessary to form a slag that is capable of absorbing sulphur, which would often otherwise be taken up by the iron; and, for this purpose, a larger quantity of flux is used than that indicated by theory, as giving the greatest fusible product. The quality of the iron produced depends greatly upon the kind of flux employed.

Slag is the vitreous mass which covers the fused metal in a smelting-hearth. The physical character of slag, such as color, texture, fluidity, etc., varies with the composition and the working condition of the furnace, so that it is not possible from inspection alone to determine the character of the metal produced, except after considerable experience of the individual furnace; and the relation between the slag and metal in one locality may be totally different in another. The fuel used in iron-smelting varies in different localities and also with the purposes for which the iron is intended. Charcoal is said to make the most superior iron, and is always used in the manufacture of iron for ordnance purposes. Coke is generally used, and bituminous and anthracite coals are also employed.

The Lane and Bodley smelting-furnace, with one-half in section, is represented in the drawing. The mixed ore, fluxes, and fuel are fed into the furnace and gradually settle down through the brick shaft until they reach where the sides are made of steel boxes, called "water jackets," and kept cool by a continuous supply of cold water; therein the combustion takes place, a high heat being obtained by air from the blower near the engine, which drives it. The blast enters the furnace through the *tuyeres*, at the mouth of which the last of the fuel is entirely consumed, the fluxes and foreign matter whilst melting uniting into *slag*. From the bottom of the crucible a channel passes diagonally upwards, terminating in a bowl in the top of the masonry outside of the water jackets, thus forming what is known as the "*syphon tap*." At the bottom of one of the water jackets is an opening, stopped with clay, which is occasionally removed to allow the slag to escape into slag-pots, where it is allowed to congeal.

It is in the smelting-furnace that the character of the iron is fixed. Iron of good character and high susceptibility may be spoiled by its treatment at the foundry; but this, with ordinary experience and intelligence, ought rarely to occur. It is impracticable, with our present knowledge, to make good and reliable guns from iron that leaves the smelting-furnace with bad qualities. The smelting of iron is a purely chemical process, and should be conducted with the same regularity and precision as any other important chemical process. There are so many disturbing causes tending to affect its character and qualities, that, after every precaution shall have been taken to remove them, perfect uniformity in the quality of the iron produced from day to day cannot be effected, yet a near approximation to uniformity is practicable.

All the stock for a "blast" of gun-iron should be carefully prepared and housed before beginning to "blow." The ore should all be roasted and also well mixed so as to be as nearly uniform, as to size of lumps and all other qualities, as possible The charcoal should all be made as nearly as possible from the same kind of wood, of the same uniformity as to quality, and well mixed together after charring. All the stock should be carefully weighed, and supplied to the furnace at regular intervals of time. The pressure, temperature, and hygrometrical condition of the blast, should be kept as nearly constant as possible. The temperature of the blast may be kept very nearly constant without using what is termed a hot-blast, by warming it just sufficiently to bring it above the highest summer temperature.

Suppose a standard of quality to have been determined, with the stock all prepared for a given number of guns, and having determined by comparison with the *standard* the quality of iron required, a further approximation to identity in quality of the metal in the guns may be made by casting each run of metal from the smelting-furnace into a number of pigs of equal size, something greater than the number of the guns to be made, and piling them in separate piles; each run of metal furnishing one pig to each pile. Each pile should contain metal enough for one gun and one test-cylinder; and be kept separate and distinct from all others in transportation, and be repiled in the the foundry-yard in the same order as at the smelting-furnace; one gun being made from each pile, after the treatment which the iron should receive at the foundry shall have been determined by experiments made on the iron in the surplus piles. The pigs should be cast in molds as prepared from a pattern, so as to be smooth and free from adhering sand as possible.

The difference between iron as it exists when presented for use in pigs and when in the body of the finished gun is very great, sometimes amounting to a difference in density of more than 20 pounds per cubic foot, and in tenacity more than as 1 to 2. This serves to show how unreliable the tests of the first fusion pig-iron are, as a means for determining the quality of iron and its suitableness for making cannon. The quality of cannon may be improved by endeavoring to ascertain the different qualities of the metal used in making them, and the best methods of treating it in the processes of melting, casting, and cooling. It is found that some kinds of iron are susceptible of very great improvement, by the different methods of treatment at the foundries; while other kinds are at their maximum strength in the crude pigs. The cause of this difference in the susceptibility for change and improvement will doubtless be found in the qualities of ores used, and in the methods of smelting them.

Usually the quality of iron is greatly modified and improved by remelting and a long continuance in fusion. But all kinds of iron are not affected in like manner by these processes. In examining the effects of the different treatment of iron at the foundry, such samples should be chosen as will best exhibit the following particulars and characteristics, viz.: 1st. The properties which distinguish the different grades of iron made from the same ores at the same furnace. 2d. The changes in the mechanical properties of iron produced by repeated meltings of one of these grades, separately, showing the changes effected at each melting. 3d. The changes produced by repeated meltings of the different grades of iron and of different fusions mixed. 4th. The changes produced in iron of the same melting and quality, by casting it into masses of different bulk, and by different methods of cooling. The softest kinds of iron will endure a greater number of meltings with advantage than the higher grades. It appears from Major Wade's experiments with Greenwood iron that when it is in its best condition for casting into proof-bars of small bulk, it is then in a state which requires an additional fusion to bring it up to its best condition for casting into the massive bulk of cannon. In selecting and preparing iron for cannon, we may proceed by repeated fusion, or by varying the proportions of the different grades and different fusions, until the maximum tenacity is attained.

An increase of density is a consequence which invariably follows the rapid cooling of cast-iron, and, as a general rule, the tenacity is increased by the same means. The density and tenacity usually vary in the same order. It appears that the tenacity generally increases quite uniformly with the density, until the latter ascends to some given point; after which an increased density is accompanied by a diminished tenacity. The turning-point of density at which the best qualities of gun-iron attain their maximum tenacity appears to be about 7.30. At this point of density, or near it, whether in proof-bars or in gun-heads, the tenacity is greatest. As the density of iron is increased, its liquidity when melted is diminished. This causes it to congeal quickly, and to form cavities in the interior of the casting. See *Iron*.

SMITH AND WESSON REVOLVER.—Prior to the recent war in the United States, no revolver had been adopted by the military authorities in which metallic cartridges were used; but the advantages of this arm were so apparent that thousands of these revolvers were bought by officers in the Army and Navy, and so great was the demand for them that orders were upon the books of this Firm for all their possible production for two years in advance. At the Paris Exposition this weapon attracted an unusual attention and from that time a demand arose which has constantly increased, resulting in large shipments to Japan, China, England, Russia, France, Spain, Peru, Chili, Brazil, Cuba, and to almost every nation on the globe. Within the last few years, improvements have been added, resulting in the production of a revolver far superior, especially for military purposes, to anything of the kind ever manufactured.

The drawing shows the construction of this arm. The frame with its handle and lock is made as formerly, except that the frame has but a single limb projecting forward from the under-side of the recoil-shield or breech. To the front end of this limb the barrel is hinged, so as to tip forward and downward in opening, as shown in Fig. 1. The barrel, with its hinge-arm or projection, is formed from a single solid piece of steel, and it also has a solid arm or strap at its upper side, which projects back over the cylinder when closed, and is locked to the breech by a spring-latch, *A*, which operates automatically when the barrel is swung into position. The cylinder is mounted on a tubular center-pin, *n*, which is screwed into the rear end of the projection under the barrel, so that the cylinder is attached to, and swings with the barrel, when opened and closed, as is shown in Fig. 1. This center-pin, *n*, is made a little shorter than the cylinder, as shown in Fig. 2, and the central hole through the cylinder is bored out round as far as the pin, *n*, extends; but in rear of the extremity of the center-pin, the hole in the cylinder is made rectangular in form, for a purpose which will be presently explained.

The arm is provided with an extractor, *D*, which consists of a plate fitted into a central recess in the rear end of the cylinder, and which extends radially to near the center of the chambers—it, of course being cut away at its edges, so as to conform in shape and size to the chambers, thus leaving them unobstructed, so that when the extractor is in its seat, the rear end of the cylinder has the appearance of an ordinary solid cylinder, which has the chambers simply bored through it. The extractor, *D*, is provided with a stem made in the form of a square bolt, and of a size corresponding with the rectangular opening in the rear end of the cylinder, previously referred to, so that when the extractor has its stem inserted into or through this opening, it is free to slide back and forth therein, but must turn with the cylinder, thus keeping the extractor always in place in relation to the chambers. The square stem is nearly as long as the cylinder, so that, when the extractor is shoved out in the act of extracting the shells, it will not pass out of the square opening, and is of such a diameter externally, as to permit it to turn freely within the tubular center-pin, *n*, while the cylinder turns upon the center pin, the cylinder and extractor thus always turning together. To this square stem of the extractor, there is secured a round stem or bolt, *B*, which extends forward through the center-pin and for some distance into a hole bored longitudinally from the rear end forward, into the lug or projection underneath the barrel, as is shown in Fig. 1. This stem *B*, is reduced in diameter towards its front end, to afford ample room for a spiral spring, which being mounted on the stem, serves to draw the extractor back to its seat after it has been operated to expel the shells. This stem, *B*, directly over the point where the barrel is hinged to the frame, and from thence forward to the spring, is provided with a series of teeth, which are cut entirely around the stem and which engage with corresponding teeth on a ratchet-wheel, *C*, that is located vertically at the center of the front end of the arm to which the barrel is hinged; this ratchet-wheel being inserted in a slot formed in the front end of the arm, and pivoted upon the same screw which forms the axis of the joint—the front end of the arm being made of a size and shape to correspond with this wheel, whereby also a large

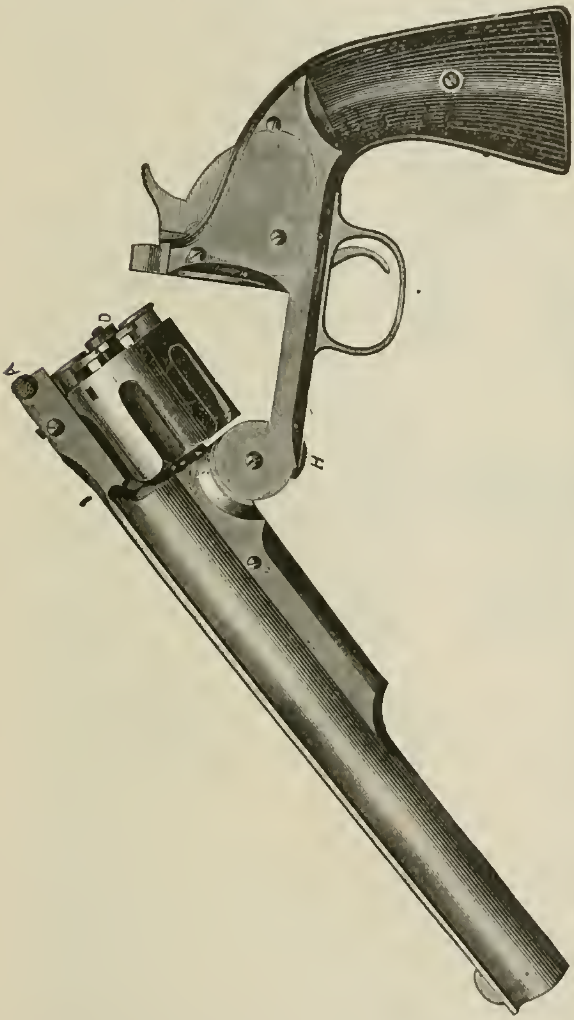


Fig. 1.

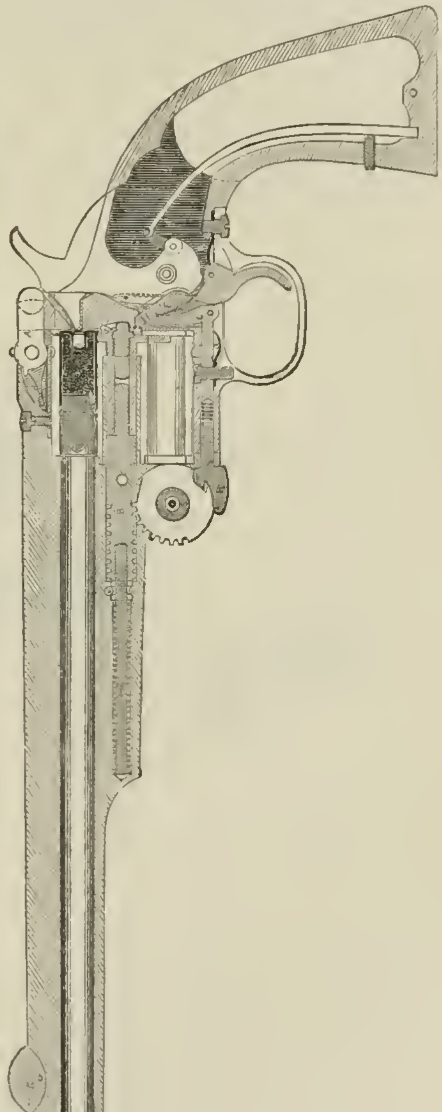


Fig. 2.

bearing is afforded for the joint, which tends to prevent wear and keeps the parts snug and firm. A pawl, *H*, is fitted in a recess bored for it in the arm of the frame, and is so located as to engage in a notch cut in the rear edge of the ratchet-wheel, *C*, by which said wheel is locked fast, and thus prevented from turning when the barrel is swung over forward—a spiral spring at the rear end of the pawl, *H*, serving to press it forward and hold it in contact with the wheel, and also to cause it to automatically engage therewith again, after same has been released. This pawl, *H*, also has a roughened projection at the under side of the arm near its front end, by pressing back on which, the pawl can be at any time disconnected from the ratchet-wheel, when of course, the latter will not act on the extractor.

The operation is as follows: The arm is held by the handle in the right hand, while with the thumb of said hand, the latch, *A*, is raised, thereby unlocking the barrel from the breech. The barrel is then swung over forward, either by the left hand, or if operations are automatic to a greater extent than in any similar arm in existence.

As a military revolver, it is believed that it has no equal. Its accuracy and penetration are shown by the following diagram of a target made at Springfield, Massachusetts, at forty yards distance; the penetration of the ball was through five inches of pine boards. Fig. 3.

The United States use this arm for cavalry, and the Government of Russia have adopted the same model for their cavalry service, an order for 20,000 having been recently executed. The system of inspection adopted by Messrs. Smith and Wesson is such that the least imperfection in material or workmanship is detected, and for which the piece is condemned.

During the past fifteen years Messrs. Smith and Wesson have by constant experiments and attention to details, largely improved their arms. One of the special improvements effected in the new model for the better protection against accidents is a rebound-

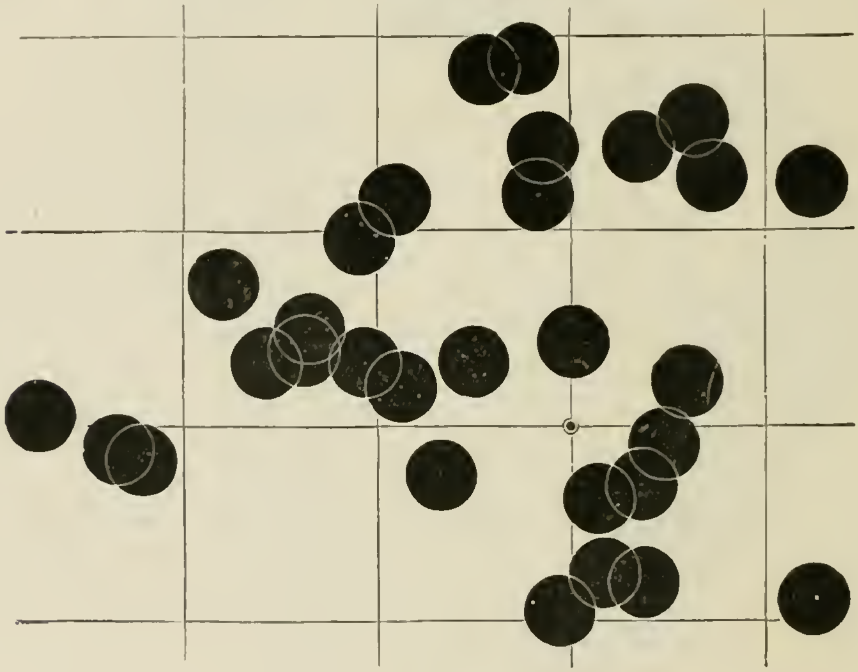


Fig. 3.

that be so engaged, by pressing the top of the barrel against any object. Now, as the ratchet-wheel is held from turning by the pawl, *H*, it follows that the teeth of said wheel engaging with the teeth of the stem, *B*, as the barrel swings forward, causes the extractor, *D*, to protrude from the rear end of the cylinder, carrying the shells out with it. The size of this wheel, *C*, is such that the extractor is caused to move enough so as to push the shells *entirely out of the chambers;* and just as this operation is completed, the shoulder of the pawl, *H*, comes in contact with the projection on the under side of the barrel, by which means the pawl is shoved back, and thereby disconnected from the ratchet, *C*, when the spring on the stem, *B*, immediately returns the extractor to its seat while the arm is still open, ready to be reloaded. When loaded, it is only necessary to swing the barrel back to its position, when the latch, *A*, automatically locks the parts together, and it is ready for firing. Figure 1, represents the arm in position for loading. It will thus be seen that while the arm is strong and consists of comparatively few parts, it accomplishes far more than any revolver ever before invented; and that its ing-lock. Although this feature has been adopted in connection with shot-guns, and now universally used, it has never before been applied to revolvers. These arms, more than any other class, are liable to premature discharge, caused by a chance blow upon the hammer when left, by carelessness, resting upon the cartridge head. By this new improvement the hammer is made to rebound automatically to a safety catch where it is held without the addition of a single piece for that purpose. The pistol is by this means *absolutely safe* in the hands of a soldier, as it cannot under any circumstances from a blow or jar be unexpectedly discharged. By several changes nine pieces have been dispensed with, and the arm materially improved, at the same time the cost being reduced to a very considerable extent. Nearly all these improvements have been patented by Messrs. Smith and Wesson in this country and Europe, and are all owned by the Firm.

It is one of the objects of this Firm to take advantage of all new inventions or suggestions, and to that end the use of hard rubber has been adopted for the construction of the handles, especially of the smaller grade of pistols. Of late a demand has sprung up for a more rapid-firing pistol than the one regularly made by Messrs. Smith and Wesson, and to meet this demand a new arm has been designed and manufactured. The drawing (Fig. 4) shows all the details of this weapon. There is also a very slight difference in the form which will be recognized in comparison with the earlier model. Upon an examination of all the details in this drawing, however, it will be seen that the new arm is very simple in its construction, and that special attention has been paid to securing for it the greatest safety possible. This arm retains the distinctive feature of the Smith and Wesson system, viz.:—the automatic extractor. One of the most important advantages of this pistol over ordinary double-acting pistols is, that instead of being made as heretofore in such a manner as to permit the cylinder to revolve after discharge of the cartridge, which releasing it, admits of the possibility of snapping upon the cartridge already discharged. It is arranged with a cylinder-stop so constructed as to firmly hold the cylinder in position except when being revolved for the act of cocking. This is accomplished by the action of the cylinder-stop, as shown, placed upon the trigger-pivot, the rear end of which rests in one of the stop-notches shown in the drawing, while the trigger is drawn back in the act of firing, the front end of the stop resting in one of the recesses of the cylinder, as shown in the drawing, while the trigger is forward.

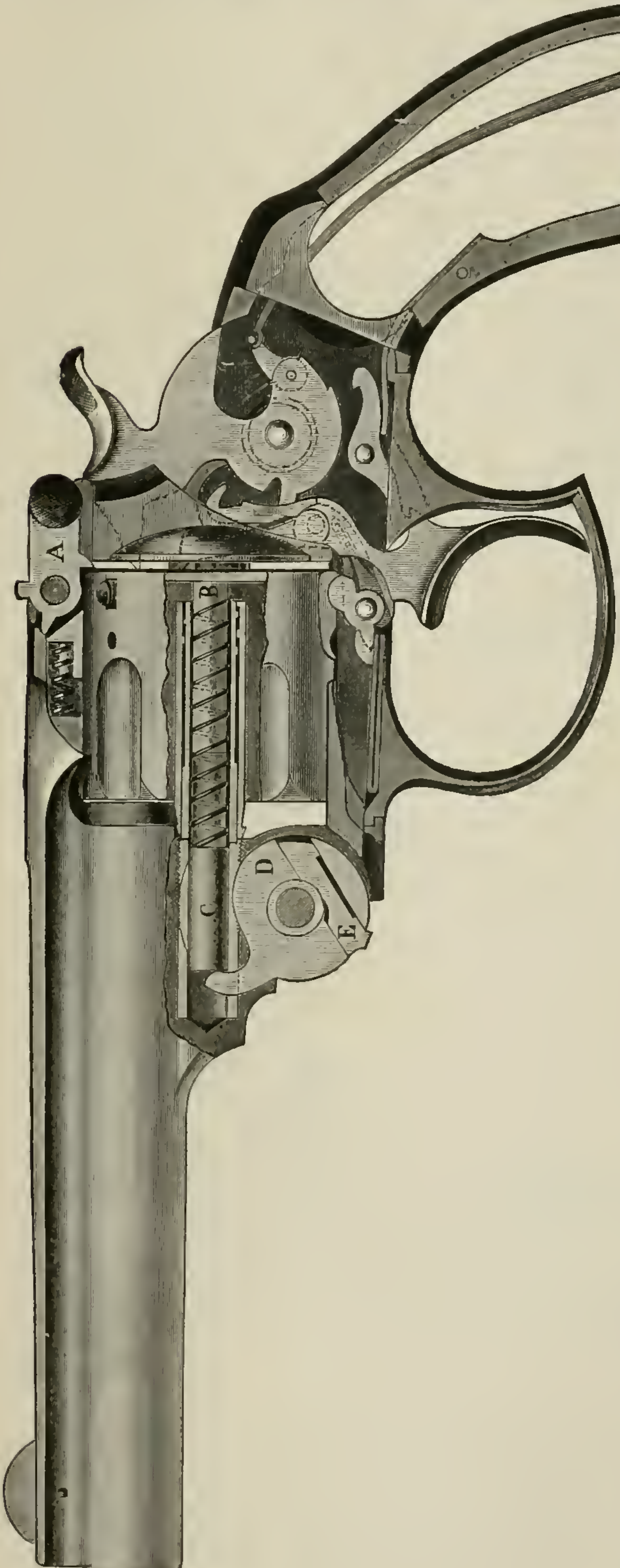


Fig. 4.

Most careful attention has also been paid to reducing the number of parts comprised in the lock of this pistol. There being but seven in all, viz., hammer, front and rear-sears, hand-trigger, cylinder-stop, and two springs. The extractor cam, D, and the extractor catch, E, differ from those used in former pistols made by Smith and Wesson, being much stronger and more simple. The full-page steel engraving represents the latest model 38, No. 2, caliber 38-100, 5 shot. See *Schofield-Smith and Wesson Revolver*.

SMOKE-BALL.—A paper shell having one vent (the thickness of the paper depending on the nature of the shell); the shell is filled with a composition which, upon igniting, evolves a large volume of smoke. It is thrown into mines or other confined situations, to suffocate the enemy's working parties. It has also been used as a signal in the Arctic Regions.

SMOOT GUN.—A breech-loading rifle, having a fixed chamber closed by a movable breech-block which rotates about a horizontal axis at 90° to the axis of the barrel, lying above the axis of the barrel and in rear being moved from above. The piece is opened by cocking the hammer and drawing back the thumb-piece of the cam-lever. A projecting stud on the cam-lever playing in the cam-recess of the breech-block draws it down into the position of loading. By simply reversing the movement of the cam-lever, the stud will act on the other side of the cam-recess, and throw up the block until it is met and stopped by the front shoulder of the cam-lever striking against a corresponding shoulder near the front of the block. The motions of loading and closing may be combined by striking the thumb-piece with the palm of the right hand as the cartridge is passed into the chamber. The piece is then locked by the position of the breech-block and also its friction against the head of the cartridge when it is fixed, by means of a double mainspring center-lock of the most usual pattern. Extraction is accomplished by a sliding extractor, a stud on the inside of which plays in a cam-recess on the outer side of the cam-lever. After passing a certain point in opening the piece, the direct pull on the extractor ceases and the ejection is secured by the acceleration which is impressed on the extractor by the action of the ejector-spring on a cam formed on the lower surface of the ejector-lever. The upper end of which lever, striking a shoulder on the extractor, throws it into a groove connected with the cam-recess, driving the shell up the inclined surface of the breech-block until it is clear of the gun.

SNAFFLE BIT. A slender bit, having a joint in the part to be placed in the mouth. It is the most common bit in use in the military service. See *Bit* and *Bridle*.

SNAKING.—When the spiral motion of rotation of an elongated projectile round its original direction (caused probably by an irregular resistance and want of homogeneity) becomes of exaggerated extent, the projectile may be seen to describe a sort of helix round its primary direction, and the accuracy of shooting is greatly influenced by the part of the helix which may first happen to be in contact with the ground. Projectiles subject to this influence are technically said *to snake*.

SNAP-CAP.—A very small leather cylinder with a metal top of the size of the hammer of the percussion musket, and fitting closely to the nipple. It is used to preserve the nipple from the action of the hammer. The snap-cap used with the Martini-Henry rifle may be described as follows:

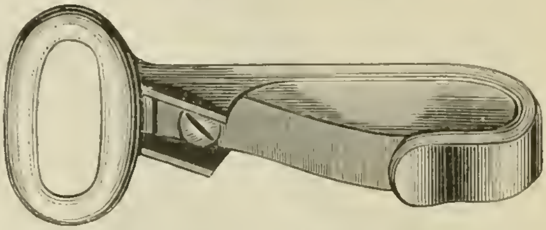
The body of the snap-cap consists of an iron tube surrounded by one of brass, the latter being made somewhat elastic. Longitudinal slits are cut to allow of sufficient compression to insert the snap-cap into the bore of the rifle.

The base is made similar to the base of a breech-loading rifle cartridge, but having a portion of the sides of the flange cut away to allow the horns of the extractor to pass, when the snap-cap is used at snapping-drill.

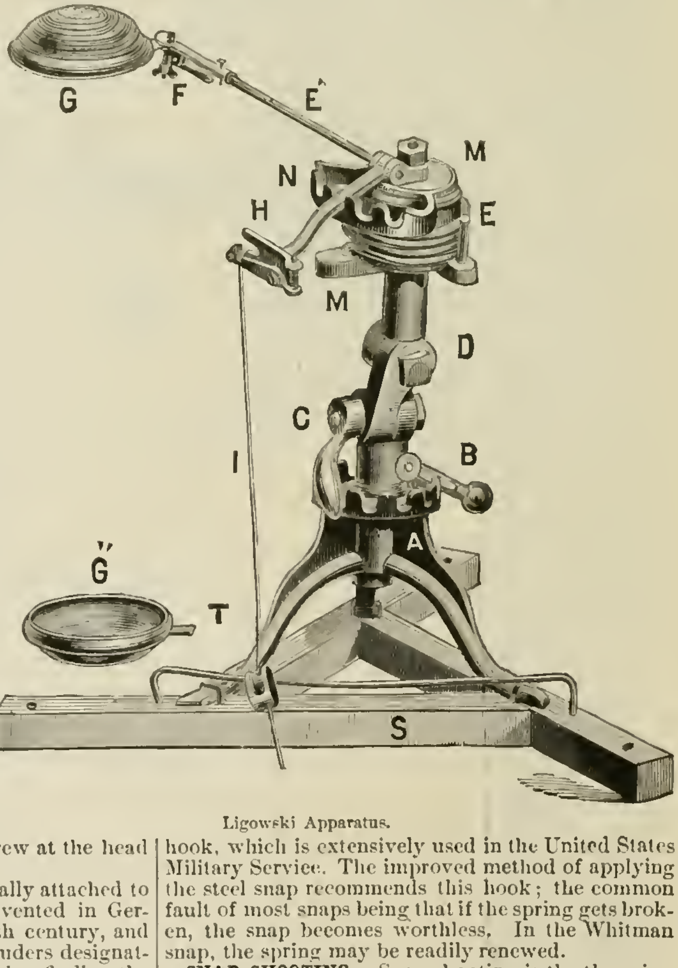
The interior of the snap-cap consists of a spiral spring, supporting a piece of ebonite, which receives the blow of the striker. The spiral spring is kept in its place by a screw at the head of the snap-cap.

SNAPHAUNCE.—A flintlock originally attached to muskets. It is said to have been invented in Germany about the end of the fourteenth century, and was so called by a set of Dutch marauders designated "Snaphans," or poultry-stealers, who, finding the light of the match betrayed them in their marauding trips, and the wheel-lock too expensive, used a lock consisting of a piece of steel, furrowed like the wheel of a wheel-lock, set on a steel post, and which moved on a pivot, and a cock in which was fixed a flint instead of a piece of pyrites; the priming-pan was provided with a cover, which, when it was required to fire the arm, was pushed on one side, and the steel bent down over the pan; on the trigger being pressed, the cock with the flint fell on the steel, and forced it back from the pan, evolving at the same time sparks which fired the priming. The improvement on this lock gave us our flintlock, which has now become an arm of the past. Also written *Snaphance*.

SNAP HOOK.—A hook having a spring-mousing by



which it is prevented from accidental disengagement with the object to which it is attached, as the bit-ring, hame-ring, or breeching-ring. The mousing formerly consisted of a spring, but a spring latch-piece is now the common form. In some snap-hooks a spring forms the latch;· in others the spring actuates the latch. The drawing represents the Whitman snap-hook, which is extensively used in the United States Military Service. The improved method of applying the steel snap recommends this hook; the common fault of most snaps being that if the spring gets broken, the snap becomes worthless. In the Whitman snap, the spring may be readily renewed.



Ligowski Apparatus.

SNAP-SHOOTING.—Snap-shooting is the throwing of both the rear and front sights of a gun into line between the eye and the target and pulling the trigger, all in one motion, and is distinguished by that name from any shooting where the aim is leisurely taken, by bringing the piece to the shoulder, getting the sights in line, hunting the target and pulling the trigger when the aim is most steady. All armies are maintained for offense and defense, and the principal weapon used is the rifle, with an imperfect knowledge of its use, the army is truly ineffective. In action, at least 99 per cent. of the shots go wild, generally in consequence of over-aiming. As an instance of this, the experience of the British troops in Zulu Land, where only one per cent. of the bullets dispatched hit the mark, may be cited. It is certainly important that all troops should be practiced in *Snap-shooting*. Practice in hitting moving objects inspires a confidence which can not be obtained in any other way, and the repetition of the three motions of loading, extracting, and aiming and firing, habituates the learner to a free use of the arms and a confidence in pulling the trigger. In the German Army they aim and snap an unloaded piece repeatedly as an exercise, considering the pulling of the trigger a necessary finish to the motion of aiming. Aided by a minimum expense, light report, easily-acquired range facilities, and a most-fascinating system, might not the practice be carried to firing and hitting, which is the desired result? This need not at all interfere with the manual, but can be practiced as an outside exercise; and the result of adopting it would be felt immediately by a company, not only in the ease and quickening of motion and improved marksmanship, but in the increased interest it would create among the members.

Mr. George Ligowsky has perfected a moving object, which is thrown from a trap in such a manner as to imitate exactly the flight of a pigeon, and which practically solves the problem of finding a suitable substitute for the live bird. The drawing illustrates the device: A, is a tripod stand with a circular rack; B, is a pawl attached to a swivel standard engaging with the circular rack upon A, for obtaining horizontal angular adjustment; C and D form an universal joint for obtaining vertical angular adjustment; M, is a head carrying the exterior spring, E, clamp-arm, E″, and segmental rack, N, which latter engages the pawl, having at its outer end the lock or trigger, H, to which the line or rope, I, is attached; F, is the clamp at the end of the swivel arm, E″, for the tongue, T, of the pigeon; G represents the pigeon in position, and G″ a reverse view of the pigeon on the ground. The weight of the trap is 17 pounds, and its height 18 inches.

To use this apparatus pin the base of the trap firmly to the ground; or what is far better, bolt the base to a plain frame-work of inch plank, about four feet long and two feet wide; secure this latter frame-work to the earth by driving two wide wooden pins on each side and nailing same to the latter. Insert the tongue, T, of the pigeon (convex side of the pigeon being upward) in the clamp, F, from the leftside perpendicular to the clamp-arm, until it rests against the check-pin and the spring-pin; pull back the clamp-arm, E″, with the left hand until caught by the pawl-trigger H, held in place by right hand; then pull the line and the bird flies from the trap. *To increase the velocity of the bird*, engage the pawl, H, farther back upon the segmental rack N. *To obtain a horizontal flight*, keep the clamp-arm, E″, nearly horizontal; to increase the *vertical* angle of flight, incline the lower joint one, two or more points (or notches) until the requisite angle of flight is obtained. *In case of violent wind*, incline the upper joint, D, one or more notches toward the wind until the pigeon alights upon its flat bottom or rim. *To change the horizontal angle of flight*, (that is, from right to left, etc.) raise the pawl, B, and throw the whole swivel-standard around until the clamp arm, E″, points in the direction towards which it be desired to throw the bird; then clamp the set or lock-screw on the tripod.

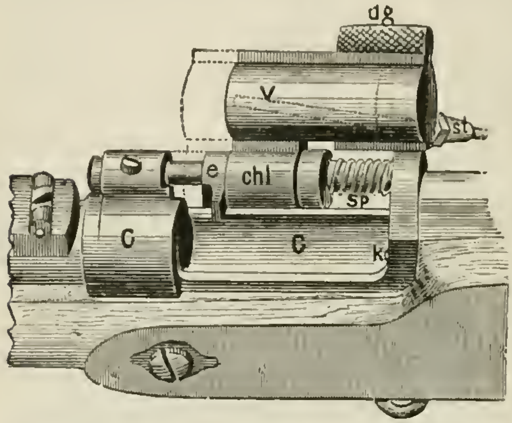
A brief study of these points will readily enable the most unskilled to send the bird at any desired angle; horizontal or vertical. The clamp, F, requires careful adjustment, but when once set must not be disturbed; if (the arm, E″, having been pointed in the direction in which it is desired to throw the same), the bird flies too far to the right, then loosen the tension of the clamp, F, by unscrewing, slightly, the binding-nut; if, on the other hand, the bird flies too far to the left, then tighten the tension.

SNARE-DRUM.—The smaller, or common military drum, as distinguished from the large bass-drum: so called because (in order to render it more resonant) there is stretched across its lower head a catgut-string

or collection of strings. These are generally used by infantry regiments to perform the beats in camp or garrison. In the French Army the drum is now, to some extent, abolished. See *Band*.

SNELL GUN.—A breech-loading rifle having a fixed chamber closed by a movable breech-block, which rotates about an axis parallel to the axis of the barrel and on the right side. It is opened by bringing the hammer to the full-cock; by firing the piece the hammer falls behind the cartridge-head, and locks the piece by engaging in a groove in the frame. The piece is fired by a center-lock, the hammer striking a side-fire cartridge directly, by a projection near its outer edge. Extraction is accomplished by a sliding-piece operated independently by the hand, and serving to guard the cartridge against an accidental fall of the hammer while loading. The friction-spring over the point of which the rim of the cartridge rides in loading, serves to keep the cartridge in the chamber while the hammer is cocked. This arm has been modified to receive a center-fire cartridge, which is ignited by a firing-pin in the form of a bent lever, pivoted on the front and left side of the hammer. As the hammer falls, the forward arm of the firing-pin strikes the right side of the frame, and throws the left arm around to the front with sufficient force to ignite the cartridge; the striking of the forward arm of the firing-pin on this frame being so timed that the fulminate shall be ignited just as the breech is closed.

SNIDER RIFLE.—The converted Enfield or "Snider" rifle was selected in 1865-66 by the British Government from the specimens submitted at an open competition of inventors. It is an extremely simple weapon, and though by no means free from faults, has given very satisfactory results up to this time. The ordinary Enfield barrel is shortened by about 2½ inches and the heel of the remainder is screwed into a strong shoe, with which is connected by a powerful hinge, the solid breech-piece, which, when shut, completely closes the breech. Through this passes the piston or striker; the normal position of the piston is maintained by a spiral spring within the nipple. Given the breech open, the cartridge is inserted and pushed forward into the barrel, where its metal rim fills the groove left around the barrel's heel. The breech-piece is closed down, the hammer drawn to full-cock, and the piece is ready for discharge. The breech-piece is securely locked by the spring bolt, which enters a recess in the false breech, and can only be withdrawn on the lever thumb-piece being



pressed by the thumb in the act of again lifting the breech-block. On the trigger being pulled, the hammer falls, drives in the piston, and out against the detonating cap of the cartridge, with a sharp blow, firing off the charge. The hammer is drawn back to half-cock, the piston flies up to its former position; the breech-piece is thrown back, and slid on its hinge along the pin until occurs a process during which a small catch hooks back into the breech, by its projecting rim, the empty cartridge-case. The canting of the rifle to one side now throws this out, a spring within the hinge moves the breech-piece to its former place, and the gun is ready for another charge.

The cost of altering an "Enfield" to a "Snider" varies from 15s. to 20s. During the transition period, upwards of a million were converted in this way, besides a large number of new arms made for Government service; but conversion and manufacture are now suspended both in the Government factories and by the large small-arms companies. The Government factories were capable of converting 1,100 rifles daily. At first, the firing of the Snider was inferior to the old Enfield; but, by alterations in the bullet, effected by Colonel Boxer, in the direction of decreasing the specific gravity at the apex by the insertion of a wooden plug (which is now, however, dispensed with, and the point of the bullet spun over the mouth of the cavity), this condition has been well reversed, and the Snider now fires 30 per cent. better than the old Enfield. Of course, these changes add some to the cost of the cartridge, which has, however, these great perfections—first, that it is absolutely impervious to wet; and, second, that fire can scarcely be communicated to it otherwise than through the detonating cap. A single cartridge has been fired within a barrel of loose cartridges without exploding any of the others. Adverting to the Snider cartridge, the whole is enclosed in a roll of thin brass foil, outside which is a covering of paper, and having for its base an iron disk, in front of which is a double cup of thin brass, while a round of millboard or pulp encircles the chamber containing the percussion-cap, which communicates with the powder. Between the powder and the ball is a layer of wool. The ball has, as explained above, the point spun over a cavity in its front, and a conical hollow is made at the base; into the wider part of this is dropped the wooden plug. For a detailed description of the action of this gun, see *Tabatière Gun*, reference being made to the drawing above. See *Needle-guns*.

SNOECK FUSE.—The construction of this fuse is based upon the property which cast-zinc possesses, of being hard and tenacious at ordinary temperatures, but very brittle when heated from 160° to 200°, Reaumer, (417° to 482° Fahr.) Hence, a zinc fuse might resist, when cold, the shocks of the charge, and balloting in the bore; but when heated sufficiently by the burning composition, would break from the shock of the falling projectile, and communicate fire to the charge. The fuse consists of a very short wooden fuse-plug, fitted in the interior with a cork collar, through which the fuse passes; and the fuse proper, which consists of a zinc tube of a truncated conical form, having at the top a projecting band, which secures the tube in its position, and at the bottom a solid portion, which, by its weight, assists in breaking the tube when the shell strikes. This tube is filled with ordinary fuse composition.

It will be noticed that this fuse is constructed on a principle very similar to the *Splingard*, but its success has been much less satisfactory. See *Fuse*.

SNOW-SHOE.—1. A species of shoe much used by the Esquimaux, Laplanders, and others who inhabit those regions where snow prevails for a great portion of the year. It consists of a flat frame, of a lanceolate form, from 8 to 14 inches in breadth at its widest part, and of great length—sometimes as much as 7, though generally about 4 feet. It is either wholly of wood or is a wooden frame filled in with wicker-work or thongs, and has cross-straps on the upper surface to attach it to the foot. The broad surface prevents the foot from sinking in the snow. 2. A snow, mud, and trotting-shoe, shown in Fig. 2, patented and made by Messrs. Shoenberger & Co., of Pittsburgh. The concave ground surface of this shoe positively prevents balling, and it will not pull off by the suction of mud or clay. No gravel or other hard substance can find its way under the shoe. Figures 1 and 2 show the Wheeler Anti-snowball Pad and Hoof-protector, a contrivance to prevent horses from "balling" and slipping in winter and from pick-

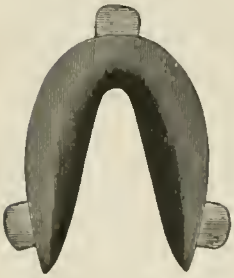


Fig. 1.—Form of Pad.

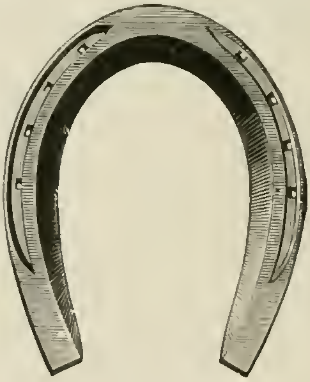


Fig. 2.

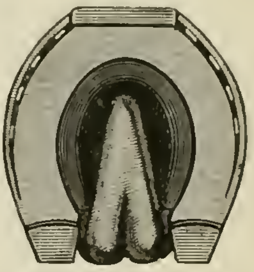


Fig. 3.—Adjusted Pad.

ing up stones in summer. It is made in sizes to fit any foot and is fitted without removing the shoe. It is made of vulcanized rubber, into which a spring of brass with catches is molded. Neither straps nor nails are required. When properly sprung into position (the frog uncovered) it cannot be thrown out by the strongest-actioned horse.

SNYDER DYNAMITE-PROJECTILE.—A newly invented shell charged with a powerful explosive and designed to be propelled from an ordinary cannon. Since the time (1805) when Robert Fulton, in an experimental trial, blew up a brig in Deal Harbor, England, with two torpedoes, filled with 180 pounds of gunpowder, by means of clock-work, the subject of torpedoes, especially for naval warfare, has commanded the attention of civilized governments, and inventions and improvements in this line have been the study of many inventors. England, from the time Fulton made his torpedo experiment, has looked with a jealous eye upon inventions in this direction. Earl St. Vincent, in speaking of the subject to Fulton, said of Sir William Pitt, who had encouraged Fulton in his trials, that he (Pitt) "is the greatest fool that ever existed, to encourage a mode of war which they, who commanded the seas, did not want, and which, if successful, would deprive them of it." That this anxiety still exists, not only in England, but among all other maritime powers, is shown by the large expenditure of money that is constantly being made in the manufacture of torpedoes.

The invention of nitro-glycerine and its adjuncts, nitro-gelatine, dynamite, forcite, giant powder, etc., gave torpedoes a fresh impetus, its destructive effect being much greater than gunpowder. But nitro-glycerine, with its kindred compounds, is of such a sensitive nature that a sudden blow or shock will cause its explosion. Consequently their uses heretofore for war purposes have been solely confined to what are known as fixed submarine mines, floating and spar torpedoes, and torpedoes propelled by machinery contained within them, or by rockets.

Fixed mines, especially when placed under water, are unreliable, and should a vessel pass over them, they could seldom be exploded at the right moment, if at all. Floating torpedoes are quite as apt to injure friends as foes, and the invention of machine-guns and electric lights renders the destruction of spar torpedoes or the thwarting of their operation easy and certain by skilled gunners before they could come into dangerous proximity to a vessel.

Locomotive, or machine torpedoes, likewise have their defects. Their manipulation is intricate and uncertain, and their range short. Of this class is the Fish or Whitehead torpedo, and notwithstanding the fact that millions of dollars have been expended in their construction and trial in war, we understand no vessel has yet been destroyed or injured by one of them. The late Commodore Wm. N. Jeffers, of the U. S. Navy, in speaking of this class of torpedoes, very aptly remarked: "They will go like the devil, but where in the devil will they go to?"

What is known as the Lay, or controlable, torpedo, has overcome many of the objections that apply to the others, yet in that implement many improvements must be made before it can be considered an effective and reliable weapon of war, and even then, like its associates, it would only be applicable to naval warfare.

Realizing the importance of torpedoes for coast defense, the United States Government has encouraged their development, and for the torpedo stations of their Army and Navy—at Willett's Point and Newport—there was appropriated by Congress during the years 1871 and 1879, inclusive, the sum of two million sixty-nine thousand dollars.

It has never been disputed by those whose opinions were worthy of consideration that, if shells or projectiles, charged with dynamite or analogous highly explosive compounds, could be safely fired from cannon, it would revolutionize the present system of warfare, especially of a maritime character. An invention has recently been perfected by which dynamite can be made to play a more important part in offensive and defensive land or naval warfare than it has hitherto been possible to attain. It consists in loading a shell or projectile with glycerine, dynamite or other high explosives, and firing the same from any ordinary gun or cannon without explosion until it strikes the object at which it is fired. The inventor accomplishes this purpose by the mechanical devices that are absolutely certain in their operations; far more so than the shells charged with gunpowder and exploded by time-fuses or other devices, and attended with less danger to those who use them. Repeated tests of this invention have been made, which, in the opinion of experienced naval and military officers who have witnessed the trials, place the utility of the system beyond the realm of doubt. By this system sufficient dynamite to sink the heaviest armored iron-clad ever floated can be fired in a single projectile.

No special kind of ordnance is required, as the invention is applicable to either breech or muzzle-loading, smooth-bore, or rifled-cannon.

By this system no shock is produced upon the projectile, and consequently less strain upon the gun than in the ordinary methods of firing. The inventor is prepared to demonstrate that with uniform weight projectiles, a longer range and greater accuracy is attainable with the same gun than by the usual methods of firing. It is confidently believed, and the United States Dynamite Projectile Company is willing to prove, by competitive tests, that they can produce a more destructive effect with a gun of six-inch caliber, using the Snyder dynamite-projectile, than can be produced with a cannon of the largest caliber ever fabricated, using the ordinary projectile or solid shot. When the saving in weight of armament of a war vessel, that may be attained by this invention is considered, its benefits will be appreciated, especially when increased speed and facility of maneuvring is desirable.

The effect produced by firing shells charged with dynamite into an enemy's camp, or fortified position, or city, can easily be imagined by any one familiar with the terrible destructiveness of exploded dynamite. However, those who have never witnessed its explosion when fired from cannon, will have a very meager conception of its havoc, as the tamping or solidifying it receives at the point of contact and explosion, by reason of the velocity with which the shell is driven, intensifies the deflagration, and augments its destructive effect. It will, furthermore, be readily apparent that the concussive effect produced by the explosions of dynamite shells would be disastrous to life within a very considerable radius.

It has been suggested that explosive compounds, in the manufacture of which nitro-glycerine is used as a base or component part, will be extra hazardous to transport or handle. This objection may seem reasonable to those having little knowledge of its nature, yet it is well known by those familiar with its character, that in many respects there is far less danger attending its transport, handling, and storage, than there is with ordinary gunpowder, as properly manufactured compounds of nitro-glycerine coming in tact with fire, if unconfined, will simply burn, while gunpowder will instantly explode. Furthermore, many of the glycerine compounds, notably nitro-glycerine, for storage, may be placed in water, for instance, in the hold of a vessel, out of the way of an enemy's shot, where it may remain for years without deterioration, or until required for charging the projectiles.

The preliminary trial at the Washington Navy Yard of the Synder dynamite-shell, using gunpowder as the projectile agent, was had very recently under the auspices of the Senate Military Committee. The gun used was a six-inch rifled breech-loading howitzer of the Moffat pattern. The shell was loaded with twelve pounds of explosive gelatine, containing 95 per cent. of pure nitro-glycerine. The firing-charge was the maximum that the gun would take, and was of common hexagonal powder. The projectile struck the target, exploding with a force that completely shattered both target and backing. The concussion of the air in the vicinity was terrific.

SNYDER SHELTER KNAPSACK.—This knapsack, the invention of Captain J. A. Snyder, of the U. S. Army, consists of ½ a shelter-tent; 3 sections of a tent-pole, with ferrules; 1 extra section suitable for top, center, or bottom piece; 1 bag, for clothing; 4 small tent-pins; 1 guy-rope; 1 set of straps. By combining two knapsacks a complete tent is made. The sections of the tent-pole are secured to the canvas by leather loops, and the sections of the pole are arranged in the loops in the shape of a square, making a sort of frame on one side. The 4 pins are secured in loops, inside of the sections of the pole. The pack, thus formed, has two straps on top, to which may be secured the overcoat, blanket, or poncho. The whole is carried on the back, well up on the shoulders by means of a broad neck-yoke tapering down toward the waist-belt. About half way between the shoulder and waist the piece forming the neck-yoke terminates in two straps, one going to the waist-belt and the other behind under the arms, hooking by brass loops to hooks in the knapsack. The knapsack is suspended by a ring on the top to a brass hook in the neck-yoke.

SOCIAL WARS. Wars with *Socii* or Allies. The most important Social War was between Rome and Italian peoples, such as the Samnites, Peligni, Marsi, etc., who desired to be admitted to the rights of citizenship. M. Livius Drusus, who had been the advocate of the Italian nationalities, was assassinated B. C. 91. The Italian allies of Rome at once revolted, and the Three Years' War that followed—during which over 300,000 men are said to have lost their lives—though the Romans, under Marius and Sulla, inflicted terrible losses upon the allies, was substantially a victory for the latter, who eventually were granted the rights demanded. Athens had two Social Wars, the first with the allied cities of Cos, Chios, and Byzantium, whose independence was secured B. C. 357-55; the second between Athens and the Ætolian and Achæn Leagues B. C. 220-17.

SOCKET.—A term generally employed to mean any hollow pipe that receives something inserted. The socket of a bayonet is the round hollow near the bend or heel of a bayonet, into which the muzzle of a fire-arm is received when the bayonet is fixed.

SODA WATER BOTTLES.—Bottles issued in India to European troops on the march, instead of wooden canteens, for holding drinking water. The bottles are covered with leather, and have a strap attached, by which the soldier can sling the bottle over his shoulder. A water bottle has lately been introduced into the service termed the *Italian* pattern. It is of wood, cut from the solid, and is furnished with a metal stopper. This pattern bottle is to be issued to all men in the dismounted services, and will be considered the universal pattern for general service.

SOD REVETMENT.—Sod-work forms a strong and durable revetment. The sods should be cut from a well-clothed sward, with the grass of a fine short

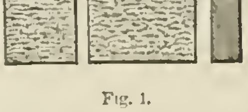


Fig. 1.

blade, and thickly matted roots. If the grass is long, it should be mowed before the sod is cut. Sods are of two sizes (Fig. 1.); one termed *stretchers*, are twelve inches square, and four-and-a-half inches thick; the others, termed *headers*, are eighteen inches long, twelve inches broad, and four-and-a-half inches thick.

The sod revetment (Fig. 2) is commenced as soon as the parapet is raised to the level of the tread of the banquette. A course of sods is then laid, either horizontally or a little inclined from the banquette; the course consists of two stretchers, B, and the one

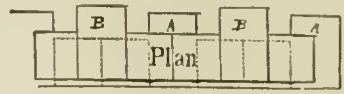


Fig. 2.

header, A, alternating, the end of the header laid to the front. The grass side is laid downward to facilitate the trimming of the top surface to a level or plane; and the sods should protrude a little beyond the line of the interior slope, for the purpose of trimming the course even at top, before laying another, and to make the interior slope regular. The course is firmly settled, by tapping each sod as it is laid with a spade or wooden mallet; and the earth of the parapet is packed closely behind the course. A second course is laid on the first, so as to cover the joints, or as it is termed, to *break joints* with it; using otherwise the same precautions as with the first. The top course is laid with the grass up; and in some cases pegs are driven through the sods of two courses to connect the whole more firmly, which is by no means necessary to form a strong sodding. When cut from a wet soil, the sods should not be laid until they are partially dried, otherwise they will shrink, and the revetment will crack in drying. In hot weather the revetment should be watered frequently, until the grass puts forth. The sods are cut rather larger than required for use, and are trimmed to a proper size from a model sod. See *Revetment*.

SOLAKS.—Bowmen or archers belonging to the personal guard of the Grand Seignor. They were always selected from the most expert bowmen that were among the Janissaries. Their only arms were the saber, bow, and arrows.

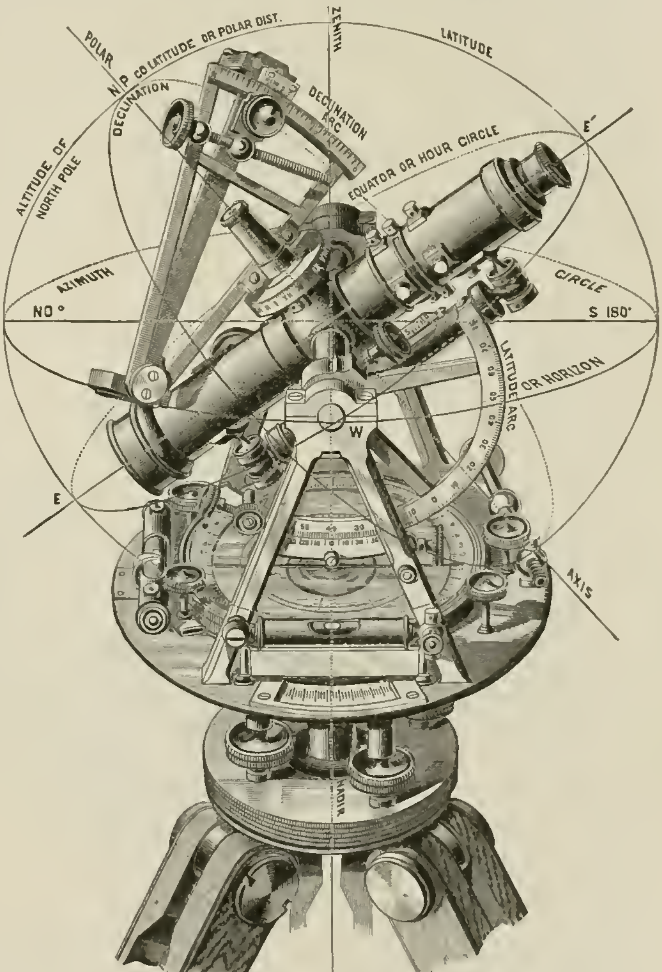
SOLAR ATTACHMENT.—An appartus placed upon a transit in order to determine the true meridian and deviation of the needle. The value and operation of the solar attachment will be better understood by a reference to the accompanying illustration. The apparatus is applied to the mountain transit, and the circles shown, represent in miniature those supposed to be drawn upon the concave surface of the heavens. When the telescope is made horizontal by its spirit level the hour-circle will be in the plane of the horizon, the polar axis will point to the zenith and the zeros of the vertical arc and its vernier coincide. In this position of the instrument, if the arm of the declination arc be placed at zero, and one lens directed to the sun, his image will be seen between the lines on the silver plate of the opposite block, as shown in the drawing, and will indicate his position in the heavens, on an instrument placed at the north pole of the earth at the time of equinoxes, or when the equator is in the plane of the horizon. Now if we incline the telescope as shown in the cut, the polar axis will descend from the direction of the zenith. The angle through which it moves, being laid off on the vertical arc, and shown by its vernier to be 40°, will be the co-latitude of the place where the instrument is supposed to be used, the latitude itself being found by subtracting 40° from 90°, making it just 50°. Now, if the declination-arm remains at zero, and the lens be again directed to the sun, his image will appear on the opposite plate as before, the instrument being used at the time of the equinox and at a latitude of 50°. When, however, the sun passes above or below the equator, his declination or angular distance from it, as given in the ephemeris, can be allowed for and set off upon the arc, and his image brought into position as before. In order to do this, however, it is necessary not only that the latitude and declination shall be correctly set off upon their arcs, but also that the instrument should be moved in azimuth until the polar axis points to the pole of the heavens,or,in other words,is placed in the plane of the meridian, and thus the position of the sun's image will indicate not only the latitude of the place, the declination of the sun for the given hour,and the apparent time, but also determine the meridian or true north and south line, passing through the place where the observation is made.

The adjustments of the solar attachments are as follows: 1. The solar lenses and lines are adjusted precisely like those of the ordinary solar,the declination-arm being first detached by removing the clamp and tangent-screws, and the conical center with its two small screws, by which the arm is attached to the arc. The adjuster,which is a short bar furnished with every instrument, is then substituted for the declination-arm, the conical center screwed in its place,at one end,and the clamp-screw into the other,being inserted through the hole left by the removal of the tangent-screw, and thus securing the adjuster firmly to the arc. The arm is then turned to the sun, as described in the article on the Solar Compass, and reversed by the opposite faces of the blocks upon the adjuster, until the image will remain in the center of the equatorial lines. This adjustment is very rarely needed, the lenses being cemented in their cells,and the plates securely fastened.

2. The vernier of the declination-arc is adjusted by setting the vernier at zero, and then raising or lowering the telescope by the tangent-screw until the sun's image appears exactly between the equatorial lines. Having the telescope-axis clamped securely, carefully revolve the arm until the image appears on the other plate. If precisely between the lines, the adjustment is complete; if not, move the declination-arm by its tangent-screw, until the image will come precisely between the lines on the two opposite plates: clamp the arm and remove the index error by loosening all the screws that fasten the vernier; place the zeros of the vernier and limb in exact coincidence,tighten the screws, and the adjustment is finished.

3. *To adjust the polar axis.*—First level the instrument carefully by the long level of the telescope,using in the operation the tangent movement of the telescope-axis in connection with the leveling-screws of the parallel plates until the bubble will remain in the center during a complete revolution of the instrument upon its axis. Place the equatorial-sights on the top of the blocks as closely as practicable with the view of a distant object; and having previously set the declination-arm at zero, sight through the interval between the equatorial-sights and the blocks at some definite point or object, the declination-arm being placed over either pair of the capstan-head screws on the under side of the disc. Keeping the declination-arm upon the object with one hand, with the other turn the instrument half around on its axis, and sight upon the same object as before. If the sight strikes either above or below, move the two capstan-head screws immediately under the arm, loosening one and tightening the other as may be needed until half the error is removed. Sight again and repeat the operation, if needed, until the sight will strike the same object in both positions of the instrument, when the adjustment of the axis in one direction will be complete. Now turn the instrument at right angles, keeping the sight still upon the same object as before; if it strikes the same point when sighted through, the axis will be truly vertical in the second position of the instrument. If not,bring the sight upon the same point by the other pair of capstan-head screws now under the declination-arc, reverse as before and continue the operation until the same object will keep in the sight in all positions. when the polar axis will be made precisely at right angles to the level and to the line of collimation of the transit.

It should here be noted that, as this is by far the most delicate and important adjustment of the solar attachment, it should be made with the greatest care,



the bubble kept perfectly in the center and frequently inspected in the course of the operation.

4. *To adjust the hour arc.*—Whenever the instrument is set in the meridian, the index of the hour arc should read apparent time. If not, loosen the two flat-head screws on the top of the hour circle, and with the hand turn the circle around until it does; fasten the screws again, and the adjustment will be complete. To obtain mean time, of course the correction of the equation for the given day, as given in the Nautical Almanac, must always be applied.

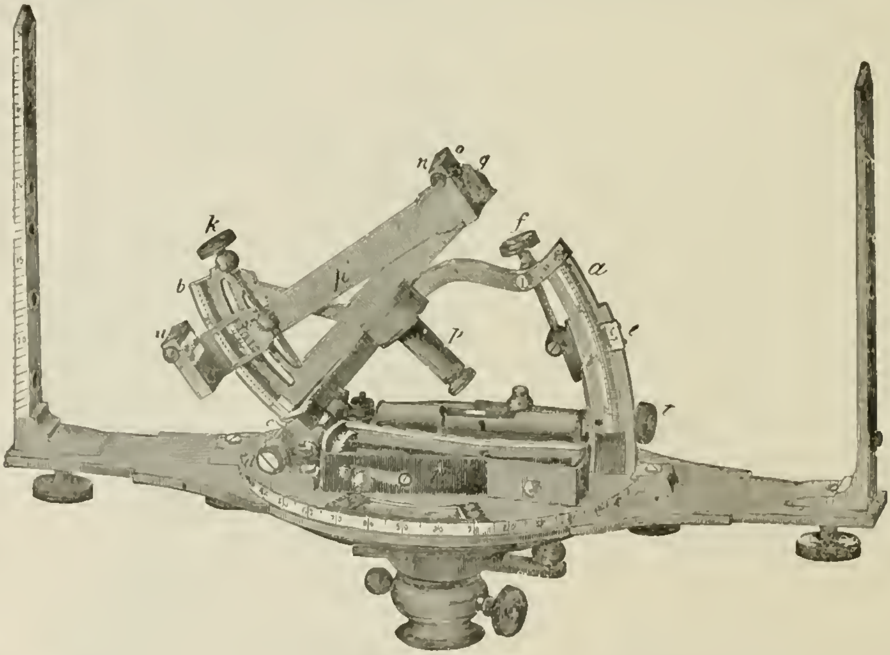
From the foregoing it will be readily understood, that good results can not be obtained from the solar attachment unless the transit is of good construction —furnished with the appliances of a level on a telescope, clamp and tangent movement to axis, and vertical arc with adjustable vernier, and the sockets or centers in such condition that the level of the telescope will remain in the center when the instrument is revolved upon either socket.

The solar attachment may be employed to run lines with great accuracy. Having set off the complement of the latitude of the place on the vertical arc, and the declination for the given day and hour as in the solar, the instrument being also carefully leveled by the telescope-bubble, set the horizontal limb at zero and clamp the plates together, loosen the lower clamp so that the transit moves easily upon its lower socket, set the instrument approximately north and south, the object end of the telescope pointing to the north, turn the proper solar lens to the sun, and with one hand on the plates and the other on the revolving arm, move them from side to side until the sun's image is brought between the equatorial lines on the silver plate.

The lower clamp of the instrument should be fastened and any further lateral movement be made by the tangent-screw of the tripod. The necessary allowance being made for refraction, the telescope will be in the true meridian, and being unclamped, it may be used like the sights of the ordinary solar compass, but with much greater accuracy and satisfaction in establishing meridian lines. Of course when the upper or vernier plate is unclamped from the limb, any angle read by the verniers is an angle from the meridian, and parallels of latitude or other angles from the true meridian may be established as with the solar compass. The bearing of the needle, when the telescope is on the meridian, will also give the variation of the needle at the point of observation. If the instrument has a movable compass circle, the variation of the needle can be set off to single minutes, the needle kept at zero, or "with the sun," and thus lines be run by the needle alone when the sun is obscured.

From what has been already said the intelligent surveyor will readily understand that the more perfect horizon obtained by the use of the telescope level, and the use of a telescope in the place of sights, render the new attachment more accurate than the ordinary solar compass. It can also be put on the telescope of any good transit at comparatively small cost, and thus enable the surveyor to establish the true meridian, to determine the correct latitude, and to obtain true time very nearly. Its adaptation to the purposes of illustration and instruction in practical astronomy in Colleges and Schools, will occur to every teacher; and we believe that for the Government Surveyor it furnishes a long-sought and much-needed instrument, superior, in many respects, to the solar compass now so commonly used. In experiments made, an error of about one-quarter of a minute in the direction of the true meridian, or in latitude, could be easily detected by observing the sun's image by a magnifier. See *Engineer's Transit* and *Saegmuller Solar Attachment*.

SOLAR COMPASS.—This instrument so ingeniously contrived for readily determining a true meridian or north and south line, was invented and patented in 1836. It has since come into general use in the surveys of U. S. public lands, the principal lines of which are required to be run with reference to the true meridian. The invention has long since become public property, and for over twenty years the solar compass has been manufactured by the Messrs. Gurley, with improvements of their own, which have made it increasingly popular and efficient. The arrangement of its sockets and plates is very similar to



that of the transit, except that the sight-vanes are attached to the under plate or limb, and this revolves around the upper or vernier plate on which the solar apparatus is placed. The limb is divided to half degrees, is figured in two rows, as usual, and reads by the two opposite verniers to single minutes. The divisions of the limb and all other arcs of the solar compass are made upon solid silver so as to avoid tarnishing.

The solar apparatus is seen in the place of the needle, and in fact operates as its substitute in the field. It consists mainly of three arcs of circles, by which can be set of the latitude of a place, the declination of the sun, and the hour of the day. These arcs, designated in the drawing by the letters *a*, *b*, and *c*, are therefore termed the latitude, the declination, and the hour-arcs respectively.

The latitude-arc, *a*, has its center of motion in two pivots, one of which is seen at *d*, the other is concealed in the drawing. It is moved either up or down within a hollow arc, seen in the drawing, by a tangent-screw at *f*, and is securely fastened in any position by a clamp-screw. The latitude arc is graduated to quarter degrees, and reads by its vernier, *e*, to single minutes; it has a range of about thirty-five degrees, so as to be adjustable to the latitude of any place in the United States.

The declination-arc, *b*, is also graduated to quarter degrees, and has a range of about twenty-eight degrees. Its vernier, *v*, reading to single minutes, is fixed to a movable arm, *h*, having its center of motion at the end of the declination-arc at *g*; the arm is moved over the surface of the declination-arc, and its vernier set to any reading by turning the head of the tangent-screw, *k*. It is also securely clamped in any position by a screw, concealed in the foregoing engraving. At each end of the arm, *h*, is a rectangular block of brass, in which is set a small convex lens, having its focus on the surface of a little silver plate, A, fastened by screws to the inside of the opposite block. On the surface of the plate are marked two sets of lines intersecting each other at right angles; of these, *b b* are termed the hour lines, and *c c* the equatorial lines, as having reference respectively to the hour of the day and the position of the sun in relation to the equator. On the top of each of the rectangular blocks is seen a little sighting-piece, termed the equatorial-sight, fastened to the block by a small milled head screw, so as to be detached at pleasure. They are used in adjusting the different parts of the solar apparatus.


A.

The hour-arc, *c*, is supported by the two pivots of the latitude-arc, already spoken of, and is also connected with that arc by a curved arm, as shown in the figure. The hour-arc has a range of about 120°, is divided to half degrees, and figured in two series, designating both the hours and the degrees, the middle division being marked 12 and 90 on either side of the graduated lines.

Through the center of the hour-arc passes a hollow socket, *p*, containing the spindle of the declination-arc, by means of which this arc can be moved from side to side over the surface of the hour-arc, or turned completely round as may be required. The hour-arc is read by the lower edge of the graduated side of the declination-arc. The axis of the declination-arc, or indeed the whole socket, *p*, is appropriately termed the polar axis.

Besides the parts shown in the drawing, there is also an arm used in the adjustment of the instrument as described hereafter, but laid aside in the box when that is effected. The parts just described constitute properly the solar apparatus. Besides these, however, are seen the needle-box, *n*, with its arc and tangent-screw, *t*, and the spirit levels, for bringing the whole instrument to a horizontal position.

The needle-box, *n*, has an arc of about 36° in extent, divided to half degrees, and figured from the center or the zero mark on either side. The needle, which is made as in other instruments, except that the arms are of unequal lengths, is raised or lowered by a lever shown in the cut. The needle-box is attached by a projecting arm to a tangent screw, *t*, by which it is moved about its center, and its needle set to any variation. This variation is also read off by the vernier on the end of the projecting arm, and reading to three minutes a graduated arc, attached to the plate of the compass.

The levels, as seen with the solar apparatus, have ground-glass vials, and are adjustable at their ends like those of any other instruments. The edge of the circular plate on which the solar work is placed, is divided and figured at intervals of ten degrees, and numbered as shown, from 0 to 90 on each side of the line of sight. These graduations are used in connection with a little brass pin, seen in the center of the plate, to obtain approximate bearings of lines, which are not important enough to require a close observation. The inside faces of the sights are also graduated and figured, to indicate the amount of refraction to be allowed when the sun is near the horizon.

The interval between two equatorial lines, *c c*, as well as between the hour lines, *b b*, is just sufficient to include the circular image of the sun as formed by the solar lens on the opposite end of the revolving arm, *h*. When, therefore, the instrument is made perfectly horizontal, the equatorial lines and the opposite lenses being accurately adjusted to each other by a previous operation, and the sun's image brought within the equatorial lines, his position in the heavens, with reference to the horizon, will be readily defined with precision.

Suppose the observation to be made at the time of one of the equinoxes; the arm, *h*, set at zero on the declination-arc, *b*, and the polar axis, *p*, placed exactly parallel to the axis of the earth. Then the motion of the arm, *h*, if revolved on the spindle of the declination-arc around the hour circle, *c*, will exactly correspond with the motion of the sun in the heavens, on the given day and at the place of observation; so that if the sun's image was brought between the lines, *c c*, in the morning, it would continue in the same position, passing neither above nor below the lines, as the arm was made to revolve in imitation of the motion of the sun about the earth.

In the morning, as the sun rises from the horizon, the arm, *h*, will be in a position nearly at right angles to that shown in the cut, the lens being turned towards the sun, and the silver plate, on which his image is thrown directly opposite. As the sun ascends, the arm must be moved around, until when he has reached the meridian, the graduated side of the declination-arc will indicate 12 on the hour circle, and the arm, *h*, the declination-arc, *b*, and the latitude-arc, *a*, will be in the same plane. As the sun declines from the meridian the arm, *h*, must be moved in the same direction, until at sunset its position will be the exact reverse of that it occupied in the morning.

Let us now suppose the observation made when the sun has passed the equinoctial point, and when his position is affected by declination. By referring to the Almanac, and setting off on the arc his declination for the given day and hour, we are still able to determine his position with the same certainty as if he remained on the equator. When the sun's declination is south, that is, from the 22d of September to the 20th of March in each year, the arc, *b*, is turned toward the plates of the compass, as shown in the engraving, and the solar lens, *o*, with the silver plate opposite are made use of in the surveys. The remainder of the year, the arc is turned from the plates, and the other lens and plate employed. When the solar compass is accurately adjusted, and its plates made perfectly horizontal, the latitude of the place, and the declination of the sun for the given day and hour, being also set off on the respective arcs, *the image of the sun cannot be brought between the equatorial lines until the polar axis is placed in the plane of the meridian of the place, or in a position parallel to the axis of the earth.* The slightest deviation from this position will cause the image to pass above or below the lines, and thus discover the error. We thus, from the position of the sun in the solar system, obtain a certain direction absolutely unchangeable, from which to run our lines, and to measure the horizontal angles required.

This very plain principle is not only the basis of the construction of the solar compass, but the sole cause of its superiority to the ordinary or magnetic instrument. For in a needle instrument, the accuracy of the horizontal angles indicated, and therefore of all the observations made, depends upon "the delicacy of the needle, and the constancy with which it assumes a certain direction, termed the magnetic meridian."

The principal causes of error in the needle, briefly stated, are the dulling of the pivot, the loss of polarity in the needle, the influence of local attraction, and the effect of the sun's rays, producing the diurnal variation. From all these imperfections the solar instrument is free. The sights and the graduated limb being adjusted to the solar apparatus, and the latitude of the place and the declination of the sun also set off upon the respective arcs, we are able, not only to run the true meridian, or a due east and west course, but also to set of the horizontal angles with minuteness and accuracy from a direction which can never change, and is unaffected by attraction of any kind.

The adjustments of this instrument, with which the surveyor will have to do, are simple and few in number, and will now be given in order.

1st. To adjust the levels.—Proceed precisely as directed for the mountain transit by bringing the bubbles into the center of the tubes by the leveling-screws of the tripod, and then reversing the instrument upon its spindle, and raising or lowering the ends of the tubes, until the bubbles will remain in the center during a complete revolution of the instrument.

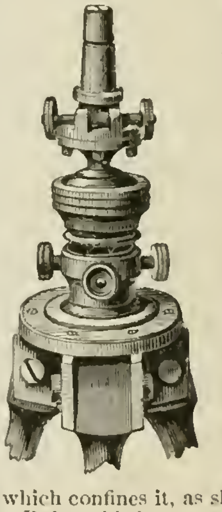
2d. To adjust the equatorial lines and solar lenses.—It is necessary, first, to detach the arm, *h*, from the declination-arc by withdrawing the screws shown in the cut from the ends of the posts of the tangent-screw, *k*, and also the clamp-screw, and the conical pivot with its small screws, by which the arm and declination-arc are connected. The arm, *h*, being thus removed, attach the adjuster in its place by replacing the conical pivot and screws, and insert the clamp-screw so as to clamp the adjuster at any point on the declination-arc. Now level the instrument, place the arm, *h*, on the adjuster, with the same side resting against the surface of the declination-arc as before it was detached. Turn the instrument on its spindle so as to bring the solar lens to be adjusted in the direction of the sun, and raise or lower the adjuster on the declination-arc, until it can be clamped in such a position as to bring the sun's image as near as may be between the equatorial lines on the opposite silver plate, and bring the image precisely into position by the tangent of the latitude-arc or the leveling-screws of the tripod. Then carefully turn the arm half way over until it rests upon the adjuster by the opposite faces of the rectangular blocks, and again observe the position of the sun's image. If it remains between the lines as before, the lens and plate are in adjustment ; but if not, loosen the three screws which confine the plate to the block, and move the plate under their heads, until one half the error in the position of the sun's image is removed. Again, bring the image between the lines, and repeat the process until it will remain in the same situation, in both positions of the arm, when the adjustment will be completed. To adjust the other lens and plate, reverse the arm end for end on the adjuster, and proceed precisely as in the former case, until the same result is attained. In tightening the screws over the silver plate care must be taken not to move the plate. This adjustment now being complete, the adjuster should be removed, and the arm, *h*, with its attachments, replaced as before.

3d. To Adjust the vernier of the declination-arc. —Having leveled the instrument, and turned its lens in the direction of the sun, clamp to the spindle, and set the vernier, *v*, of the declination-arc, at zero, by means of the tangent-screw at *k*, and clamp to the arc. See that the spindle moves easily and yet truly in the socket, or polar axis, and raise or lower the latitude-arc by turning the tangent-screw, *f*, until the sun's image is brought between the equatorial lines on one of the plates. Clamp the latitude-arc by the screw, and bring the image precisely into position by the leveling-screws of the tripod or socket, and without disturbing the instrument, carefully revolve the arm, *h*, until the opposite lens and plate are brought in the direction of the sun, and note if the sun's image comes between the lines as before. If it does, there is no index error of the declination-arc ; if not, with the tangent-screw, *k*, move the arm until the sun's image passes over half the error ; and again bring the image between the lines, and repeat the operation as before until the image will occupy the same position on both the plates. We shall now find, however, that the zero marks on the arc and the vernier do not correspond, and to remedy this error, the little flat-head screws above the vernier must be loosened until it can be moved so as to make the zeroes coincide, when the operation will be completed.

4th. To adjust the solar apparatus to the compass sights.—First level the instrument, and with the clamp and tangent-screws set the main plate at 90° by the verniers and horizontal limb. Then remove the clamp-screw, and raise the latitude-arc until the polar axis is by estimation very nearly horizontal, and if necessary, tighten the screws on the pivots of the arc, so as to retain it in this position. Fix the vernier of the declination-arc at zero, and direct the equatorial-sights to some distant and well marked object, and observe the same through the compass sights. If the same object is seen through both, and the verniers read to 90° on the limb, the adjustment is complete ; if not, the correction must be made by moving the position of the verniers.

It should be remarked that since the solar work is attached permanently to the sockets, and this adjustment is made by the maker, it will need no further attention at the hands of the surveyor except in case of serious accidents. The other adjustments are of course also made in the process of finishing the instrument, and are liable to very little derangement in the ordinary use of the solar compass.

For more rapid leveling of the solar compass, the



Messrs. Gurley have recently devised an arrangement represented in the drawing, which is screwed into the top of the tripod like the ordinary leveling head. This can be used either with a simple ball-spindle, or with the compound ball with tangent-screw as shown in the drawing. The instrument is leveled very nearly upon the ball, and finally made truly horizontal by the leveling-screws. It also revolves upon the spindle as upon the ordinary compass-ball, but it can be clamped at pleasure to the spindle, and then by the tangent-screw be directed precisely to any object. A simple ball with extra cap is also supplied, which can be easily substituted for the compound ball, by unscrewing the cap which confines it, as shown in the drawing.

Before this instrument can be used at any given place, it is necessary to set off upon its arcs both the declination of the sun as affected by its refraction for the given day and hour, and the latitude of the place where the observation is made.

The declination of the sun, given in the ephemeris of the Nautical Almanac from year to year, is calculated for apparent noon at Greenwich, England. To determine it for any other hour at a place in the U. S., reference must be had, not only to the difference of time arising from the longitude, but also to the change of declination from day to day. The longitude of the place, and consequently its difference in time, if not given directly in the tables of the Almanac, can be ascertained very nearly by reference to that of other places given, which are situated on, or very nearly on, the same meridian. It is the practice of surveyors in the States east of the Mississippi to allow a difference of *six* hours for the difference in longitude, calling the declination given in the Almanac for 12 M., that of 6 A. M., at the place of observation. Beyond the meridian of Santa Fe, the allowance would be about *seven* hours, and in California, Oregon, and Washington Territory very nearly *eight* hours. Having thus the difference of time, we very readily obtain the declination for a certain hour in the morning, which would be earlier or later as the longitude was greater or less, and the same as that of apparent noon at Greenwich on the given day. Thus, suppose the observation made at a place, say, five hours later than Greenwich, then the declination given in the Almanac for the given day at noon, affected by the refraction, would be the declination at the place of observation for 7 o'clock, A. M.; this gives us the starting-point. To obtain the declination for the other hours of the day, take from the Almanac the declination for apparent noon of the given day, and, as the declination is increasing or decreasing, add to or subtract from the declination of the first hour the difference for one hour as given in the ephemeris, which will give, when affected by the refraction, the declination for the succeeding hour; and proceed thus in making a table of the declination for every hour of the day.

To set off the latitude, find the declination of the sun for the given day at noon, at the place of observation as just described, and with the tangent-screw set it off upon the declination-arc, and clamp the arm firmly to the arc. Observe in the Almanac the equation of time for the given day, in order to know about the time the sun will reach the meridian. Then, about fifteen or twenty minutes before this time, set up the instrument, level it carefully, fix the divided surface of the declination-arc at 12 on the hour circle, and turn the instrument upon its spindle until the solar lens is brought into the direction of the sun. Loosen the clamp-screw of the latitude-arc, and with the tangent-screw raise or lower this arc until the image of the sun is brought precisely between the equatorial lines, and turn the instrument from time to time so as to keep the image also between the hour lines on the plate. As the sun ascends, its image will move below the lines, and the arc must be moved to follow it. Continue thus, keeping it between the two sets of lines until its image begins to pass above the equatorial lines, which is also the moment of its passing the meridian. Now read off the vernier of the arc, and we have the latitude of the place, which is always to be set off on the arc when the compass is used at the given place. It is the practice of surveyors using the solar compass to set off, in the manner just described, the latitude of the point where the survey begins, and to repeat the observation and correction of the latitude-arc every day when the weather is favorable, there being also nearly an hour at mid-day when the sun is so near meridian as not to give the direction of lines with the certainty required.

Having set off in the manner just given the latitude and declination upon their respective arcs, the instrument being also in adjustment, the surveyor is ready to run lines by the sun.

To do this, the instrument is set over the station and carefully leveled, the plates clamped at zero on the horizontal limb, and the sights directed north and south, the direction being given, when unknown, approximately by the needle. The solar lens is then turned to the sun, and with one hand on the instrument, and the other on the revolving arm, both are moved from side to side, until the sun's image is made to appear on the silver plate; when by carefully continuing the operation, it may be brought precisely between the equatorial lines. Allowance being now made for refraction, the line of sights will indicate the true meridian; the observation may now be made, and the flagman put in his position. When a due east and west line is to be run, the verniers of the horizontal limb are set at 90°, and the sun's image kept between the lines as before. The solar compass being so constructed that when the sun's image is in position the limb must be clamped at 0 in order to run a true meridian line, it will be evident that the bearing of any line from the meridian, may be read by the verniers of the limb precisely as in the ordinary magnetic compass; the bearings of lines are read from the ends of the needle.

In running lines, the magnetic needle is always kept with the sun; that is, the point of the needle is made to indicate 0 on the arc of the compass-box, by turning the tangent-screw connected with its arm on the opposite side of the plate. By this means the lines can be run by the needle alone in case of the temporary disappearance of the sun; but, of course, in such cases the surveyor must be sure that no local attraction is exerted. The variation of the needle, which is noted at every station, is read off in degrees and minutes on the arc, by the edge of which latter the vernier of the needle-box moves.

When very long lines are run by the solar compass, either by the true meridian, or due east and west, an allowance must be made for the curvature of the earth. Thus, in running north or south, the latitude changes about one minute for every distance of 92 chains 30 links, and the side of a township requires a change on the latitude arc of 5′ 12″, the township, of course, being six miles square. This allowance is of constant use where the surveyor fails to get an observation on the sun at noon, and is a very close approximation to the truth. In running due east and west, as in tracing the standard parallels of latitude, the sights are set at 90° on the limb, and the line is run at right angles to the meridian. If no allowance were made for the earth's curvature, these lines would, if sufficiently produced, reach the equator, to which they are constantly tending. Of course, in running short lines either east or west, the variation from the parallel would be so small as to be of no practical importance; but when long sights are taken, the correction should be made by taking fore and back sights at every station, noticing the error on the back sight, and setting off one half of it on the fore sight on the side towards the pole.

The time of day is readily ascertained by the solar compass when the sun is on the meridian, as at the time of making the observation for latitude. The time thus given is that of apparent noon, and can be reduced to mean time, by merely applying the equation of time as directed in the Almanac, and adding or subtracting as the sun is slow or fast. The time, of course, can also be taken before or after noon, by bringing the sun's image between the hour lines, and noticing the position of the divided edge of the revolving arm, with reference to the graduations of the hour circle, allowing for minutes of time for each degree of the arc, and thus obtaining apparent time, which must be corrected by the equation of time as just described.

In using the compass upon the sun, if the revolving arm be turned a little one side of its proper position, a false or reflected image of the sun will appear on the silver plate in nearly the same place as that occupied by the true one. It is caused by the reflection of the true image from the surface of the arm, and is a fruitful source of error to the inexperienced surveyor. It can, however, be readily distinguished from the real image by being very much less bright, and not so clearly defined.

When the bearings of lines, such as the course of a stream, or the boundaries of a forest, are not desired with the certainty given by the verniers and horizontal limb, a rough approximation of the angle they make with the true meridian, is obtained by the divisions on the outside of the circular plate. In this operation, a pencil, or thin straight edge of any sort, is held perpendicularly against the circular edge of the plate, and moved around until it is in range with the eye, the brass center-pin, and the object that is observed. The bearing of the line with great exactness is then read off at the point where the pencil is placed.

The solar compass, like the ordinary instrument, can be used at all seasons of the year, the most favorable time being, of course, in the summer, when the declination is north, and the days are long, and more generally fair. It is best not to take the sun at morning and evening, when it is within half an hour of the horizon, nor at noon, as we have before stated, for about the same interval, before and after it passes the meridian.

It will readily occur to all who have read the preceding description of the solar compass, that while it is indispensable in the surveys of public lands, it also possesses important advantages over the magnetic compass, when used in the ordinary surveys of the military engineer. For not only can lines be run and angles be measured without regard to the diurnal variation, or the effect of local attraction, but the bearings being taken from the true meridian, will remain unchanged for all time. The constant uncertainty caused by the variation of the needle, and the litigation to which it so often gives rise, may thus be entirely prevented by the use of the solar compass in determining all Government lines. It is also said by those familiar with the use of this instrument, that, in favorable weather, surveys can be more rapidly made with it than with the ordinary needle instrument; there being no time consumed in waiting for the needle to settle, or in avoiding the errors of local attraction. When the sun is obscured, the lines may be run by the needle alone, it being always kept with the sun, or at 0 on its arc, and thus indicating the direction of the true meridian. The sun, however, must ever be regarded as the most reliable guide, and should, if possible, be taken at every station. It is with the design of making the principles and use of the solar compass intelligible to all in the military service, that we have given a very extended account of this instrument, believing that when its merits become better understood, it will come into general use.

We have described the standard instrument of the United States, as made by Messrs. W. & L. E. Gurley, and it may be well to state briefly its points of superiority.

1. A motion of the horizontal plates almost entirely free from friction, combined with perfect solidity.

2. A fine clamp and tangent movement to the divided limb, as shown under the plate.

3 A tangent movement with clamp, for the declination-arc, as shown at *k*.

4. A tangent movement with clamp to the latitude-arc, as shown at *f*

5. A tangent motion for the whole instrument about its sockets, as shown in the last drawing.

6. Great facility of adjustment, and, consequently an important saving of time. See *Compass*, *Dial-compass*, *Engineer's Transit*, *Plain Compass*, and *Pocket Solar Compass*.

SOLAR TELEGRAPH.—A telegraph in which the rays of the sun are projected from and upon mirrors. The duration of the rays makes the alphabet, after the system of Morse. It was proposed to apply it to the use of the French Army in Algeria, the posts to be established at twenty leagues from each other. See *Heliostat*.

SOLDAN.—The title of the Lieutenant Generals of the Caliphs, which they bore in their Provinces and Armies. These officers afterwards made themselves Sovereigns. Saladin, General of the forces of King Noureddin of Damascus, was the first that took upon him this title in Egypt, 1165, after having killed the Caliph Caym.

SOLDER.—An easily fusible alloy used for joining metals. Solders are of various kinds, suited to different metals. They always require to be used with a flux, such as borax, resin, chloride of zinc, sal-ammoniac, etc. The following are the principal solders: *Pewterers' solder*—bismuth, 2 parts; lead, 4 parts; tin, 3 parts. This can be used for coarse work by the direct application of naked fire; but for fine work, requiring the protection of a muffle-furnace, the composition must be bismuth and lead, of each 1 part; tin, 2 parts. *Plumbers' solder* for coarse work—tin, 1 part; lead, 3 parts. For finer work—tin, 2 parts; lead, 1 part. *Spelter solder*—12 parts zinc to 16 parts of copper. *Soft spelter solder*—equal parts of copper and zinc. When solders are applied in the common work of plumbers and tinmen, a tool called the soldering-iron is used; this is made red-hot, and affords a convenient means of applying fire direct to the solder and flux. Although called the soldering-iron, the portion of the tool to be heated must be of copper. In many manufactures, a flame produced by a mixture of atmospheric air and coal-gas is used to melt the solder; and for fine work, the common blow-pipe is often used.

SOLDIER.—One who enters into an obligation to some Chieftain or Government to devote for a specified period his whole energies, and even if necessary his life itself, to the furtherance of the policy of that Chief or Government. The consideration may be immediate pay, or prospective reward; or the contract may be merely an act of loyal devotion. The acknowledgement of the service by the employer constitutes the man a recognized soldier, and empowers him to take life in open warfare, without being liable to the penalties of an assassin and a robber. The fact of being mercenary, that is, of receiving wages for killing and being killed, does not render a soldier's trade less honorable. He bears arms that others may be enabled to do without them; he is precluded by the exigencies of military training from maintaining himself by peaceful occupation; and it is therefore but fair that those whom he protects should support him, and give him, over and above actual maintenance, reasonable wages for the continual risk of his life. If a man willingly enlist himself as a soldier in what he believes to be an unrighteous cause, it is an act of moral turpitude; but when once enlisted, the soldier ceases to be morally responsible for the justice or iniquity of the war he wages; that rests with his employer. Obedience, implicit and entire, is his sole virtue. The maxim is, "The military force never deliberates, but always obeys."

SOLDIER OF FORTUNE.—During the frequent wars which occurred in Italy, before the military profession became so generally prevalent in Europe, it was usual for men of enterprise and reputation to offer their services to the different States that were engaged. They were originally called condottieri, or leaders of reputation. They afterwards extended their sphere of action, and under the title of *Soldiers of Fortune*, sought for employment in every Country or State that would pay them.

SOLDIERS' DAUGHTERS' HOME.—An Institution founded March 8, 1855, at Hampstead, for the maintenance and education, on the principles of the Church of England, of the daughters of soldiers, whether orphans or not. Every girl receives a supply of uniform clothing on admission, and an outfit of the value of nearly £8, including a Bible and a Prayer-book, when placed in service. Nearly one thousand girls have been received into the Asylum since its foundation, of whom 6 have been trained as Schoolmistresses and Assistant Teachers, and 261 have been placed in service, and have generally done well; 138 rewards of £2 and £1 each have been distributed among the girls in service for 2 years' continuance in one place with certified good conduct. There are now in the Home, where accommodation can be found for 200 girls, 170 girls, of whom 21 are supported by kind friends and by regiments, the remainder exclusively by the income of the Home.

SOLDIERS' FRIEND.—A term in the military service which is generally applied to such officers as pay the strictest attention to their men; granting them reasonable indulgencies without injuring the service; seeing their wants relieved, and above all things, enforcing just dealings and prompt settlements.

SOLDIERS' HOMES.—The first Institution of this character established by the United States Government was founded by Act of Congress passed March 3, 1851—"to found a Military Asylum for the relief and support of invalid and disabled soldiers of the Army of the United States." The funds to conduct this Institution originated in tribute levied by General Scott on the City of Mexico, after its capture, for the benefit of the United States Army. The Act referred to above defined the beneficiaries thereof to be soldiers who had served 20 years; pensioners, after surrendering their pensions; and persons disabled by wounds or sickness incurred in the military service of their country. Besides the sum of money already named, the Act appropriated an unexpended balance of a previous appropriation to the same purpose, and placed the Institution in charge of a Board of Commissioners, to include the General of the Army and those General Officers commanding the Eastern and Western Military Divisions; and the Chiefs of the Medical, Pay, Commissary, and Quartermaster's Departments, and the Adjutant General of the Army. This portion of the Act was revised by the Act of March 3, 1859, reducing the number of Commissioners to include only the Adjutant General, Surgeon General, and Commissary General of Subsistence.

The following funds are, at present, set apart for the maintenance of the *Soldiers' Home*:—All stoppages or fines adjudged against soldiers by sentence of Courts-Martial, over and above any amount that may be due for the reimbursement of government or individuals; all forfeitures on account of desertion; all moneys belonging to the estate of deceased soldiers, which may be unclaimed for the period of three years subsequent to the death of said soldier or soldiers, to be repaid by the Commissioners of the Institution, upon the demand of the heirs or legal representatives of the deceased; also the sum of 12½ cents per month is stopped from every Non-commissioned Officer, musician, artificer, and private of the United States Army.

Applications for admission to the Soldiers' Home are made to the Adjutant General of the Army for reference to the Board of Commissioners. When a soldier, by reason of old age and long service, or of disability contracted in line of duty, becomes a candidate for admission to the Soldiers' Home, his Company Commander so reports, through proper military channels, to the Adjutant General of the Army, giving all details that may be needed for a full understanding of the case. This report is referred to the Board of Commissioners of the Home, and if, in their opinion, the soldier is entitled to become an inmate, the necessary authority is then given to order him to Washington for temporary admission to the Soldiers' Home. The Governor of the *Home*, in less than thirty days, reports the man's physical condition to the Adjutant General, with a view to his return to duty or discharge from the service. The descriptive list, *which should be sent by mail*, gives full particulars in regard to physical condition and the circumstances under which any disability may have been contracted.

It is expected that men already discharged from the Army, and entitled to admission to the Home, will bear their own expenses in reaching it. Urgent exceptional cases may be reported to the Adjutant General for decision of the Secretary of War. The transportation, by the Quartermaster's Department, of persons to the Soldiers' Home is forbidden, unless it is ordered by the Secretary of War on the application of the Board of Commissioners of the Soldiers' Home. Inmates of this Institution receive a small allowance of pocket-money per month, and they are also paid for any labor they can perform. About $8 per month is allowed to old soldiers, who, having families, are permitted to live elsewhere than at the Home.

Various temporary Asylums were erected or leased between 1851 and 1857. In 1851 a purchase of land was made for this purpose in the City of Washington, distant about 3½ miles from the Capitol; including, with later purchases, about 460 acres. This is, in fact, the only permanently established Soldiers' Home under the Act of 1851. It comprehends a farm, orchards, gardens, park, etc.; the building of white marble calculated to accommodate about 500 inmates at one time; and a chapel, well-stocked library, and hospital complete the excellent service of the Institution. The number of inmates of this Establishment up to the year 1878 was in the neighborhood of 2,000. Besides this one there were founded under the Acts of 1865 and 1873 Homes for the volunteer soldiers of the war of 1861–65 in Chelsea, near Augusta, Maine; Hampton, Virginia; Dayton, Ohio; and Milwaukee, Wisconsin. Appropriations are made annually by Congress for the support of these Institutions. Similar Institutions are the Chelsea Hospital, in England, Kilmainham Hospital, near Dublin, and similar establishments in Berlin. See *Royal Military Asylum* and *Hôtel des Invalides*.

SOLDIERS' THIGH.—When tight breeches were worn in the British Army, the term had its peculiar military application, from the notorious poverty of Army men. *Soldiers' thigh* figuratively means an empty purse; or, speaking familiarly, a pair of breeches that fit close and look smooth, because the pockets have nothing in them.

SOLDIERY.—Soldiers collectively. A body of soldiers. The military.

SOLDURIERS.—A term anciently used among the French, to signify those persons who attached themselves to some particular General or Military Knight, whose fortunes they followed, in consequence of being paid and supported by him.

SOLE.—1. A veterinary term. That portion of a horse's foot which, together with the bars and frog, comes in direct contact with the ground. 2. In fortification, the foot or bottom of the embrasure. This is frequently termed *solid*.

SOLERET A LA POULAINE.—The first recorded pointed soleret. It was used in the first half of the 14th century, and is so called *poulaine*, from the prow of a galley. See *Solerets*.

SOLERET ARC TIERS POINT.—The form of soleret worn from 1450 to 1485. See *Solerets*.

SOLERET BEC DE CANE.—This form of soleret was employed about 1560, and must not be confounded with those called *ogivale tiers point* of the fifteenth century. See *Solerets*.

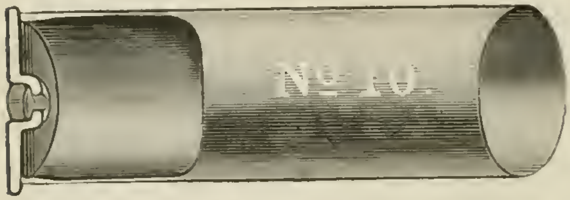
SOLERET DEMI-POULAINE.—The form of soleret worn in the latter part of the 14th century. Sometimes called *ogivale de lancette*. See *Solerets*.

SOLERET DEMI-SABOT.—The variety of soleret worn about 1480 and 1485. It forms part of the Maximilian fluted suit. The shape of this soleret indicates the end of the 15th, and slightly the beginning of the 16th century. See *Solerets*.

SOLERET PIED D'OURS.—A style of *soleret* shaped like a bear's paw, belonging to fluted armor and worn from 1490 to 1560. It was followed by the form *Bec de cane*. See *Solerets*.

SOLERETS.—Articulated plates or coverings for the feet in iron. They do not appear to date farther back than the first of the 14th century. The first known *soleret* is pointed (*soleret à la poulaine*). This shoe, towards the middle of the 14th century, made way for the *demi-poulaine* or *ogivale de lancette*, and reappeared toward the close of the century. In the 15th century, appeared the styles or shapes—*arc tiers point*, *demi-sabot*, *pied d'ours*, and *bec de cane*. This last soleret was replaced by the boot and top boot. Also written *Soulière*.

SOLID HEAD SHELL.—The construction of this shell, shown in section in the drawing, is extremely simple. The fulminate is in a cap, and is struck by a firing-pin when the hammer descends. Both the center and rim-fire cartridges require the firing-pin of the gun to be specially arranged, in order to strike the cartridge at the proper point, though cartridges have been devised in the United States to be both rim and center-fire, and guns have also been made to fire either or both kinds of cartridges. The idea of using sheet-metal for this purpose seems to have originated with the French. In 1826, Cazalat patented a shell of this kind, having a receptacle with a covering patch of water-proof paper for the fulminate at its base. A hole in the bottom of the cup admitted fire



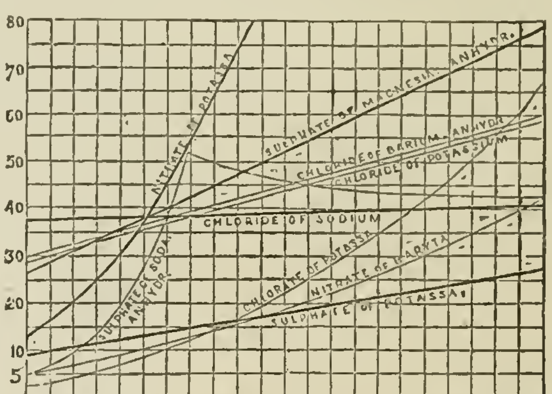
Solid Head No. 10—shot shell cut open.

to the charge. This appears to have been in advance of the age, being drawn from a single piece of copper, and being *center-fire*. See *Cannon-primers*, and *Center-fire Metallic-case Cartridge*.

SOLID SHOT.—Solid projectiles are used in guns and small-arms, and produce their effect by impact alone. When used in heavy guns they are known as *solid shot, round shot*, or *shot*. They are made of cast-iron, and on account of their very great strength and density, and the comparatively large charges of powder with which they are fired, are used when great range, accuracy and penetration are required. They are the only projectiles that can be used with any great effect against very strong stone walls, or floating batteries covered with wrought-iron plates. Solid shot for guns are classified according to their weight, which, in the United States' land service, is as follows, viz.; Field service, 6 and 12-pounders; siege service, 12, 18, and 24-pounders; sea-coast service, 32 and 42 pounders. Solid shot for columbiads are classified according to the diameter of the bore, as 8 and 10-inch solid shot. These projectiles are very often made of steel. The only *solid* shot used in the English service for rifled guns are the Paliser shot of the following calibers: 12½-inch, 12-inch, 10-inch, 9-inch, 8-inch, and 7-inch, and they are only intended to be used against iron-clad vessels. See *Bullet, Projectiles, Shot, Studded Projectiles*, and *Weight of Projectiles*.

SOLID SQUARE.—A square body of troops; a body in which the ranks and files are always equal.

SOLUTION.—A substance is said to undergo solution, or to become dissolved, whenever the force of adhesion between it and a liquid in which it is immersed is sufficient to overcome the force of cohesion between the solid particles. Thus sugar or salt is dissolved by water, camphor or resin by spirit of wine, and silver by mercury. The liquid which effects the solution is termed the *solvent*, or sometimes *menstruum;* and some solutions have special names, for example, the term *syrup* is applied to a solution of sugar in water; *tincture* to solution of a solid in alcohol. If a solid body be introduced in successive small portions into a definite quantity of a liquid capable of dissolving it, the first portions disappear the most rapidly, and each successive portion dissolves more slowly than its predecessor, until a point is reached at which the liquid ceases to possess any further solvent power. When this occurs the forces of cohesion and adhesion are balanced, and the liquid is said to be *saturated*. Solution is promoted by increasing the extent of surface in a solid, or by reducing it to powder. An elevation of temperature, by diminishing cohesion, will generally also increase the solvent power of the liquid; but there are exceptions to this rule—as for instance, in the case of lime and its salts, water just above the freezing-point dissolving nearly twice as much lime as it does when boiling. A compound of lime and sugar, very soluble in cold water, is separated from the solution almost completely if heated to boiling. But the most remarkable case of the kind occurs in sulphate of soda (Glauber's salt), which in its crystalline form dissolves in about ten times its weight of ice-cold water, and rapidly becomes more soluble as the temperature rises until it reaches 91°, from this point until the solution boils the solubility slightly decreases, the boiling liquid retaining, however, about four-fifths of the quantity which was dissolved at 91°. Carbonate and seleniate of soda, and sulphate of iron, exhibit the same peculiarity in a less marked degree. "These anomalous results may be partly explained," says Dr. Miller, "by the consideration that heat diminishes the force of adhesion as well as that of cohesion. Generally speaking, cohesion is the more rapidly diminished of the two, but not uniformly so, and in these cases it would appear that the adhesive force decreases in a greater ratio than the cohesion of the saline particles." The accompanying diagram shows the unequal solubility of various of the more common salts in water of different temperatures. The *lines of solubility* cut the verticals raised from points indicating the temperature upon the lower horizontal line, at heights proportional to the quantities of salt dissolved by 100 parts of water. For example, 100 parts of water dissolve—at 32°, 8 parts; at 122°, 17 parts; and at 212°, 26 parts of sulphate of potash. Water which has been saturated with one substance—that is, which refuses to dissolve any more of that substance, will very often continue to dissolve others. In true or simple solution the properties, both of the solid and the solvent, are retained. When, however, any chemical action ensues between the solid and the liquid, the resulting solution commonly presents perfectly new and distinct features; as, for example, when the metals are dissolved by acids, or oils by the alkalies (as in soap-making). The uses



of solution in laboratory processes are numerous. By the difference in degree of their solubility we can separate one substance from another; and by dissolving a body we can purify it, either by filtration or by crystallization. Moreover, when it is required that two bodies shall react on one another, they do so with incomparably more force in their dissolved than in their solid state.

SOMERSET.—A saddle for the wounded, padded before the knee and behind the thigh. The first saddle of this kind was made for Lord Fitzroy Somerset who had lost his leg below the knee at the battle of Waterloo, and from whom it took its name.

SORN.—Formerly a servile tenure in Scotland, by which a Chieftain might, with all his followers, live upon his tenants at free quarters.

SORTIES.—These, if well timed, will generally decide the fate of the affair. They should be made when the assaulting column is thrown into confusion, or shows any signs of irresolution in its movements;

or when its flank or its rear is carelessly exposed. They are sometimes made to alarm the enemy for his own safety; or to make a diversion in favor of expected succors in blockaded posts. Cavalry is the best arm for a sortie, on account of the rapidity of its movements, and the violence of its shock. When infantry is employed for this purpose, it should use the bayonet alone. Should the enemy succeed in forcing his way into the work, the reserve must attack with the bayonet, before he has time to form; but it must be confessed that success oftener crowns an offensive movement, on the part of the assailed, in endeavoring to regain possession of their works, than any effort to drive back the enemy at the moment, when flushed with success, he has the hope of a certain victory. The only well-grounded prospect that the assailed have of repelling the assault, when the enemy has gained the top of the scarp, is to meet him in an offensive attitude at the point of the bayonet on top of the parapet. The particular arrangements of the defense consist in defending all obstacles, such as abattis, palisadings, etc., by a warm well-aimed fire, as the particular object of all these obstacles is to keep the enemy exposed for a longer time to the fire. Large stones, heavy round logs, and the loaded hollow projectiles, should be in readiness to be rolled over on the enemy whilst he is in the ditch endeavoring to mount the scarp. Large branches of trees prepared as for an abattis, with chevaux-de-frise, and other obstacles, should be at hand to obstruct the breach. Finally, in an isolated post, if the enemy, after having been repulsed makes a show of blockading it, or of renewing his attack, and there is no prospect of succor arriving, the garrison should attempt an escape by night.

In siege operations, the policy of the besiegers is to expose as little as possible to the chances of hand-to-hand conflicts, but to endeavor to gain their ends by the action of their artillery, and by skill and perseverance, pushing forward their trenches until they reach the last position that the besieged can take up, still keeping under cover. The besieged, however, are often constrained to a bolder course; sometimes to open the way for succors to reach them; and sometimes to avail themselves of opportunities presented by the very great mistakes of the besiegers trying to drive them from their trenches, spike the guns of their batteries, and even destroy their depots. The parallels and their guards are to provide against such attacks; and, with proper measures and due vigilance, they ought never to succeed, but the besieged be made to pay dearly for each attempt. In past sieges, when the first parallel was usually opened at about 600 yards from the defenses, a sortie against it was regarded as a very uncertain operation, and only to be attempted when the garrison was strong and had a respectable force of cavalry and of light batteries to act with their infantry in the sortie. This contingency, however, should be guarded against by having the flanks of the first parallel secured by a redoubt armed with field-guns; with the epaulments for cavalry thrown up a few hundred yards to the rear of the flanks; and by a suitable reserve ready to move forward at a moment's notice to the support of the troops in the parallel. After the first parallel is completed and occupied by the guards, the besieged will seldom attempt a sortie in force before the ground is broken upon the position of the second parallel, and the besiegers should be prepared for this probability by having an extra force in and near the first parallel, to support the few guards who may be in the advanced boyaux for the protection of the workmen from the sorties of small bodies. So soon as a serious movement of the besieged beyond their defenses is observed, the working parties should be withdrawn in a prompt and orderly manner, taking with them all their trenching-tools, along the approaches, the guards in these covering their movement to rear, thus leaving the front of the first parallel unmasked to deliver its fire on the sortie. No effort is made to check the sortie except by the fire of the trenches until the troops composing it have reached the advanced trenches, when a charge may be made over the steps made for that purpose in the trench and parapet of the parallel, or through breaks left in the parallel itself of sufficient width for the passage of a column of infantry. From the completion and occupation of the second parallel, none but sorties of small bodies, seldom exceeding fifteen men are to be apprehended, with the object of temporarily stopping some approach.

SOUGH.—A small drain at the foot of an embankment, to convey the surface water from it into a side drain. Also, an *adit* or *day-level* for carrying off the water.

SOUND.—The impression produced on the ear by the vibrations of the elastic medium, such as air or water, in which it is plunged. That this is the case is proved, *first*, by the fact that a bell or tuning-fork *in vacuo* gives no sound when struck; *second*, by the fact that the mere currents, as such (winds, running water, etc.), do not produce the sensation of sound until they are frittered down into vibratory motions by obstacles. The general nature of the mechanical process by which sound is propagated in the air will be illustrated, and compared with the other cases of wave-motion, in our article on WAVES. Meanwhile, it is only necessary for us to observe that, as the velocity of sound is ten times greater than that of wind in the most violent hurricane, it is not the *air* itself which is transferred from place to place, but a *state of disturbance* (condensation or rarefaction) of the air.

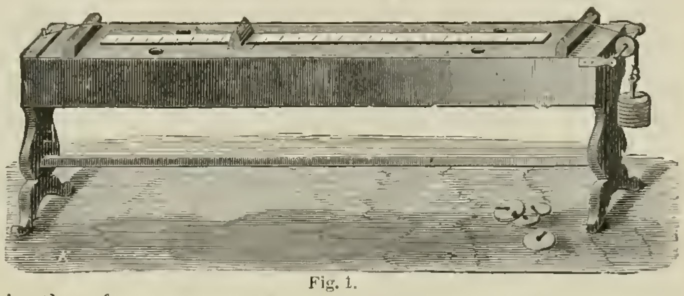


Fig. 1.

Each successive layer of air in the path of the sound suffers this disturbance in turn, and by virtue of its elasticity passes it on to the next. Newton was the first who attempted to deduce from mechanical principles the velocity of sound, but only for the particular case in which each particle of air in the path or the sound is supposed to move backward and forward according to the same law as the bob of a pendulum. He showed that this species of motion is consistent with the elastic properties of air, as given by Boyle's or Mariotte's law, viz., that the pressure of air is proportional to its density. The velocity of sound in this case is of course to be found from the time which elapses between the commencement of the motion of any one particle of air, and that of another at a given distance from it, in the direction in which the sound is moving. The numerical result deduced by Newton with the then received experimental data for the compressibility of air, was 979 ft. per second. This investigation was very defective, applying, in fact, solely to the special case of a pure musical note, continually propagated without lateral divergence; yet the solution obtained by Lagrange from a complete analysis of the question, gave precisely the same mathematical result. But, by direct measurements, carefully made, by observing at night the interval which elapses between the flash and the report of a cannon at a known distance, the velocity of sound has been found to be considerably greater—in fact, about 1,090 feet per second, at the temperature of freezing water. Newton seeks for the discrepancy between theory and observation in the idea that the size of the particles of air is finite compared with their mutual distance; and that sound is instantaneously propagated through the particles themselves. Thus, supposing the particles to have a diameter $\frac{1}{9}$th of the distance between them, we must add $\frac{1}{9}$th to the space traveled by sound in a second, *i.e.*, to the velocity—which will thus be brought up to $(1+\frac{1}{9})$ 979 feet.=1088 feet, nearly, which is a very close approximation to the actual value given above.

This is not one of Newton's happiest conjectures—for, independent of the fact that such an assumption would limit definitely the amount of the compression which air could undergo, and, besides, is quite inconsistent with the truth of Boyle's law for even moderate pressures, it would result from it that sound should travel slower in rarefied, and quicker in condensed air. Now, experiment shows that the velocity of sound is unaffected by the height of the barometer; and, indeed, it is easy to see that this ought to be the case. For in condensed air the pressures are increased proportionally to the increase of condensation, and the mass of a given bulk of air is increased in the same proportion. Hence, in a sound-wave in condensed air, the forces and the masses are increased proportionally, and thus the rate of motion is unaltered. But the temperature of the air *has* an effect on sound, since we know that the elastic force is increased by heat, even when the density is not diminished; and therefore the velocity of sound increases with the temperature at the rate of about $4\frac{1}{2}$ feet per Fahr. degree, as is found by experiment. Newton's explanation of the discrepancy between theory and experiment being thus set aside, various suggestions were made to account for it; some, among whom was Euler, imagining that the mathematical methods employed, being only approximate, involved a serious error. The explanation was finally given by Laplace, and is simple and satisfactory. When air is *suddenly* compressed (as it is by the passage of a sound wave), it is heated; when suddenly rarefied it is cooled, and this effect is large enough to introduce a serious modification into the mathematical investigations. The effect is in either case to *increase* the forces at work—for, when compressed, and consequently heated, the pressure is greater than that due to the mere compression—and, when rarefied, and consequently cooled, the pressure is diminished by more than the amount due to the mere rarefaction. When this source of error is removed, the mathematical investigation gives a result as nearly agreeing with that of observation as is consistent with the unavoidable errors of all experimental data. It is to be observed that, in noticing this investigation, nothing has been said as to the pitch or quality of the sound, for these have nothing to do with the velocity. It must, however, be remarked here that, in the mathematical investigation, the compressions and rarefactions are assumed to be very small; *i.e.*, the sound is supposed to be of moderate intensity. It does not follow, therefore, that very violent sounds have the same velocity as moderate ones, and many curious observations made during thunder-storms seem to show that such violent sounds are propagated with a greatly increased velocity. It is recorded that in one of Parry's Arctic voyages, during gun-practice, the officer's command "Fire" was heard at great distances across ice *after* the report of the gun.

Since sound consists in a wave-propagation, we should expect to find it exhibit all the ordinary phenomena of waves. Thus, for instance, it is *reflected* according to the same law as light. It is *refracted* in passing from one medium to another of different density or elasticity. This has been proved by concentrating in a focus the feeble sound of the ticking of a watch, and rendering it audible at a considerable distance, by means of a lens of collodion films filled with carbonic acid gas. Sounds *interfere* to reinforce each other, or to produce silence; just as the crest of one wave in water may be superposed on the crest of another, or may apparently destroy all motion by filling up its trough. The simplest mode of showing this is to hold near the ear a vibrating tuning-fork and turn it slowly round its axis. In some positions, the sounds from the two branches reinforce, in others they weaken, each other. But if, while the sound is almost inaudible an obstacle be interposed between the ear and one of the branches, the sound is heard distinctly. Beats form another excellent instance.

The most untutored ear distinguishes at once between a mere *noise* and a *musical note*. It of course distinguishes a *loud* sound from a faint one. Moreover, it distinguishes musical notes from one another by their shrillness or gravity, or, as it is technically called their *pitch*. Again, as in the case of vowel-sounds sung to the *same* musical note, or as in the case of different instruments (flute and violin for instance) playing the same note it distinguishes something further—which is called the *quality* of the note. It is on the pitch of notes that the theory of music is based, for the quality is only of importance in giving variety as in band music—or in giving richness of tone in a solo. The most perfect *music*, so far as theory goes, may be executed on the poorest instrument, but it gives little pleasure from the want of richness or quality. In the same way a singer may possess faultless intonation, yet the performance, though *musically* perfect, may, from the harsh quality of the voice,

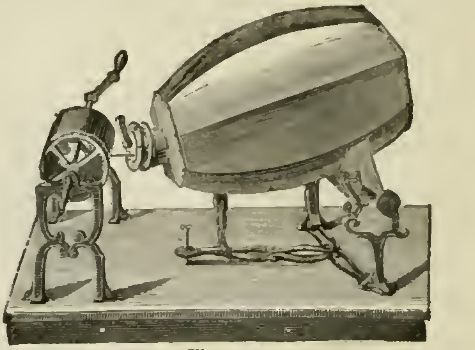


Fig. 2.

be unpleasant. Many interesting experiments may be made with the sonometer, a simple form of which is shown in Fig. 1. This instrument will serve to determine the number of vibrations made by a string emitting musical sound. It is provided with a series of weights, to vary the tension of the string. The scale is divided to correspond to the modified chromatic gamut, the true chromatic gamut, or the French meter divided to thousandths, at pleasure. By means of the phonautograph, represented in Fig. 2, phonetic sounds may be recorded automatically by diagrams in a manner analogous to that in which the indicator-diagram of a steam-engine records the pressure of the steam. The future of this instrument is undetermined. It would be possible to so connect the style with electrical devices that its excursions, both as to distance and continuity, might be exactly repeated at any distance by the telegraphic circuit; or the instrument might be made to operate a type-writer, and so the words spoken might become a record printed in ordinary letters on paper.

The various simple sounds which can be obtained from a string are called *harmonics* of the fundamental note; the latter being the sound given by the string when vibrating as a whole. For each vibration of the fundamental note, the harmonics have two, three, four, and etc. Of these, the first is the octave of the fundamental note; the second the twelfth, or the fifth of the octave; the third the double octave; and so on. Thus, if we have a string whose fundamental note is C, the series of simple sounds it is capable of yielding is:

C, C_1, G_1, C_2, E_2, G_2, (B $flat_2$) C_3 D_3 E_3, etc.

Of those written, all belong to the ordinary musical scale except the seventh, which is too flat to be used in music. This slight remark shows us at once how purely artificial is the theory of music, being founded not upon a physical, but on a sensuous basis. To produce any one of these harmonics with ease from a violin string, we have only to touch it lightly at $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., of its length from either end and bow as usual. This process is often employed by musicians, and gives a very curious and pleasing effect with the violoncello or the double-bass. The effect of the finger is to reduce to rest the point the string touched; and thus to make it a point of no vibration, or as it is technically called, a *node*. In the case of a piano-forte wire, a blow is given near one end, producing a displacement which runs back and forward along the wire in the time in which the wire would vibrate as a whole. The successive impacts of this wave on the ends of the wire (which are firmly screwed to the sounding-board), are the principal causes of the sound.

The theory of band instruments is quite as simple. Thus, in a flute, the sound is produced by a current of air passing across an orifice at the closed end. This produces a wave which runs along the tube, is reflected at the open end, runs back, and partially intercepts the stream of air for an instant, and so on. Thus the stream of air is intercepted at regular intervals of time, and we have the same result as in the sirène. In this case, there is but *one* node, viz., at the middle of the pipe. If we blow more sharply, we create two nodes, each distant from an end by $\frac{1}{4}$ of the length of the tube. The interruptions are now twice as frequent, and we have the first harmonic of the fundamental note. And so on, the series of harmonics being the same as for a string.

SOUTH BOSTON FOUNDRY.—The South Boston Foundry possesses the only works for heavy ordnance existing in this country, and can cast guns weighing ninety tons in the rough. The West Point Foundry makes the production of coiled wrought-iron tubes a specialty, and produces medium and light ordnance. Both make all varieties of guns and projectiles, but the South Boston Foundry has, also, with the Ames Company, of Chicopee, Mass., been since 1836 recognized contractors for bronze guns. The survival of the existing ordnance-works has been due not to chance but to their excellent work, and, failing proper support on the part of Congress, to their engaging in other lines of manufacture. The South Boston Iron Company, for instance, was the first maker of chill rolls in this country, Mr. Alger having patented the method in 1811; also improvements in plows and cylinder stoves for anthracite before 1840, later, fine statuary castings in iron; and heavy machinery was made from the first or since 1828. At all times many foundry specialties, such as gearing, pulleys, kettles, etc., have been made. About forty years ago almost all the machine-shops of Boston and vicinity drew their castings from "Alger's Foundry." Captain Thos. A. P. Catesby Jones writes in 1835 concerning the different foundries: "The Boston Foundry, owned by Mr. Alger, has not, I believe, cast *any* guns for the Navy, nor am I certain that he has for the Army; but for shot he had a considerable contract with the Ordnance Department in 1833, and his specimens were the best I have ever seen. And from the extensive plan, perfect machinery, and the experienced workmen connected with that work, I should place great confidence in the productions of that Foundry."

All the cannon and shot required for the gradual increase of the Navy were cast at the Columbian, Bellona, and the West Point Foundries. The quality of the castings of these three works does not materially differ, but the shot turned out by the West Point Foundry are greatly superior in all respects to those cast at the Bellona and Columbian Foundries. Lieutenant Wahlback states, in his Annual Report in 1847, that "the cannon furnished by the South Boston Iron Foundry have all been cast since the revised regulations of 1840, and are not, therefore, included in the foregoing. The few trials I have made of guns from this Foundry have afforded the most favorable results, and the quality of the metal is unsurpassed." About 1840 the character of "gun-iron" used for ordnance became definitely fixed, largely due to the efforts of Major Wade. Previous to that time, each foundry used its own iron in its own way, taking either hot or cold-blast, and of the grade the founder thought best. But it was found about that time that only cold-blast charcoal-iron carefully made, properly mixed, and refined in air furnaces, gave uniformly good and very reliable results. A knowledge of the mechanical properties of metals was first exactly obtained by Major Wade's testing-machine, which has gone all over the world as the American testing-machine. Originally called the "Metallo-Dynamometer," it was built by Mr. Alger about 1840 under the directions of Major Wade, and the original machine is still in daily use at the foundry, giving accurate results. The knowledge thus gained enabled the value of new guns to be fixed, from the character of their metal, without subjecting them to the damaging proof previously applied to each gun. Their reliability was shown by a few rounds of service charges, and American guns cast under the United States regulations since 1840 have had the highest reputation for strength and endurance.

The South Boston Iron Company began to cast heavy guns about 1839, and erected in 1842 what was then the heaviest shop in the country for ordnance. Previous to that time many light guns of bronze and cast-iron up to twenty-four-pounders had been made. Beginning at that period it had the advantage of all previous failures and avoided the hap-hazard methods of the earlier foundries. About 1836 Cyrus Alger patented and made the first guns of malleable iron, cast and converted in an oven, supplying fifteen of them during 1837 and 1838. The first gun rifled in America was rifled at the Foundry in 1834. About 1840 Mr. Alger invented the following improvements in fuses and in casting shell, all of which have been adopted and are still in use in the United States service and abroad, but for which he received no compensation whatever from the Government.

First.—The use of a fuse composition rammed in a paper case fitting into a wooden or metal plug inserted in the shell. *Second.*—A safety-plug of lead fitting like a cup in the bottom of the paper case, the top edges of the cup are thin enough to expand tightly against the paper, but be easily detached and the cup thrown into the shell cavity by the shock of discharge. The cup will thus ordinarily shut off the fuse from the powder, but opens the passage as soon as the fuse begins to burn. *Third.*—A safety-cap to ensure the ignition of the fuse under all circumstances combined with a leaden disc, and removed when loading, to prevent ignition out of the gun. *Fourth.*—Placing the holes for the escape of gas from the burning fuse in a metal plug and obliquely, and in such a position that the fuse is not extinguished by mud nor by ricochetting on water. *Fifth.*—The use of a metal bushing in connection with a hollow core-arbor to receive the fuse, "that is, a bushing, with a small hole to receive fuse, which is placed directly upon the core-arbor, and, is retained in place as a part of the shell by the metal cast around it."

These fuses were immediately adopted, as leaving nothing to improve for a time-fuse for smooth-bores of the heavier classes. They were used in the Mexican War, and ever since in the United States for all smooth-bore ammunition. The metal bushing has been extensively copied everywhere, and a chilled-cored shot could not be made without it. The earliest piece of what would now be called heavy ordnance, cast at the South Boston Foundry, was the ten-inch Columbiad. This gun marked, at the same time, a departure from old ideas and the introduction by Col. Bomford of horizontal shell fire of great power. It was cast 6th September, 1839, under Col. Bomford's superintendence, and was copied soon after by Gen. Paixhan, in France. Its dimensions were in extreme length, 111 inches; length of the bore, 90 inches; weight of the gun, 14,500 pounds; weight of the shot, 130 pounds; of the shell, 90 pounds; and of powder charge, eighteen pounds. In 1839 a Board of Ordnance Officers was sent to Europe to inspect European ordnance and ordnance-works. It purchased 6 and 12-pounder cast-iron guns, and 12 and 24-pounder iron howitzers from Swedish, French, and English foundries.

These guns were subjected to extreme proof at Fort Monroe, 1841-42, with the result that the Finspong guns proved themselves the best of all tried, including West Point guns of similar sizes. The proof of the Finspong 6-pounder was as follows, the gun bursting at the last fire. The charges had two wads in each:

Series.	Pounds powder in each round.	No. of balls in each round.	Rounds.
First.	2	1	20
Second.	3	2	20
Third.	3	3	10
Fourth.	6	7	2
Totals.	142	104	52

The Stäfsjo gun stood forty-nine rounds in similar series, the Aker, forty-seven rounds, the West Point thirty-nine rounds, and the Gospel Oak gun thirty-eight rounds, respectively. There were twenty rounds each in the first and second, and ten in the third series; the Finspong gun only reached the fourth series.

In March, 1844, the South Boston Foundry submitted a 6-pounder cast-iron gun, No. 7, of their own make, for extreme proof, which took place at City Point, South Boston. In strength and endurance it was found superior to the Finspong as above mentioned.

Rounds.	Powder charge, pounds.	Number of balls each round.	Number of balls.
16	2	1 to 16	136
4	2½	13 to 16	58
2	3	14 and 15	29
14	3	16 each.	224
2	6	7	14
38	102		461

The result of this and other proofs was so much to the credit of the South Boston Foundry, that it again cast for the Army, ordnance on 8th July, 1846, the first twelve-inch Columbiad of Colonel Bomford's design. This gun weighed, finished, 25,510 pounds; for the period it was truly a colossal gun and was the largest that could be made in the country at that date. The weight of its shell was 172 pounds, with twenty pounds of powder, and ten degrees of elevation; the shell ranged 2,770 yards, and its extreme range with maximum elevation was 5,761 yards, or three and one-half miles. The weight of the gun precluded it from sea service at that period. This twelve-inch seacoast gun remained the limit of size of our Army guns till 1860.

About 1844 Mr. Alger, taking advantage of Colonel Bomford's experiments on the pressure exerted by fired gunpowder at different points of the bore, then brought out a 32-pounder which was the first gun wholly plain in outline, and was the original of what is now known as the Dahlgren gun. This 32-pounder gun was known as Alger's 32-pounder, and after its proof and trials was carefully preserved and still exists at the South Boston Foundry. On comparing its outline with the Dahlgren it will be found to differ no more than is due to the powder pressure curves of the respective charges, and to the absence of the tulip muzzle. The trunnions were cast hollow so as to diminish the "shrink" due to their mass of metal.

In connection with this gun Mr. Alger submitted a "port-carriage" to the Navy Department, involving a friction-compressor binding the wooden chassis and the now universally adopted *eccentric axle* for the wheels of the carriage itself. By this arrangement the gun-carriage slides back upon firing—the whole weight of the gun, creating friction, and when raised off the chassis and on its wheels by turning the eccentric axles, rolls back easily into the firing position. Major Wade witnessed about 1843, "in Boston, the trial of several devices for checking the recoil of cannon by friction—by means of clamps, compressors, and eccentric axles—designed by Captain Van Brunt of the Navy, and by Mr. Cyrus Alger. The eccentric axle designed by Mr. Alger, caused the gun-carriage to *slide* in its recoil and to move on *rolling wheels* when returning to battery. This appeared to be the best of the methods then tried."

During the course of the improvements of our Navy guns by the late Admiral Dahlgren, the South Boston Foundry made many guns remarkable for their strength and endurance. Admiral Dahlgren said that Cyrus Alger "possessed that rare quality, sagacity, which constitutes in truth the highest attribute of the intellectual man, and enabled him to arrive at results which others sought by disciplined study and often in vain." The shell-guns of Dahlgren design were introduced largely into our Navy not long before the Civil War, and the safe limit of charge for the eleven-inch gun was not known till investigation was compelled by the failure of the "Monitor's eleven-inch guns, which were made at the South Boston Foundry to penetrate the armor of the Merrimac." It was perhaps not expected they would be brought against armor, or if the idea was broached it was answered by the statement that "the occasions on which shot could be advantageously used are so rare as hardly to warrant their being considered as part of the regular allowance." The South Boston nine and eleven-inch shell-guns exhibited endurance, which bore a comparison with the best forged Armstrong guns of 1862.

A cast-iron eleven-inch gun, if fired with thirty-one pounds of powder and ninety-three pounds of shot, would be doing more proportional work than the Armstrong wrought-iron gun which in April, 1862, pierced the Warrior target with a round 156-pound shot and fifty pounds of powder, afterwards bursting under that charge. It is proper to say here, we do not know but that between the two dates it had fired greater charges. But an eleven-inch of South Boston make (No. 1,262 S. B. F. 1862) was fired 155 times as follows: 22 rounds, twenty pounds of powder; 101 rounds, twenty-five pounds of powder; 32 rounds, thirty pounds of powder; shot from 165 to 169 pounds each. After this proof the gun exhibited no marks of a strain or of defects of any kind. Another eleven-inch gun was fired 170 rounds in two successive days without injury, although the gun became so heated that it was found warm eighteen hours after the last round.

The trial gun, for extreme proof, of a contract in 1857 (No. 1,098 S. B. F. 1857) a nine-inch Dahlgren shell-gun, 9,090 pounds in weight, endured the following proof before its destruction, a series of 1,532 rounds. [See table on next page.]

With twenty pounds of powder and 343½ pounds weight of shot, the gun recoiled nineteen feet; with twenty pounds powder and 469 pounds shot, the recoil was thirty-three feet; and with twenty pounds of powder and 636½ pounds of shot, the recoil was twenty feet up a steep slope, although the breech of the gun had been completely buried before firing. With ten shot the bore was nearly filled, the fronts of the last being seven and three-fourths inches from the muzzle. At bursting the gun was torn in two from cascabel to middle of chase, the part blown off, about two-fifths the circumference, being broken into five large fragments. The proof-firing was extremely rapid, 500 rounds being accomplished in four successive days. The enlargements due to firing were inconsiderable, the bore remaining in serviceable condition, and the endurance was reported on the 1,527th round as "really astonishing." Nothing could exceed the confidence these guns inspired in the War, and their efficiency on the new Ironsides is a matter of history. The Monitor was armed with eleven-inch guns fired with 169 pound shot and fifteen pounds powder. It was not known then that the charge could be increased to thirty pounds, as was afterward proved safe in case of necessity. This increase would give a shot of 169 pounds, an initial velocity of 1,400 feet, and a similar increase of charge of the nine-inch gun from ten to thirteen and one-half pounds of powder, would give an initial velocity of about 1,290 feet to its shot. The low velocity of her shot was consequently the reason why in all probability the Monitor failed to sink the Merrimac.

Rounds.	Powder charge.	Number of shot each round.	Tot'l wei'ht shot each round.
1	15 pds.	1 shot	91 pounds.
9	10 "	1 shell	72 "
1,500	10 "	1 "	72 "
5	15 "	1 shot	90½ "
5	15 "	2 "	181 "
2	15 "	3 "	271½ "
3	15 "	4 shell	288 "
1	20 "	3 shot and 1 shell	343½ "
1	20 "	2 " " 4 "	469 "
1	20 "	2 " " 6 "	613 "
1	20 "	7 shot	636½ "
1	20 "	8 "	724 "
1	20 "	9 "	812 "
1	20 "	10 "	903 " and burst.

In 1860 the fifteen-inch gun of 49,000 pounds was cast, and proved in 1861. Being demanded for both naval and sea-coast armament in great numbers, the South Boston Iron Company erected a new ordnance-foundry and machine-shop, and began in 1863 to apply the Rodman method to the production of fifteen-inch guns. This shop was designed to cast and finish the largest guns then thought practicable. During the War the service demands prevented any extended experiments on the strength of the gun. But after the War, and armored ships had to be met, it was found safe to fire 100 pounds of powder with the 450 shot instead of fifty pounds, the heaviest service charge during the War. The initial velocity was thus increased to 1,600 feet per second. It is a fact that a fifteen-inch Rodman gun made at South Boston Foundry has endured twenty-six rounds with 140 pounds of mammoth powder and 450 pounds shot without bursting.

Perhaps the best instance of the reliability of both guns and shot, made by American methods will be found in the history of the fifteen-inch Rodman gun of South Boston, model made by Cyrus Alger & Co., in 1867 for the British Government (S. B. F. No. 186). The report of the Ordnance Select Committee during its trial at Shoeburyness was understood to have stated "that it was doubtful if the Rodman gun can be burst with *any charge* of American powder, as it will not burn more than 100 pounds, which it has fired without injury."

The trial of the gun lasted a year from June 1867, during which it was tried against all the armor-shields in use. It was fired thirty-six times; fifteen rounds of these were with charges of 100 pounds mammoth powder or its equivalent (83¼ pounds R. L. G.) The velocities of the shot at impact were 1,174 to 1,500 feet per second, and it was shown that at 200 yards the gun could not penetrate eight-inch armor nor materially injure the nine-inch Hughes elastic shield. This conclusion caused the gun to be regarded as a formidable weapon, but not especially dangerous to the British men-of-war as the Admiralty had previously adopted heavier armor. If, however, the force of the shot failed to meet the expectations of American officers, yet their material—gun-iron—also that of the gun itself, exhibited its wonderful tenacity in the best light. A shot which struck the Gibraltar target with a velocity of 1,174 feet per second and making an indent four inches deep, rebounded twelve feet to the front nearly entire. The striking face was flattened and a few largish fragments splintered off. Many others exhibited similar behavior, the shot rebounding to the front, set up and disfigured. Their toughness induced the belief that they must in some way be made partially of wrought-iron. They were of course entirely of cast-iron, but cast-iron in its most perfect state, combining all the hardness possible for cast-iron. The essential characteristic of gun-iron is its elasticity, which it exhibits to a limit of 9,000 to 12,000 pounds per square inch, an amount somewhat less than that of ordinary bronze and nearly half that of average wrought-iron.

The South Boston Foundry has made, since 1836, a specialty of producing bronze guns, and turned out for the United States and Massachusetts probably the first sound ones made in this country. Bronze cast in sand is liable to many defects—porosity, and separation—often the gravest, and the Company is entitled to the credit of at least the application of cast-iron molds for guns, and it believes it made the first discovery of that improvement before 1855. In sand molds it made gun bronze, the average tenacity of which was 41,270, and density 8.64, which is considered now a first-class bronze. But after the adoption of chill-casting very high results were obtained. The average density of 24-pounder navy howitzers, between S. B. F. Nos. 1,417 and 1,693 of 1863–64, was 8.72, and the average tenacity 50,041 pounds per square inch. Nine guns included in the above series exhibited an average density of 8.80 and an average tenacity of 60,610 pounds to the square inch. These are believed to be the highest recorded qualities of bronze gun metal.

In 1869 Mr. S. B. Dean, while Engineer of the South Boston Iron Company, discovered that bronze guns could be greatly improved and rendered highly useful as rifles by rough-boring the gun, and then forcibly expanding the bore to its finished size by means of mandrels successively enlarging in diameter. This process he patented here, in France, and unwisely perhaps in Austria, where it has been pirated by the Austrian artillery under the name Uchatius System." All the field-guns and many siege-guns of the Austrian Army are now made of so-called "steel bronze," a very good name, considering the fact they should be the "Dean bronze" guns. The effect of the Dean method is to bring the exterior of the gun under tension while the interior is hardened and rendered capable of resisting the wear of the rifled projectile. The first condition renders the gun stronger, all portions helping each other against the explosion, and is the counterpart of the Rodman process where the exterior is put under tension by shrinking it, as it were, on the more quickly cooling interior of the gun. The hardening effect is great and highly valuable.

The following table of properties of similar cylinders, one of them cut from the chase of a three and one-half inch Dean rifle after the process of "condensing," clearly exhibits the improvement effected.

	Uncondensed.	Condensed.
Hardness,	1.40	5.12
Density,	8.35	8.70
Tenacity,	35,810 lbs.	51,571 lbs.

In 1863 Mr. Francis Alger, son of Cyrus, patented the use of a bag or pouch to hold the bursting-charge of a Shrapnel or a shell. He made the bag waterproof and attached it to the fuse. This method has been widely adopted, and in large shells is an essential safeguard against the explosion of the bursting-charge by the shock of the explosion, and consequent friction of the powder against the shell. Various improvements in fuses for rifled shell were experimented with and Mr. F. Alger patented in 1862 a combined time and percussion-fuse of merit.

During the Civil War the South Boston Iron Company furnished the Government with over 1,700 guns, including 700 bronze guns and howitzers, about 700 solid cast-guns of eleven-inch caliber and less, 332 Rodman guns of ten-inch caliber and over, and only 19 rifled-guns of all sizes. This record will show how largely the war was fought with smooth-bore guns. The Rodman guns were barely fifteen-inch guns for the Army, and to meet the demand a new ordnance-foundry and machine-shop put into operation in 1863, which is now the only works for Heavy Ordnance in the United States, and is capable of turning out large guns of about fifty tons in weight. During the War it made nothing heavier than fifteen-inch guns of 49,000 pounds. It might be expected that the foundry would have many interesting records of so busy a period, but its energies, as of the Ordnance Bureaus of the Army and Navy, were almost wholly devoted to producing guns of serviceable design. Even the usual proofs were dispensed with, so great was the need for ordnance, and after the trial gun of a class had fired 1,000 rounds in proof the rest of the class were accepted according to the tests of their material.

In respect to the projectiles, however, the Company did good work. The need of good rifle projectiles became decided when rifles began to be appreciated, as our artillerists became more experienced. Many experimental projectiles claimed attention and the Company decided on the Schenkle plan as affording the best solution of the difficulty. The projectile was cast with a conical base over which a papier mâché sabot fitted almost half the length of the shot. The explosion drove the sabot up, the cone thus compressing it between the shot and the gun, and causing it to take the grooves. In service eighty-two per cent. took the grooves most perfectly in the Parrott gun, for which they were not intended. Being light it fell off almost immediately in the flight without danger to the troops over whom it was fired. The shot was thoroughly rotated and was considered most reliable until it was found that the sabot, under influence of moisture, often swelled so much as to refuse to enter the gun. The South Boston Foundry furnished some 500,000 rounds of ammunition of all sizes to the Government, of which some 400,000 were Schenkle projectiles. Although the question of a perfect projectile remained unsolved, yet the Schenkle percussion-fuse furnished with the shot was one of the unqualified successes of the War. It was found absolutely certain in action, and combined extreme simplicity with perfect safety. It now remains the standard fuse of our Navy, and requires very slight modification to render it equal to all requirements. During actual service in the Civil War eighty-two per cent. proved perfect.—*Norton's American Inventions and Improvements in Breech-loading Small-arms, Heavy Ordnance, and Munitions of War.* See *Foundry*, and *West Point Foundry*.

SOVEREIGN.—The name applied in politics to the person or body of persons in whom the legislative power of a State is vested. In limited Monarchies, Sovereignty is in a qualified sense ascribed to the King, who, though the Supreme Magistrate, is not the sole legislator. A State in which the legislative authority is not trammeled by any Foreign Power is called a Sovereign State. The States of the German Empire were all designated *Mi-Souveraines*, because their sovereignty was qualified by their subordination to the Imperial Authority; and the same term may be applied to the States of the American Union.

SOW.—The main trough (or the body of metal contained therein) leading from the tap-hole of a cupola or smelting-furnace, and from which ramify the passages leading to the separate molds in casting; or to the shallow ditches in the floor which receive the *pigs* of cast-metal. 2. A kind of covered shed formerly used by besiegers in filling up and passing the ditch of a besieged place, sapping or mining the wall, and the like. It had its name from its being used for rooting up the earth like swine, or because the soldiers therein were like pigs under a sow.

SOWAR.—A trooper in an Indian cavalry regiment.

SPACE.—Room; the interval between troops when drawn up in line or column. In a battle, the amount of frontage which would be required for troops to act in. Most Generals make 1,000 yards as a fair calculation for every 6,000 or 8,000 men of all arms.

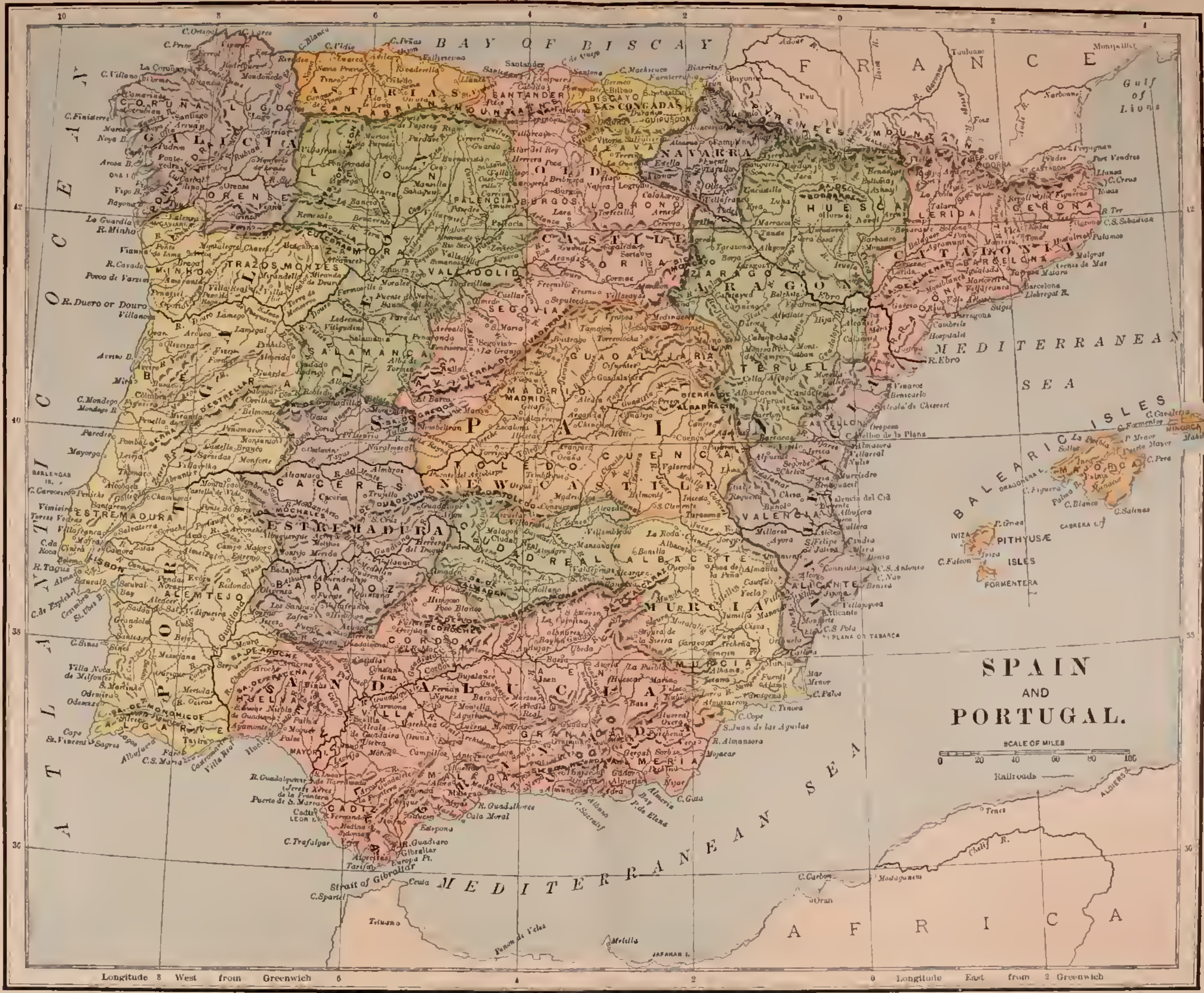
SPADE-BAYONET.—A very broad-bladed bayonet; it may be used in digging shelter-holes or rifle-pits. See *Bayonet*.

SPADROON.—A sword much lighter than a broadsword, and made both to cut and thrust.

SPAHIS.—The cavaliers furnished by the holders of military fiefs to the Turkish Army, and who formed the *Elite* of its cavalry. The Spahis, along with the Janissaries owe their organization firstly to Orchan, the second of the Ottoman Sultans, finally to Sultan Amurath I.; and when levied *en masse*, could number 140,000, but such a levy was seldom called for. In the field, they were divided into two classes, distinguished by the colors (red and yellow) of their standards; one class had pistols and carbine, the other a bow and arrows, and both carried a saber, lance, and *jerid*, or javelin. They were excellent irregular troops; but when European organization was introduced into the Turkish Army, they were replaced (1826) by regular horse. At the present time, the French have numerous regiments of Spahis, raised from among the native tribes of Algeria and from France in about equal proportions; the dress, especially of the indigenous soldiers, partakes very much of the Arab character. The natives are allowed to rise to any grade below that of Captain; but all the superior officers must be of French descent. See *Zouaves*.

SPANCELLED.—In Heraldry, the term applied to a horse, two of whose legs are strongly fettered by a log of wood.

SPANDAU FIRING-SCHOOL.—This School for the instruction of the Prussian soldier in the use of the musket was created in 1851, and it is to the influence exerted by the teaching given there that the remarkable skill shown by the Prussian infantry is specially due. It is established at Spandau, and is provided with large buildings, embracing shops, laboratories, magazines for ammunition, lecture and model-rooms, and sheltered grounds for drills and gymnastic exercises. The object of the School is to perfect, by the constant study and practice of those having it in charge, the arms and munitions in use in the Army; the thorough trial of all arms adopted in the service of foreign nations; the experimenting with new inventions; and finally, the instruction of teachers, intended to impart a thorough knowledge of fire-arms and their use to the whole Army. Its permanent organization consists of a Superintendent, 4 Captains, 8 Lieutenants, 1 Adjutant, 1 Paymaster, 1 Armorer, 4 Sergeant Majors, and 5 Sergeants. Four Lieutenants are added for temporary duty as Instructors, and are always selected from those who have passed through the course; they are changed every year. The detail sent annually to the School is divided into two classes: the first remains one year, and the second


SPAIN
AND
PORTUGAL.
SCALE OF MILES
Railroads
BAY OF BISCAY
FRANCE
Gulf of Lions
MEDITERRANEAN SEA
BALEARIC ISLES
MAJORCA
MINORCA
PITHYUSÆ ISLES
IVIZA
FORMENTERA
ATLANTIC OCEAN
AFRICA
Strait of Gibraltar
GALICIA
ASTURIAS
LEON
OLD CASTILE
NAVARRA
ARAGON
CATALONIA
NEW CASTILE
VALENCIA
MURCIA
ANDALUCIA
ESTREMADURA
GRANADA
PORTUGAL
SPAIN
Longitude West from Greenwich
Longitude East from Greenwich

only six months. The second class consists of 69 Lieutenants, 130 Non-commissioned Officers, and 244 soldiers, with the necessary number of buglers, drummers, orderlies, tailors, and shoemakers. The first class is composed of 1 Sergeant, candidate for Paymaster, 17 Non-commissioned Officers, 138 soldiers, and the necessary buglers, drummers, etc. They are engaged during the winter in making experiments, and in the current work of the School.

The course of practical instruction commences on the 1st of April, and embraces the following subjects: 1*st Course.*—Preparatory drill. Aiming from a rest. Aiming from the shoulder. Firing. Estimating distances. Description of the musket and targets. The Officers and Non-commissioned Officers are also instructed in the fabrication of arms and in making ammunition, etc. 2*d Course.*—This is devoted entirely to firing under the different circumstances of actual service. 3*d Course.*—This is only for Officers and Non-commissioned Officers, and serves to develop the knowledge already gained. The Officers are occupied, in addition to their other duties, in assisting in teaching the theoretical course, the history of fire-arms, their manufacture, the fabrication of cartridges, and finally in considering the different arms adopted in foreign armies. The Non-commissioned Officers and soldiers are occupied with gymnastic exercises, bayonet-fencing, and from time to time with the manual of the musket. The target-ranges, 13 in number, are on a tract of ground covered with a young growth of pines, through which avenues are cut, varying in length from 80 to 1,600 meters, and terminating in a rise of ground, which serves as a butt to stop the balls. Wires for telegraphic communication connect targets and firing-stands with the Officers and principal workshops. The targets are made of wooden frames covered with a thick card-paper; they are both fixed and movable, and have the most varied forms, representing detached men, some standing or kneeling, others half concealed, a company of infantry or cavalry, a battery of artillery, or even a battalion of troops.

The soldier is taught to fire not only at movable targets, but also at such as appear unexpectedly at some point of the field. For this purpose the target is mounted on a car which travels on rails laid across the range, and is drawn at variable speeds by men stationed on either side, behind traverses, pulling on a rope attached to the car. The troops, acting as skirmishers, debouch suddenly from the woods, and fire at the different targets, at unknown distances, some stationary, others movable. Thus the soldier is accustomed to estimate distances, to do it promptly, and to judge of the rate of motion of movable objects, and the allowance to be made in aiming at such. Besides, this kind of practice has the effect to teach the soldier to preserve his composure when an enemy, whatever it may be, appears unexpectedly before him. The Officers, by such exercises, have the opportunity of learning what is required of them, and studying the art of directing troops upon the field. While at the School, the men receive extra pay of one thaler per month, and as a distinction wear on the cuff of the coat a button bearing a special device. Those who prove themselves to be good marksmen wear, as a badge of their skill, two white stripes on the coat-collar. Those who have passed through the course of instruction given at the School return to their several regiments to act as Instructors of Musketry to the regiment. Each soldier is allowed to fire 100 cartridges annually, and encouragement to become expert marksmen is given by the State granting large sums for premiums for the best shots.

SPANISH RIFLING.—The Spaniards have modified the French system by adopting a uniform twist, and placing the studs upon the projectile in pairs. Three grooves are used; the cast-iron guns are reinforced with hoops having definite initial tension.

SPANISH SYSTEM OF FORTIFICATION.—The construction of the Spanish system was nearly the same as the Italian system—but the lines of defense were directed on the curtain angle. See *Italian System of Fortification.*

SPANISH TUTANIA.—An alloy composed of 24 parts of tin, 2 of antimony, and 1 of steel.

SPANNER.—A screw-wrench, used for the purpose of tightening nuts upon screws.

The spanner used in the field is "McMahon's 15." It has a fixed and a movable claw for use as a wrench. The movable claw can be set at any distance from the fixed claw by means of a thumb-screw.

SPAR BRIDGE.—A light bridge for crossing broken arches, rivers with steep banks etc., in which it is not practicable or convenient to obtain supports for the bridge from the bottom or on the surface of the river. Works on military bridging give the following as the best known for spanning all intervals with timber:—

Single-lever bridge.—Composed of two frames locking into each other, and not meeting at a greater angle than 120°. This nature of bridge is not suitable for a greater span than 30 feet.

Double-lever bridge.—Suitable for spans of 40 feet; it consists of two frames locking into a connecting frame or two or more longitudinal pieces, with cross transoms. The opening is thus divided into three spaces, and the span of the road bearers is about 14 feet.

Single-truss bridge.—This can be used for spans up to 50 feet; it consists of two frames locking into each other in the same manner as the single-lever bridge, and provides three points of support, viz., one on each frame, and a third suspended by the ropes from the head of the frames.

Lever-truss bridge.—Suitable for spans of about 50 ft.; it is a combination of the single and truss bridges.

SPARE GUN-CARRIAGE.—This is merely an ordinary gun-carriage, fitted up so as to carry four axletrees, the iron-work for a spare gun-carriage, a pair of shafts, two sponges, one wadhook, and other spare articles for the battery.

SPARTHE.—An Anglo-Saxon term for a halbert or battle-axe.

SPARUM.—A kind of dart, which was used by the ancients in war, which was shot from a cross-bow. The wound it occasioned was extremely dangerous, as its point was triangular. Several of these darts were discharged in a volley.

SPATHA.—A long sword, with but one edge and a sharp point, used by the Romans. It was borrowed by the early Romans from some barbarous tribes, and then introduced among others. Its presence does not prevent the simultaneous appearance of the various short swords.

SPATTERDASHES.—A kind of covering for the legs of soldiers, made of cloth, or of a coarse linen waxed over, and buttoned tight, by which means the wet was kept off.

SPATTS.—A variety of spatterdashes that reached only a little above the ankle.

SPAVIN.—A disease of horses, which occurs under two different forms, both interfering with soundness. In young, weakly, overworked subjects, the hock-joint is sometimes distended with a dark-colored thickened synovia or joint-oil. This is bog or blood spavin. Wet bandages, occasional friction, a laxative diet, and rest should for several weeks be diligently tried; and if such remedies prove unsuccessful, the swelling must be dressed with a strong blistering ointment, or be fired. The second variety of spavin is the more common and serious. Toward the inside of the hock, at the head of the shank-bone, or between some of the small bones of the hock, a bony enlargement may be seen and felt. This is bone-spavin. At first there is tenderness, heat, swelling, and considerable lameness; but as the inflammation in the bone and its investing membrane abates, the lameness is less perceptible, although the animal continues to drag his leg and go stiffly. In recent and slight cases, cold water should be applied continuously;

but in serious cases, when the limb is swollen and tender, hot fomentations are best. For several days they must be perseveringly employed. When the limb is again cool and free from pain, an iodide of mercury or fly-blister should be applied, and the animal treated to three months' rest in a small paddock, the end of a barn, or a roomy loose-box. In persistent cases, firing or setoning usually gives much relief.

SPAYADE.—In Heraldry, a stag in his third year; a spay.

SPEAKING-TRUMPET.—An instrument which, on being applied to the mouth, carries sound to a considerable distance. It was formerly used in all large armies; and at the siege of Gibraltar, General Elliott (afterwards Lord Heathfield) caused all the words of command to be given through a speaking-trumpet.

SPEAR.—A weapon having a wooden shaft mounted with a very sharp steel point. It has been known and used from time immemorial, first as a hand or missile-weapon, and subsequently as a pike or lance. In the early Norman period, A. D. 1066-1087, the spear was a well-known military arm. It was sometimes ornamental, like the lance of the present day, with a small flag fixed just below the metal point, and termed, in the language of that day, the *gonfanon* or *gonfalon*. See *Javelin*, *Lance*, and *Pike*.

SPECIAL DUTY.—Soldiers may be employed on duties not strictly military, when the exigencies of the service require it, for the reason that they are incident to the operation of an army; as, mechanics, laborers, cooks, and attendants in hospitals, clerks, scouts, etc. Soldiers, when detailed on these duties are generally reported on special or extra duty, but are required to attend the regular inspections and musters, and if not proficient in drill, should be required to attend drills until they know their duties as soldiers. Officers, when placed on duty which temporarily relieves them from duty with their companies, as Acting Commissaries and Quartermasters, or on Court-Martial duty, etc., are reported as being on *special duty*.

SPECIAL ORDERS.—Such orders as do not concern the troops generally; such as relate to the march of some particular corps, the establishment of some temporary post, the detaching of any individuals, the granting requests, and generally such matters as need not be published to the whole command. See *General Orders* and *Orders*.

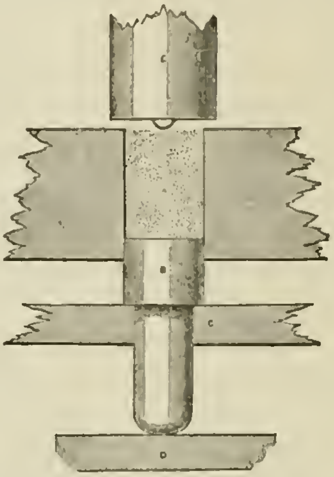
SPECIAL POWDERS.—For some years, it has been a recognized fact, that the ignition, combustion, and explosive effect of gunpowder depend, in a great degree, on the size, shape, and the density of the grain, and that guns of different calibers require for their most efficient service all powders differing in these features, in order to secure the best results. The rapid increase in weight of projectiles with the increase in caliber of guns, and the comparatively smaller power of resistance of the guns, render it necessary that the rate of combustion of the charge be regulated, so as to reduce the strains on the guns as much as possible, while at the same time preserving high initial velocity to the projectile, thus rendering practicable the use of the heaviest guns, projectiles, and charges.

The amount of gas evolved at the first instant of inflammation and combustion is measurably controlled by the size and form of grains, offering a lesser surface of ignition, and the increased density, offering greater resistance to the penetration of the hot gases through the grains, graduates its rapidity of burning. The from of grain affecting the amount of surface exposed to combustion—that shape which offers a comparatively small surface at the first instant of ignition, increasing progressively, is theoretically the best.

Experiments by all civilized nations have settled beyond cavil the important part played by powders suited in the above qualities to the guns in which they are to be used, and have led to the adoption of large-grain powders in heavy guns, resulting in the production, among the best, of mammoth, pebble, cubical, hexagonal, and perforated prismatic powder; the honor of the first investigation and practical results in this direction, being universally awarded to the late General Rodman, United States Army.

Special powders are readily made by machinery, and the fundamental parts of every such machine are: (1) a mold in which to place the powder-meal; (2) a punch accurately fitting the mold, with which to compress the powder; and (3) some appliance for pressing the finished pellets out of the molds.

A safe arrangement for combining these three is shown in the drawing. A, is a small charge of powder



placed in the mold; B, a punch which fits it accurately. This punch has a shoulder on which it rests quite loose on a second plate, C, underneath the mold-plate. The lower end of this punch rests on the upper surface of the hydraulic ram, D. An upper descending punch, E, of larger diameter than the mold, can be brought down to the surface of the mold-plate either by a screw or by a hydraulic pressure so as to close the mold.

With such an arrangement a pellet can be very safely made; firstly, by bringing the top punch down on the plate, and fixing it there so as to confine the powder; secondly, by raising the lower punch, by means of the ram, till a proper amount of compression has been given to the powder; thirdly, by stopping the pressure from beneath, raising the upper punch; and, fourthly, by raising the finished pellet out of the mold by the pressure of the ram underneath. It is plain that any form can be given to the pellets by altering the shape of the molds and punches, and that hollows or perforations can be made in the pellet if required. There is no difference really in any of these powders, except in the shape.

Nearly all the great Powers of Europe have powder-mills under the immediate supervision of their own officers and agents; and the quality of powder made at them is held deservedly in high estimation. While these mills are insufficient for supplying all the wants of the respective Governments, the great care in selection and manipulation of the best materials, and close attention to every detail of manufacture, serve to maintain a high standard of quality of powder, and regulate the price and excellence of that amount obtained from private manufacturers. The United States would profit by following so excellent an example, by establishing a powder-mill, under official directon, of a limited capacity. The Royal Gunpowder Factory of England is located at Waltham Abbey; those of Russia are the Ohktenskoi; the Michael-Schosta (saltpeter district), the Kazan (at which most powders for the military and naval service are made). Germany obtains her powders, in part, from the Government factories at Spandau and Neisse; the standard quality of that procured from private factories being regulated by the former. France now has five gunpowder-works—Ripault, Bouchet, Saint Chamas, Angoulême, and Esquerdes. Belgium has a large powder-mill at Wetteren and produces large gunpowders of most excellent quality. See *Compensating Powder, Hexagonal Powder, Pebble Powder, Prismatic Powder*, and *Progressive Powder*.

SPECIFICATION.—In preferring charges great care should be used to specify the date and locality of the alleged offense. When doubt exists, it may be alleged that the act specified was committed "at or near" a certain place, and "on or about" a certain date. Before charges are forwarded to Department Headquarters for trial by any General Court, Post Commandants should investigate the character and force of all the testimony on which they are based, and be reasonably assured that the alleged facts can be fully established; and also, *that the offenses charged are of so grave a nature that a Garrison Court cannot adjudge a sufficient penalty*. Charges should be laid under the specific Articles of War pertaining to the offense.

Charges cannot be legally preferred under the 62d Article of War when the offense committed is in violation of any other Article. In an absence from any appointed parade, drill or other exercise, but not from the limits of the post, the specification should usually be charged under the 33d Article of War —but otherwise under the 32d, and sometimes under both. Soldiers found drunk on any guard, party, or other duty, after having been actually placed on such duty, and in the ranks, and not until then discovered to be drunk, should be charged with violation of the 38th Article of War—but otherwise under the 62d Article, as when unable to turn out for or attend guard-mounting.

Charges laid under Articles of War which prescribe possible capital punishment, such as the 21st or 39th Articles, are not properly cognizable by a Garrison or Regimental Court, nor should *degrading crimes*—like theft, to the prejudice of good order, etc.—be tried before such tribunals, because they cannot sentence to dishonorable discharge. Persons convicted of any criminal offense cannot be enlisted into the Army, and this policy of the law suggests the propriety of dishonorably discharging all convicted of degrading crimes of a felonius nature.

The non-performance of any stated duty enjoined in regulations or standing orders is *not*, in itself, a "disobedience of orders in violation of the 21st Article of War". Such a charge should be laid under the 62d Article, and would, if but a slight neglect of duty, be cognizable before a Garrison Court. To support the charge of "disobedience of orders under the 21st Article," and thus make it solely cognizable by a General Court-Martial, there must be shown, in the performance of such stated duty, such an intentional disregard of authority as is evinced by a willful refusal or omission to comply with the specific command of a Superior Officer.

In time of peace, under the 47th Article of War, the crime of "desertion" is *not* a capital one. If a charge against an enlisted man for this offense is to be referred to a Court for trial more than two years after date of his unlawful abandonment of the military service, the fact that he was not amenable to justice within that period should, under present rulings, be made to appear affirmatively in evidence, so that the proceedings, findings, and sentence may not be liable to be set aside. The better practice would, therefore, seem to be to insert in the specification, after allegation of apprehension or surrender, the further allegation, required by the 103d Article of War, as to the manifest impediment which prevented the prisoner from being amenable to justice within two years of the commission of the offense.

In preparing several specifications under a charge, the date and place of the alleged offense should be written in each, and not merely in the final specification, of which the prisoner may be acquitted.

SPECIFIC GRAVITY.—The specific gravity of any substance is the proportion which the weight of a certain bulk of that body bears to the same bulk of another body, which is taken as a standard. The standard for substances solid and liquid is distilled water at the temperature of 62° Fah., barometer 30 inches; and the weight of a cubic inch of this standard is given in the Parliamentary Reports for 1825 as 252.456 troy grains, hence a cubic foot of it weighs 997.129 avoirdupois ounces, or 62.32 avoirdupois pounds. It is convenient to remember that a cubic foot of water weighs about 1,000 ounces avoirdupois, as the error resulting from employing this estimate does not amount to much more than the $\frac{1}{350}$th of the whole. For aëriform bodies, the standard is atmospheric air, a cubic inch of which, at a temperature of 32° Fah., weighs .32698, and at 60° Fah., .30935 grains troy. The specific gravity of solid bodies is best measured by the hydrostatic balance, which gives the weight of a volume of water equal in bulk to the solid, by which it is only necessary to divide the weight of the solid in air to obtain the specific gravity; that of liquids may be obtained by the areometer, or by comparing the weight lost by a solid body in the liquid and in water, and dividing the former by the latter—or by means of the *specific-gravity bottle*, which holds exactly 1,000 grains of distilled water in its standard condition. The bottle is emptied of water, filled with the liquid, and is then weighed; the result gives the weight of a volume of the fluid equal in bulk to 1,000 grains of the standard, and hence this weight divided by 1,000 gives the specific gravity. The specific gravity of an aëriform fluid is determined by weighing a glass globe filled first with the fluid, and then with atmospheric air. Following is a table of the specific gravities of the substances most frequently dealt with in the arsenal and laboratory:

SOLIDS (METALS).

	Sp. Gr.		Sp. Gr.
Iridium (ham'ered)	23·	Iron	7·78
Platinum	20·15	Tin	7·29
Mercury	14·	Zinc	7·19
Lead	11·35	Antimony	6·70
Silver	10·74	Arsenic	5·76
Bismuth	9·82	Aluminium	2·67
Cobalt	7·81	Calcium	1·58
Copper	8·78	Sodium	·97
Manganese	8·01	Potassium	·86

LIQUIDS.

	Sp. Gr.		Sp. Gr.
Sulphuric Acid	1·84	Champagne Wine	1·
Nitric Acid	1·5	Burgundy Wine	·99
Aqua Regia	1·23	Whiskey, average	·92
Oil of Cinnamon	1·04	Oil of Turpentine	·87
Oil of Cloves	1·03	Brandy	·84
Milk	1·03	Alcohol, pure	·80
Tar	1.01	Ether, Sulphuric	·72

GASES.

	Sp. Gr.		Sp. Gr.
Hydriodic Acid	4·34	Oxygen	1·11
Chlorine	2·44	Olefiant Gas	·98
Sulphurous Acid	2·22	Nitrogen	·97
Cyanogen	1·80	Prussic Acid	·94
Carbonic Acid	1·52	Ammonia	·59
Muriatic Acid	1·28	Hydrogen	·07

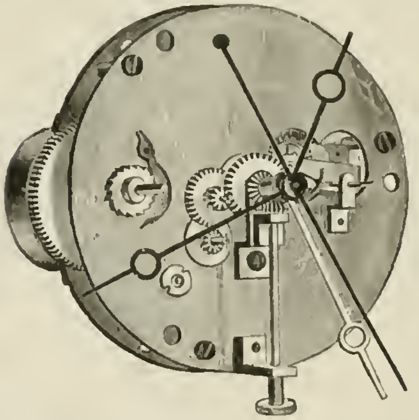
See *Areometer*, and *Hydrometer*.

SPECKLE SYSTEM OF FORTIFICATION.—In this system, the bastions are large, with orillons and cavaliers, the flanks are triple, and parts of the middle and upper ones are perpendicular to the lines of defense. There are cavaliers on the curtains. The covered-way is *en cremaillère*, and flanked by places of arms. Beyond the glacis there is an advanced ditch. The walls have counter-forts 5 yards apart, connected at the top by arches, which bear the parapet and render breaching difficult. It is the modern revetment "en décharge." When this method is reinforced, the flanks are perpendicular to the lines of defense, and the ravelin is made very salient.

SPECTROSCOPE.—The instrument by the aid of which spectral phenomena may be most conveniently studied. It consists essentially of, first, an illuminated slit, from which parallel rays of light proceed; secondly, a prism or train of prisms, to separate the differently refrangible rays; and thirdly, a telescope, to view a magnified image of the spectrum produced.

SPECULUM METAL.—An alloy of copper and tin, used for making the reflecting surfaces of reflecting telescopes. The best consists of 126.4 parts copper to 58.9 tin. To obtain a perfect alloy, and to cast it successfully, is a matter of great difficulty, requiring much skill and experience. See *Telescope*.

SPEED INDICATOR.—A device for indicating the number of revolutions made by a shaft in a given time. The instrument mostly used in the United States is shown (inside view) in the drawing, and is made by the American Steam-gauge Company, Boston. It consists of a nicely made eight-day Howard clock movement, fully jewelled, and placed in one of the eight and a half inch dial nickel-plated steam-gauge cases. Upon the face of the clock are shown four hands, all moving from the center; viz., hour, minute, second, and fourth the *speed* hand, which is made of a different color to distinguish it from the others. The *speed* hand is wholly independent of the clock proper, being driven by a bevel-gear connected with a shaft leading to the outside of the case. On the shaft is placed a ratchet-wheel with a number of teeth in it to correspond with the number of revolu-



tions the engine makes per minute; for instance, if the engine makes fifty-seven revolutions per minute, there must be fifty-seven teeth in the ratchet-wheel; or, whatever number of revolutions the engine makes per minute, there must be a corresponding number of teeth in the ratchet-wheel. By this it will be seen that when the engine has made fifty-seven revolutions, and there are fifty-seven teeth in the ratchet-wheel, it will have caused the speed hand to make one revolution around the dial of the clock, and the second-hand will also have made one revolution around the dial of clock. The second hand that is used is quite long, extending from center of dial to the outside circle of same. If the engine makes more revolutions per minute than it ought to, it will be detected by an increase in the movement of the speed hand; or, if the engine makes less revolutions per minute than it should, it will be detected by a decrease in the movement of the speed hand. When the engine stops, of course the speed hand will stop, but the clock will continue to move at its regular rate. After the engine is started and attained its usual speed, if the speed and second hands are at some distance apart, place the thumb and the forefinger upon the knurled wheel on shaft connecting the ratchet and bevel-gear, and move it forward until the speed and the second hands are brought together. In connecting the speed-indicator with the engine, it is only necessary to take the motion from some part of the engine most convenient, in the same manner that a revolution-counter is connected; and if a revolution-counter be used, the motion can be taken from it, which is the most convenient.

SPENCER LEE MAGAZINE GUN.—In this arm, the breech-block is supported against the pressure of the gas, when the piece is fired, by a recoil-block, solid with the guard, which has a circular recess concentric with the rear of the breech-block. The latter is slipped in the recess sideways and has, when assembled, a motion of rotation in a vertical plane. The recoil-block is in turn supported by the rear of the receiver. The trigger and the hammer are pivoted in the guard-plate, the nose of the former or the sear being held in position in the notch of the latter by the sear-spring. The main-spring is connected with the hammer and the under rear of the breech-block by swivels. When the trigger is pulled the head of the firing-pin is struck by the upper end of the hammer. The breech-block is operated by a cam-pin, with friction roller on the inside of the rear end on the left of two sliding bars, connected by the hand-grasp. The cam-pin travels in the groove on the left side of the breech-block, which also has a frog or switch, pivoted near its rear. When the cam-pin enters the groove, as it does when the forked side is forced to the rear, it rolls over the incline of the frog. The pin cannot rise, since the bars of the slide travel in grooves on the inside of the receiver. Hence the frog must be pressed downward, and its point in turn, pressing on the bottom of the groove in the block, compels the latter to descend. When the pin passes out of the groove to the rear, the front of the breech-block would rise above the receiver under the pressure of the mainspring, if not held down by the extractor, as explained later on. When the slide is returned to its first position, the cam-pin travels on the lower side of the groove, the frog turning freely about its pivot, and the front of the block is forced to descend to the level of the chamber. The piece is cocked in the act of opening the breech-block by the cam-pin coming in contact with the hammer and pressing it back until the nose of the sear enters the notch. At the front of the breech-block is a movable face or head, which is forced against the base of the cartridge during the closing of the breech. On the opening of the latter the head drops away, and thus facilitates extraction of the shells.

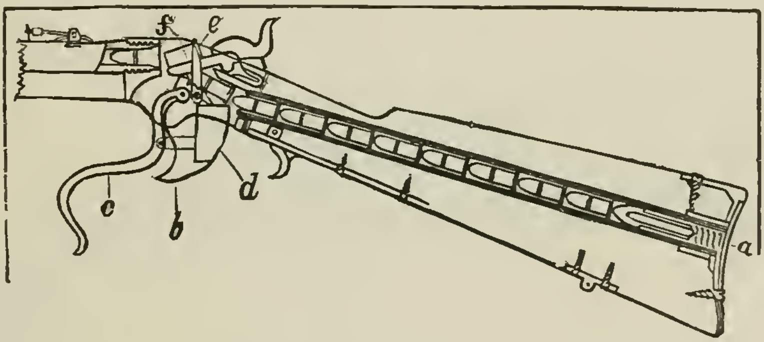
A device for locking the hammer until the breech-block is closed is interposed between the head of the hammer and a shoulder on the shaft. Closing the breech-block rotates the shaft and withdraws the shoulder from the front of the locking-bar. The latter is free to move to the front to the extent permitted by the recess in which the tenon on the bar enters, and the hammer can fall if the trigger be pulled.

The magazine is that known as the Lee, with very slight modification. It is attached to the under side of the breech-block, and rises and falls within. The breech-block is recessed on its under side sufficiently to receive a single cartridge. When this cartridge is drawn forward into the chamber another from the magazine takes its right place in the block. It will be seen then that the complete backward motion on the slide causes the block to descend, the shell to be pushed out on its upper surface, and then the block to fly up and eject the empty shell; the forward motion then carries a cartridge from the magazine into the chamber and causes the block to descend to its proper position in rear of it. A cut-off may be so turned as to limit the backward motion of the side, thus preventing the extractor passing beyond the shoulder. The block then cannot rise and bring the cartridges from the magazine opposite the chamber. The piece may then consequently be used as a single-loader. When the cut-off is turned vertically downward, the piece may be used as a magazine-gun. If turned upward to its farthest extent, a small pin, on its under side, will enter a notch in the slide and lock it, and therefore the breech-block. Three motions are necessary to operate this piece as a magazine-gun, viz., the movement of the slide to the rear, to the front, and the pulling of the trigger. In addition, when used as a single-loader, loading. See *Magazine-gun*, and *Spencer-Roper Small-arms*.

SPENCER LINE-THROWING GUN.—The Spencer line-throwing gun is a smooth-bore, and consists of the body, the trunnion-ring and the breech-plug or fermeture. The body is made of low steel, forged solid, and afterward bored out. The exterior of the body is divided into three principal parts viz., the first reinforce, the second reinforce, and the chase. The *first reinforce* is a frustum of a cone with the larger base turned toward the muzzle of the gun. The *second reinforce* is a short frustum, generated by revolving about the axis a convexo-concave line whose middle point touches continually a circle having its center on, and its plane perpendicular to, the axis. This reinforce conjoins the first reinforce and the chase. The *chase* is a frustum of a cone, terminated in front by the face of the piece without swell of the muzzle or a muzzle-band. The *trunnion-ring* is a cylindrical ring of wrought-iron, which embraces the first reinforce near its rear end. This ring bears the trunnions, which are forged solid with the ring, and then turned down and properly aligned. The *breech-plug* is made of low steel. It is divided into two symmetrical parts by a meridian plane, which is horizontal when the fermeture is in position for firing. One of the halves has four dowel pins, two on each side, that fit into corresponding holes in the other half. These dowels or pins serve to preserve the relative positions of the parts when put together. The front end of the breech-plug, as a whole, is recessed to form the small hemispherical chamber that terminates the bore.

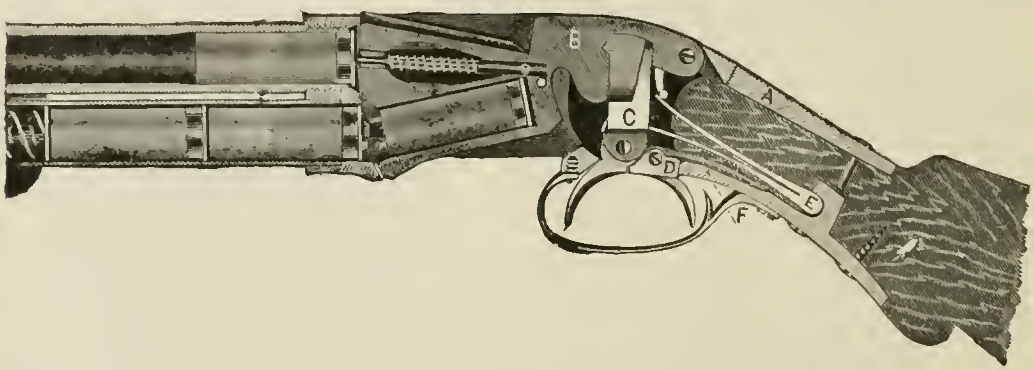
The axial portion of the breech-plug is cut away, forming a funnel-shaped cavity connecting with the chamber at its forward and smaller end. The bounding lines of this cavity, as seen in the longitudinal section, are curves, convex toward the axis of the bore prolonged. The hole through the fermeture is made of this form to guide the line as it passes through the bore of the gun and prevent cutting it off. The head of the fermeture, or part which projects beyond the posterior terminal plane of the gun, is slightly rounded for the same reason. Two holes perpendicular to the axis are bored in this basal projection to receive the cylindrical projection on the spanner-wrench used to close the fermeture. The cylindrical exterior of the body of the breech-plug is divided into eight equal parts, four sectors being armed with sectional screw-threads and four being blanks. The sectional screws and blank spaces alternate. The rear end of the bore of the gun is counterbored, and has sectional screw-threads and blanks to correspond with those in the breech-plug. The plug is inserted by turning it to the left until the threads on the block come opposite a blank space in the gun, then press the plug forward until it reaches the bottom of the counterbore, when an eighth of a turn to the right with a spanner-wrench engages the threads on the block with the corresponding ones on the inner surface of the counterbore, and brings the block firmly to its seat, at the same time locking the system. To withdraw the plug, give it an eighth of a revolution to the left, and *pull out* the plug. The vent is perpendicular to the axis of the bore, and is placed 1″ .6 in front of the trunnion-ring. It is obvious that the gun has a large muzzle preponderance. The projectiles are made of cast-iron. They are cylindrical in form, with short ogival points. The rear ends are rounded off. An axial hole is drilled in the base of the shot to receive the base-screw, used to connect the projectile with a spiral spring. Three sizes of projectiles are made, differing only in length and weight.

SPENCER RIFLE.—The magazine of the Spencer repeating-rifle lies in the butt of the stock, and is capable of holding seven copper case cartridges. A follower (*a*) impelled by a spiral spring pushes the line of cartridges towards the chamber of the barrel. When the chamber is closed, the point of the foremost cartridge rests against the *carrier-block* (*b*). When it is opened which is done by depressing the *lever-guard* (*c*), this cartridge is pushed forward into the position shown in the figure. By raising the lever-guard the cartridge is carried around and pushed into the mouth of the chamber, which is firmly closed



by the *breech-block* (*d*). The *extractor* (*e*) is a flat lever attached to the left side of the carrier-block, and withdraws the empty case by pressing against the under side of the rim. Another small lever, called the *guide* (*f*), falls into the space occupied by the carrier-block, and forms an inclined plane, up which plane the empty case moves to clear the piece. A *key* (not shown in the figure) has lately been introduced into this arm, by which the supply of cartridges can be cut off or let on at pleasure, and enables the soldier to reserve all the cartridges in the magazine for an emergency. When the magazine is locked, the piece can be loaded directly from the cartridge-box, as a simple breech-loader. The operation of this key is simply to prevent the carrier-block from falling so far as to uncover the magazine: at the same time it falls far enough to uncover the chamber for the insertion of a cartridge by hand.

SPENCER ROPER SMALL ARMS.—The most recent and novel principle developed in arms of great precision, whether for fowling or campaigning purposes, is exemplified in a shot-gun, the joint production of the inventors—C. M. Spencer and Sylvester H. Roper. The name of the former is a tradition of the Civil War, his repeating-rifle, which first appeared during the concluding years of that great struggle, and was issued in large numbers by the Federal Government, being esteemed by careful students of military annals an important factor of the Union triumph. Mr. Roper, if less world-wide known than his fellow-worker, has long been recognized in this country among the masters of mechanical motion, and has patented several devices particularly tending to the natural and rapid manual of small-arms. It is now some three years since the first outcome of the two inventors' efforts, to produce a fowling-piece which should take the place of the two double-barrel guns in a ducking trip, or be good for three quails out of a covey, was in working shape. The long experience of the sportsman combined with the shrewd application of the inventor, at once discarded all possibilities of improving the double-gun beyond its present perfection, or of successfully adapting the repeating systems of military and sporting-arms. The solution of the problem was to be sought in a path hitherto unexplored. Obviously the only resort was to a theory never before considered, which would call into exercise a change of manual while necessitating a change of mechanism.



The distinctive feature of the Spencer-Roper principle is, that for the first time in the history of small-arms, the left hand is available for something more than a support to the barrel and as a regulator of the aim ; but retaining these functions becomes an essential factor of the system, relieving its neighbor of a large portion of its duties while itself actuating the retaining processes. The original model, developing Messrs. Spencer & Roper's idea, carried 11 cartridges, which could be discharged at "will" in 4 seconds. The model, as recently perfected, has a capacity of 6 cartridges, (experience having demonstrated that to be the suitable number for use and the best working of the piece) of which 5 are held in the tubular magazine beneath the barrel, and one placed in the chamber. The gun has no fore-arm, or tip, of wood ; but about 6 inches in front of the frame, embracing the magazine, and well insulated from the possibly heated barrel is placed a bulge, of the same material as the stock or of hard-rubber, termed the hand-rest, which connects with the flat side-bars or switches, occupying the interval between the barrel and the magazine. The manipulation of the gun is exceedingly simple. When once the magazine is filled, the piece is brought to the shoulder, and the fingers of the right hand in position about the trigger-guard, while the left hand grasps the hand-rest and poises the piece. A backward and forward movement of the hand-rest throws a cartridge into the carrier-block, cocks the hammer, projects the charge into the gun, and the trigger is pulled. The rapidity of emptying the magazine being limited only by the natural dexterity and the experience of the operator. This manual and the action of the arm will be better understood by a reference to the sectional drawing of the piece, when in condition for firing, having one cartridge in the chamber and the magazine supposed to be filled. A, indicates the outline of the frame or receiver ; B, the block which serves both to carry up the cartridge and close the breech ; G, the firing-pin, in position to strike the cap of the cartridge, when actuated by the hammer, D, which is at cock; C, the trigger; E, indicates the mainspring, engaged; and, F, the trigger-spring in the same position.

The sectional drawing does not illustrate the operation of the extractor, which is positive, or the relation of the slides, or the switch-action to the locking-system. The extractor is pivoted in a slot of the right slide, and can not be seen in a left-sectional view. The operation of the backward and forward movement is exerted through the left side of the system, the slide in its backward passage traveling in a groove of the receiver, or frame, and actuating by a cam the downward movement of the breech-block until the position of the extractor on the right side of the system is such as to relieve the main-spring and cause the block to re-ascend. It will be observed that the elements of safety are at the *maximum* in this system. While the receiver is of the most durable design, the breech-block, pivoted at the rear, takes up the recoil in a plane in a direct line with the shock, and is itself supported by the solid back of the receiver. While the gun is, as the term implies, "hammerless," it is essentially safer than other arms so named, it being possible when the gun is cocked and loaded, to let down the hammer to the safety-notch and cock it again when desired, by introducing the two fingers gently between the projection of the hammer and trigger.

The organization of machine-plant and factory-room for the production of small-arms, on the American system of gauges and interchangeable parts, requires so large an expenditure of time and labor, that it is quite possible the publication of this first extended analysis of its distinctive merits will anticipate the commercial introduction of this latest achievement in small-arms. The aim of its inventors and promoters has most wisely been, so far as possible, to perfect their new gun before offering it to the public. With this view a number of guns, made by hand, have been, since the production of the original model placed in the hands of experts with the request that they should be submitted to the most difficult requirements of sporting service and subjected to the severest usage. To this *exigeant* testing the present perfection of the invention owes very much in the way of suggestion and consequent improvement. There is no such thing as perfection in any field of invention without arduous study and thorough experience of the difficulties to be encountered; no *Deus ex Machina* except in classic tradition.

The production of a new repeating-rifle was not contemplated by either of the inventors of the repeating shot-gun. In the early spring of 1881, however, there was issued from the Army Head-quarters at Washington an order for a Board of Officers to assemble in New York, "to examine and consider all magazine-guns that may be brought before it, and recommend such (one or more) of these guns as in its opinion are suitable for the military service." About the commencement of 1882, the Board having in the meanwhile prosecuted its trials of various models at Springfield, and adjourned to New York to conclude its labors, Mr. Spencer was strongly urged to adapt the system of the shot-gun to military purposes. In March the new repeating-rifle was introduced to the Board. In this evolution of a shot-gun into a military arm, the inventor following the lessons of long experience in repeating-arms, eschewed everything in the shape of a magazine which should be a part of the arm itself or in which the position of the reserve ammunition should permit the projectile of one cartridge to impinge upon the head of another. The model subjected was practically a single-loading breech-loader, with a receiver open at the bottom to receive and operate the Lee detachable magazine. The magazine referred to has been considered at length in another part of this work. The action of the Board of Officers was most complimentary to this arm. In the resumé of trials it was found that while in the generality of the tests, the Spencer-Lee was very rarely beaten, in that of "rapidity with accuracy," the recognized test for the efficiency of magazine-guns, it was very far from having an equal.

The model of the Spencer-Lee submitted to the Board was, with such very slight alteration, as was required by the substitution of a detachable for a tubular fixed magazine, generally similar in design to the original Spencer-Roper shot-gun, the breech-block pivoted at the rear and falling in a vertical plane, and the slides having a like function in opening and closing the action. Since the report of the Board was rendered, for considerations of length of system, a breech-block moving laterally, has been substituted for the original design. The models thus far produced have met an uniform approval. Considering the extraordinary merits of the Spencer-Roper shot-gun, it would certainly seem that a military arm, based upon a like theory of accuracy wedded to great rapidity should take the place of the single-loaders now in use. The infantry and cavalry arm of the future must be that one which will deliver the most shots in a very limited period, bounded by seconds rather than by minutes. An English authority has within a short time, uttered the *dictum*, "that as the fighting machine, which it is desirable to bring to the highest perfection, consists of two parts, a man and a rifle, the mechanical part, *i. e.*, the rifle, should be the quickest and best attainable: and the man, the other part should then be levelled up to it by careful instruction." Henceforth there can be no discipline of Woolwich, or instruction at Hythe, which can lift a man up to the level of his half of the fighting-machine, if he knows his enemy possesses the more rapid weapon. Within a few weeks the improved Spencer-Lee rifle has delivered 70 shots in one minute and three-quarters, of which each one would have struck its man. See *Lee Magazine-gun*, and *Magazine-gun*.

SPENT.—A projectile is said to be spent when it reaches an object without sufficient force to pass through it, or otherwise to wound than by contusion.

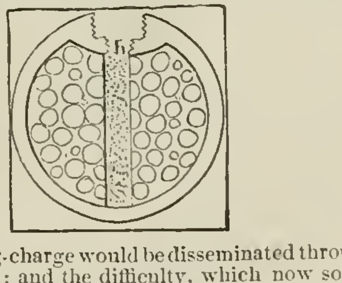
SPEW.—In gunnery, to run at the mouth; applied to a gun when, from too quick firing, it bends at the chase, or the muzzle droops.

SPHERE.—A regular solid figure, every point of whose surface is equally distant from its center; and whose outline is traced by a circle revolving round its diameter. All sections of a sphere by a plane are necessarily circles, and all sections by planes passing through the center, or by planes cutting the sphere at equal distances from the center, are equal. The former sections are called *great*, and the latter *small circles*. Small circles may vary in size between a mere point and a great circle, approaching either limit as nearly as we please. The surface of a sphere is equal to that of four of its great circles, or (taking x for the radius of the sphere) to $4\pi x^2$; and its volume to that of a cone whose altitude is twice that of the sphere, or $4x$, and whose base is a great circle of the sphere, the formula for it being $\frac{4x}{3} \times \pi x^2$, or $\frac{4}{3} \pi x^3$. The most remarkable geometrical property of the sphere is the relation which its surface and volume bear to those of the circumscribing cylinder, *i. e.*, a cylinder whose length and diameter of each end are each equal to the diameter of the sphere, and in which, therefore, the sphere will be exactly contained. The concave surface of such a cylinder is exactly equal to the surface of the sphere; and not only so, but if a section parallel to the base of the cylinder be made through both cylinder and sphere, the curved surfaces of the portions cut off are equal; whether such portion be cut off from one end or be intercepted between two parallel sections; it follows from this that the curved surface of any section of a sphere with parallel ends is equal to the product of the circumference of a great circle of the sphere by the height or thickness of the section, and that the curved surfaces of all sections of a sphere are proportional to the thickness of such sections. The volume of the sphere, also, is equal to two-thirds of that of the circumscribing cylinder.

SPHERICAL CASE-SHOT.—Though projectiles similar to spherical case-shot were used in France as early as the time of Louis XIV., the credit of perfecting them is due to Colonel Shrapnel, of the British Army. They were first successfully used by the English against the French, in the Peninsular War.

The envelope in the spherical case-shot, is a thin cast-iron shell, the weight of which, when empty, is about one-half that of the equivalent solid shot. To prepare this shot, it is first filled with round musket-balls, 17 to the lb., and the interstices are then filled up by pouring in melted sulphur or resin; the object of which is to solidify the mass of bullets, and prevent them from striking, by their inertia, against the sides of the case and cracking it, when the piece is fired. A hole is bored through the mass of sulphur and bullets, to receive the bursting-charge; and, in order not to displace too many bullets, and not to scatter them too far when the shot bursts, the bursting-charge should only be sufficient to produce rupture.

If the iron, of which the case is made, were always of suitable quality, and the cavity filled with bullets snugly packed in, there would be no necessity for sulphur to prevent accidents. In this case, it would not be necessary to remove any of the bullets,



as the bursting-charge would be disseminated through the interstices; and the difficulty, which now sometimes arises from their adhering to fragments of the case, would be entirely obviated.

To increase the effect of a small bursting-charge, the lower portion of the fuse-hole, *b*, is partially closed by screwing into it a disk perforated with a small hole for the passage of the flame from the fuse. The spherical case-shot mostly used for field-service is the 12-pounder; it contains about 80 bullets; its bursting-charge is 1 oz. of powder; and it weighs when finished 11.75 lbs.,—nearly as much as a solid shot of the same caliber.

The rupture of a spherical case-shot may be made to take place at any point of its flight: and in this respect it is superior to the canister and grape-shot, which begin to separate the moment they leave the piece. See *Case-shot* and *Projectiles*.

SPHERICAL CHAMBER.—This chamber consists of a sphere, joined to the bore of the piece by means of a cylinder, which serves as a channel to the gases. As this cylinder decreases in diameter, the gas finds more difficulty in escaping, and greater force is developed. This chamber is more objectionable than the cylindrical chamber, from its liability to break the projectiles, although it gives a very great range. This form of chamber is not now in use, as it is hard to make and soon becomes foul, when used.

SPHERICAL PROJECTILES.—These projectiles are commonly used in all smooth-bore guns, and for this purpose possess certain advantages over those of an elongated form. 1st. They present a uniform surface to the resistance of the air as they turn over in their flight. 2d. The centers of figure and inertia coincide. 3d. They touch the surface of the bore at only one point; they are therefore less liable to wedge in the bore and endanger the safety of the piece. 4th. Their rebound on land and water being certain and regular, they are well suited to ricochet-firing. See *Projectiles* and *Shot*.

SPHERICAL-SHOT MACHINE.—A machine for imparting a truly spherical form to steel or iron cannon-balls. The ball, hot from the molds or from subsequent heating, is placed in cups which are preferably caused to rotate in opposite directions and at different speeds. One of the cups is upon a spindle at the end of a shaft which has longitudinal motion by a tail-center, actuated by a hydraulic press or otherwise, and serves to press the cups together. The other cup-spindle is fixed. The cups are slacked off at times during the operation, to briug fresh surfaces of the ball under operation.

SPHERO-HEXAGONAL POWDER.—This is a molded powder, the grain, which is shown in the drawing, differing from the ordinary hexagonal powder by being formed of two hemispheres, instead of two pyramidal frustums united upon a hexagonal zone or base. It was thought that the nearly spherical form of the grains would insure very uniform results.

The granulation is the same for all, viz., 123 to the pound, but the density varies as follows:

	Density.
H. A	1.75
H. B	1.73
H. C.	1.72

These powders have been thoroughly tested, and contrary to all expectation, the results obtained with the H. B. and the H.C. powders, which from their lower densities should be quicker-burning powders, were very much inferior to the H. A. as regards both pressure and velocity. A sphero-hexagonal powder, I. B., of density 1.728, and granulation 123, was employed in recent experiments with the 3.17-in., chambered rifle, and with most excellent results.

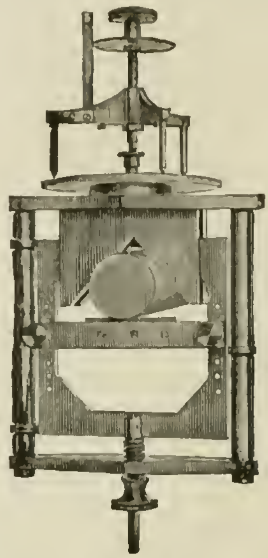
The following is a mean summary with the maximum charge employed:

Nature of gun.	Kind of powder.	Weight of charge.		Weight of projectile		Initial velocity.	Pressure.
		Lbs.	*Ozs.*	*Lbs.*	*Ozs.*		
3.17-inch chambered rifle.	I. B. sphero-hexagonal.	5	13	10	8	2,026	30,000

The amount of air-space allowed in the chamber with the above charge was about 32 cubic inches per pound of powder. See *Gunpowder*.

SPHEROMETER.—An instrument for measuring the curvature of surfaces. It consists of a three-armed frame, standing on three steel pins, which usually form with each other an equilateral triangle; in the center of the instrument is a vertical screw with a fine thread, and having a large graduated head. The screw is turned downward until its point reaches the surface on which the instrument stands; if this is a true plane, the index of the graduated screw-head should mark zero; if, on the contrary, it is either a convex or a concave, the corresponding positive or negative reading indicates the degree of sphericity.

The drawing represents an exceedingly accurate instrument, designed by Fauth & Co., for measuring the inequality of pivots. It is much more reliable and expeditious than the contact-level. It is made to measure pivots from $2\frac{1}{4}$ inches down to the smallest size. The round glass disc on which the three



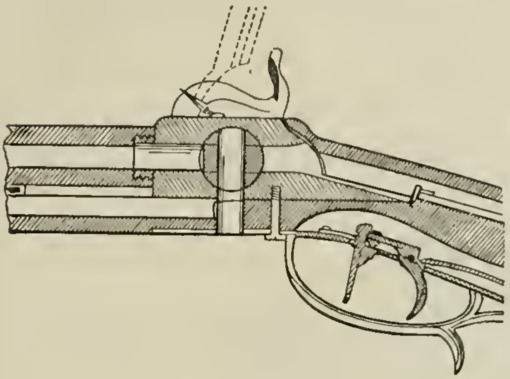
legs rest is perfectly flat; the screw is made with the utmost exactness, bearing on a jewelled center, and the nut is so constructed that there can be no dead motion.

SPICULUM.—A pilum, with a shaft $5\frac{1}{2}$ feet long, which, when impelled by a strong arm, was able to transfix a foot-soldier through his shield, or a horseman through his breast-plate.

SPIDER.—In casting a gun the core is lowered into the mold of the gun. To center and secure the core-barrel in position it is necessary to have a frame, usually termed a "*spider*," to support and hold rigidly in place the core when properly centered. It is made of cast-iron, about two and one-half feet high, having three legs, each of which has a projection at the bottom, fitted with an adjustable screw, which rests upon the upper flange of the flask; there is also a funnel or sleeve fitted in the central part of the top, through which the core-barrel passes and fits closely, holding it firmly, so that any movement of the frame will produce a change in the position of the core. See *Molding*.

SPIDER HELMET.—The casque of the French soldiers under Henry IV. It has a peak or flat vizor, with iron strips or ribbons all round.

SPIGGOT BREECH.—What has been called the "faucet" or "spiggot" breech was at one time considered a promising form of breech-closing device, and is believed to have been the very first American breech-loader. The breech-block or plug is perforated, and is in fact like the closing plug of a spiggot. The cartridge must be thrust entirely through the breech-piece, when made in the form shown in the drawing, before the breech can be closed. This form of breech was a good one for a gun using destructible cartridge-cases, but a metallic shell could not be easily withdrawn. Some heavy guns are still made on this principle. There is another form of faucet or spiggot-breech in which the cartridge is held in the breech-plug, and fired therein when in line with the barrel. In such construction the breech-plug is not generally bored through. As the plug must be greater in diameter than the length of the cartridge, this breech mechanism has not been very much used.



Spiggot Breech.

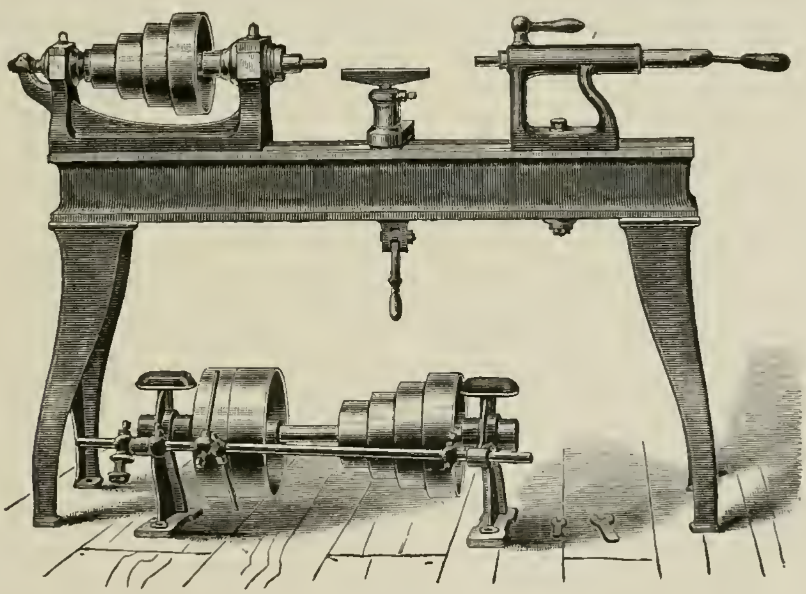
SPIKE.—A spike employed to temporarily disable a cannon should be made of hardened steel, with a soft point that it may be clinched on the inside. A nail without a head, or a bit of ramrod, may be used in place of a regular spike. To spike a piece, drive in the spike flush with the outer surface of the vent, and clinch it on the inside with a rammer. To prevent the spike from being blown out, wedge a shot in the bottom of the bore by wrapping it with cloth or felt, or by means of iron wedges, driven in with a bar of iron; wooden wedges might be easily burned out by means of a charcoal fire lighted with a pair of bellows. When a piece is likely to be retaken, a *spring-spike* is used, having a shoulder to prevent its being too easily extracted. See *Disabling Cannon.*

SPINDLE.—1. The *arbor* or the *mandrel* of a lathe. The *live* spindle is in the *head-stock*, the *dead* spindle is in the *tail-stock*, where its function is merely to center and support the object, and not to partake of its movement or impart motion. 2. The tapering end or *arm* on the end of an axle-tree. The hub of the wheel is slipped on the *spindle*, and is secured there by the linch-pin or nut. 3. The pin on which the pattern of a mold is formed.

SPIN HAY.—To twist it up in ropes, very hard, for an expedition, by which means it is less bulky and also less troublesome for the Cavalry to carry behind them. An expert horseman can spin five days' forage into a very narrow compass.

SPINNING-LATHE.—A form of lathe used in armories. The drawing shows the Pratt and Whitney pattern. The machine generally employed for britannia work, has a swing of 16 inches. Cone-pulley of four grades, largest diameter is 10 inches, for 2½-inch belt. Front bearing of head-stock spindle, 1⅝ inches diameter, 5 inches long. Screw-thread for face-plate 1½ inches diameter, 8 pitch. Pulleys countershaft 7 by 3 inches. Footstock spindle operated by lever or screw, as may be desired. Distance between centers of 6-feet bed, 3 feet 4 inches. Weight, with countershaft, 750 pounds.

For spinning sheet metals up to 15 inches in diameter and 30 in length the lathe with a double-head is used. The work is secured and released by the combined action of a treadle, rack and pinion, and weight, the treadle extending the entire length of the lathe. There are two heads, each carrying a cone of four grades, and the front support of the long spindle may be secured at any point on the slides. The lathe has a bed 5 feet in length, swings 15 inches, and weighs, with T-rests, countershaft having two cones, etc., 675 pounds. See *Lathe.*



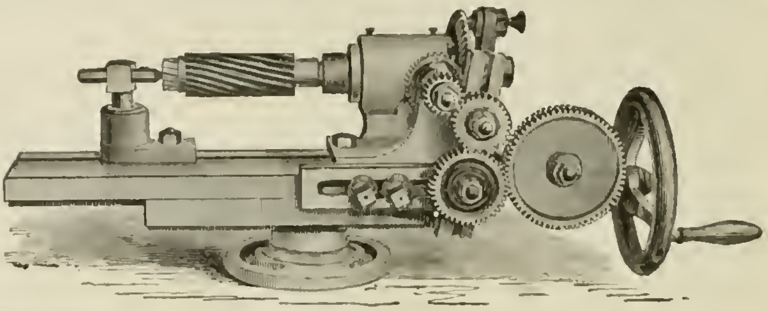
Spinning-lathe.

SPIRAL.—In geometry, the name given to a certain class of curves which, during their gradual regression from a point, wind round it repeatedly. Their equations are generally expressed in terms of polar co-ordinates, and are all necessarily of the form $r=f(A)$, where A never signifies a function of the angle, but the angle itself or a multiple of it. Several such curves have received distinguishing epithets, either on account of the properties they possess or from their inventor; the chief of them are—the *equable spiral* or the *spiral of Archimedes*, whose equation is $r=aA$ and which commencing at the origin, circles round and regrades from it with unvarying uniformity; the *hyperbolic* or *reciprocal spiral* ($rA=a$); the *logarithmic* or *equiangular spiral* ($r=ab^A$), which recedes from the center or origin with a velocity increasing as the distance, and always cuts the radius vector at the same angle; etc.

SPIRAL BIT.—A gun implement used for clearing the vents of ordnance when choked, after the gun drift has failed to do so.

SPIRAL-CAM.—A portion of the firing mechanism in certain machine-guns. See *Gatling Gun* and *Cam-ring.*

SPIRAL-CUTTER.—An attachment for the milling-machine, used in the armories to perform a great variety of work in the fabrication of small-arms, etc. The device, shown in the drawing, will originate and cut spirals 8 inches in length, right or left hand, and of any pitch, from one turn in 2 inches to one turn in 6 feet. Four gears go with the device, making 12 changes, as each can be used either as driver or driven, and all the studs are alike in size. If other pitches are required, common lathe gears can be used by fitting a bushing to them. A table of changes, angles and pitches, with rules for cutting any desired pitch



Spiral-cutter.

accompanies the machine. The piece to be cut can be held either upon centers, upon an arbor fitted to spindle, or one end in a chuck screwed upon a spindle. The spindle is hollow, allowing a $\frac{15}{32}$ inch rod to pass through it. To meet occasional wants, the spiral-cutter is sometimes made automatic and capable of cutting a conical spiral 9 inches long, supporting the outer center while cutting. See *Milling*.

SPIRALE.—A piece of ordnance used in France in the fifteenth century.

SPIRAL SPRING COILING-MACHINE.—A contrivance for coiling wire. The machines used in most armories for this purpose, are made in two sizes by the Pratt and Whitney Company, and are suitable for coiling from $\frac{1}{4}$-inch and smaller wire, springs of a minimum diameter of eight times the diameter of the wire. No. 1 machine has one set of rolls, and will coil wire of $\frac{3}{32}$-inch and smaller diameter. No. 2 machine has two sets of rolls and back-gears, and will coil wire of $\frac{1}{4}$ to $\frac{3}{32}$-inch diameter. The wire in the original coil may be placed on a reel, one end inserted between the rolls into the former, and the whole or any part wound into one continuous spring. Great care should be taken that the rear end of the wire does not pass beyond the grip of rolls; if it does so, there will be much difficulty in clearing the former. To avoid trouble, the spring should be cut close to the former at the point of exit, and the rolls reversed in motion to draw the wire back through the former. Close or open coils can be wound according to pitch of the former used. The first former of any pitch is apt to be expensive, as trials are usually necessary to attain the desired result. Countershafts are suitably arranged.

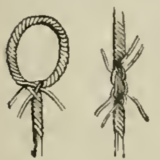
SPITHEAD FORTS.—The troubled state of European politics which gave rise in 1859 to the Volunteer Movement, led also to the recommendation of an extensive plan of defenses for the Arsenals and Coast. A Board of Commissioners drew up a scheme for these defenses, to cost about £5,000,000, of which a sum of £2,000,000 was for Portsmouth, Spithead, and the neighboring Coast. At present the entrance to the important Arsenal and Dockyard at Portsmouth is defended by Fort Monckton on the Gosport side, Southsea Castle on the other side, Cumberland Fort at the entrance to Langston Harbor, and Lumps and Eastney Forts between the two last named, and some defensive lines between the Island of Portsea and the mainland. £580,000 was voted in 1860 as a beginning, to increase the number and strength of these forts, to build detached forts on shoals in the sea between the mainland and the Isle of Wight, and to raise fortified lines on Portsdown Hill (the principal work being Fort Southwick), wholly northward of Portsmouth Harbor. The works were commenced but the often-conflicting lessons furnished by the American war led to much delay and endless variations of plan.

The National Defense Commissioners had proposed five advanced forts on the shoals known as Horse Sand, Noman or No Man's Land shoal, Sturbridge shoal, Spit Point, and a point intervening between Horse Sand and Portsea Island. But after much discussion and numerous alterations of plan, it was only in 1864 that it was determined to proceed with the foundations at least of two—the Horse and the Noman forts. The foundation of each fort consists of rings of stone-work, laid on the levelled bed of the shoal, tapering a little upward from a width of 54 ft. to one of 43 ft., the outer diameter of the ring gradually lessening from 231 to 213 feet. From 20 to 15 ft. of submarine masonry is required. Outside the rings of stone are layers of rubble to protect the stone-work from the action of tidal rush. Two years later similar forts were begun on Spit bank and St. Helens shoal. In 1865 a mortar-battery had been erected at Puckpool in the Isle of Wight, commanding at long range the approach to Spithead. In 1868, after it had been found impossible to secure a foundation for a fifth fort on the Sturbridge shoal, Puckpool battery was strengthened and armed with 30 mortars and 4 guns of 25 tons.

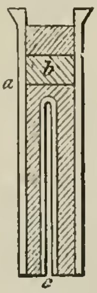
All this time the Government had not determined which of three modes to adopt for constructing the forts—whether to form them entirely of iron, or of granite faced with iron, or simply of granite, leaving the facing for after-consideration. The plan most in favor with the Government in 1866 was to erect on each of the foundations at Spithead a *revolving* iron fort or tower of enormous magnitude. Circumstances in 1867 induced the Government again to pause. Experiments on the Rodman 15-in. and 20-in. guns led the Engineers to believe that no iron casing for forts could resist shot of 500 lbs. to 1,100 lbs. from such ordnance; while the rolling of an armor-plate 15 inches thick revived the hopes of those who believe that armor will eventually vanquish guns. Finally, the forts were finished, of a granite core, surrounded by a great thickness of iron plates. Above each fort are revolving turrets carrying 35-ton guns, which throw shells of 700 lbs. The inner line of defense has been strengthened by new works at Gilkicker, Southsea Castle, etc., and by the increase of the size of the guns, and the addition of iron shields in the embrasures.

SPLENT—SPLINT.—The bony enlargement on the horse's leg, between the knee and fetlock, usually appearing on the inside of one or of both fore-legs, frequently situated between the large and the small canon bones, depending upon concussion, and is most common in young horses that have been rattled rapidly along hard roads before their bones are consolidated. When of recent and rapid growth, the splint is hot and tender, and causes lameness, especially noticeable when the horse is trotted along a hard road. A piece of spongiopiline saturated with cold water should be applied to the splint, kept in position with a light linen bandage, and wetted with cold water or a refrigerant mixture each hour. Perfect rest must be enjoined for ten days or a fortnight. When the limb is cool, and free from tenderness, the swelling, which will still remain, may be greatly reduced by some stimulating applications, such as the ointment of the red iodide of mercury, the common fly blister, or the firing-iron. See *Splints*.

SPLICE.—To join the two ends of a rope together without a knot, or to unite the end of a rope to any part thereof, by interweaving the strands in a regular manner. The instrument used for the purpose is a marline-spike. There are two kinds of splice, *short* and *long*. To make a *short splice*, untwist from 4 to 8 inches of each of the two ends of the rope, and interlock the strands up to the close parts of the rope, those of the two ends alternating; hold in the left hand one end of the rope with the loose strands in the front, and cross each strand of that end over the strand of the other end which is to the left hand of it; then by means of the marline-spike pass it under the same strand of the second end, and draw very firmly on the strand which is passed through. Pursue the same course with all the strands of the second rope. To increase the strength of the splice, pass each strand round the one on its left a second time, and cut off the loose ends. The short splice is used for slings, block-straps, or when the rope is not intended to pass through blocks. To make a *long splice* for a rope which is to pass through a pulley, the short splice being too thick, untwist about 8 inches of the two ends, and interlock as before, untwist a strand of one end from the close part of the rope and replace it by the strand of the other rope which comes to hand; cross the end of the latter strand over the one which is replaced, and pass it under the adjacent strands. Substitute, in this manner, every other strand of the other rope, and cut off the loose ends. The long splice is used to unite two ends of a rope which is to pass through a block. See *Cordage* and *Knots*.



SPLINGARD FUSE.—A concussion-fuse is made to operate either by the shock of the discharge, or by the shock experienced in striking the object, and is applicable to spherical projectiles. One of the simplest, as well as one of the most effective, concussion-fuses is that invented by Captain Splingard, of the Belgian Service. It is composed of two principal parts—the wooden plug, and the paper fuse. The chief peculiarity lies in the arrangement of the paper fuse. The case (*a*) is made of paper, rendered incombustible by a solution of sulphate of ammonia and alum, and filled with fuse composition (*b*) of variable quickness of burning. A long cavity is formed in the lower part of the composition, by driving it around a spindle, as in a rocket; this cavity is filled with moist plaster of Paris, and a long needle is inserted in it, nearly to the bottom of the plaster, forming a tube (*c*) enclosed in and supported by the composition. The composition is ignited in the usual way, at the top, and, as it burns away, leaves a portion of the plaster tube unsupported; when the shell strikes its object, the shock breaks off the unsupported part of the tube; the flame of the composition communicates with the bursting-charge; if the tube do not break, the composition burns up, and the bursting-charge is ignited, as in an ordinary time-fuse. The upper portion of the composition burns away quickly, in order to leave the tube unsupported soon after the projectile leaves its piece. See *Concussion-fuse* and *Fuse*.

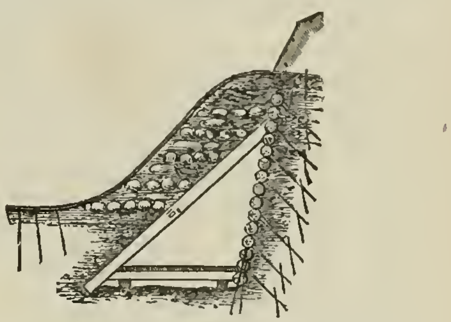


SPLINTER-BAR.—A transverse horizontal bar to which the shafts, or the pole and traces, are attached. It should be well supported throughout its length by the futchells (or frame sides and summers where no under-carriage is used), at short intervals, to neutralize the straining moments from the *traces*. If the ends project far beyond the futchells or sides of the carriage, stays must be added across the angles.

SPLINTER-PROOF.—The mouth of a magazine is usually covered by the *splinter-proof* shelter. This is constructed by taking scantling eight by ten inches, cut into suitable length and placing it in an inclined position, so as to cover the mouth, and leave an easy access to it. The pieces usually are inclined 45°, and are placed side by side; they are covered by at least two feet of earth, or sods; and hides or tarpaulins are thrown over the whole.

The magazines here referred to are only suited for works which are not expected to be occupied but for some weeks, and are not exposed to an attack of any but light field-guns. In all cases where lumber is abundant, it will be best to cover at top by a foot in thickness of pieces laid in juxtaposition, and to give a covering of at least six feet thickness of earth on the most exposed side, and place the magazine entirely underground.

Splinter-proofs for the trenches and enclosed works faced with timber from eight to twelve inches diam-

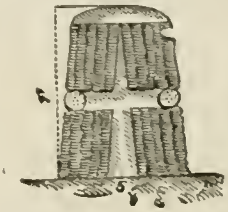


eter, and covered with a sheeting of thick boards and from four to six feet of earth, which are supported by uprights at the back, having a board flooring as shown in the figure, have been recently used in our field-works and trenches with great benefit in the saving of life.

The drawing shows a cross section of a splinter-proof shelter laid against the side of a traverse. The traverse is revetted with fascines, and the timber-work is thoroughly covered with sandbags and tarpaulins, or raw hides.

Splinter-proofs made after the foregoing plan, but smaller, may be placed against the parapet between the guns. These not only afford shelter for the men, but give a place to keep implements and a few rounds of ammunition ready for immediate use.

SPLINTER-PROOF TRAVERSE.—This traverse, intended to be used only as a protection against splinters and the fragments of shells scattered around by their explosion, is not so thick as other traverses. The usual height is the same as that of the parapet, and the thickness at the base is from seven to eight feet. The length varies, being in some cases only ten feet, and in others as much as sixteen feet. As a rule, a traverse of this kind is not joined to the parapet, but is separated from it by a narrow passage which can be used by the men to pass from one side of the traverse to the other. It is usually constructed as follows:—A rectangular space is marked upon the ground for the base of the traverse. A row of gabions is then placed in juxtaposition along the line representing the base of the traverse, and is given a slope inwards, either by setting the gabions on the slightly inclined excavation in the ground, or by raising the outer edges by means of fascines laid along on the ground. The gabions are then filled with earth, and also the interior space enclosed by them. When the earth has risen above the top of the gabions, two rows of fascines are laid upon the top of the gabions to form a base for a second row of gabions. The second row is then filled with earth, and the process of filling with earth continues until the earth is high enough. The top is rounded off, or is made ridge-shaped, and the traverse is completed. The same method may be used for the construction of traverses required for defilade, when there is a very pressing emergency for them. Splinter-proof tra-



verses are placed between the guns along a line of parapet which is exposed only to a direct fire from the enemy, and are only intended to confine the effects of bursting projectiles to a limited space. They are usually constructed only when there is a necessity for them, and then hastily. Gabions, sand-bags, fascines, or any of the materials used for revetments, may be employed in their construction.

SPLINTS.—1. In ancient armor, the small overlapping plates for defence of the bend of the arm; they constituted part of the suit called the *almaine-rivets*, which was worn for the defence of the lower part of the body. 2. In surgery, certain mechanical contrivances for keeping a fractured limb in its proper position, and for preventing any motion of the fractured ends; they are also employed for securing perfect immobility of the parts to which they are applied in other cases, as in diseased joints, after resection of joints, etc. See *Surgery*.

SPOILS.—Whatever is taken from the enemy in time of war. Among the ancient Greeks, the spoils were divided among the whole army, the General taking the largest share. Among the Romans, the spoils belonged to the Republic.

SPOKES.—The small bars inserted in the nave of the wheel and which serve to support the felloes. The *working-spoke* is exposed to all the chief strains and shocks. The general transverse section of the spoke is fixed by the pressure due to traction sustained by the working-spoke. This pressure, P, varies as

$$\frac{W}{\cos d - c \sin d};$$

in which d is the angle contained between the vertical drawn through the center of the wheel, and the radius through the obstacle; c the co-efficient of friction of arm and pipe-box, and W the weight of the load on the wheel. On inspecting the equation

$$P = \frac{W}{\cos d - c \sin d},$$

we see that when $d = 0$, $P = W$; hence the pressure on the working-spoke is never less than W, and it increases greatly as the height of the obstacle increases. The first shock from side-thrusts has to be sustained by the spoke, the strain upon which increases towards the nave. Hence the section of the spoke in the plane of side-thrusts (perpendicular to the face of the wheel) should deepen as it approaches the nave. But this increase of strength at the foot of the spokes is limited by the dimensions of the nave, and other considerations of weight and manufacturing convenience; and it has been found, on account of these limitations, insufficient of itself to meet the entire straining moment from the more severe natures of side or diagonal-thrust, the most injurious effect of which can be removed by arranging the spokes so that their longer axes, lying on the surface of a cone, are directed to its apex, which is in the axis of the wheel, the face of the wheel forming the base of the cone. In this construction the spokes cannot be bent back by side-thrusts without extending the tire. By increasing the *angle of dish* and decreasing the *strut* we will lessen the strain on the spoke; but experience has shown that a *dish* of not less than ½ inch per foot of the wheel's diameter is necessary for heavy carriages destined to travel at speed over rough country. The *strut* generally adopted is about ½ inch in a 5-foot wheel. The spokes may be as numerous as is consistent with securing a strong and rigid junction with the nave. The more numerous, the less the strain on each spoke. See *Wheel*.

SPOKESHAVE.—A small iron plane something like a penknife, set in the middle of a frame, which can be used with both hands. It works easily in the direction of the grain, and is used for shaping and smoothing small rounded surfaces. This instrument is used by the carriage-maker, cooper, saddler, and other artisans.

SPONGE.—A mop for cleaning the bore of a cannon after a discharge. The sponge-head is a wooden cylinder covered with a fabric, of which the warp is hemp and the weft woolen yarn, woven in loops like a Brussels carpet. Alum-dressed sheep-skin with the wool on is sometimes used. In field-service, the *rammer* is at one end of the staff and the sponge at the other. Fig. 1. represents the ordinary sponge, and Fig. 2, a choke-bore cleaner, for small-arms. Fig. 3. shows a hair-brush used for this service with rifled

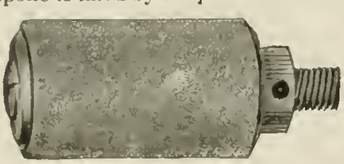


Fig. 1.

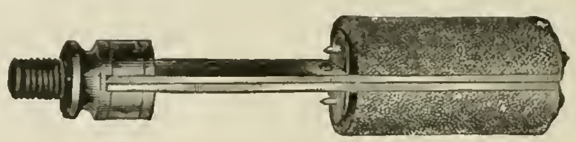


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

guns. Figures 4 and 5 show the ordinary forms of rubber cleaners for small-arms.

SPONGE-BUCKET.—A sheet-iron bucket, for washing the bore of the piece. The top and bottom are turned over the sides and fastened with rivets; or the bottom may be fastened to the sides by a double fold, and stiffened with a hoop shrunk on above the seam.

SPONGE-CLOTH.—A peculiar kind of cloth, moist with oil; it is employed to clean the screws of Armstrong guns, and is made of cloth so woven that no fiber comes off in use by which the worms of the screw could be clogged.

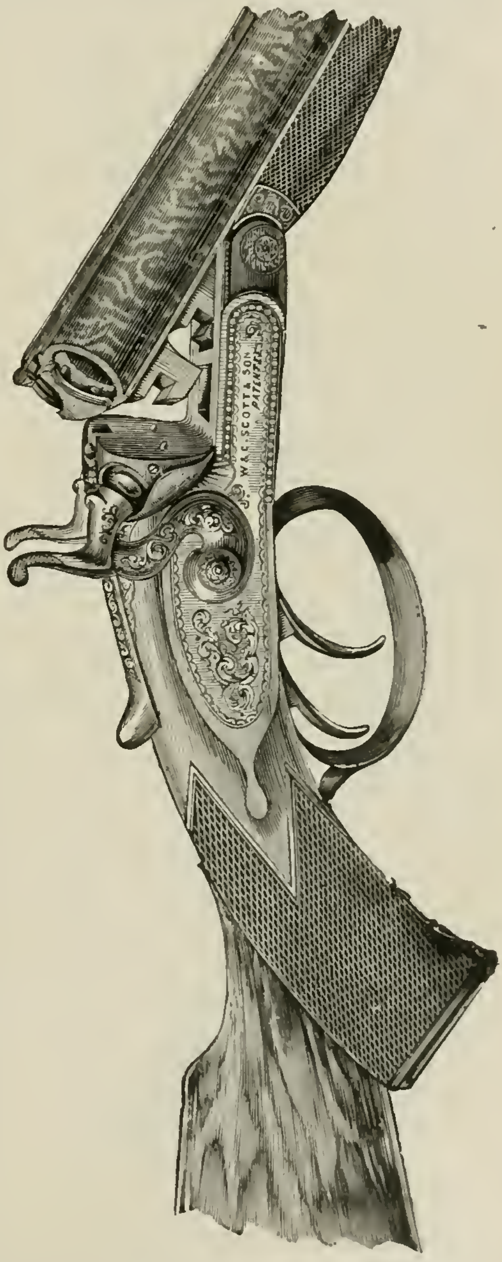
SPONGE-COVER.—A strong bag of linen or canvas, used to protect and preserve the sponge. The diameter of the bag is equal to that of the bore of the gun, and the length sufficient to allow the mouth to be drawn together, around the staff, by means of a cord inserted in the hem. A loop of canvas sewed to the bottom, serves as a handle by which to pull the cover off. The covers are marked with the caliber of the piece to which they belong.

SPONTANEOUS COMBUSTION.—Taking fire of itself. This phenomenon is known in the mineral and organic world. Frequently cases are stated of coals becoming ignited of their own accord. This is more often seen on board ships laden with coal, where, from the heat of the hold, and the moisture from water which a ship takes in from leakage, or other causes, the coal becomes heated and moistened, and from the conjunction of pyrites in the coal, in which the protosulphide is associated with the bisulphide of iron, it takes fire. New-burnt charcoal, and particularly new-ground charcoal, is very liable to spontaneous combustion. Phosphorus is another mineral subject which, in its dry state, is very liable to burn spontaneously. Articles of cotton or wool saturated with oil (vegetable), and heaped together, are very liable to burn spontaneously, oil having always an affinity for oxygen, and thus causing ignition. Many of the disasters which occur in powder-houses, when the houses have been closed and an explosion has taken place, may possibly have occurred from cotton-waste containing oil being left collected in a corner of the house.

SPONTOON.—A weapon bearing resemblance to a halberd, which, prior to 1789, was borne instead of a half-pike by officers of British infantry. It was a medium for signaling orders to the regiment. The spontoon planted in the ground commanded a halt; pointed backward or forward, advance or retreat; and so on. The ungraceful and grotesque shape of the weapon points out very accurately the time of its invention—the period of wigs and three-cornered hats. The last *spontoons* known in France were those carried by the French Guards in 1789.

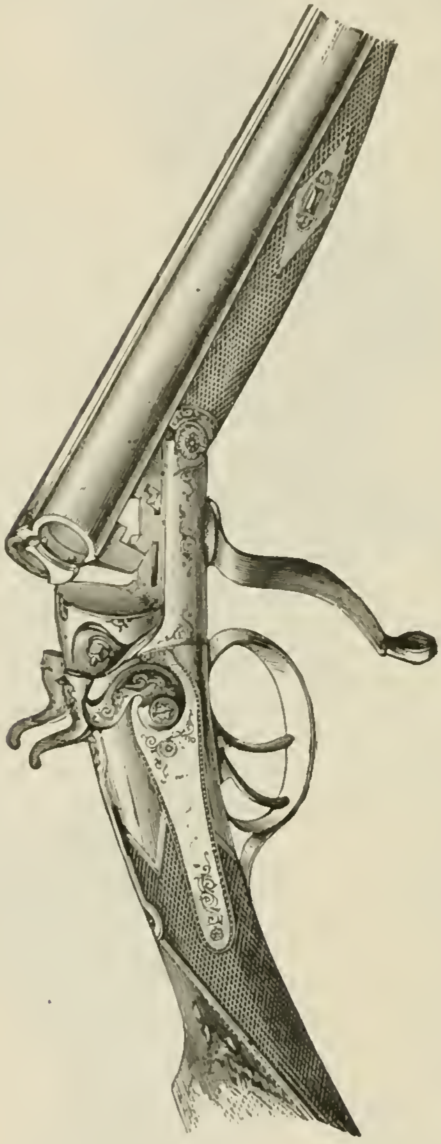
SPORTING-ARMS.—This teeming subject to be adequately treated would require much more space than could possibly be given it in a work like the present. We must content ourselves, therefore, with a brief outline of the history of game-shooting, some hints on the selection, handling, and use of guns, and a list of the game resorts in the United States. From the time of Nimrod to the present day the capture of wild animals has always afforded man the keenest enjoyment, and no occupation is more healthful, invigorating, or beneficial. Although over-indulgence in anything is hurtful and brings satiety, nothing is less prone to pall than shooting. The ping of the rifle-bullet or crack of the shot-gun has charms that never tire. It would be idle to describe the pleasures of the field and forest; the votaries of the chase are even now too numerous, and each year sees an alarming increase in their number, whilst unfortunately game (especially the large mammalia) is rapidly decreasing.

It is doubtful at what time guns were first used as sporting-arms, but early French and Italian works seem to indicate the close of the 14th century. We find a curious illustration in an old manuscript entitled "Ye Gonne and howe to Use itt," dated 1446. This curious sketch is evidently a caricature, but it is sufficient to show that all fire-arms were used for game-shooting in the early part of the 15th century. We get notices of the same in several records of that century, and by the close of the 16th the gun seems to have become so general a sporting weapon as to necessitate special regulations in several European countries. About 1580, an Italian work informs us,



Scott Top-lever, Double-bolt.

shooting at birds flying and animals in motion was first practiced, but this could not have been to any great extent. It was not until the close of the 18th century that shooting on the wing became at all common; since that time it has been so universally practiced as to make shooting at any fixed object with a shot-gun unsportsmanlike. The well-balanced and light guns made by the crack gunsmiths of the early part of this century greatly favored snap-shooting, and many of the sportsmen of those days, if they did not make such large bags as those of to-day, enjoyed sport into a good old age, and were hale and hearty to the last. So much for the days of flint and steel. It is seldom sportsmen shoot alone now. Drives or *battues* are much more in vogue; otherwise sportsmen, as a rule, shoot in company, very often substituting markers for pointers and setters, and contenting themselves with a retriever, and not always that. This method of walking the game is not half so pleasurable as shooting over well-broken dogs, but when



Leader Breech-loader.

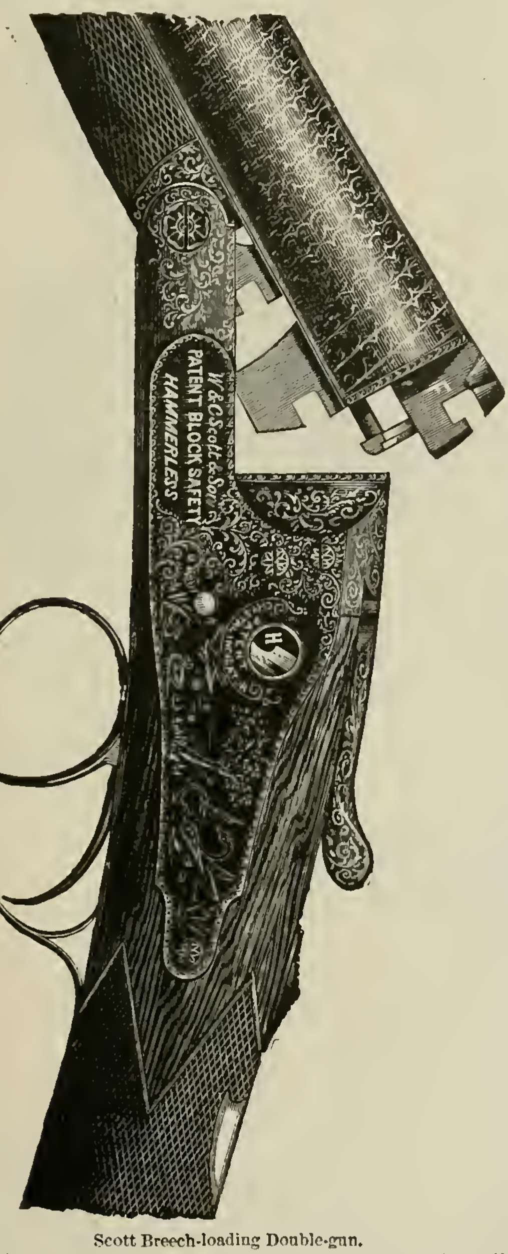
properly carried out it invariably insures a larger bag.

In his selection of a rifle or a shot-gun for game-shooting in this country, the sportsman is frequently puzzled on account of the contrariety of opinion existing among some of the crack shots. In the following paragraphs, which we take from a work by an experienced hunter, he may find some hints to assist him in his choice.

For a timber gun, or rifle at short-range, the improved Winchester, model 1876, should be selected. It is a close, clean shooter, is easily kept in order, and is handily packed while in the woods, or carried on a saddle. When cartridges are carried in the magazine for several days, the ends of the balls become battered, but they can easily be trimmed up with a knife or file. . . . For large game and long-range shooting, the Sharp's and the Remington rifles should be recommended. They both shoot close, hold the same cartridges, and are of equal merit. The vertical movement of the breech-block is safe, easy, and not liable to get out of repair; it is easily removed and cleaned, and there are no screws to be misplaced or lost. The barrel can be wiped from the breech, thus removing all dirt from the working parts, and in shooting it is second to none. The Remington rifle of all grades shoots admirably, . . . and is a great favorite with marksmen upon the various shooting-ranges of the East. . . . When shooting rapidly, the Sharp's rifle is very conveniently loaded, as the cartridges naturally fall down into the barrel. With some other makes it is often necessary to set the cartridge with the fingers. The Maynard rifle shoots well, and does good shooting when hunting antelope and other large game. The shells of long, heavy cartridges will stick in most rifles when a little foul. A breech-loading rifle should never be used when dirty. When having been shooting rapidly, wipe out the rifle at the first opportunity; and clean, with a greasy cloth, the dust from a few of the cartridges in the front of the belt. When riding over the dusty plains it is almost impossible to keep cartridges greased and clean. The needle-gun and Winchester rifle are superior to others in throwing shells clean from the barrel. The Winchester will throw the shells clean from the hunter's shoulder, and when firing rapidly at running deer, at long-range, a second shot is often fired before the first shell strikes the ground.

Sportsmen nowadays are very fastidious, and buy many imported shot-guns; and it is to be regretted that the home manufacture is not more encouraged. American rifles are the finest in the world, and our shot-guns might be if the manufacturers were sufficiently patronized. We have a dozen good makers in the United States that would turn out beautiful guns if sportsmen would pay for the work in them. The different grades of the Remington guns are an example. These cost less than forty dollars. They shoot hard and close, and work admirably. They are the gun "for the million," and are the best breech-loaders in the market. The Fox gun differs from all others, having a side action when loading, thus doing away with the clumsy fall of the barrel which occurs when charging other breech-loaders. It is not so liable to wear, being unlike the greater number of breech-loading shot-guns in having no hinge for the barrels to work on. The now well-known Baker gun has grown very popular, and its utility will make it the deer-hunter's favorite. In this gun we have a heavy, strong-shooting breech-loading rifle and a fine double breech-loading shot-gun. With a heavy ball in the rifle-barrel, a charge of loose "buck" in one shot-barrel and a wire cartridge of buckshot in the other, the hunter is well "fixed" for all emergencies. The sights of this gun are directly over the rifle-barrel, and the hunter has only to calculate on the trajectory.

The shooting qualities of breech and muzzle-loading guns are subjects of great discussion. Our experience is that the muzzle-loader shoots the stronger and better, particularly with light charges. The greater portion of breech-loading guns will recoil when long, crimped cartridges are used, the crimping appearing to make the difficulty. The metallic shells, if properly charged, shoot stronger and with less recoil than the crimped paper ones; and yet the metal shells often stick in the best of guns, and cause much trouble. Many sportsmen shoot too much shot, and use that which is too coarse. Equal bulk of powder and shot are good proportions, except when shooting very coarse shot, when a few extra pellets may be added. It is necessary to use more powder when shooting cartridges than when using the muzzle-loader. When hunting ruffed grouse in timber, in their wild, shy season, charge the right-hand barrel with No. 7 shot, and the left-hand barrel with No. 6. Use No. 5 shot for pinnated grouse on the Prairies. Every gun has its specific charge for good shooting, and is regulated by its weight and bore. Practice only will determine this point; and when decided upon, do not deviate from the proper load. A gun will make the most regular pattern when clean; when



Scott Breech-loading Double-gun.

dirty it very often sends the shot quite irregularly, in bunches; and when an occasional long shot is successful, the amateur sportsman might think a gun is most reliable when foul. Experience, however, teaches one that a clean gun shoots the better. When shooting rapidly from the muzzle-loading gun, if it becomes foul and begins to recoil, the charge may be slightly lessened, as the dirt in the barrels causes the wads to fit tightly, and the strength of the powder is more fully used than in a clean gun.

It is now acknowledged that it is better to make use of both eyes, and to pay no attention whatever to the gun whilst aiming. In short, the *eye*, *hand*, and *trigger* must act in perfect unison, and without any consideration having to be given to either. On a bird rising, the hand should *intuitively* raise the gun until it covers the object, from off which the eyes are not taken before the trigger is pulled. This only requires practice; and if such is forthcoming, and the body kept in perfect health, a good wing-shot is sure to result. Health is undoubtedly of the greatest importance to professional shots, and is necessary to good shooting. It cannot be expected that one who has not the power over his muscles to keep the hand steady can exert them to raise at once a gun and to level it to the greatest nicety. It is now the prevailing notion that most misses are caused by shooting behind or below the mark that is aimed at. To remedy this, straight stocks are recommended, and the following method has been devised to ascertain whether the gun is properly brought up. The shooter is to place himself three or four yards from a good-sized mirror, and aim at his own eye, raising the gun repeatedly, steadily but quickly, as in shooting at the bird. Upon looking into the mirror, with the gun as brought up to the shoulder, if the two round holes, or end elevation of the muzzle, are alone discernible in the mirror, the fit and handling of the gun are theoretically correct; if a little of the lower or under side of the barrel is likewise to be seen, so much the better; but if any of the top rib, or top side, of the barrels figures in the mirror, the chances are that nine shots out of every ten will be below the birds.

With fast-flying birds, and game running at full speed, it is a much disputed point among all who use the gun whether the shooter should hold "on" or "ahead." The latter appears to have the best of the argument, theoretically and practically. To prove that either plan is the correct one would be next to impossible; but says Greener: "With due deference to the majority of sportsmen, we hold with the practice of holding on." A great deal of difference is doubtless caused by the manner of bringing up the gun the shooter has acquired; some bring up the gun with a swing in the direction the mark is moving, others bring it up and follow the object, while the majority of good shots put up the gun and, it is supposed, fire ahead. Now, those who shoot with the gun on the swing, and who *intuitively* increase the speed of the swing in the same ratio as the increase in the speed of the mark, never require to hold ahead, even in the opinion of the strongest supporters of the hold ahead theory. The second class of poking shots are generally most uncertain in their aim, and the habit is detrimental to becoming an expert snap-shot, whilst we cannot but believe that many who imagine they hold ahead in reality hold on.

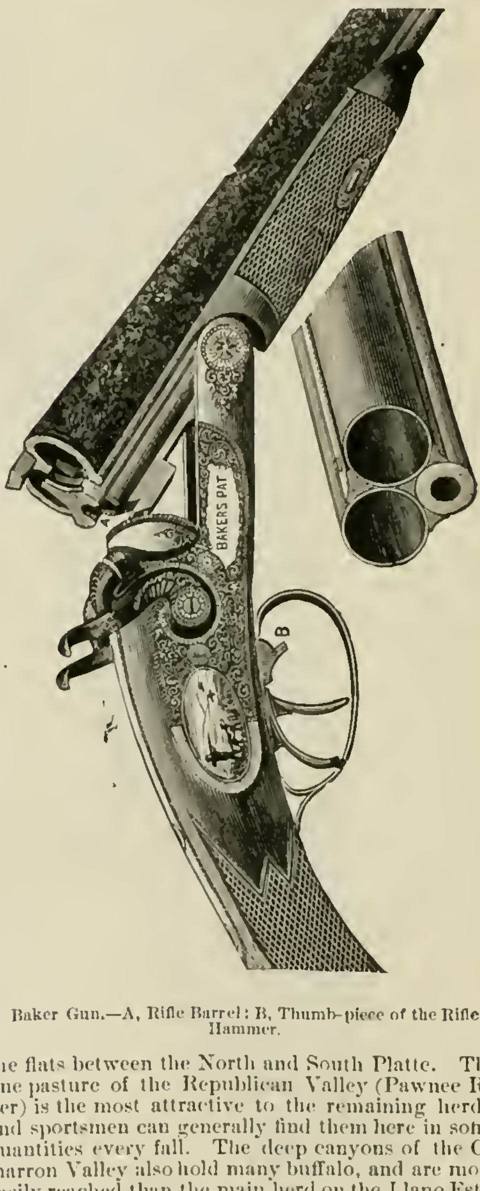
In the first place, having practiced raising the gun and perfecting the handling so that it shall intuitively follow the eye, it must be most difficult to point the gun away from the object at which both of the eyes are staring; and if the eyes are then removed from the object to some distance ahead, it is impossible to accurately tell what distance the line of aim is from the bird. This is especially the case when gazing at the sky; and for a shooter to be able to aim ten or fifteen yards ahead, as is advised by some wild-fowlers, is next to impossible to do with regularity. When gazing at no fixed object, it is as easy to move 30° across the sky as ten yards, and that without being aware of the discrepancy. Those who hold on, by shooting very promptly, prove the truth of the theory that it is necessary for the hand and eye to act in unison; whilst they who hold ahead, although agreeing that the hand must follow the eye, yet so shoot that the hand must point the gun in a different direction from the object on which the eye is fixed. An ordinary full-choke possesses a killing circle of at least thirty inches in diameter at thirty yards. Assuming a bird crossing to be fired at by a holder-on, the shot, traveling at the rate of 225 yards per second, would reach the bird at thirty yards in less than one-fifth of a second from the instant of pulling the trigger; so that it would indeed be a fast-flying bird to get without the killing circle in that time. The time required from the instant of pulling the trigger to the explosion of the cap is greater than that occupied by the shot traveling fifty yards; but with hammerless guns the time is less than with hammer guns, the blow given being much shorter, and direct instead of being conveyed by an exploding-pin. Some quick shots, however, anticipate the time it takes to *fire* the gun, and pull the trigger whilst raising the gun up to the shoulder. This requires a considerable practice to perfect, and the gun must, of course, be within an ace of the proper position; but, however the practice may be deprecated, it is certainly *au fait* for trap as well as general snap-shooting.

In grasping the gun, a disputed point is the position of the left hand. As a rule, sportsmen grasp the barrels in the very weakest place, viz., just in front of the cartridge-chambers. Others again, to shield themselves as far as possible from danger, grasp the front of the trigger-guard by the left hand. This position is wrong, as but little command is obtained over the gun, the liability of injury by the breaking of the breech-action is not at all lessened, and usually a piece of horn has to be attached to the trigger-guard, spoiling the beauty and handiness of the gun. To have full command over the gun, and at the same time exposing the hand and arm to a minimum of risk in case of a burst, *grasp the gun well forward*—if close to the fore end tip so much the better—but do not bring the hand any nearer to the breech than six inches, and keep the elbow well depressed. By having a proper command over the gun, it can be raised quickly and easily, and even a heavy or clumsy gun may be manipulated with tolerable success.

GAME AND GAME RESORTS.

Large Game.—The buffalo is considered the first game of North America. Although rapidly decreasing in numbers, there are still several millions distributed over the United States and Canada. Buffalo-hunting as a sport is tame after the excitement of killing the first half-dozen, for no more skill is required to kill twenty or one hundred buffaloes than to kill one. The Indians still hunt the buffalo with bows and arrows, and consequently get to close quarters. A ball-gun is sometimes used by other hunters, but a rifle is preferable; a brace of saddle-pistols or an army revolver is generally carried in addition. There are at present two buffalo-ranges in the United States—the southern, extending from 32° to 37° 32′ north latitude and from 99° to 104° west longitude; or, roughly speaking, from the Arkansas River on the north to the rivers Brazos and Colorado on the south. The western limit is the Rio Pecos; the eastern, the Washita Mountains in the Indian Territory. This vast tract includes part of Texas, Indian Territory, New Mexico, Kansas, and Colorado, and several Indian Reservations. The northern buffalo-range cannot be exactly defined. It extends from the Missouri River on the north and east to the Rocky Mountains on the west and the South Fork of the Big Cheyenne River on the south. This tract also includes parts of Montana, Wyoming, and Dakota, and numerous Indian Reservations. The abundance of buffalo may be judged by the fact that it was estimated that 4,500,000 buffaloes were killed during the three years 1872–74, and in 1878 over 60,000 buffalo-robes were shipped down the Yellowstone River. In the season of 1880 a professional robe-hunter killed 2,000 head of buffalo in Montana. Many buffalo are likewise to be found in broken herds between the two buffalo-ranges we have mentioned. Some thousands inhabit the country between the Arkansas and the South Platte, and in 1874 a large number crossed over to

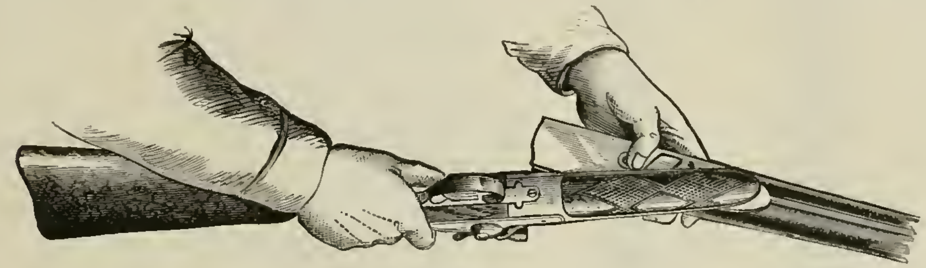
Sporting Rear-sight.



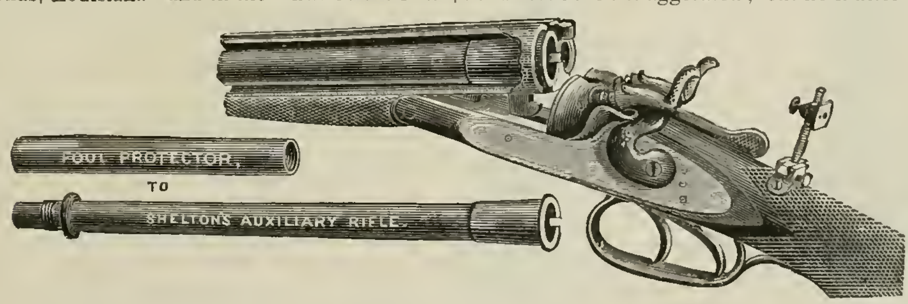
Baker Gun.—A, Rifle Barrel: B, Thumb-piece of the Rifle Hammer.

the flats between the North and South Platte. The fine pasture of the Republican Valley (Pawnee River) is the most attractive to the remaining herds, and sportsmen can generally find them here in some quantities every fall. The deep canyons of the Cimarron Valley also hold many buffalo, and are more easily reached than the main herd on the Llano Estacado, or Staked Plain. In the northern range, the valleys of the Yellowstone, Bighorn, Tongue, Powder, Sweetwater and Wind Rivers are the most favored localities for the buffalo, as well as elk, deer, antelope, and other "Injun cattle." The "Rocky Mountain buffalo" is smaller and shaggier than the buffalo of the plains, and is far more difficult to stalk. It inhabits the deepest, darkest defiles, or the craggy, almost precipitous sides of mountains inaccessible to any but the most practiced mountaineers. Its size makes it easily distinguishable from the ordinary buffalo, which, generally speaking, may be found on all the eastern slopes of the Rockies not yet taken into cultivation. Wild cattle are shot by ranchmen in Texas and Mexico; the sport is more dangerous and exciting than buffalo-hunting. The American elk is found all over North America where civilization has not exterminated it. Montana, Wyoming, Kansas, and Indian Territory are known to be simply alive with these animals, and doubtless other Territories are stocked in a similar manner. An excellent country for the elk, deer, bear, antelopes and mountain-sheep is that near the Bear, Snake, and Upper Cache-La-Poudre Rivers, on the south side of the Union Pacific Railroad. The Upper and Middle Parks in Colorado are also very well stocked with all sorts of game.

In all the States westward of the Rockies to the Pacific Coast, game may be found in sufficient numbers to satisfy even an inordinate sporting appetite. In California, deer and bear constitute the chief varieties of large game, and these, particularly the former, are very plentiful in nearly all parts of the State. Nevada is the worst hunting-ground of any of the Western States. Eastward of the Mississippi the hunting of large game is confined to a few moose and fewer panthers, and the black bears, which are only plentiful among the canebrakes of some Southern States, and the wilds of Northern Maine and Michigan. They are, however, frequently found in Eastern Tennessee, Western Pennsylvania, North Carolina, and Virginia, and are sometimes seen in even more thickly settled portions of the country. Panthers are mostly found in the canebrakes of the South—Florida, Texas, Louisiana—and in the wilds of the Alleghanies, Cumberland, and the Blue Ridge Mountains. The moose is only found in the northern portions of Maine and Michigan, and in British territory. Other deer, the black-tailed, and the white-tailed or the red deer, are found throughout the States. Northern Wisconsin, Michigan and New York, Western Pennsylvania, West Virginia, Virginia, Tennessee, and North Carolina are well stocked, and in all the States South and West there is deer-shooting galore in districts remote from the settlements. For antelope the plains of the Southern and Western States are best suited. Northern Texas, Kansas, Colorado, and Montana abound with antelope; but the rapid settling up of the country, especially sheep-farming, is making this game far less plentiful. The bighorn, or Rocky Mountain sheep, is to be found among the highest peaks of the Rockies and the Black Hills. This animal is considered the finest sporting animal in the United States, its habits being similar to the European mouflon. Great care and judgment are required to stalk it successfully. The American hare, or jack-rabbit, is common throughout the East as well as the South and West. A blue hare is found in the Rocky Mountain range. Besides these animals the hunter on the Plains may meet with the cougar, puma, or Mexican lion, which, if he is a good, unerring shot, he may attack. If at all nervous, the hunter had better leave the animal alone, as it is one of the strongest and most dangerous of the carnivora. They are great destroyers of game, and, like wolves, coyotes, foxes, otters, skunks, lynxes, wolverines, panthers, and bears, should never be spared upon a favorable opportunity offering itself. For bear-hunting, dogs are a valuable acquisition, and without them a hunter might often travel the woods for weeks without bringing one to bag. Dogs are likewise of the greatest service in cougar and panther hunting. All bears, including the grizzly, as well as panthers and cougars, will, if possible, get out of the way of man, and will rarely attack unless wounded, or in defense of their young. The grizzly bear is common in California, and often met by hunters after the bighorn in the Rocky Mountains. It is the most formidable of all the bear tribe, and often attains gigantic proportions; one specimen exhibited weighed some 2,000 pounds. It is very tenacious of life, and should be hunted with dogs, a large-bore rifle, and in company. Stories of the "bar-fites" coming from California are doubtless much exaggerated; but no hunter once in the clutches of a dying or wounded grizzly can hope to escape scathless; and no man dare close with the grizzly, as is regularly done in Scandinavia with the common brown bear. According to Caton the American deer are of eight kinds: "The moose, wapiti or elk, woodland caribou, mule-deer, Columbia black-tail, common or Virginia deer, barren-ground caribou, Acapulco deer." Hunters make but four distinctions: moose, wapiti, caribou, and blacktail.



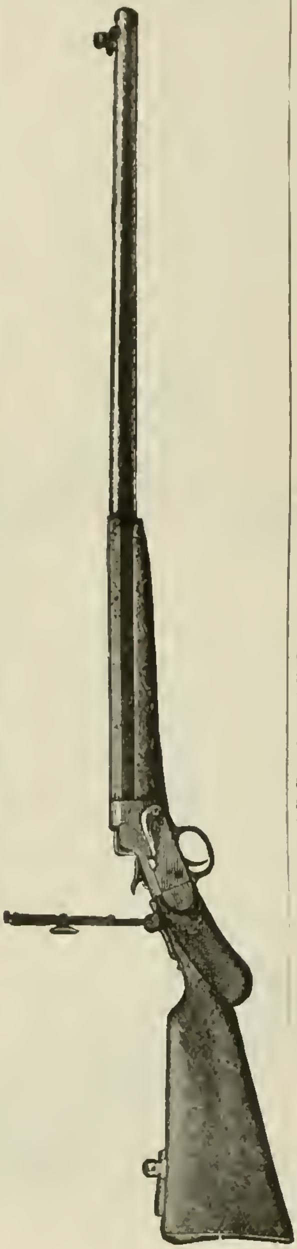
Fox Gun.



Shelton's Auxiliary Rifle.

Game for the shot-gun abounds in every State, the chief game-birds being quail, grouse (five varieties), woodcock, snipe, wild-turkeys and wild-fowl. For *quail-shooting* in the East, Ohio, Indiana, Virginia, North Carolina, Kentucky, Tennessee, Arkansas, Wisconsin, Missouri, Illinois, and Iowa offer the greatest inducements. In California it is not unusual to bag fifty couple in one day's shooting; but there two varieties are known, both differing from the Eastern quail, and called respectively the mountain and val-

Remington Magazine-rifle.

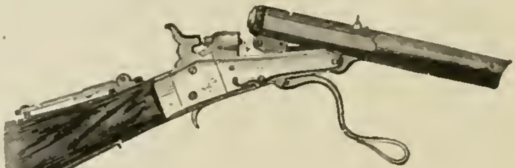


Remington Long range Creedmoor Rifle.

ley quail. The former are by far the more numerous. The favorite haunts of the latter are the valleys and foot-hills of the Sierra Nevada and coast mountain ranges. In size they are about equal to the bob-white or Eastern quail, while the mountain quail is considerably larger, and is to be met with in the more elevated regions.

Grouse-shooting.—The blackcock is generally known by frontiersmen as the sage-cock. The best localities are on the eastern slopes of the Rockies. Fort Fred Steele is said to be the best center for the hunting-grounds of this grouse. The dusky, blue, black, or mountain grouse is found in almost all of the mountainous regions of the West, inhabiting the mountain-slopes from an altitude of 6,000 feet to the snow-line. His close-lying, solitary habits seem to indicate that he belongs to the same branch of the *Tetraonidæ* as the European ptarmigan. He affords no better sport, but is rated an equal delicacy for the table. The sharp-tailed grouse, so commonly known as the willow-grouse, is more common in British territory, but has penetrated from the North to the Canadian and the Missouri Rivers; it is also found in the West. The ruffed grouse is common in most of the States East; it is not often found on the Southern Plains, but it may frequently be met with on the foot-hills in timber, it being essentially a covert bird. A very large number has been killed in the Black Hills and also the surroundings of the Laramie Plains. Pinnated grouse, or prairie-chickens, are most abundant in all parts of Wisconsin, Minnesota, Iowa, Nebraska, Kansas, Missouri, Indian Territory, and Texas. In some parts of Michigan, Illinois, and Indiana they are to be found in limited numbers, but are fast disappearing in all parts of the Eastern States, and, strange to say, appearing in Western States, where a few years ago they were unknown; they may now be found in some parts of Utah and Nevada, and in great numbers up the Arkansas Valley. *Wild-turkeys* afford the best sport of any American birds, being constantly on the alert, and possessing a most acute sense of smell. Full-grown cocks frequently weigh as much as 20 or 25 lbs. They are most abundant in the less inhabited portions of Western Virginia, North Carolina, Tennessee, Missouri, Arkansas, Mississippi, and Texas. A few are met with in Michigan and Illinois, more in some of the Southern States, and very many in some portions of New Mexico and Arizona; but in those States situated north of Kentucky and east of Indiana they are rarely, if ever, met with. A species of *rock-partridge* is said to frequent North-western Texas and South-eastern New Mexico. They weigh about 1 lb., and resemble in shape and plumage the bob-white. Their favorite resort is the grassy tops of limestone mesas; they are found in coveys, and lie well to the dog. *Woodcock shooting* is to be had all along the valley of the Mississippi and its tributaries, from Minnesota to the Gulf of Mexico. This is the choicest woodcock-ground, but bags of ten to twenty birds are frequently made in most all Eastern States, as hereafter detailed. None are to be found in California, or, to the best of our knowledge, in any of the Pacific Coast States. *Jacksnipe* are found in quantities in resorts mentioned for duck-shooting.

The *wild-fowl* of the United States comprise the trumpeter swan; Canada and white-fronted geese, canvas-back, ring-necked, red-headed, scaup, dusky shoveler, gadwell, buffle-headed, wood or summer, pin-tail, and common wild ducks; blue and green-winged teal, the widgeon, and many other birds. Duck or mallard-shooting is found in the marshes in the fall, in the corn-fields in winter, and in timber in the spring. Decoys, sinks, and other devices are common. The wild-rice ponds are the best feeding-ground for ducks in the fall; they are often of wide extent, and, as it is impossible to see over the top of the rice, care is required in "taking the bearings," or the wild-fowler may be lost. A pocket-compass is an article of necessity in wild-fowl shooting. The wild-fowl resorts in the United States are so numerous that we have deemed it more simple to take each



Maynard Improved Rifle.

State separately, and to give the places most recommended not only for wild-fowl, but also of every other kind of shooting, and to include accounts of such local methods of taking the game as we think may prove of use or interest. We *italicise* those places in which game is most plentiful. In the Atlantic States the best places for big bags of wild-fowl are on the

Parker Gun.

Chesapeake Bay and its tributaries, Currituck and Albemarle Sounds, the rice-swamps of South Carolina, and the glades of Florida. To the westward they are found in fewer numbers, until we reach Indiana and Michigan.

In *Maine*, Piscataquis County affords the best of shooting. The *Moosehead Lake* region is the most renowned: here may be found an occasional moose, a few bears, with more caribou, wolves, rabbits, and plenty of small game—ducks, geese, ruffed grouse. Mount Spencer and *Brassua Lake* are the best localities in this region. Sebec Lake in the same County, affords very fair sport at ducks, grouse, and small game.

New Hampshire.—The northern portion of this State affords fair shooting. In Carroll County there are deer and bob-whites; in Cheshire County the lakes about *Keene* abound with ruffed grouse, ducks, jack-rabbits, and small game. In Coos County, the forests near the Connecticut lakes are said to contain moose, deer, otter, mink, and small game. For these lakes go to *Island Pond Station*.

Vermont.—Essex County, in the north-eastern portion of the State, reached from Island Pond Station, is a comparative wilderness, and abounds in small game, but nothing very attractive.

Massachusetts.—There is good wild-fowl shooting on many parts of the coast and the Elizabeth Islands. In 1880 woodcock and quail were plentiful near West Boylston. The best points for wild-fowl are Buzzard's Bay, Chatham, Cotuit Port, Marshpee, and No Man's Land. The State is very thickly populated; and, although the wild-fowl shooting is very good, there is nothing to attract sportsmen from distances.

Rhode Island.—All wild-fowl shooting along the coast is fair. Block Island, Souh Kingston, and Watch Hill are the best resorts.

Connecticut.—In Middlesex County there is good duck-shooting at *Saybrook Point*, and snipe and duck near New Haven; in Litchfield County, good wild-fowl, grouse, quail, and wood-cock shooting near the Twin Lakes at Canaan; and good duck-shooting at Noank, New London County.

New York.—In the northern portion of this State there is a favorite resort of all sportsmen, the Adirondack Wilderness, in extent seventy-five square miles, abounding with small game; its qualities have, however, been overrated, and it is much thronged with sportsmen. It is best approached from Martin's, on the Lower Saranac. Deer-shooting is practiced here in a most unsportsmanlike manner: the bucks being driven into the lakes, and sportsmen following in boats. The deer are often shot within ten feet of the boat, and it is said that in some instances the boatman has had hold of the deer's tail before the the hunter fired. Grouse, snipe, and woodcock are plentiful, and quail and ducks in season. On Long Island there are deer, quail, ducks, and ruffed grouse. The northern portion of the Island is fair ground for shooting, also the Great South, Peconic, and Shinnecock Bays; but all are too easy of access. Good snipe-shooting is to be had near Cayuga Lake, in the Montezuma Marshes. Wild-fowl abound at the Thousand Islands, where there is woodock, quail, and snipe shooting. Alexandria Bay is the chief resort at these Islands. Others are Goose, Eel, and Halstead Bays. The north-eastern part of Ulster County is noted for ruffed grouse.

New Jersey offers few inducements to sportsmen. There is wild-fowl on the sea-coast, and duck and snipe shooting in *Atlantic*, *Ocean*, and Morris Counties.

Pennsylvania.—Many parts of this State abound with game. Near to the Blue or Kittatinny Mountains, the Sideling Hills and the Alleghanies are the best game resorts. In Blair County, Altoona is the point for good deer, partridge and woodcock ground, with an occasional bear. Other good ground lies in Cameron, *Clinton*, McKeon, Pike, and Potter Counties. Wolves and panthers are sometimes met with. Deer are not at all scarce, and ruffed grouse, bob-whites, woodcock, and small game are also found in abundance.

Virginia and West Virginia.—The latter of these two States offers great inducements to the sportsman. The Alleghany and Cumberland Mountains cover innumerable deer and a few panthers and bears. Smyth County, in Virginia, and Morgan and Tucker Counties, in West Virginia, are noted for sport. *Hoys Wilderness* and the Blackwater region, in the latter County, are plentifully stocked. Oakland Station, on the B. and O. R. R., is a good starting-point. Sport in West Virginia comprises black-tailed and other deer, wild turkeys, ruffed grouse, woodcock, quail, and other small game. On the coast of Virginia is Chesapeake Bay, the famous wild-fowl resort; Cobb's Island, and the mouths of the Rappahannock, Mattapony and Pamunkey Rivers, are also visited by large numbers of wild-fowl.

North and South Carolina.—These States are practically destitute of large game, and offer no inducement for the sportsman to leave the better ground in West Virginia. The coast of North Carolina is thronged with wild-fowl. *Beaufort*, in Carteret County, *Newberne*, in Craven County, and Carrituck County, especially near Knott's Island, are the best quarters; in the first and last canvas-back ducks are met with, and in all black and other ducks, geese, snipe, etc. South Carolina has similar wild-fowl, and a few deer and foxes inland.

Georgia.—The sea-coast is similar to that of the two preceding States. Wild-fowl are quite numerous; and in the County of Bartow there is turkey and quail shooting.

Florida is at present a sportman's paradise Wild-fowl are particularly numerous, especially south of Lake Okeechobee. The other game consists of panthers, bear, red and Virginia deer, jackrabbits, turkeys, quail, woodcock, and snipe, besides foxes, raccoons, and other minor game in abundance and variety. The St. John's River is a good point, about the center of the peninsula. The *Indian River Country* up the St. John's River abounds with game. Titusville and Mellonville are good places to start from, but a cruise of some weeks round the south and the western parts of the peninsula is most successful for all shooting. The snipe and duck-shooting is not to be excelled. Hernando County and Homosassa are very good districts, and fairly easy of access. The southwestern and southern part of the peninsula is, however, the best; to the southwest of Lake Okeechobee to Charlotte Harbor, and along the Calooeahachee River, turkey and deer are unusually numerous. In the western part of the State good shooting may be had from Pensacola, consisting of bear, deer and turkey. In the Grand Lagoon there are myriads of wild-fowl.

Alabama is fairly stocked with game: the deer and turkey in abundance, and wild ducks, geese, bears, and foxes in goodly numbers. Choctaw County, in the western part of the State, is good ground for deer, bear, opossums, turkeys, etc. Clarke County has the same, and along the Alabama River there is plenty of wild-fowl. Lauderdale County is also very good, and the muscle-shoals on the Tennessee River swarm with wild-fowl. In the northern portion of the State, at the foot of the Alleghanies, game of all kinds is plentiful.

Mississippi is abundantly stocked with wild-fowl in the western portions. The forests are fairly stocked with turkeys, deer, bears, and small game. Corinth, in Alcorn County, Coldwater, in DeSoto County, Panola, in Panola County, and Hudson and *Austin*, in Tunica County, are near good grounds; wild-fowl are plentiful down the Mississippi River and in the St. Francis Lakes.

Tennessee is fairly stocked with deer, opossums, foxes, wild-fowl, small game, and a few bears and turkeys. The famous Reelfoot Lake is in this State, near Tiptonville. The lake is thirty miles long, and from three to ten wide; and besides excellent duck, snipe, and wild-fowl shooting there is good *bass-fishing*.

Davis Breech-loader.

Kentucky is only famous for its fox-hunting in the English style. There is a fair quantity of small game and ducks, etc., down the Ohio, Tennessee, Cumberland, and Mississippi Rivers.

Illinois is a similar State, but abounding with wild-fowl. We will mention a few good grounds. They are: Henry, Chillicothe, Spring Lake, Liverpool, Havana, Beardstown, and Naples, on the Illinois River; Annawan, near the Winnebago Swamps; on the Calumet River near Chicago; near Quincy; *New Boston;* Grand Tower; near the mouth of the Big Muddy River; and at numerous other places, particularly along the Mississippi River. In Du Page County there is also very fair pinnated-grouse, quail, woodcock, bob-white, and similar shooting.

Indiana has but little large game, but pinnated-grouse, rabbits, wild-fowl, and small game are abundant. Wayne is near good grouse, quail, and fair deer ground. Blackford, Knox, and Laporte Counties are also well stocked with ruffed grouse, quail, snipe, woodcock, etc. Vincennes and Montpelier are first-rate headquarters for the sportsman. For wild-fowl, English, Beaver, and Wolf Lakes, the swamps bordering on Michigan, the Calumet, etc., have been strongly recommended.

Ohio.—This is not an attractive State for a sportsman, and he must for the most part be content with wild-fowl and small game, such as quail and snipe. The best shooting is on the shores of Lake Erie, near Sandusky City or Cleveland,

Michigan is one of the finest resorts accessible to the general sportsman. Northern Michigan is best for sport. Near *Negaunee* there is fair deer shooting, and the whole country beyond Escanaba is fairly stocked with deer, fur-bearing animals, and also small game. In the northern and more inaccessible part of Michigan both bear and deer are plentiful, and good sport is to be had. Good wild-fowl shooting is to be had almost anywhere along the borders of the great lakes, and especially on the *St. Clair Flats*, near Detroit. There are many islands in the lakes famous for shooting, notably Royal Island, St. Ignace, and the Apostle Islands (twenty-seven in number).

Wisconsin is fairly stocked with large game, and has wild-fowl and small game in abundance. For wild-fowl the best resorts are Horicon, *Puckawa*, and *Koshkonong* Lakes, also Lake Winneconne, and the numerous shallow inlets and bays along Lake Michigan, and the lowlands of the Chippewa, St. Croix, and Mississippi Rivers. For large game the north and the northeastern districts are likely to prove the most successful.

Minnesota.—This Land of Lakes, undoubtedly the fisherman's paradise, is very fairly stocked with large game, and abounds with wild-fowl, fur-bearing animals, and small game. The Northern Pacific Railway runs through some of the best hunting-grounds of North America. Duluth is a good place to start from; Detroit and Fargo, on the North Red River, are excellent starting-points farther west. The Red Lake region and Fort Pembina are recommended for large game; while for duck-shooting one cannot go wrong, there being more suitable feeding-ground for water-fowl in this State, probably, than in any other State in the Union. There are likewise grouse, woodcock, and snipe in abundance.

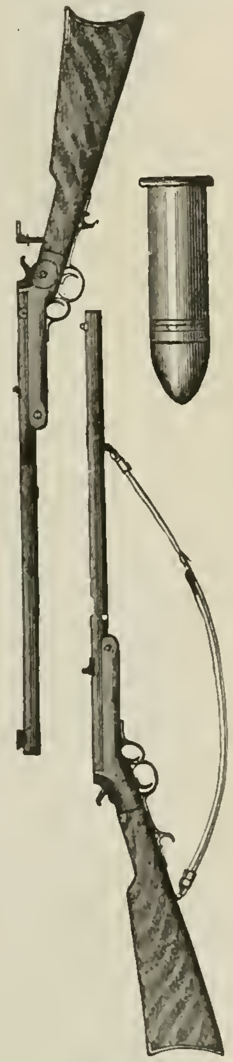
Iowa is not celebrated for large game, but is excellent for its pinnated-grouse and duck-shooting. For ducks and wild-fowl, *Comanche*, on the Mississippi, is a good center; but all along that river, and the Missouri, and the hundreds of small, muddy-bottomed streams and ponds throughout the State, the sportsman can scarcely fail to make a large bag.

Missouri.—The southeastern part of this State is excellent wild-fowl ground. In some of the forests north and west there is a fair sprinkling of deer and a few turkeys. For wild-fowl the Mississippi offers the best ground, and also the *Little*, Black, and *St. Francis* Rivers, and all about the sunken lands near New Madrid. These grounds extend into Arkansas, and along the Castor, St. Francis, Black, White, Little Red, Arkansas, and Washita Rivers, and at other numerous lakes along the Mississippi, as the Big, Swan, and Cottonwood Lakes. Farther north there is good shooting near Hannibal and Lagrange.

Arkansas is well supplied with large and small game; but to reap the full benefit it is requisite to camp out. Start from *Texarkana* for bear, deer, wild turkey, and grouse-shooting; or *Forest City*, forty miles below Memphis, for large game and innumerable wild-fowl. Small game is general throughout the State.

Louisiana is very fully stocked with game. The

Smith and Wesson's Repeating-rifle.



F. Wesson's Breech-loading Rifle.

north is well timbered, and intersected with numerous *bayous*. In the south, the many bays, lagoons, marshes, and canebrakes swarm with wild-fowl and alligators. For wild-fowl the mouths of the Mississippi are without parallel. In the canebrakes are many bears and turkeys, both of which are hunted by dogs. The north and center abound with deer, turkeys, and rabbits, while bears are numerous, and, in the season, snipe, woodcock, and quail in very large numbers. Alexandria is strongly recommended for its shooting.

Texas.—This State, with an area of nearly 240,000 square miles, contains some of the finest hunting-grounds in the world, but, for the most part, difficult of access. The coast all along, and especially about Galveston and the mouth of the Rio Grande del Norte, abounds with various kinds of wild-fowl. Houston is a much-visited center for deer, grouse, and quail-shooting. Bears, deer, and like game are general in the wooded parts of the State. Northern Texas is the home of the buffalo, but the ground is best approached from Kansas. This and Western Texas are very well

English Side-action, Bar-locks.

stocked with all kinds of game found on the Plains; but owing to the numerous Indians, and the still more numerous white thieves, none but a large and well-escorted party dare cross the Llano Estacado or the Rio Pecos. The most available ground from the south lies to the west of San Antonio. In Texas "fire-hunting" is practiced for deer, and antelope are in some districts very numerous.

Indian Territory abounds with game of every description. It is, however, against the law of the United States for any white man to kill game on Indian Reservations.

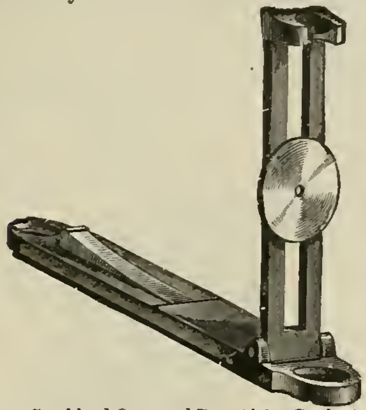
New Mexico likewise abounds with game, but is infested with robbers and difficult of access. Excursions may be made from the advanced posts on the Atchison, Topeka, and Santa Fe Railway with fair

Lefaucheux System.

success, but the toil in most cases would exceed the sport.

Arizona is well stocked with game and water-fowl. Yuma is now easily reached by rail from California. It is a mountainous country, and up to the present is chiefly occupied by miners. The next few years will doubtless open up this country wonderfully, when it will be the finest hunting-ground west of the Rockies. Camping-out in large companies will, however, be necessary for several years, and the best districts are most difficult and dangerous to get access to.

California abounds with many varieties of game. Nevada County is one of the most accessible for game,



Rear Combined Open and Peep Sight, Graduated.

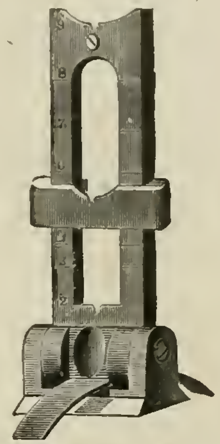
and the regions of Lakes Tahoe and Independence (reached from Emigrant Gap Station, U. P. Railway) are famous for bear (grizzly) and large game. The

Remington Sporting and Target Rifle.

Oregon Branch of the C. P. Railway runs through a fine shooting-region. The San Joaquin Valley is also good ground, and from Los Angeles may be reached the *Big Pine Mountains*, where game of all kinds is very numerous. There is also a good district near *Humboldt Bay*, in the north, reached by steamer from San Francisco. The peninsula of Lower California is too wild and remote a region to offer special inducements to sportsmen. In many parts of California wild-fowl are so numerous as to necessitate the posting of guards about newly sown grain-fields to protect the crops. The resorts are very numerous, some of the most celebrated being the San Joaquin and Sacramento Rivers, the mouth of Feather River, Cash Creek, Tomales, Suisun, Sonoma, and San Francisco Bays, Tulare and Clear Lakes.

Nevada is not an attractive country to the sportsman, being for the greater part desert land. The best game resorts lie within an easy distance of the C. P. Railway. The Humboldt range is fairly stocked with game; the Sierra Nevada is a favorite resort, and reached by stage from Reno. *Washoe County* is the best stocked: good starting-places and headquarters being Verdi, Washoe City, and Wadsworth. Winnemucca, Wells, Carlin, and Elko are in the midst of a good antelope, deer, grouse, and duck country. At the first there is also the chance of blackcock and bighorn.

Utah does not abound with large game, but is fairly stocked with antelope, blackcock, and other grouse;



Common Musket Rear-sight.

and on the Great Salt Lake there are plenty of geese, ducks, swans, and wild-fowl. Ogden has fair sport in its neighborhood.

Colorado is and is not recommended for large game shooting. It seems that in Colorado, game, although not scarce, is by no means so plentiful as in Wyoming and Montana. Near Denver there are grouse, quail, geese, and turkeys. For larger game the North and Middle Parks have been recommended. Manitou, Estes Park, and Central City are in the neighborhood of antelope, bear, deer, and a little wapiti shooting. There are several varieties of ducks and geese, but wild-fowl and small game are not so abundant as in other States.

Kansas was once the sportsman's paradise, but is so rapidly settling up that it is not safe to recommend it for large game. There are, or were, plenty of antelope, but the inclosure of the land for sheep-farms has greatly interfered with the habits of this retiring animal. Some of the best shooting may be had from the Stations on the Kansas Pacific and the Atchison, Topeka and Santa Fe Railways. Hutchinson, on the latter, is a good starting-place for the antelope country. Fort Dodge is also in a good country. Turkeys are not scarce, and grouse and quail may be shot anywhere west of Salina.

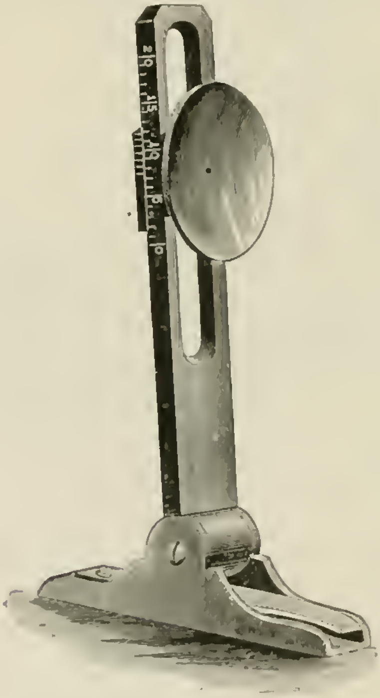
Nebraska is fairly stocked with elk, deer, antelope, turkeys, and goodly numbers of grouse, rabbits, and wild-fowl. For elk the Loup Fork of the Platte River is said to be very good; other Stations are in Dawson

County. Near the borders of Wyoming, deer and antelope are fairly plentiful. Antelope and *Ogalalla* Stations have good ground in their vicinity. For wild-fowl the Elkhorn Valley is a good district, but they are pretty numerous throughout the State.

Wyoming is, as we have already mentioned, the best locality for large game in the States; wapiti, buffalo, deer, antelope, bears, moose, and mountain sheep being numerous in some districts. The Laramie Plains, the Fremont Peak, and especially the Bighorn Mountains, Wind River and Yellowstone Valley regions are, it is reported, alive with game. Buffalo are found chiefly in the northern section; bears chiefly in the Black Hills; antelope, deer, and small game everywhere.

Dakota.—This Territory contains the larger portion of the northern buffalo range; it is sparsely settled, and contains large and numerous Indian Reservations. Bismarck, on the Northern Pacific Railway, is a good starting-point. The ground may be reached from Rawlins on the U. P. Railway. There is game in abundance, but camping out is necessary.

Montana.—This Territory also includes part of the buffalo range. Game is in great abundance throughout the Territory. Rawlins or Bismarck may be made starting-points. Helena is a good center to work the



Vernier Peep Sight.

Missouri Valley. The finest natural scenery and sport are to be found in this Territory, but at present it is difficult of access.

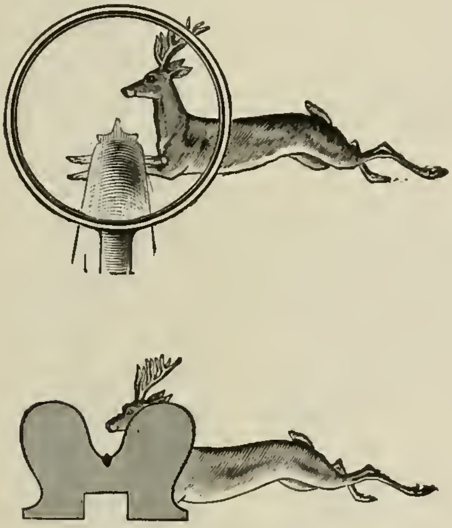
Idaho.—This mountainous Territory is but little known. For good sport it is second only to Montana. Buffalo will not be found in quantities, if at all; but there are plenty of deer, wapiti, bears, and a few panthers and antelope; wolves, foxes, and fur-bearers are in any quantity. Its inaccessibility makes it more the paradise of the trapper than that of the sportsman. Sportsmen usually start from Kelton Station, on the U. P. Railway, and fit out at Idaho City or at Boise. The Snake River region is one of the best and most accessible. Consult *Farrow's Mountain Scouting*, New York, 1881.

Oregon is a fine field for sportsmen, but difficult of access. In most of the valleys large numbers of elk and three other varieties of deer roam almost unmolested. The Yaquina Valley and Cascade Mountains are the finest regions; antelope are very numerous in the latter; quail and grouse abound in great numbers, whilst there are myriads of geese, ducks, and other wild-fowl. The country is rich in the common fur-animals, and also silver foxes, and pumas or cougars.

Washington Territory also abounds in large game, fur-bearing animals, and all kinds of feathered game. The only difficulty is the trouble of getting there, and then getting safely back to the settlements with the spoil. Vancouver is a good place from which to fit out.

Remington Heavy Model Double-gun.

Alaska.—This very recently acquired territory of the United States is in regular communication with San Francisco by steamer. It is a wild, boggy country, rich in fur-bearing animals, notably the fur-seal; and fish, bears, and deer are fairly plentiful; but it can never be recommended as a sporting locality, as it rains almost incessantly nine months out of every twelve, and its inhabitants are among the most degraded of Aborigines. Of the unexplored country inland it is conjectured much must be valuable and habitable, but near the coast the average rainfall is 96 inches yearly. The various military and sporting-arms at present manufactured and possessing great merit are illustrated and described at length under

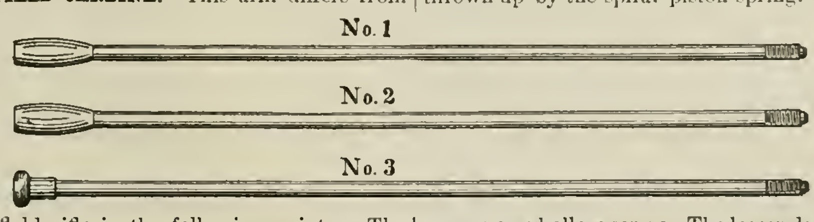


Lyman Sight.

the irrespective titles throughout this work. These descriptions, together with the illustrations given in this article, will enable the reader to readily comprehend the merits and distinguishing features of the different arms and systems. See *Baker Gun*, *Breech-loader*, *Parker Gun*, *Remington Rifle*, *Small-arms*, *Spencer-Roper Small-arms*, and *Springfield Rifle*.

SPREAD-EAGLE.—In Heraldry, an eagle, or the figure of an eagle, with its wings elevated and its legs extended; often met as a device in Heraldry, upon military ornaments, and the like.

SPRINGFIELD CARBINE.—This arm differs from



the Springfield rifle in the following points:—The barrel is 22 inches long; the thickness of metal at the breech and at the muzzle is not changed. It has a half stock; but one band, which has a hook-swivel for stacking; and has no ramrod. It is slung by a ring which plays on a bar attached to the left side of the stock, opposite to the lock. The front sight is removable, so that it can be replaced in case of wear; it is secured to the stud by a pin; the base of the rear sight is graduated to 500 yards, and the leaf to 1200 yards. The tumbler has an additional notch, the *safety (locking) notch*, on which to carry the hammer when the breech is closed, as it then overlies the firing-pin-guard and prevents the block from opening. The drawing represents the three parts of a *jointed ramrod*, which is intended to be used for cleaning the carbine, and, with the aid of the headless shell-extractor, removing burst cartridge-shells. No. 1 and No 2 joints are alike, and have a male screw at one end and a female screw at the other. The third joint has a head at one end and a male screw at the other. To prevent cutting away too much of the stock, the receptacle for the ramrod is formed of three small holes instead of one large hole of sufficent diameter to contain three joints. The total length of the arm is 41.3 inches, and its weight 6.87 lbs. See *Small-arms* and *Springfield Rifle*.

SPRINGFIELD-JONES MAGAZINE-GUN.—This arm is the well-known United States Service Springfield rifle, with several alterations and additions as follows: The firing-pin guard has been removed, and the outer end of the thumb-piece slotted in the direction of the axis of the barrel. This slot receives one end of a lever, which is secured by a pin about which it may turn in a direction toward the under side of the thumb-piece. A flat spring lying in a groove in the upper surface of the thumb-piece—to which it is secured by a screw, bearing on a flat and against a shoulder on the upper extremity of the lever, returns it to position and limits its motion in the reverse direction. An arm, securely attached by the tumbler-screw to the hammer, on which a shoulder has been cut to prevent rotation, bears against the lower end of the lever and raises the thumb-piece when the hammer is brought to the half or full-cock, and thus unlocks the breech-block. A piston, pivoted to the left side of the breech-block, is surrounded by a spiral spring, the rear end of which finds a bearing on a metal plate attached to the left hand side of the stock, the front of which is bent at right angles to the receiver. A hole through the plate admits the rear end of the piston. When the breech-block is unlocked by the cocking of the hammer the spiral spring throws up the block and extracts the empty shell. The well of the receiver has been deepened at the rear, and the lower part of the breech-pin cut away to form a channel through which the cartridges may feed from the magazine, which is in the butt-stock. The ejector-stud has been replaced by a movable one, which is depressed to the bottom of the receiver at the instant the cartridge leaves the magazine. This stud is pivoted at its rear to a block just above the trigger-mortise. A short distance in advance of its pivot it passes through a pin, which bends about the magazine-tube and enters the tang-screw hole above. The magazine proper consists simply of the familiar-tube, spiral spring, and piston, and requires no comment. The operation of the magazine system is as follows: The piece having been cocked and the breech-block being thrown up by the spiral piston spring, the operator presses on a hollow screw. The lower detent then descends, and the first cartridge, under the pressure of the magazine spring, slips by and enters the chamber. As the lower detent is depressed the upper one also descends, checking the second cartridge. When the pressure on the hollow screw is relieved a spring returns the detents to the original positions: the second cartridge then passes the upper and is checked by the lower detent. As a single-loader the piece is operated in the ordinary manner, the lower detent serving as a cut-off to the magazine. As a magazine-gun three motions are necessary to operate it, viz., opened, closed, fired. As a single-loader four distinct motions are necessary, viz., opened, loaded, closed, fired. This gun carries five cartridges in the magazine and one in the chamber. See *Magazine-gun*.

SPRINGFIELD RIFLE.—The small-arms employed in the United States Service are the *rifle* for infantry, and a *carbine* and *revolver* for all mounted soldiers. After a series of exhaustive experiments and a full trial, the *Springfield* system was adopted for the rifle and carbine, with a caliber of 0.45-inch. The barrel of the rifle is of low steel. Its length is 32.6 inches;

the thickness of metal at the breech is 0.297-inch; from this point it gradually diminishes (the exterior element being a slightly re-entering curve) to the muzzle, where it is 0.14″-inch. The rifling consists of three plain concentric grooves, 0.235 inch wide, equal in width to the lands, 0.005-inch deep, with a uniform twist of one turn in twenty-two inches. The grooves start from the center of the throat, the bottom of them is therefore not continuous with the surface of the chamber. The chamber extends 2″.155 from the base of the bore, and is made slightly conical so as to facilitate the withdrawal of the cartridge-case. The contraction of the chamber, caused by the difference in diameter of the cartridge-shell and of the bullet, is known as the *throat*. At the mouth of the chamber a *counter-bore* is cut for the head of the cartridge, and a slot is cut in the barrel for the reception of the ejector. Fig. 1 represents a section—nine-tenths size—of the breech-loading system, by a vertical plane passing through the axis of the receiver, with the several parts projected thereon, and showing their relative position.

A, is the bottom of the receiver; B, the *barrel*, with screw-thread; C, the *breech-screw*, with its circular recess to receive the cam-latch; E, the *hinge-pin* around which the *breech-block* (D) turns; F, the *cam-latch*, that locks the breech-block in place; G, the *cam-latch spring* to press the cam-latch into the recess; H, the *firing-pin*, which transmits the blow of the hammer to the priming of the cartridge; I, the *firing-pin spring* (no longer used), to press the firing-pin back whenever the hammer is raised; J, the *extractor*, to withdraw the empty cartridge-shell after firing. K, is the *ejector-spring spindle*. When the breech-block is closed, the point of the ejector-spring spindle presses against the extractor above the position of the axis of the hinge-block, and no motion takes place. When the breech-block is raised so as to press against the *lug* (M) of the extractor, the point (J) moves slowly to the rear, withdrawing the shell—the upper part of the extractor meanwhile compressing the ejector-spring. When the direction of the pressure of the spring passes below the center of the hinge, the extractor moves rapidly and throws the shell clear of the receiver. L is the *ejector-stud*, which serves to deflect the shell upward and thereby clear the *well* of the receiver, as seen in the drawing.

Fig. 2 represents a side-view of the breech-block; full size. A is the *hinge*; B is the *face* of the block; C is the *arch* (now filled in to give the block greater stiffness), D is the *comb*; E is the *breech-block cap recess* and *screw-hole*; F is the *cam-latch recess* and *cam-shaft hole*, the latter being a loose fit for the cam-shaft which passes through it; J is the *hammer-guard*; K is the *hinge-pin hole*, which is slightly elongated horizontally.

When the piece is fired, the horizontal elongation of the hinge-pin hole permits the breech-block to slide bodily backward under the influence of the discharge. By this means, and by the enlargement of the cam-shaft hole, a direct bearing is obtained by the interposition of the *cam*, which, abutting against the front surface of its recess in the block at one end transfers the recoil directly to its recess in the face of the breech-screw at the other end, wthout subjecting the shaft on which it turns to any strain. The bearing of the cam is above the center of the breech-screw, and its resistance consequently tends to press the rear end of the breech-block downward and forward.

The tendency of the front of the block toward lifting, in case of an escape of the gas from the cartridge, is prevented by the engagement of its forward end under the ears or hinges of the receiver, as shown in the drawing.

The *hammer-guard* on the breech-block is intended to prevent the accidental striking of the firing-pin by

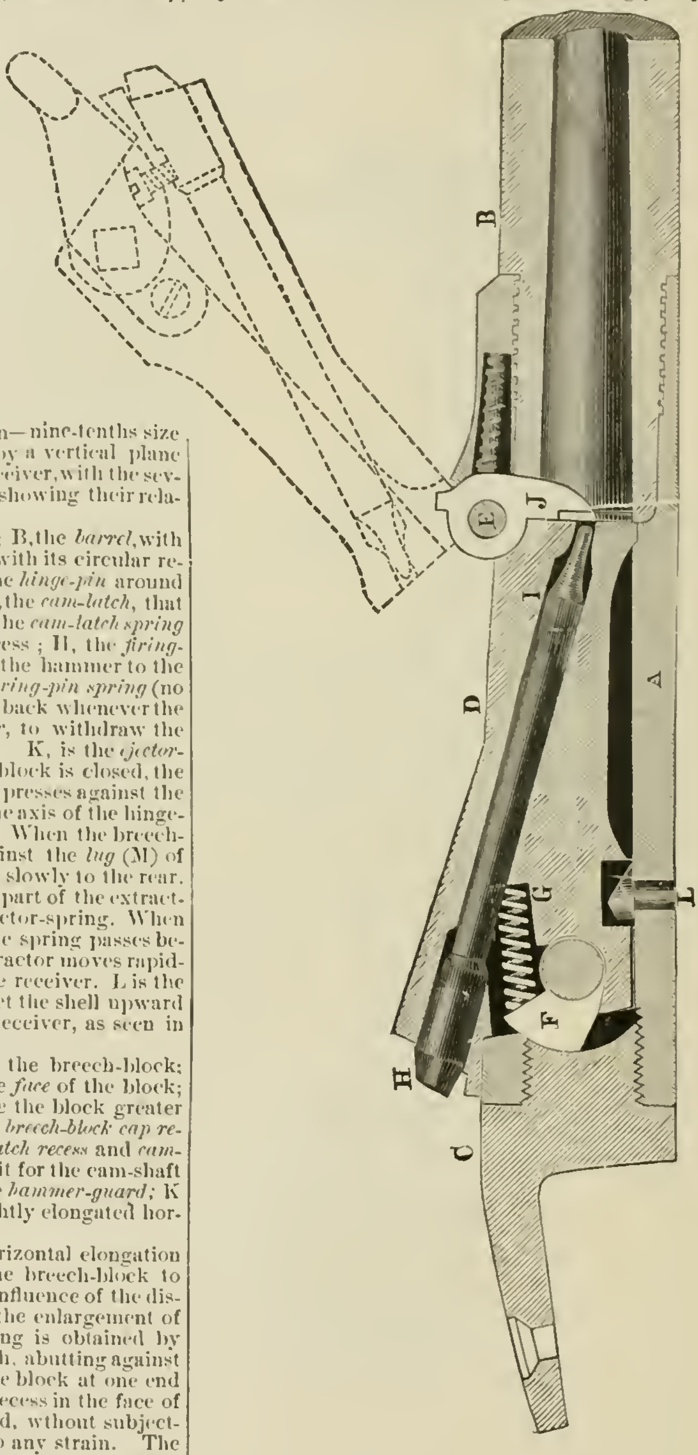


Fig. 1.

the hammer when by the act of closing the piece, the firing-guard is thrown up. Neither the hammer-guard nor the firing-pin guard is intended to hold down the breech-block by catching under the hammer. The tendency of the block to rise is felt, if at all, at the forward end. The *breech-screw* closes the rear of the receiver; it is composed of the *body*, *tenon*, which fits into a mortise in the stock and prevents the barrel from turning in its bed, and the *tang*, which assists in securing the receiver and barrel to the stock, and for this purpose is pierced with a hole for the *tang-screw*, which also passes through the stock and screws into the guard-plate.

Fig. 3 represents the firing-pin, full size. It is kept in place by the firing-pin screw, which projects into the *slot* (A) on its under side. The position of this screw is shown in the broken lines representing the raised position of the breech-block (see Fig. 1).

3d. The highest portion of the base and the lowest graduation-mark of the leaf correspond to the same range, thereby obviating a blank space in the old sight.

4th. For greater convenience in manipulating the sight, the graduation-marks are placed on the left-hand side of the base.

5th. The shape and size of the rifle and carbine-sights are the same; they differ only in the position of the graduation-marks, and are distinguished by the letters R and C stamped on the respective bases.

The construction of the inside of the lock is shown, half-size, in Fig. 6. The *tumbler* (B) passes from the inside through the lock-plate, and is connected

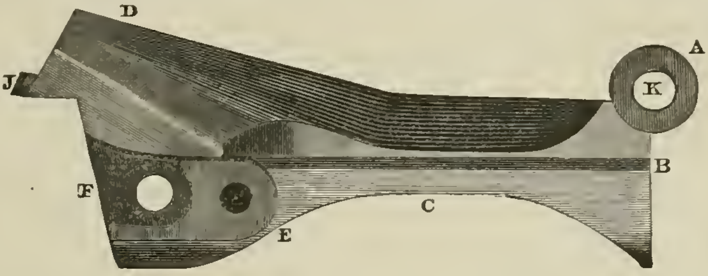


Fig. 2.

Fig. 4 represents front and side-views of the front-sight and bayonet-stud, three-fourths size, which is brazed on to the barrel. A is the *sight;* B, the *stud*, by which the bayonet is fastened to the barrel.

Fig. 5 represents a side and rear-view of the rear-sight, full size. It consists of the *base* (A), the *leaf* (B), and the *slide* (C). The base is fastened to the barrel by two screws. To prevent the unnecessary removal of the base, these screws are made without any slit in the head. The leaf is hinged to the base by means of a pin. It is held firmly when either closed or raised by the rear-sight base-spring. The slide (C) moves easily on the leaf to which it is made friction-tight by the rear-sight slide-spring. For distances up to 500 yards the graduation-marks are stamped upon the side of the base, and the leaf is turned down so that the slide may rest upon the mark which gives the desired range. For distances greater than 500 yards the leaf stands upright, and the slide is adjusted so that its top edge will indicate the desired number.

D represents a cross-section of the *base* through the front screw-hole, while the *dovetail mortise* indicates the manner in which the base-spring is fastened.

Fig. 4.

The rear-sight here represented was adopted in 1877. It differs from the original sight for the .45″ caliber rifle and carbine in the following particulars, viz:

1st. The shape of the sighting-notch is more open, or like a "buck-horn" sight, and its center is more clearly defined by a slight vertical cut.

2d. The steps are removed from the base, and the number of graduations on the leaf are increased so as to give ranges between each 100 yards.

by the square and tumbler-screw to the *hammer* (A). The small end of the tumbler is held in place by the *bridle* (C), which is fastened to the plate by the *bridle-screw* (D). The *sear* (E) is held in place by the *sear-screw* (F), which also passes through the long arm of the bridle. The *sear-spring* (G) keeps the sear in the tumbler-notch, and is held to the lock-plate by the *sear-spring screw* (H). The *main-spring* (I) abuts against the bolster, and is connected to the tumbler by the *swivel* (J). K K are the side-screw holes.

Fig. 7 represents the lock-plate, half-size, showing the position of the holes, etc. A is the cam-latch notch; B, the *bolster;* C, main-spring notch; D, mortise for main-spring pivot: E, hole for arbor of the

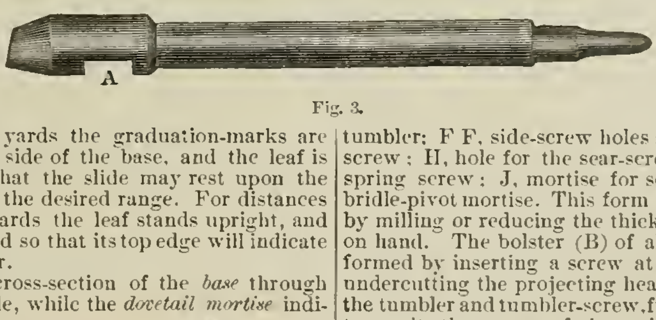


Fig. 3.

tumbler; F F, side-screw holes; G, hole for bridle-screw; H, hole for the sear-screw; I, hole for sear-spring screw; J, mortise for sear-spring stud; K, bridle-pivot mortise. This form of lock-plate is made by milling or reducing the thickness of the old ones on hand. The bolster (B) of all *new* lock-plates is formed by inserting a screw at the same point and undercutting the projecting head. Fig. 8 represents the tumbler and tumbler-screw, full size. The tumbler transmits the power of the main-spring to the hammer. A is the *body*; B is the *arbor*, which passes through the lock-plate. The part of the arbor exterior to the lock plate is called the *square* (C). It fits into the tumbler-hole of the hammer; in the end of the arbor is a hole (F) into which the tumbler-screw (I) is screwed, fastening the hammer to the tumbler. The *pivot* (D) supports the other end of the tumbler in the bridle. At the front end of the tumbler is a slot into which the main-spring swivel fits, and is connected with a tumbler by a rivet passing through the *hole* (E). On the under side are the *safety-notch* (K), the *half-cock notch* (H), and the *cock-notch* (G), into which the sear catches when the hammer is drawn back to safety, half, and full-cock positions, respectively. Fig. 9 represents a side and bottom-view, half size, of the guard-plate which supports the trigger and strengthens the weak part of the stock. A is the *strap;* B B, the *bolsters;* C C, the *trigger-stud* and *mortise*. D D, holes for *guard-bow*. E E, holes for *wood-screws;* F, hole for *trigger-*

screw; G, hole for *tang-screw.* The trigger is attached to the guard-plate by a screw about which it moves The pressure exerted by the upper part of the blade of the trigger against the tang of the sear, disengages the nose of the sear from the notch of the tumbler, relieves the main-spring, and brings down the hammer with force upon the firing-pin. The ramrod is divided into the *head,* slotted and grooved for the wiping rag; the *notch* which catches against the ramrod-stop and holds the rod in place; and the *cannelures,* for the purpose of giving the fingers a firm grip in cleaning the piece. All the metallic parts of the rifle are browned, except those which are case-hardened; these are blackened. The total length of the arm, without bayonet, is 51.9 inches and its weight 8.38 lbs The trigger is adjusted to pull off at from 6 to 8 lbs.

The model of the Springfield rifle for officers has a

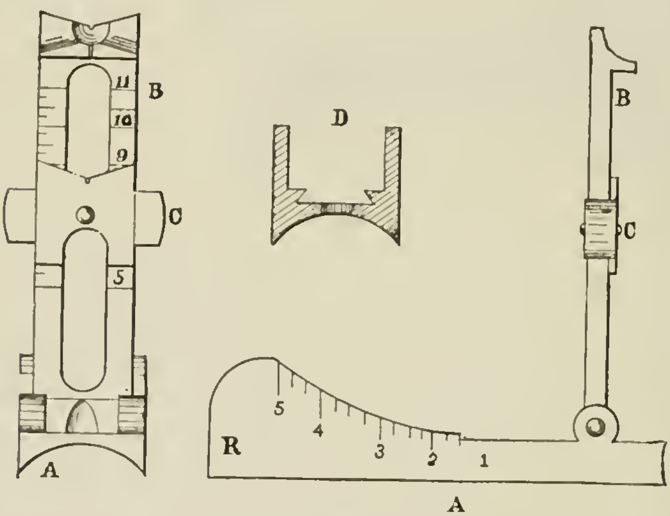


Fig. 5. Rear Sight.

weight of 8 pounds, varying with the density of the wood used in the stock. The length of the barrel is 26 inches. The stock is checked "fore and aft" the breech, and is tipped with white metal. The rifle has a plain "buck-horn" sight on the barrel, graduated like the service-sight, and also has peep and globe-sights. The globe-sight can be folded down on the barrel when its pin becomes an open front-sight, which is used with the buck-horn sight. The peep has a lateral as well as a vertical motion, and by turning the screw and loosening it, may be adjusted to counteract any deviation to the right or left. When at the bottom of the slide, the peep is adjusted for a range of 50 yards; when at the top, it is adjusted for a range of 1,100 yards. The peep sight may be folded down on the barrel either forward or backward. In the former position, the peep should be pushed to the bottom of the slide, or the hammer—in being cocked—will strike it. The globe-sight is distant from the buck-horn and peep sights just 20.8 inches and 32.75 inches, respectively. The rifle has a "single-set" trigger. When *set,* it is a hair-trigger; when *unset,* it is the ordinary service-trigger, requiring a pull of about four pounds. The trigger should be set by pushing it forward with the thumb, *after cocking the hammer*—never *before.* A "fly" in the tumbler carries the sear over the half-cock notch when the trigger is set. The ramrod is of wood, both ends being ferruled with brass, nickel-plated. The ferrule on the smaller end has a slot for the admission of a wiping-rag; that on the larger end has a milled head for convenience in drawing out the rod. A small pin in the under side of the barrel, entering a hole in the rod just below this milled head, prevents the rod from slipping out of place. The breech-block, receiver, hammer, lock, band, and the heel of the butt-plate are all plainly engraved. The description and dimensions of the parts of the rifle, other than those above mentioned, are the same as those of the corresponding parts of the Springfield rifle, caliber .45". All of these rifles made after April, 1877, have a detachable pistol-grip handle; and the peep sight, as well as the buck-horn sight, are graduated with *approximate* accuracy for the Frankford rifle-cartridge. The lowest elevation on both sights corresponds to 50 yards range.

The following directions for using the Springfield breech-loading system should be carefully observed: 1. Raise the breech-block by pressing against the thumb-piece upward and forward till the breech-block rests on the receiver; if there be an empty shell in the chamber, it will be loosened from its place by the extractor and thrown out by the ejector-spring. Place the cartridge in the chamber with the thumb and two forefingers; then seize the thumb-piece with the thumb and forefinger—the other fingers in front of the breech-block—and close it down; the breech-block will press the cartridge home. The cam-latch will spring into its place and lock it; but, to make sure of this, it may be well that the soldier acquire the habit of pressing the thumb on the thumb-piece as the hand is withdrawn. 2. The surface of the cam-latch and that of the recess in the breech-screw should be kept free from dust and rust, to prevent sticking in opening the breech after each discharge; these surfaces should be well oiled occasionally and *then wiped dry.* The force of the discharge is exerted against both ends of the body of the cam-latch; and to insure this, the arbor and body of the cam-latch shaft are made purposely to fit their bearings loosely. 3. The hammer should habitually be carried at the safety-notch, and great care should be taken that the motion of the firing-pin be not obstructed by dust or rust. 4. Should the extractor cut through the rim of the shell and thereby fail to withdraw it, draw the ramrod and drive the shell out. 5. The chamber should be kept clean, and great care should be observed to prevent cartridges fouled with dirt, and particularly sand, from being inserted or discharged in the piece, as the expansion of the shell presses the sand into the metal

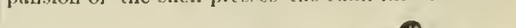


Fig. 6.

and mars the surface of the chamber, and thus causes the shell to stick. Care should also be taken in cleaning the chamber to wipe away all *free oil,* as its presence is found to lead to a pulling apart of the cartridge-shell somewhere between its head and the seat of the bullet. The shell of an exploded cartridge should not be allowed to remain in the chamber any length of time for fear it may adhere by corrosion. 6. Should the thumb-piece interfere with the head of the hammer in raising the breech-block, it is probable that either the tumbler or sear-screw is too loose or broken. 7. It should be borne in mind that the ejector, cam-latch, and firing-pin springs are *convenient* rather than *essential*; and that the breaking of one or all of them does not necessarily unfit the piece for further service. The extractor alone will loosen

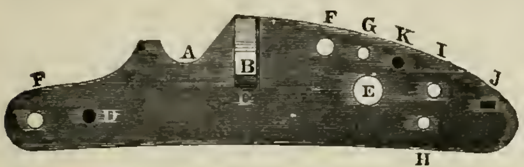


Fig. 7.

the shell so that it can be easily removed by the fore-finger, or it will fall to the ground if the muzzle be elevated when the breech is open. 8. Should the head of a cartridge come off in the act of firing—*a*. Insert the headless-shell extractor (spring-point foremost) into the rear end of the cartridge-shell, and push it forward with the thumb until the rear end of the extractor is flush with the end of the barrel. Turn the back of the hand toward the well of the receiver, and with the finger push in the extractor until its base is flush with the rear end of the headless shell. This insures the hook-prongs being at least four-tenths (0″.4) of one inch beyond the front end of the shell. The length of the headless shell is only 2 inches, while that of the extractor, from the base to the hooked shoulder of prongs, is 2″.4. *b*. Leaving the breech-block open, draw the ramrod, or cleaning-rod, insert it in the muzzle of the piece, lower it carefully until it rests upon the head of the extractor; then press down gently upon the rod, and it will push the extractor before it until the prongs strike the edge of the shell. Now press down firmly, but without shock, and the hooks of the prongs will grip the forward end of the shell. The resistance to any further motion will indicate that the hooks have come to a bearing. Spring the ramrod—the first time gently—and the extractor and shell will be ejected together. The breech must be so placed that the block will not interfere with the ejection.

To replace the broken and defective parts, as well as to facilitate the cleaning the arm, the soldier should learn the proper method of taking the rifle apart and putting it together. The parts should always be dismounted in the following order:—1. Unfix the bayonet. 2. Put a plug of soft wood in the muzzle of the barrel. 3. Draw the ramrod. 4. Turn out the tang-screw. 5. Take off the lock. To do this, first put the hammer at half-cock: then unscrew partially the side-screws, and, with a slight tap of the head of each screw with a wooden instrument, loosen the lock from its bed in the stock; then turn out the side-screws and remove the lock with the left hand. 6. Remove the side-screws; taking care not to disturb the washers. 7. Take off the upper band. 8. Take off the lower band. 9. Take out the barrel. In doing this, turn the rifle horizontally, with the barrel downward, holding the barrel loosely with the left hand below the rear sight, the right hand grasping the stock by the handle; and if it does not leave the stock, tap the plug in the muzzle gently against the ground or floor, which will loosen the breech end from the stock. This is preferable to lifting the barrel out by the muzzle, because if the tang of the breech-screw should bind in the wood, the head of the stock would be liable to be split by raising the muzzle first. 10. Remove the hinge-pin by pressing on its point with the point of the tumbler-punch until the end carrying the arm projects sufficiently far to enable it to be grasped and removed by the fingers. 11. Remove the breech-block carefully, so as not to allow the extractor and ejector-spring to fall to the ground. 12. Remove the extractor and ejector-spring. 13. Remove the cam-latch by unscrewing the breech-block cap-screw, and loosening the cap with the point of the screw-driver. 14. Remove the cam-latch spring. 15. Turn out the firing-pin screw, then take out the firing-pin and spring from the breech-block. The foregoing parts are all that will usually be found necessary to be taken off or dismounted. The soldier should never dismount the *band-springs*, *guard*, *side-screws*, *washers*, *butt-plate*, or *rear-sight*, except when an officer considers it necessary. The breech-screw should only be taken out by an armorer, and never in ordinary cleaning. The lock should not be taken apart, nor the bayonet-clasp taken off, except when absolutely necessary in the opinion of an officer. The parts which are especially assigned to be dismounted by an experienced armorer will be stated in their regular order following No. 15, viz: 16. Take out the upper and lower band-springs, using a wire-punch of proper size. 17. Take out the side-screws. 18. Take out the guard, using care to prevent injuring the wood at each end of the guard-plate. 19. Take out the side-screw washers with a drift-punch. 20. Take out the butt-plate screws with the largest blade of the screw-driver, and remove the butt-plate. 21. Remove the rear-sight by turning out the rear-sight screws with a clamp screw-driver. 22. Remove the receiver. In doing this, be particular to see that the extractor is removed beforehand. 23. Turn out the breech-screw by means of a "breech-screw wrench," suited to the tenon of the breech-screw. No other wrench should ever be used for this purpose, and the receiver should be held during the operation in neatly-fitting clamps. 24. The lock is taken apart in the following order: *a*. Bring the hammer to full-cock and clamp the notch of the screw-driver over the two branches of the main-spring. Remove the spring from the lock-plate, being careful not to let it go from the notch of the screw-driver. *b*. Turn out the sear-

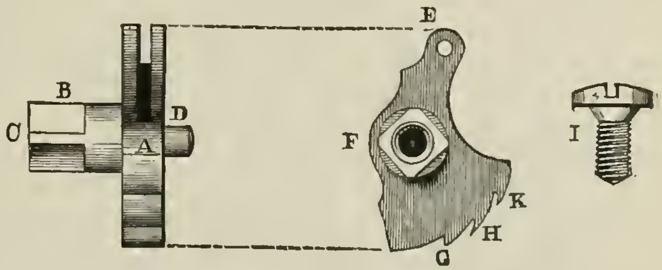


Fig. 8.

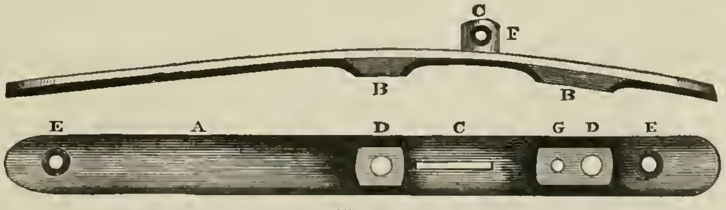


Fig. 9.

spring screw. Before turning this screw entirely out, strike the elbow of the spring with the screw-driver so as to disengage the pivot from its mortise; then remove the screw and spring. *c.* Remove the sear-screw and sear. *d.* Remove the bridle-screw and bridle. *e.* Remove the tumbler-screw. *f.* Remove the tumbler. This is driven out with a punch inserted in the screw-hole, which at the same time liberates the hammer. *g.* Detach the main-spring swivel from the tumbler with a drift-punch. See *Fabrication of Fire-arms*, *Headless Shell-extractor*, *Portable Fire-arms*, *Small-arms*, and *Springfield Carbine*.

SPRINGFIELD RIFLE MODIFIED. Besides the very well-known model 1870, described above, there are various modifications, differing from each other in points of mechanism and action.

In the *Springfield-Stillman*, the lock is set in a prolongation of the tang of the breech-screw, and is altered mainly from the Sharps lock. The firing-pin screw is replaced by a stop-pin kept in place by the breech-block cap.

In the *Springfield-Allin*, the cam-latch and thumb-piece are in one piece instead of being riveted together as in the 1870 model. It is fired by a center-lock, the main-spring of which lies under the receiver, being dovetailed into it at its forward end. The firing-pin screw is replaced by a stop-pin, which is kept in place by the breech-block cap.

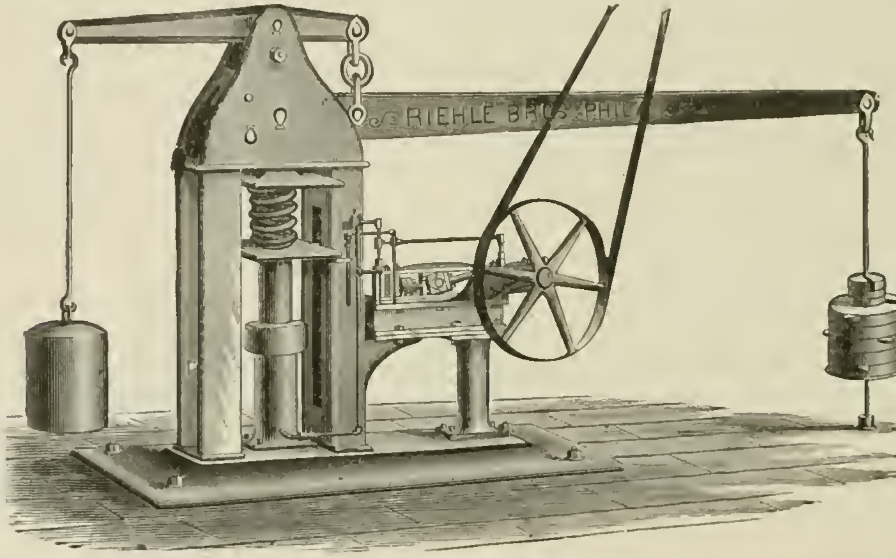
In one model, the lock-plate is of uniform thickness, about one half that of the 1870 model, the main-spring bolster being replaced by a screw. The shape of the hammer and of the surrounding parts of the stock are changed, so as to promote economy of manufacture and ease of manipulation.

In another model, the shape of the ejector-stud is modified, and a lining inserted into the receiver, with the intention of facilitating the introduction of the cartridges.

SPRINGS.—Elastic contrivances designed to facilitate the movement of carriages over rough roads. Their action may thus be explained: As the carriage advances along an even road, the spring is constantly deflected to that extent which balances all the weight of the carriage. As soon as the wheel encounters an obstacle, the motion of the axle-tree is changed suddenly from a horizontal to a circular path; the center of the circle, or the axis, being the point of contact between the wheel and obstacle. If A be the angle contained between the radius from this point and the vertical, V the original velocity of the carriage which the horse has to maintain; then, the velocity of the axle-tree in its new path $= V$ sec. A and the vertical component of this new velocity $= V \times$ tan. A, which is the velocity with which the axle-tree is impelled upwards towards the carriage, the wheels being deflected in proportion. But if there be no springs, the *carriage itself* must be given this new vertical velocity; and the carriage offers a resistance to rising proportional to its mass and to the *square* of the velocity of the new motion. And the additional resistance experienced by the horse is proportional to this, causing a jerk on the traces and making the work heavier. By using springs, however, the vertical motion of the axle-tree is applied to the spring with a *gradually increasing* pressure, producing a correspondingly increasing deflection until the inertia of the carriage is overcome; in the meanwhile, if the speed be considerable, the obstacle is passed over before any material effect is produced upon the carriage. Experiment points to the following conclusion: For carriages calculated to travel at a walking pace, springs are of little or no use. Their value, however, is at once felt when the pace increases to a *trot*, and is augmented with each increment of speed, especially upon hard, rough roads.

SPRING SPIKE.—A spike having a shoulder and spring to prevent its being too easily extracted. It is used when guns are spiked temporarily and are likely to be retaken. See *Spike*.

SPRING TESTER.—A machine for ascertaining the elasticity of springs under pressure. The drawing shows an improved machine of this class with the following:



DIMENSIONS.

Extreme height	5 ft. 8 in.
" length	11 ft.
" width	5 ft.
Weight	5,300 lbs.

Capacity 10,000, 25,000 and 30,000 pounds.

ADAPTATION.

Compression Surface above	16 in. × 16½ in.
" " below	16½ in. × 5 ft.
Space between Surfaces	1 ft. 10 in.
Dynamic Motion	1¼ in.
Motion of Plunger	10 in.

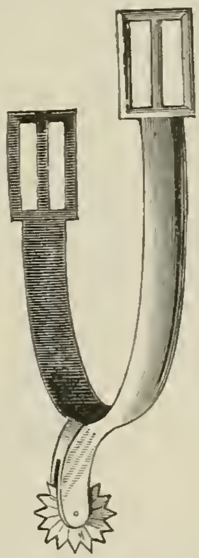
The power-pump is operated by a pulley and belt. A lug projects from the corner of the lower table or compression surface; this lug intercepts a pawl that is connected with a valve that controls the flow of the liquid, and when the long table moves upward to the desired height, the fluid is diverted from under the plunger back into the reservoir, thus securing a uniform test.

The upper table bears against weighing levers, and is comparatively motionless, while the lower table moves upwards and communicates the pressure through the springs to the upper table, and thence to the lever and weights as shown. The lower table is well extended so as to take in a long spring. See *Testing-machine*.

SPRITES.—Wooden arrows which were anciently projected from muskets.

SPRUE.—Strictly, the hole through which melted metal is poured into the gate, and thence into the mold. The term is applied to the waste pieces of metal cast in this hole. See *Molding*,

SPUR.—1. An apparatus fastened to the heel of a horseman, for goading the horse. It is much less used than formerly. All cavalry soldiers wear spurs; but their use, except in the heat of an actual charge, is discouraged as much as possible. In the days of chivalry, the use of the spur was limited to knights, and it was among the emblems of knighthood. "To win his Spurs," was for a young man to earn knighthood by gallant conduct. The degradation of a knight involved the hacking off of his spurs; and the serving before a knight of a pair of spurs on a dish, was a strong hint by his host that he had outstayed his welcome.



In the United States Army, all the mounted officers wear spurs made of yellow metal or gilt with ornamentation, and the cavalrymen wear the same pattern with a plain surface.

2. A tower or block-house placed in the outworks before the port.

3. A wall that crosses part of a rampart and connects to the interior work.

SPUR-NECK.—The part of the spur projecting from the shank and holding the rowel. About the 15th century, when tournaments were greatly in fashion, the *spur-neck* was extravagantly long. It became shorter again in the 16th century, when the spurs had very often rowels of twelve, fifteen and even eighteen points.

SPUR-TUBES.—Quill priming-tubes filled with inflammable composition, and ignited by applying the match. The body of the tube is filled with a composition of mealed powder moistened with camphorated alcohol until a thick paste is formed; the composition is introduced into the quill by pressing its lower end into the paste, thus taking up a portion of it, and repeating the operation until the quill is filled. A small wire is then run through the axis of the tube, and allowed to remain there until the paste is dry, when it is withdrawn, leaving the composition perforated throughout its entire length. The object of piercing the composition is to expose more surface to the action of the flame; the ignition of the whole contents of the quill is thus rendered instantaneous. The head of the tube, or spur is formed by inserting a strand of quick-match, about an inch long, into the composition through a hole near the head of the quill. This is protected by a small tube of stiff paper lashed at right angles to the quill. The end of the quick-match is covered with a paper cap, and the whole is shellacked over to protect it from moisture.

SPY.—A person who secretly, in disguise or under false pretense, seeks information with the intention of communicating it to the enemy. The spy is punishable with death by hanging by the neck, whether or not he succeed in obtaining the information or in conveying it to the enemy. If a citizen of the United States obtains information in a legitimate manner, and betrays it to the enemy, be he a military or civil officer, or a private citizen, he shall suffer death.

Spies have been used in all wars from the time when Moses sent Joshua on such a purpose to the present time. Their employments are quite recognized by the law of nations as interpreted by Grotius, Vattel, and Martens; nor is it held to be any dishonor to a General to avail himself of their services. On the other hand, the spy himself is looked upon as an outlaw, and one devoid of honor. If taken by the enemy, he is put to death ignominiously and without mercy. As, however, the calling is so dangerous, and so little redounds to honor, it is never permissible for a General to compel by threats, etc., any person, whether of his own or the hostile party, to act as spy; but he is at liberty to accept all such services when proffered. A spy is well paid lest he betray his employer. In the British Army spies are usually controlled by the Quartermaster General. Martial law, though distinct enough in ordering the death of a spy, is not clear in defining what constitutes a spy. A man—not of the enemy—within the enemy's lines, and in the enemy's uniform, would presumably be a spy. If in a civil dress, and unable to give a good account of himself, his chance of hanging would be considerable; but if found in one camp in the uniform of the opposite side, he might not be treated otherwise than as a prisoner of war, or at least as a deserter from the enemy.

Both as regards honor and penalties, it would seem that spies ought in fairness to be divided into two classes—first, those who betray their own country to an enemy; secondly, those who, being enemies, contrive surreptitiously to obtain information by penetrating into the opposing army. The first class are traitors of a deep dye, for whom no ignominious death is too bad; but the second class are often brave men, who dare much in the service of their country, It is unfair to accord to them the same treatment as the traitors.

SPY-GLASS.—In order that all the advantages gained by the use of the spy-glass may be more fully understood, we shall here briefly consider the optical principles involved in its construction. The object-glass, receiving the rays of light which proceed from all the points of a visible object, converges them to a focus, and there forms a minute, inverted and very bright image, which may be seen by placing a piece of ground-glass to receive it at that point. The eye-piece, acting as a compound microscope, magnifies this image, restores it to its natural position, and conveys it to the eye. The visual angle which the image there subtends, is as many times greater than that which would be formed without the use of the spy-glass as the number which expresses its magnifying power. Thus, a spy-glass which magnifies twenty times increases the visual angle just as much, and therefore diminishes the apparent distance of the object twenty times; or, in other words, it will show an object two hundred feet distant, with the same distinctness as if it was distant only ten feet from the naked eye. The drawing will give a correct idea of the manner in which the rays of light coming from an object are affected by passing thorogh the several glasses of a spy-glass. We shall only consider the rays which proceed from the extremities. These, after passing through the object-glass are converged to that point—the common focus of the object and eye-glasses. At this place the rays cross each other, and the image is then inverted. The rays next come to the object-lens, and passing through it are refracted so as again to cross each other, and come thus to the amplifying lens. By this they are again refracted, made more nearly parallel, and thus reach the large field-lens. After passing through this, they form a magnified and erect image in the focus of the eye-lens. By the eye-lens the image is still further magnified, and at last enters the eye of the observer, subtending an angle as much greater than that at the point, O, as is the magnifying power of the spy-glass. The United States Signal Service instrument, made by Messrs. Queen & Co., embodies the three most important qualifications of a good spy-glass, viz., great defining power, lightness, and portability. This glass will, under ordinary circumstances, enable the observer to make out signals at a distance of twenty-six miles, read the name on a light-ship at nine miles, make out wild fowl at sixteen miles, show shot marks at very longest ranges, the time by a church clock at six miles, and persons walking at ten and one-half miles. It is fitted with two leather caps, to which is attached a strap, thus forming a light and efficient case. See *Object-glass.*

SQUAD.—Any small number of men assembled for the purposes of drill or inspection. A troop or company of soldiers should be separated into as many squads as there are Officers or Sergeants at hand to drill them. The *awkward squad* comprises recruits not yet fitted to take their places in the regimental line.

SQUAD-BAGS.—Canvas bags provided for troops (one for every 25 men), for the purpose of relieving a soldier from carrying a complete kit on the line of march or in the field. In India, where knapsacks are not carried by the soldier on the march, a small squad-bag is issued to each soldier.

SQUAD-BOOK.—In the British Service, the roll of a squad, containing, besides the names, the trades and other particulars of the men.

SQUADRON.—In military language, two troops of cavalry. It is the unit by which the force of cavalry with an army is always computed. Three or four squadrons constitute a regiment. The actual strength of a squadron varies of course with that of the component troops; but it ranges from 120 to 200 sabers.

In naval affairs a squadron is a section of a fleet, and constitutes the command of a junior Flag Officer or Commodore.

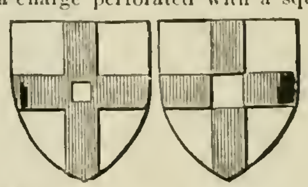
SQUAMATA.—A flexible cuirass composed of small iron or bronze scales sewed on linen or leather, and first worn by cavalry soldiers in the time of Polybius. Also written *Squammata.*

SQUARE.—In military evolutions, the forming of a body of men into a rectangular figure, with several ranks or rows of men facing on each side. With men of ordinary firmness a square should resist the charges of the heaviest horse. The formation is not new, for a Grecian syntagma was a solid quare of 16 men in every direction; but in modern warfare the solid square, having been found cumbrous, has been abandoned for the hollow square, with officers, horses, colors, etc., in the center. The front rank kneels, and the two next stoop, which enables five ranks of men to maintain a rolling fire upon an advancing enemy, or to pour in a murderous volley at close quarters. The application of the *solid square* to resist cavalry appears to have been introduced in 1798, when the French Army in Egypt, being weak in cavalry, was opposed to overwhelming hordes of Mamelukes. At the battles of Chebreifs and of the Pyramids, Bonaparte formed his infantry echeloned in squares against the Egyptian horse.

A large square has not proportionally a greater fire than a small one, and it is no stronger. In a charge of cavalry, that portion only which attacks the face of a square is to be dreaded. If the face is much extended the number of cavalry that can bear down against it is augmented in like manner. A square of three thousand men is not then any stronger than a square of one thousand. It would therefore be absurd to form three thousand men in one square, because they can be more readily formed into three or four squares, which will mutually protect each other, and form, as it were, a system of redoubts. And if one of these combined squares is broken by cavalry, the cavalry becomes disordered in the act, and the remaining squares are left intact. Besides, in presenting a small front to the attack of cavalry, horses, fearing to charge against the shower of balls which welcome them, are apt to oblique to the right or to the left. If the face of the square is extended they cannot do so, and the shock must fall on some part of the face, but the smaller the faces of combined squares the greater will be the intervals, and the more certain the success of the defense.

From these considerations, it is apparent that large squares ought not to be used, but that squares of a single battalion are worthy of all commendation. The formation of troops in two ranks is the prescribed order of the United States infantry tactics. Marshal Marmont says: "Nothing can be said in favor of a third rank. Persons of experience know that if one can, at a review, fire a volley in three ranks, it is impossible in war. It is better, therefore, to adopt the two-deep formation, and to render it permanent." The tactics direct that the divisions, as a general rule, shall always be formed before forming square. Marshal Bugeaud is of opinion that the square formed from the column by company, which would give a depth of four or six men to the different faces of the square, is greatly to be preferred. Apart from the fact that such squares are more expeditiously formed, the face of the square is reduced one-half, and the square is strengthened by the reduction.

SQUARE-PIERCED.—In Heraldry, a term used to designate a charge perforated with a square opening, so as to show the field.



Square-pierced. Quarter-pierced.

A cross square-pierced is often improperly confounded with a cross quarter-pierced, where the intersecting part of the cross is not merely perforated, but entirely removed.

SQUARE POWDER.—The grain of this powder is formed of two quadrangular pyramidal frustums united on a square base. The side of this base is about 1.25 inches, and the thickness of the grain 1.30 inches.

These powders were intended as experimental powders for large calibers, and were made of three different densities, but of the same granulation, viz;

	Granulation.	Density.
G. S.	11	1.775
G. T.	11	1.760
G. W.	11	1.715

The tests were made in a 11-inch rifle, using as high as 85 pounds of G. S., with a 505-pound projectile. The results demonstrated that the density of the G. S. was too high for the granulation. G. W. proved too violent owing to its low density, even with the moderate charge of 70 pounds.

The results obtained with G. T. were as follows:

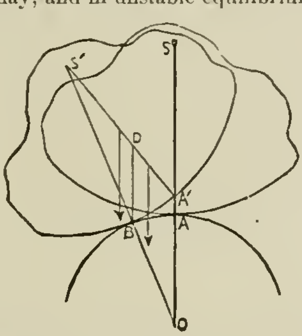
Nature of gun.	Kind of powder.	Weight of ch'rge	Weight of pr'jec.	Vel'ty at 110 feet.	Pressure
		Lbs.	*Lbs.*	*Feet.*	
11-inch rifle.......	G. T. square.	70	505	1245	31500
		75	505	1314	33000

These results, though only fair, yet indicate that the charge might safely be increased to 80 pounds, with the promise of much better results; since for an increase of 5 pounds, *i. e.*, from 70 to 75, the velocity has been increased 71 feet, while the pressure, on the other hand, has run up only 1,500 pounds. See *Gunpowder*.

SQUIRE.—The name formerly given to an attendant on a warrior.

STAB.—To pierce with a pointed weapon; as, to be stabbed by a bayonet, dagger, etc.

STABILITY.—When a body rests upon a surface in such a manner that a vertical from its center of gravity falls within the largest polygon which can be formed by joining the various points of contact of base and surface, it will stand; but if the contrary is the case, it will fall, unless extraneously supported. If the base of the body be a plane, and the supporting surface convex, or *vice versa*, or if both base and surface be convex, there will then be only one point of support, and if the body be at rest, its center of gravity must be vertically over the point of contact. Should a body so placed receive a slight impulse, it will either oscillate to and fro, ultimately returning to its original position, or remove further and further from its original position, showing a tendency not to return, or appear indifferent to any one position. In the first case, the body is said to be in *stable*, in the second case, in *unstable*, and in the third, in *neutral* equilibrium. It will appear at once that the predetermining cause of equilibrium being of one rather than of another of these species, is the tendency of the center of gravity of every body to seek a lower position. In stable equilibrium the center of gravity of the body may, and in unstable equilibrium may not,



attain a lower position, while in neutral equilibrium its position continues unaltered. In illustration of the mode in which the species of equilibrium possessed by a body which has received a slight impulse is determined, let us take the case of a body with a spherical base resting upon a spherical surface; let S and O be the centers of the spherical surfaces respectively, and let A be their point of contact (the center of gravity being consequently in the line SA, or in it produced toward S, and after displacement, in the line S'A', produced if necessary), let the new position of S, after the body has been slightly displaced, be S', and the new point of contact B; join OS, OS' S'A', and draw BD vertically, that is, parallel to OS.

Then A'D : A'S' :: OB : OS', or $A'D = \frac{A'S' \times OB}{OS'}$,

that is, A'D= the product of the radii of the two surfaces divided by their sum. Now should the center of gravity of the displaced body fall between D and A', it will have a moment round B tending to restore the body to its former position (*stable equilibrium*); should the center of gravity be beyond D from A', its moment round B will tend to increase the displacement (*unstable equilibrium*); while, if it fall in the line BD, it will still be above the point of contact, as it was at first, and there will be no tendency either to return to, or to move further from, the original position (*neutral equilibrium*). These conditions may be briefly expressed by the following formulæ, in which R is the radius of the supporting surface, *r*, of the spherical base of the body, and X the distance of the center of gravity from the point A; when equilibrium is stable, X is less than $\frac{R \times r}{R + r}$; when unstable, X is greater than $\frac{R \times r}{R + r}$; and when neutral, $X = \frac{R \times r}{R + r}$. From these formulæ, the conditions of equilibrium of a body, with a spherical base on a plane surface can be at once deduced by making $R = \infty$. the three species of equilibrium being then represented in order by X less than *r*, X greater than *r*, and $X = r$; the simplest illustrations of these being respectively a segment of a sphere, a tall cone on a spherical base, and a sphere.

STABLE HORSE.—A name formerly applied to that part of the Tippoo Sahib's cavalry which was best armed, accoutered, and most regularly disciplined.

STABLES.—Foul air is the cause of many diseases of the horse. Hence the importance and economy of spacious, clean, and well-ventilated stables. Ceilings should be twelve or fifteen feet high, with large ventilators through the roof, and a window or side-aperture in each stall. If possible, the building should have no upper story or loft. In stables with a loft, ventilation from the top is always insufficient, and there must be side-openings well above the horses, so that the draught will pass over their heads. These openings must never be closed except on the windward side, to keep out rain or snow.

On the southern frontier, a cavalry-stable is best constructed on three of four sides of a rectangle so as to inclose a stable-parade or court. First build an exterior stone or adobe wall, twelve or fifteen feet high: resting on this wall, and on posts or columns set back some fifteen feet in the interior, is a roof so pitched as to shed the rain outside of the inclosure; the stalls are arranged along the wall, with a window opposite each horse. In cold weather, the spaces between the posts can be partly boarded up, and the window-shutters fastened. The forage and store-rooms are constructed at the angles, taking advantage of the inclosure-walls, which form two sides of the rooms. A hospital-stable should be somewhat isolated, and have a large yard for turning-out invalids, who should be protected from sun and high winds by an open shed against one side of the inclosure.

A picket-line is established in the immediate vicinity of every company-stable; the horses being tied on each side of a timber framed on posts, to a rope passed through the posts. There should be shallow trenches behind the horses to carry off rain, and the ground on which they stand having just slope enough to let water run into the trenches. Constant attention must be paid to maintaining the ground about the picket-line in good order.

A Non-commissioned Officer is detailed, in each company, to take immediate charge of the police and sanitary condition of the stable, picket-line, etc. He is the custodian of the forage and stable property generally. The stable is to be kept thoroughly policed, free from smells, and well whitewashed. There must be no accumulations of manure or foul litter inside or near the doors or windows without. The feed boxes are washed out from time to time, and kept clean. The ground about the picket-line is swept daily, and all dung, etc., carried to the manure-heap.

Except at night when the horses are bedded down, no manure or urine should remain in the stalls; the stable-police remove it as fast as it accumulates. If practicable, all wood-work within reach of the horses and not protected by sheet-iron or any other metal, is painted every four months with thin gas-tar, to prevent its being gnawed. The same precaution must be followed with regard to the troughs, picket-posts, and picket-line. One or more lamps should be hung in each stable, to burn during the night. Saddles generally rest on strong pins in the heel-posts; bridles on smaller pins below them. The name of each horse,and that of his rider,should be placed over his stall. Horses should always stand on earth. Clay is the best for this purpose,as it packs well. Gravel, or sandy earth, is not suitable. Each man is held responsible for the renewal of the earth, and also the leveling of the floor of his stall. The sloping of the floor of stalls, from the manger to the heel post,is injurious and uncomfortable to the animal, who stands in an unnatural position, with the forelegs higher than the hind ones. When earthen floors are not level, they give more trouble, as the horse will paw a hollow for his fore-feet unless he can elevate his hind-legs by backing out of the stall.

Whenever the horses go out of the stable,the windows of their stalls should be kept open,unless necessary to exclude rain or snow, or when cold draughts affect the animals in contiguous or opposite stalls. Stable-doors are never closed in the daytime, except to keep out wet or exclude cold winds which blow on the horses. If the doors be in a single piece,bars are put across the door-way; if divided in half, it will be usually sufficient to open the upper part. At night, except in very hot weather, they should be closed and locked, communication with the stable being kept up by a man-hole.

Except in very cold windy weather, or in very hot weather where there is no shade,horses should stand most of the day at the picket-line,as they have better air and are less confined, while the stables become drier and more healthful. In ordinary climates,military stables must be kept as cool as possible. If the horses do not stand directly in the draught,the colder the stable the less will they suffer if called suddenly to take the field. For the same reason,horses should never be blanketed in the stable, except in the excessively cold weather of a high latitude.

Stable-guards are for the protection of the horses, equipments, and forage, as well as for the enforcement of the special regulations in regard to stables and horses.

The sentinels of the stable-guards are posted and relieved like those of other guards. They are forbidden to strike or otherwise punish horses; and, if consistent with safety,wear the saber-belt only when on post at the stable or picket-line.

The employment of stable-guards for *police* and *fatigue duty at the stable*, is strictly forbidden; but this does not prohibit men not on post from being called upon to groom their own horses, or to assist in feeding grain before reveille.

It is recommended that morning stable-duty be always after the men have breakfasted. Evening stable duty should be one hour and a half before retreat. Horses are groomed twice daily, at morning and at evening stable-calls. The grooming is always at the picket-line, except in stormy weather. The men are marched to the horses, and get to work as soon as the command COMMENCE GROOMING is given by the First Sergeant. In garrison,two or more men in each company, called the *stable police*, are usually kept at work between morning and evening stable-calls, in removing manure, policing generally, feeding, etc. In camp,as a general rule,the whole company polices the picket-line, feeds hay, etc.,at such times as may be most convenient.

To groom the horse, take the curry-comb in right hand, fingers over back of comb; begin on the near side at the upper part of the neck, thence proceed to the chest, arm, shoulders, back, belly,flank,loins, and rump. Then go to the off side, taking comb in left hand, and proceed as before. The curry-comb is not applied to the head or very tender parts, and must not be used on the legs from the knees or hocks downward, except to carefully loosen matted dirt. In cold weather, or when the hair is long,the curry-comb is freely used; at other times but little, particularly when the horse is changing his coat. It must always be applied very gently to horses with tender skins and short coats. Next take the brush in left hand, and change curry-comb to right; begin at the neck, and on the near side,and proceed in the same order as in currying, brushing also the parts not touched by the comb; on the off side take brush in right hand, curry-comb in left. In places difficult to clean, apply the brush backward and forward, finishing by leaving the coat smooth. After every few strokes, clean the brush from dust with curry-comb. Having done with the brush, rub or dust off the horse with the grooming-cloth, and wipe about the eyes and nostrils,and clean the dock. The skin under the flank and between the hind-quarters must be soft,clean,and free from dust. Curry-combs, cards, or common combs, must never be applied to the mane or tail; but the brush, fingers, and cloth are freely used on both. A wisp is used for wet places; it is rubbed against the hair until the places become dry.

In garrison,it is recommended that grain be fed at first call for reveille by the Non-commissioned Officer in charge of the stables,assisted by one or two members of of the stable-guard, or men detailed for the purpose. The grain, in a box on wheels, is rolled in front of each stall, whence it is transferred to the feed-boxes by allowance-measures. Grain is fed again at evening stable-duty as in the morning, but not until after the hay has been fed and the stable swept up. In camp or on the march,grain is fed at morning and evening stable-duty. The men are marched to the forage-wagon,or other grain depository, where the Non-commissioned Officer in charge, with an allowance-measure, issues to each in turn.

Hay, in garrison, is fed thrice daily; immediately after morning stable-duty, in the middle of the day, and at evening stable-duty; at the evening feed each animal should have at least one-half of his daily allowance. The dust must be well shaken out of the hay before it is put in the mangers. During the short days of winter, the feeding at noon may be omitted without injury to the animals.

Hay, in camp, is fed at the picket-rope, morning, noon, and evening; but on the march,in the evening only. The occasional use of bran is important for stabled horses. In spring, or in early summer, they should have grass for at least a week or ten days, during which time they ought not to be much worked. Salt should be given once a week. When forage cannot be obtained,grazing should be allowed at every spare moment, especially early in the morning, when the dew is on the grass. The daily allowance of oats, barley, or corn, is twelve pounds to each horse; that of hay fourteen pounds; the allowance of straw for bedding is one hundred pounds a month to each animal. Good oats weigh about forty pounds to the bushel; barley about forty-eight pounds; corn about fifty-six pounds. Pressed hay weighs eleven pounds per cubic foot. The average weight of a bale of hay is from three hundred to three hundred and twenty-five pounds. The standard bushel used in the United States contains 2150.4 cubic inches. A cubic yard contains 21.69 bushels. A box 16 × 16.8 × 8 inches holds one bushel; a box 12×11.2×8 inches holds half a bushel; a box 8×8.4×8 inches holds one peck.

Horses must be watered quietly and without confusion; the manner in which this duty is performed is a good test of the discipline of any mounted command. They are led or ridden, at a walk, to and from water, depending upon its distance from the stable. At the drinking-place, no horse should be hurried,or have his head jerked up from the water, until he has done drinking. In the field, or on the march, the watering is from the most convenient running water; in garrison, it is usually from troughs. In warm weather, water drawn from a cold well or spring before being used, should stand long enough for the chill to pass off. During the hot months, horses are watered thrice daily; in the morning, at noon, and just before grooming in the afternoon. At other times, two waterings are enough; after the morning and at evening stable-duty. In very cold weather, once a day, at noon, is sufficient. It is to be always remembered that a horse will rarely drink enough very early in the morning. The daily allowance of water for a horse is four gallons. On the march, horses are watered with buckets carried on the carriages; the oftener the better, as it is not usually known when another watering-place will be reached. When horses have to make a day's march without water, they will be watered after they are fed, just before leaving camp in the morning. If a mounted command have to march a long distance without water, so that it will be necessary to encamp *en route*, the animals are well fed but denied water until just before starting, when they are permitted to drink freely. The command marches in the afternoon, and does not encamp until it has accomplished at least half of the distance, and moves early the next morning to reach water.

STACK ARMS.—A movement in the *Manual of Arms*, for setting up rifles or muskets together, with the bayonets crossing one another, and forming a sort of conical pile. The movement is thus executed: The men being in line and at *order arms*, the Instructor commands:

1. STACK, 2. ARMS.

At the command *stack*, each even number of the front rank carries his piece with the right hand diagonally in front of the center of the body, and grasps it with the left hand above the lower band, the barrel to the rear, the muzzle opposite the right arm: he then grasps the piece of his rear-rank man with his right hand above the lower band, and places the shank of the bayonet upon that of his own, the barrel to the right; the odd number of the front-rank, with the right hand, then places the shank of his bayonet in the angle formed by the bayonets of the other two pieces, the barrel to the front, retaining his hold on the piece above the lower band; the butts of all the pieces about six inches from the ground.

At the command *arms*, the even number of the front-rank, with his right hand, passes the butt of the musket of the rear-rank man thirty inches to the front, passing it between the butts of the other two pieces; the stack is then lowered, the butt of the musket of the even number striking the ground just to the left of his left toe, that of the odd number striking the ground between his feet.

The stack being formed and aligned, the command, *lay on loose pieces* is given; at which the remaining pieces in the rear-rank are passed to the even numbers of the front-rank, who lay them on the stacks. The pieces of the file-closers are laid on the stacks at the same time. The stacks are broken in an inverse manner.

If in single rank, number two of each four makes the stack, and at the command *stack*, takes the piece of number three with the left hand above the lower band and uses it as explained for the piece of the even number rear-rank man; the stack is completed as in two ranks, after which the piece of number four is passed to the right and placed upon the stack.

In breaking the stack, the piece of number four is first passed to him; the stack is then broken as when in two ranks, except that number two grasps his own piece with the right and the piece of number three with the left hand. See *Hook-swivel.*

STACKET.—An old term for stockade. See *Stockade.*

STACKING-SWIVEL.—The swivel attached to the upper band of a breech-loading rifle or carbine, to enable stacks to be formed without attaching the bayonet or using the wiper.

STACK OF ARMS.—A number of muskets or rifles set up together, with the bayonets crossing one another, forming a sort of conical pile.

STADIA.—A very simple aid in estimating distances consisting of a small stick, held vertically in the hand at arm's length, and bringing the top of a man's head in line with the top of the stick, noting where a line from the eye of the observer to the feet of the man cuts the stick, or *stadia*, as it is called. To graduate the stadia, a man of the ordinary height of a foot-soldier, 5 ft. 8 in., is placed at a known distance, say 50 yards; and the distance on the stick covered by him when it is held at arm's length is marked and divided into 8 equal parts. If the distance is now increased, until the man covers only one of these divisions, we know he is at a distance equal to 50 yds. $\times 8 = 400$ yds. This instrument is not very accurate, except for short distances. A much more accurate stadia is constructed by making use of a metal plate, having a slit in it in the form of an isosceles triangle, the base of which held at a certain distance from the eye, will subtend a man, (5 ft. 8 in.) say at the distance of 100 yards. A slider moves along the triangle, being always parallel to the base, and the length of it comprised between the two sides of the triangle, represents the height of men at different distances, which are marked in yds., on the side of the triangle, above or below, according as the object looked at is a foot-soldier or horseman. In order to keep the stadia always at the same distance from the eye, a string is attached to the slider, the opposite end having a knot tied in it, which is held between the teeth while using the instrument, which is held in the right hand, the slider being moved with the left-hand finger. The string should always be kept stretched when the instrument is used, and the line in a vertical position. It must be graduated experimentally, by noting the positions in which the slider represents the height of the object. The instrument used is not, however, reliable. Its uncertainty increases in an equal ratio with the distance of the object observed. At the extreme ranges it is quite useless. At the School for Firing at Vincennes, therefore, they rely entirely on the eye alone for the judgment of distances, and great pains by careful practice and instruction is taken to perfect that judgment. A simple instrument by which distances can be determined is, therefore, still a great desideratum. See *Range-finder.*

STADIMETER.—An instrument invented by Messrs. Paucellier and Wagner, of the French Topographical Corps, for ascertaining the distance between any two points. It consists of a horizontal, graduated rule, mounted on an upright staff. It is viewed through an intervening telescope provided with a micrometer. The number of divisions of the micrometer that cover a certain number of the divisions on the rule indicates the distance between it and the telescope.

STADOMETER.—A contrivance for estimating distances, usually employed on the drill-ground, to save measuring. It consists of a bar 5 feet 2 inches long, marked with an index having a sliding sight and a cross-head at one end extending at right angles to its length, and is supported at a convenient height by legs at each end. Two fore-sights, one at two inches and the other at four, are placed on the head.

In using this instrument the sight on the index-bar is aligned upon the desired point. A flag is then placed at 40 yards at right angles from that point (the angle being obtained by the use of a cross-staff having two sets of sights), and the sliding-sight on the index-bar slipped down until the fore-sight on the head is aligned on the flag, when the scale will show the distance, as every four inches represents 40 yards. To measure over 600 yards, the inner fore-sight on the head is used, and the distance on the scale doubled, since at that angle every 2 inches would represent 40 yards.

The author has contrived a *stadometer*, the principle of which is based on the proportionality of the corresponding sides of similar triangles and an application of the plummets. It does good work on an undulating and broken drill-ground, where actual chain-measurement would be impracticable if not impossible. Prolonged practice and experience, in the appreciation of distances, are necessary to give the *coup d' œil* that insures sufficient accuracy. The practice should be conducted over smooth, broken, and undulating ground, and frequently from elevated points. The distances should frequently be estimated in all directions as regards light and the condition of the atmosphere.

STAFF.—The staff of an army consists of a body of skilled officers, whose duty it is to combine and give vitality to the movements and mechanical action of the several regiments and drilled bodies composing the force. The distinction between an officer on the staff of an army and a regimental officer is that the latter is concerned with his own regiment alone, while the former deals with his army, or section of an army exceeding a regiment, and regulates the combined action of the several arms and bodies of men. A good staff is all-important to the success of a military enterprise.

In the British Service the *General Staff* of an army comprises the General in actual command, with the subordinate Generals commanding the several divisions and brigades, and as assistants, the officers of the Adjutant General's Department—*i. e.*, the Adjutant General, his deputy, assistants, and deputy-assistants if the army be large enough to require all. Similarly, the officers of the Quartermaster General's Department; the Brigade Major; the Provost Marshal; and the Judge Advocate; and the Controller (at the head of the Civil Departments), the functions of all of whom are described under their respective heads. The head of the General Staff of the British Army is at present a Field Marshal Commanding-in-Chief, whose headquarters are at the War Office, of which Department he is an *ex officio* member. He is responsible for the discipline of the Army, and is assisted by the General Officers in command of the military districts in England and Scotland, the semi-independent Commander-in-Chief in Ireland, and the Commanders-in-Chief in the various foreign possesions and colonies. India forms a nearly independent command, under a Commander-in-Chief, whose headquarters remain in Bengal. There are subordinate Commanders-in-Chief in Bombay, and Madras; and in each Presidency there are several military divisions. A certain period of military service, and certain qualifications, are required in an officer before he can be appointed to the General Staff, and a proportion of the posts is given to officers who have passed the Staff College. The fact of having passed through it, however, is not held to constitute any claim to a Staff appointment.

The *Personal Staff* consists of the Aids-de-Camp and Military Secretaries to the respective General Officers. These officers are appointed, within certain limits, by the Generals whom they serve.

The *Garrison Staff* consists of the officers governing in fortresses and garrisons; as Commandants, Fort Majors, Town Majors, Fort Adjutants, and Garrison Adjutants.

The *Civil or Department Staff* includes those non-combatant officers who have to provide for the daily requirements of the troops. These are the Commissaries for supplies and stores, Chaplains, Medical and Veterinary Departments.

The *Recruiting Staff* consists of an Inspector General (at the War Office), and of the officers of the several brigade depots. The *Pensioner Staff* includes only the Staff officers of the enrolled force. The *Regimental Staff* includes the Colonel, Lieutenant Colonel, Adjutant, Paymaster, Quartermaster, Inspector of Musketry, and Medical Officers.

In the French and in most Continental armies the Staff is divided into the Etat Major, or General Staff and the *Intendance* put under an *Intendant General*, which comprises all the Civil Departments. There is a Regimental Staff in addition. The want of concentration of the Civil Departments often felt in the British Service, led to the creation, in 1869, of the Control Department, subsequently split into two branches, the Commissariat and the Ordnance Store Departments.

In the United States Service, the General Staff consists of the officers of the several Military Bureaux.

The Staff of Division and Department Commanders is limited to the following: The authorized Aides-de-Camp. One Assistant Adjutant General, or an officer to act as Assistant Adjutant General. One or more officers of the Inspector General's Department, if available; if none are available, an officer may be assigned to these duties with the sanction of the Secretary of War. One Judge Advocate, or an officer assigned to that duty with the sanction of the Secretary of War. One Chief Quartermaster and one Chief Commissary of Subsistence, who shall also take full charge of the depot and purchases for their respective departments at the place where the headquarters are located. One Medical Director, who shall also perform the duty of Attending Surgeon at the place where headquarters are established. A Chief Paymaster, who shall make his proportion of payments in the command. An Engineer and an Ordnance Officer when needed.

As far as practicable, all appointments and details on the Staff are equalized among the several regiments. General Officers appoint their own Aides-de-Camp. Brevet Brigadier and Major Generals on duty as such may, with the special sanction of the War Department, be allowed the Aides-de-Camp of their brevet grades. An officer shall not fill any Staff appointment, or other situation, the duties of which will detach him from his company, regiment, or corps, until he has served at least three years with his regiment or corps; nor shall any officer (Aides-de-Camp excepted) so remain detached longer than four years. An officer of a mounted corps shall not be separated from his regiment, except for duty connected with his particular arm.

The Commander of a regiment appoints the Adjutant from subalterns of the regiment, nominates the Regimental Quartermaster to the Secretary of War for appointment, if approved. He also appoints the Non commissioned Staff of the regiment; and upon the recommendation of the Company-Commanders, the Sergeants and Corporals of companies. A regimental Staff Officer who accepts a detail for recruiting or other service which will remove him from the discharge of his Staff duties for any considerable time is held to have vacated his Staff position from the date he accepts the detail. This does not apply to details on Courts-Martial, Boards, or any such like duty.

It is necessary that a General Staff Officer should have a knowledge of horsemanship—he should also not be ignorant of the sword exercise; he should have some knowledge of topography; he should be familiar with foreign languages, should have studied military administration and also castrametation; but above all, he should possess a complete knowledge of tactics, and be able to judge skilfully of military positions. An officer grown old in the silence of a Bureau would hardly, in the tumult of battle, or under critical circumstances, second his General by aiding him intelligently concerning all warlike operations. Can he interrogate spies; watch over the observance of order in military trains; draw up orders and instructions; mark out military positions; improvise a fortification; organize and conduct foraging parties; direct markers for grand maneuvers? Open the march of armies? Vault at the head of the light cavalry? Stimulate and enlighten the troops by his interpretation of the orders he carries, by his intuitive knowledge of their tactical position, by his coup d'œil, by the propriety of his counsels, and by the vigor of his impulsions? None but officers whose experience has been gained by service with troops, can do these things with promptitude and effect; but these are the important duties of the General Staff, and service with troops, therefore, is the true criterion of merit in such Staff Officers. In organizing a permanent General Staff Corps, it consequently becomes necessary either to employ in peace that large body of officers necessary in war for the Staff duties, upon duties entirely foreign to their functions in war, or else leave them in idleness. Either course must unfit them for the services required of them on campaign, and it therefore follows, that a permanent General Staff involves a useless number of officers in time of peace, and a deficiency of experience, instruction, and aptitude for their duties in time of war. It is impossible to avoid this vicious circle with a permanent General Staff. The only true system of Staff organization, then, is that which admits of supernumerary General and Regimental Officers, selected temporarily for Staff duties by Commanders of troops, as provided by the Act of Congress of 1799, drawn by Alexander Hamilton. "The leading qualifications which should distinguish an officer selected for the Head of the Staff (says Napoleon), are to know the country thoroughly; to be able to conduct a *reconnaissance* with skill; to superintend the transmission of orders promptly; and to lay down the most complicated movements intelligibly, but in few words, and with simplicity."

STAFF ADMINISTRATION.—The supply and payment of the Army, and the direction of the expenditures of the appropriations for its support, are by law committed to the Secretary of War. He exercises control through the several Bureaus of the War Department and the several branches of the military service and the officers thereof. He determines where particular supplies shall be purchased or contracted for; where they shall be delivered, inspected, and stored, and how distributed—whether at general depots for the use of the whole Army, or at particular posts or headquarters for parts thereof. He decides, also, through and by means of what officers within the laws these purchases and contracts shall be made.

All officers of the Staff who are assigned to the command of a General or other officer remain under that officer's military command, and are under his supervision, control, and command in all their official acts relating to matters within his command, and to all matters, acts, and things not specially excepted from his command and control under the law and by the Secretary of War, in accordance with the Regulations and General Orders published by the War Department or issued by the Secretary of War from time to time.

It is the duty of every Commanding Officer to enforce a rigid economy in the public expenses, and to correct all irregularities and extravagances which he may discover; to see that all disbursements are prudently and economically made; that public property is properly cared for, and not lost or destroyed through neglect; to carefully scrutinize all contracts and disbursement accounts submitted for his approval, and to see that the public interests are fully protected.

The administrative control exercised by Department Commanders when troops are in the field, devolves on the Commanders of Divisions; or, when the command is less than a Division, on the Commander of the whole. See *Staff*.

STAFF COLLEGE.—A Government Institution established in 1858, about two miles from Sandhurst. The following are the more important regulations governing this Institution.

I. The Staff College is open to officers of all arms of the Service, and shall consist of 40 students; admission to the College being determined by a competitive examination. Only one officer at a time can belong to the College from a battalion of infantry, or a regiment of cavalry, and only ten officers at a time from the two corps of Royal Artillery and Royal Engineers, but, so far as the exigencies of the Service shall permit, there will be no limitation to the numbers allowed to compete for admission. Every application to study at the Staff College must be made whilst the officer making it is present and serving with his regiment, through the Commanding Officer. No application from an officer on leave will be entertained, and officers are not to be granted leave to be absent from their regiments or depots with the view of preparing themselves to compete for admission to the Staff College.

II. Twenty vacancies will be offered for competition annually, three of which may be filled by officers of the Royal Artillery and two by officers of the Royal Engineers, provided they are among the twenty candidates highest on the list. The principle under which officers are allowed to enter the Staff College being that of pure competition, it follows that candidates who may be found qualified at any examination, but who, from want of a sufficient number of vacancies, cannot then be admitted, will not have any claim to subsequent admission without undergoing another competitive examination.

III. No payment is required from students to the funds of the College, beyond an entrance fee of £3 from an unmarried and £1 10s. from a married officer, as a contribution to the College mess funds in addition to the regulated quarterly subscription; and an entrance subscription of £3 3s. to the College library.

IV. The qualifications requisite for admission are:

(*a*) A service of not less than five years, previous to examination, exclusive of leave of absence. This is not to apply to the usual leave of absence annually granted to officers on home service.

(*b*) A certificate from his Commanding Officer, that the candidate is in every respect a thoroughly good regimental officer.

(*c*) A report on the following questions, to be confidentially answered by a Board, consisting of the Commanding Officer and the two next senior officers of the candidate's regiment, viz.:

Is his conduct marked by steadiness and prudence, and is he temperate in his habits? Is he extravagant in his mode of living? Does he display zeal, activity, intelligence, and discretion in the performance of his duties, and does he take an interest in his profession?

[Any other characteristics of the officer which render him suited or otherwise for the duties of a Staff Officer, are reported].

Is his disposition such as would enable him to perform those duties with tact and discrimination, and in a manner calculated to ensure their being cheerfully carried out by those to whom orders would be conveyed by him; or are his manners and temper objectionable, and likely to cause him to disagree with those with whom he might be associated or brought in contact? Is he active in his habits? Is he a good (fair or indifferent) rider, and is he short-sighted?

(*d*) A certificate that the candidate, if not a Captain, has passed the examination for a troop or company.

(*e*) A medical certificate of good health and fitness for the active duties of the Staff.

Officers on half-pay whose regiments have been disbanded are, if possible, to obtain answers to these questions from the three senior officers under whom they have most recently served.

V. Every application to study at the Staff College must be forwarded through his Commanding Officer, whilst the officer is present and serving with his regiment. No application from an officer on leave will be entertained.

VI. Every candidate, before being admitted to the entrance examination, will, if practicable, be attached for a month to the Staff of a General Officer commanding a brigade or division, who at the expiration of this period will report confidentially upon the candidate's general fitness for Staff employment, and especially upon his aptitude for business and for conducting official correspondence.

VII. The competitive examination for entrance to the Staff College comprises the following subjects, the relative value of each at the examination being shown by the number of marks attached to it:

Mathematics, limited to arithmetic, algebra, geometry, plane trigonometry, and elementary mechanics	900
Military history and geography	900
French	300
German	300
Hindustani	300
Fortification	600
Military drawing	300
Geology, exclusive of mineralogy	300
Chemistry, heat, electricity, and magnetism	300

A qualification will be exacted from every candidate in—

1. Mathematics. 400 marks will be allotted to arithmetic, the first four books of Euclid, and algebra as far as simple equations inclusive; and of this number, at least 250 must be obtained for qualification.

2. Either French, German, or Hindustani. The qualifying minimum is, in French, 150 marks; in German or Hindustani, 100 marks.

3. Elementary field-fortification. One-third of 150 marks, to be assigned to a simple paper, will be required as the qualification in this subject.

VIII. The remaining subjects, as well as the higher portions of mathematics, may be taken up or not, at the option of the candidate, the marks gained therein and in the obligatory subjects, after deducting 60 from the marks gained in each voluntary subject, being reckoned in determining his position in the list of competitors.

IX. In regard to military history, early notice will on each occasion be given of the special campaigns on which questions will be set at the next ensuing examination.

X. The examination of officers serving in the United Kingdom, for entrance to the Staff College, is held in London, about the month of June, under the direction of the Director General of Military Education. (See par. xxix.)

XI. In the case of officers serving abroad, the examination is conducted by means of the same printed questions as are set for the examination of candidates in London. These questions are to be answered in writing in the presence of a Board of Officers, which will be appointed by the General Officer in command, and which will certify that the candidate has obtained no assistance from books, or help of any kind in the examination. (See par. xxx.)

XII. Notice will be given of each examination, and detailed instructions for the guidance of candidates will be published annually in the General Orders of the Army. Candidates are recommended to obtain the reports of the past examinations for admission, with copies of the examination papers, published by Taylor & Francis, Red Lion Court, Fleet Street.

XIII. The College course of study commences annually on or about the 1st of February. The transmission of the printed examination papers to stations abroad is so arranged that the examinations may be held simultaneously, and the merits of the candidates decided upon in time to admit of those who are successful joining the Staff College by the 1st of February next ensuing.

XIV. A synopsis of the course of study will be forwarded to any officer on application to the Director General of Military Education, War Office.

XV. The following are the subjects of instruction at the Staff College, viz.:—

OBLIGATORY.

1. Mathematics (first year only). 2. Fortification and field-engineering. 3. Artillery. 4. Topographical drawing, military surveying and sketching, and road making. 5. Reconnaissance. 6. Military art, history, and geography. 7. Military administration and law. 8. French, or German, or Hindustani. 9. Riding.

Instruction in mathematics is limited to the first year, and will comprise mensuration, the mode of determining heights and distances by ground problems, and by the ordinary trigonometrical calculations with the aid of logarithms, the use of the sextant, and elementary mechanics.

VOLUNTARY.

1. The two languages not selected as obligatory. 2. Geology, exclusive of mineralogy. 3. Experimental sciences. 4. Photography. 5. Military telegraphy.

Officers desirous of showing their proficiency in any or all of the above subjects, as well as in other modern languages not taught at the College, and in landscape drawing, may be examined therein, and a special report of their qualifications in each subject will be made to the Field Marshal Commanding-in-Chief, provided they obtain three-fifths of the maximum allotted to that subject; but they will not be allowed to count any marks thus gained at the final examination.

XVI. The course of study occupies two years, which period is not to be exceeded except in case of illness, and then only with the sanction of the Field Marshal Commanding-in-Chief. The Commandant, in arranging the details of the course of instruction, will be assisted by a College Board composed of the Professors.

XVII. The yearly course is divided into two terms, viz., from the 1st February to the 15th July, and from the 1st September to the 15th December, the intervening periods constituting the vacations.

XVIII. Confidential reports as to the character and abilities of every officer at the College, and his qualifications for Staff employment, will be forwarded at the end of every term by the Commandant to the Field Marshal Commanding-in-Chief, and any student who is reported unlikely to make an efficient Staff Officer will be required to leave the College. Examinations are held at the end of every half-year; the summer examinations being conducted by the Professors of the College, and the winter examinations by Examiners independent of the Establishment.

XIX. The examination at the end of the second term is probationary, and any student will be required to withdraw from the College who shall fail to obtain the minimum aggregate of marks. The marks gained at this examination will not be carried on to the credit of students at the final examination, except those gained in mathematics.

The subjects of the probationary examination, with the proportions of credits attached, will be as follows:

1. Mathematics	3
2. Fortification	3
3. Military history	3
4. Topographical drawing, military surveying and sketching	2½
5. Military administration	3
6. French, German, or Hindustani	2

The minimum aggregate required to pass at the probationary examination is .55. The counting minimum in each subject is .4.

XX. Should, moreover, any marked case of deficiency or neglect be brought under the notice of the Director General of Military Education, at any half-yearly examination, or at any other period, the student so reported will be liable to removal.

XXI. At the end of the second year a final examination will be held for the purpose of testing the general proficiency of the students in the obligatory subjects of the College course, as well as the qualifications of other officers who, under par. xxv., may be admitted to the examination.

Credit will be given to each subject at the final examination in the following proportions:

1.	Fortifications, field engineering, and artillery	6
2.	Military drawing and surveying, etc.	2½
3.	Reconnaissance	4½
4.	Military art, history, and geography	6
5.	Military administration	4
	Military law	2
6.	French, German, or Hindustani	4
7.	Mathematics	3

XXII. In the examination in modern languages great stress will be laid on original composition, and on colloquial knowledge.

XXIII. For qualification the students will be required to obtain .55 on the aggregate allotted to the seven obligatory subjects mentioned in par. xxi., the counting minimum in each subject being .4. For "honors" they must gain .8 on that aggregate of marks. For "special mention" in any subject .9 must be obtained.

XXIV. After the final examination the Director General of Military Education will draw up and submit to the Field Marshal Commanding-in-Chief a list of the passed candidates, arranged in the order of seniority of their regiments, distinguishing those who have gained "honors."

XXV. Officers of all branches of the Service shall be allowed to pass the final examination at the Staff College (subject to the following restrictions), without having gone through the course of instruction at the College. Candidates presenting themselves for the final examination without having gone through the course of instruction must have a previous service of seven years, and similar qualifications in other respects to those exacted (in par. IV.) from candidates for admission to the Staff College.

Previous to the time appointed for the final examination, they must reside at the College for such a period in the months of October and November, as may be necessary to allow of their taking part in the examination in reconnaissance, and of their being tested under the direction of the Commandant in the practical subjects of instruction at the College.

They must also pass the qualifying examination in mathematics prescribed in par. VII. They will also be tested in riding.

XXVI. Officers who have passed their final examination at the Staff College will either—

1. Be attached for three months, during the following summer drill season, to the Staff of a General Officer at some camp where all the three arms of the Service are present. During this period they shall be regularly employed as acting Staff Officers, and shall be required to make themselves acquainted with the organization of the several arms, and with the combined movements of troops. At the end of three months a confidential report shall be forwarded by the General Officer, stating minutely their abilities, the manner in which they have performed their duties, and the department of the Staff for which they appear to be most fit; or—

2. Be attached, during the following summer drill season, to other arms of the Service, for the purpose of acquiring instruction in those duties and field movements which are not common to their own. Certificates of their efficiency therein will be forwarded to the Adjutant General by the officers commanding the corps to which they have been attached.

Officers of cavalry and infantry will attend at Woolwich, or such other station as may be named, for instruction in artillery for a period of two months.

Officers of cavalry will be attached to infantry for two months.

Officers of artillery, horse-artillery excepted, will be attached to cavalry for one month, and officers of engineers and infantry for two months.

Officers of artillery and engineers will not be required to be attached to infantry.

XXVII. Candidates who shall have proved their fitness for employment in the Topographical Department of the War Office, by a superior knowledge of French and German, as well as of topography, will be named in the report of the Director General of Military Education as qualified for employment in that Department.

XXVIII. Officers who fail either at the probationary examination, or at the final examination, whether they have or have not gone through the course of instruction at the College, will not be allowed to present themselves again, either for admission to the College or at the final examination under par. XXV.

XXIX. Officers serving in the United Kingdom who are desirous of entering the Staff College must, before a date which will be made known, inform their Commanding Officers, by whom the certificates from (*a*) to (*e*), par. IV., will be prepared and forwarded through the usual channel to the Adjutant General of the forces. General Officers, in transmitting these applications, will record their opinions as to the fitness or otherwise of the applicants for Staff work, should they be able to do so from their personal knowledge of them.

If these certificates are satisfactory, orders will be issued for carrying out the test prescribed in par. VI. General Officers will report not latter than 20th May upon the candidates then attached to their Staff; after which date the officers, if approved, will receive, from the Director General of Military Education, the rules to be observed at their examination. The examination will take place in London on a date which will be made known by the Civil Service Commissioners.

XXX. General Officers commanding abroad will issue their own local orders specifying the date up to which applications will be received by them from officers wishing to be examined. Care should be taken that sufficient time is allowed for the qualification described in par. VI. to be obtained, so that all the necessry papers and certificates may be received at the Horse Guards on or before the 1st May.

General Officers in forwarding these applications, will carry out the instructions laid down in par. XXIX.

The examination papers will be sent out for those officers only whose applications shall have been thus received.

XXXI. The examination will commence on the 8th June, or as soon after that date as the examination papers shall be received from the Director General of Military Education; but no examination can be allowed to commence after the 30th June.

A Board of Officers will be appointed at the most convenient station of the district, by the General Officer in command, and will consist of three officers; one of them to be, when practicable, a Staff Officer, having the rank of Field Officer, and the other two, if possible, not under the rank of Captain. One of these officers will belong to one of the scientific corps, where any such officer can be obtained.

The questions are to be answered in the presence of the Board.

The Board will give to each candidate a number, which he will affix to each of his examination papers, instead of his name. He will retain the same number throughout the examination.

The Board will give to each candidate a paper of the printed examination questions on each subject, at the time specified for the examination in that subject.

The candidates will write their answers to the questions in the presence of the Board, and their papers, together with the printed examination questions, will be collected at the hour appointed, and made up into a packet, which will be sealed before being taken from the examination room.

The Board will, immediately on the conclusion of the examination, forward the papers of the candidates to the General Officer Commanding, for transmission to the Director General of Military Education, accompanied by a certificate that the candidates obtained no assistance from books, or help of any kind, in their examination. The Board will, at the same time, forward the names of the candidates, corresponding with their index numbers in the examination, in a separate envelope, for transmission to the Director General of Military Education. See *Royal Military Academy.*

STAFF CORPS.—Formerly an organized regiment of officers, many of whom served under the Duke of Wellington on the Staff. After the close of the Peninsular War, the Corps died out. The Staff Corps, as now known under that name, is that in India, which is formed into three Corps, one in each Presidency, and which was raised after the mutiny of 1855-58. The Corps are made up chiefly of officers of cavalry and infantry of the late Indian Army, and vacancies are filled up by young officers from her Majesty's European regiments.

STAFF PAY.—Pay given to officers and soldiers in the Government Service, who perform duties either on the Permanent Staff of an army or in Regimental or Departmental employment. Following is a table of salaries allowed for English Staff Officers and Departments of the several Presidencies in India. (See next page). See *Pay.*

	R	
MILITARY SECRETARIATS.		
Secretary to Government of India, Military Department	3500	Cons'lidated.
" " Madras, Military Department	2500	
" " Bombay, Military Department	2500	
Deputy Secretary to Government of India, Military Department	1000	With Staff Corps pay of rank.
" " " Madras, Military Department	800	
" " " Bombay, Military Department	800	
First Assistant Secretary to Government of India, Military Department	700	
Other Assistant Secretaries, Military Department	500	
ADJUTANT GENERAL'S DEPARTMENT.		
Adjutant General in India	3000	Cons'lidated.
" " Madras	2200	
" " Bombay	2200	
Deputy Adjutant General, Bengal	1000	With Staff Corps pay of rank.
" " " Madras	800	
" " " Bombay	800	
First Assistant Adjutant General at Army Headquarters, Bengal	600	
Assistant Adjutant General at Army Headquarters, Madras	600	
" " " Bombay	600	
" " " Bengal	500	
Deputy Assistant Adjutant General at Army Headquarters, Bengal	500	
Deputy Adjutant General, R.A., in India	800	
Assistant Adjutant General (for musketry)	600	
QUARTERMASTER GENERAL'S DEPARTMENT.		
Quartermaster General, Bengal	2500	Cons'lidated.
" " Madras	2200	
" " Bombay	2200	
Deputy Quartermaster General, Bengal	1000	With Staff Corps pay of rank.
" " Madras	800	
" " Bombay	800	
First Assistant Quartermaster General, Bengal	600	
Assistant Quartermasters General (all Presidencies)	500	
Deputy Assistant Quartermasters General (all Presidencies)	400	
JUDGE ADVOCATE GENERAL'S DEPARTMENT.		
Judge Advocate General	2400	Cons'lidated.
Deputy Judge Advocate General, Bengal	1200	With Staff Corps pay of rank.
" " " Madras	1000	
" " " Bombay	1000	
" " Advocates of Divisions (all Presidencies)	500	
DIVISIONAL STAFF.		Cons'lidated.
General Officers Commanding Divisions	3500	With Staff Corps pay of rank.
Assistant Adjutants General of Divisions	500	
BRIGADE STAFF.		
Brigadier General, 1st class (all Presidencies)	1400	With Staff Corps pay of rank.
" 2d class (all Presidencies)	1200	
Brigade Majors (all Presidencies)	400	
CHIEF AND DISTRICT INSPECTORS OF MUSKETRY.		
Chief Inspector of Musketry, Bengal	600	With Staff Corps pay of rank.
" " Madras	400	
" " Bombay	400	
District Inspectors of Musketry (all Presidencies)	300	With Regimental pay of rank.
ACCOUNT BRANCH, MILITARY DEPARTMENT.		
Accountant General	2250	Cons'lidated.
Deputy Accountant General	1500	
Controller of Military Accounts, Bengal	2500	
" " Madras	2200	
" " Bombay	2200	
First Examiner, Pay Department, Bengal	800	Over.
Second Examiner, Pay Department, Bengal	600	
Examiner, Pay Department, Madras	800	
" " Bombay	800	
" Commissariat Accounts, Bengal	1000	
" " " Madras	900	
" " " Bombay	900	
" Ordnance Accounts (all Presidencies)	500	

	R	
PAY DEPARTMENT.		
Presidency Paymaster, Bengal	800	With Staff Corps pay of rank.
" " Madras	700	
" " Bombay	700	
Paymaster of Circles (all Presidencies)	600	
Superintendent of Family Payments and Pensions, Madras	600	
Deputy Paymasters, Bengal	300	
Pension Paymaster, Bombay	350	
" " Out-stations	250	
Assistants, Pay Department, Bengal, at the Presidency	200	With Regimental or Staff Corps pay of rank.
" " Out-stations	150	
COMMISSARIAT DEPARTMENT.		
Commissary General, Bengal	2500	Cons'lidated.
" " Madras	2200	
" " Bombay	2200	
Deputy Commissaries General, Bengal	1000	With Staff Corps pay of rank.
" " Madras	900	
" " Bombay	900	
Assistant Commissaries General, 1st class (all Presidencies)	800	
" " 2d class (all Presidencies)	600	
Deputy Assistant Commissaries General, 1st class	500	
" " " 2d class	400	
Sub-Assistant Commissaries General, 1st class	300	
" " 2d class	200	
" " 3d class	100	
STUD DEPARTMENT.		
Superintendent of Studs, Bengal	1000	With Staff Corps pay of rank.
Deputy Superintendent of Studs, Bengal	700	
Remount Agent, Madras	700	
Assistants, 1st class Studs, Bengal	400	
" 2d class Studs, Bengal	300	
Sub-Assistants, 2d class Studs, Bengal	200	
Doing Duty Officers	100	With pay and allowances of rank.
CLOTHING DEPARTMENT.		
Superintendent and Agent for Army Clothing, Bengal	1000	With Staff Corps pay of rank.
" " " Madras	700	
" " " Bombay	700	
PERSONAL STAFF.		
Military Secretary and Aide-de-Camp to the Governor General	1500	Cons'lidated.
" " to the Governor, Madras	1000	
" " " Bombay	1000	
Military Secretary to the Commander-in-Chief in India	1500	
" " Madras	1000	
" " Bombay	1000	
Aides-de-Camp to the Governor General, each	300	With Staff Corps pay of rank.
" to the Governor, Madras	300	
" " Bombay	300	
Aides-de-Camp to the Commander-in-Chief in India, each	250	
" " Madras, each	250	
" " Bombay, each	250	
Interpreter to the Commander-in-Chief in India	450	
" " Madras and Bombay	350	
Private Secretary and Aide-de-Camp to a Lieutenant Governor	350	
Aide-de-Camp to Lieutenant Governor	250	
" to General Officers Commanding Divisions	250	
MISCELLANEOUS.		
Military Secretary to Government, Punjab	700	With Staff Corps pay of rank.
Staff Officer, Punjab Frontier Force	500	
Military Storekeeper, Bengal	400	
Secretary and Examiner in Hindustani in Madras	400	
Commandant Convalescent Depots, 1st class	200	With Regimental or Staff Corps pay of rank.
" " " 2d class	100	
Station Staff Officers, 1st class (including all office charges)	150	With Staff Corps pay & allowances of rank.
" " " 2d class (including all office charges)	100	
" " " 3d class (including all office charges)	50	
" " " at very small Stations	25	

NATIVE CAVALRY REGIMENTS, ALL PRESIDENCIES.	R	
Commandant	700	With Staff Corps pay of rank.
Second in Command and Squadron Officer	300	
Second Squadron Officer	210	
Third " "	180	
Adjutant	250	
First Squadron Subaltern	150	
Second " "	150	
NATIVE INFANTRY REGIMENTS, ALL PRESIDENCIES.		
Commandant	600	With Staff Corps pay of rank.
Second in Command and Wing Officer	270	
Wing Officer	230	
Adjutant	200	
Quartermaster	150	
First Wing Subaltern	100	
Second " "	100	

STAFF SERGEANTS.—Non-commissioned Officers employed on the Staff of a Regiment, District, or Division. The following are classed under the above head, in the English Army:—

The Master Gunner, Sergeant Major, Schoolmaster, Bandmaster, Quartermaster Sergeant, Sergeant Instructor of Musketry, Sergeant Instructor in Fencing and Gymnastics, Sergeant Assistant Instructor of Gunnery, Farrier Major, Drum, Trumpet, Pipe or Bugle Major, Paymaster Sergeant, Orderly-room Sergeant, Armorer Sergeant, Hospital Sergeant, Saddler Sergeant, Collarmaker Major, and Wheeler Major. The above Staff Sergeants are entitled to lodging, fuel, and light allowance, when there is no barrack accommodation.

STAFF SLING.—This form of sling was composed of a shaft about one yard in length, and a leathern sling fixed on to one end. The slinger held it in both hands, and could hurl stones with a great violence. This weapon was subsequently employed to throw grenades.

STAIRS.—Except for temporary purposes, the stairs in fortifications are constructed of stone; each step is a solid block, which is 6 feet long in the clear; its breadth at top or the tread 12 inches, and its height or rise 8 inches. Stairs are usually placed along the counterscarp and gorge-walls of the outworks, forming a communication, for infantry only, between the ditch and the terre-plein of the work to which they lead. They are also used within the enceinte in positions where there is not sufficient room for ramps, or where, for greater security from surprise, it is desirable to present a narrower and more difficult defile to the assailant. In cases where room is wanting and the communication not in habitual use, the width of the stair may be reduced to 4 feet. See *Communications.*

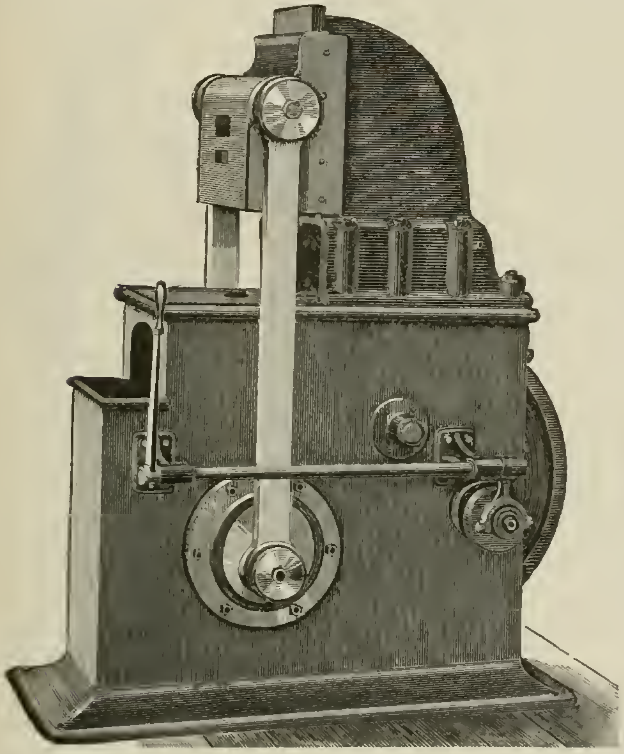
STAKES.—Small pieces of wood, either formed by hand or cut from the small branches of abatis. They are used as an obstacle against the advance of an attacking force, being sharply pointed and driven into the ground until only 1 or 2 feet project. They should be placed either in front of the counterscarp or in the ditch.

STAMPEDE.—Terror and confusion among flying troops, horses, etc. It is a favorite trick of Indians to stampede the stock upon their first arrival in camp, when the attention of every one is preoccupied and more or less confusion reigns. They seldom attempt a stampede at night, preferring the daylight for such work, and invariably select the early dawn of day or some moment when the command is in a probable state of confusion. A stampede is one of the most dreaded disasters that can happen. Frequently, the animals are not only widely scattered, but irretrievably lost; and much damage follows the rush of the infuriated herd through the camp, frequently trampling the men and tents, and killing themselves by coming in contact with trees and projecting rocks. When attempting a stampede, a few Indians will sometimes steal into camp, go to the bell-mare, remove the bell, place it on one one of their fleetest animals, and ride out of camp (before noticed) being followed by the entire herd. Again, they sneakingly approach as near the herd as possible, and dash into it, with their horses at full speed, at the same time terrifying them by the most hideous yells, and succeed in driving off the stock before any effectual resistance can be made. It is often effected by starting an Indian pony into the herd or the camp, with a buffalo robe dangling at his heels. The alarm is soon communicated to all the animals. When the herd is once started, it is pushed forward as rapidly as possible for a few days, so as to make distance between it and the pursuing party, while many Indians pass to the rear to offer resistance to the pursuers, if close at hand. Horses, and especially mules, that have been once stampeded, cannot be trusted beyond the control of the herders. They will, at very unreasonable moments, stampede in the most frantic manner without any apparent good reason. Even the passage of a deer, wolf, strange horse or herder among them will cause them to take alarm and scatter all over the country. The herders cannot be too diligent; they should at all times be ready for every emergency, and whenever the animals take fright they should hasten with the bell-mare in advance of them and gradually turn them in the direction of camp.

STAMPING-MACHINE.—There are many different types of stamping-machines for the great variety of work encountered in the Armory. For the ordinary and lighter work, a stamping-machine is employed, of which the essential portions are a *die*, a *reverse* or counter-die, and a *hammer*. A toothed rack, with arrangement for catching the hammer after it rebounds, is only used for special purposes. The die, which is made of cast-iron or steel, is fixed to the bottom of the stamp, and the reverse is attached to the hammer, which works between two guides. Pieces of thin rolled brass are cut to size, and one placed upon the die; the hammer, with the counter-die, is now raised to sufficient height by a windlass and rope, or other means, and allowed to fall, and thus force the thin plate into the die. The plates from the first blow are then annealed. Repeated blows and annealings follow until the article is "brought up," slight alterations in the reverse being from time to time required. Sometimes as many as 30 blows are necessary, but 10 or 12 strokes will suffice for an object with a considerable depth of raising. Globular articles are stamped in two or more pieces, and then soldered together.

The drawing represents the Pratt & Whitney double connection power-press, which is very extensively used in the manufacture of the parts of small-arms, etc. It is intended for heavy punching and for cold-drawing pieces which are difficult or costly to finish by milling or filing. It is capable of a resistance of 400,000 pounds. The driving-wheel, 36 inches diameter, carries a belt 4½ inches wide. On its shaft is a pinion engaging with a large gear-wheel on an intermediate shaft. A pinion on this shaft gears with another wheel on a shaft that carries the eccentrics which produce the stroke. The machine may be stopped or started instantly at any point of its stroke by means of the Pratt friction-clutch. The opening in the bed for the reception of dies is 9 inches square. The machine is built with a stroke of from 1 to 6 inches, as may be required. The weight of the machine, including countershaft, with 30 by 5½ inch pulleys, is 6,000 pounds.

The stamping process was first adapted to the production of hollow shapes in sheet-iron by Mr. T. Griffiths in 1841; and since then, the manufacture of a great variety of shapes has been improved and extended to a surprising extent. In the case of a dish-cover, for example, a single sheet of iron is brought to the required shape by the repeated stampings and



burnishings upon a chuck. It is afterward tinned with great ease, there being no joints to interfere with the operation; and for the same reason, iron basins stamped out of the single sheet can be readily enameled. The old way of forming these articles by hand-labor was very tedious and clumsy. German silver is too brittle a metal to be stamped like brass or iron, consequently it has only hitherto been made into small objects, such as spoons and forks, by this process. But the Messrs. Elkington, of Birmingham, are now making articles of considerable size in this material, by means of a stamping-press worked by hydraulic power. A number of the graduated dies are used for one object, each pair coming very gradually nearer the desired shape, but none of them making an impression deep enough to strain the metal. See *Die-sinking*.

STANCHION-GUN.—A small cannon, mounted on a pivot; also, a boat-gun, mounted on the gun-wall.

STAND.—This word, primarily signifying the act of opposing, is employed in various military phrases. *To stand one's ground*, is to keep the ground or station one has taken. *To stand fire*, is to receive the fire of arms from an enemy without giving way. *To make a stand*, is to halt for the purpose of offering resistance to a pursuing enemy. *To stand at ease*, is to enjoy, when in the ranks, a certain indulgence with regard to bodily position, with or without arms. *To stand fast*, is the term used as a caution to some particular part of a line or column, to remain quiescent while the rest are moving. *To stand to the guns*, is to prepare for action by taking station at the guns. *To stand to arms*, is a cautionary command, when soldiers are put upon the alert.

STANDARD.—In its widest sense, a standard is a flag or ensign under which men are united together for some common purpose. The use of the standard as a rallying-point in battle takes us back to remote ages. The Jewish Army was marshaled with the aid of standards belonging to the four tribes of Judah, Reuben, Ephraim, and Dan, and the Egyptians had ensigns with representations of their favorite animals. The flag of Persia was white, and, according to Xenophon, bore in his time a golden eagle with expanded wings; it was fixed on a chariot, and thus conveyed to the field of battle. Æschylus, in enumerating six chiefs who, headed by Polynices, set themselves in battle array against Thebes, describes the device on the standard of each. In the earliest era of Roman history a bundle of hay or fern is said to have been used as a military standard, which was succeeded by bronze or silver figures of animals attached to a staff, of which Pliny enumerates five—the eagle, the wolf, the minotaur, the horse, and the boar. In the second Consulship of Marius, 104 B. C., the other animals were laid aside, and only the eagle retained; and down to the time of the later Emperors, the eagle, often with a representation of the Emperor's head beneath it, continued to be carried with the legion. On the top of the staff was often a figure of Victory or Mars. Each cohort had also an ensign of its own, consisting of a serpent or dragon woven on a square piece of cloth, and elevated on a gilt staff with a cross-bar. Under the Christian Emperors, the *labarum* was substituted for the imperial standard. Various standards of great celebrity occur in mediæval history, among which may be enumerated the Flag of the Prophet; the standard taken from the Danes by Alfred of England; and the Oriflamme, originally belonging to the Abbey of St. Denis, and borne by the Counts of Vexin, which eventually became the standard of the French Kingdom.

In strict language, the term standard is applied exclusively to a particular kind of flag, long in proportion to its depth, tapering toward the fly, and except when belonging to Princes of the Blood Royal, slit at the end. Each Baron, Knight or other Commander in feudal times, had a recognized standard, which was distributed among his followers. The length of the standard varied according to the rank of the bearer. A King's standard was from 8 to 9 yards in length; a Duke's, 7 yards; a Marquis's, 6½ yards; an Earl's, 6 yards; a Viscount's, 5½ yards; a Baron's, 5 yards; a Banneret's, 4½ yards; and a Knight's, 4 yards. There was never a complete coat-of-arms on the standard; it generally exhibited the crest or supporter with a device or a badge of the owner, and every English standard of the Tudor era had the cross of St. George placed at the head. Standards were registered by the Heralds, and the charges on them selected and authorized by an Officer of Arms.

The so-called Royal Standard of Great Britain is more properly a banner being a square flag with the national arms covering the entire field without any external accessories. The so-called cavalry standards in use in the British Army are also in strictness banners. They are small in size: their color is determined by the color of the regimental facings, and they are charged with the cipher, number, insignia and honors of the regiment. The banners of the Household Troops are, however, all crimson and richly embroidered with the Royal ensignia of England. Corresponding to the standards of the cavalry are the colors of the infantry regiments, of which each has "a pair," one, called the Queen's Color being the Union Jack, charged with some ornamental device; the other, the Regimental Color, with the cipher, number, device, motto, and honors of the corps, cantoned with a small Union Jack. When a regiment obtains new colors, they are usually given by the wife of the Colonel or some lady of distinction.

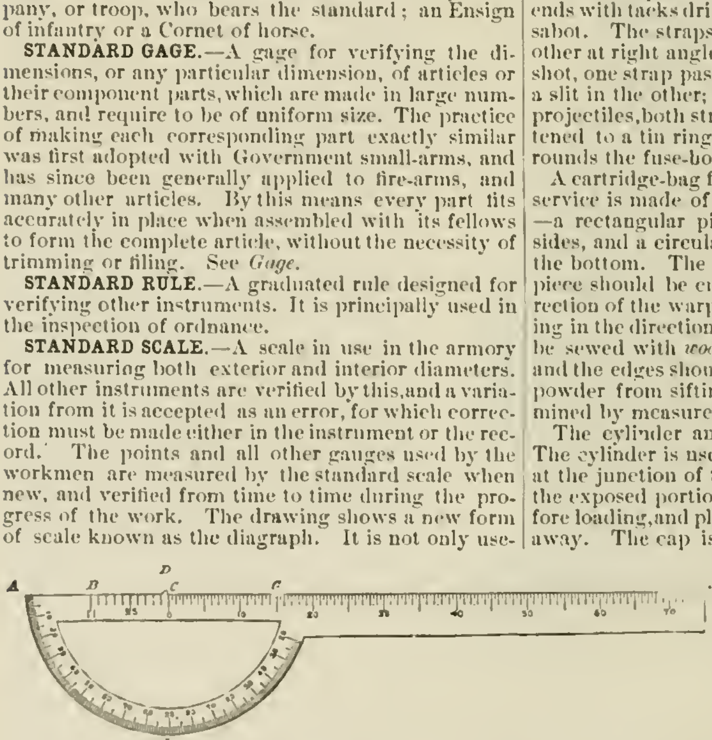
In the United States, each mounted regiment has a silken standard, and each company a silken guidon. The standard bears the Arms of the United States, embroidered in silk, on a blue ground, with the number and name of the regiment in a scroll underneath the eagle. The flag of the standard is two feet five inches wide, and two feet three inches on the lance, and is edged with yellow silk fringe. See *Banner*, *Colors*, *Flags*, *Guidon*, and *Labarum*.

STANDARD-BEARER.—An officer of an army, company, or troop, who bears the standard; an Ensign of infantry or a Cornet of horse.

STANDARD GAGE.—A gage for verifying the dimensions, or any particular dimension, of articles or their component parts, which are made in large numbers, and require to be of uniform size. The practice of making each corresponding part exactly similar was first adopted with Government small-arms, and has since been generally applied to fire-arms, and many other articles. By this means every part fits accurately in place when assembled with its fellows to form the complete article, without the necessity of trimming or filing. See *Gage*.

STANDARD RULE.—A graduated rule designed for verifying other instruments. It is principally used in the inspection of ordnance.

STANDARD SCALE.—A scale in use in the armory for measuring both exterior and interior diameters. All other instruments are verified by this, and a variation from it is accepted as an error, for which correction must be made either in the instrument or the record. The points and all other gauges used by the workmen are measured by the standard scale when new, and verified from time to time during the progress of the work. The drawing shows a new form of scale known as the diagraph. It is not only use-



ful in the verification of measures, but is very handy in drawing patterns and diagrams with great rapidity. With the addition of compasses for circles, it will be found an improvement upon an entire box of ordinary instruments, doing the same work with greater accuracy and facility. See *Corrective Gauges*, and *Inspection of Ordnance*.

STANDING ARMY.—An army which is kept up by a country, and is liable to every species of duty, without any limitations being fixed for its service.

STANDING ORDERS.—Certain general rules and instructions, which are to be invariably followed, and are not subject to the temporary intervention of rank. Of this description are those orders which the permanent Commander may judge fit to have inserted in the order books, and which are not to be altered by the temporary Commander.

STANDING SAP.—A method of sapping less irksome but not quite so rapid as the ordinary method of advancing. The squad consists of three men. No. 1 leaves a turn of 18 inches, and digs a trench 18 inches wide and 3 feet deep. No 2 widens this trench 18 inches and No. 3 widens No. 2's work 18 inches.

STAND OF AMMUNITION.—A stand of ammunition is composed of the projectile, the sabot, the straps, and the cartridge-bag. The projectiles used in howitzers are shell, shrapnel, and canister.

The sabot is a thick, circular disk of wood, to which the cartridge-bag and projectile are attached. For a spherical projectile, the sabot has a spherical cavity and a circular groove to which the cartridge-bag is tied; in the canister-sabot, the spherical cavity is omitted, and a circular offset is added. The effects of a sabot are:—1st. To prevent the formation of a *lodgement* in the bore. 2d. To moderate the action of the powder on the projectile. 3d. To prevent the projectile from moving from its place. In consequence of the scattering of the fragments, it is dangerous to use the sabot in firing over the heads of one's own men.

The projectile is secured by two tin straps, fastened at the ends with tacks driven into the sabot. The straps cross each other at right angles; for solid shot, one strap passes through a slit in the other; for hollow projectiles, both straps are fastened to a tin ring which surrounds the fuse-hole.

A cartridge-bag for the field-service is made of two pieces —a rectangular piece for the sides, and a circular piece for the bottom. The rectangular piece should be cut in the direction of the warp, to prevent the bag from stretching in the direction of its diameter; the seams should be sewed with *woolen* yarn, 12 stitches to the inch, and the edges should be basted down, to prevent the powder from sifting through. The charge is determined by measurement.

The cylinder and cap are made of a stout paper. The cylinder is used to give stiffness to the cartridge at the junction of the sabot and bag; the cap covers the exposed portion of the bag, and is drawn off before loading, and placed over the projectile, or thrown away. The cap is made by cutting off a portion of the cylinder, and choking one end. The cartridge-bag is attached to the projectile by tying it around the grooves of the sabot with twine.

As soon as the ammunition is finished it should be ganged to see that it is of the proper caliber; it is afterwards packed in well seasoned pine boxes, so disposed that the sabot may rest on a ledge in the box, leaving the charge below free from any pressure. The shell, shrapnel, and canister for the 12 pdr. howitzers are packed in boxes containing nine each. A fuse-cutter (for the Bormann fuse) is placed in the rim of each box containing loaded projectiles. The boxes are painted black and marked with the contents. The lids are fitted with hinges and secured with screws. A key is becketed to each box for unscrewing the lid. In consequence of the objection to packing powder in wood, thereby rendering it more liable to deterioration, various plans have been suggested for fitting the cartridge to be attached to the sabot at will, and stowing them separately; and it has been ordered that this be done. See *Ammunition*, and *Field and Mountain Ammunition*.

STAND OF ARMS.—A complete set for one soldier, whether horse or foot: as a rifle and bayonet, cartridge-box and belt, etc. Frequently the rifle and bayonet alone.

STAND OF COLORS.—The common expression for a single color, or flag.

STAND TO HORSE.—A position assumed by troopers preparatory to mounting. The horses being equipped with blankets and watering-bridles, the Instructor commands: STAND TO HORSE. At this command, each soldier stands face to front, on the near side of the horse, his breast on a line with the lower jaw, takes the position of the soldier dismounted, except that his right hand, nails down, grasps both reins, six inches from the bit.

STANG-BALL.—A projectile made up of two half-balls united by a bar. See *Bar-shot.*

STAR.—1. The star is of frequent occurrence as a heraldic bearing; it sometimes represents the heavenly body so called, and sometimes the rowel of a spur. In the latter instance, it is blazoned a *mullet.* Stars of more than five points should have the num-

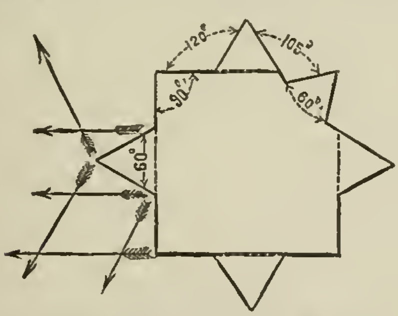
Stars.

ber of points designated, and the points may be wavy. A star, or *estoile*, with wavy points, is often designated a blazing star: and when the points are more than six in number, it is usual to represent only every second point as waved.

The star is a well-known ensign of knightly rank. A star of some specified form constitutes part of the insignia of every order of knighthood.

2. The Order of the Star was an order of knighthood formerly existing in France, founded by John II. in 1350 in imitation of the then recently instituted Order of the Garter in England. The ceremony of installation was originally performed on the festival of the Epiphany and the name of the Order is supposed to have been allusive to the Star of the Magi.

STAR FORTS.—Star forts in plan consist of a polygon having alternately salient and re-entering angles. The object of this disposition is to obtain cross-fires on the approaches upon the salients, and to remove the dead space in the portions of the ditch at the salients. This can only be effected in star forts having at least eight salients. In all other cases, when the salients are limited to 60°, the re-entering angles become too obtuse to admit any but a very oblique fire from the faces in the direction of the salients. The star fort is sometimes planned by placing redans on the middle of the faces of a square redoubt, as shown in the drawing, thus presenting alternate salients of 90° and 60°. In some special cases the salients of 90° are reduced to 60° by prolonging



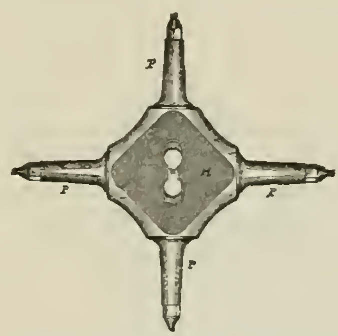
Plan of Star Fort for a polygon of eight sides.

inwards the faces of the redans. When the site is horizontal there is no good reason for making the work irregular in its parts. The star fort, from its imperfect flanking dispositions, is but little if at all superior in strength to the redoubt. For the same interior space for the uses of the garrison, the star fort presents a much longer line of parapet than the redoubt, to be defended. It is therefore only on irregular sites, or broken ground, that an application will be found for it. Since the introduction of modern improved arms, but little regard has been given to flanking arrangements in field-works, experience having developed the fact that they are of very little practical advantage. Lines and groups of works are now laid out so as to cover each other by flank and cross-fire. A work entirely detached, should, however, have within itself proper flanking arrangements. See *Field-works* and *Inclosed Works.*

STAR-GAUGE.—An instrument for measuring the diameter of the bore of a gun at any part. The head is made of brass, with four steel sockets for the measuring points, used in gauging smooth-bore guns or tubes, two of the sockets being soldered fast into the head and the other two movable. The two stationary points act simply as guides, and are held horizontally in the bore, while the movable or the measuring points are held and act vertically.

A wedge or tapering plate, *W*, the sides of which are cylindrical, runs through a slit in the head; an aperture in the inner end of the movable sockets, *AA*, embraces the cylinders, so that when the wedge is moved forward or backward, the sockets are projected or withdrawn.

The tapering of the wedge has a certain known proportion to its length, so that if it is moved in either direction a given distance, a proportional movement is imparted to the sockets. The sides of the wedge incline 0.35 inch in a length of 2.2 inches, so that by pushing it the thirty-fifth part of this distance (about 0.06 inch), the distance between the two sockets is increased .01 inch. There are four steel measuring-points, *P*, for each caliber, fitted with very strong shoulders at one end, below which threads are cut



for screwing into the sockets in the head. A wrench is made to fit the shoulders, so as to turn the points firmly into their places; when two of these are screwed into the fixed sockets, the distance between their extremities is equal to the true diameter of the bore.

In front of this set are three movable sockets, used when gauging rifled guns. These are capable of a lateral motion to enable them to be adjusted for use with guns of any size or of any number of grooves. The staff, to which the head is permanently attached, is a hollow brass tube, made in three or more sections, and graduated for its entire length into inches and quarters, beginning at the measuring-points (smooth-bore), so as to indicate the distance of the latter from the muzzle of the gun. Through the staff passes a square steel rod, divided into the same number of sections as the staff, and which are arranged with threads, so as to be screwed together.

The handle is a brass tube, and is secured on to the rear of the square rod. It has a sliding motion along the end of the staff to which it is fitted. Toward the front part is a slit, on the side of which is marked a scale to indicate the movements of the measuring-points. Each joint of the staff carries a mark made on a small silver plate, which shows through the slit the zero point upon the scale, when the measuring-points are adjusted to the true diameter of the bore. For purposes of adjustment the rear half of the handle can be moved by screwing backward or forward along the front half, and it can be secured, when desired, by a clamp-screw.

A ring-gauge—being a simple steel ring of sufficient thickness to insure stiffness—is used for each caliber in connection with and for adjusting the gauge. Each ring-gauge is accompanied by a set of measuring-points, which are screwed into the sockets by an ordinary wrench. A rest in the form of a T is placed in the mouth of the gun to support the instrument in the axis of the bore. The upright branch is movable for convenience in packing, and each carries a slide which can be adjusted for different sizes of bore. To facilitate the adjustment of the rest, the positions of the slides on the different branches are permanently marked for different calibers of guns.

To adjust the instrument, the ring-gauge of the required diameter is so held as to surround the corresponding points which have been fitted to the sockets. The points are then pushed out by the handle till in contact with the ring; and if the zero points do not coincide, the clamp-screw is loosened and the rear part of the handle is screwed backwards or forwards till the coincidence is effected. The clamp-screw is then tightened and the instrument is ready for use.

Before and after every set of measurements the adjustment of the instrument must be similarly verified. Where more than two lengths are used, the staff must be supported when taking measurements near the muzzle of the gun. In rifled pieces the measurements should be made at intervals of $\frac{1}{4}$ of an inch from the bottom of the cylindrical part of the bore to the front of the seat of the shot, and at intervals of 1 inch from that point to the muzzle. The measurements are at first taken from land to land, and afterward from groove to groove. See *Inspection of Ordnance*.

STAR OF INDIA.—The Order of the Star of India is an order of knighthood instituted by Queen Victoria in June, 1861, with the view of affording the Princes, Chiefs, and people of the Indian Empire a testimony of her Majesty's regard, commemorating her Majesty's resolution to take on herself the government of India, and rendering honor to merit and loyalty. The Order consists of the Sovereign, a Grand-master, who is to be the Governor General of India for the time being, and 25 knights, together with such extra and honorary knights as the Crown may appoint. The members of the Order are to be military, naval, and civil officers who have rendered important service to the Indian Empire, and such native Chiefs and Princes of India as have entitled themselves to her Majesty's favor. The insignia consist of a collar, badge, and star. The *collar* of the Order is composed of the heraldic rose of England, two palm branches in saltire tied with a ribbon, and a lotus-flower alternating with each other, all of gold enameled, and connected by a double golden chain. From an imperial crown, intervening between two lotus-leaves, depends the *badge*, consisting of a brilliant star of five points, and hanging from it an oval medallion, with an onyx cameo profile bust of Queen Victoria, encircled by the motto: "Heaven's light our guide" in gold letters, on an enriched border of light-blue enamel. The *investment badge* is similar to the collar-badge, but with the star, the setting of the cameo, and the motto all of diamonds; it is worn pendent from a ribbon of pale blue with white borders. The *star* of the Order is a five pointed star or mullet of diamonds on an irradiated field of gold. Around it, on an azure fillet bordered with gold, is the same motto in diamonds, the whole encircled by wavy rays of gold.

Star of India.

STARS.—Decorations for rockets. There are several varieties :—*White stars* consist of 16 parts of niter; 8 parts of sulphur; and 4 parts of mealed powder. *Blue stars* usually consists of 69 parts of potassium chlorate ; 24 parts of sulphur ; and 7 parts of copper sulphate. *Red stars* consist of 32 parts of strontium nitrate ; 9 parts of good sulphur ; 8 parts of potassium chlorate; and 2 parts of lamp-black. *Green stars* consist of 18 parts of barium nitrate ; 6 parts of sulphur; 4 parts of potassium chlorate ; and 1 part of lamp-black. *Purple stars* consist of 24 parts of potassium chlorate ; 4 parts of sulphur ; and 3 parts of copper sulphate. *Yellow stars* consist of 1 part of charcoal ; 1 part of sulphur ; and 6 parts of sodium nitrate. *Five-pointed stars* consist of 7 parts of sulphur, and 10 parts of mealed powder.

To prepare the composition, reduce the materials to the finest powder; mix them with the hands; pass them three times through the sieve, mixing them each time with the hand. Moisten the composition with whisky in which gum has been dissolved, so that the composition shall retain its form when pressed in the hand. Fill the mold by pressing it in the composition spread out in a wooden bowl : push out the star with the piston, letting it fall lightly on a sheet of paper dusted over with mealed powder. *Colored stars* are made in the same manner as white ones, using the compositions indicated in the table. See *Compositions*, *Fireworks*, and *Signal-rocket*.

STAR-SHELL.—A thin iron shell used with light muzzle-loading guns, filled with stars, and intended to light up an enemy's position at night. It contains six stars of magnesium-light composition, burning about 13 or 14 seconds, and seven stars of signal-light composition, burning about 34 or 36 seconds. It is complete in itself, having the burster ($\frac{1}{2}$ drachm of powder) with quick-match priming arranged in the interior, and only requires the time-fuse to be prepared and fixed when required for action. By adopting a code where certain words are represented by different colors, a complete system of communication might be kept up between two bodies of troops at a considerable distance from each other.

STATANT.—In Heraldry, a term applied to an animal standing still, with all the feet touching on the ground. If the face be turned to the spectator, it is said to be *statant gardant*, or in the case of a stag, *at gaze*.

STATE.—In the British Service, a statement of the number of officers and men of any body of troops, distinguishing those present, those employed, absent, or sick, and the different ranks under separate headings.

STATICS.—The science of the equilibrium or balancing of forces on a body or system of bodies, has gradually advanced from the days of Archimedes to the grand developments it has now acquired. Singularly enough, though most of its simpler theorems are very generally known, are almost popular, in fact, there is no science in which elementary teaching is so defective. The ordinary proofs of its fundamental principles, such as the *parallelogram of forces*, the *principle of the lever*, etc., are usually founded on the supposition that a body in equilibrium is *absolutely at rest*. Now, any one who knows that the earth rotates about its axis, that it revolves about the sun, that the sun is in motion relatively to the so-called fixed stars; that *they* are, in all probability, in motion about something else which is itself in motion, etc., will at once see that there is no such thing as absolute rest, and that *relative rest* or motion, unchanged with reference to surrounding bodies, is all that we mean by equilibrium. He will then, at once, see that the foundations of all statics are to be sought in the laws of motion. And, in fact, Newton's second law of motion gives us the necessary and sufficient conditions of equilibrium of a single particle under the action of any forces; while his third law, with the annexed scholium, gives these conditions for any body or system of bodies whatever.

The simplest statement of the conditions of equilibrium of a rigid body which can be given, is that furnished by this scholium of Newton's, which is now known by the name of the principle of energy (see FORCE) or work. It is as follows: A rigid body is in equilibrium if, and is not in equilibrium unless, in *any* small displacement whatever, no work is done on the whole by the forces to which it is subject. In the case of what are called the *mechanical powers*, this is equivalent to the statement that work expended on a machine is wholly given back by the machine—or that the work done by the *power* is equal to the work spent in overcoming the *resistance*. It is shown in the geometrical science of kinematics that any motion whatever of a rigid body can be reduced to *three* displacements in any three rectangular directions, together with *three* rotations about any three rectangular axes—so that the equilibrium of a rigid body is secured if no work be done on the whole in any of these *six* displacements. There are thus six conditions of equilibrium for a rigid body under the action of any forces—and these are reduced to *three* (two displacements and one rotation), if the forces are confined to one plane; and to *one* (a displacement) if the forces act all in one line.

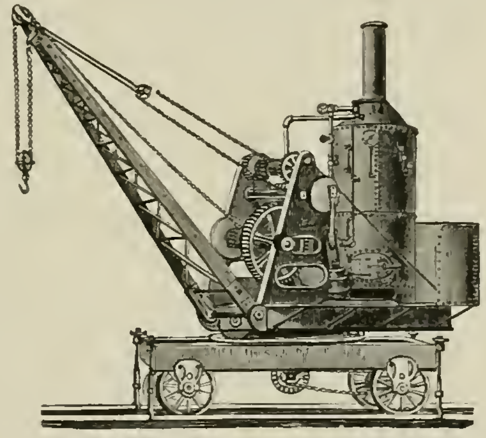
Equilibrium may be *stable*, *unstable*, or *neutral*. It is said to be stable if the body, when slightly displaced in any way from its position of equilibrium, and left free, tends to *return* to that position. It is unstable if there is any displacement possible which will leave the body in a position in which it tends to *fall further away* from its position of equilibrium. It is neutral if the body, when displaced, is still in equilibrium. It is easily shown, but we cannot spare the space for the proof, that a position of stable equilibrium is, in general, that in which the potential energy (see FORCE) of the body is a minimum—of unstable equilibrium, where it is a maximum (for some one direction of displacement at least)—of neutral equilibrium, where the potential energy remains unchanged by any small displacement. Thus a perfect sphere, of uniform material, is in neutral equilibrium on a horizontal plane—while an oblate spheroid, with its axis of rotation vertical, is in stable equilibrium; and a prolate spheroid, with its axis vertical, is in unstable equilibrium on the plane. Similar statements hold for other than rigid bodies. Thus, a chain, or a mass of fluid, is in stable equilibrium when its potential energy is least, *i. e.*, when its center of gravity is as low as possible. This simple statement is sufficient for the mathematical solution of either question.

STATION.—A locality chosen for the garrisoning of troops. The name of *stationes*, or stations, was given by the Romans to the guard which was kept in the day time at the gates of the camp, and at the intrenchments. The *statio agraria* was an advanced post to prevent surprise, insure the safety of prisoners, etc. The chief use was to keep the military *sway* secure from hostile incursions, whence we find them at the concurrence of roads. The term is also extensively applied to the old military stations of the Romans, when encampments of towns existed. The *statira castra* were encampments for a short time; the *aestiva castra* were the same, but might be occupied only for one night. The *hyberna castra*, or winter camps, were elaborately fortified, even with stone walls, houses within, etc., so that many towns grew out of them. See *Post*.

STATUS IN QUO.—A treaty between belligerents, which leaves each party *in statu quo ante bellum*, that is in the state in which it was before the war. Also written *status quo*.

STAYS.—Bars, generally of round or angle-iron, spanning an angle in frame-work, to neutralize the bending moment about the junction of two beams forming the angle. Stays are of frequent necessity in the construction of artillery carriages.

STEAM-CRANE.—The application of steam to the working of cranes was an obvious one, and is now universal where much hoisting-work has to be done; it not only effects a great saving in labor, but causes the work to be much more quickly done, a consideration quite as important. Steam-cranes and winches are now almost invariably used at foundries. When working on a wharf, and in many other situations, it is often very convenient that the crane should be movable, so that it may go to its work in the multitude of cases where that arrangement is more convenient than the converse. For this purpose it is mounted on a plain railway truck, either of wood or iron, the truck being generally provided with clamps at the ends, by which it can be firmly secured to the rails when lifting the weights. The balance construction, now universally adopted for portable cranes, was invented or suggested by the late Mr. R. W. Thomson, C.E. in 1856—its essential feature being the use of the boiler as a counterpoise to the weight to be lifted. The principal parts of a steam-crane are: 1. The boiler, which must be of some very simple construction, as it has so frequently to be worked with excessively dirty water. 2. The framing, which is generally made



of cast-iron, and supports the boiler, the engine and gear, and the jib. 3. The engine (which has almost always two small cylinders, and is fitted with reversing gear), and the pinions, wheels, drums, etc., for the hoisting and other motions. 4. The "jib" (either of wood or iron), over a pulley in the top of which the chain passes, and the purpose of which is to enable the different objects to be lifted quite clear of the ground, and deposited, when necessary, on trucks, etc., 5. The pillar, which is firmly attached to the truck, and which, passing upward through the center of the frame, forms the pivot on which it turns round. 6. The truck itself, which supports the whole machine. If the crane is stationary, the truck, of course, is not required, the bottom of the pillar being imbedded in masonry; and for large cranes the boiler is generally made separate from the machine itself, and sometimes the engines also. A portable balance steam-crane is when complete fitted with the following motions.—1. Gear for hoisting generally with two or more speeds, to be used according to the weight to be lifted; 2. Gear for raising or lowering the outer end of the jib; 3. Gear for slewing the jib (with boiler and frame attached to it); 4. Gear for propelling the truck along the rails. A complete and well-designed crane of this kind, made by Messrs.

Williamson Bros., will lift from 5 to 7 tons, according to the position of the jib. The revolving base has a tank under the boiler, from which the feed-water is supplied by means of an injector. At the sides and the back end of boiler, a sheet-iron frame is fitted for use as a coal-bunker; or, if required, iron or other ballast can be placed in it, to assist in balancing heavy loads. The carriage or truck is constructed of wrought and cast-iron, to which are fitted rail-clamps; and, where the crane is for a narrow gauge, can be fitted with cross-girders to increase base.

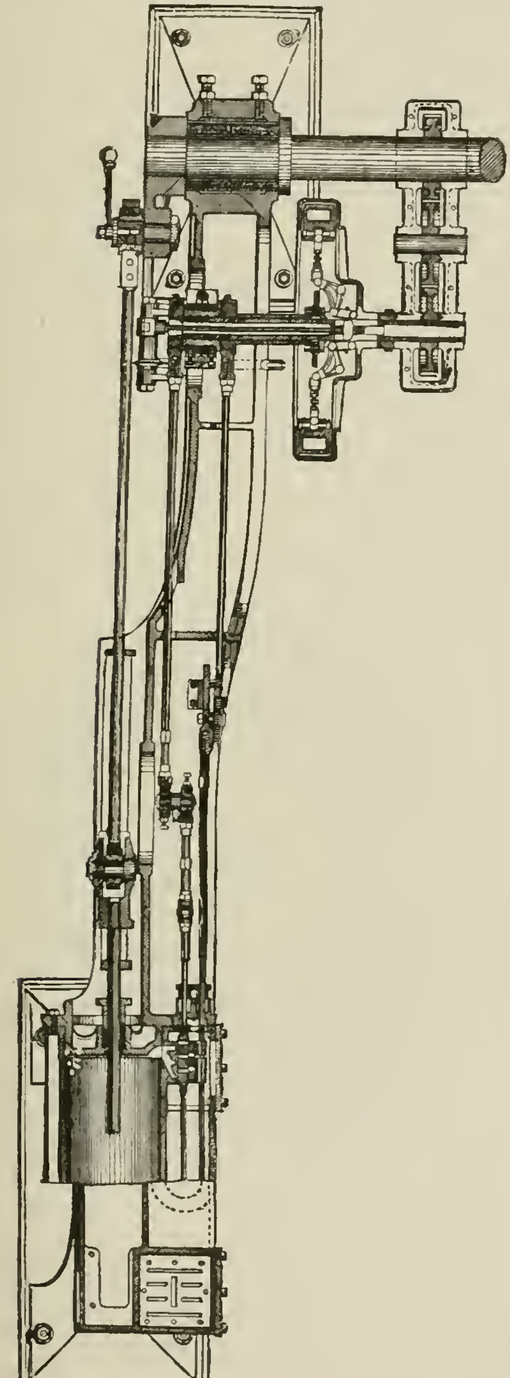
STEAM-ENGINE.—Steam-engines, in their infancy, were known as fire-engines; and in point of fact the older term is the more correct, because the water or steam is only used as a convenient medium through which the form of energy which we call heat is made to perform the required mechanical operations. In modern engines, sufficient heat is added to the steam to raise it to a very high pressure, and the excess of this pressure over the pressure opposed to it (either atmospheric pressure or the still lower pressure in a condenser) is both the cause and measure of the work done by the engine. In earlier machines, however, the steam was raised only to atmospheric pressure, and admitted into the engine only to be at once condensed by a jet of cold water. The excess of the atmospheric pressure above the pressure in the partial vacuum caused by the condensation was then the direct cause of work. Engines of this kind are not now used; they were called atmospheric engines. As a source of power, steam has several advantages over wind and water. It is independent of the weather, may be applied anywhere, affords a constant equable motion, and is capable of indefinite increase. Its invention, therefore, has caused a new era in the arts; and the revolution which it has brought about in industry of all kinds, as well as the influence it has had on civilization in general, and must yet have in a higher degree, are altogether incalculable.

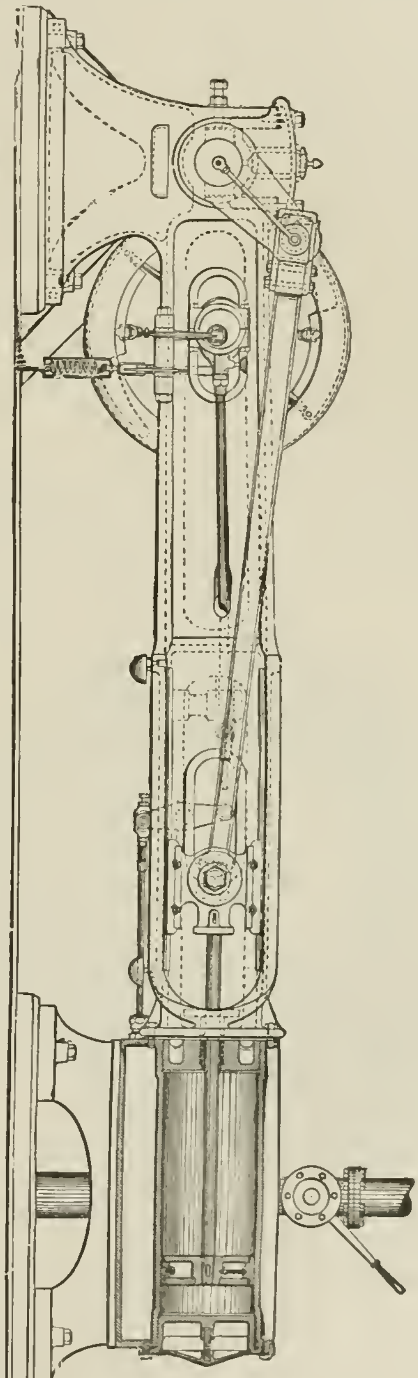
The invention of steam as a propelling power is claimed by various nations: but the first extensive employment of it, and most of the improvements made upon the steam-engine, the world indisputably owes to the English and the Americans. It would appear that as early as 1543 a Spanish Captain, named Blasco de Garay, showed in the harbor of Barcelona a steamboat of his own invention. It is most likely that Blasco's engine was on the principle of the Æolipile of Hero, invented 130 B.C., in which steam produces rotatory motion by issuing from orifices, as water does in Barker's Mill. The preacher Mathesius, in his sermon to miners (Nuremberg, 1562), prays for a man who "raises water by fire and air," showing the early application of steam-power in Germany; and the German engineer, Sol. de Caus, in the service of the Elector Palatine in Heidelberg, describes in his work, *Les Raisons des Forces Mouvantes avec Diverses Machines*, 1615, a steam-machine, which was merely a contrivance for forcing the water contained in a copper ball through a tube by applying heat. An Italian engineer, G. Branca, invented, in 1629, a sort of steam windmill; the steam being generated in a boiler, was directed by a spout against the flat vanes of a wheel, which was thus set in motion.

In England, among the first notices we have of the idea of employing steam as a propelling force, is that contained in a small volume, published in 1647, entitled *The Art of Gunnery*, by Nat. Nye, mathematician; in which he proposes to "charge a piece of ordnance without gunpowder," by putting water instead of powder, ramming down an air-tight plug of wood, and then the shot, and applying a fire to the breech "till it burst out suddenly." But the first successful effort was that of the Marquis of Worcester. In his *Century of Inventions*, the manuscript of which dates from 1655, he describes a steam-apparatus by which he raised a column of water to the height of 40 feet. This, under the name of "Fire-waterwork," appears actually to have been at work at Vauxhall in 1656. Sir Samuel Morland, in 1683, submitted to Louis XIV., a project for raising water by means of steam, accompanying it with ingenious calculations and tables. The first patent for the application of steam-power to various kinds of machines was taken out in 1698 by Captain Savery. In 1699, he exhibited before the Royal Society a working model of his invention. His engines were the first used to any great extent in industrial operations; they seem to have been employed for some years in the drainage of mines in Cornwall and Devonshire. The essential improvement in them over the older ones was the use of a boiler separate from the vessel in which the steam did its work. One vessel, in all former engines, had served both purposes. He made use of the condensation of steam in a close vessel to produce a vacuum, and thus raise the water to a certain height, after which the elasticity of steam pressing upon its surface was made to raise it still further in a second vessel.

In all the attempts at pumping-engines heretofore made, including Savery's, the steam acted directly upon the water to be moved without any intervening part. To Dr. Papin, a celebrated Frenchman, is due the idea of the *piston*. It was first used by him in a model constructed in 1690, where the cylinder was still made to do duty also as a boiler; but in an improved steam-pump invented about 1700 he used it as a diaphragm floating on the top of the water in a separate vessel, or cylinder, and the steam, by pressing on the top of it, forced the water out of the cylinder at the other end. The next great step in advance was made about 1705 in the atmospheric engine, conjointly invented by Newcomen, Cawley, and Savery. This machine held its own for nearly seventy years, and was very largely applied to mines.

The next essential improvements on the steam engine were those of Watt, which began a new era in the history of steam-power. The first and most important improvement made by Watt was the separate condenser, patented in 1769. He had observed that the jet of cold water thrown into the cylinder to condense the steam, necessarily reduced the temperature of the cylinder so much that a great deal of the steam flowing in at each upward stroke of the piston was condensed before the cylinder got back the heat abstracted from it by the spurt of cold water used for condensing the steam in the cylinder. The loss of steam arising from this was so great that only about one-fourth of what was admitted into the cylinder was actually available as motive power. Watt, therefore, provided a separate vessel in which to condense the steam, and which could be kept constantly in a state of vacuum, without the loss which arose when the cylinder itself was used as a condenser. This device, which now looks simple enough, was the greatest of Watt's inventions, and it forms the foundation of his fame. His genius was such that in a few years he changed the steam-engine from a clumsy, wasteful, and almost impracticable machine into a machine practically the same as we now have. The principal improvements since his time have been either in matters relating to the boiler; in details of construction consequent on our increased facilities, improved machinery, and greater knowledge of the strength of materials; in the enlarged application of his principle of expansive working; or in the application of the steam-engine to the propulsion of carriages and vessels. His principal inventions were as follows: 1. The condensation of steam in a vessel separate from the cylinder, so as to avoid the cooling of the latter. 2. The use of a pump, designated an "air-pump," to withdraw the condensed water, and mixed steam and air, from the condenser. 3. To surround the cylinder either with a steam-jacket, or with some non-conducting body, in order to prevent radiation of heat (these three, with others, were included in the specification of 1769). 4. To use the steam expansively in the way explained further on in this article (this was invented before 1769, but not published till 1782); and 5. The now universally used double-acting engine, and the conversion of the reciprocating motion of the beam into a rotary motion by means of a crank (both these were invented before 1778, the engine being patented in 1782, but the crank having before that date been pirated and patented by another. Watt also patented and published his parallel motion, throttle-valve, governor, and indicator; all four of which are still used.





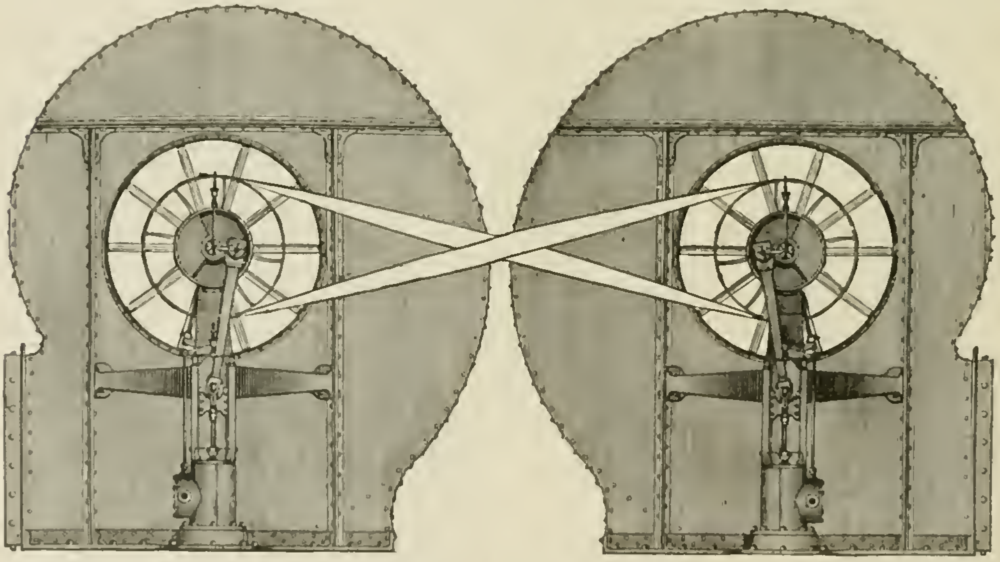
It would be inconsistent with our limits to enter into any description of the constructive details of steam-engines; we can only afford to give a general notion of the way in which the motion is originated, and to explain the chief principles on which the motive-power and economy of engines depend. For the purpose of our illustration we have selected the Cummer Engine—one of the most perfect and satisfactory engines ever designed. The illustration herewith presented shows an elevation and a part of the vertical section of this standard automatic engine, and also a horizontal section which shows the form of the girder and cylinder, and clearly exhibits the various working parts, in their relation to each other. In the elevation there appears a section of the piston and there is shown the form of cross-head, connecting-rod, and crank. The horizontal section further details the cross-head, the sub ends of the connecting-rod, and crank. The main bearing with its quarter-boxes, shoes and means for adjustment is clearly detailed, and there is shown the train of three gears which drives the governor-shaft from the main-shaft; the governor also appears in section showing the weights, the bell crank, and attachments to the shaft-rod. The elevation and plan exhibits the large bell crank, to the vertical arm of which the thrust-rod is attached, while the horizontal arm supports all the hanging weights, and has attached to it the spiral spring which appears in the elevation. Referring once more to the horizontal section, it will be noticed that the main eccentric is attached directly to the governor-shaft, and the cut-off eccentric is attached to a long sleeve, which by suitable connection with the governor-weights, is made to rotate the eccentric forward or backward, and thus change the point of cut-off. The main eccentric operates the main-valves and also the exhaust-valves through the intervention of a rock-arm. The eccentric-rods and valve-stems have means for adjustment of length, these, with the joints at the rock-arm and the slide to prevent vibration of the cut-off valve-stem, as well as the mode for attaching the valves to the valve-stems, are all shown in the horizontal section.

The lower right hand portion of this section, shows that part of the cylinder where the exhaust-valve for this end is situated. The piston rod stuffing-box is bushed with brass. In the vertical section appears a novel form of cylinder-head which projects within the cylinder and reduces the clearance to as low an amount as possible. The forward head is formed by the end of the girder-frame, but in the larger sizes the head is made separate and bolted to the frame. Objections have been made against this deep form of cylinder-head, on the ground that the annular space between the head and counterbore affords so much more condensing surface than the ordinary form of cylinder-head; but, in point of fact, this objection does not hold at all, because the cylinder-heads are made a true fit for one inch or so at the outside bearing and a sliding fit for all the rest of the length. The space between the counterbore and the head, which is about the thickness of a piece of paper, becomes, when in use, completely filled up with a deposit from the oil used to lubricate the cylinder, which is driven in by the steam and effectually prevents any condensation from this cause. The various details alluded to in this general description, will be found more thoroughly illustrated and described under specific headings. See *Cylinder*, *Fly-wheel*, *Governor*, *Indicator*, and *Piston*.

STEAM-FAN.—A fanner driven by steam. These machines have a wide range of application, being employed for blowing furnaces of all kinds provided with grate-bars, such as steam-boilers, steamboat, gunboat, ironclad and steam yacht boilers, iron melting, heating, puddling, and nail furnaces. Coal-screenings and all kinds of refuse coal, tan bark, sawdust, etc., may be successfully used for fuel by the use of blast from these fans. For heating dry houses and rooms for drying lumber of all kinds, and all materials manufactured from wood; leather, glue, grain, fruits, fish, herbs, paints, cotton, wool, knit goods, and all other textile fabrics. For cold storage where the air is drawn over ice for cooling and preserving meats of all kinds, fish, fowls, dairy products, etc. Also, for any and all other purposes where a large volume of hot or cold wind is required.

The larger sizes are particularly adapted for cooling and ventilating mines, casemates, manufacturing establishments, work-shops, chemical-works, powder-mills, tanneries, slaughter-houses, store-houses, warehouses, vaults, offices, hospitals, cell-houses in prisons, public-halls, assembly-chambers, court-rooms, school-houses, cook-rooms, hot fire-rooms on steamers, and all kinds of ships of war, cooling men working near hot furnaces in rolling-mills, steel-mills, etc.

The drawing shows two of Sturtevant's steam-fans coupled so as to economize power and save the unnecessary wear and tear of engines. By reducing the speed 20 per cent. it is possible to run with half the power—one engine running both blowers or fans. When blowers are used for warming and ventilating buildings, it is frequently the case that for very many reasons it is desirable to use two, located not very far apart. Sometimes one of these is used for blasting in, while the other is used for exhausting out, both being of the same size, and the situation such as to require both fans to run at the same time. In most of these cases it is not necessary to run both engines. For example, suppose, by running both engines, both fans could be made to run at 200 revolutions; by uncoupling one engine and driving both fans by the other, the two fans will then make 160 revolutions in place of 200. Then in case only 100 to 120 revolutions are needed, the valve can be adjusted to cut off shorter and not let the engine take so much steam. This saves running both engines in mild weather; in fact, two blowers can be run at half speed with one engine cutting off very short, while it would require both engines cutting off at one-half or two-thirds to



run at full speed. In the case of large blowers, for all very heavy work, say from 8 feet to 25 feet diameter of the fan, it is found to be more satisfactory to build them entirely of wrought-iron, using the best beam and angle-iron for the frame, and plate-iron for the housing. It will be seen that this mode of construction is applicable to any size. These blowers can be built very light or very heavy, for light or heavy work. By light work is meant warming and ventilating buildings. Those used for blowing furnaces in iron-mills, etc., require to be built very heavy and strong. In this class of blowers it is necessary to use thicker plates and heavier beam and angle-iron. See *Blower*, *Fanner*, and *Iron*.

STEAM-GUN.—A gun whose projectile-force is derived from the expansion of steam issuing through a shotted tube. Mr. Henry Bessemer has proposed a steam fire-engine to throw bullets instead of water. He calculates that it will throw $181\frac{3}{4}$ pounds, representing 2540 rifle-bullets per minute, to the distance of one mile, with a consumption of 5 pounds of coal and 3 gallons of water. The calculation for steam at 150 pounds pressure is that it would escape at an initial velocity of 1,900 feet per second, and, acting upon a two-ounce leaden ball. presenting an area of $\frac{1}{8}$ of an inch, would exert a force upon it of 90 pounds. Mr. Bessemer suggests a universal joint tube for delivering a sweeping fire; and a mantlet to shield the gunners.

The idea of employing the expansive force of steam for propelling projectiles is not a new one, but its application has seldom met with success, since penetration has been sought for. Among other contributions to the subject is a paper " On the Numerical Expression of the Destructive Energy in the Explosions of Steam Boilers, and on its Comparison with the Destructive Energy of Gunpowder," by Mr. G. B. Airy. He reaches the conclusion that the destructive energy of one cubic foot of water, at the temperature which produces the pressure of 60 pounds to the square inch, is equal to that of one pound of gunpowder.

In Richardson and Watts' "Chemical Technology," Vol. I., Part IV., page 523, London, 1865, we also find the following:—"High-pressure steam is exceedingly well adapted to the performance of this kind of work; unluckily it would require high pressure steam of 400 atmospheres or 5,000 lbs. pressure on the round inch to perform this duty, and as such steam could only be generated in a furnace intensely heated, it is scarcely probable that boilers will be found sufficiently strong and durable to work continuously under such pressure. If they were found to be practicable, nothing more would be necessary than to bring a steam pipe from the boiler to the breech of every gun in a fortress or a ship, and the admission of the charge of such steam into the chamber by a valve would be sufficient to discharge the missile of the 68-pounder with a speed of 1,600 feet a second." The well-known Mr. Perkins studied this subject carefully, but applied it somewhat differently. He found that steam of this pressure could be generated only by water nearly red-hot; and instead of throwing the steam into the breech by a pipe, he threw the red-hot water into the breech of his gun, allowing it when there to expand itself into steam and expend its force in giving speed to the ball. This expedient of Perkins is well worthy of study. It has both the defects and advantages of a gunpowder-gun. The red-hot water thrown into the barrel would have the fault of being too powerful at the beginning of its expansion and too weak at the end. The barrel would be filled partly with water and partly with steam; and as the water grew into steam it would lower its temperature and its pressure, so that the explosive force would fall off very much towards the end of the stroke. This is the inevitable evil of allowing the water to become vapor in the gun. When the steam is generated in a separate boiler, and freely admitted into the breech of the gun, there is reservoir enough of heat and steam to maintain the even pressure in following up the ball from the breech to muzzle. It is the evil of charges converted into gas within the breech of the gun, that their temperature and pressure are too high at starting and too low at the end. The steam-gun would in this respect be the best of our projectile forces.

Compressed air has many of the advantages and some of the defects of steam; and the frequent use of the air-gun has shown its convenience as well as its efficiency. Air can be compressed into a reservoir by mechanical force, just as steam can be raised in a boiler by heat; and by compressing 400 times the natural quantity of air into a given space, a pressure of 400 atmospheres might possibly be obtained in this way. If an air-pipe communicated from this reservoir to the breech of the gun, air of 400 atmospheres of pressure would certainly be able to follow up the 68-pounder shot, with pressure and velocity able to discharge it with a speed of 1,600 feet per second. and, therefore, to do our work; but the apparatus would be full of mechanical difficulties. Liquid gases are known to be receptacles of enormous mechanical power. Carbonic acid gas, liquefied and shut up in a reservoir, generates large volumes of gas with great rapidity the moment it is permitted to expand. Other gases expand with still greater rapidity and force; and if we could ever conceive liquid gases to be easily made, safely carried, and comfortably handled, a charge of liquid gas bottled up in the breech of a gun would be a very effectual propelling power, and quite able to generate the force we want, and to apply it within the time we require. This system, however, is also beset with mechanical difficulties.

The preceding illustrations of steam, compressed air, and liquid gases lead us on very instructively to the manner in which fire has become necessary to do the work of a gun. A supply of heat is essential to the expansion of a gas, and a rapid supply is indispensable to the rapid performance of the work. In steam, the fire is not only external to the gun but external to the boiler in which the steam is generated. In gunpowder, the fire is introduced into the inside of the gun, for the purpose of supplying the heat that is wanted to raise the gases to their elastic pressure, and to maintain them at that pressure while expanding. Red-hot steam introduced into the breech of the gun rapidly cools down and loses its heat and power in expanding. If we could introduce fire into the breech of the gun at the same time, to maintain the heat of the steam and the water, the steam would become an admirable propelling force. Carbonic acid gas expanding rapidly from the liquid into the gaseous state cools down so suddenly as not only to lose its mechanical power, but to freeze into solid flakes of snow. If we could charge the breech of the gun with fire as well as with liquid gas, the fire would give it the heat it wants, prevent its congelation, and maintain its power to the end of the discharge. What gunpowder and gun-cotton do is really to provide a reservoir of gas and a fire to heat it simultaneously and in the same chamber. In the case of gunpowder the fire is fed with charcoal, in the case of gun-cotton the fire is fed with gun-cotton wool, another form of carbon. In gunpowder, large quantities of carbonic acid gas are generated, possibly in the liquid state, and are heated by the internal furnace of the charge, possibly red-hot. In like manner in a gun-cotton charge, red-hot water or steam is introduced with other gases, possibly also liquids, together with an internal furnace of flame; and thus the work is done—first, by the release of the gases themselves, and, secondly, by the continuance of the elasticity of those gases by the internal supply of heat. This is how gunpowder and gun-cotton really do the work of a steam-gun, a carbonic acid gun, or any other kind of gas-gun.

STEAM-HAMMER.—Properly called a steam-operated hammer. The term is usually, however, restricted to one working vertically by the attachment of its rod to a piston in an upright cylinder above. The steam-hammer has doubtless contributed much more than any other mechanical invention of modern times in developing the wonderful resources of the iron trade, and is still looked upon as a marvel of engineering skill and ability. The cannon-forging steam-hammer at the Springfield Arsenal, that at Woolwich for use in the Royal gun factories, and the wonderful hammer (capable of working a mass of steel of 100 tons) at the works of Krupp, of Essen, are a few of the monster machines employed in the manufacture of the present heavy ordnance. The first idea of a steam-hammer appears to belong to James Watt, the great father of engineers, and was patented by him in 1784. In 1806, William Deverell, "described as an Engineer of Surry," also took out a patent for a steam-hammer; but in neither case does it appear that steam-hammers were actually constructed. From this time till 1837, the idea seems to have been entirely lost sight of, when it was again taken up by Mr. James Nasmyth, of the Bridgewater Foundry, Patricroft, near Manchester, as the result of an application made to him by Mr. Francis Humphreys, engineer to the Great Western Steamship Company, who had been unable to induce any forge-master to undertake the forgings required for the paddle-shafts of the *Great Britain* steamship, then in course of construction. Mr. Nasmyth sent a sketch of his hammer plan to Mr. Humphreys, who, along with Mr. Brunel and others, heartily approved of the scheme, but in consequence of an alteration being made in the propelling arrangement of the great ship, the paddle-shaft was not required, and the hammer was not then constructed. The scheme was offered to many of the large forge-masters and engineers; but while all seemed to admire the idea they failed to appreciate its value and the hammer remained a mere sketch in Mr. Nasmyth's "Scheme-book" till 1842, when, in December of that year, Mr. Nasmyth secured a patent for his invention, and the first steam-hammer was made in accordance with his plan at the Bridgewater foundry early in 1843, but although considered by some as an improvement upon the old "helves" hitherto used for forging purposes, it was very far from being a perfect or even a marketable tool. The hammer was worked by means of an ordinary slide-valve and a long lever, requiring great labor and constant attention in order to give the blow required; so that some contrivance was necessary, capable of an adjustment, in order to have complete command over the power of the blow, and that, the instant the blow was struck, the block should rise again, so that not only no loss of time should ensue, but that the heat in the mass of iron on the anvil might not be reduced or carried off by the cold face of the block. The peculiar difficulty of securing a true automatic arrangement will be seen when it is considered that the instant of percussion must vary with almost every blow that is struck; for the piece on the anvil becomes thinner and thinner by each succeeding blow, and in flat bars a blow is first given on the flat side and then on the edge, the difference in the fall of the hammer in the two cases being oftentimes several inches; and further, that the hammer must be under perfect control at all times.

Mr. Nasmyth, after very many and protracted trials, failed to produce the motion required, and, as a consequence, the whole hammer scheme was on the point of being abandoned. In this dilemma, and during Mr. Nasmyth's absence from the works, his partner, Mr. Gaskell, applied to their engineering manager, Mr. Robert Wilson, who afterward became managing partner and successor to Mr. Nasmyth, to endeavor to solve the problem which had hitherto baffled the skill of Mr. Nasmyth. Mr. Wilson took the matter in hand, and in little more than a week, a motion was invented and attached to a hammer upon which former experiments had been made, and was at once found to answer most admirably every condition required. Under the influence of this very beautiful mechanical motion every variety of blow could be given, from the gentlest tap up to the heaviest blow within the compass of the hammer, and that, too, perfectly self-acting in every respect, the long lever and the hard work before referred to being now entirely banished. By simply altering the position of the tappet-lever by means of two screws, a blow of the exact force required could be produced and continued so long as steam was supplied. So completely was the hammer now under control, that it became a favorite amusement to place a wine-glass containing an egg upon the anvil, and let the block descend upon it with its quick motion; and so nice was its adjustment, and so delicate its mechanism, that the great block, weighing perhaps several tons, could be heard playing "tap, tap" upon the egg without cracking the shell, when at a signal to the man in charge, down would come the great mass, and the egg and glass would be apparently, as Walter Savage Landor has it, "blasted into space." On Aug. 18, 1843, the first hammer was delivered to Messrs. Hird, Dawson, and Hardy, of the Low Moor Iron Works, near Bradford, Yorkshire, and gave such satisfaction, that orders for

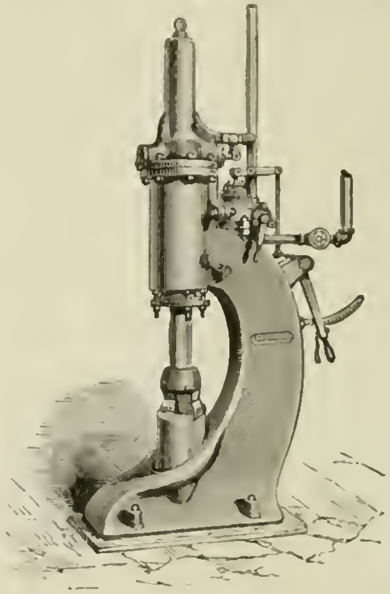


Fig. 1.

this remarkable tool began to flow in from all parts of the country. The hammer remained in this condition, with the exception of a few minor details, from 1843 to 1853, when Mr. Wilson (who in the interim had removed to the Low Moor Iron Works) invented, patented, and applied to the hammers at Low Moor and elsewhere, what is called the "circular-balanced valve."

The modern steam-hammers are much simplified and are variously constructed in detail. Fig. 1, shows a single upright steam-hammer, as made by William Sellers and Company. This hammer is a modification of the Morrison steam-hammer, provided with automatic valve gear and ranging in size from 300 pounds up to 2,500 pounds. In these hammers, the motion to work the valve has been obtained from a diagonal groove in the upper end of the hammer bar. In early practice this diagonal groove was planed in the flat surface, which surface Mr. Morrison adopted as a means of preventing the bar from turning; but as this slot so made was found to cause a slight tendency to rotate the bar back and forth, it has been abandoned, and inclined grooves, diametrically opposite to each other, are made to work a brass yoke, whose line of vibration is through the central axis of the bar, thus entirely obviating the above objection, and very much increasing the extent of wearing surface, and permitting the guiding of the bar by brass keys in these opposite grooves. The ports in the steam chest have been so modified, so as to use a supplemental valve to throttle the exhaust below the piston, without impeding the free exhaust above the piston. This enables the hammer to strike quick, light blows for finishing; in other words, the hammer can go up as quickly, but when coming down its force may be gauged by the steam cushion upon which it descends, which steam, thus condensed in bulk, re-expands in the up stroke, to the manifest economy of steam used. To fully appreciate the importance of this improvement it must be borne in mind that any attempt to gauge the intensity of the blow by throttling the ingress of steam to the cylinder, slows down its speed and renders its automatic blows irregular without proportionately decreasing their force, as in many cases the weight of the bar alone is too great for the character of work in progress. A slow motion of the working-lever will permit a corresponding slow raising of the hammer and its slow descent, with a squeezing force upon the work, so that it permits its advantageous use as a squeezer for bending and holding work between the dies. In short, the valve motion with the one working lever enables the workman to have as perfect control of the rapidity, force, and character of the blow as is possible with a hammer held in his hand and controlled by his will. These hammers up to and including 2,500 pounds weight of ram are made with one upright only; those of 1,000 pounds and under are so made as to inclose in their base the top of the anvil block, which block rests on a separate foundation, and thus relieves the frame from shock.

Fig. 2, represents a single frame steam-hammer

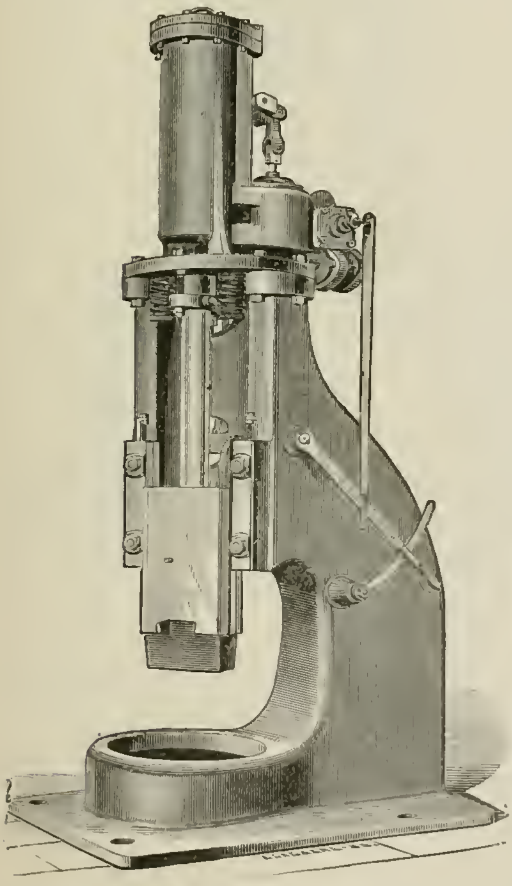


Fig. 2.

made at the Machine Tool Works of Mr. Frederick B. Miles, Philadelphia. In Fig. 3, we have a double frame steam-hammer by the same maker. These hammers are of distinctively American origin. Their general design and arrangement, valve gear and minor details, are all of native invention, not copied from foreign models. This valve gear, of but three moving pieces, takes up its own lost motion by gravity, and having no connection with the ram, it escapes all concussion. It is managed so as to produce every variety of effect by a single lever with no extra gear. The latest improvement made in them is *adjustable guides* for taking up the wear of ram, keeping the dies matched, and preventing the breakage of piston rods. In the single frame hammers there are detached anvils, and the valve gear, both hand and self-acting, is arranged for top steam. The ram and guides are set *diagonally* to the frames at the proper angle for the drawing and finishing. The weights of drop are 200, 300, 500, 700, 1100, 1500, 2400 lbs. The diameters of cylinders are 4$\frac{3}{4}$, 5$\frac{1}{2}$, 6$\frac{1}{4}$, 7, 10, 12$\frac{1}{2}$, 14, inches. The length of strokes are 13, 16, 20, 22, 27, 44, 56 inches. They can be fitted, when required, with a treadle, by which the hammer-man can work the valve gear with his foot. The hammer can be started upward off the anvil, or made to hang *suspended* and start with a *downward blow*. In the double frame hammers the valve gear, arranged for top steam, is both hand and self-acting. The safety buffers prevent damage from careless handling, and enable the piston packing to be examined or renewed without disconnecting. The steam and exhaust connections have stuffing-box joints, and are placed at the side, leaving two fronts clear for cranes. The common weights of drop are 1200, 1500, 2000, 2500, 3000, 4000, 5000, 6000, 8000, 10000, 15000, 20000, and 30000 pounds respectively. The diameters of cylinders are 10, 10$\frac{3}{4}$, 12, 14, 15, 18, 20, 22, 22, 25, 30, 36 and 40 inches. The length of strokes are 30, 30, 36, 36, 48, 48, 54, 54, 60, 72, 84, 96, and 108 inches. The hammers are rated in size according to the weight of the ram and piston. This takes no account of the top steam, which enormously multiplies the force of the blow; nor has it any reference to the entire weight of the machine.

The foundations are simple and inexpensive. They consist of one long pier for the anvil seat, and two smaller ones to support the bed-plate. The drawing, Fig. 4, shows the arrangement. The anvil rests upon a separate foundation pier in order to reduce the effect of concussion upon the frame. This pier is made long, extending beyond the hammer on each side, so as to get plenty of area to rest upon; and the ends are left open for convenient access, in case the anvil should settle and require re-adjustment. In marshy places the piers should rest on piles or on timber platforms, and the anvil should be raised 2 or 3 inches higher than in the drawing, to allow for settlement. A warning mark, on the guides, shows when the piston touches the bottom of the cylinder. Before this mark is reached, the anvil must be raised, or a higher anvil die used.

The 80-ton steam-hammer of Creusot is a monster in this line. It consists of four distinct parts: the foundations or sub-structures, the anvil and its supports forming the superstructure, the steam-cylinder and various valves, and finally the moving mass which constitutes the hammer. The foundations consist of a bed of masonry laid in cement, and resting at a depth of 36 feet below the ground upon solid rock, and of a cast-iron anvil base filled in between with oak timbers designed to lesson by its elasticity the vibration transmitted from the hammer. The masonry bed contains 784 cubic yards; its upper face covered with layers of oak about 3.3 feet thick, laid horizontal, upon which rests the anvil base. At the Works at Perm it was found more convenient to make the anvil base in a single piece, and to mold and cast it on the very site upon which it was to be finally used. The Messrs. Schneider & Co. decided that this arrangement would be inconvenient, and, moreover, as it would not be possible to transport to its selected site a mass weighing 720 tons, they decided to make the anvil base in six horizontal layers resting one upon the other. Each layer is formed of two pieces, except the upper one, which carries the anvil block, which is a single piece weighing just 120 tons. The anvil base, which has a total thickness of 17.4 feet and is 108 feet square at bottom and 23 feet square at the top, is formed of 11 pieces, the pieces constituting a layer being firmly united, and the layers themselves being secured each to the other above and below. The space between the anvil base and the walls of the pit containing it, is filled in with oak timbers driven in on end. As is seen, the anvil base is independent of the frame for the hammer branches of the frame. The latter, inclining toward each other in the shape of the letter "A," rest upon foundations and are keyed to a bed-plate sealed in the masonry surrounding the anvil base; they are united at the top by the entablement. They are hollow castings with a rectangular cross-section, and each branch is made in two sections, which are united half way up by straps and bolts. The slides are also attached to their respective supports by means of bolts. Finally, the frame is strongly braced by four wrought-iron plates which also secures the slides. The height of the frame is 32.91 feet and its weight, together with that of the slides, is 250 tons. The plates for stiffening the frame weigh altogether about 25 tons, and the supporting bed-plates weigh just 90 tons. This arrangement of the frame, so connected by iron plates, is of great rigidity, as has been shown since the hammer commenced work. This frame, as has been previously stated, supports the entablement (table), the weight of which is 30 tons; upon it is placed the steam-cylinder composed of two sections, each 9.84 feet in height, connected together by clamps and bolts. The circulation of steam is attained by means of two valves and the action is of single effect. The diameter of the cylinder is 74.8 inches, from which is obtained a surface of 4,238 square inches after deducting the area of the rod, which has a diameter of 13.27 inches. This, for a steam pressure of 5 atmospheres, permits an effort upon the piston of about 140 tons.

As the weight of the hammer is 80 tons, it is apparent that the power is more than sufficient to raise it, and its weight may consequently be increased. The stroke of the piston is 16.4 feet. This fall multiplied into 176,400 pounds—the weight of the falling mass will give a working-force of 2,893,200 foot-pounds. The 50-ton hammer at Essen, the stroke of which is only 9.84 feet, has a working force of only 1,081,950 foot-pounds. Supposing the two hammers acting upon an ingot 4.92 feet in height, the hammer at Creusot would still have available 2,025,240 foot-pounds, while that at Essen would have at its disposal only 542,475 foot-pounds, from which it is very evident that the former hammer in this particular instance would be more than three times more powerful. The width between the branches is about 24.61 feet and the height under the braces is 10.5 feet, which secures an ample space for the manipulation of large masses of metal. The height of the hammer from the foundation plate to the top of the cylinder is 61 feet, and adding 18.4 feet for the anvil base and 19.7 feet for the foundation on which it rests, it is seen that this colossal structure is in all nearly 100 feet high. In spite of this condition so unfavorable to stability, in spite of the enormous effect resulting from the shock of 2,893,200 foot-pounds, the structure, constructed of parts skillfully proportioned, does not vibrate, and the foundation, cushioned by the filling of timbers previously mentioned, transmits to the ground slight vibrations less sensible than those from a hammer of much less power. The valves are worked by rods attached to one branch of the frame and descending to a point about 10 feet above the ground; the workmen who manipulates these stands upon a platform and is protected, not only from the intense heat of the forging but from the sparks, etc., thrown off under hammering.

The four cranes for use with the hammer are all of the same type, and differ from each other only in their power. As we have before stated, three of them have a capacity of 100 tons and the fourth a capacity of 160 tons. They belong to that class which have only a lower pivot, and their shape is that of the swan's neck. They are made of plate and angle-iron. They turn about their pivot, resting on the ground-level upon a friction circle. This circle forms part of a kind of tubing in cast-iron firmly secured to the masonry foundations. This tubing is itself united to the cast-iron plate which supports the hammer frame. As this arrangement is applied to each of the four cranes, their foundations thus become, as well as that of the hammer, solidly united together over a very extended surface, thereby giving to the whole structure very great stability. From the pivot to the top of the jib each crane, as a total height of 57 feet composed as follows: From the pivot to the ground level, 27.5 feet, and from the ground to the top of the jib, 29.5 feet. The swing of the cranes are 30.6 feet. Each of these cranes has four movements, given by steam-engines attached to the cranes themselves, which, with two cylinders, have a capacity of 60 horse power with 250 strokes per minute. These four movements are as follows, viz: *First*—Swinging the cranes. *Second.*—Raising the charge. *Third.*—Traveling the charge. *Fourth.*—Turning the load. There is nothing special in the first three movements; they are given by means of gearing which permits the direction of the motion to be readily changed. The load is attached by a system of movable pulleys, over

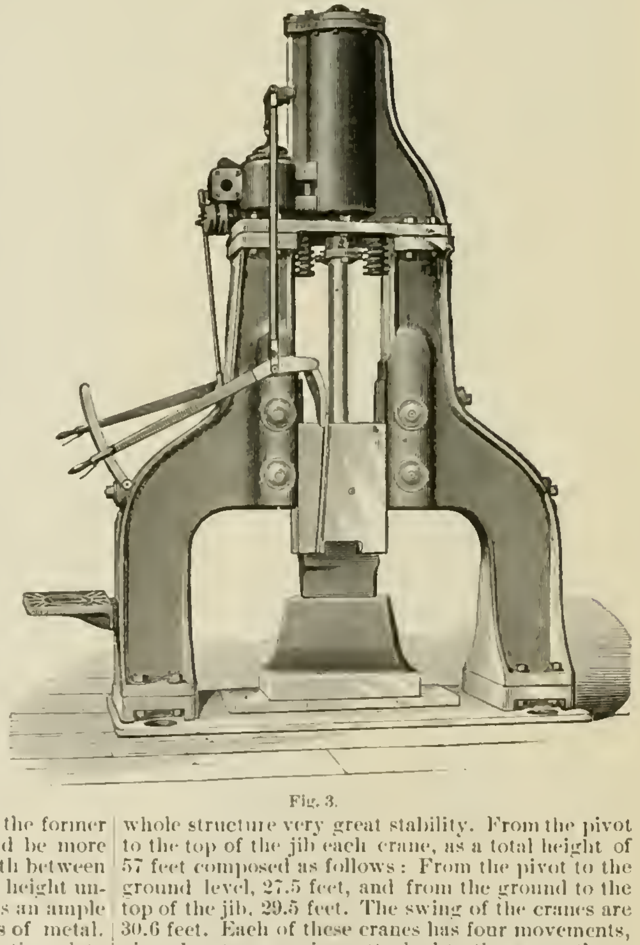


Fig. 3.

which passes the chain, which is also wrapped about the drum with helecoidal grooves attached to the body of the crane. The traveling of the load is effected by means of a small truck running upon rails placed upon the anus of the cranes. The most peculiar movement is that of turning the load. With small hammers this is done by hand by the aid of levers and a large gang of men; but such an operation would not be any longer practicable in handling a piece weighing 100 tons or more, such as this hammer is intended to work.

The 80-ton hammer at the Saint Chamond Works (Loire) should receive a passing notice. The following gives the weight of the pieces entering into the composition of the hammer and also gives the principles of its construction and its functions:

Anvil base	1,102,500	pounds.
Plates of courses	269,010	"
Legs	595,350	"
Table and cylinder . . .	326,340	"
Piston distributer, platform, sheathing plates, assembling parts, hammer-carrier, hammer.	352,850	"
Total	2,646,050	"

Weight of moving mass . .	176,400	pounds.
Maximum fall	15.75	feet.
Work of fall	1,240	ft.-tons.
Spread of legs	21.65	feet.
Breadth of hammer . . .	6.23	"
Height disposable for forging	13.12	"
Diameter of cylinder . . .	6.23	"
" " shaft . . .	1.11	"
" " receiving-valve .	1.14	"
" " discharging-valve	1.64	"
Steam pressure	95	lbs. per sq. in.
Pressure to raise 80,000 kilos	43	" " " "

The cranes used with the steam-hammer are pivoted above and below. To provide the journals for the upper pivots there is placed around the hammer a metal *gallows* of which the base is anchored in the ground and the top of which carries the collars to receive these pivots. This gallows is composed essentially of two horizontal beams of sheet and T-iron, bound by a latticed straining piece at right angles to their extremities. Buried in the ground they find their bearings in metal platforms formed equally of intertied beams. The platforms are laid down in the massive masonry, monumentally formed and provided for the fitting in of the vertical beams of the gallows, and secure by their weight the stability of the cranes. These are constructed in sheet T of soft steel. The pivots and pieces for fitting are of cast-steel. They each carry a steam-engine of two cylinders which provide for four kinds of movements, viz: 1st. The movement for elevating the charge. 2d. The movement for traveling the charge upon the cranes. 3d. The circular movement of the crane around its axis. 4th. A movement of "*virage*." This last movement, invented there some years ago by M. Fouchére, Master Mechanic of the great forging shop of the Company, allows the piece suspended by the crane to turn over and over in such a manner as to easily present all the points of its surface successively to the blows of the hammer. One man standing upon a platform moving with the crane is sufficient to control all these various movements. Besides the three, the hammer possesses a fourth crane (smaller), serving for putting in and out of place the necessary woking tools.

This Work altogether contains 5,219,200 pounds of metal divided as follows:

Shop, gallows, cranes . .	1,719,900	pounds.
Hammer	2,646,000	"
Furnace, generators, boilers	771,750	"

And 17,920,000 pounds of masonry and notwithstanding all that it has been built with a remarkable promptness. The preliminary designs date only in fact from the month of January, 1878; matured ones only from March, 1878, and the Works were opened in the month of May of the same year. The first trials were made on the 4th of August, 1879, which actually gave a total of from 14 to 16 months from beginning to the completion of the undertaking. The skillful conduction of this immense undertaking and its completion with such rapidity is a high testimony

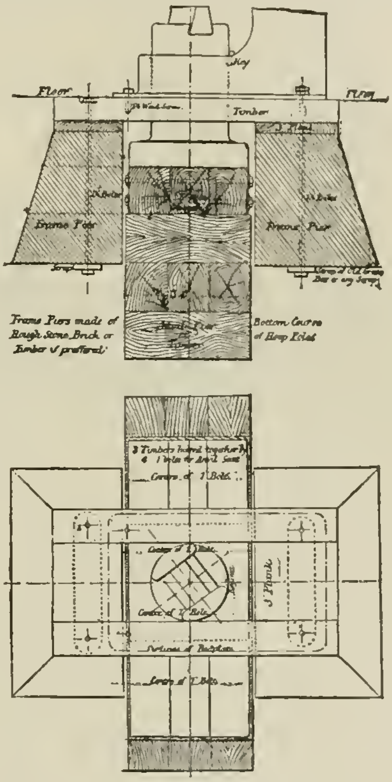


Fig. 4.

to the ability of the engineers of the Company, who have fully contributed to their portion of the work. Since it has been in operation the 80-ton hammer has to-day already forged a number of large pieces, among which we may mention the following: Three ingots of 45 tons, 5.2 feet diameter, for tubes for use in the 42-cm. (16.5 inches) cannon. These tubes have a length of 32.8 feet and a diameter of 2.46 feet. One ingot of 45 tons, 4.92 feet diameter, for front portion of the 42-cm. cannon. One ingot of 70 tons, 6.5 feet diameter, for rear portion of the 42-cm. cannon. The functions of the 80-ton hammer has left nothing to be desired during this period, and the forgings are of a most satisfactory character.

STEAM-PUMP.—This application of the steam-engine to pumping purposes is most useful to the military engineer. In its simplest form, a tube through which the steam is forced enters a hollow globe to a little beyond its center. On either side of this tube are openings into the globe for the entrance of water. These openings are much larger than the steam-pipe. Opposite the latter is the exit tube for the mixed steam and water, which has a trumpet-shape and a length of about once and a half times the diameter of the globe. The rush of steam across the semi-diameter of the globe and through this funnel produces exhaustion in the lateral halves of the globe, into which spaces the water is forced by the external pressure of the air. The first direct acting piston-pumps were probably invented by Mr. H. R. Worthington, of New York, while making experiments for canal steam navigation in 1840. He patented a steam-pump to feed marine boilers in 1844. The steam-cylinder was fed through a pipe which had a valve at the other end within the boiler. To this valve there was adjusted a float which controlled the supply of steam, which extended the cylinder through a slide valve which was acted upon by a spring controlled by the motion of the piston. The present Worthington and Baker pump was evolved from this apparatus. It is a combination of pump and steam-cylinder, driven

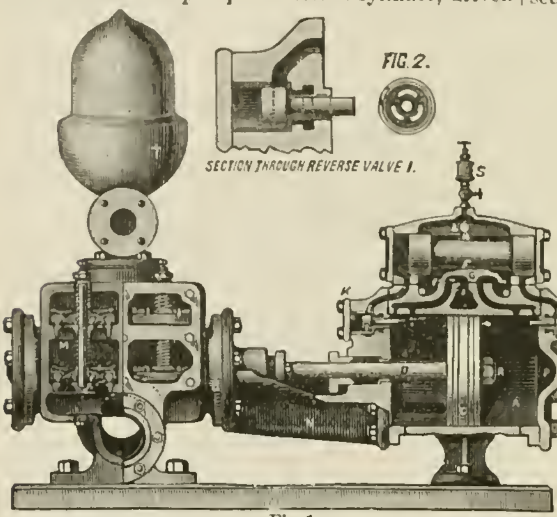


Fig. 1.

by direct action and without intervention of fly-wheel or any appliance for producing rotary motion. The steam-cylinder has the usual arrangement for the entrance and exit of steam, and the rod and piston is attached to a plunger of a double-acting pump. At the middle of the piston-rod, between the pump and steam-cylinder, there is attached an arm which, in passing to and fro, strikes the long end of a lever, which changes the steam-valves so as to alternately admit steam on one side or the other of the piston. Various improvements have been made to control the action of the slide-valve. One method is the employment of a secondary cylinder and piston, to which steam is admitted by a sub-valve, acted upon by the main piston, near the end of the stroke. Another method is the employment of a fly-wheel. We will first mention those pumps having an attached crank and fly-wheel. Of these an example is furnished by the Eclipse steam-pump, made at Pittsburg, Penn. The crank-shaft actuates a rocking-lever, by which is moved the slide controlling the admission and exhaust of steam. The Clayton pump, made at Brooklyn, N. Y., has a yoke which couples the piston and pumping-rods, and answers for the support of the crank-shaft journal. One end of the shaft, by suitable attachments, controls the valve, while the other supports the fly-wheel. These fly-wheel pumps have the advantage of a perfect control of the steam valve. The direct-acting pumps have been the subject of many inventions, the principal object sought being the arrest of the piston at any rate of speed at a proper distance from the cylinder-head. This has been accomplished by various devices. We have not space to describe the different forms of apparatus, but will mention the following as good examples :—Knowles's steam-pump, which employs an auxiliary piston-valve or chest-piston, which has a reciprocating and rotary motion, which imparts motion to the main valve; Blake's steam pump, in which both the main and the auxiliary valves are plain, flat slide-valves, the auxiliary valve being a continuation of the ports of the main cylinder, and therefore forming a movable valve-seat; the Cameron steam-pump, in which the steam-piston, at the end of the stroke, acts upon valves at either end of the cylinder, alternately admitting and exhausting steam; the isochromal steam-pump, made at Hamilton, Ohio, which has a governor to regulate the strokes of the piston; and the National steam-pump, in which the valve-gear consists of a main piston-valve, doing the work of an auxiliary piston, the valve stem performing the office of an auxiliary valve.

The Cameron steam-pump, so universally employed in foundries, arsenals, and garrisons, is shown in section in Fig. 1. A is the steam-cylinder shown in the section; C, the piston; D, the piston-rod; L, the steam-chest; F, the plunger; G, the slide-valve; H, a starting-bar connected with a handle on the outside; I I, are the reversing-valves, and K K the bonnets over the reversing-valves; N is the body-piece connecting the steam and water-cylinders; B is the water cylinder with the valve-chest bonnet removed; M is a valve-seat shown in section —the valve over it is also shown in section; T is the discharge-air vessel. Fig. 2 shows an enlarged sectional view of the reversing-valve chamber with phosphor-bronze lining. The operation is very simple:

Suppose the steam-piston, C, moving from right to left; when it reaches the reversing-valve, I, it opens it and exhausts the space on the left-hand end of the plunger, F, through the passage, E, which leads to the exhaust-pipe; the greater pressure inside of the steam-chest changes the position of the plunger, F, and slide-valve, G, and the motion of the piston, C, is instantly reversed. The same operation repeated at each stroke makes the motion continuous. The reversing-valves, I I, are closed by a pressure of steam on their larger ends, conveyed by an unseen passage direct from the steam-chest.

Fig. 2, shows the pump complete with boiler-feed, boiler-base, smoke-bonnet, section of smoke-stack, grate-bars, gauge-cocks, steam-gauge, water-gauge, safety-valve, globe-valves, blow-off cock, steam and

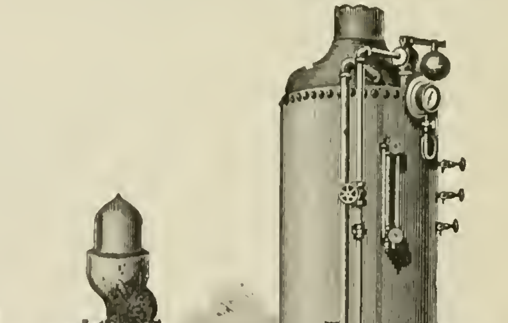


Fig. 2.

exhaust-pipes, boiler-feed connection, valves, unions, etc.

The table (page 205) shows the approximate pounds pressure due to columns of water from 50 to 200 feet in height; also the number of gallons of water that will be delivered per minute, and the height in feet to which it will be discharged through nozzles from

Height in feet of column of water.		50	60	70	80	90	100	120	140	160	180	200
Pounds pressure due to same.		22	27	31	36	40	44	54	62	71	80	89
DIAMETER OF NOZZLE. 5/8	No. of gallons will deliver per minute.	50	55	60	63	67	72	78	85	87	83	101
	Height in feet, will discharge. . . .	44	51	58	64	70	75	84	91	96	99	100
3/4	No. of gallons will deliver per minute.	73	79	86	92	98	103	113	122	127	137	146
	Height in feet, will discharge. . . .	45	52	60	67	73	79	90	99	106	112	116
7/8	No. of gallons will deliver per minute.	101	109	118	127	133	140	156	161	173	187	199
	Height in feet, will discharge. . . .	46	54	61	70	75	82	94	105	114	122	129
1	No. of gallons will deliver per minute.	133	142	155	159	179	183	201	217	226	244	260
	Height in feet, will discharge. . . .	46	55	62	70	77	84	97	109	120	129	137
1¼	No. of gallons will deliver per minute.	203	224	241	258	272	288	316	341	353	380	407
	Height in feet, will discharge. . . .	47	56	64	72	81	87	102	116	128	139	150

The loss by friction in 2½-inch rubber hose, throwing a 1-inch stream 100 feet high, is 15 pounds for each 100 feet of hose.

⅝ to 1¼ inches in diameter, under heads from 50 to 200 feet in height, or the corresponding pounds pressure. See *Hydraulic Power* and *Pumping-engine.*

STEAM-SAPPER.—The steam-sapper or road-traction engine can be used as a locomotive on rails by changing the road driving-wheels. There are two sizes of these engines in the English Service, one 6 tons and the other 8 tons weight; 80 per cent. of the weight is borne on the driving-wheels. The steam-sapper is specially made for drawing loads on roads and across country; on good roads they will draw three times their own weight up a slope of 1 in 12; when used on rails (at 4 ft. 8½ in. gauge), they can ascend a gradient of 1 in 20 with a load equal to their own weight; and they can go round curves of 2 chains radius. They are constructed to travel on road or on rails at two speeds, four miles and eight miles an hour. Some of these steam-sappers have been provided with a crane equal to lifting and moving about with 5 tons weight; there are also some with a winding drum and 400 yards of steel wire rope, which enable them to draw loads up a slope of 1 in 2: the ones fitted with the crane are invaluable in artillery parks, being able to move about with a load suspended and to deposit it in a fresh site. These road-traction engines are a valuable auxiliary to an army in the field. In the event of a railway having to be constructed for a military expedition, they can be advantageously employed in hauling the materials for the line to where they may be required over the open country, or as steam-cranes at the point of disembarkation to land the heavier portion of the railway plant. "Steam-sappers" can also be used as winding stations at the tops of inclines, where the trains cannot be drawn up either by animal or steam-power. Road-traction engines made in the way previously mentioned, and of almost exactly the same pattern as has been adopted in H. M. Service, are used by France, Russia, and Italy in their army transport-trains. It is, however, desirable to confine these useful machines to the work they are specially designed for, that is, drawing good loads on a road or in an open country, and for lifting weights; locomotives for traction on rails require particular construction to get all the work possible out of them. See *Railway Communications*, and *Traction-engine.*

STEAM-SHEAR.—A machine used for slitting metal plates. The plates, 20 to 30 feet long and 6 or 7 feet wide, are placed on a table provided with rollers and guides, which is advanced toward the knives until a strip of the desired width and of the whole length of the plate is severed. One used by the Otis Iron and Steel Company, weighs about 80,000 pounds, has knives 87 inches long, and shears 1¼-inch steel plates at a single stroke.

STECHEN.—A passage at arms. A description of tournament practiced at the close of the 12th century.

STEEL.—To give a brief definition of steel is a difficult task. Until lately, steel has been usually defined to be iron containing a small amount of carbon, an amount smaller than that present in cast-iron, but greater than the maximum quantity to be found in characteristic wrought-iron; *i. e.*, iron containing between 0.3 per cent. and 2 per cent. of carbon was termed steel. This proportion of carbon is, however, only approximate, and Dr. Percy gives from 0.5 to 0.65 per cent. of carbon as the limit at which, when free from other foreign matter, iron may be considered as passing into steel, so that when hardened by quenching in water it will strike fire readily with flint. According to this definition, where carbon is present "in certain proportions, the limits of which cannot be exactly prescribed, we have the various kinds of steel, which are highly elastic, malleable, ductile, forgeable, weldable, capable of receiving very different degrees of hardness by tempering, and fusible in furnaces." Owing, however, to the gradual development of new modes of manufacture, and to the enormous increase in recent years in the production of cast-steels of all kinds, the arbitrary definition of steel above given leads to much confusion and serious mistakes, and though it may be called a mere question of words, the above definition has no doubt exercised a deleterious effect upon the introduction of steel in place of worked or wrought-iron for many purposes for which it is well suited.

A simpler definition of steel seems likely to be adopted, a definition which possesses the advantages of precision, and is in harmony with the current modes of manufacture. According to this, *steel is an alloy of iron, cast while in a fluid state into a malleable ingot.* It is held, according to this nomenclature, that steel and wrought-iron cannot always be distinguished by a chemical analysis (for the same proportions of carbon, manganese, silicon, etc., may exist in any malleable alloy of iron), and that the fundamental and essential difference between steel and all compounds of iron, merely worked or wrought, is a structural difference easily determined. All malleable products of iron industry—that is so say, all varieties of iron, except cast-iron—may be divided into piled-metal (wrought-iron) and ingot-metal (steel); the former embracing all malleable-iron or alloys of iron produced without fusion of the metals while in a malleable state, and the latter applying to all irons, however produced, which are cast into a malleable ingot. These two classes differ more widely in mode of manufacture, appearance, and in many important properties than the varieties of each class among themselves, and form two parallel and continuous series, the corresponding members of which are chemically identical, differing only in mode of production and in mechanical structure, and rising in each series from the purest and softest iron to the hardest and most highly carbureted varieties.

M. Adolph Grenier, of Seraing, adopting this definition of steel, classifies the two parallel series of products, the irons and the steels, as follows:

Percentage of carbon.

0. to 0. 15	0.15 to 0. 45	0.45 to 0. 15	0.55. to 1.50 or more.

Series of the irons.

Ordinary irons.	Granular irons.	Steel irons or puddled steel	Cemented steel, Styrian steel

Series of the steels.

Extra soft steels.	Soft steels.	Half soft steels.	Hard steels.

is homogeneous throughout and free from flaws or intermixed impurities.

We now can understand fully what steel means in accordance with either of the definitions given of the term, whether depending merely upon its chemical constitution as to the amount of carbon present or upon the physical treatment of the metal, which must be melted and cast into a malleable mass. In either case it is evident that the properties of the metal must vary very much, but more especially if we adopt the second definition. The soft or low steels approximate, like ordinary wrought-iron, to pure iron, and the hard or high natures of steel approach cast-iron in their properties. Over wrought-iron steel has always the advantage of being homogeneous, but it is unfortunately uncertain in quality, a surprising fact when we think how it is produced; still it is so, and we find that ingots of this metal of the same chemical constitution, produced in the same way and from identical materials, often differ much from one another in the properties of elasticity and tenacity. Many nostrums have been proposed for overcoming this de-

The production of the more highly carbureted varieties of the iron group, such as puddled-steel or cement steel, except with the view to casting the metal subsequently, is now carried on upon a comparatively limited scale, while that of the steels proper, or cast-steel, is increasing enormously each year. For the construction of ordnance, we may say that cast-steel is at present and will in the future be as a rule employed, so we may safely take the new definition of steel and look upon this metal *as a melted malleable alloy of iron produced in any way whatever, and containing a smaller proportion of carbon or other hardening element than is contained in cast-iron.* Steel may be produced in a variety of ways, by more or less decarbureting cast-iron under such conditions as to obtain a melted product. By dissolving wrought-iron or steel-scrap, or spongy reduced iron in melted cast-iron. By the direct melting or puddled-iron, or other variety of iron of the requisite degree of hardness (the hardness referring to the amount of carbon in the iron). By melting a mixture of soft wrought-iron, or iron-sponge, with carbon or with cast-iron or of malleable-iron, which is too hard for the variety of steel required, with oxidizing agents, or by directly melting together a mixture of iron ore and carbon as a single operation.

The processes by which steel-making is practically carried out are by melting in pots or crucibles, giving "pot" or "crucible" steel; on the open hearth or bed of a reverberatory furnace, giving Siemens or Siemens-Martin steel; or by blowing the air through molten cast-iron, producing Bessemer steel. In whatever way made, the material is essentially the same, depending on its chemical composition and physical structure for its properties. It differs much from wrought-iron, even when chemically the same metal, because a mass of wrought-iron is made up from a number of bars or of blooms heated and welded together, each of these again being composed of separate granules with impurities interposed, such as slag, etc., entangled so that the mass is unavoidably full of flaws and imperfect welds. Steel, on the other hand, has been brought into a state of perfect fusion, and cast while liquid into a malleable ingot, which

fect, which appears to be due to the molecular condition of the metal as affected during the melting and the subsequent treatment of the ingot.

It is in modification and improvements of the latter that quality appears to lie, and already many plans are being attempted for the insurance of greater certainty in the quality of steel, such, *e. g.*, as casting it under pressure to get rid of the bubbles or blow-holes.

Steel will not, like wrought-iron, stand a high welding heat, especially if it be of a "hard" or "high" nature. If hammered at too great a heat the ingot will fall to pieces. After being cast, steel is hammered or rolled, and it acquires a fibrous structure during this process, as may be easily shown if a bar of this metal be acted on by a strong acid. When first cast, steel, excepting the higher varieties, is comparatively soft and inelastic, and can thus be treated in a similar manner to any wrought-iron; but, with the exception of the very low or soft varieties, it may be subsequently hardened by what is called "tempering," when the metal is heated and plunged into mercury, water, oil, or some other liquid. in order to cool it more or less quickly. The effect of such tempering depends very much upon the amount of carbon present in the steel, as well as upon the degree of heat it is previously raised to, and has a marvelous effect in increasing both tenacity and elastic limit in the case of good steel. Besides the great uncertainty of steel, we must remember that it is very inferior to wrought-iron in another important point, that of being easily weldable. The importance of this property with regard to facility and economy in working large masses of metal can hardly be exaggerated.

The qualities of steel may be summed up as follows: In tenacity it varies, roughly speaking, from 30 to 60 tons per square inch, and its limit of elasticity lies between 13 and 30 tons. The softer the steel the more ductile it is, the less readily can it be tempered, the lower in its limit of elasticity and tenacity. All other things being equal, the more rapidly it is cooled the harder it becomes; but at the same time the higher natures are rendered more brittle. When cooled in a comparatively bad conductor of heat, such as oil, the mass parts with its heat slowly, and is not only made more elastic and harder, but also toughened; while in any case the limits of elasticity and tenacity approach one another more nearly. The effect of tempering upon the metal is, of course, comparative; thus experiments have shown that certain soft steels containing from 0.15 per cent. to 0.22 per cent., or 0.24 per cent. of carbon, were very decidedly toughened by heating to a red heat, and then being quenched in water. The steel used for Woolwich gun-barrels, containing about 0.3 per cent. of carbon, would be made very hard, but also very brittle, if so heated; therefore it is tempered in oil, as being a worse conductor of heat than water, and is thus toughened.

This is shown well by the following table given by Mr. Kerkaldy:

Nature of specimen.	Tenacity (tons per square inch).	Elongation per inch.	Character of fracture.
1. Highly heated and cooled in water.	30	0	Entirely granular.
2. Highly heated and cooled slowly	36½	22	Entirely fibrous.
3. Moderately heated and cooled in oil	53	14½	One-third granular, two-thirds fibrous.
4. Highly heated and cooled in oil.	68	2½	Almost entirely granular.

Should the steel be too highly carbureted, or be in too large a mass, it is liable to fracture during the process of toughening. With the higher natures we can obtain very great strength and elasticity, though we lose in ductility, and have a more brittle material. We have also the great advantage of hardness and homogeneity, giving us, when required, a very smooth surface quite free from flaws. Until further improvements are made, the advantages are counterbalanced by great uncertainty as to the behavior of the material, especially in the higher or harder steels. The greater cost of steel of sufficiently good quality is also one disadvantage when we compare it with wrought-iron. The brittleness and uncertainty of this material prevent us employing steel as a sole material for any gun save the small 7-pounder for boat and mountain service. Although, however, steel is not such a material as we should employ for the sole manufacture of a gun, yet it is admirably suited for the inner barrel, as it is very strong and gives a hard, clean surface, while its limit of elasticity is high, so that even a heavy strain does not stretch it permanently and deform the bore. It may indeed split if subject to too great a pressure when not properly supported by the exterior layers, but by putting a wrought-iron jacket outside we prevent any danger from that cause; for, should the steel-tube burst, the wrought-iron exterior will prevent any explosive rupture. The lower table exhibits the mechanical properties of United States steel as made at the Midvale Works. See *Annealing, Bessemer Steel, Blistered Steel, Cast-steel, Crucible-steel, High Steel, Iron, Low Steel, Mild Steel, Natural Steel, Puddled Steel, Semi-steel Shear Steel, Siemens-Martin Steel, Steel Works, Tempering, Tilted Steel,* and *Whitworth Metal.*

STEEL-BRONZE.—An alloy of tin and copper, so hardened as to render it as durable and strong as the steel; hence its name. The mode of treating this alloy is the invention of a Frenchman, M. Lavessière. It has been of late improved on by General Uchatius, Director of the Royal Arsenal at Vienna, and is employed by him in the manufacture of light field guns. It takes its name, not from any steel entering into its composition, but is simply given to signify that the metal does possess, in some degree, the properties of steel, so as to qualify it as a substitute for that metal in gun-making. It is also alleged that there is no phosphorus in it. The composition of steel-bronze differs only slightly from that of ordinary bronze (90 per cent. of copper and 10 per cent. of tin), the alloy consisting of 92 per cent. of copper and 8 per cent. of tin. The great secret of producing this metal lies in the manner it is cast, and this comprises two op-

Original dimensions of specimens.	Nature of property.	
	Density	7.8483
	Tenacity	113,220
	Hardness	18.00
	Hardness of copper	3.33
	Pulling stress:	
Length, 10″; diameter, 0″.65	Elastic limit ... pounds	50,000
	Extension per inch at elastic limit ... inch	0.0023
	Ultimate resistance ... pounds	90.000
	Ultimate extension per inch ... inch	0.1898
	Ultimate restoration per inch ... do	0.0052
	Ultimate permanent set per inch ... do	0.1358
	Thrusting stress:	
Length, 10″; diameter, 1″.165	Elastic limit ... pounds	25,000
	Compression per inch at elastic limit ... inch	0.00097
	Compression per inch under 45,000 pounds per square inch ... inch	0.0092
	Corresponding restoration per inch ... do	0.00159
	Corresponding permanent set per inch ... do	0.00033
	Bending stress:	
Length, 20″; diameter, 2″×2″	Elastic limit ... pounds	5.000
	Deflection at elastic limit ... inch	0.03
	Deflection under 25,000 pounds ... do	0.645
	Corresponding restoration ... do	0.151
	Corresponding permanent set ... do	0.498
Length, 2″; diameter, 0″. 8	Resistance to crushing force ... pounds	135,000

erations, viz.: (1) casting in an iron mould; around a metallic core; and (2) passing the metal, when cold, through the rolling mill. The moulds are of cast-iron and 3.9 inches thick; in the center of each is placed a wrought copper core, 1.9 inches in diameter, around which the metal is cast and chilled. See *Dean Gun.*

STEEL-BRONZE GUN.—A gun lately introduced into the Austrian service, and made of steel-bronze. The mode of manufacture is as follows: The metal having been prepared as shown above, the cylinders are bored to a diameter smaller than that required for the bore of the gun. For this purpose the cylinders are placed vertically on a support, then steel punches or cones are forced into the aperture by the means of a powerful hydraulic press. The size of these cones increases gradually, so as to produce a progressive widening of the inside of the bore; six cones are sufficient to alter a diameter of 3.15 inches into one of 3.425 inches. In the formation of the gun in the process adopted, the surface of the bore acquires a hardness equal to that of steel, and the strain given by the distension of the interior is far greater than can be given to the powder chamber on the explosion of the greatest charge it can be made to hold. General Uchatius states in his report the reasons that led him to adopt the above process, in the following words:—"The work done by the powder to the detriment of the gun at the commencement of the shooting, namely, the enlargement of the bore, must be exerted by mechanical pressure beforehand, and to a still greater degree than the work done by the strongest occurring powder-gas pressure, whereby the elastic power of resistance of the barrel will be so increased that the subsequent smaller powder-gas pressures will exert no further effect, and the metal immediately surrounding the surface of the bore must be given the necessary degree of hardness by subjecting it to a process analogous to that of rolling out." Thus is repeated what is done in the manufacture of the Nacomber gun, with this difference, that that gun is "built up" of wrought-iron discs, "set" by means of a powerful hammer, and the breech encircled with heavy steel rings. General Uchatius further says of his gun: "All metal strata surrounding the bore concentrically are in a state of elastic tension, and exert a pressure, from without inwards, equal to the pressure exerted by the hydraulic press ramming from within outwards, and which the table of pressures shows to correspond very nearly with a state of about 2,400 atmospheres."

The experiments made with these new guns have shown that the *bronze-steel*, as it is also called, is not only as hard as cast steel, but far more elastic, and the action of the powder-gas seems to injure the gun very little; further, it is less liable to damage from atmospheric action than steel. The initial velocity is very little less than that of the Krupp gun, and to these advantages must be added the great difference in price (cost of construction), which is stated to be only £35 per gun. The dimensions of this new gun are the same as the Krupp gun of 8.7 centimeters, from which it was copied, the only difference being in the length of the bore, which is 6 feet 5 inches. The wedge and the vent bush are also slightly different; the bore is provided with a copper Broadwell ring, and closed with a flat wedge of Uchatius' construction; the vent bush is bored in a copper screw, and is perpendicular to the axis of the bore. The Austrian Committee of Artillery, after the late experiments with the steel-bronze gun, reported as follows: "The steel-bronze B.L.R. gun, throwing a projectile of about 14 lbs., with a charge of 3.3 lbs., showed great durability; after 2,147 rounds had been fired from it almost without interruption, the melting of the tin particles was considerably less than the burning out of the breech surface of the Krupp gun of the same caliber that was tried along with it: and, besides, the erosion did not exceed the admissible limits. The comparative firing showed that the steel-bronze gun possesses the same accuracy as that of the cast-steel gun. Notwithstanding the melting of the tin particles, the accuracy of the firing was in no way diminished, and the projectile that was purposely allowed to burst in the bore after 2,121 rounds damaged the parts but little where the explosion took place, and even then, the firing was not inferior to what had taken place. The extreme durability of the bore is due not only to the excellence of the material, but also to the construction of the loading chamber, as well as to the construction of the projectile. The projectiles used in the trial were of two kinds: a common shell and a bolt-shaped shell, with double case, of 2½ calibers in length, with four belts of copper wire or guide-ring incased in its cylindrical portion.

Competent artillerists in Germany, it is stated, have shown themselves favorable to the steel-bronze, and the Committee of Artillery at Berlin has caused two pieces of this metal to be manufactured for the purpose of carrying out experiments. If these give good results, it is proposed to employ steel-bronze in the manufacture of garrison and naval guns, and thus utilize the large stock of bronze ordnance possessed by the German Artillery.

STEEL GUNS.—As the name implies, guns made of steel. In the British Artillery, guns entirely made of that metal have not been adopted, except for one nature of mountain gun. The M.L.R. guns of the service have the inner barrel made of steel. The mountain gun above alluded to (7-pdr.) is made from a solid block of steel, rough bored and shaped, then toughened in oil, and afterwards finished in the usual manner. The bore is 3 inches, and rifled with three grooves on the French system, having a twist of one turn in 20 calibers. This rifling differs from the modified French system (as applied to the 9-pdr. and 16-pdr.) in not having the corners rounded, and in the curve of the bottom of the groove being described concentric to the bore. The grooves are 0.6 inch wide at the bottom and 0.1 inch deep.

Since the introduction of rifled ordnance in Europe and America, special attention has been directed to steel as a material capable of withstanding the immense strain to which rifled guns are subjected; but English artillerists found an objection to this metal chiefly on account of its brittleness and want of endurance, the trials made with steel guns in England and on the Continent, some years ago, not having been considered satisfactory. The want of confidence in steel guns arose probably from the fear that manufacturers had not yet attained to the perfect method of forming the gun or the want of knowledge in the manufacture of the metal itself; but the system lately pursued by Sir J. Whitworth, of compressing steel in its fluid state by hydraulic pressure, has produced guns which afford all the endurance and strength that can be desired. In the compression of this metal, all the cavities or air cells are driven out, and it becomes perfectly homogeneous. Steel possesses important advantages over wrought-iron, such as elasticity, tenacity, and hardness, but it is more expensive.

Steel, as a metal for the manufacture of ordnance, has been adopted by most Continental Nations, the chief manufacturer being Mr. Krupp, of Essen, in Prussia, whose guns have been adopted not only by Germany, but also by Russia, Belgium, Holland, Italy, Spain, Egypt, Turkey, and even Japan. Austria, for a time, carried on experiments with some of Krupp's guns with the view of introducing them into her service; but preference has since been given to steel-bronze, which is stated from experiments to be superior to steel. Krupp's guns of a small caliber are manufactured from one solid block; those above 8-inch caliber are compound, being weighted and strengthened by external rings in the manner described under the head of Krupp guns.

The uncertainty of some of Krupp's heaviest guns was shown some years ago, particularly in the trials made in Russia. Two burst after firing a comparatively few number of rounds, one 66, the other 109 rounds: the former is stated to have burst from the jamming of the shot; the latter, it is inferred, from defective metal, although the contrary is reported. Four guns were then tested for endurance; two of which, M.L.R. guns, withstood, the one, 215, the other 286 rounds. The other two were S.B. guns, and withstood 1,025 and 790 rounds respectively None of them burst, but they were all worn and eaten into the seat of the shot, by gas, to such an extent that the Committee considered that the service of the rifled guns could not with safety be assigned a higher duration than 250 rounds. An 11-inch cast-steel Krupp gun, tried in 1871 at Cronstadt, burst at the muzzle after the ninth shot, this result being probably due, in the opinion of the committee, to a flaw in the metal near the muzzle. During the war of 1870-71, many of Krupp's light guns are stated to have become unserviceable, but probably they became so, not so much from any fault in the metal, as from a mechanical derangement in the breech-loading apparatus, which has doubtless since been remedied. The Krupp guns lately manufactured for the German Army appear from the reports to be very satisfactory.

Such are a few of the principal results attained in the manufacture of the early steel ordnance. Whether guns of this metal will eventually be introduced into the British Service, it is difficult to say; as far as can at present be seen, no change is likely to be made. Another drawback, besides the uncertainty of the metal resisting the strain of the charge, is the great cost involved in melting and casting the material, together with the expense of turning and boring such a hard metal, all which add greatly to the price of the gun.

The relative cost of steel guns compared with those of pieces manufactured of other materials has been computed as follows:—

	Per ton.
Cast-iron guns.	£21
Armstrong (original construction), wrought-iron with steel tube. . .	100
Armstrong (Fraser construction) . .	65
Steel, on Krupp's or Whitworth's plan	170
Gun-metal	190

Russia has large steel factories at Aboukoffsky and at Oberchoff. In England, the Sheffield Works and the Vavasseur Factory in London manufacture steel guns. See *Steel Works*.

STEEL-PRESS.— A press for solidifying molten steel. The suggestion is embodied in one of Bessemer's early patents, but has been developed by Sir Joseph Whitworth and by Révollier, Biétrix, & Co., of St. Etienne, who adopted it in 1867, having built steel-works specially arranged for it in connection with furnaces for making steel by the Siemens-Martin process. According to the plans adopted by Révollier & Co., the metal was run from the furnace into a ladle, which, by means of a turn-table crane, was conveyed to the ingot-molds, and the metal turned into the latter. The molds were placed on an ingot-carriage, and after filling they were run under an hydraulic press.

STEEL PROJECTILES. — Projectiles of this class have proved more efficient than those of any other metal, but their expense has heretofore been too great to warrant their general use. For rifle projectiles they are made from the solid ingots of steel turned to form, and bored out for shells. They are hardened by heating and cooling quickly, the head being to a certain extent chilled. The manufacture is expensive and tedious, and the tempering is a matter of difficulty, the shells being liable to crack. In order to overcome this difficulty hollow shot have been devised, the hole through the center allowing the sudden shrinkage to take place without the injurious effects above alluded to.

The operation of forming a cavity in a solid steel projectile is done in a machine or lathe, of peculiar construction. The solid projectile is first bored out from the base to the top of the cavity in the ordinary way. It is then put in a chuck and a cutter inserted in the hole thus formed. The cutter is firmly fixed to the rest, and its point is bent at right angles to its length. As the cavity enlarges, new cutters with longer points are employed until the desired size is obtained. A former of peculiar shape guides the feed-motion of the cutter and gives form to the cavity. The point of the projectile rests in the cavity of the center-piece of the lathe and the base is held firmly by jaws.

Whitworth's steel shells are formed from ingots of steel cast in the form of hoops, and drawn down to the necessary size under the hydraulic press. The ends are closed with screw-plugs. They are therefore less costly than might be thought. See *Chilled Projectiles*, *Projectiles*, and *Whitworth Projectile*.

STEEL WORKS.—Iron-smelting is the largest and most important in the whole domain of metallurgy, and at first sight, presents a remarkable contrast to all other branches of the smelter's art. For in case of most of the other metals employed as such in the arts, we have, as sources of supply, a numerous class of minerals varying greatly in richness and composition, and susceptible of reduction to the metallic state by processes also differing greatly among each other; while, in the case of iron, the few minerals that can be made useful as ores are restricted within much narrower workable limits, and form only one class of chemical compounds, namely, oxides, whose reduction can be effected practically only by one agent—that is, carbon or carbonic oxide. But as a very high temperature is necessary to effect the reduction, the metal almost always combines with a greater or less proportion of the reducing agent, as well as of other elementary substances, such as silicon, sulphur, and phosphorus, that may be present either in the ore, the fuel, or the flux, so that the ultimate result is never a pure metal, but a series of compounds, varying in properties from great hardness to perfect malleability, and from ready fusibility to almost absolute infusibility.

Practically speaking, absolutely pure iron may be said to be of no commercial value. But, on the other hand, extraordinarily small traces of foreign elements exert a very marked influence on the metal, and it is precisely these small, and, in many cases, unnoticed differences of composition, that render so many points in the chemistry and practical working of iron obscure and difficult to be understood. When it is considered that the investigation of such problems calls for researches involving the utmost refinements of analytical chemistry, it is not remarkable that contradictory statements and opinions still abound on many points of the chemistry of iron-making. The mechanical considerations involved in this subject are almost as important as the chemical; for, unlike the smelter of other metals, who is able by fusion alone to bring his finished product to a merchantable state, the iron smelter has to deal with pasty infusible masses, which require to be compacted and moulded by pressure by powerful machines, such as hammers, presses, rollers, etc., before they can be made available for consumption.

Iron is employed in the arts under three several states, whose variable properties are mainly due to differences in the quantity of carbon present, and in a much lesser degree to that of other foreign matters. When alloyed with a maximum of the latter element, an amount which in ordinary smelting does not exceed 6 per cent., or fall below 2 per cent., the substance obtained is known as cast iron or *pig metal*. This is a hard and comparatively brittle substance, which can be readily fused at a high temperature, and is susceptible of being moulded into solid forms by casting, but also in most modern iron works forms an intermediate product in the manufacture of the other classes. According as the metal may be most adapted for founders' or forge-masters' use, it is distinguished as forge or foundry pig.

Wrought or Malleable Iron is the nearest approach to the chemically pure metal that can be obtained on the large scale, may be almost absolutely free from carbon, and never contains more than 0.25 per cent. It is a soft, malleable, and extremely tenacious substance, infusable, except at the extreme temperatures obtainable in furnaces of special construction, but capable of being agglomerated by pressure, when at a white heat, to a compact state by the process of welding. When heated and suddenly cooled, it retains its softness. It may be produced either directly from the ore or by the conversion of pig iron. The varieties of the malleable iron are distinguished by many different names, but these have reference rather to form and destination than to differences of composition.

Those varieties of iron in which the amount of carbon is above the maximum of malleable, and below the minimum of cast metal, are known as *steel*. The distinguished property of this class of products is the power of being hardened or softened at pleasure, by sudden or rapid cooling, by the process known as *tempering*. Being intermediate in position between wrought and cast iron, steel is both fusible and malleable, but requires a higher temperature for fusion than the latter, and greater compressing power, owing to its lower welding temperature, than the former. Those varieties that are richest in carbon are the hardest and most fusible, and are known as *strong steels*, while those that are nearer malleable iron in composition are distinguished as *mild steels* or *steely irons*. Steel may be obtained either direct from the ore at one operation, or indirectly by a variety of processes of greater or less complexity from either cast or wrought iron.

The history of the production of iron is probably almost co-extensive with that of the human race; at least, it goes back far beyond the periods of authentic history. According to the Pentateuch (Gen. iv. 22) the discovery of iron is attributed to Tubal Cain, who is said to have been sixth in descent from Adam. Pagan tradition assigns the discovery to Vulcan, placing it about the time of Deucalion's deluge. There can be little doubt that the discovery was made at a very early period, as the production of small masses of malleable iron is one of the simplest of all metallurgical operations, requiring only a small furnace without blowing apparatus, such as can be made by digging a hole in the side of any bank exposed to the prevailing wind, a supply of easily reducible ore, and charcoal for fuel. Such processes as these have been described as in use in Africa by Mungo Park, and are still employed in Birmah; and probably something of the same kind is indicated by the tradition which ascribes the discovery of iron in Scythia to the effects of forest fires in districts containing iron ores, when portions of the reduced metal are said to have been found among the ashes of the burnt trees.

It may have been, however, that the masses of iron referred to were meteorites, whose existence was first made apparent by the clearing of the ground. Homer refers several times to iron and steel. Thus in the twenty-third Illiad, Achilles, at the funeral games of Patroclus, gives a disc of iron as the prize; and in the ninth Odyssey, the hissing of the burning stake that Ulysses plunges into the eye of Polyhemus is compared to the noise produced when steel is hardened by quenching it with water when at a red heat. Probably the first important improvement in the manufacture was the introduction of the artificial blast, which is of great antiquity. In Egyptian sculptures of the reign of Thothmes III. (1505 B. C.) smiths are represented working at a forge, which is provided with two simple leather bellows, worked by the pressure of men's feet for the exhaust, and inflated by strings pulled by hand, in a manner exactly similar to that still employed in Birmah. Aristotle (B. C. 384-322) describes the process of making cast steel used in India, which is still produced under the name of *wootz*; and also the manner in which the Chalybes of the Euxine procured iron. Pliny (A. D. 2379) mentions the great masses of iron ore still worked in Elba, Styria, and Spain, and describes the methods of making iron and steel, especially remarking that the quality of the latter depended upon the water used in quenching, and that small tools were tempered in oil. ("Natural History," bk. xxxiv. chap. 41.) Diodorus (B. C. 60-40), in describing the iron works of Elba, states that the ore was reduced to small pieces and heated in furnaces; the charge, when properly softened, was removed and divided into small masses, which had a spongy appearance (blooms), and were exported to main land of Italy for conversion into tools.

Galen (A.D, 131) remarks that knives made of Indian iron (steel) were remarkable for their strength and hardness, but were often so brittle that the cutting edge splintered off, owing to their having been very improperly tempered. According to Franquoy, bellows with valves were introduced by the Romans into Gaul during the fourth century A.D. These, although single acting and made of leather, were a considerable advance upon the savage form, which required strings for their inflation. The wooden double bellows, which are still in use in some parts of the Continent, may be regarded as the precursors of the cylinder blowing engine, and were introduced into the Harz about 1620, either from Franconia or Thuringia.

During the Middle Ages the great improvement consisted in the gradually increasing height of the furnace, consequent on the use of ores of an infusible and difficultly reducible character. This necessitated a special means of withdrawing the reduced mass of iron (lump or bloom), which was effected through a lateral opening in the hearth, or lower part of the furnace, instead of being lifted out from above, as was done with the ordinary open fire. With the increased length of the operation, the reduced metal being left for a considerable time in contact with the fuel, facility was given for a greater absorption of carbon, resulting in the formation of a larger quantity of molten pig iron, which was run out with the slag, than was the case with the open fires. The increased height of the furnace is well seen in Agricola ("De Re Metallica," lib. xii. edit. 1546), who describes two different methods of iron-working as common in his time. The text is not very clear, but the engravings represent, in the first case, an ordinary bloomery, in which malleable iron is produced directly from the ore, together with a certain quantity of hard or pig iron; while, in the second method described as in use with refractory ores, the furnace has a shaft of such a height that the furnace-man requires to ascend a short flight of steps to reach the throat, or charging-place. It is surprising that this author makes no mention of foundry work; but as he states that the "hard iron" of the bloomery was useful for stamp heads, he was probably acquainted with the use of iron castings, but not with their mode of manufacture. The omission may also be accounted for by supposing that no foundries existed in Saxony, to which country most of Agricola's descriptions refer, until sometime after their establishment in the Rhenish and Low Countries. The subject of iron-founding is noticed by Lazarus Ercker in his "Probierbuch," published in 1574. Karsten supposed that the *Stückofen*, or high bloomery furnace above referred to, was of Eastern origin, and was first introduced into Styria, travelling thence westward to Burgundy and Alsace, subsequently returning eastward into Bohemia and Saxony; and that the later forms of *Blauofen* and high furnace (the proto-types of the modern blast furnace) were invented in the Netherlands. The first indication of the latter are found in Lorraine and in the German Rhineland. Franquoy, who seeks with patriotic zeal to establish the priority of invention of the blast furnace to the Liége district, states that according to documentary evidence the *hauts fourneaux* at Vennes and Grivegnée in that country were established before A.D. 1400, and also that the furnace at Marche les Dames was built by William, Count of Namur, A.D. 1340. Karsten, on the other hand, states that although the knowledge of pig iron dates from time immemorial, its use and systematic production for foundry purposes cannot be traced back with certainty to an earlier period than the end of the fifteen century.

In England, the blast furnace was probably in use at a very early period, as we have evidence, accord- to Lower, of ornamental castings being made in Sussex some time in the fourteenth century. The principal seats of the iron trade at that period in England were in the great forests of Sussex, Gloucestershire, and South Wales, where, under the older forms of bloomeries, iron works had existed since the days of the Romans. The gradual diminution of the forests of Sussex under the demands of the furnace, a process of destruction which may be seen going on at the present time with increased rapidity in Sweden, North America, and other countries producing charcoal iron, led to the passing of a stringent act in 1584 (27th Elizabeth) forbidding the further erection of iron works in the Weald of Sussex except under certain limitations. With the commencement of the seventeenth century came the first attempts at smelting with mineral fuel, the pioneer of this particular improvement being Dud Dudley, who in 1619 produced both pig and wrought iron with coal in Worcestershire; but the scheme was unsuccessful, owing to the opposition of the charcoal iron masters, so that after trials in several localities extending over upwards of thirty years, all of which ended unfortunately, the inventor finally abandoned the subject. A similar trial was made in Hainault by Octavius Stada, a native of Bohemia, in 1625, who obtained a monopoly of the invention for twenty-five years, but it lead to no practical results. It was not till more than a century later, namely, in 1735, that the problem of smelting with coal was successfully solved by Abraham Darby, of Colebrookdale, who was the first to use coke in the blast furnace, an improvement which spread rapidly into all other iron-producing districts situated on or near the coal measures. The last furnace in the Weald of Sussex, at Ashburnham, was blown out in 1829, and there are now only two or three scattered representatives of the ancient charcoal furnaces remaining in the whole United Kingdom. The century following the success of Abraham Darby is marked by the introduction of the two great inventions which especially distinguish the modern period of iron manufacture; that is, the substitution of the reverberatory furnace for the open fire in the forge, and the use of heated air in the blast furnace. The former change effected by the puddling process, invented by Cort in 1784, has almost superseded all the older methods of making malleable iron; and the latter, due to Neilson and Condie, and first used at the Clyde iron Works in 1828, has greatly increased the productive power of the blast furnace, with a diminution in the consumption of fuel.

Since the introduction of the hot blast, the chief improvement in the blast furnace is that of intercepting the gases, which were formerly allowed to burn to waste at the throat, and leading them off by distributing pipes, to be usefully employed as fuel under steam boilers, hot blast stoves, &c. This was patented in France in 1811 by Aubertot, the gases being employed for heating steel furnaces. In 1832 the waste gases were used for heating the blast at Wasseralfingen, in Bavaria, and a similar apparatus was first erected in England in 1848 by J. P. Budd, at Ystalyfera, in Glamorganshire, since which time various modifications of the same plan have been adopted to a considerable extent, especially in those furnaces that are obliged to draw their fuel from a distance, but in other districts, as for example in South Staffordshire and Scotland, the old flaming throats still prevail. Within the last few years, the chief invention and improvements have been in steel manufacture, and many new processes have been introduced. Prominent among these is that named after its inventor, Henry Bessemer, which, although only of a few years' standing, has already effected important services by the production of a material admirably adapted for use in railway and other engineering work in place of wrought iron. Perhaps the problem of most immediate interest at present is that of the economical substitution of mechanical for manual power in the process of puddling, so as to enable the forge-master to manipulate larger masses of malleable iron at a time, and thus to put him more nearly on an equality with cast-steel makers than is now the case.

With the exception of the Weald of Sussex, very little change has taken place in the position of our principal iron-working centers from the earliest time down to the present day. Since the great expansion of railways several new and important localities have been brought into work, the ores being carried to the fuel or the reverse, according as might be most advantageous. In this way the great northern coal field of England, which is almost absolutely without ironstone, gives rise to the largest production in the kingdom by feeding the Cleveland district with coal and coke, and drawing ironstone for its own furnaces in return. The prevalence of cheap ores in the oolitic districts has brought the blast furnace to within fifty miles of London in Northamptonshire, and the pastoral districts of Wiltshire have been invaded by the same visitor. It need not, therefore, be a matter of much surprise if at some future period the Wealden furnaces were to be re-lighted, as they could be easily supplied with fuel from the western coal fields should the supply of ore be sufficient to warrant the attempt, especially as on the opposite coast of France large furnaces have been established for smelting ores out of the same formation, and which are supplied with fuel from England.

Under the various headings in this ENCYCLOPEDIA, the properties and uses of steel for gun construction, etc., have been given. In this article, considering steel as the intermediate link between ordinary cast and malleable iron, we will dwell at length on the methods of its production, its analysis, mechanical properties and tests. For a still more elaborate essay on the subject, the reader may consult *Bauerman's Metallurgy of Iron*, from which the substance of this article is taken. Steel may be produced in many different ways, of which the following are the more important:—

1. By the Catalan forge directly from the ore.
2. From pig iron, by fusion and partial oxidation in the hearth finery.
3. From the same metal, by a similar process in the puddling furnace.
4. By exposing bar iron to the action of solid or gaseous carbonaceous matter at a temperature below its melting point. This method is known as conversion by cementation, and the amount of change produced is mainly dependent upon the time employed. When merely a surface coating of steel is required, the process adopted is known as case-hardening; while, on the other hand, if sufficiently long continued, the iron may be completely converted into cast iron. A process which may be regarded as the reverse of cementation is practised to a certain extent upon cast iron. A process which may be regarded as the reverse of cementation is practised to a certain extent upon cast iron, by exposing it to heat in closed vessels filled with finely-powdered hematite. The surface of the casting is decarburised at the expense of the oxygen of the peroxide of iron, with the production of a malleable coating. This is known as the method of making malleable cast iron. In the above processes steel is produced without melting, and is converted into bars by hammering and rolling, in a similar manner to that adopted in the manufacture of malleable iron. A more homogeneous product may be obtained by fusion, according to the following methods:

5. The cemented or blistered steel produced in No. 4 is broken up into small pieces and melted in crucibles, with or without fluxes, in quantities of from 60 to 80 lbs. This is the original method of making cast steel introduced by Huntsman, in the neighborhood of Sheffield, and is still largely used in the same district for the production of the higher class of cutlery and tool steel.

6. By blowing air through molten pig iron until it is wholly or partially decarburised. In the former case the necessary amount of carbon is restored by the addition of highly-carburised pig, such as spiegeleisen, in small quantity. This is what is known as Bessemer's process.

In addition to the above processes, several new methods of making cast-steel have been proposed and adopted to a certain extent, but not generally. The essence of these methods consists in fusing cast-iron with oxidising, or wrought-iron with carburising additions or by fusing cast and wrought-iron in proper proportions alone, as in the last step of the Bessemer process. The following are some of the more prominent:—

Uchatius Process. This consists in melting in crucibles granulated pig iron with peroxide of iron, produced from roasted spathic iron ore, and a small quantity of oxide of manganese. By varying the proportions of metal and ore, and especially by the addition of a certain quantity of malleable scrap iron, a softer or milder steel may be obtained.

Obuchow's method of producing cast-steel is generally similar to that of Uchatius. White pig is fused with malleable iron or steel scrap, with variable additions of magnetic iron ore, titaniferous black sand, such as is obtained in gold-washing, arsenious acid, niter, and clay, or with arsenious and magnetite alone. The operation is concluded as follows:— The scrap iron, magnetic oxide, and clay are placed in a large clay crucible which has been previously brought up nearly to a white heat; the cast-iron is then run in melted from a cupola, and the crucible is heated until the contents are perfectly fluid; the remaining ingredients, namely, arsenious acid and niter, are then added, the whole being well stirred. The steel is cast in closed cast-iron moulds, and the ingots, as soon as they have cooled down to a red heat, are removed, and taken at once to the hammer and tilted.

Price and Nicholson's process consists in melting malleable iron with refined metal, that is pig iron free from silicon, the relative proportions of the two metals being adjusted according to the character of the steel that it is desired to produce.

Indian cast-steel or *wootz*, is made from malleable iron cut into small pieces, which are charged in quantities of about 1 lb. weight in clay crucibles, together with about 10 per cent. of dried wood of *Cassia auriculata*, and two or three leaves of *Asclepias gigantea*. The covers of the crucibles are luted on with clay, and when dry, some twenty are heated together in a charcoal hearth for about two hours. On breaking the crucible after fusion, a round cake of steel is obtained, about 1 inch in thickness and 5 inches in diameter, which is perfectly smelted, and usually presents a series of finely-radiating striations on its upper surface. Wootz is extremely hard, containing a large amount of carbon, and requires great care in tempering and forging.

The addition of charcoal or other carbonaceous matter in the fusion of blister steel furnishes a ready method of controlling the hardness of cast-steel, and is commonly practised, especially where a proportion of malleable-iron is added to the charge. The same effect may be produced by the use of crucibles made of blacklead instead of clay, the carbon required for the conversion of the malleable iron into steel being furnished by the substance of the crucible: the latter modification is said to be largely used by Krupp at Essen, in Westphalia.

In making the so-called *natural steel* in open fires, a method that was formerly practiced to a considerable extent in Styria, Westphalia, and other parts of Europe, but which is now being rapidly superseded by more improved processes, the hearth differs from that used in making malleable iron by having less depth, while the twyer is at a lower level and more strongly inclined, as the molten mass is not brought directly before the twyer, but is decarburized under the combined influence of the blast and slag, with an increased expenditure of time and fuel. As a rule, about double the quantity of coal and one half more time is required to convert a charge of pig-iron into steel than would be the case if the same weight was operated upon for malleable iron. The best varieties of pig iron for the purpose are those containing a considerable quantity of carbon, such as spiegeleisen, or the strongly mottled variety called *blumige floss*, containing flowers or spots of gray upon a white ground. Dark gray pig can be used, but should first be subjected to refining.

In Styria the process is conducted on hearths, with a bottom of charcoal dust about 12 inches thick. The first portion of the charge, weighing 120 lbs., is melted down with a small quantity of cinder, the latter being strewed over the coals, the reheating of the blooms (*masseln*), about ten or twelve in all, from the former operation, going on at the same time. When only two blooms are left, a further addition of pig iron is made to the extent of from 30 to 60 lbs., and the blowing is continued until the hearth is filled to within one or two inches of the twyer. The fire is then allowed to go down quickly, the slag is tapped through a hole in the front plate into a trough filled with water, and the lump of crude steel remaining in the hearth is allowed to cool, out of contact of the air, by covering it with a shovelful of moistened cinders. In about a quarter or half an hour after stopping the blast, the lump is lifted out of the furnace, and is then divided under the hammer into ten or twelve pieces, which, as has already been stated, are reheated during the fining of the next charge.

The bars drawn under the hammer are hardened by quenching in cold water, and broken, in order to test their quality. They are sorted according to hardness into several classes, distinguished by special names. The best are known as chisel or tool steel, noble steel, and crude steel, below which come a variety of steely irons, used for scythe-making, wagon-wheel tires, and similar purposes. Usually the forges are small, each containing two fires and a hammer, having three water-wheels, two for the bellows, and one driving the hammer, which weighs from 5 to 6 cwt., making from 70 to 120 strokes per minute, with a maximum lift of about two feet. When small-sized bars or scythes are made in the same forge, a lighter tilt-hammer of 3 or 4 cwt. is generally used. With both fires at work, four men produce about 12 or 15 cwt. of crude steel blooms in sixteen hours. The consumption of charcoal is about 30 cubic feet per cwt. under ordinary conditions, but may be reduced to between 22 and 25 cubic feet by using covered hearths and hot blast. The proportional yield of the different kinds of steel is as follows for every 100 parts of pig iron treated:—

60	parts	of steel of all kinds (crude, noble and chisel steel.)
20	"	mock, or over-refined steel, containing soft iron.
10	"	steely iron of different kinds.
10	"	loss.
100		

The Carinthian process is carried out with much larger quantities of pig iron at one time than is the Styrian. The charge, weighing about 5 cwt., is melted down in a hearth some 2 feet square, with an effective depth of from 7 to 9 inches below the twyer. The bottom of the hearth is lined with charcoal dust or brasque in the usual way. The twyer is about $1\frac{1}{4}$ inches wide, and plunges from 10° to 16°. The charge is kept melted before the blast for three hours, as in the ordinary process of refining, and after removal of the slag, is converted into thin plates by throwing water on the surface, and stripping off the chilled metal in crusts or discs of about 1 or 1½ inch thick. After the fire is made up, the first portion of the bloom obtained in the preceding operation is reheated and hammered—an operation requiring about an hour and a half. A quantity of from 40 to 70 lbs. of pig iron, with a little cinder, is then melted down gradually, and upon this the refined metal of the first operation is added by small quantities at a time, until the whole charge forms a more or less pasty or imperfectly fluid mass (*sauer*) on the hearth bottom, which is broken up with a bar and piled into a heap in the center. The amount of working depends upon the feel of the iron. If it *dries* too rapidly, fresh pig iron must be added, while in the opposite case of being too fluid, oxidation is promoted by the addition of hammer scale. The upper portion of the mass, being under the influence of the blast, loses its carbon; while the lower part, being in contact with the glowing charcoal lining the hearth remains in the condition of cast-iron. After making up the pile, the second portion of the previous bloom is reheated, and when this is finished, the contents of the hearth, having subsided to a uniform level surface, are found to be sufficiently fined to allow the formation of a fresh bloom, which is broken out and divided into two parts for further treatment. The half blooms are again divided, and finally finished into bars, which are hardened, broken and selected in the same way as in Styria. It will be seen that the same hearth is, in addition to its proper work, made to do duty alternately as a refinery and reheating fire, an arrangement that must be attended with considerable waste both of time and fuel. The loss upon the pig iron is from 20 to 30 per cent., including the reheating; the consumption of charcoal is from 40 to 50 cubic feet per cwt. About 75 per cent. of the produce is good steel, which is reheated in special small fires, and drawn under light hammers into bars, which are packed in cases and sold as Brescian steel.

The so-called true Brescian process practised at Paal, in Styria, differs in certain details of manipulation from the preceding, the most important point being, that in reheating the blooms, they are plunged into the bath of molten pig iron, whereby they undergo a kind of surface hardening by cementation.

In Siegen, where spiegeleisen is, or was, formerly treated in the open fire, the charge is melted down in small quantities of 60 or 80 lbs. weight upon a bottom of mottled iron. As soon as the fusion commences the slag is tapped to within 2½ inches of the bottom, and further additions of spiegeleisen are made in diminishing quantities, from 40 lbs. at the fifth to 20 lbs. at the seventh and last charge. It is sought as much as possible to keep the mass at the consistency of soft butter during the entire operation. The bloom (*schrei*) ultimately obtained weighs 4 cwt., the time required being about eight hours. It is divided into seven or eight pieces, which are tilted into bars, with a loss of about 20 per cent. Reckoned upon the pig iron, the loss is 30 per cent., 100 lbs. giving 70 lbs. of steel, of which about three-fourths are of good quality, and capable of being properly hardened, and the remainder mild steel or steely iron. It is doubtful whether this process is still practised, having latterly been superseded by the method of steel puddling.

Puddled Steel. There is no essential difference between the methods of making wrought-iron and steel in the puddling furnace, other than the degree of decarburization to which the pig iron is subjected. The most highly-carburized varieties of pig iron, especially those containing manganese, such as spiegeleisen, are best adapted for the process. The furnace is usually of a somewhat smaller size than that employed for making malleable iron; or rather, the size of the bed is diminished in proportion to that of the fireplace and stack, in order to be able to command a very high temperature. The charge does not usually exceeed 3 or 3½ cwt., which is introduced in fragments as nearly as possible of the same size and thickness, and spread out so as to expose a large surface to the flame, in order that fusion may be effected uniformly and without much oxidation. The use of only one kind or class of pig iron is also necessary, otherwise, supposing white and grey iron to be mixed, a portion of the charge would probably fine and come to nature while the more fusible part was still unchanged. This is exactly the reverse condition to that required in puddling for malleable iron, where a mixture of two different kinds of pigs has an advantageous effect in accelerating the process. In all steel puddling, on the other hand, the charge is rendered perfectly fluid, and covered with molten slag, in order that the fining may go on very slowly and uniformly. The presence of protoxide of manganese in the slag is important, as contributing fluidity without increasing the decarburising influence. By keeping the contents of the furnace well stirred together during the second part of the process, the iron separated in malleable condition may, in the event of its becoming too much decarburised, be brought back to the proper condition by dissolving it in the unaltered pig iron below, in a somewhat similar manner to that which is practised in the Siegen open fire process, where the iron is prevented from drying to too stiff a consistency by the addition of fresh quantities of pig iron at intervals. In order to induce fining in the molten mass, the damper must be closed until the charge thickens and commences to rise, when the heat must be carefully raised during the time of stirring, which usually takes from thirty-five to forty-five minutes, or somewhat longer than is the case in puddling for malleable iron. The high temperature prevailing in the furnace keeps the contents of the hearth well melted, and by continued stirring, fresh particles of metal are constantly brought to the surface of the fluid covering of slag. The appearance of fine, white, brilliant grains is a sign of the process going on well, and indicates the formation of steel of good quality and uniform texture. If, on the other hand, the separated grains are large, and resemble snowflakes, the product is likely to be of a coarse fracture, and imperfectly refined. The slag must be less basic than that formed in puddling for malleable iron, as the presence of a large excess of oxides of iron not only reduces the fluidity, but acts too energetically on the removal of the combined carbon from the pig iron.

The balling of the granular clots of steel as they come to nature is an operation requiring considerable skill; it must be done in a neutral or non-oxidizing atmosphere, such as is obtained by shutting the damper, and keeping the hearth filled with flame and smoke with an ordinary furnace, or shutting off the top blast when a gas furnace is used. The balls are shingled at a lower temperature than those of malleable, and when they cannot be immediately taken to the hammer, are protected against oxidation by rolling them in the melted slag, so as to obtain a superficial crust or varnish, which excludes the air from contact with the heated metal. The slowness of the fining process, and the extra amount of stirring required, are sufficient to explain the apparent anomaly that a partial should require longer time than a complete decarburisation. Under ordinary circumstances the time required for working off a heat is in either case as follows:—

	Fibrous Iron.	Steel.
Melting down...........	30 to 40 min.	40 to 50 min.
Stirring	30 " 35 "	45 " 50 "
Boiling and fining......	25 " 30 "	20 " 25 "
Balling......................	10 "	10 "
	85 115	105 135

As originally fully described in the specifications of Riepe, by whom the process was introduced into

England; the charge recommended to be used is 280 lbs., which is to be exposed to a red heat until the metal begins to fuse, when the temperature is reduced by lowering the damper. Forge or mill cinder, to the extent of twelve or sixteen shovelsful, is then added, and when the whole was melted, a small quantity of peroxide of manganese salt and clay ground together. After this mixture has acted for a few minutes the damper is fully opened, and about 40 lbs. of pig iron is placed upon an elevated bed of cinder near the fire-bridge. When this begins to trickle down, and the boiling of the contents of the furnace commences, it is raked into the hearth, and the whole mass is well mixed together. When the grains of steel begin to break through the cinder, as already described, the damper is to be partially closed, and the operation of stirring below the cinder commenced, taking care that the heat be not raised above cherry redness, or the welding temperature of shear steel. The remainder of the process of balling is done with a closed damper, as already described. It appears to be doubtful, according to the statements of most of the recent writers on the subject, whether the process can be properly conducted at the low temperature specified. The use of the highest heat attainable in the puddling furnace was afterwards claimed by another patentee, and on subsequent litigation, the term "cherry redness" was explained as meaning a bright red heat when the furnace was illuminated by direct sunlight. Parry states that if the heat be too high during the boiling, the mixed cinder and metal separate from each other, and the decarburisation proceeds slowly; while, on the other hand, if the temperature be too low, the cinder and metal cannot be properly mixed, being of too stiff a consistency, and the steel will not be homogeneous. The temperature must be raised to a full yellow heat on the appearance of the floating granules in the slag. The fire should be made up at the end of the boiling process, in order to prevent the passage of air by opening the fire-hole during the balling. It is necessary to shingle the balls as soon as possible, in order to prevent the decarburising action of the rich slag retained by capillary attraction upon the spongy particles of steel. When the slag is poor in protoxide of iron it sets very quickly, and when more basic, acts powerfully in removing carbon. The presence of oxide of manganese is advantageous, as communicating fluidity without increasing the oxidizing effect—a point of considerable importance, as the shingling takes place at a lower temperature than is the case with malleable iron. In some cases an addition of peroxide of manganese is made immediately before balling, or the mixture of peroxide of manganese, clay, and salt, already mentioned as being recommended by Schafhaütl for improving ordinary iron, is added at intervals after the melting down of the pig iron during the stirring. At Lohe, in Siegen, twelve heats of $3\frac{1}{2}$ cwt of white fibrous "steel" pig iron are puddled in the turn of twelve hours. Each charge yields from seven to eight balls, weighing 40 lbs. each. The loss upon the pig iron is 9 per cent. in puddling, with a further amount of 11 per cent. upon the reheating, which is done in covered hearths with a single twyer, somewhat like the South Wales hollow fire. The blooms are drawn into bars under a tilt hammer. The produce is assorted according to the fracture: 78 per cent. is good hard steel, capable of being broken when cooled in water; the remaining 22 per cent. is more or less mixed with soft iron. The total expenditure of coal is double the weight of the steel produced; out of this 84 per cent. goes for puddling, and the remaining 16 per cent. for reheating. These quantities refer to Ruhr coal, which is not of a very high quality. The total production for twelve hours is about 31 cwt. When grey pig iron is used, either alone or mixed with mottled, it is necessary to add from 10 to 15 per cent. of scale and cinder. In such cases the consumption of coal may be somewhat increased, as the process lasts a little longer than when working with iron melted from spathic ores. In Styrian works using lignite, with the advantage of good pig iron, the consumption is from 32 to 42 cwt. per ton of steel blooms made, without counting charcoal or wood for reheating. The use of gas furnaces is said to be of great advantage in the steel puddling process, both as regards the saving of fuel and diminishing the waste of iron. At Kirchhunden, in Siegen, the saving is stated at from 35 to 40 per cent. in the coal, and from 9 to 10 per cent. on the amount of iron burnt. According to observations made in several localities, the consumption of fuel is diminished when the sides of the hearth are cooled by a circulation of air instead of water. The chemical changes going on in the process of steel puddling have been investigated by Schilling and other chemists in a similar manner to that followed originally by Calvert and Johnson. The following are Schilling's results of the composition of the metal and slag at the different points of the process, as carried out at Zorge, in Hanover. The charge consisted of white pig iron from Gittelde, and grey from Zorge, mixed in equal weights. The fuel employed in the blast furnace was charcoal, the consumption being at the rate of 100 lbs. for every 87 lbs. of pig iron produced. See table below.

The metal of the sample No. III. was tough and strong cast-iron; No. IV., taken after five tools had been heated in rabbling, was stronger than the preceding, but of a tin-white color; No. V. was very cellular, and much resembled white pig iron, but was

ANALYSES OF IRON AND SLAG TAKEN AT DIFFERENT STAGES OF PUDDLING (SCHILLING)

	I.	II.	III.	IV.	V.	VI.	VII	VIII.	IX.	X.
Graphitic cardon............	0·08	2·13	1·11	—	—	—		—	—	—
Combined carbon............	2·60	1·03	1·81	2·49	2·36	2·26	1·77	1·33	1·08	0·94
Sulphur........................	0·09	0·109	0·10	0·03	0·027	0·012	trace throughout			
Phosphorus....................	0·48	0·46	0·47	0·24	0·17	0·11	0·08	0·071	0·075	0·075
Silicon........................	0·99	1·50	1·24	0·34	0·16	0·11	0·11	0·11	0·11	0·11
Manganese.....................	2·01	1·13	1·66	0·47	0·47	0·47	0·31	0·31	0·27	0·27

No. I. White pig iron from Gittelde.
" II. Grey pig iron from Zorge.
" III. Mean composition of charge.
" IV. Charges after melting down $47\frac{1}{4}$ minutes from the commencement of process.
" V. Metal at the commencement of rising, $18\frac{1}{2}$ minutes from the preceding.
" VI. Metal during boiling 14 min. later.
" VII. Another sample taken during boiling, 17 minutes later than No. VI.
" VIII. Granules of steel commencing to separate, $14\frac{3}{4}$ minutes later.
" IX. Sample taken at the formation of the first ball, 9 minutes later.
" X. Sample taken at the formation of the last ball, 9 minutes later.

slightly malleable. No.VI. was decidedly malleable and apparantly possessed most of the properties of steel, notwithstanding the large amount of carbon present. No increase of carbon was observed in the earlier stages of the process, as recorded by Calvert and Johnson and Lan. Schilling ascribes this difference to the use of a gas-furnace, and the introduction of an excess of air into the furnace by the top blast:

CORRESPONDING COMPOSITION OF SLAGS.

Slags taken with.	IV.	V.	VI.	VII.	VIII.	IX.	
Silica	20·98	20 51	20·12	20·34	20·27	20·40	20·52
Phosphoric acid	5·25	5·25	5·25	5·25	2·25	5·25	5·25
Peroxide of iron	7·12	4·09	4·12	5·20	5·20	4·95	6·24
Protoxide of iron	58·98	62.03	62·14	61·20	61·20	61·34	59·88
Alumina	2·78	2·82	2·87	2·87	2·91	3·05	2·86
Protoxide of manganese	1·64	1·64	1·64	1·64	1·64	1·64	1·64
Lime	1·84	2·14	2·04	1·69	2·12	1·72	1·69
Magnesia	1·62	1·57	1·62	1·52	2·04	1·81	1·79
Alkalies	0·93	0·82		assumed at 0·87			
Sulphuric acid	trace			not determined			
	101·14	100·81	100·68	100·58	101·50	101·08	100·74

In these slags, which are nearly uniform in composition throughout, the oxygen ratio of acid to bases is as 11·687: 18·212, or nearly 1 : 1½ that of a sesquibasic silicate. This is supposing the peroxide of iron to be in combination with silica, and not replacing it. The large and constant amount of phosphoric acid is ascribed, not to the oxidation of phosphorus contained in the pig iron, which is obviously in too small a quantity to produce such an effect, but to the ash of the wood burnt in the gas generator, and carried over by the draught, owing to the defective arrangement of the ash pit. It is evident, therefore, that even the above elaborate series of analyses does not furnish us with an exact idea of the changes going on during the process.

Production of Steel by Cementation. This process consists essentially in the exposure of bars of malleable iron, in close contact with charcoal, to a high and long-continued heat, the air being excluded. The furnace, employed for this purpose, is an oblong chamber with a semi-cylindrical roof, containing two large chests or converting pots, also of rectangular form, which are heated by a fire grate, placed below them, and running along the entire length of the chamber. The flame is distributed uniformly by a system of transverse rectangular flues, across the bottom and up the sides of the pots,and finally passes through a number of short vertical chimneys in the sides of the chamber into a tall covering hood or stack, of conical form, like that of an ordinary glass-house furnace or potter's kiln. The size of the boxes varies in different localities, according to the weight of iron heated at one time, from 8 to 15 feet in length, and from 2½ to 3 feet in breadth and height, corresponding to a capacity of between 8 and 12 tons of bar iron, with the necessary quantity of the cementing powder. In Yorkshire they are usually built of sandstone flags, but in other places ordinary fire-bricks and lumps or slabs of the same material are used. The introduction and withdrawal of the charge are affected through man-holes, in the shorter side walls of the covering chambers, placed above the level of the top of the boxes; these holes are of course walled up with brickwork when the furnace is lighted. In some instances, where the furnace is of small size,the roof of the chamber is made in several pieces, so as to be easily removed at the end of the operation, in order to facilitate the withdrawal of the cemented bars. Two small square holes, communicating with the interior of the boxes, are placed a little lower down on the same side of the furnace; these contain the trial bars used in determining the progress of conversion.

Bar iron smelted from Swedish magnetic ores is used in the production of the best kinds of cement steel at Sheffield, and, as a rule, hammered bars are preferred to those made by rolling. The most esteemed brands are those produced at the small forges in the eastern part of Sweden, in connection with the Dannemora mines; that of Löfsta having the highest reputation. The ordinary sizes of bars employed are from 2 to 5 inches in breadth, and from one-third to three-quarters of an inch in thickness; the flat form being preferred to those of round or square section. In filling the pots, an allowance is made for the expansion of the iron by heat; a space of about 2 inches in the direction of the length, and a little less transversely, being left between the edges of each layer of bars and the walls, and in like manner the butt ends of adjacent bars in each line must not be brought in contact with one another.

The cementing material is in all cases charcoal, in the form of a coarse powder obtained by sifting through a riddle with ½ or ¾-inch meshes. No special variety of charcoal is necessary, that of the hardest wood obtainable in the neighborhood being generally used; as, for example, birch in Sweden, beech in Rhenish Prussia, and oak in England. Hard-wood charcoal is said to be advantageous on account of the large amount of alkaline salts in the ash, which are regarded as favoring the production of cyanogen compounds. For the same purpose, an addition to the charcoal of small quantities of carbonate of baryta, alkaline carbonates, yellow prussiate of potash, animal charcoal, or organic matter containing nitrogen, has been recommended at different times, and tried experimentally; but none of these substances are in general use, except in the superficial converting process of case-hardening.

In charging the pots, the bottom is first covered with a coating of charcoal, and upon it the bars are arranged in tiers lying on the flat sides, and separated from each other by a layer of charcoal about half an inch thick. About one-third of the total cubic contents of the pot is occupied by the iron, the remaining two-thirds being filled with charcoal. When the whole charge has been introduced, the top of the pot is covered with a layer of clay or other refractory material. At Sheffield, grinder's waste, or wheelswarf—a mixture of finely-divided, partially-rusted steel with quartzose sand, produced by the waste of the grindstones employed in grinding the cutlery—is generally used. It is plastered over in a damp state, and frits together to a kind of glaze when strongly heated, forming a covering impervious to the air. A certain proportion of fresh charcoal, to the extent of one-half or two-thirds of the total quantity, must be used in each operation; that remaining from a former charge requires to be subjected to washing and sifting before it can be used again. The mixture of the two kinds is found to give a better result than when fresh coal is used alone, and the conversion is more rapidly effected.

When the furnace is charged, all the apertures are carefully stopped with brickwork or fire-clay, to prevent the access of air. The fire is then lighted, and in about twenty-four hours the chests are raised to a red heat, and in about two or three days more will have attained the proper temperature. According to the nature of the steel required, the fire is kept up for a period of from seven to nine or eleven days: the hardest quality for melting purposes requiring the longest, and spring and shear steel the shorter time. Conversion begins at a temperature of about 1,000°, but goes on more actively at the melting-point of copper, about 1,170°: at higher temperatures cast-iron is produced.

The progress of the conversion is determined by the appearance of the trial bar; the first is taken out after about a week's firing. When there is no longer an unaltered kernel of soft iron apparent in the center, the conversion is considered to be complete, the fire is allowed to go down, and the furnace is left to cool for three days; the man-hole stoppings are then removed, and on the sixth day the withdrawal of the cemented bars is commenced, and takes one or two days more, so that the whole operation requires from seventeen to twenty days. The physical properties of the iron are considerably modified by conversion; the color of the fractured surface changes from the original bluish tinge of malleable iron to a somewhat reddish white, like that of bismuth, and at the same time the luster is very considerably diminished. The texture is in all cases scaly crystalline. The finer the grain and the darker the color, as a general rule, the more highly carburised or harder will be the steel produced; at the same time, both specific gravity and tenacity are reduced. A more decided peculiarity of the converted bars, however, is the blistering of the external furnaces, whence the term *blister steel* is derived. When the blisters are small, and tolerably regularly distributed, the steel is of good quality; but when large, and only occurring along particular lines, they may be considered as indicative of defective composition or want of homogeneity in the iron employed. The cause of this phenomenon is not quite clearly made out. The most probable explanation is, that it is due to the irregular action of the cementing material upon included particles of slag, consisting of basic protosilicate of iron, which is reduced to the metallic state with the evolution of carbonic oxide, which blows up the surface of the metal when in a softened condition from the heat of the furnace. The average increase of weight in the conversion of bar iron into blistered steel is from $\frac{1}{2}$ to $\frac{3}{4}$ per cent. The fuel necessary per 100 lbs. of the latter is as follows:—

Coal	75 to 90 lbs.
Lignite . . .	160 " 210 "
Peat	200 " 300 "
Wood . . .	300

Blister-steel bars may be used for common purposes, such as steeling the faces of hammers, without further treatment; but more generally they are subjected to one or more reheatings in packets or faggots, and weldings by hammering or rolling, whereby the texture becomes more uniform, and strength and elasticity are increased, but with a progressive diminution of hardness. Spring steel is produced by heating blistered bars at an orange-red heat, and drawing them down either under the hammer or by rolling. *Shear steel* is a better quality, obtained by drawing the original bars to lengths of 3 feet, which are piled together in faggots and welded, the reheating being effected in a hollow fire. The surface of the faggot is covered with clay, which forms a cinder in the heating process, and prevents the blast from acting on the combined carbon of the crude bars. The product of this operation is known as *single shear*. It may be further refined by doubling the bars, and repeating the process of heating and welding, making double-shear steel. The best and most uniform quality of steel can, however, only be obtained by fusing the blistered bars in crucibles.

Case-hardening, or the production of a thin superficial layer of steel upon malleable iron, is a rapid process of cementation carried out on a small scale. An iron box, heated in a smith's forge, is used as a cementation chest. The charcoal is usually obtained by carbonising animal matter, such as bones, horn, or leather. The articles to be case-hardened are embedded in the charcoal in the ordinary way, and are then exposed to heat for a short time, taking care not to use too high a temperature. Under the most favorable circumstances the cemented layer may attain a depth of about three-eighths of an inch in four or five hours. The work when removed from the fire, is hardened by plunging it while in a heated state into cold water, if it is required to be uniformly hard over the whole surface, otherwise it is allowed to cool, and the steeled surface is removed by turning down such parts as are intended to remain malleable, and the other portion is subsequently hardened by heating and quenching in water as before.

The following is the most rapid method of case-hardening:—The piece of iron to be treated, after being polished, is raised to a bright red heat, and the surface to be hardened is rubbed or sprinkled with finely-powdered yellow prussiate (ferrocyanide of potassium). As soon as the powder has volatilised or disappeared, the work is quenched in cold water in the usual way. If the process has been properly conducted, the surfaces covered by the salt will be found to have become hard enough to resist the file.

Malleable Cast-iron. The process of annealing, or rendering the surface of cast-iron articles malleable, so that they may be filed or hammered, is a kind of inverse cementation, finely-divided peroxide of iron being employed to remove the carbon from the surface of the casting. Cast-iron smelted from the red hematite is generally preferred for this purpose, especially that made with charcoal. The fusion takes place in crucibles in an air furnace, such as is used in for smelting cast-steel, good coke being used as fuel. The castings, when removed from the moulds, are very brittle, and cannot be touched with the file. They are then packed in cast-iron crucibles containing powdered red hematite, which are arranged in rows one above another in a furnace of rectangular section, somewhat similar in character to an ordinary cementation chamber. When the furnace is charged, all the apertures are carefully closed, and heat is applied gradually, so that the whole contents may be be brought up to a red heat in twenty-four hours; the firing is then continued for from three to five days more, according to the depth of the malleable skin required on the finished work. Articles of irregular thickness that are intended to be bored out must be subjected to the process a second time, in order to obtain the proper degree of alteration.

The appearance of the finished articles, when drawn from the furnace, is similar to that of malleable iron, but lighter in color; the density is about the same as cast-iron, the increased specific gravity of the malleable portion being counteracted by its porosity. The fractured surface is white and finely granular, with a very high lustre, occasionally presenting a grey silky appearance, recalling that of soft steel. When the thickness of the object is more than half or two-thirds of an inch, a kernel of very soft grey cast-iron is left in the center. In the latter case the central portion may sometimes be broken by bending the object without the external skin giving way.

Malleable castings, prepared in the above manner, may be easily wrought cold, but become very brittle when heated, breaking to pieces under the hammer at an incipient white heat; at a higher emperature the kernel or unaltered cast-iron melts, so that articles that have been subjected to the process cannot be united by welding, but may be brazed without difficulty. On account of the more refractory nature of the material, the use of malleable cast-iron crucibles has been suggested for melting silver in mints, instead of the cast-iron pots ordinarily used for that purpose. The principal application of the process is, however, to small articles of hardware, such as keys, buckles, gun-furniture, etc. Recently, however, it has been applied on a larger scale by M'Haffie, of Glasgow, to parts of machinery, such as toothed wheels and screw propellers, the latter having been successfully adopted in steamers employed in the whaling and sealing trade in the Greenland seas, where ordinary cast-iron screws are especially liable to be broken by the floating ice. The malleable skin may be partially converted into steel by case-hardening in the same way as ordinary soft iron, so that these different states of cast-iron, malleable iron and steel may be combined in the same object. Common articles of cutlery made in this way are distinguished as *run-steel* goods.

Production of Steel by Fusion. In all the preceding methods, the steel produced, whether by fining or cementation, is, as a rule, very unequal in quality; and uniformity can only be attained by repeated faggoting and welding, steps which are necessarily attended with a loss of carbon, and consequent reduction of hardness. The requisite uniformity of composition may, however, be obtained by breaking up the crude bars produced in the forge, or by cementation, and exposing them to a strong heat in crucibles out of contact with the air. The product, when melted, is poured out into cast-iron moulds, forming ingots of *cast-steel*, which are much more regular in composition and texture than the original material.

The practise of melting steel was introduced at Sheffield by Huntsman about the year 1740, and is still carried out in substantially the same manner at the present day. Although a simple operation, it is an expensive process, owing to the large consumption of fuel and crucibles required for a comparatively small production of ingot.

The crucibles generally used in a steel-melting-house are made of mixtures of different kinds of fire-clay from the coal measures, with a certain proportion of ground potsherds and coke dust; the usual size is from 16 to 18 inches in height, and from 5 to 7 inches in diameter at the mouth, with a slight belly at about two-thirds of the height from the bottom. The capacity varies from 35 to 80 lbs. Usually two pots are placed in a furnace; they stand upon cylindrical discs or cheeses of fire-brick resting on the grate bars. Previously to being used they require to be gradually heated to redness in an open fire or annealing grate, which is done by placing them in batches of twenty, bottom upwards, together with their covers, upon a bed of red-hot coal in the grate; and the intermediate space is then filled with coke, and the fire is urged until the necessary heat has been obtained. The pots are then removed to the melting furnaces, and fixed in position on their stands. The fires are replenished with coke, and as soon as they have been brought up to a strong heat, which takes place in about twenty minutes, the charge of blister steel, properly assorted and broken into small pieces, is introduced through a wrought-iron funnel; after which the cover is placed on the top of the pot, and the full heat of the furnace is given for about three and a half hours, during which time fresh fuel must be added every three-quarters of an hour. When the fusion is complete, which is ascertained by removing the cover and searching the contents of the crucible with a pointed rod, in order to ascertain whether any hard unmelted lumps remain, the crucible is cleared from adherent slaggy masses by stirring below the grate, and is then lifted out by the furnaceman with a pair of curved-nosed tongs. The ingot mold, made of cast-iron, is blackened by coating it with train oil and heating; or, in some cases, a thin wash of fire-clay, mixed with water to the consistency of cream, is used. When the pot is removed from the furnace it is deposited in the teaming hole, a small pit filled with broken pieces of coke, and the lifting bags are changed for those used in casting. The contents of the crucible are allowed to cool for a short time before pouring. When the ingot mold is filled, its mouth is covered with a plug of cast or wrought-iron, or a shovelful of sand, in order to prevent the top of the ingot from becoming spongy by the escape of gases before solidification.

After the first cast the crucible is cleared from adherent clinker, and returned to the furnace for a second melting. The charge is somewhat reduced, and the consumption of coke, as well as the time of fusion, is diminished in a similar proportion. Thus the first melting takes from four to six hours, while the second and third only require from two to two and a half hours each. The furnace is allowed to cool after from three to five meltings have been made, as there is no advantage to be gained by keeping it constantly heated, owing to the corrosion of the lining bricks produced by the very high temperature, whereby the capacity and the power of the consuming fuel is increased, without any corresponding increase in the amount of steel melted. Under ordinary circumstances the total amount of coke burnt is from three to three and a half times the weight of the ingots produced, when of a good quality; but when made from inferior varieties of coal, it may be as high as five or six times the weight.

In France furnaces are used capable of containing a large number of crucibles which are not brought into direct contact with the fuel, but are arranged in series in a chamber, which is heated by a fireplace similar to that of a reverberatory furnace. The chambers, which are made to hold from four to nine pots, are covered with a square lid in the usual way. In addition to the chimney draught, a blast is used below the grate, and a portion of the waste heat is sometimes applied to raising steam for the hammers and rolling-mills used in finishing the ingots. Siemens' regenerative gas-furnace has also been applied with considerable advantage to steel melting, and by its use the consumption of fuel per ton is reduced from 3½ tons of coke to 1½ tons of inferior slack.

When very large masses of cast-steel are required, the contents of all the crucibles are either poured into the foundry ladle before filling the mold, or the pouring is so arranged that by bringing up relays of fresh pots, a constant stream may be kept up without intermission. In this way large castings, up to as much as 40 tons, are made by Krupp, in Essen, from crucibles containing 70 lbs. of steel. The furnaces hold from 2 to 24 pots each. The materials used are reported to be puddled steel and wrought-iron scrap, with an addition of carbonaceous matter, in order to render the malleable iron fusible, a somewhat similar process to that adopted in making the native Indian steel, called wootz. The drawing of the crucibles from the furnace is also facilitated by placing them on a platform, which is raised by a mechanical lifting apparatus placed below the ash-pit, thus doing away with the use of the lifting-tongs.

At the River Don Steel Works in Sheffield, cast-steel is largely made by the method introduced by Mushet in 1801, which consists in melting malleable scrap-iron with charcoal and oxide of manganese in crucibles directly, without using any blister-steel. The furnaces are 288 in number, each of sufficient size to contain two pots charged with 100 lbs. With the whole number at work, a casting of 25 tons weight may be made, the pouring from the 576 pots being completed in five minutes. In order to keep up the supply, the pots are conveyed from their melting-holes to the casting-place on small barrows, instead of being carried by the tongs, as was formerly the custom. The steel produced is to a great extent employed in making castings for direct use, such as railway crossings, wheels, and bells, instead of merely running it into ingots, which are subsequently worked up under the hammer. The molds used for this purpose are made sufficiently refractory by the use of a thin layer of burned clay, produced by grinding old metal pots, which is applied immediately over the pattern, the remainder of the box being filled with ordinary molding sand. This method of steel casting was first practiced at Bochum, in Westphalia, where it is still carried out on a rather large scale. Castings made to pattern, which are not intended to be subsequently hammered, must be annealed and allowed to cool very slowly.

An addition of manganese, either as a carburet reduced by heating the oxide with carbon at a very high temperature, or a mixture of black oxide of manganese with carbonized pitch or resin, is very commonly used for improving steel in the process of melting. This is the celebrated process of Heath, which formed the subject of long and protracted litigation a few years back. The appearance of fracture of ingots of cast-steel varies with their hardness or relative proportion of carbon. The softer kinds are bright and finely granular. The harder qualities often show crystalline plates of a certain size, arranged in parallel stripes or columns at right angles to the surface of the mold, so that in a square ingot the columns intersect, forming a cross. In all cases the ingots are more or less unsound, being filled with small vesicular cavities, so that they require to be reheated and hammered before they can be converted into bars. This is done in the manner already described for making shear-steel, care being taken to effect the reheating at as low a temperature as possible, and to prevent the metal from burning by keeping it out of access of the air while in the fire.

Bessemer's Process. This, one of the simplest methods of producing cast-steel in large quantities, combines the action of the puddling and ordinary steel-melting furnace into one operation. The essence of the process consists in injecting large quantities of air into a bath of molten cast iron through a large number of small orifices, in order that the combustion of the carbon and other matters in combination may take place rapidly and uniformly. By this means a very high temperature is developed in the converting vessel, the heat being sufficient to melt the decarburised malleable iron, instead of producing same in a pasty, weldable condition, as is the case in the puddling-furnace. This great increase of temperature is obviously due to the rapidity of combustion, owing to the intimate contact of the air, which is injected at a much higher pressure, from 15 to 20 lbs. to the square inch, than is used in the ordinary operation of iron-melting, with the molten metal, instead of the decarburised iron merely taking place at the surface of the bath, or where the pasty metal is in contact with particles of scale, cinder, or similar oxidizing agents, as is the case in puddling. It will be remembered that, in the latter process, the temperature of the puddling furnace has to be artificially reduced by closing the damper, in order to bring about the reactions between the different portions of the charge, which only go on very slowly when the contents of the hearth are in a liquid state. In Bessemer's process, however, the increase of temperature goes on progressively from the moment the blowing commences until the conclusion of the operation, the heat produced being developed by combustion going on in the molten mass, in the order in which the combined foreign substances are removed being similar to that observed in puddling and refining. After the whole of the carbon has been eliminated; the heat is kept up, if the blowing be prolonged by the combustion of the iron, giving a product exactly similar in general properties to the *burnt iron* which is obtained when malleable iron is too often or too highly heated in the process of welding.

This process is, therefore, not adapted for the production of soft malleable iron, but, with certain modifications, is capable of producing steel of good quality, within a considerable range of composition and hardness. This may be done in two ways: the first is that practised in Sweden, where the blowing is interrupted after a partial decarburisation of the charge, the proper moment for stopping the operation being determined by the appearance of the flame issuing from the mouth of the converting vessel; or the metal may be completely decarburised, and then brought back to the composition of steel by the addition of highly-carburised melted pig iron, such as spiegeleisen, in sufficient quantity to restore the necessary amount of carbon. The latter modification of the process is due to Mushet, and is now generally preferred to the older method as being more certain in result.

The varieties of cast-iron best adapted for conversion into steel by the Bessemer process are those smelted from hematite or magnetic ores not below No. 2 in greyness. White iron can only be treated with difficulty and increased waste, partly owing to its imperfect fluidity when melted, which increases the resistance offered to the passage of the blast, but more particularly on account of its deficiency in carbon and silicon. The carbon being in the combined state, the production of carbonic oxide takes place at too early a stage of the process, and not being present in sufficient quantity, prevents the attainment of the proper temperature in the converting vessel.

The chief essentials in the chemical composition of the pig iron are almost absolute freedom from sulphur, phosphorus and copper, as neither of these ingredients is sensibly reduced in the amount by the process; silicon and manganese, on the other hand, may be almost completely removed, and their presence is beneficial within certain limits. As long as manganese remains scarcely any iron is oxidized, the silica produced from the silicon of the metal uniting with protoxide of manganese to form a slag, which is very fluid, but also is very destructive to the siliceous linings of the converting vessels.

The best English pig iron for use in the Bessemer process is that smelted from Cumberland hematite, about No. 1 or No. 2 in greyness. It should contain from 1½ to 2 per cent. of phosphorus. At Essen, in Westphalia, the limiting quantities of foreign matters in the pig iron preferred for Bessemer steel-making are as follows, according to Jordan. The metal generelly used is smelted from mixtures of spathic ore and Nassau hematite.

Manganese, maximum	1.00	per cent.
Sulphur "	.04	"
Phosphorus "	.06	"
Carbon, minimum	5.00	"
Silicon "	2.00	"

The furnaces, or *converters*, employed in the process are of two different kinds. The oldest, or fixed form, which has been used to a certain extent in Sweden, is a cylindrical vessel of refractory brickwork, somewhat similar to a foundry cupola, but broader and lower in proportion. Near the bottom, which is made with a slightly forward incline towards the tap-hole, is placed a series of small twyers, which are arranged at equal distances around the entire circumference. The top of the vessel is covered by a dome, terminating in a conical neck, turned towards a hood placed above it, for carrying off the flame and sparks given out during the blowing.

The second, or movable, form of converter, which is now almost universally adopted, consists of an egg or pear-shaped vessel suspended upon trunnions, and provided with appropriate moving mechanism, whereby it may be rotated vertically through an angle of about 180°. The outer casing or shell is made of wrought-iron plates riveted together, and, as originally made, was not unlike a soda-water bottle in shape, supposing the pointed end to be flattened, and the neck turned over at an angle of about 30° to the body. In the newer forms, however, especially those intended for working with large charges, increased capacity is obtained by making the body and lower part cylindrical, thus approximating in outline to the older fixed converters.

The suspension is effected by means of a stout hoop of wrought-iron or steel carrying two trunnions, which is shrunk on to the body of the converter at the widest part. One of these trunnions, which run in bearings supported by cast-iron standards, is solid, while the other is hollow, forming a passage for the blast, and carries a spur pinion.

The interior lining of the converter must be made of the most refractory material at hand. Fire-brick or clay may be used; but in Sheffield, and in England generally, a nearly pure siliceous sandstone from below the coal measures, known as ganister, is found to be better adapted for this purpose than any other substance. It is prepared by grinding to a fine powder, and may be used alone or mixed with a certain proportion of powdered fire-brick; in either case a small quantity of water is used, sufficient to make the powder slightly coherent, which is then rammed hard between the inside of the shell and a wooden core, which is afterwards removed. The old form of vessel is made in two parts, which are united by screw bolts, and can be taken apart for convenience in lining. In the cylindrical-bodied form, the lower part is made removable, the union being effected by eye-bolts and cotters.

The bottom of the converter is in either case flat, and contains the twyer-box. This is a cylindrical chamber, connected by a curved pipe with the hollow trunnion. The twyers are cylindrical or slightly tapered fire-bricks, each perforated by seven parallel holes, about half an inch in diameter. Usually from five to seven of these bricks are used, which are arranged vertically and at equal distances apart in the lining of the bottom of the converter. Their lower ends pass through a perforated guard plate in the top of the air chamber, the vertical position being maintained by stops bearing against the horizontal arms, which may be turned on one side, when it is necessary to remove or replace the bricks, without being obliged to take out the bottom of the converter.

In the earlier Bessemer works two converters are placed opposite to each other with a deep cylindrical casting pit between them. In the center of the pit is fixed another water-pressure engine, with a vertical cylinder and solid plunger piston, carrying at its upper end a cross-arm, formed of two parallel girders strongly braced together, to one end of which is attached the ladle,the overhanging weight being supported by a counterpoise attached to the opposite end. The ladle, which is similar to that used by iron founders, but considerably larger,is made of wrought iron lined with fire-clay, having a small hole in the bottom for running out the melted steel into the ingot molds placed below. The hole is closed by an iron rod coated with fire-clay. The opposite end of the rod passes through a slide bar on the outside of the ladle, and may be raised or lowered by means of a hand lever. In order to traverse the ladle about the central pillar, so as to bring the center of the hole over each of the molds in succession, the top platform is provided with spur gearing, so that it may be moved like a railway turn-table. This motion is worked by a man standing on the platform, as is also another for reversing the ladle on its bearings, in order to remove the waste after the end of the cast. The valve of the central engine, which raises and lowers the ladle, is in charge of the same man who works the tipping engines for the converters. He is usually stationed in a box at one side of the converting house, raised a sufficient height above the ground to command a clear view of the whole of the apparatus. The power for working the engines is obtained from a small steam-engine driving the necessary force pumps, which deliver their supply into two accumulators for equalising the pressure.

The method of conducting the process is as follows:—The charge of pig iron, which may be of any weight between 1½ and 10 tons—3 to 8 tons are now generally used in preference to the smaller weights—is melted in a cupola, or brought melted in a ladle from the blast furnace. The converter, having been previously brought up to a red heat by filling it with ignited coke, is reversed in order to remove any unconsumed fuel, and afterwards turned back to a horizontal position to receive the charge of molten metal, which is run in through a movable gutter of wrought-iron lined with sand. It is then slowly brought back to the vertical position, and the blast is turned on. At first the flame issuing from the neck is of a yellowish or reddish color, but slightly luminous, with only a comparatively small amount of sparks. During this period, lasting from four to six minutes, the action going on is similar to that in the refinery in the first stage of puddling, namely, the conversion of graphitic into combined carbon, and the oxidation of silicon, with the formation of a silicate of protoxide of iron and manganese. In the second or boiling period, when the oxygen of the blast begins to attack the carbon, the action becomes very violent, the flame increases in brilliancy, and great showers of sparks, fragments of burning iron, and finely-divided slag are thrown out, owing to the rapid ebullition produced by the evolution of carbonic oxide from all parts of the melted metal. This lasts for about six or eight minutes longer, when the sparks diminish and the action goes on more quietly without the production of sparks. The flame gives the characteristic bluish violet of carbonic oxide, and is intensely hot—a point marking the last or fining stage. When the last trace of carbon is burnt away, the flame suddenly drops, and is succeeded by a stream of luminous white-hot gas, consisting principally of nitrogen, the heat being kept up from this moment, if the blowing be continued, entirely by the combustion of the molten decarburised iron. As soon, however, as the flame indicates that the whole of the carbon is removed, the converter is turned back to the horizontal position, and the proper quantity, usually about 10 per cent., of molten spiegeleisen, or other similar compound of iron, carbon, and manganese, is run in from the air furnace in the same manner as the original charge. Formerly the blowing was resumed for a few minutes after addition of the spiegeleisen, but this is now discontinued, and the contents of the converter are emptied into the ladle, which has been brought into the proper position by lowering the central pillar of the crane. The ingot moulds usually employed are made of cast-iron, open at both ends, of an octagonal or circular form of base, and somewhat smaller in diameter at the top than the bottom. They are arranged in a a semi-circle on the floor of the casting pit. The ladle is raised to a sufficient height to clear the top of the moulds, and is turned so as to bring the hole over the center of each one successfully; the plug is lifted, and the molten steel flows out in a stream about an inch thick. Care must be taken to prevent the stream from striking against the side of the mould, in which case the ingot is likely to be unsound. When the mould is filled a small quantity of sand is thrown on the surface of the metal, which is then covered by a piece of thin sheet iron, and the whole is secured by a cross bar passing through two eyes on the top of the mould. After the converter is charged, the blast must be admitted before it is turned back to the vertical position, otherwise the moulten metal would run down through the twyers. A pressure of from 5 to 6 lbs. per square inch is required to overcome the hydraulic head of the liquid column of metal, and from 9 to 14 lbs. more to force the air through at the proper velocity, or from 15 to 20 lbs, per square inch total pressure. An arrangement for opening and shutting the valve by the rotation of the converter is provided. The valve, which is of a double-beat form, has its stem prolonged upwards, and carries a weight tending to keep it pressed against its seat. The lifting mechanism consists of a lever worked by an eccentric disc attached to the axis of the converter. When the latter is lowered for filling, the pressure of the eccentric is taken off the lever, and the valve closes; but when the motion takes place in the opposite direction, the cam part of the disc lifts the lever, and with it the valve. By this arrangement, the opening and shutting of the valves at the right moment, a point of great importance, are made completely independent of the action of the man working the converter.

In both Sweden and Austria the process is usually conducted without remelting the pig iron, which is tapped directly from the blast furnace into the converter. In the former country the addition of spiegeleisen was formerly dispensed with, the blowing being only continued for a very short time after the more rapid boiling has ceased. The uncertainty of being able to stop the process at the right moment has led to the more general adoption of total decarburisation, and the addition of spiegeleisen in the manner already described.

Although spiegeleisen as now made usually contains much more manganese, 20 per cent. and above, than that formerly produced from spathic ores, its use has in great part been superseded by the richer alloys, known as *ferro-manganese*, which contain up to as much as 87 per cent. of the latter metal. They are especially valuable in making extra soft steel where it is desired to add a proportion of manganese without increasing that of carbon, as is done in the production of the so-called phosphorus steel. Another alloy, containing about 10 per cent. of silicon and 20 of manganese (*silico ferro-manganese*), is also specially applied in the production of steel castings, a certain proportion of silicon causing the metal to set in the mould without developing blow-holes.

It need scarcely be said that the reactions going on in the Bessemer converter are substantially similar to those observed in puddling and hearth fining. The following, one of the earliest complete series of analysis of products taken at different stages of the process that was published, refers to the Austrian Government Works at Neuburg, in Styria. The pig iron operated upon is smelted from the spathic ores of the Erzberg with charcoal.

ANALYSIS OF METAL.	I.	II.	III.	IV.	V.
Carbon, graphitic	3.180	—	—	—	—
" combined	0.750	2.465	0.919	0.087	0.234
Silicon	1.960	0.443	0.112	0.028	0.033
Phosphorus	0.040	0.040	0.045	0.045	0.044
Sulphur	0.018	trace	trace	trace	trace
Manganese	3.460	1.645	0.429	0.113	0.139
Copper	0.085	0.091	0.095	0.120	0.105

No. I. Original pig iron.
" II. Metal taken at end of first stage.
" III. " " after the boil.
" IV. " " end of the blowing.
" V. " restored to steel by addition of pig iron.

COMPOSITION OF SLAGS.	II.	III.	IV.	V.
Silica	46·78	51·75	46·75	47·27
Alumina	4·65	2·98	2·80	3·45
Protoxide of iron	6·78	5·50	16·86	15·43
" manganese	37·00	37·90	32·23	31·89
Lime	2·98	1·76	1·19	1·23
Magnesia	1·53	0·45	0·52	0·61
Potash, Soda	traces throughout			
Sulphur	0·04	trace	trace	trace
Phosphorus	0·03	0·02	0·01	0·01

These analyses are numbered to correspond with those of the metal taken at the same time.

It will be seen from the above analyses that the iron is not oxidized by the blast to any great extent until nearly the whole of the manganese and carbon have been removed. The retention of the entire quantity of phosphorus contained in the original pig iron in the finished steel is in accordance with observations made in other countries. Newer methods of conducting the process, whereby steel of good quality can be produced from Cleveland and similar brands of pig metal rich in phosphorus, are described further on.

In Sweden and Austria the finished steel is classified by numbers, according to the hardness and percentage of carbon, commencing with the most highly carburised. The amount of carbon is determined by Eggertz's colorimetric method. The following is the proportion of carbon in Bessemer steel from Heft:

No.	Specific gravity.	Carbon.	Silicon.
II.	7·791	1·35	0.02
III.	7·828	1·15	trace
IV.	7·848	0·85	0·02
V.	7.856	0·72	0·03
VI.	7·836	0·53	trace
VII.	7·872	0·11	trace

In Sweden a similar basis of classification is adopted; but instead of arbitrary numbers, the qualities are distinguished by the actual percentages of the carbon.

At Seraing, in Belgium, the follwing scale is used. It applies only to the milder qualities.

Class.	Carbon per cent.	Tensile strength. Kilog. per sq. m.m.	Elongation per cent.	Properties.
Extra soft	0·25—0·35	48—56	20 to 25	Welds, but does not harden.
Soft	0·35—0·45	56—69	10 to 20	Welds and hardens imperfectly
Semi-hard	0·45—0·55			
Hard	0·55—0,65	69—105	5 to 10	Hardens, but does not weld.

Ingots with more than 0·65 per cent. are classed as extra hard, but they are not produced in the regular system of working.

The slags of the Bessemer process vary considerably in composition from those of the puddling-furnace, being much more acid and approximate to the pyroxene formula $RO\ SiO^2$. At Hörde, in Westphalia, a crystallized slag has been obtained which yielded by analysis—

Silica	41·73
Protoxide of iron	20·59
" manganese	32·74
Lime	1·58
Magnesia	0·17
	99·76

Oxygen, ratio of silica : bases = 23.85 : 12.43.
Specific gravity, 3.08.

The crystals were found to be of the angular augite form, the angles being intermediate between those of the natural minerals Pajsbergite and Babingtonite as is also their composition.

The enormously high temperature developed by the action of the cold air on moulten cast-iron in the Bessemer process is obviously due to the extreme rapidity with which the operation takes place, and the advantageous form of the converter for concentrating the heat developed. For, although the reactions, and consequently the heat produced, are in no way different from those of other finery processes, whether in the open fire or reverberatory furnace—carbon, silicon, manganese, and some iron being burnt in either case, with the productions of carbonic oxide, silicate of protoxide of iron and manganese, and malleable iron—we have, in the blowing of a charge weighing five tons, an amount of work done in about twenty minutes that would require from two and a half to three days in its performance in the puddling-furnace. It has been pointed out by Jordan that the principal part of the heat developed in the process is due to the combustion of the silicon, which, when oxidized to silicic acid, combines with protoxide of iron and other bases, and remains in the bath in the form of slag; while in the case of carbon a portion of the heat is expended in volatilizing the carbonic oxide produced, which escapes at the temperature of the melted metal, and burns to waste at the mouth of the converter. Should the calorific power of silicon be assumed to be the same as that of carbon, the amount of heat produced by the combustion of one kilogramme of silicon to silicic acid will be 8,000 units when burnt in pure oxygen, or 6,382 in air; the difference between the two quantities corresponding to the amount required to heat up the inert nitrogen. Under the latter condition, one kilogramme of carbon will produce only 475 effective units, being the difference between 2,473 units theoretically developed, and 1,998 units carried off by the gaseous products, carbonic oxide and nitrogen, supposing them to escape at a temperature of 1,400°. The use of steam instead of air as an oxidizing agent, is, in the case of combustion of iron or carbon, always disavantageous, on account of the great amount of heat required to free the oxygen from its combination with hydrogen, which is not reproduced to the same extent in the subsequent formation of carbonic oxide or protroxide of iron. With silicon, however, the conditions are somewhat different, as there is a small sensible gain. This will explain the reason why the use of steam in the refinery is only recommended for a few minutes at the commencement of the operation—that is, as long as free silicon remains in the pig iron under treatment.

By applying the quantities given above to the calculation of the amount of heat developed in the blowing of one ton of Bessemer pig iron of the ordinary quality produced in the South of France, which is the following composition per ton of 1,000 kilog.—

Carbon . . .	42.50
Silicon . . .	20.00
Iron and manganese.	937.50
	1000.09

Jordan arrives at the following results —

Kilogr.	Units of heat.
The combustion of 20 of silicon produces	127,648.
The combustion of 42.5 of carbon produces	20,176
The combustion of 87.5 of iron and mang. produces	66.237.
Or a total of	214,061.

If we take the specific heat of molten and malleable iron at 0.16, the amount of heat developed will be sufficient to raise the temperature of the metal, which is supposed to be completely decarburised, about 1,350 degrees above that of the cast-iron when run into the converter.

The great heating power of silicon is therefore to be regarded as the reason for the use of dark grey iron in the Bessemer process; under all ordinary circumstances, about 2 or 2.5 per cent. silicon being considered as essential. Jordan states that in the steel works in the south of France the process could only be carried out by running the cast-iron directly from the blast-furnace into the converter, the amount of silicon being not sufficient to allow of remelting of the pigs—an operation which is usually attended with a loss of about 1 per cent. of silicon. The place of silicon as a heat-producer in the Bessemer process may be, to some extent, taken by manganese, as is the case in Styria, where the cast-iron used is smelted from the spathic ores. It is, however, less advantageous, because the deficiency in silica, which is required to flux the protoxide of manganese formed, can only be supplied by the destruction of the siliceous lining of the converter.

Although silicon is an essential component of good Bessemer pig iron, it is of importance that the amount per cent. should be somewhere above the same as, or not very much more than, that of the carbon. An excess of the former element works prejudically in two ways—first, it gives rise to an increased waste of iron in the slag; and, secondly, it cannot be completely removed before the whole of the carbon is burnt away, so that it may happen, in the blowing of such metal, that, although the process is apparently complete as determined by the usual indication of the cessation of the flame from the converter, sufficient silicon is retained in the decarburised metal to render the finished steel brittle and useless. Snelus gives the following analyses in illustration of this point. (See table at head of page.)

	I.	II.	III.	IV.
Carbon	0.445	0.515	0.550	0.490
Silicon	0.814	0.270	0.640	0.009
Sulphur	—	—	0.067	0.033
Phosphorus	—	—	0.038	0.036
Manganese	—	—	0.554	0.576
Copper	—	—	0.554	0.025

Analyses I., II. and III., are examples of underblown and brittle steel, rich in silicon; IV. is the ordinary composition of good Besemer rail-steel made at Dowlais.

The following series of analyses, by the same chemist, of metal taken at different stages of the blow, show very distinctly the gradual removal of the carbon along with the silicon: :

	I.	II.	III.	IV.	V.	VI.
Carbon, graphitic	2.070	—	—	—	—	—
" combined	1.200	2.170	1.550	0.097	0.566	0.519
Silicon	1.952	0.795	0.635	0.020	0.030	0.030
Sulphur	0.014	trace	trace	trace	trace	trace
Phosphorus	0.048	0.051	0.064	0.057	0.055	0.053
Manganese	0.086	trace	trace	trace	0.309	0.309
Copper	—	—	—	—	0 039	0.039
Ratio of carbon to silicon	1.6: 1	2.7: 1	2.4: 1	4.8: 1	19: 1	17: 1

I. melted charge of pig; II. metal at end of first stage, 6 minutes from start; III. metal after blowing 9 minutes; IV. over-blown metal, 13 minutes from start, before adding spiegeleisen; V. steel from ingot; VI. steel from finished rail.

It will be noticed on comparing these analyses with the similar series from Styria that the observed phenomena are substantially the same in both instances. The difference in the amount of copper, which is much larger in the Styrian steel than in that from Dowlais, is to be attributed to the fact that the pig iron used in the former is entirely smelted from spathic ore, while in the latter only the spiegeleisen is due to that source. Copper pyrites, in small quantity, is almost invariably present in spathic carbonates, and, however carefully they may be roasted and weathered, some copper, as a general rule, is reduced, and passes into the iron in the blast furnace.

The progress of the conversion of the charge can be controlled to some extent by observing the spectrum given by the flame with the spectroscope; and more particularly the moment of complete decarburisation may be determined with considerable accuracy, especially if the flame be bright and free from smoke. The spectrum produced when combustion is most active is characterized by groups of numerous lines in the yellow and green portions, that of sodium being the most prominent and the first to appear among the former. There is also a well-defined group of lines in the blue field, and under the most favorable conditions the violet and red lines of potassium and lithium, together with an extra violet line accompanying the former, are seen. For this, however, an instrument of great defining power, and an extremely bright flame are essential. When the metal is completely decarburised, the yellow and green lines disappear, but the sodium is persistent, sometimes even after the tipping of the converter. On the addition of the spiegeleisen, the whole of the lines reappear with great brilliancy. When there is much manganese in the cast-iron employed, as is the case in Styria, the use of the spectroscope is difficult, owing to the brown smoky character of the flame.

At Seraing, it has been found that the disappearance of the dark absorption-bands, which alternate with the bright lines, can be much more readily determined than the latter, which often reappear after their apparent extinction, and is therefore to be preferred as admitting of much closer and easier observation. The exact chemical character of the spectrum of the Bessemer flame has not as yet been made out, although it has been the cause of considerable controversy, there being two different opinions as to its origin. One of these supposes the lines to be due to carbonic oxide and their cessation to the complete combustion of the carbon, while the other considers that they are mainly produced by manganese, and that their sudden disappearance may be accounted for by the diminution in the amount of the metal volatilized until the quantity present in the flame is reduced below that necessary to produce them, it having been found that for the detection of manganese by the spectroscope much larger quantities must be employed than are sufficient to produce the ordinary reaction with soda on platinum foil before the blowpipe.

Another indication of the progress of the operation, is that afforded by the character of the slag. This has been employed in Austria and Sweden. An iron rod is inserted into the converter, and when brought out a portion of the slag adheres to the point. So long as any carbon remains unconsumed a peculiar brownish tint is observed, but as soon as the point of total decarburisation is reached, the slag assumes a dead black color, with a peculiar metallic lustre characteristic of the presence of protoxide of iron in considerable quantity. This test is said to be capable of great precision in the hands of experienced workmen.

At Seraing the following relations have been observed between the color of the converter slag and the temper or proportion of carbon in the blown metal.

Lemon yellow .	0·75 per cent and above
Orange . . .	0·60 " "
Light Brown . .	0·45 " "
Dark brown . .	0·30 " "
Bluish black . .	0·15 " "

In the earlier period of the working of the process at Sheffield, the yield of ingots was 77½ per cent., on the weight of the pig iron charged, 15 per cent. being lost in the converter and 7½ per cent. in the remelting in the reverberatory furnace. With three-ton converters the lining required renewal after blowing 250 tons, but the endurance of the twyers was much less, and they required to be replaced after every third or fourth operation. This was done by knocking out the stumps of the worn twyers and inserting new ones, the joint being made tight by pouring in a semi-fluid paste of ganister, or letting the vessel cool so as to be able to send a man to ram the crevices up with the mixture. With this arrangement the number of blows that could be obtained with a pair of converters was only from about six to eight in twenty-four hours, as, although the actual blowing did not require more than fifteen or twenty minutes, much time was consumed in the necessary operations of casting, and especially the placing and removal of the ingot molds. For more rapid work it is necessary, therefore to save time in the subsidiary operations of—(*a*) smelting the pig metal; (*b*) repairing or replacing the converter linings, wholly or in part; and (*c*) handling, *i. e.*, placing, filling, and removing the ingot molds. The first of these requirements is met by the provision of a large number of cupola melting furnaces, or by taking the metal directly in the melted state from the blast-furnaces. The former method is practised in America, the latter being confined to European works, where it is becoming general when the conditions are favorable for its use. Where the works are small, as in Sweden, the converters may be placed close to the pig beds and below them, so that the molten iron may have the smallest possible distance to travel; but in England, where the steel works are necessarily at a distance from the blast-furnaces, the metal is lifted into a ladle mounted upon wheels, which is drawn to the converter by a locomotive, and is either delivered at such a height that it may be tapped directly into the converter, or is lifted by a hydraulic lift The railway for the ladle usually runs the whole length of the range of the blast-furnaces in a tunnel below the level of the ordinary pig beds, and the charge is drawn from two or more blast-furnaces to obtain uniformity in the quality of the metal. At Barrow the melted metal is taken by a line, which is nearly two miles in length, between the blast-furnace and the steel works, but it is not appreciably chilled by the journey. At Givors, in the South of France, by a combination of this kind a very great economy in fuel has been attained; with two blast-furnaces and two converters about 24,000 tons of steel ingots are produced annually without any further expenditure of fuel than the coke consumed in the blast-furnaces. The metal is run directly into the converters, and the waste gas of the furnace tops is sufficient to drive the smelting and Bessemer blast-engines and the hydraulic cranes connected with the converters, as well as to heat the blast by the use of Cowper's stove.

For facilitating the repair of the twyers, which are subjected to rapid corrosion by the action of the slag, it is now customary to attach the bottom to the body of the converter by eye-bolts and cotters, so that it can be easily detached and replaced when necessary. Particular attention is paid to this point in America, where a special hydraulic lift is placed below the converter for the purpose of facilitating this operation. In the new process of Thomas and Gilchrist, the lining of the converter-body, being very rapidly acted upon, requires more frequent replacing than in the older method, and therefore it is necessary to arrange for the substitution of new converters for worn ones without stopping to cool down. This may be done by making the body detachable from the trunnion-belt, so that when the converter is reversed it may be dropped upon a lift and lowered to a railway truck, the new one in the same way being lifted into its place, mouth downwards, when it is keyed up and turned over into the working position. This is the plan devised by the late A. L. Holley, in America. At Eston, the more direct method of lifting the entire converter out of the trunnion bearings by a steam-crane traveling on an overhead railway has been adopted.

The third requirement, that of an increased facility in handling the ingots, has been obtained by modifying the arrangement of all the different parts of the plant, and more particularly in the position of the converters with reference to the ingot moulds. In the original arrangement, where the two converters were placed with their mouths turned towards each other, at opposite ends of the diameter of the circle swept by the center crane, the space for the moulds was restricted to a semi-circle or less; while by placing them side by side, with their axes parallel, or but slightly converging, a much larger space, up to three-quarters or more of the entire circle, is rendered available for placing moulds, and the number of ingot cranes may be increased. This arrangement was first adopted in America, where it is combined with the further improvement of restricting the central ladle crane entirely to the service of the converters, the ladle, when the melted steel is poured, being transferred to a second crane, commanding a pit of larger radius containing the moulds. The transfer is made by bringing the arms of the two cranes into the same line, and moving the ladle, which is mounted on wheels, by hand gearing or by a hydraulic piston mounted on the frame of the larger crane. It is also found more convenient to work with the moulds at the natural level of the ground, so that in all new works the sunk pits are no longer used, the converters being mounted on piers or cast-iron standards. The following are the principal working results obtained in two English and two American works, in 1880:—

Dowlais, S. Wales. Two converters, 10-ton charges pig iron, with 1.2 per cent. manganese and 8 per cent. of spiegel, with 15 per cent. manganese; and 13 twyer bricks, with 13 air channels of ⅝ inch, giving a twyer area of 487 square inches per ton of metal blown. Blast pressure of 15 to 25 lbs. per square inch. The bottoms last 12 blows without any intermediate replacing of twyers. Length of blow 18 minutes. Number of casts per day 28. Make of ingots per week 1,600. Yield 88 per cent.

Rhymney, S. Wales. Three converters, 8-ton charges pig iron, 2 per cent. manganese, and 10 per cent. spiegel, with 20 per cent. manganese; 16 twyer bricks, with 13⅜-inch holes. Twyer area per ton 2.87

square inches. Blast pressure 30 lbs. The bottoms last from 16 to 30 blows, with the consumption of 24 extra twyer bricks. Length of blow from 13 to 15 minutes. Number of casts per day 36. Make per week 1,600 to 1,800 tons. Yield 85 per cent.

Bethlehem, Pennsylvania. Two converters. 7-ton charges pig iron, with 1.5 per cent manganese, 10 per cent. steel scrap, 10 per cent. spiegel, with 15 per cent. manganese; 12 twyer bricks each with some 12 ⅝-inch holes. Twyer area 2.48 square inches per ton. Blast pressure 25 pounds per square inch. Bottoms last 8 to 9 blows, with 12 extra twyer bricks per week. Length of blow 15 to 16 minutes. Number of casts 45 to 46 per day. Make per week 1,800 to 2,000 tons. Yield 90 per cent.

Cambria, Pennsylvania. Two converters, 7-ton charges pig iron, with 1.5 per cent. manganese, 18 to 20 per cent. steel scrap, 7 per cent. spiegel, with 15 per cent. manganese; 11 twyers, with 12 $\frac{7}{16}$-inch holes. Twyer area 3.19 square inches per ton. Blast pressure 28 lbs. Bottoms last from 10 to 19 blows. Time of blow 17 minutes. Number of casts 72 per day. Make per week 2,600 tons. Yield 90 per cent.

The average production of each of the 24 converters at work in America, in the month of November, 1881, was 5,400 tons. The Edgar Thompson and Bethlehem works, Pittsburg, each with a pair of 8-ton converters made in the year 1881, 16,235 tons and 16,729 tons respectively. At the former works 496 casts were made in the week ending December 3rd, 1881, giving 3,813 tons of ingots, the largest make in twenty-four hours being 700 tons. It is not, however, considered by European steel-makers that these very high working results could be imitated with advantage on economic grounds.

Basic-Bessemer Process. The method of conducting the Bessemer process described above, and requiring for its success a rich pure pig metal essentially free from phosphorus and sulphur, but containing a notable proportion of silicon, was, with certain modifications in detail, alone practised up to within two or three years of the present time. As the proportion of such pig metal available is comparatively small as compared with the inferior ores of the more highly phosphuretted kinds smelted from the newer sedimentary formations in Cleveland, Luxemburg, and elsewhere in Europe, the discovery of means of utilizing the latter for steel-making has long been sought by different investigators. In 1872 Snelus determined by experiment that the retention of phosphorus by the metal was intimately related to the character of the slag (which, as has already been shown, is essentially a normal silicate of the form of $ROSiO^2$), and that when this could be rendered of a more basic character the greatest part of the phosphorus could be eliminated in the slag in the same way as in the puddling furnace. This he did by the addition of lime and oxide of iron, and more particularly by substituting for the ordinary siliceous converter lining of ganister, one in which lime and magnesia were the essential constituents, the best results being obtained with bricks made of magnesian limestone which had been burnt at a very high temperature. These experiments, made upon Cleveland pig iron with 1 to 2 per cent. of phosphorus, showed that good steel could be made from it with only 0.1, or not sensibly more than in that made from hematite. But they were unpublished until the announcement of similar results having been obtained by Thomas and Gilchrist, at Blaenafon, and subsequently as a working experiment at Eston, in Cleveland, where it has since been carried out on the largest scale in regular practice, as well as at Hörde and Ruhrort, in Westphalia, and several other works in Germany and Eastern France. The process is now conducted in the following manner: The converter, which is lined either with bricks made of hard burnt dolomite set in tar asphalte, or with the same rendered plastic and rammed round a core, is heated by a fire off coke breeze, and a quantity of quick-lime equal to 15 to 20 per cent. of the weight of the charge of metal is thrown in. The latter may contain any amount of phosphorus, but should be as free as possible from silicon and sulphur, the latter being corrected by a proportion of manganese when white iron is used. It should be poured in as hot as possible. The blowing is conducted in the ordinary way until the whole of the carbon is burnt off, which requires about ten minutes, when, instead of casting, the blast is kept on for two or three minutes longer, which causes a great increase in the temperature of the bath with a thickening of the converter smoke. This so-called *afterblow* is the period of dephosphorisation; its duration is controlled by taking a test of the metal in a ladle, which is cast and flattened under a steam-hammer, cooled in water, and broken, which can be done in five minutes. When the desired malleability is obtained the converter is tipped to run out the slag, and spiegeleisen or ferromanganese is added in the usual way. The removal of the slag is important, as a portion of the phosphorus may be reabsorbed if it is left in contact with the melted metal.

At Eston the converter linings are made of dolomite carefully ground and burnt, mixed with tar which has been well boiled to deprive it completely of water. The upper part is removable, and is lined separately; the body is, however, relined in place by inserting a tapered cast-iron plug heated by a coke fire, and corresponding in size to the inside dimensions of the new lining. The space between this and the old lining, which is not allowed to wear thinner that 3 or 4 inches, is filled with the mixture of tar and dolomite, which becomes plastic when heated. When the blow is finished both the metal and slag are poured into a ladle, and a proportion of hematite pig, very rich in silicon, equal to 4½ per cent. of the charge, is run in through a spout. This causes a very violent reaction, the whole bulk of the slag being blown out and run into a proper receptacle. The spiegel is then added and the metal is cast. The bottoms are made by ramming a mixture containing less tar than that used for the body lining around a series of ½-inch core pins which occupy the place of the twyer bricks. They last eleven blows, as compared with eight when made of ganister. Nearly 1,000 tons of steel can be made without relining the body. According to Thomas's summary of the general results obtained, the production of steel for lining is considerable less than in the original process, and therefore for a given make the number of converters or the facilities for changing them should be increased, but no increase of engine-boiler or crane power is necessary.

With three converters from 22 to 24 charges are blown each day in Germany. The linings require considerable repairs after a number of charges varying from 40 to 70 (average 56) have been blown; the bottoms may last from 8½ to 21 blows (average 14). The average consumption of basic material in lining is rather under 1 cwt. per ton of steel, and for preparing it 24 cwt. of coal or 16 cwt. of coke is required. The consumption of the lime for slag-making is about 3 cwt. per ton of the steel. This slag contains about 50 per cent. of lime, iron 10 per cent., phosphoric acid 12 per cent., silica 15 per cent. in maximum, and variable quantities of manganese according to the source of the metal. It is now returned to the blast-furnace as flux. The loss upon the weight of the pig charged varies from 13 to 19 per cent., averaging 15 per cent. as compared with 12 when working hematite iron. The duration of the operation, including the afterblow, varies from thirteen to twenty-five minutes, not including time for sampling, which when practised takes from three to four minutes more. White pig iron is now generally preferred, but white, grey, or mottled metal may be used indifferently. The amount of phosphorus in eleven varieties actually treated varied from 1 to 3 per cent., that of silicon from 0·5 to 1·3 per cent., and of manganese from 0·35 to 2·0 per cent. Where the silicon exceeds about 1 per cent. the metal may be best treated by blowing it first in an ordinary ganister-lined converter for a few minutes, and then transferring it to the basic-lined one, whereby the wear of the latter is sensibly diminished.

The progressive transformation of the metal during the operation has been studied by several chemists. The following is an example given by Jordan of the blowing of a charge at the Rhenish Steel Works, in Westphalia:—

	A	B	C	D
Carbon	3·276	0·590	0·026	0·302
Silicon	0·476	0·022	0·002	0·016
Manganese	1·131	0·122	0·197	0·540
Phosphorus	2·600	2·064	0·062	0·092
Sulphur	0·062	0·139	0·051	0·040

A. Original metal melted from cupola.

B. After blowing ten minutes, the silicon is almost entirely, and the carbon nearly, removed, while the phosphorus is almost unchanged. The ordinary blow lasted $13\frac{1}{4}$ minutes, when the carbon had diminished to 0·124 per cent.

C. After two minutes' overblow, the phosphorus is rapidly oxidized together with the iron, the carbon and silicon not being further changed.

D. After addition of spiegeleisen. This augments the carbon and silicon, and, to a slight extent, manganese and phosphorus—the latter by the reducing action of the carbon of the metal upon the phosphoric acid of the slag. In this case the proportion of sulphur retained is rather high; usually about one-half is eliminated.

The final slags were of the following composition:

	E	F
Silica	8·05	8·22
Phosphoric Acid (P_2O_5)	18·55	17·15
Iron, Protoxide	8·37	9·24
Manganese	4·45	6·27
Lime	56·54	56·03
Magnesia	3 10	3·29
Sulphur	0.33	0·29

E. At the end of the blow. F. After the addition of the spiegeleisen.

Open-hearth Processes. The production of cast-steel by dissolving the malleable scrap in molten cast-iron without the use of crucibles was patented by Heath in 1845, and a similar method in 1855 by Price and Nicholson. The first actual fusion of cast-steel in the bed of a reverberatory furnace was effected by Sudre, in France, in 1860, when quantities of tool steel up to two tons at a time were run into ingots from a furnace analogous to that used in iron melting, the heat being intensified by a forced draught under the grate, with the result of rapidly destroying the furnace. The introduction of the regenerative furnace, in which the highest temperature can be obtained without strong draught or cutting flame, has, however, furnished the required solution of the problem, and in 1862 it was applied by Attwood, of Towlaw, and Martin, of Sireuil, in France, and subsequently with improvements and modifications in the furnaces and the modes of manipulation by Siemens, Pernot, and others. As it was first worked on the large scale by Messrs. Martin, the name Martin-Siemens process is generally used on the Continent; the modification, using iron ore instead of scrap-iron, is known as the Siemens' process; and latterly the general name of open-hearth process has come into use for both.

In the newer forms of this furnace the roof is made with a strong slope from the flue ends to the center, giving a more plunging flame. The ventilating space below the bed is much enlarged. The gas ports for equal area are made longer and narrower, and the regenerators of increased size are roofed with semi-circular instead of segmental arches, in order to give a larger exhaust flue for the flame, and thus to moderate its temperature before it reaches the regenerator. The size and capacity are also greatly increased, the original charges of 35 cwt. to 5 tons having been increased to 8, 10, or in some instances 15 tons. The materials used are very good pig iron from hematite, which need not be as grey as that required in the Bessemer process for the initial bath, malleable iron in the form of blooms, sponge, or puddle bars, clean scrap, whether of iron or steel, old rails, and iron ore of good quality, as additions, and spiegeleisen and ferro-manganese for the final tempering.

The first operation consists of forming the bath by charging the required qualities of pig iron, to which, when melted, additions of iron or steel are made in small quantities at a time; they are charged cold on the hinder flame bridge, and when strongly heated are turned into the bath. This is the English practice; on the Continent an auxiliary-heating furnace is generally used, the scrap being made red-hot before charging. The direction of the draught in the melting furnace is changed every half-hour. The proportion of scrap used depends upon its character and the condition of the furnace. With an almost neutral flame, No. 1 grey pig iron will dissolve ten times its weight of Bessemer scrap with 0.3 or 0.4 per cent. of carbon, but No. 3 will not take more than three or four times its weight of soft puddled iron, and when the flame is cutting, a considerably less proportion.

When the charge is melted the metal is tested from time to time by taking samples in a ladle, which, after cooling in water, are hammered and broken. When the required pitch, as indicated by the toughness and fracture, has been attained, from 6 to 9 per cent. of spiegeleisen or ferro-manganese is added, and when this is melted the charge is tapped out into the ladle and cast into ingots, in the same way as in the Bessemer process. The time required for working a 5 to 6 ton charge is from nine to eleven hours. The loss in melting Bessemer scrap with No. 3 hematite pig is from 4 to 5 per cent. of the total weight of the charge. The coal used is from 13 to 14 cwt. per ton of steel made.

In the Siemens' process, with iron ore, the bath of pig iron is decarburised by the addition of rich pure hematite or magnetite, in about 2-inch lumps. This causes a violent boiling, which is kept up until the metal is nearly soft enough, when it is allowed to stand for a short time to allow the iron to clear from the slag, a small quantity of limestone being added at intervals to throw down some of the iron. The spiegel is then added, about 1 per cent. more being used than in the scrap process. From 20 to 24 cwt. of ore are used in a 5-ton charge; about one-half the metal is reduced and passes into the steel, so that the yield in ingots is from 1 to 2 per cent. in excess of the weight of pig metal and spiegeleisen charge. The consumption of coal is rather larger than in the scrap process, or from 14 to 15 cwt. per ton of steel. The two processes are often combined, both scrap and ore being used in the same charge. The latter is obviously of value as a tempering material.

At Saint Chamond, in France, the Siemens' process is carried on at a very large scale in Pernot's furnace. This furnace has a circular bed on wheels that can be rotated when heated, and is removable for repair. The bed, made of sand upon an iron-plate bottom, is contained in a frame made of cast-iron staves, kept together by a stout iron hoop. It is inclined about six degrees to the horizon, and is supported by a central spindle and conical friction rollers, upon a cast-iron traveling-frame, with four or six wheels, running upon a railway. By means of gearing wheels the bed is rotated at from two to four revolutions per minute. The pig iron and scrap are heated to redness before charging, and as the position of the different pieces of the latter is constantly changing, be ing alternately brought under the full action of the flame and plunged into the liquid, the fusion is very rapid. One-half of the bed being also exposed to the flame by the slipping of the charge at each revolution, the bottom heat is continuously renewed, and the chilling or sticking of the charge on the bottom is prevented. The removable hearth allows repairs of the roof to be more readily and quickly made than is the case with those of fixed construction. The diameter of the hearth within the lining is about 7 feet in the 8-ton, and 13¾ feet in the 20-ton furnace; the depth of the bath being about 8 or 9 inches in the center. The former melts from three to four charges, and the latter two, in the twenty-four hours.

The following represent the progressive steps in the melting of a charge in the 20-ton furnace:—

Hour.	Pig iron Tons.	Steel Waste Tons.	Puddled Iron Tons.	Ferro-manganese Tons.	Carbon in bath Per cent
2.10 a.m.	5,000	5,000	—	—	—
4.45 "	—	3,000	—	—	0.5
7.0 "	—	3,000	—	—	0.4
9.40 "	500	—	2,000	—	0.25
11.50 "	—	—	1,000	—	0.25
1.25 p.m	—	—	—	0,693	0.12
1.30 "	Metal tapped out	.	.	.	0.35

The pig iron contained 3.35 per cent., and the ferro-manganese 50 per cent. of manganese. The coal used is about 1.5 cwt. in the heating-furnace, and 5 to 5.2 in the melting-furnace, per ton of the ingots, or only about one-half of that of the fixed furnace. The loss upon the weight of the charge is 4 to 5 per cent. on hard, and 6 to 7 per cent. on soft steel.

In Ponsard's modification of the rotatory heart furnace, or "Forno Convertisseur," a wind chest is added to the bottom spindle, and twyers are inserted in the side lining, so that a decarbonizing blast may be injected as in the Bessemer process. This has been used experimentally with fair results, but has not been adopted in the large scale.

The dephosphorising process by means of lime may also be carried on in the open-hearth furnace. Experiments have been made in this direction at the Alexandrowsky works, in Russia. The bed of the furnace is made of a mixture of calcined dolomite and tar, which burns to a very hard mass. The composition of the charge was as follows:—

		Per Cent.
Iron Ore from Sweden .	Fe 48 per cent.	6.7
Lime	. . . .	6.7
Cleveland Pig Iron .	P. 1.62 "	25.0
Broken Ingot Molds .	" 0.70	4.5
Malleable Scrap .	. " 0.30 "	44.5
Hematite Pig . . .	. . . .	6.7
Spiegeleisen . .	. Mn 15.0 "	5.4
Ferro-manganese .	. " 75.0 "	0.5
		100

About two-thirds of the lime and ore were first charged with the pig iron and part of the scrap, the remainder of the former and the latter following at short intervals. When a test-piece of the metal, after cooling in water, can be bent double without breaking, the hematite pig is added, and, after its complete incorporation and a fresh testing of the metal, then the spiegel and ferro-manganese. Before tapping, and before each ddition to the charge, care must be taken to remove the highly phosphuretted slag. The proportion of phosphorus in the original metal equals 0.571 per cent.; that is reduced to 0.06 in the ingots.

Fluid Compression of Steel.—Large masses of cast-steel, whether from the crucible, Bessemer, or open-hearth furnace, are rarely solid throughout; the tops of large ingots being generally pitted or honeycombed with small holes for some distance down, and the unsoundness increases with the softness of the metal. It was formerly supposed that these bubbles were due to the evolution of carbonic oxide, produced by the reducing action of combined carbon upon oxide of iron taken up in the metal in the last stage of the process; but the researches of Parry, Muller, and other chemists have shown that the gas included is steel is almost entirely nitrogen, which is absorbed in large quantities by the fluid metal and given out on solidification in the same way as oxygen is absorbed by melted silver. Muller considers that the beneficial effect of the final addition of spiegeleisen is in part due to the sudden large evolution of carbonic oxide, which sweeps out much of the dissolved hydrogen. This is borne out by the experiments of Allen, who finds that Bessemer metal gives sounder ingots when it is stirred by a rotating paddle lowered into the ladle before the casting, than when poured in the ordinary way. A large amount of gas is given off in stirring, which fires on meeting the air.

Another method of obtaining sound ingots is that of causing the metal to solidify under a pressure. This was first adopted by Sir Joseph Whitworth, who had molds built up in segments of cast-iron with numerous perforations for the escape of gases, and bound together with a strong tube of cast-steel. The interior of the mold is lined with sand. When the metal is run in, the piston of a hydraulic press descends upon the upper surface, and a pressure of about 6 tons to the square inch is applied. The ingots are considerably shortened as compared with those cast in open moulds, but it has been questioned whether their soundness is invariably increased.

A simpler method of consolidation has been applied by Captain Jones, who subjects the top of the liquid metal in a closed mould to steam pressure. A steam drum is fixed to the side of the ingot-crane, having a number of cocks corresponding to those of the moulds, and also india-rubber connecting pipes. The moulds and bases are kept together by clamps attached to long iron rods fitting over projecting lugs at the bottoms. At the upper end of the mould a conical seat is turned, which carries the pouring cup. When the mould is filled, the lid, with a coupling and flexible steam pipe, is substituted and wedged down, the conical seat giving a steam tight joint. The steam, which may be from 80 to 150 lbs. pressure per square inch, is then turned on, and is allowed to act until the metal has set. The highest pressure is required with mild steel. The ingots are perfectly sound, and are 1½ to 1 inches shorter than those cast in the ordinary way with sand stopping.

In a modification of the above method recently patented by Krupp, the pressure of carbonic acid gas is substituted for that of steam. The acid in the liquid state is contained in a bottle communicating with the mould near the top, by a pipe of small bore. The mould, hooped with steel, is connected with the cover by bolts and wedges, an expanding copper ring helping to make the joint gas tight. The feeding hole in the cover is closed by a sliding wedge. When the metal is poured the surface is covered with a layer of sand, slag, or other bad-conducting material, the feeding hole is closed, and the gas tube opened. The pressure exacted depends on the temperature of the fluid acid, which is immersed in a cistern of water, which may be artificially heated or cooled as required. The tension of carbonic gas increases very rapidly with the temperature, it being 52 atmospheres at 15 degrees, 82 at 35 degrees, 400 at 100 degrees, and 800 at 200 degrees.

Manipulation of Steel Ingots. It was formerly customary to subject all heavy ingots, whether from the Bessemer or open-hearth process, to the action of a steam-hammer before rolling, but this is now given up, at least in rail manufacture, for which purpose the bulk of the steel so produced is applied. The ingots, when returned from the mould are conveyed while stil hot to a reheating-furnace, usually of the Siemens, Bicheroux, or some equivalent form, and when at a good orange-red heat are passed through the "cogging" mill, corresponding to the blooming mill of the puddling forge, which reduces them from a pyramidal to a parallel-sided form with a corresponding elongation. These are then returned to the furnace, and when reheated are finished at one operation in the rail mill. As the crop ends and pieces of irregular lengths are more difficult to dispose of than those of malleable iron, it is now customary to use large ingots giving finished bars long enough to cut into several rails with only one pair of crop ends. At Eston ingots of 35 cwt. giving four rail lengths are used. At Workington ingots giving three rails are passed nine times through the cogging mill, and thirteen times through the rail mill to obtain the finished section. The hammer is still in general use for ingots intended for rolling into plates as well as for billets for wire-making, and also in forging the large ingots intended for heavy gun tubes. For this latter purpose hammers from 50 to 80 tons falling weight have been constructed. Two of the latter weight are in use, one at Creusot and the other at Saint Chamond, in France.

Pointed steel projectiles for piercing armor plates are made at Terre-Noire from open-hearth steel, with carbon 0.45 to 0.60, silicon 0.25 to 0.3, and manganese 0.5 to 0.6 per cent., by casting in metal moulds with a contracted sunk head of sand above. They are made solid, and if required as shells are bored out afterwards. In the hardening process the projectile is heated to redness, and the point is dipped into water until the redness has disappeared, when it is transferred to an oil bath and allowed to cool. The weight of the oil in the bath should be at least four times that of the piece immersed. The oil adhering to the hardened piece is removed by a gentle tempering heat. Large objects must be annealed vertically to avoid warping by unequal lateral contraction.

Combining Steel with Wrought-iron. Compound armor plates for ships are now made by casting melted steel upon a wrought-iron base and rolling the combined mass when sufficiently cooled. For a compound plate of the finished size, 16 feet by 6½ feet and 8 inches thick, a foundation plate of wrought-iron, 9¾ feet by 6 feet and 12½ inches thick, is prepared, and a mild steel plate, 2 inches thick, made from a 50-cwt. ingot of open-hearth steel, containing about 0.45 per cent. of carbon, is attached to it by distance pieces and steel screws, leaving a hollow space of 5 inches between the two plates. This when brought to a strong red heat is placed upright in a rectangular moulding box, the steel side being placed close to a thick cast-iron plate, the remaining sides being filled with foundry sand, and the bottom built up with fire-brick. The space between the plates is then filled with melted open-hearth steel poured from a 5-ton ladle at the highest attainable temperature, the metal being run through several feed-holes in a gutter lined with fire-clay fixed above the mould, which is sunk in a pit in the usual way. When the casting has cooled to a red heat it is lifted by a crane and rolled to the required dimensions at once. The resistance of these plates to penetration is about 20 per cent. greater than that of soft iron plates of equal thickness. The adhesion between the two metals is perfect, a layer of steely iron being formed at the junction, while the outer steel face retains its full temper. The latter is about one-third of the total thickness in the heavier plates, and somewhat more in the lighter ones, or about 3 inches in an 8-inch and 4 to 4½ inches in a 14-inch compound plate. If the plate is to be curved, the soft cover is placed on the convex side. The wrought-iron side-pieces and screws are removed in the process of planing the plate to the finished dimensions.

The following are the analyses of the constituents of a good compound plate:

	Steel Face.	Iron Foundation.
Carbon	0.573	0.040
Silicon	0.173	0.117
Manganese	0.617	0.090
Phosphorus	0.054	0.165
Sulphur	0.046	0.010
Copper	0.026	0.016

Hardening and Tempering Steel. The property of becoming hardened by sudden cooling from a high temperature is possessed by all varieties of malleable iron containing more than 0.25 per cent. of carbon. The degree of hardness imparted by the operation is dependent partly on the amount of carbon present, and partly, but in a greater degree, on the difference of temperature between the heated metal and that of the fluid employed in hardening, and the rapidity with which the cooling takes place. Those fluids that possess the highest conducting power for heat produce the greatest hardening. Thus, mercury is most efficacious in this respect, whereas alcohol is entirely without action. The specific gravity of steel is diminished by hardening. According to Hausmann, hard unweldable cast-steel from Solingen was reduced from 7.844 to 7.760, and a softer welding quality from 7.858 to 7.801, by quenching from a red heat in cold water. The change of volume is not uniform even for objects of a regular form. Caron found, by repeating the operation on the same bar for many times in succession, that hammered bars contracted in their length and increased in the other dimensions. With rolled bars and sheets, on the other hand, an increase in length was observed. After thirty hardenings, the specific gravity was diminished from 7.817 to 7.743.

The process of tempering consists in reheating hardened steel to a temperature varying with the degree of hardness required, and cooling it by immersion in the same manner. The proper temperature is indicated by the color of the thin film of oxide formed on the surface of the heated steel, according to the following scale:—

Temperature.	Color.	Proper temper for
220°	Pale yellow.	Lancets.
230	Straw yellow.	Razors and surgical instrum'ts
243	Golden yellow.	Common razors and pennkniv's
255	Brown.	Cold chisels, shears, scissors.
265	Brown dappled with purple.	Axes, planes, &c.
277	Purple.	Table knives, large shears.
288	Bright blue.	Swords, coiled springs.
293	Full blue.	Fine saws, augers, &c.
316	Dark blue.	Hand and pit saws.

The reheating is generally effected in baths of molten metals, or metallic alloys having definite fusing points. Thus, alloys of tin and lead, in varying proportions, may be used up to a temperature of about 300°; above which, boiling linseed oil and pure lead are to be employed. Steel gun-tubes and projectiles are tempered in oil, whereby their tenacity is considerably increased.

The chief points required to be determined in the analysis of the different kinds of metallic iron and steel for commercial purposes are carbon, distinguishing the graphitic from that in the combined state, silicon, sulphur, phosphorus, manganese, and copper, while the remaining common heavy metals, and those of the alkaline earths, are of less importance, as occurring only in minute quantities, and requiring the use of refined analytical methods, which involve too great an expenditure of time and materials to be employed except in special inquiries.

Determination of the total amount of Carbon. When iron containing carbon in the state of combination is dissolved in hydrochloric acid, protochloride of iron is formed with the evolution of hydrogen, which in the nascent state combines with a portion of the carbon set free, at the same time forming volatile hydrocarbons, which escape, giving a fetid odor to the gas. If, however, instead of hydrochloric acid, a metallic chloride, reducible by iron, is used, no evolution of hydrogen takes place, and the whole of the carbon goes down in an insoluble form, and may be collected. The uncombined or graphitic carbon is not in any way attacked by the acid. The reagent generally used is protochloride of copper, $CuCl^2$, which was first introduced by Berzelius. About 100 grains of the metal in a finely-divided state, usually drill chips, borings, or filings, are treated with a moderately strong solution of protochloride of copper until the whole is decomposed. Protochloride of iron is formed, and metallic copper, which remains undissolved, together with the carbon and silicon. The insoluble residue is collected on a filter, and washed, first with weak hydrochloric acid, then with a solution of potash, and lastly with water, leaving only the carbon and copper behind, which, when dried, are burnt with oxide of copper in a hard glass tube, according to the ordinary method adopted in organic analysis. As the graphite is difficultly combustible, it is best to burn it off in a current of free oxygen. The total amount of carbon is deduced from the carbonic acid produced in the combustion, which is absorbed by caustic potash in the usual way. In Richter's modification of the above process a solution of the double chloride of copper and sodium, $NaCl + CuCl^2$, is employed instead of chloride of copper alone. By properly proportioning the amount of the double salt employed, the separation of metallic copper may be prevented, which is retained in solution as subchloride.

Regnault's method of burning the iron directly with oxide of copper, or chromate of lead, can only be adopted when the substance under examination is susceptible of being reduced to a fine powder, an operation of considerable difficulty with many varieties of iron. Weyl's method, which does not require the sample to be powdered, consists in effecting the solution of the iron with hydrochloric acid, aided by a weak galvanic current. A lump of the iron to be treated is partly immersed in weak hydrochloric acid, in connection with the positive pole of a single Bunsen cell, the negative pole being formed by a plate of platinum. The distance between the poles must be regulated so that no sesquichloride of iron is formed, a point that may be readily determined by the appearance of a yellow tint in the liquid. As soon as the immersed portion of the iron is dissolved the remainder is removed, washed, dried, and carefully weighed: the difference or loss on the original weight gives the amount of iron dissolved. The carbon and other insoluble matters are collected on an asbestos filter, and treated in a similar manner to that already described.

Ullgren's method depends upon the oxidation of the total amount of carbon to carbonic acid without heat by means of chromic acid. The first operation consists in treating the finely divided iron with sulphate of copper, producing metallic copper and protosulphate of iron, carbon and other insoluble substances being precipitated. The precipitate is washed by decantation, and removed into a flask with the smallest possible quantity of water. Strong sulphuric acid is then added, and after the liquid has cooled, a certain quantity of chromic acid, which is decomposed by the carbon, producing carbonic acid, which is collected in a weighed tube containing caustic potash in the usual way. This method was reputed to give good results, but, according to Schnitzler, is not available for the analysis of steel, the results indicated being inferior in accuracy to that of Berzelius, and in some instances as much as 30 per cent. too low on the total amount of carbon contained.

A new method, suggested by Fresenius, of dissolving the iron in hydrochloric acid, and leading the carburetted hydrogen formed over ignited oxide of copper, so as to convert it into carbonic acid, is said to give good results with steel and dark grey pig iron containing but little combined carbon. The graphitic portion remaining in the residue is then estimated by a second combustion. Schnitzler gives the following estimation of carbon in the same steel by different methods as a measure of their relative accuracy:—

	I.	II.	III.	IV.	V.	VI.	VII.
Combined carbon, per cent.	—	—	—	—	—	0·19	0·18
Graphitic carbon per cent.	—	—	—	—	—	0·78	0·74
Total carbon.	0·74	0·75	0.68	0·93	0·96	0·92	0·92

Nos. I., II., III. Determinations by Weyl's methods Nos. IV., V. by Berzelius's method with chloride of copper. Nos. VI., VII. by Fresenius's method of determining the combined carbon directly. The latter is not applicable to such irons as contain a large amount of combined carbon, such as spiegeleisen, which, when dissolved in acid, deposit hydrocarbon oils that are not carried off by the hydrogen evolved

Boussingault uses bichloride of mercury in the determination of carbon, for the solution of the iron, which is converted into protochloride of iron, without the decomposition of water, so that no gas is given off capable of combining with the carbon as it is liberated, and the consequent formation of volatile hydrocarbons is avoided. The iron, finely powdered or in fillings, mixed with fifteen times its weight of bichloride of mercury and sufficient water to form a thin paste, is triturated in an agate mortar for half an hour. When thoroughly incorporated, the paste is transferred to a hard glass flask, and heated to 80° or 100° for an hour, when it is thrown on a filter and washed with warm water, to remove the soluble protochloride of iron. The residue on the filter, consisting of protochloride of mercury, with carbon and the other insoluble matters of the iron, is dried in a water-bath, transferred into a platinum boat, and introduced into a tube communicating with a generator or gas-holder supplying a stream of dry hydrogen. The tube is gradually heated to redness, when the protochloride of mercury, is volatilized without decomposition, leaving the carbon in the form of a black powder, which is allowed to cool in hydrogen, and then weighed. When the boat is slightly heated, the carbon fires in the air and burns like tinder; if, however, graphite is present, it must be borne in a current of oxygen. The siliceous residue, after the combustion of the carbon, is due to the combined silicon of the iron, but the quantity obtained does not represent the whole amount, because the first action of the bichloride of mercury is to produce chloride of silicon, which is transformed by water into hydrochloric acid and silica, and the latter being partly in the soluble form, passes away with the wash-water, in the filtration.

Graphite, or uncombined carbon, is determined in the insoluble residue remaining after solution in hydrochloric acid, which is digested with a strong solution of caustic potash to remove the silicon produced from the oxidation of the silicon. The black residue, after the solution of the silica, is repeatedly washed until perfectly free from alkali, dried, weighed, and calcined at a strong heat in a current of air until the whole of the carbonaceous matter is burnt off. The weight of the small amount of residue is then determined, and deducted from that obtained previously. The difference gives the quantity of graphite. The combined carbon is obtained by deducting the last result from that of the total amount of carbon by one of the preceding methods.

Silicon is determined by weighing the insoluble residue of the hydrochloric acid solution after it has been ignited to a strong red heat in a current of air to remove the whole of the carbon. This residue is nearly all silica, but its purity must be tested by dissolving in caustic potash. The insoluble portion, if any, is collected, and its weight is deducted from that obtained at the former weighing.

Determination of Phosphorus.—A weighed portion of the metal is digested in aqua regia evaporated to dryness, and the residue redissolved in hydrochloric acid. The solution is then treated as in the analyses of iron ores, the determination being made as pyrophosphate of magnesia, or preferably as phospho-molybdate of ammonia.

Sulphur may be estimated in grey pig iron by collecting the sulphuretted hydrogen gas evolved by the action of hydrochloric acid, and passing it through a solution of acetate of lead. The precipitate, sulphide of lead, is collected, washed, and converted into sulphate by digesting with nitric acid, evaporation to dryness, and gentle ignition. The amount of sulphur is calculated from the weight of sulphate of lead so obtained: it contains 10·55 per cent of sulphur. The above is not applicable to white iron, owing to the difficulty of acting upon it with hydrochloric acid; but aqua regia may be used, and the sulphur is then directly converted into sulphuric acid, and may be precipitated with chloride of barium, and weighed as sulphate of baryta in the usual way. Another method of oxidizing the sulphur consists in fusing the finely-divided metal with niter and carbonate of soda in a gold crucible; the fused mass is extracted with water, and the sulphuric acid existing in the solution as an alkaline sulphate is precipitated by chloride of barium as before.

It is rarely necessary to determine the amount of iron. When required, the volumetric methods by solutions of permanganate or bichromate of potassium described under Assaying are to be used. Manganese may be determined as in the analysis of ores. Arsenic and copper are precipitated from the hydrochloric acid solution by sulphuretted hydrogen, care being taken to reduce the whole of the iron to the state of protochloride. The two sulphides may be separated by digestion in sulphide of potassium, which dissolves the sulphide of arsenic, leaving the sulphide of copper untouched. Nickel and cobalt, if present, will be found in the solution obtained after the removal of arsenic and copper by sulphuretted hydrogen. The iron is first converted to a persalt, and is then separated as peroxide by a slight excess of carbonate of baryta; after which nickel and cobalt are precipitated by sulphide of ammonium. Chromium and vanadium are to be looked for in the carbonaceous residue obtained by dissolving a considerable quantity of the iron in weak acid. The ignited residue is fused with niter at a gentle heat for an hour, and when cooled, the mass is powdered and boiled with water. Vanadate and chromate of potash pass into the solution, are converted, by means of chloride of barium, into the corresponding baryta salts, which are insoluble, and are collected upon a filter. The chromate and vanadate of baryta are decomposed with sulphuric acid, whereby chromic and vanadic acid, are set free, and remain as such in the filtrate after separation from the sulphate of baryta. The filtrate is neutralized with ammonia, concentrated by evaporation, and a fragment of chloride of ammonium is placed in it. In proportion as the solution becomes saturated by the latter salt, vanadate of ammonia is deposited as a white or yellowish crystalline powder, which may be collected and subjected to further treatment by the blowpipe or otherwise, in order to verify its properties. The chromic acid is precipitated from the solution by means of acetate of lead as a yellow chromate of lead.

Eggertz's methods of determining small quantities of sulphur and phosphorus may be conveniently used for estimating these substances in pig irons of high quality, such as those produced in Sweden, but are not applicable to the bulk of the iron produced with mineral fuel from the ores of stratified deposits.

For sulphur, one-tenth of a gramme of finely divided pig iron is placed in a stoppered bottle, with 1 gramme of water and half a gramme of sulphuric acid. A clean bright plate of silver is suspended by a wire in the upper part of the bottle, and the discoloration in a given time (about fifteen minutes) is proportional to the amount of sulphuretted hydrogen evolved. As this is very small, the plate, instead of being blackened, is tarnished with very thin films, presenting the same order of color as those observed in tempering steel according to their thickness varying from straw-yellow to bright blue. No absolute measure of quantity is obtained, the result being determined by comparing the color on the plate with a standard series, obtained previously by experimenting upon samples whose composition has been determined by analysis. Thus, a blue color indicates that the metal will yield a sensibly red-short iron when converted into malleable iron in the hearth finery; but if the plate is only browned, the sulphur is not in sufficient quantity to affect the quality of the iron.

In the determination of small quantities of phosphorus, 1 gramme or 15 grains of the iron or steel to be examined is reduced to a fine powder, and treated with strong nitric acid at the heat of boiling water. When the metal is dissolved, the solution is evaporated to dryness, the residue moistened with 4 cubic centimeters of aqua regia made of equal volumes of hydrochloric and nitric acids. After standing for about an hour, an equal volume of water is added, and the solution filtered. The filtrate and wash-water should not exceed 20 cubic centimeters.

The precipitation of the phosphoric acid is effected by a solution of molybdate of ammonia, containing 60 milligrammes of molybdic acid per cubic centimeter. It is added to the solution of the iron in the proportion of 2 cubic centimeters per milligramme of phosphorus supposed to be present, and digested, with occasional stirring, at about 40° for three hours. If no precipitate is formed, a further addition of molybdate of ammonia is made. The yellow crystalline precipitate, which contains 1.63 per cent. of phosphorus, is collected in a filter, washed with water acidified with nitric acid, and weighed after drying in a water bath. If, however, the quantity is very small, the determination may be made by measuring the volume of the precipitate in a narrow glass tube with a scale made especially for the purpose.

Eggertz's method of determining combined carbon in iron or steel depends upon the discoloration produced by carbon in solution of pernitrate of iron, which, under ordinary circumstances, is colorless, or at most of a slightly greenish tint. The standard series of colors is made by dissolving quantities of 1 decigramme of steel of known composition in nitric acid at very low temperature, and diluting with water to a standard volume. The solutions, which give different shades of brown, are preserved in glass tubes. A similar weight of the steel to be examined is dissolved in pure nitric acid under the conditions observed in making the standard series. The solution is decanted from the residue, poured into a burette of the same diameter as the tubes containing the standard series, and diluted with water until it matches one of the tints. The amount of carbon is then found by calculation from the relative volumes of the solutions. Steel, with a medium amount of carbon, say 0.8 per cent., will give a yellowish-green solution; a very hard variety, with 1.5 per cent., brownish red; and the softest, with 0.40 per cent., only a slight greenish tinge.

The Swedish classification of Bessemer steel by numbers, based upon the percentage of carbon determined by the above process, is as follows:—No. 1 contains 2 per cent.; No. 1.5, 1.75; No. 2, 1.5; and so on up to No. 4.5, with only 0.25 per cent., below which point the scale is not extended.

The following determinations of carbon in various kinds of iron and steel made in Sweden are by Eggertz:—

Softest Swedish Bessemer iron contains	0.08	per cent. of carbon.
Soft steel . "	0.75	" "
Best quality of cast-steel . contains	1.4 to 1.5	" "
Natural forge steel contains	0.99 " 2.44	" "

Cement steel contains 0.50 " 1.90 " "
Cast steel " 0.86 " 1.94 " "
Hardest welding cast-
steel . contains 1.80 " " "
Malleable cast-iron
contains 0.88 " 1.52 " "
Draw-plate steel
contains 3.30 " "

The following modification of this process is adopted at Seraing, in Belgium, for the determination of carbon in mild Bessemer steel. Two samples, each weighing 0.2 grammes, of the ingot to be tested are taken; one being in the state of filings, and the other of borings. These are treated with 20 cubic centimeters of nitric acid, of specific quartz 1.2; the solution being effected in a water-bath at 80°. For the test-standard, the same weight of two different samples, of the hardest steel made in the works, whose carbon has already been determined, and containing 0.61 and 0.63 per cent. respectively, are dissolved up in the same manner. The whole of the four solutions are then brought down to one tint by adding water to the darker ones, care being taken to conduct the operation in tubes of exactly the same diameter. The amount of carbon can then be computed from the volume of the solutions. If the difference in the results given by the two samples does not exceed 0.03 per cent., the arithmetical mean between them is adopted as the true amount; but should it be larger, the operation is repeated.

In order to obviate the necessity of making standard solutions for every set of determinations, different colored liquids have been employed with a view of obtaining a permanent scale of colors. Among these may be mentioned caramel, or burnt sugar, which gives various shades of yellow and brown, but alters very quickly; and partially decomposed solution of indigo in sulphuric acid, which is said to keep its characteristic color without alteration for a considerable time. Another recommended by Hetman consists of a mixture of bichromate of potash and nitrate of cobalt. In most cases, however, the direct system of comparison with solutions obtained from steel of known compositions is to be preferred.

Silicon. The determination of silicon in iron and steel is a matter of some difficulty, as the mere weighing of the ignited insoluble residue from the hydrochloric acid solution and calculation of the silica found, as silicon, depends upon the assumption that the iron is free from silicates, which is often contrary to the fact, especially in malleable iron, which may contain a notable amount of intermingled slag that has not been perfectly expelled in the welding, and exists as a mechanical impurity, having no relation whatever to the real composition of the metal. This defective interpretation of the ultimate analyses is probably the cause of the contradictory statements current as to the amount of silicon that may be present beneficially in malleable iron. Eggertz has introduced a method of determining silicon in the presence of slags, which is based upon the fact that when iron is slowly acted upon by bromine, a solution of iodine, it dissolves, and the silicon set free is converted into silica, which is completely soluble in a boiling solution of carbonate of soda, while that in combination in the slag, if any be present, is not acted upon. The same method may be employed with cast-iron, as blast furnace slag, which sometimes occurs in it as a mechanical impurity is not sensibly acted upon either by iodine, bromine, or carbonate of soda.

The process is conducted as follows: Three grammes or 45 grains of iron in the state of filings or borings, sufficiently small to pass through a sieve with meshes $\frac{1}{70}$ of an inch in diameter, is treated with five times its weight of iodine, in a volume of fifteen cubic centimeters of water contained in a beaker of about six or seven times that capacity. Water that has been boiled to free it from air is used, and the operation must be performed at as low a temperature as possible, in order to prevent oxidation of the iron by the air, it is usual, therefore, to keep the beaker cool by the use of ice. When the iron is completely dissolved, the solution is increased to three times the original volume by the addition of very cold water in order to prevent the separation of basic salts of iron, and is well stirred and left to settle. The lighter scales of graphitic carbon remain in suspension, and are poured off with the bulk of the liquid into a filter 2 inches in diameter, with only about one-tenth of the original quantity of the insoluble residue which forms a heavy powder at the bottom of the beaker. A few drops of hydrochloric acid are added, and the liquid stirred with a glass rod; if this produces a disengagement of gas the whole of the iron is not dissolved, and a little iodine and carbonate of soda is added in order to complete the solution. The acidified water must be poured quickly on the filter in order to prevent the decomposition of the slag. When the whole of the residue is transferred to the filter it is washed with cold water until the whole of the iron is found to be completely removed when tested by a solution of ferrocyanide of potassium. The filtrate is evaporated to dryness with the addition of hydrochloric acid in order to recover any small amount of silica that may have gone into solution with the iron. The original residue which may contain graphite, silica, and slag is transferred without drying into a large platinum crucible, and after concentrating the wash-water to 6 cubic centimeters, a saturated solution of carbonate of soda is added, and the crucible is heated for one hour in a water-bath, the liquid being stirred from time to time with a platinum spatula in order to divide any lumps in the insoluble residue. The solution is then carefully poured from the insoluble mass in the crucible on to a small filter, and a fresh quantity of carbonate of soda solution is added and boiled for another hour, when the whole contents of the crucible are thrown upon the filter and washed. The alkaline solution of silica is acidified with hydrochloric acid, added to that containing the iron, and evaporated in a water-bath. This operation is repeated with the addition of fresh acid until the silica is perfectly freed from iron, when it is filtered, dried, ignited, and weighed as often as may be necessary to ensure its complete purity, which must be further tested by heating it with hydrochloric acid. When 3 grammes of iron are treated, 0.016 grammes of silica correspond to 0.001 gramme of silicon. The insoluble residue from the carbonate of soda solution may contain graphite slag, oxide of iron, and titanic acid. There is no way of distinguishing the amount of oxide of iron present as such, in addition to that in combination with silica, except by assuming the composition of the slag to be constant, which is not the case.

Eggertz found by the use of this process, that the amount of silicon in good bar iron may vary from 0.01 to 0.10 per cent, ; but into samples of Krupp's cast-steel it was as high as 0.30 per cent. Slag has been found usually in mere traces in cast-steel, but in one instance it amounted to 0.2 per cent. Malleable iron, however, contained much more. In wire iron from a charcoal hearth 0.33 per cent. was found, in armor-plates from 0.75 to 3.00 per cent., and in a rail as much as from 4.00 to 5.00 per cent.

Special Methods of Determining Manganese.—According to Pattinson, manganese is completely precipitated as hydrated dioxide from a hydrochloric acid solution when a certain proportion of ferric chloride is present, by the addition of solution of bleaching powder, or bromine, and carbonate of lime in excess, at a temperature of 50 to 70 degrees. The dark brown precipitate, when filtered and washed until all traces of chlorine or bromine are removed, is transferred on the filter to a beaker containing a measured volume of a solution of ferrous sulphate in sulphuric acid, whose contents of iron are known, in which it readily dissolves, the maganese dioxide producing manganous sulphate, and converting its equavalent of ferrous into ferric sulplate. The amount of ferrous sulphate remaining in the solution is then ascertained by a standard solution of bichromate of potash, as in the assaying of an iron ore. The difference gives the amount peroxidized by the second atom of oxygen in the manganese dioxide, and from it the amount of the latter metal is calculated according to the following equation:—

$$2\,FeO\,SO^3 + MnO^2 + 2\,SO^3 = MnO\,SO^3 + Fe^2O^3 3SO^3,$$

each unit of ferrous salt corresponding to 0.18 of its weight of manganese. In determining the standard of the iron salt solution a filter of the same size as that used in separating the manganese should be added, in order to compensate for any possible reducing action due to the paper. The original solution should contain at least half as much iron as manganese. The method is equally applicable to the analysis of ores or metal.

In America the precipitation of maganese as dioxide by boiling a nitric acid solution with chlorate of potash is much used in the analysis of pig iron and steel. In the former case carbon and silicon must be removed by a preliminary filtration of the nitric acid solution through asbestos, but with steel this is not necessary. The precipitated manganese dioxide is filtered upon asbestos, and after washing is dissolved in dilute sulphuric acid in the presence of a known excess of a standard solution of oxalic acid, the amount of which remaining unchanged is determined by a standard solution of permanganate of potash. The reaction is:—

$$MnO^2 + SO^3 + C^2O^3 = MnO\,SO^3 + 2\,CO^2,$$

each unit of oxalic acid corresponding to 0.763 of its weight of manganese. This method is proposed by F. H. Williams, who recommends the use of a permanganate solution of which one cubic centimeter corresponds to one milligramme of iron and one of oxalic acid, requiring three times its volume of the former solution to oxidize it.

Ford adopts a direct method of determination in connection with this process. The precipitated dioxide of manganese is dissolved in hydrochloric acid, rendered neutral, with ammonia; acetate of soda is added, and the solution is boiled and filtered. An excess of phosphate of soda and ammonia is added to the filtrate, which is made slightly ammoniacal, when on stirring a finely crystalline precipitate of phosphate of ammonia and manganese goes down, which on ignition is converted into pyrophosphate of manganese.

The quality and character of malleable iron or of steel may to some extent be judged by the appearances presented by fractured surfaces, which are fibrous and comparatively dull in the softer kinds, while in the harder ones they are brilliant and granular or crystalline in various degrees, The fineness and uniformity of the grain is most marked in the harder varieties of tilted cast-steel, especially those containing tungsten and manganese in considerable quantity, which are nearly glassy in fracture, while unwrought ingots are usually of coarsely crystalline structure, somewhat resembling that of antimony. The nature of the fracture may vary, however, with the manner in which the rupturing strain is applied. If this be very sudden the broken surfaces are almost invariably crystalline, as is seen in coupling-hooks and pins broken in railway accidents, although they are usually made of iron which ordinarily shows a fibrous fractuure when broken by strains progressively augmented. The crystalline structure of melted or balled iron or steel is very considerably modified by the process of lamination, the crystalline masses becoming distorted and elongated by the action of the rolling-mill, fiber being developed in the direction of the length of the bar. At each successive piling the grain becomes finer and more regular, owing to the breaking down and rewelding of the fibers in the bars forming the pile. Tresca has compared the effect of forge rolling to that of the process of carding and drawing cotton, the result in both cases being the production of parallel fiber. When the work is done upon the metal in a plastic state at a high temperature, the density is increased; but when a powerful tractive strain is exerted, as in wire drawing or planishing bars by cold rolling, the metal elongates more rapidly than its transverse section diminishes, and the density is diminished while the tenacity is considerably increased. The softness and lower tenacity, together with the original higher density, may be restored by annealing.

The changes referred to above are illustrated by the following results taken from Kirkaldy's experiments on wrought-iron and steel made at Glasgow in 1858–61; from which it appears the diminution in specific gravity in bars stretched by a severe tensile strain varied from 0·7 to 1.2 per cent. By cold rolling the diminution amounted to 0·7 per cent. for bars, and 0·36 per cent. for plates.

Mark or Name.	Specific Gravity.	Tensile Strength.
Govan puddled bar . .	7·450	20·9 tons per sq. in.
" hammered bar . .	7·764	28·7 " "
" rolled bar, 1½ in. square	7·720	25·6 " "
" " reduced to 1¼ in.	7·729	25·4 " "
" " " 1 "	7·722	25·6 " "
" " " ¾ "	7·702	25·9 " "
" " " ½ "	7·685	26·6 " "
Blochairn best rolled bar .	7·636	27·1 " "
" " cold rolled .	7·582	30·6 to 30·5 "
" " annealed .	—	25·2 to 27·8 "
" best boiler plate .	7·566	20·5 lengthways; 19·2 crossways
" " cold rolled	7·539	39.7 lengthways; 36·0 crossways
" " annealed	—	22·7 lengthways; 21·7 crossways

The same observer found in 1858—61 that the tensile strength of the best brands of British bar-iron varied from 24 to 27·5 tons per square inch: bars of irregular section bear a somewhat similar strain, or from 24 to 27·4 tons. The strength of plates varied from 20·4 to 24·6 tons lengthways, or in the direction of the greatest longtudinal extension produced by rolling, and from 18·5 to 22·6 tons crossways. The specific gravity varies from 7·531 to 7·760, being greatest in Yorkshire iron, which is made almost entirely under the hammer.

The relation between the composition of malleable iron and steel and their resistance to strains of different kinds has of late years been investigated by many observers. The following table, showing the limits of elasticity and tensile strength of various kinds of malleable iron and steel, is taken from one of the earliest of these investigations made in Sweden for the Jernkontor, by Styffe:—

Percentage of Carbon	Specific gravity Soft.	Hardened.	Tensile strength, tons per square inch.
1·5	7·785	7·736	34—39
1·2	7·832	7·771	37—40
0.9	7·874	7·808	56—59
0·6	7·879	7·807	37—41
0·4	7.893	7·839	30—34

The absolute strength appears to be greatest when the steel contains from 1 to 1¼ per cent. of carbon.

The following table contains the relation between the specific gravity and tensile strength of Bessemer steel of various degrees of carburisation made at Sandviken, in Sweden. (See next page.)

An elaborate series of experiments on the effect produced by varying single constituents in steel as regards mechanical properties has been published by the Terre-Noire Company, at the Paris Exhibition, in 1878. The metal investigated was principally open-hearth-steel. In the first series five charges were made with different proportions of carbon, phosphorus and manganese being kept as nearly uniform as possible; in the second series, manganese was varied; and in the third, phosphorus. These were subjected to the different tests of flexure tension, impact, and compression, both in the natural state, and when

Quality of Iron.	Percentage of Carbon.	Percentage of Phosphorus.	Limit of Elasticity. Tons per square in.	Breaking strain. Tons per square in.
Hogbo Bessemer steel, rolled bar....	2·16	..	29·8	40·2
"	1·85	..	26·7	46 2
Wilkmanshytta Uchatius steel bar...	1·22	..	33·8	66·9
Carlsdal Bessemer steel..............	1·19	..	31·4	64·8
" Uchatius steel......... ...	1·16	..	33·2	64·7
Hogbo Bessemer steel...............	1·14	0·018	39·6	59·0
" " hammered...........	0·68	..	31·8	46·8
Krupp's cast-steel hammered........	0·62	0·020	23·7	39·5
Hogbo Bessemer iron hammered...	0·33	..	24·1	33·0
Low Moor rolled tire bar............	0·21	0·068	16·7	27·3
Lesjofors rolled bar made in the Lancashire hearth................	0·06	0·022	14·0	22·5

tempered in water and oil. An abstract of the results obtained with the natural metal is contained in the following table.

than that of the best bar iron: that is, it will stand a greater transverse strain without fracture, but it is more rigid, or for equal increments of weight, takes a smaller permanent set. The latter was for square bars of the best wrought-iron, 4 inches in the side and 39½ inches between the bearings, under a strain of 30 tons applied in the center, 1.6 to 1.9 inches, while for similar bars of No. 59 it was only 0.4 inch. The elasticity and ultimate strength appear to be in direct proportion to the amount of carbon, as is also the rigidity, the latter property in the harder varieties appearing as fragility under impact. Increase of manganese has generally the same effect as augmentation of carbon, the elastic limit and ultimate tensile strength being increased, while the elongation before fracture is diminished.

Chromium has a remarkable influence upon the resistance of the metal to compression. The same test piece of No. 278, when water-tempered, and twice subjected to a pressure of 200 tons per square

Index No.	Carbon.	Silicon. Per cent.	Phosphorus. Per cent.	Mn.	F. Tons per square inch.	E. Tons per square inch.	T. Tons per square inch.	L. Per cent.	I. Ft.-lbs.	C. Per cent.
I. Steel varying in Carbon.										
59	0·150	—	0·035	0·213	?	14·0	22·7	34·0	?	71·5
66	0·490	—	0.070	0·200	?	16·6	31·0	24·0	?	64·0
70	0·709	—	0.062	0·266	4·0	20·1	43·2	15·0	17980	60·3
74	0·875	—	0·055	0·250	4·25	12·7	47·0	9·5	15195	55·5
82	1·050	—	0·063	0·255	4·13	24·9	54·7	4·5	11771	53·8
II. Steel varying in Manganese.										
26	0·450	—	0·067	0·521	?	17·3	34.3	24·2	?	64·3
33	0·467	—	0·072	1·060	?	22·7	41·3	21·0	?	62·4
30	0·515	—	0·061	1·305	5·4	27·6	52·4	15·7	17980	59·9
21	0·560	—	0·058	2·008	5·8	30·9	62·7	9·5	16647	—
III. Steel varying in Phosphorus.										
41	0·310	—	0·247	0·746	?	21·0	36·0	26·2	?	61·9
35	0·274	—	0·273	0·800	4·13	21·5	35·5	23·5	17980	57·7
45	0·310	—	0·398	0·693	2·92	23·3	38·9	22·2	13591	58·2
IV. Steel cast without Blow-holes.										
152	0·875	0·322	0·085	0·772	2·10	24·9	41·0	1·5	9611	52·8
148	9·750	0·163	0·097	0·672	2·29	19·4	40·3	3·5	11771	57·5
144	0·459	0·221	0·078	0·670	2·35	16·8	27·5	3·0	11771	62·6
140	0·287	0·233	0·076	0·693	2·79	13·3	28·38	8·8	15195	66·0
278	0·450	0·280	0·750	0·750	—	23·2	40·0	2·2	—	57·5
V. Continuous series, Cast-iron to Steel.										Tons.
156	3·425	3·540	0·125	0·120	0·83	—	4·56	—	2481	20·5
164	3·351	1·000	0·092	—	0·95	—	5·61	—	2865	32·3
192	2·900	0·990	0·087	—	1·24	—	9·20	—	3738	49·7
256	2·425	0·938	0·091	0·145	1·56	—	11·75	—	4052	62·7
233	2·150	0·700	0·085	0·180	1·84	—	14·15	—	4238	79·7
404	1·530	0·730	0·112	0·160	1·94	—	15·74	—	3926	111·1

Column F contains the breaking strains of bars 39½ inches between the points of support, and loaded in the middle. E, the limits of elasticity. T, the ultimate tensile strength, all expressed in tons per square inch. L, the percentage of elongation on the original length of bars broken by tension. I, the energy of blow producing fracture in foot-lbs. in the falling weight test. C, compression expressed in loss per cent. of original height, under a load of 200 tons per square inch in the series I. to IV., and the crushing strain in tons per square inch in series V. ? signifies the fracture was not produced by the highest available stress.

From these experiments it appears that the flexibility of very mild steel, such as No. 59, is greater inch, was only shortened about 2.5 per cent.

Phosphorus, when present in notable quantity in steel, increases the rigidity, and sensibly diminishes the power of resisting impact. Such metal, however, can only be rendered workable by keeping down the proportion of carbon, which is effected in practice by the use of high ferro-manganese, with the necessary result of introducing a large proportion of manganese. This condition is involved in the manufacture of the so-called *phosphorus-steel*, which has been successfully made on the large scale for some time, it being more particularly applied in the re-manufacture of old iron rails in the open-hearth furnaces.

Series IV. contains the tests of steels cast with a considerable addition of silicon as well as manganese, which has the property of giving ingots free from blow-holes. This gives a very strong metal suitable in the harder varieties for all armor-piercing projectiles.

Series V. shows the gradation of cast-iron into steel by the progressive diminution of carbon. No. 156 is a dark grey pig metal, whose low mechanical resistance is to be ascribed to the large amount of silicon present, as No. 161, containing the same amount of carbon, is sensibly stronger. With 2 per cent. of carbon, the metal may be hardened by chill-casting, but below this point there is not much difference between objects cast in sand or metal moulds. The property of malleability appears in No. 104, with 1.5 per cent. of carbon which can be forged and drawn under the hammer, and also tempered to some extent, and may be considered to be steel, although it is extremely rigid, and breaks under a tensile strain almost without elongation.

In comparative tests of iron and steel it is essential that all the samples should be subjected to exactly similar treatment; that is, the test-pieces must be of the same dimensions, especially as regards length and thickness. For equal quality of material a thin section gives a proportionately higher resistance per unit of surface than a thicker one. This is especially seen in steel wires, which may be obtained of a tensile strength of 100 to 140 tons to the square inch. The proportional elongation before fracture is also greater with short than with long test-pieces, and the lengths of those used by the different investigators vary very considerably; 4, 6, or 8 inches being, however, common. The figures in the foregoing table refer to cylindrical pieces of 4 inches long and 0.4 inch diameter.

Another method of estimating the toughness of steel consists in measuring the area of the fractured surface and comparing it with that of the original transverse section. These will always differ, the differences being greatest in the softer kinds of metal. Thus the difference between the original and fractured surfaces was 65.7 per cent. in No. 59, while in No. 82 it was only 12.4 per cent. It is matter of controversy whether the toughness of the metal is best evidenced by contraction or by elongation; the latter is the more convenient test, as the determination of the area of fracture is rather a troublesome process.

Working Tests. The tensile strength alone is not a sufficient measure of the quality of malleable iron or steel, as, especially with the latter, a metal of great strength may be deficient in softness and incapable of working properly under the hammer. Whenever, therefore, where the metal is to be subjected to further treatment, such as punching and drilling for riveting holes in boiler or shipbuilding works, special forge tests, both hot and cold, and in the case of steel tempering tests, are adopted, examples of which are given below.

Another useful supplemental test, especially in the case of welded iron, is obtained by polishing a section of the bar or plate, and then etching it with some corrosive liquid which brings out the lines of junction of the different elements of the pile and cinder patches or other defects. Either weak hydrochloric acid applied upon blotting paper, or a very dilute solution of chloride of platinum, may be used as an etching fluid.

Rails which are subjected to heavy percussive strains in use are tested in England for safety by allowing a heavy weight to fall upon them from a height which varies with the weight per yard and the character of the metal. For iron rails, according to Sandberg, a proper safety-strength is given by the product of the weight in cwts. into the fall in feet which should equal the weight per yard. Thus a 56-lb. rail supported on bearings 3 feet apart should not be indented more than $\frac{3}{4}$ inch to 1 inch by a weight of 7 cwt. falling 8 feet. For steel rails a heavier weight and higher fall are necessary to prevent the use of too hard a metal, and the former is therefore increased to a ton and the latter to 15 feet with light or 20 feet with heavy sections.

The prescription of a particular chemical composition for steel rails has been proposed by Dr. Dudley for the Pennsylvania Railway Company, who gives us the following as permissible limits:—

Phosphorus, not above	. .	0.10 per cent.
Silicon	" . .	0.04 "
Carbon	0.25 to 0.35, preferably	0.30 "
Manganese	0.30 to 0.40, "	0.35 "
Sulphur and Copper	. .	not specified.
Other impurities	. . .	only traces.

Minimum tensile strength, 29 tons per square inch.
Minimum elongation, 20 per cent.

This specification is founded upon the results of the analysis of a considerable number of worn rails, some of which had broken in use while others had not. At the same time the theory was propounded that the hardening properties of the phosphorus, silicon, carbon, and the manganese were to each other in the proportion of $1 : \frac{1}{3} : \frac{1}{3} : \frac{1}{5}$, and that the sum of the phosphorus and of the respective fractions of the other constituents expressed in hundredths per cent. gave a measure of the hardness in so-called *phosphorus units*. By this method the number of such units in good rails varied from 20 to 36, while in those that broke in use it varied from 33 to 53. This theory has, however, not found general acceptance, mainly from its being founded upon too small a number of observations; but the conclusion that great hardness is detrimental to the wearing power of steel rails accords with the previous experiments of J. T. Smith, who found that on the Furness line the loss of weight of rails that had been eight years in use averaged only 13.54 per cent. when the steel contained 0.30 per cent. of carbon, while with harder ones with 0.44 per cent. of carbon the average wear was 15.18 per cent.

The German Union of Railway Managers in 1880 proposed the following scheme of classification for steel used in railway materials, which has subsequently been adopted in its main points by the German and Austrian Government lines:—

1. According to quality and temper:—

First Class.	Kilograms per sq.m.m.	Contract'n per cent.	Qualitative fact'r
Hard .....tensile strength	65	25	90
Medium " "	55	35	90
Soft...... " "	45	45	90
Second Class.			
Hard .... " "	55	20	75
Soft...... " "	45	30	75
2. According to uses:—			
Axles.....tensile strength	50	30	90
Engine tires " "	60	25	95
Car'ge&wagon tires "	45	35	90
Rails...... " "	50	20	85

The qualitative factor in the last column is the sum of the other two with in some cases the addition of an arbitrary quantity. The above scheme, which is based on the tensile strength only, is by many persons regarded as unsuited for practical requirements, and the Society of German Ironmasters has propounded a more complete one, as being better fitted for the use of both producers and consumers. An abstract of this will be found in the Proceedings of the Institute of Civil Engineers, vol. lxvii., p. 484.

The following are the tests prescribed by the Admiralty for the plate iron intended for use in the Navy and may be taken as indicating the average strength of iron of fair quality. See next page.

Plates should be tested, both hot and cold, on a cast-iron slab having a fair surface, with an edge at right angles, the corner being rounded off with a radius of half an inch. The portion of plate tested to be 4 feet in length across the grain, and the full width of the plate with the grain. The bend should be made from 3 to 6 inches from the edge. All plates to be free from lumination and injurious surface defects.

PLATE IRON, FIRST CLASS, OR B. B.			SECOND CLASS, OR B.	
	Length-ways.	Cross-ways.	L'ngth-ways.	Cross-ways.
Tensile strength, per square inch.	22 tons	18 tons	20 tons	17 tons
Forge test, hot. All plates of 1 inch in thickness and below must be capable of bending hot without fracture thro'gh an angle of......	125°	90°	90°	60°
Forge test, cold. All plates should admit of bending cold without a fracture as follows:—				
1 in. thick to angle of	15	5	10	—
$\frac{3}{4}$ " "	25	10	20	5
$\frac{1}{2}$ " "	35	15	30	10
$\frac{1}{4}$ " "	70	30	55	20
$\frac{3}{16}$ in. and under to angle of..........	90	40	75	30

The tests to be applied to one plate of each lot of fifty of the same thickness.

The tests specified for steel are as follows:—Strips cut lengthwise or crosswise to have an ultimate tensile strength of not less than 26 or more than 30 tons per square inch of section, with an elongation of 20 per cent. in a length of 8 inches. Beam, angle, bulb, and bar steel to satisfy such forge tests, hot and cold, as may be sufficient to prove soundness of material and fitness for service. Strips cut crosswise or lengthwise $1\frac{1}{2}$ inches wide, heated uniformly to a low cherry red heat, and cooled in water at 82° Fahr., must stand bending in a press to a curve whose corner radius is $1\frac{1}{2}$ times the thickness of the plate. The strips are all to be cut in a planing-machine, and to have the sharp edges taken off. The durability of every bar or plate supplied to be ascertained by the application of one or both of these tests to the shearings, or by cold bending under the hammer. All steel to be free from lamination and injurious surface defects. Lloyd's rule specifies 26 to 31 tons as the limit of tensile strength, with an elongation of 16 per cent. on 8 inches for steel ship plates. Angle iron must bear flattening under the hammer and doubling back cold. In other respects the tests are similar to those of the Admiralty.

We will conclude this article with some observations on *blast furnaces* and their accessories together with a brief notice of their capacities. In the very early days of iron-smelting the only merchantable product was bar or malleable iron obtained directly from the ore; cast-iron being a subsequent discovery, consequent upon the employment of larger furnaces and higher temperatures in the treatment of more refractory minerals. In process of time, it was found that the production of cast or pig metal, as an intermediate stage in the manufacture of malleable iron, was attended with advantages not possessed by the older method, so that at present it is followed exclusively; the latter being confined almost entirely to a small and constantly diminishing area in Europe, besides being more extensively practised in Africa and India.

The subject, therefore, naturally divides itself into two main heads:—

I. Direct method, or extraction of malleable iron from the ore, and

II. Indirect method, or production of pig iron from the ore, and subsequent conversion into malleable iron by some form of finery process.

The difference between the two processes is mainly due to the height of the furnace. In the direct method, where a low charcoal hearth or forge is used, a portion of the ore is reduced to the metallic state at a comparatively low temperature, while another part combines as protoxide with any silica that may be present, forming a highly fusible and basic slag, into which the reduced spongy mass sinks, any excess of carbon taken up being removed by the oxidizing agency of the slag aided by the blast which is introduced through an inclosed nozzle or twyer, so as to impinge directly upon the metallic bath.

On the other hand, the furnace used for the production of cast-iron is mainly distinguished by its great height, and may be described in general terms as a conical hearth, whose walls are continued upwards into a chimney or stack of increasing but variable section; the blast-nozzle being laid horizontally instead of in an inclined position. The height of the upper portion, *i. e.* above the twyer level, may be from ten to twenty times as great as that below, or hearth proper. When the furnace is at work, or, as it is technically termed, *in blast*, it is kept filled to the top or *throat* with alternate layers of fuel, ore, and flux, the latter being mixed in proper proportions to produce the most fusible combinations of the earthy matters, a constant stream of air being maintained through the twyers, at a sufficient pressure to pass freely through the contents of the furnace. Part of the incandescent fuel subjected to the blast is completely consumed, burning to carbonic acid with a development of the maximum of heat, whereby the matters immediately adjacent are melted, and fall into the hearth, where they separate by liquation into the metal and slag; the latter, being specifically lighter, rises to the surface, and protects the former from the decarburising action of the blast. The carbonic acid formed in the first instance, encountering fresh fuel, is reduced to the state of carbonic oxide, a process that is attended with a great absorption of heat, so that the region in which a temperature sufficiently high for the fusion of metal and slag prevails does not extend more than a very short distance from the point of introduction of the air. The carbonic oxide so produced, and the unaltered nitrogen of the air, when brought in contact with an oxide of iron at a red heat, is again oxidized to carbonic acid, with the simultaneous production of metallic iron, which becomes carburetted by further contact with carbonaceous matters in its descent towards the hearth. The alternate production of carbonic acid and carbonic oxide, by the reciprocal action of carbon and oxides of iron upon the gases, is continued in the upper part of the furnace as long as the temperature remains sufficiently high, the quantity of the former gas being augmented by the decomposition of the limestone flux generally used. Ultimately, however, a sufficient amount of carbonic oxide remains in the so-called waste gases, either to form a great body of flame at the throat of the furnace when the current is allowed to flow freely into the air, or a valuable fuel, yielding sufficient heat for all the accessory operations of the furnace, when collected and utilized. The shaft of the blast furnace may, therefore, be considered as combining within itself, and performing the functions of, several distinct furnaces; thus the hearth is devoted entirely to fusion, while the middle region is essentially a concentration chamber, and the top parts, when raw fuel and flux are used, combine the functions of a limekiln with those of a coke oven. Taken as a whole, therefore, the reactions in the manufacture of pig iron are more complex than those of the open-fire process of making malleable iron direct from the ore; but, as the latter is only one out of many methods by which the same product is obtained, it will be more convenient to defer its consideration, and commence with a description of the former.

In its original or what may be considered typical form, the blast furnace consists of a shaft or chamber formed of two truncated cones, joined by their bases. The upper and more acute of the two cones is placed upright; and is known as the *stack*, while the lower and more obtuse one is inverted: the line of junction forming the widest part of the furnace is called the boshes, possibly a corruption of the German *bauch*. Sometimes the lower cone is continued down to the level of the ground, but more generally the lower part of the furnace is enlarged, forming what is known as the *hearth*, in which the molten materials collect below the level of the twyers or pipes through which the blast is introduced. In France, the space between the twyers and the broadest part, or top, of the boshes is known as the laboratory or working place (*ouvrage*). The top, or throat, of the furnace is surrounded by a platform for the convenience of charging, and is in many cases covered by a short cylindrical chimney, which leads off the flame escaping at the throat; this portion of the furnace is known as the *tunnel head*.

In the newer forms of furnaces, the conical or spindle-shaped body and cylindrical hearth, with their sharply-contrasted divisions, are, for the most part, superseded by more flowing forms, the straight slopes of the sides being converted into curves, giving a more or less barrel-shaped outline to the stack. The same terms are, however, alike applied to the different parts, the boshes being taken as indicating the widest part of the stack, and the hearth that lying below the twyers.

The construction of blast furnaces varies very considerably in different localities, in regard to size and proportion of parts to each other, as well as material employed. In the early days of pig-iron manufacture, when a square horizontal section was in general use, the external form was usually that of a square base, pyramidal tower, tapering uniformly from the ground upwards, which became modified, on the introduction of the circular stacks, to a conical or cylindrical form, the lower portions near the ground, and surrounding the hearth, still retaining the square base. Both of the above forms are characterized by extremely massive construction, the lower parts, or stack pillars, forming solid four-sided blocks of masonry, braced with iron rods, and united by cylindrical arches into the so-called twyer houses, a complete circular passage being usually formed through the mass of the pillars. When the whole furnace is of rectangular section it is braced by a similar system of tie rods through the entire height, but in conical or cylindrical forms iron hoops, placed at short distances apart, are used for the same purpose. With every increase of size the massive character of the external casing of the blast furnace has diminished by the reduction of the mass of masonry, and the substitution of cast and wrought-iron whenever it is possible to do so. Thus in many modern English furnaces the old stack pillars and twyer houses have been replaced by cast-iron columns or standards, arranged in a circle, whose entablature is a cast-iron ring, carrying the whole of the superstructure, or stack, so that the hearth casing, instead of being accessible only at the twyers, is now freely exposed all round. In like manner, the old solid stack casing of masonry and hooping has given place to a cylinder of wrought-iron plates riveted together. The latter class are known as cupola furnaces, from their resemblance to the common iron founder's furnace of the same name. Examples of these different forms of construction may be seen in almost every iron-making district. The older kinds, with massive stacks, are, as might be expected, to be found chiefly in the older districts, such as South Wales, Staffordshire, and Scotland; while in the newer furnaces of the north-eastern counties and Lancashire, the iron-jacketed cupola type is more commonly seen.

The shaft, or stack, of the furnace, *i.e.* the upper part above the boshes, is constructed at the same time as the casing. It is now invariably formed of fire-bricks, which are moulded to the proper curve of each ring. The thickness of the shaft or ring wall is about 15 or 18 inches, the joints being brought to a fine face and set in fire-clay. A second wall is, in the more massive class of furnaces, placed immediately outside the first; this may be either of common or seconds fire-brick, and set in cement; outside of all, comes the exterior casing, which, as has been already stated, may be either of iron, brick, or masonry.

A small annular space, filled either with loose sand or small fragments of broken slag, is usually interposed between each successive lining, in order to allow for any alterations of form produced by the expansion of the inner one. In the outer casing a number of square holes are often provided for the escape of moisture; these are more especially used in furnaces which only remain in blast for a certain period of the year, as is the case in Sweden, but in those that work continuously, they are often omitted.

The lower portion of the furnace, including the hearth and boshes, is built after the completion of the stack. The foundation of the hearth varies with the nature of the ground, and may sometimes require to be commenced, in concrete and rubble work, at a considerable depth below the surface; the hearth bottom consists of a thick layer of fire-brick, or sandstone, in blocks, or as large a size as can be obtained, or in some cases both materials are used. The bricks for this purpose are laid in the form of an inverted flat arch, in order that they may not be forced up in the event of the molten metal finding its way through the joints. When a bed of masonry is used below the hearth bottom, it is generally built with a system of channels or flues intersecting at right angles, through which air circulates, and prevents the access of moisture from the ground to the hearth.

The sides of the hearth and boshes, up to their junction with the stack, require to be made of refractory material, and also of considerable thickness, having to withstand a very high degree of heat, in addition to the common action of the molten slags. When the rectangular hearth was used, it was customery to build these parts of sandstone similar to that employed for the hearth bottom, but for the circular form brick is generally adopted, and is in almost all cases to be preferred.

In Sweden and Germany the hearth and boshes are often formed of a mixture of finely-crushed quartz or ground fire-brick, and fire-clay, applied in a plastic state, and rammed tight between the casing walls and a wooden core or mold of the proper shape of the cavity required, which is afterwards removed. This kind of hearth, which is represented in the Swedish furnace, is found to answer very well in all practice for furnaces of small diameter, but requires to be carefully dried before being heated, in order to prevent irregular shrinkage and cracking.

A short distance above the ground level the passages for the introduction of the blast are perforated through the wall of the hearth. These are known as the *twyer holes*, and vary in number from two to six. On the front or working side of the hearth, a square or flat-arched opening extends from the hearth bottom to a little above the level of the twyer holes. The vertical sides of this opening are prolonged outwards for a short distance into a rectangular cavity, known as the fore-hearth, which is bounded in front by a wall of refractory material, called the *dam*. The arch covering the opening is called the *tymp arch*.

The exterior of the hearth, and the faces of the numerous apertures pierced through it, are strengthened with cast-iron plates and wrought-iron bracings. The under side of the arch is, in large furnaces, usually protected by a cast-iron box or block, having a wrought-iron serpantine pipe inside, through which a current of water is kept flowing, in order to protect the brickwork from destruction by the intense heat to which it is exposed, and the corrosive action of the molten slag which is constantly flowing through it.

The dam in front of the hearth is formed of fire-brick, and carried up to the twyer level. Externally it is supported by a cast-iron plate, called the dam plate. A semicircular furrow in the top edge, known as the cinder notch, forms a passage for the slag, which is now often moulded into large blocks by receiving it in a shallow square-bodied railway truck, having movable sides of wrought-iron. When the truck or *cinder tub* is full, it is removed, and the block of slag, weighing in some instances as much as 7 tons, is, as soon as it has cooled sufficiently to become solidified, removed and thrown away. In charcoal and other small furnaces the front of the dam is generally formed into a gently-sloping inclined plane or *cinder fall*, where the slag as it runs out solidifies in a comparatively thin layer, and may be broken up and removed by hand. In Staffordshire, the slag is allowed to collect in a shallow basin in the floor of the casting house, called the roughing hole, where it consolidates to an irregular disc-shaped lump, which is afterwards lifted out by a crane, and sent off on a truck to the slag bank or cinder tip.

The tap hole for withdrawing the molten iron from the hearth is a narrow vertical slit pierced through the dam, and extending from the hearth bottom about 12 or 15 inches upwards. During the time that the hearth is filling, it is stopped by a packing of sand rammed in tight, which can be easily perforated by a pointed bar, at the time of casting. The space between the top of the dam and the tymp arch is also stopped with sand or brick, a small passage being left for the escape of slag. Sometimes the dam is raised above the level of the twyer, so that a greater depth of melted slag is retained in the furnace, and flows out continuously, the top of the fore-hearth not being stopped. At either side of the tymp there are often fixed to the hearth-casing a series of cast-iron plates with vertical racks or notches, which form points of support or fulcra for the heavy tools used in clearing the hearth and other operations in the interior of the furnace; these are known in France as *gendarmes*.

In Styria furnaces are built without fore-hearths or tymp arches, the hearth being entirely closed, and the slag and metal are allowed to accumulate, and are tapped off together at short intervals. This construction is now becoming general in other countries, with the addition of a passage for the slags, which is kept constantly open. For the latter purpose, Lurman's slag twyer is used. This is a large water-cooled bronze twyer of $7\frac{1}{2}$ inches bore in the place of the tymp, into which is inserted another of $1\frac{1}{2}$ or 2 inches aperture, through which the slag runs.

The upper end of the stack, or throat of the furnace, is surrounded by a platform or charging plate sufficiently broad to give room for working the barrows used in filling ore, fuel and fluxes. In the older square-stacked furnaces, sufficient space for this purpose could usually be found between the ring wall and the external casing; but in the more taper cylindrical or conical forms of modern times, additional surface is necessary. This is provided by an overhanging gallery carried upon brackets, constructed entirely of cast and wrought-iron. When two or more furnaces are placed adjacent to each other, their galleries are united by bridges, which communicate with the lifts for bringing up materials to the furnace top.

When the gases are allowed to burn at the throat, it is necessary to provide a chimney in order to carry the flame clear of the charging place. For this purpose a short cylinder of brickwork hooped with wrought-iron, or even of cast-iron, is used, known as the *tunnel-head*. The charging holes are rectangular apertures, varying in number with the diameter of the throat, in the lower part of the tunnel-head, through which the charges of ore, fluxes, and fuel are introduced. Except at the time of charging they are generally closed by wrought-iron shutters. The arrangements of the head of the furnace when the gases are collected are somewhat more complicated, and will be described further on.

Lifts.—In hilly countries, where the valleys are deep, it often happens that blast furnaces can be placed below the general level of the ground, supplying the ores and fuel, so that all materials necessary for working may be delivered at the furnace top without any special appliances. In flat ground, on the other hand, such as prevails in most of the iron districts of England, it becomes necessary to resort to mechanical lifts for raising the charges. The following are some of the forms more generally employed.

Inclined Planes. These are mostly to be found in old works, the more directly vertical lift being generally preferred at the present day. They are usually made with a double line of railway, or with a single line and crossings for the return trucks, carried on trestle work. The inclination is usually not more than 25 or 30 degrees. The most convenient form of truck is a triangular frame, with two pairs of wheels of unequal height, supporting a horizontal platform of sufficient size to carry four or more of the iron wheelbarrows used in charging, with their loads. The motive power is usually a steam engine of from 10 to 20 horse power, working a pair of winding drums. The load is drawn either by wire ropes, or in Staffordshire by flat-linked chains, such as are used in the same district for drawing in collieries.

At the Barrow Iron Works, in Lancashire, two inclined planes are used for the supply of seven furnaces. They are carried by bow and string girders of wrought-iron, and extend from the ground to the top of the furnace, with only one intermediate support. The platform-wagon, carrying the barrows, is received into a recess in the charging platform, and a similar one below, so that the barrows with the loads may be wheeled on and off on their arrival at either end. The motive-power is a high-pressure steam engine placed behind the furnaces, working a wire-rope drum. About 4,000 tons of materials are lifted weekly by each plane.

The most approved form of lift, where large quantities of material have to be raised to a considerable height, is a cage moving between vertical guides exactly similar to those used in collieries. As the load is comparatively quickly raised, it is a useful precaution, where steam-power is used, to have no self-acting valve gear, but to let the engine be entirely worked by hand, in order to prevent the chance of accidents from overwinding.

The water balance is an old and favorite form of lift for small furnaces. It consists of two cages moving vertically and guided, united by a rope or chain passing over a guide pulley; below the floor of each cage is fixed a water-tight box, provided with a discharge valve in the bottom. When the empty cage is at the top of its stroke, water is allowed to flow into the box until the weight is sufficient to pull up the other cage with a fresh load, the speed being regulated by a brake on the guide pulley. As soon as the return cage reaches the ground, the projecting stalk of the discharge valve strikes against a catch, and is driven up; leaving a passage for the water, which runs out, and the cage is ready for another ascent when loaded. The chief merit about this plan is its extreme simplicity and the large useful effect got from the water, especially if a natural fall can be used, otherwise it must be pumped up by special machinery. The principal objection to it is the difficulty of keeping the water boxes tight, the lift houses being generally damp and sloppy from leakages.

A more perfect kind of hydraulic lift is that constructed upon Sir William Armstrong's system, where the lifting cage is connected to a water-pressure engine by means of a chain passing over a system of compound pulleys, so that when the engine makes a stroke of 6 or 8 feet the load is lifted through a height six or eight times greater, according to the multiplying purchase of the tackle.

Pneumatic lifts are now used to a considerable extent in England, as the necessary power, compressed air, may be readily obtained from the main blast engines supplying the furnaces. The simplest form is a wrought-iron cylinder, open at the bottom and closed at the top, about 6 or 8 feet in diameter, and somewhat longer than the height of the furnace, suspended in a tank by counter-balance weights passing over pulleys in a manner exactly similar to an ordinary gasometer. A pipe for the admission of air at 3 or 4 lbs. per square inch above the atmospheric pressure, is introduced through the tank. The wagon to be lifted is carried on the top of the bell, and as the whole of the moving parts of the apparatus are balanced, the amount of power required is only that necessary to raise the additional load. For the return stroke, the air within the bell is allowed to escape by opening a valve communicating with the atmosphere, the weight of the empty wagon being sufficient to lower the bell in the tank.

In Gjers' pneumatic lift, which is much used in the newer Cleveland furnaces, the motive power, instead of being taken from the main blast engine, is furnished by a pair of double-acting air-pumps, the lift being effected by the pressure of the atmosphere acting against a vacuum in a cylinder, while the empty wagons are returned by compressing air under the piston. The Jacob's ladder, or endless chain system of lift, usually described in older works, is probably no longer in use.

The use of cast-iron cylinder blast-engines has almost everywhere superseded the ruder contrivances of wooden chests with square pistons, bellows, etc. In Sweden, for small furnaces and forges, the single-acting form of engine is much used, being cheap and economical in working and maintenance. Usually three inverted vertical cylinders are employed, of about 3½ or 4 feet diameter and length of stroke carried on cast-iron or wooden standards, and driven directly by a water-wheel.

The cylinder is provided with an air-tight piston, to which a reciprocating motion is imparted by appropriate mechanism. Two sets of valves are placed on the cylinder cover: the longer series open inwards as the piston recedes, given a passage for the admission of the external air, and at the change of stroke are closed by the compressing force exerted by the piston on the included air; and the second series, or discharge valves, which are in connection with the blast reservoir open, and allow the compressed air to pass out. In the single-acting engine only one end of the cylinder is covered and provided with valves; while in the double-acting form both ends are similarly arranged, so that one side of the piston is drawing the air through the intake valves, while the other is compressing the volume taken in at the preceding stroke, and driving it over into the reservoir through the discharge valves.

The valves employed are generally oblong rectangular plates, with their shorter sides placed vertically—one of the long sides forming the hinge. In order to combine rigidity with lightness, it is usual to make them of a combination of thin sheet iron, with contact surfaces of felt, leather or india-rubber. The hinge may be either of metal, very accurately fitted, or merely a flexible leather flap. The seats or boxes to which they are affixed are usually rectangular tubes projecting from the outer face of the cylinder cover. In order that the valves may close by their own weight when relieved from the pressure of the air, it is usual to fix the beating face of the seat in an inclined position, or counter-balance weights or springs of steel or india-rubber may be used for the same purpose.

As the motion of the valves is similar to that of the pendulum, the time required for opening and shutting them is dependent on their vertical length, so that the piston cannot be driven beyond a certain speed, unless mechanical means, capable of being increased *pari passu* with the speed of the engine, be employed. This has been attempted in the so-called slide-blowing engines, where the flap valves are replaced by a slide similar to that used in steam engines, which travels at the same rate as the piston, and places the apertures at either end alternately in communication with the external air and the blast reservoir. The system of construction has been adopted at different times both in England and on the continent. The best-known form is Slate's engine, where the slide is annular, and placed outside of the vertical blast cylinder, receiving motion by means of a pair of parallel rods connected with the rotary shaft of a steam engine below. The form of the slide is the solid of revolution produced by the rotation of an ordinary -∽- shaped slide valve about a vertical axis, formed by the center line of the steam and blast pistons. In Thomas and Laurent's arrangement the cylinder is horizontal; the air passages are of a retangular form, and are, together with the slide, placed laterally in the same manner as the steam ports and slide valve in an ordinary horizontal steam engine.

In Fossey's engine, the side valves are replaced by discs with radial perforations, which are put in slow rotary motion by gearing from tne fly-wheel shaft. A jacket is cast round the cylinder, with an interspace forming the passage from the cylinder to the reservoir. The apertures in the disc are sixteen in number, a corresponding series being formed in the cylinder ends, which are alternately opened and closed by the rotation of the disc in conformity with the motion of the piston. In the former position the external air is admitted, while in the latter the volume enclosed is driven over into the jacket and reservoir. In practice the use of the slide blast engine has not been found to be advantageous; owing to the large amount of mechanical effect consumed by the friction of the slide against the rubbing face of the cylinder, which would be great in itself, on account of the high speed at which they require to be driven, but is materially increased, owing to the dusty state of the atmosphere almost unavoidable in iron works.

In the ordinary form of engine with flap or clack valves it is necessary to provide as large an area of air ways as can be got out of the surface of the cylinder cover. The intake passages should be made, if possible, equal to one-half, and the outlet about one-eight, of the area of the piston. As it is impossible in large engines to use single valves of these dimensions, on account of their weight, and consequent liability to give rise to injurious shocks in working, it is customary, therefore, to employ a number of small valves, whose united areas make up the required amount of surface.

The question of the relative advantages of the horizontal and vertical blast cylinders has been discussed at considerable length by engineers, both in England and on the Continent. As in many other matters depending upon practical experience, there is much to be said on either side. For engines of small dimensions the horizontal form is cheaper, and may be worked with the least amount of clearance from the vertical position of the cylinder covers, which may be pierced through like a gridiron, giving a bearing for the valves, without any overhanging parts or valve boxes. The required foundations may also be less massive than in the vertical form, owing to the longer bearing of the framing, when a horizontal direct-acting steam-engine is the motor; this, of course, necessitates the comparatively larger surface for the engine-house. On the other hand, the difficulty of lubrication is increased, as the powdered graphite, which is generally used for this purpose, instead of being uniformly distributed round the pistons, is apt to fall to the bottom of the cylinder, while the upper side works dry, and the cylinder wall is worn irregularly, and becomes ovalised. The difficulty of keeping the weight of the piston off the bottom, and producing the same kind of unequal wear, is also urged against the use of large horizontal cylinders; but this objection which has also been applied in the case of horizontal steam engines, does not appear to be productive of any practical disadvantage in the larger modern engines used for screw propulsion, whose diameters are quite equal to those of the average of blast cylinders.

In regard to vertical beam engines the chief disadvantages are their very great length and expensive character of construction, and the extra amount of clearance, equal to the volume of the valve boxes, rendered necessary by the horizontal position of the cylinder covers; on the other, they have the great advantage of stability, and may be made of any dimensions; thus, in South Wales, engines are in use with blast cylinders up to 12 feet in diameter. In engines giving small volumes of blast at very high pressure, such as are used in Bessemer's process, the valves require to be made extremely light: the construction employed in such cases is a plain ring or plate of india-rubber covering a perforated plate, which opens and shuts by its own elasticity when exposed to, or relieved from, pressure.

In Coulthard's blast-engines the air passages are circular holes in the cylinder, similar to those used by Bessemer, but the valves are light wooden balls covered with india-rubber, which are arranged on inclined and grooved seats, sloping in a direction contrary to that of the current of air, so that when the pressure is sufficient to drive the balls up the incline the air way is opened; but as soon as it is relieved, they roll down again, and stop the passage.

The combination of the blast and steam cylinders, when steam power is used, is effected in various ways. The large vertical engines of modern date in this country are beam engines, the main bearing being supported either on the engine-house wall or on an entablature carried by cast-iron columns. The piston-rods are attached by the ordinary parallel motion. On the steam side, the beam is often continued beyond the point of articulation of the piston-rod, and turned upward into a short crane neck, to the end of which the connecting-rod working the fly-wheel is attached. This arrangement permits the use of a long light connecting-rod, without unduly increasing the surface occupied by the engine.

In Belgium, direct-acting engines with vertical cylinders are much used, the blast cylinder being placed uppermost. In an engine of this class built at Seraing, Evans's beam, with an oscillating center, is adopted, in order to keep the working parts within a comparatively small space, the length of the base of the engine-house being little more than the radius of the fly-wheel, or about 25 feet. The height, owing to the two cylinders being placed one above another, is considerable, being not less than 40 feet. The steam cylinder is 41½ inches, and the blast cylinder 66 inches; the length of stroke 88 inches. When working with steam of 30 lbs. pressure, and blowing air at 4½ lbs. above the atmosphere in sufficient quantity for a large furnace burning coke, the work done is equal to between 80 and 100 horse power. In the newer kind of engines built at the same works, the vertical direct-acting form is preserved, but the piston-rods are guided by sliding blocks instead of the older and more complicated arrangement of Evans.

In Austria a class of small direct-acting engines of the same character is used for charcoal furnaces, having the steam cylinder placed uppermost, which, together with the framing for the guides, is bolted on to the top flange of the blast cylinder. They are usually of small dimensions, averaging from 25 to 30 horse power, and delivers from 2,300 to 2,500 cubic feet of air per minute.

In Siegen, and other parts of Rhenish Prussia, horizontal blast engines are preferred. The commonest pattern has both cylinders placed in the same line; the rod which carries the two pistons goes through both covers of the blast cylinder, and is guided on either side. Usually two engines are coupled together upon the same fly-wheel, but the construction is such that they may be disconnected if only the power of one engine is wanted. For charcoal furnaces from 30 to 40 horse power is considered sufficient, but with the larger ones, working on coke, from 80 to 100 horse power is found to be necessary, as in other districts.

The same kind of horizontal engine is generally adopted in new works in Sweden and Lapland, having only a single charcoal furnace.

The working limits of blast pressure vary with the nature of the fuel employed, and the burden of the furnace, etc. Thus, in some of the small charcoal furnaces of Northern Europe, it does not exceed half or three-quarters of an inch of mercury above that of the atmosphere; while in American anthracite furnaces as much as 15 inches, or 7½ lbs., is used. In England 2½ or 3 lbs. is used with cold blast and tender fuel, but 3½, 4, or 5 lbs. is common with hard coke. In Bessemer's process of steel-making, by forcing air through a column of molten pig iron, a pressure of from 15 to 20 lbs. per square inch is used.

The largest blast engines hitherto constructed are those at Dowlais and Ebbw Vale, in South Wales; the former, which was erected by the late Mr. Truran, has a cylinder 144 inches in diameter, with the same length of stroke; the area of the admission valves is 56 square feet, that of the discharge valves 16 square feet, the former being equal to half the surface of the piston. The steam cylinder is 55 inches in diameter, with a piston making a stroke of 13 feet, the motion being transmitted by an unequal-armed beam. Owing to the large area of the air ways a very high speed, as many as 20 strokes per minute, can be obtained. The volume of blast delivered is about 51,000 cubic feet, at a pressure of 3½ lbs., sufficient for the supply of six large furnaces and four refineries. The main blast pipe is 5 feet in diameter. The Ebbw Vale engine has a blowing cylinder of the same size, but the steam cylinder is 72 inches in diameter.

The practice of blowing several furnaces by one engine of a large size, though mechanically advantageous, is attended with considerable risk, as the safety of the furnaces may be endangered in the event of a break-down, unless there be a reserve of blowing power. It is therefore preferable to divide the work between two or more engines, according to the number of furnaces in blast. Where there is only a single furnace, as is usually the case in charcoal-smelting, two small engines coupled together, but capable of being worked independently of each other, may be used, for the same reason.

The air or blast issues from the blowing cylinder in an irregular stream, owing to the variation in pressure at different points of the stroke, the supply being intermitted during the period of actual compression after the closing of the intake, and before the opening of the discharge valves. In order, therefore, to produce a steady current in the furnace, it is necessary to use some means of equalizing the pressure. This may be done either by receiving the blast into a reservoir whose volume is several times that of the blowing cylinder, or by delivering it into a second cylinder containing a loaded piston, which rises when the supply of blast is greater than the amount required by the furnaces; but when the quantity diminishes the piston falls, and exerts a compressing force, until the equilibrium is restored by increasing the speed of the engine. The same effect may be produced, with less loss from friction, by the use of a loaded bell, or gasometer, floating in a water tank.

Fixed reservoirs are usually made of wrought-iron formerly a spherical, or balloon-shaped form was commonly adopted, but they are now more generally made cylindrical, with flat ends like high-pressure steam boilers. The thickness of the plates, of course, depends upon the pressure and dimensions employed, as well as on the form adopted: from one-twelfth to one-eighth of an inch may be taken as sizes commonly used. The volume of the regulator may be from twenty-five to fifty times as great as the amount of blast in cubic feet delivered by the engine per second, when it is placed near the furnace, but this may be considerably diminished when a long blast main is used. Indeed, it often happens that sufficient uniformity can be got in the latter case, especially when several engines are used, by blowing into the main direct, without the use of a special regulator. Regulators in masonry or brickwork are usually lined with cement in order to protect the air from taking up moisture. A regulator of this character consisting of a chamber cut out in the solid rock, was applied at Devon Iron Works, in Scotland, as early as 1792.

The use of heated air in the blast furnace, which was first introduced by Neilson in 1828, has been found to be attended with a great economy of fuel, and at the same time the working power of the furnace is increased. It is therefore employed at the present day in iron-making districts all over the world, almost to the exclusion of cold blast, the latter being retained only for certain special makes which command an extra price, and may therefore be produced without the strict regard to economical considerations which is necessary when working on an article of lower repute.

The amount to which the temperature of the blast may be raised with advantage does not appear to have any practical limit, every fresh increase being attended with further saving of fuel; thus, in the first instance, 100° were found to be an advantage over air at the ordinary temperature; then came temperature of 200°—400°, up to the melting point of zinc; and now it is actually used at a visible red heat, or about 700°. Thus it was found that a saving was produced of 5 cwt. of coke per ton of iron made by using air heated to about 650°, instead of the lower temperature of 350° or 400°, previously employed. The difficulty of keeping the apparatus tight, and the rapid destruction of metal pipes when heated to redness in air, render a special construction necessary for the production of such extremely hot blast economically. The greater number of blast-heating apparatus in use at the present time, and known as *hot blast ovens* or *stoves*, consist essentially of a series of parallel, or spiral tubes, arranged in a chamber of fire-brick, and heated externally by a fire. The opposite ends of these tubes are connected with two mains intersecting them at right angles. One of these supplies cold air, while the other, or hot blast main, removes the heated air.

In the older forms of stoves, such as that originally adopted at Calder, in Lanarkshire, the fireplace is an oblong rectangle in plan. The two mains, which are placed parallel to the longer sides, are of a circular section, and cast with a number of circular sockets for the heating pipes. These are arched, horse-shoe, siphon, or inverted U pipes, also circular in section, placed with the arched portion upright, and luted into the sockets on the mains. The fire-grate runs along the whole length of the bottom, and the flame, after playing on the undersides of the tubes, passes between and around them, by means of appropriate flues, into the chimney, while the cold air, entering by the main on one side, flows continuously through the arched pipes, where it becomes heated, and passes off to the furnace by the opposite main.

To obviate the defects of this apparatus, many special modifications have been introduced. Thus, in order to get a greater amount of heating surface, the horse-shoe pipes are now usually made of flattened elliptical, or rectangular, instead of circular section. A smaller radius of curvature for the arch has been obtained by the use of inverted V pipes, and more uniformity in heating, by the introduction of stops at intervals in the entry main, so that the air is made to pass alternately backward and forward several times across the arch, instead of moving only in one direction, as was the case in the original form. Whatever system of construction is used, the air should pass through the apparatus in the reverse direction to the flame, entering cold, at the end farthest from the hottest point of the fire. Arch-headed pipes are very easily broken by irregular expansion at the crowns, if a certain freedom of motion is not allowed to the ends; this is equally provided against by placing one of the mains loose on its bed, supporting it by spherical bearings, so that it may travel outward to a slight extent as the pipes become heated.

Round and oval ovens have been introduced to obtain a more uniform heat than can be got by the old rectangular form. These terms refer to the shape of the base, or fire-place. The mains are replaced by a cast-iron box of a square or trapeziform section, divided by a central partition, one division corresponding to the cold, and the other to the hot blast main. The vertical pipes, instead of being arched at the top, are united by a short horizontal one, the limbs being close together. This variety is much used in Staffordshire and Lancashire.

A modification somewhat similar to the last, known as the *pistol pipe*, is used in Scotland, Cleveland, and other districts in this country, and is also rather in favor in France and Germany. The two vertical pipes or limbs are replaced by a single one, divided by an internal partition reaching nearly to the top. It is closed at the upper end, and is either straight, slightly bulbed, or bent over into a half arch. One of the divisions is connected with the intake, and the other with the exit, so that the cold air rises on one side, and passes through the bulbed chamber at the top, down the other, heated to the furnace. When the curved head is used, it is usual to place two series of pipes in opposite directions, with the heads, meeting so as to form an arch for mutual support; but, of course, the question of unequal expansion does not arise, as each half of the arch is independent of the other. The term pistol pipe is derived from the resemblance of the curved head to a pistol stock, the straight portion corresponding to the barrel.

All the preceding forms of stoves are characterized by the use of air ways presenting continual changes of form; thus the blast passes from the main through the heating pipes alternately backwards and forwards. In what are known as spiral-pipe ovens, the heating is effected in tubes of uniform section, arranged similarly to the worm of a still. Among these may be mentioned the apparatus in use at Ebbw Vale, a horizontal coil of cast-iron pipes exposed to a fire running the whole length of the axis. The pipes are formed in segments corresponding to one-half of a complete turn of the screw, and are united by ordinary socket joints. The union of the pipes and mains in stoves is always effected in the same manner, the latter being cast with sockets for receiving the ends or feet of the pipes, which are often made slightly conical, spigot fashion. The joint is made air-tight by rust cement.

Stoves with straight or serpentine horizontal pipes are much in vogue in Germany, and are known after the name of the works at Wasseralfingen, in Wurtemberg, where they were first introduced. In the original construction a number of straight pipes of circular bore, placed horizontally, extend from side to side of the walls of the fire chamber in a manner exactly similar to the tubes of a locomotive, and are united into a continuous serpentine coil by external arched bends not exposed to the fire. In this way the difficulty arising from the tendency of the pipes to break at the bends, owing to irregular expansion when heated, is avoided. The newer forms differ chiefly from the foregoing in the section of the pipes, which are now usually elliptical instead of circular. The position of the longer axis may be either horizontal or vertical; the latter, being the most advantageous arrangement, is usually adopted.

Thomas and Laurent's stove, used in several of the newer French furnaces, consists of three vertical tubes of a large diameter, united by external horse-shoe pieces placed externally, as in the Wasseralfingen apparatus. In order to obtain a larger heating surface, the inner side of the tube is studded with projecting radiating ribs about 3 inches high, the remaining interior space being filled with a cylindrical core of cast-iron or fire-brick. These ribs are not continuous in the same place throughout the entire height of the tube, but are interrupted at different levels, the series above and below being arranged so as to break joint with the central one. By this means the air is forced to travel in a somewhat deviating course through the passages enclosed between the core and the ribs. A very considerable heating effect is claimed for this arrangement, which is similar to that of the stoves known as "gill calorifiers," used for warming large rooms; but it is attended, owing to the irregular section of the air ways, with a notable loss of pressure from friction. In considering hot blast stoves, we have hitherto assumed that the heating of the air is to be effected by means of fuel burnt on a grate below the pipes. This is still done to a considerable extent, but the substitution of the waste gases of the furnace is now almost equally common, especially in furnaces using fuel brought from a distance. For this purpose it is necessary to bring a branch pipe to the stove from the main gas conduit, which terminates either in a series of jets, or more commonly in a rectangular mouth-piece, a special aperture of a similar character, for the admission of air, being placed immediately above or below. It is generally advisable to have a grate with a small fire, which insures ignition of the gases; without this, in case of the flame becoming extinguished, air would be liable to get back into the gas main, where it would most probably produce an explosion.

Pressure-gauges. For low-pressure blast, such as is used in small charcoal furnaces, or for determining the tension of the waste gases, a water gauge is generally used, but for the more highly compressed air used in furnaces on mineral fuel, mercury gauges are necessary. When the blast is at a very high temperature, it is necessary to make the observations as quickly as possible, or to cool the air down by passing it through a tube placed in a current of water, before allowing it to come in contact with the mercury. By multiplying the indications of the mercurial gauge in inches by 13.59, the corresponding height measured in water is obtained, and conversely, inches of water gauge may be reduced to mercurial inches by dividing by the same constants. When, as is usually the case, the height of the water gauge is expressed in feet and inches, it may be reduced to the corresponding pressure in inches and lines of mercury by multiplying by 0.882. The amount of blast passing through a twyer is found by multiplying the velocity of the current passing per minute or second, as deduced from the pressure, by its sectional area. The result, of course, must be corrected for temperature, atmospheric pressure, and moisture, and for the contraction of the jet at the point of efflux. The latter correction varies in amount with the form of the nozzle, and is somewhat greater for cylindrical than conical pipes, and also increases with the pressure employed. As a general rule, the diminution of volume from this cause may be taken at about 3 per cent., and the real amount found by multiplying the theoretical quantity by 0.92. The determination of the amount of blast carried into the furnace, from the observations given above, may be approximately found by the following formula, given by Weisbach, as a simplification of the more exact one deduced by him from Poisson's law, checked by actual experiment:—

$$Q = 1179F\sqrt{\frac{h}{b}} \times \frac{1.018}{(1 + 0003672\,t)^{\frac{1}{2}}} \qquad (1)$$

where Q = the number of cubic feet discharged per second, reduced to the temperature of 10° Centigrade, and 30 inches barometrical pressure, F = area of twyer, h = observed height of pressure gauge in inches of mercury, b = observed height of barometer. The second part gives the correction for the heat of the blast, when t = its temperature in Centigrade degrees.

In the first part of the above formula, F is taken in square feet, by dividing by 144, or, putting F = 1 square inch, we obtain the following expression:—

$$Q = 8.2\sqrt{\frac{h}{b}} \qquad (2)$$

which gives the volume of the blast per second per square inch of the sectional area of the twyer. The following table gives the value of Q for different values of the fraction $\frac{h}{b}$ in formula (2):—

$\frac{h}{b}$	Q	$\frac{h}{b}$	Q
0.01	0.82	0.30	4.49
.02	1.16	.35	4.85
.05	1.83	.40	5.19
.10	2.59	.45	5.50
.15	3.18	.50	5.80
.20	3.67	.55	6.08
.25	4.10	.60	6.35

These quantities require to be corrected for the temperature when hot blast is used by the second part of formula (1);

The quantity of air passing into a furnace may also be decided from the composition of the waste gases when the furnace works with a closed top, and the whole of the volatile products are collected.

Determination of the Temperature of the Blast. Mercurial thermometers cannot be used in determining temperature much above 200° or 250° with accuracy, owing to the irregular expansion of the mercury when very near its boiling-point. For measuring the high temperatures prevailing in blast furnace operations, metallic pyrometers of various kinds are employed, depending either on the expansion of a single metal, or a combination of two, such as iron and copper or platinum. These, although convenient, are liable to give inaccurate results after a time, from the metals becoming permanently expanded when repeatedly heated.

In practice the temperature of the blast is generally determined by its power of fusing metal. This is done by exposing a thin rod of the metal to the current in the tywer, a hole being made for the purpose in the elbow of the branch pipe connecting the twyer with the blast main.

The following are the reputed melting-points of the metals available for determining the temperatures of hot blast:—

	Degrees.
Tin	245
Bismuth	250
Lead	330
Zinc	410
Antimony	512

In experiments on the temperature of the interior of the furnace, such as those made by Tunner in Styria, and Rinman and others in Sweden, alloys of gold and silver, and silver and platinum, are used, the increase of the melting-point being assumed as directly proportional to the increase in the amount of the more refractory metal. This method was also used by Plattner in determining the temperature of slags.

Pouillet's pyrometric method, which consists in observing the increase of temperature produced in a weighed quantity of water by plunging into it a mass of metal, whose weight and specific heat are known, heated to the temperature to be measured, has also been applied to the construction of pyrometers for blast-furnaces; a ball of copper is used for medium, and platinum for higher temperatures. From the increase in the sensible heat of the water, the loss experienced by the metal may be found by the following formula:—

$$t' = \frac{w\ t}{w'\ s}, \text{ where}$$

w = weight of water, t = its increase of temperature, w' = weight of metal ball, s = its specific heat. To this result must be added the observed temperature of the water in order to get at that of the furnace.

Siemens' pyrometer, which is used to a considerable extent for measuring hot blast temperatures, is of this kind, and is thus described by the inventor:—

It consists of a portable vessel, formed of three concentric cylinders of thin copper plate, the space between the inner and middle one being filled with cowhair, and that between the middle and outer one with air, so as to prevent as perfectly as possible the loss of heat from the interior. A delicate mercurial thermometer is fixed in the interior of the vessel, being protected by a perforated shield, and furnished with a movable sliding-scale, showing pyrometer degrees, each of which is equal to 50° of the ordinary thermometric scale. For obtaining the temperature, balls of copper or platinum are used, which are so adjusted that fifty of them would be equal in thermal capacity to an imperial pint of water. Each ball is perforated by a hole, through which a rod is passed in exposing the same to the action of the heat to be measured. Immediately before using the instrument, an imperial pint of water is poured into it, and the slide is so moved that the zero point of its scale corresponds with the top of the mercury in the thermometer. The ball, after having been exposed to the heat for two or three minutes, is plunged into the water. The mercury will then be observed to rise, and the absolute measure of the temperature is obtained by adding the reading on the pyrometer scale opposite the new level of the mercury to the original temperature of the water before the ball was introduced. With a little practice very satisfactory results may be obtained with this instrument; but its application is limited to the heat at which the metal ball is deteriorated; nor can it be used for measuring the temperature of inaccessible places.

Another pyrometer, recently invented by Mr. Siemens, is based upon the property possessed by pure metals of offering an increased resistence to the passage of an electric current in proportion as their temperature increases. A platinum wire of known resistance is wound upon a helical groove on the surface of a cylinder of fire-clay, and enclosed within a cylindrical casing of platinum if the temperature to be measured exceeds the welding point of iron, or copper for lower temperatures. The two ends of the coil are brought endways, and are attached within the tube to thicker wires of copper, insulated for a short distance by a coating of pipe clay, and further on, when beyond the influence of the heated space, by india rubber or gutta percha. These wires communicate with the measuring instrument, which may be placed at any convenient distance. The latter is a specially constructed galvanometrical arrangement, and is so graduated that a reading in degrees on a divided scale may be at once obtained. These do not give an absolute measure of temperature, but the final result is taken out from a table calculated for each instrument. The pyrometer coil may be either fixed permanently, if it is desired to have a means of continuously determining the temperature of a particular place, or it may be introduced into the furnace through a door or other opening for a minute or two, which is sufficient time to obtain a reading. The latter is the only method available for very high temperatures; for by continuous exposure the protecting case, even when of platinum, would be ultimately destroyed. The electrical resistance of platinum wire is increased fourfold by a rise of temperature from 0 to 1650°.

It is in all cases desirable to place the stoves as near to the furnace as is consistent with the other requirements of the works, in order that the blast may lose as little of its acquired heat as possible, by not having to travel a long distance through pipes exposed to the air. In some instances, especially in small charcoal furnaces, where the stoves are heated by waste gases, they are placed on a level with the furnace top, the gases being led in by a short flue in order to economise their sensible heat, as well as the much greater quantity derived from their subsequent combustion. The hot blast main is then carried down vertically to the twyers. This practice is tolerably common in Swedish and German charcoal furnaces, and appears to be very general in the United States, where the blast-engine boilers are often carried on the top of high-vaulted structures in the same manner. Much greater regularity of draught, and especially freedom from choking by dust, can be obtained when the stoves are placed at the ground level, and the gases are brought down by a suitable conduit.

The blast coming from the stove passes through a ring main, which, in the old square-cased furnaces, is carried through the circular passage traversing the stack pillars; but in the newer forms is generally attached to the columns, surrounding the hearth at a certain distance above the ground. A vertical branch pipe, or *goose neck*, is led off opposite to each twyer hole, and at the proper level is turned over at right angles into a horizontal arm, to which the blast nozzle, or blowpipe, is attached. A throttle, or slide valve, for stopping or regulating the blast, is attached to each branch, as well as to the main near the stove. In cold blast furnaces the air is led through a conical copper nozzle, attached to a branch pipe by a flexible leather tube; but with hot blast it is requisite to make all the fittings of metal, and the necessary means of adjustment are provided by interposing a sliding or telescopic tube and a ball-and-socket joint between the end of the branch pipe and the twyer. By the former the twyer is set to the proper length, while the latter allows the direction of the entering blast to be varied, so that it be made level, plunging or rising at pleasure. When hot blast is used, it is necessary to protect the walls of the hearth from the intense heat generated by the energetic combustion going on immediately in front of the twyers. This is done by the use of water twyers, which are hollow, conical, or tapering D-shaped tubes, with double walls, which are kept cool by a current of water circulating through the interspace.

The number and arrangement of twyers vary very considerably. The smaller charcoal furnaces have often only two, placed on opposite sides of the hearth. Three is a more usual number, one being placed at the back; *i. e.*, opposite to the tymp, and the others at the sides of the hearth. When a larger number is used, they are generally placed at equal intervals all round the hearth. This method is usually adopted in cupola furnaces; but in South Wales, where there are many large furnaces with only three twyer arches, they are sometimes arranged in series; thus, two will be put through each of the side openings, and the same number at the back, or three at the sides, and one or two at the back, etc. This is done to avoid the use of twyers of an excessive diameter, and, by multiplying the points of contact with the fuel, to make the combustion more uniform over the entire area of the hearth. Sometimes a special twyer is added on the tymph side, for the purpose of removing irregularities caused by local cooling, and is only used in case of the hearth becoming obstructed.

In small charcoal furnaces, working with an open throat, the gases are often taken off by wrought-iron pipes perforating the wall of the furnace about 10 or 12 feet below the top. This plan is commonly used in Sweden for supplying gases to mine kilns, hot-blast stoves, etc., but can only be practiced on a small scale. The supply is apt to be somewhat irregular, from the stoppage of the holes by the descending charge. A more perfect method for the same purpose, is that of contracting the throat by the insertion of a cast or wrought-iron cylinder of somewhat smaller diameter than the ring-wall, so that an annular space at the top is kept clear the materials of the charge, and forms a connecting flue for the gases. In order to prevent the charges from blocking up the lower part, it is usual to increase the diameter of the shaft by the amount required to form the flue, and the tube restores the furnace to its original section.

When it is desired to collect the whole of the gases given off at the top of the furnace, it is necessary to work with a closed throat. The most generally used, and, at the same time, one of the simplest contrivances for this purpose is that known as the cup and cone. It consists of an inverted conical cast-iron funnel fixed to the top of the furnace, whose lower aperture is of about one-half of the diameter of the throat. An upright cast-iron cone is placed in the furnace below the cup; it is suspended by a chain attached to its apex, so that it may be raised or lowered at pleasure; in the former position it bears against the bottom of the cup, and forms an air-tight stopper, preventing the escape of any gas from the top of the furnace, which then finds its way out by proper passages through the wall of the furnace in the space above the charges enclosed by the cup; but when lowered it allows the charges in the cup to be dropped into the furnace, and at the same time acts as a distributer. Only the small amount of gas that is lost during the time of charging is allowed to escape, and as this operation is very quickly performed, the current through the mains is kept up with great regularity. The cone is suspended by an arch-headed lever, carrying a counterbalance at the end of the opposite arm. The rising or lowering is effected by a pinion, moved by a hand-wheel gearing into a segmental rack attached to the counterbalance weight. The gas passes through a lateral flue into a square wrought-iron main-pipe, or conduit, which distributes it to the various pipes feeding the boiler fires and hot-blast stoves. A modification of the cup and cone is in use in Cleveland, where the cone is replaced by an external cylinderical stopper, which is lifted during the charging time, and lowered when the throat is stopped, the object being to allow the charges to occupy the space which is necessarily kept empty for working the cone on the old system. It was found, however, that the working of the furnace was injured from the want of a proper distributer for the charges, on account of the absence of the cone; when this was supplied by suspending a conical ring by three chains to the bottom of the plug, regularity in charging was restored.

In the charcoal furnaces of Lake Superior and Styria, a charging barrow is used, which is constructed exactly in the same manner as the cup and cone. The body of the barrow is an inverted eight-sided pyramidal cup, the bottom being an upright cone, which, when dropped by a lever attached to its summit, leaves an annular space for the materials to pass out into the furnace, at the same time they are directed towards the circumference of the throat, in sliding over the surface of the cone. At Rhonitz, in Hungary, charging barrows are used having sliding cylindrical sides in addition to the dropping conical bottom, so that the charging takes place in a ring towards the sides of the furnace as well as at the center.

Büttgenbach's system of furnace construction originally adopted at Neuss on the Rhine, has been followed to some extent in France and Germany. In this neither red-brick nor sheet-iron casing is used, the stack wall being formed of single rings of moulded fire-bricks, with a few wrought-iron hoops. This is carried upon cast-iron columns, or brick-piers, the hearth being entirely independent and accessible on all sides. The charging platform is carried by the gas down-comer, which, instead of being a single large tube, is diverted into several smaller ones, which together form a kind of scaffolding to support the top of the furnace, part of it being carried by the stack wall, which is free to expand and contract under changes of temperature, as it is relieved from the downward pressure of the heavy structure at the top.

In a furnace at Schwechat, near Vienna, the stack consists of a single thickness of fire-brick hooped with iron rings, carried upon arches uniting piers of red brick-work 23 feet high, upon a base 40 feet square. The upper end of the stack is cased with sheet-iron for a height of about 12 feet, and the hoops are united together by flat bars of iron, forming a casing which, while it allows the bricks to be freely exposed to the air, is sufficiently strong to bear a part of the weight of the top of the furnace, the remaining support being given by the gas down-comers. The hearth has seven courses of water-blocks built into it between the twyers and the junction with the stack. These are flat cast-iron boxes covered with sheet-iron and open behind. Water is introduced by a pipe into the uppermost series, and flows downward through the lower ones; the cooling action tends to preserve the brick-work of the boshes from corrosion, especially when the ore contains much manganese. The gas brought down from the furnace top is received in a ring-shaped tube, partly filled with water and open at the side. The water is raised in the opening by the pressure of the gas, and forms an air-tight joint. The furnace is $61\frac{3}{4}$ feet high, $18\frac{1}{2}$ feet diameter in the boshes, and $7\frac{1}{2}$ feet in the hearth; the capacity is 9990 cubic feet, and the daily make 45 to 50 tons of Bessemer iron from the spathic ore of Styria.

In laying out new works at the present time it is usual to build the furnaces of a more or less skittle or tub-shaped section, all sharply contrasted slopes being avoided, the diameter increasing continuously from the throat to the boshes, and then being contracted in a similar manner down to the hearth-bottom, without having a cylindrical hearth. The form of the body of such a furnace is well represented by a common soda-water bottle, supposing the neck and the pointed bottom to be removed. In Scotland the same kind of section is used, with the addition of a broad cylindrical hearth. In Cleveland slightly-curved stacks, with conical boshes and cylindrical hearths, are the rule. In South Wales the latter conditions are often reversed, the lower part, up to the top of the boshes, being made conical, while the stack, which is for a certain distance cylindrical, is terminated by a strongly-curved dome. In all cases of the above, however, the hearths are of considerable breadth.

In French, Belgian, and German furnaces curved sections are less common than in this country. A more especial characteristic is, however, the small diameter of hearth generally adopted, the sides being brought in from the boshes in a strongly-curved convex sweep. This type, which is usually combined with an extremely massive construction of hearth, is very similar in form to an inverted claret-bottle, having the bottom and the greater part of the neck removed; the body, which increases from the bottom upward with a slight taper, representing the stack, the shoulder the sweep of the boshes, and the narrow neck the hearth. Swedish charcoal furnaces are generally of considerable height when compared with their diameter; the hearth and boshes form part of the same cone, usually very acute. The stack is either wholly or in part cylindrical. In Styria the charcoal furnaces used for smelting spathic ores resemble those of Sweden by their considerable height, as compared with the breadth and the steep slope of the conical parts, but are specially distinguished by their narrow throats, which often do not exceed $2\frac{1}{2}$ feet.

The height and other dimensions of blast-furnaces vary very considerably in different localities with the nature of the ores and fuel. No special rules can be laid down as to the form best suited for a particular class of ore, experience having shown that the requirements of each class are to be met by special arrangements. The most useful guide in the construction of new furnaces is furnished by the condition of those that have been blown out after working upon the same kind of ore. It was by comparisons of this kind that the modern barrel-shaped furnace was elaborated by Gibbons, in South Staffordshire, from the older conical form, the section of the newer furnace being modified wherever the action of the fire was found to be strongest: thus square hearths were burnt out to a circular form, and the sharp angle at the joining of the hearth and boshes was also removed. It was therefore apparent that, by altering these parts in conformity with the indications, a double advantage was attained, a certain amount of materials being saved, while the furnace was sooner brought to its best working condition than was the case when it had first to be cut into shape by the heat.

If we consider the nature of the work done in the blast furnace with reference to the amount of iron produced in a given time, it will be evident that an increase of such production can only be obtained from the same ores by passing a large number of charges through in the same time; this, however, depends upon the facilities possessed for withdrawing them by fusion at the bottom; for, however great the cubic contents may be, it is clear that new materials can only be supplied in proportion to the speed with which those charged before them are removed. The power of fusion is, however, to be measured by the space offered for combustion of fuel by the blast, and as in the best condition of work, this space should be confined as much as possible to the plane of the twyers, it follows that increase of space for more active combustion is to be got mainly by augmenting the width of the hearth. The amount of such an increase is to be determined by the power of the blast, which must be of sufficient tension to penetrate to the center of the hearth.

Greater height may be given to a furnace, either to increase its capacity, or to intercept more completely the enormous quantity of heat carried upward by the gaseous products of combustion. Strictly speaking, there should be no combustion of fuel, except in the region of fusion, and the space immediately adjoining, where the carbonic acid produced at the twyers is converted into carbonic oxide. The latter gas, and the nitrogen of the air consumed, are charged with the reduction of the oxides of iron in the ore to the metallic state, and the progressive heating of the materials in the upper region of the furnace. The greater the distance, therefore, of the upper end of the column of materials from the level of most active combustion, the more perfectly will the heat be abstracted from the gases; therefore, we might expect that the greatest economy of fuel would be found in the tallest furnaces, and this is practically the case, as exemplified in the newer furnaces in Cleveland, which have been successively increased from a height of 50 or 60 feet to 70 feet and upwards, in one instance attaining as much as 96 feet, with an increased saving of fuel in each case. Of course only the sensible heat is abstracted from the gases,—an amount that is quite independent of the further and much larger quantity that may be got by burning them in air.

The conditions limiting the height of the furnace are mainly due to the character of the ores and fuel, as regards their power of resisting crushing when exposed to the pressure of a tall column of materials, and the initial velocity of the blast. The favorable results given above, as obtained in Cleveland, are due to the extremely hard character of the coke employed, which, according to Bell, is capable of resisting a crushing strain of 5 cwt. per square inch. Very tall furnaces, therefore, can scarcely be used with tender fuel, such as soft charcoal, or coal, and pulverulent ores. Much of the anthracite of South Wales is in the same condition, as it decrepitates, and is apt to choke up the furnace, if not removed by an extra-powerful blast. The furnaces, therefore, worked with this fuel, though of large diameter, and provided with a great number of twyers, are usually of small height.

The time occupied in the descent of the materials from the throat to the hearth is chiefly dependent upon the capacity of the furnace. It is of the greatest importance that this should be so regulated as to insure an early commencement of the reduction of the ore to the metallic state at a low temperature, otherwise, in the event of protoxide of iron and silica coming in contact with each other in a more highly-heated atmosphere, a silicate is formed, which is easily fusible, but difficultly reducible, and, running down into the hearth, forms what is known as a scouring or black cinder, at the same time giving rise to white iron. The harder a furnace is driven, therefore, the greater is the tendency to deterioration in the quantity of the metal produced, owing to the quicker descent of the charges; and it will, therefore, be apparent that when an increased make is desired, larger furnaces should be used.

The difficulty of insuring uniformity of temperature in circular hearths of large character has led to the proposal of a more elongated form, such as an ellipse or oblong rectangle: the latter being adopted in Rachette's furnace, which was introduced in Russia a few years back, and has been tried experimentally in other parts of Europe. The oblong hearth is combined with a shaft, increasing regularly in diameter upwards, the section at the throat being from two and a half to three and a half times as large as that measured at the level of the twyers. The object of this arrangement, which gives a furnace similar in form to a calcining kiln, is to produce a more prolonged contact between the gases and the materials of the charge, by reducing the velocity of the upward current. The use of drying flues is another new feature in Rachette's furnace; these are a series of ramifying rectangular passages, traversing the outer casing of the stack at different levels, which are in connection with a similar chamber placed below the hearth. Before blowing in, a fire, placed in the chamber, warms up the whole of the masonry uniformly, and more quickly than can be done on the old system; afterwards the flues may be used for the reverse purpose of cooling the masonry by the circulation of cold air. The twyers, from twelve to sixteen in number, are arranged in two rows, breaking joint with each other, on the opposite long sides of the hearth; a dam and tapping place are provided on each of the short sides, so that the removal of slag and iron may be effected from either end.

In the simplest of the preceding cases the charge is dropped into the center of the throat, and forms a conical heap, sloping outwards to the circumference at an angle varying, with the nature of the materials, from about 35° to 40°, the latter being the maximum inclination of the talus formed by coke. Owing to differences of form and density, the fragments of ore and fuel take up different positions in the furnace, the former usually remaining in the place where they first strike the surface of the column, while the lighter and more voluminous masses of fuel roll down the slope until they have established a talus at the proper angle of repose. It will easily be seen, therefore, that this is the worst possible combination, the fuel being mainly distributed towards the circumference, where there is a comparatively free passage for the gases, while the ore remains in a dense column, impenetrable at the center, and descends without being properly heated. When coke is used, the friction of the fragments against the wall is so very great as to increase the tendency to form obstructions, or *scaffolds*, and their attendant evil. known as slips, when the charge falls, owing to the removal of the obstruction, by gradually increasing pressure from above, and by the removal of supports below. The ore in the center, by its greater velocity of descent, passes through the fuel charged before it, producing an inversion of charge, so that the slags change irregularly from white to black, according to the preponderance of the ore or fuel at the twyers.

When the charges are thrown in close to the circumference of the throat, the surface of the column of materials forms a conical cup, the lighter fragments rolling inwards towards the center, while the ore remains at the outside. The tendency is, therefore, for the fuel and larger masses of ore to collect in the middle, where it forms a column, which, on account of its ready permeability as compared with, the more densely-packed ore at the sides, gives a more equable draught over the entire horizontal section of the shaft, at the same time that the bulk of the ore descends slowly through the region of maximum heating by the gases, both conditions tending to uniformity of working and economy of fuel. When the throat is very wide, however, and the furnace low, the draught at the center may become too strong, leading to an unnecessary consumption of fuel by diverting the gases from the sides. The continual contact of metallic oxides has also an injurious effect upon the lining of the furnace, as the silica of the bricks is liable to combine with protoxide of iron, forming a fusible silicate, by which they are rapidly destroyed.

When a conical funnel or charging plates are used, the surface of the column in the furnace presents an annular ridge, sloping both towards the center and the circumference, the ores occupying the crest of the ring, while the fuel and larger blocks are intermixed at either side. This is by far the most favorable condition for uniform working, as then the charge and fuel are more perfectly mixed than by either of the preceding methods. The use of the movable cones below the funnel, is in the ordinary cup-and-cone arrangements, corrects the tendency to accumulations at the center, which is experienced when the charging funnel is too much contracted at its lower end.

Tapping. The molten metal accumulating in the hearth of the furnace is removed at regular intervals by tapping, or piercing a hole through the lower part of the dam, and allowing the metal to flow into the sand or cast-iron moulds placed in front of the furnace. Before tapping, the blast is shut off, and the tymp stopping removed. The tap-hole is opened by driving in the point of a wrought-iron bar, which is held by one man, while another strikes the end with a sledge hammer if necessary. The moulds, or pig beds, usually consists of a series of furrows in the sand of the casting floor, moulded by wooden cores of a D-shaped section. The curved side is placed downwards, and usually has the name or mark (brand) of the works attached to it. The moulds are arranged in parallel series on either side of a central feeder, known as a sow; and as soon as one series is filled, the current is allowed to flow into the next, and so on until the cast is completed. In Sweden cast-iron moulds are generally used instead of sand.

When the ore contains lead, a certain quantity may be obtained in the metallic state by tapping the hearth at the lowest possible point, or by making a hole below the hearth bottom, and collecting the metal which finds its way through the joints of the stones. In the latter case a small fire is kept burning in the hole to prevent the lead from solidifying, and it is then allowed to accumulate until a sufficient quantity has been obtained for a cast.

Blowing in. When a furnace is quite new, the whole of the masonry must be very carefully dried before it can be lighted. This may require several weeks, according to the state of the atmosphere and the nature of the materials employed. When perfectly dry the hearth is filled with wood, and the upper part of the furnace, to the top of the boshes, with coke, which is then lighted from below. As soon as the fire has burnt through to the surface a light charge of ore is given, which is repeated when the fire reappears at the top. Twelve hours after lighting, a grating of bars, carried by an external bearer laid across the rack plates of the hearth, is placed within the furnace, a little below the level of the tymp; the column of materials being thus supported, the cinders and ashes of the coke filling the hearth are then removed, and the air passing through the grate bars, revives the combustion in the upper part of the furnace. When the lower part of the mass is glowing, the bars are withdrawn, and the ignited materials are allowed to fall into the hearth. The fire is then slackened by stopping up the forehearth as before. The same process is repeated at the end of every twelve hours, or if it is desired to get the furnace in blast quicker, every six hours. As soon as the first charge gets down to the hearth the dam and twyers are fixed in position, and the blast is turned on, cold air, and nozzles of a reduced diameter, being adopted at first. The furnace is then filled to the throat, as if in regular work; but the weight of the charges, as well as the temperature of blast and diameter of twyers, must be gradually increased, so as to get to the proper burden in about seven or eight days. When several kinds of ore are at hand it is well to begin with the poorest, as for the same volume of charge the burden will be lighter. The above is the old method of scaffolding, which is still used in France. In England a more rapid plan is adopted. The top of the wood in the hearth is covered by a considerable quantity of coke, followed by alternate layers of coke and limestone, the latter for fluxing the ash of the fuel, until the furnace is one-third full. When the fire is well started, and small charges of ore are added, the blowing is commenced with twyers of a very reduced area. If properly managed, grey iron and clean cinders may be obtained from the beginning; but for this purpose it is essential not to increase the burden too rapidly, or to drive too hard at first.

Blowing out. When a furnace is to be put out of blast, it is advisable to reduce the charges as much as possible for a short time before, in order to get the hearth as hot as possible, so as to remove any metallic obstructions. The gas tubes, and all metal fittings of the throat, are then removed, and the charging being stopped, the contents of the furnace are entirely liquefied by the last charge of fuel. The last tapping must be made from as low a point as possible. The sides and bottom of the hearth are often found to be covered with masses of imperfectly-agglomerated malleable iron, the so-called bears, wolves, or sows, and isolated crystals, or even large masses of a copper-red compound, formerly supposed to be metallic titanium, but which has been shown by Wöhler to be a cyano-nitride having the composition $Ti\ C^2N + 3\ Ti^3N$.

Stoppage of Furnace. It may sometimes happen, through failure of the blast engine, or a deficiency of materials, that a furnace must be stopped for some time. This is done by closing up the throat and all the twyer holes hermetically with sand or clay. If the charges have been previously diminished to a certain extent, so as to keep a good body of fuel in the furnace, it may be stopped for about a week without serious inconvenience; but if the blast be interrupted for a longer period, the cooling takes place to such an extent that the furnace becomes blocked up, and would probably be obliged to be abandoned.

The greatly-increased production of modern, as compared with older furnaces, is due partly to their much larger size, and partly to more rapid driving, produced by giving more blast. No general rule can be laid down as to the time necessary for complete reduction of the ores previous to their actual fusion and the separation of metal and slag by liquation, as it is obviously dependent upon many variable elements, such as the greater or less density of the ores and fuel, the richness of the former, whether they are readily reducible, or have a tendency to scorification, etc. This point must, therefore, be determined by actual experiment for each particular furnace, by varying the amount of blast and the burden of ore and fluxes, until the particular result required, either in respect to quality or quantity of produce, is obtained. Other things being equal, the time of reduction will be lessened the more perfectly the materials are exposed to the action of the upward gaseous current. It therefore becomes of the greatest importance to render the flow of gases as uniform as possible throughout the mass, by the use of proper charging and gas-collecting appliances. Especial care must be taken that no hindrance is offered to the free efflux of the current at the top of the furnace. For this reason, these methods, based upon the collection of the gases above, or in the center of the charge, are to be preferred to such as employ lateral flues, penetrating the wall below the level of the throat, whereby the current is diverted, without being allowed to give up its heat to the upper part of the column of materials above the flues. An increase in the volume of blast, keeping the pressure constant, has a tendency to put the furnace on white iron. By increasing both pressure and temperature, on the other hand, especially with refractory ores, greyer or more highly-carburised iron is likely to be produced.

The nature of the work done by blast-furnaces can only be understood by examining the conditions of production prevailing in different districts. The following example gives some of the working details of a furnace selected merely for the purpose of illustration.

At Eisenerz, in Styria, the furnaces consist of two truncated cones, with a very narrow throat, and are distinguished from the ordinary blast-furnace by being without a fore-hearth, the metal and slag being allowed to collect in the hearth, which is comparatively shallow, and are tapped off together at short intervals, the number of casts varying from 5 to 16 in twenty-four hours. The ores are chiefly spathic, poor in manganese, partly pure, and partly altered into brown hematite. In order to get rid as completely as possible of the sulphur due to the presence of pyrites in small quantities, they are allowed to weather for two, three, or more years after roasting. The amount of iron varies from 35 to 55 per cent. The object sought to be attained is the production of white iron, for conversion into bar iron, from rich and easily-reducible ores, with a minimum expenditure of fuel (charcoal). This is done by working under a very heavy burden, the tendency to obstructions caused by this proceeding being counteracted by giving charges of fuel alone at regular intervals. Some varieties of ore are of the self-fluxing kind; but as a rule they contain a considerable quantity of lime, requiring the addition of siliceous and aluminous fluxes, such as clay or clay slate. The following are the charges and yields of two furnaces, taken as a sample :—

1. *Von Fridau's Furnace, Vordernberg.* The charge consists of 5 to 6 cwt. of roasted ore, 10 per cent. of clay, and 8 to 10 lbs. of washed metal, *i. e.* granulated pig iron, recovered from the slag by stamping and washing. The fuel is measured; 2 tubs, or 15$\frac{1}{2}$ feet, or about 101 lbs. of soft pine-wood charcoal being employed per charge. The burden of ore is gradually raised from 3 to 6 cwt. per charge, and then diminished similarly, a blank charge of fuel being given at each change. The daily production is from 18$\frac{1}{4}$ to 20 tons. The twyers plunge or incline at an angle of 5°, so that the furnace fulfils, to some extent, the functions of a refinery.

2. *Von Fischer's Furnace, Vordernberg.* This is one of the smallest furnaces in the world. The usual charge includes 223 lbs. ore, 15 lbs. clay, and 4 lbs. of washed metal, to 1$\frac{3}{4}$ tub (13$\frac{3}{4}$ cubic feet or 95 lbs.) of charcoal. The daily production is 7$\frac{1}{4}$ tons; the furnace is tapped at intervals of one and a half hours, fourteen charges being made during the same period, including a blank one, *i. e.* of fuel without burden.

These furnaces are driven at a very high speed. The first tapping takes place twelve hours after lighting, and afterwards at intervals of two to two and a half hours. The burden of ores smelted per tub of 7$\frac{3}{4}$ feet of charcoal varies from 170 to 220 lbs. with cold, and from 220 to 250 lbs. with hot blast. The consumption of charcoal is from 65 to 70 per cent. of the weight of the metal produced, or from 13$\frac{1}{2}$ to 14 cwt. per ton. See *Steel.*

STEVENS GUN.—Messrs. J. Stevens & Co. of Chicopee Falls, Mass., have obtained a special reputation for their sporting-arms. Fig. 1, represents the combined central-fire rifle and shot-gun, the shot-barrel fitting in the same stock. Fig. 2, represents the new model Hunter's Pet, which is much used as a *pistol-carbine*, and for accurate shooting at short range. This arm weighs from 2 pounds for a 10-in.

Fig. 1.

Fig. 2.

barrel to 2$\frac{3}{4}$ for an 18-in. A heavier pattern weighs about 5$\frac{1}{4}$ lbs., and is good for all shooting up to 40 rods.

The Stevens' shooting-gallery rifle is a specialty and challenges the world. There are more of them used in shooting-galleries than of all others combined. The Austin Bros., Boone Bros., Frayne Combination, Capt. Joe Rambolt and wife, Baughman and Butler, Buffalo Bill, Wild Harry, Fanny Herring, and others always use them when shooting apples from the heads of each other. In some cases the marksman points the rifle over the shoulder, and takes aim by the reflection in a small looking-glass before him. They give this rifle decided preference over all other weapons in performing these dangerous feats.

The Stevens gun can be easily taken apart and carried in a valise or trunk, which is a great advantage over other styles. This point is greatly appreciated by those who travel long distances, as the arm once carefully packed with other traps, needs no further attention until required for use. This is a strong point with all the Stevens arms, viz.:—their great portability. Another good feature is, unless specially ordered otherwise, they are all chambered for the ordinary rim-fire ammunition, which can be had in any village in the land. Absolutely no traps at all are required except a wiping-rod, which should be frequently used with a woolen rag wet with oil to keep the barrels in the best condition for fine shooting.

STEP.—In a military sense, step signifies pace, or progression by one removal of the foot. The term is also figuratively used to signify promotion; thus, the *step* from a Lieutenant to a Captain, and so on to higher grades. To *step out*, is to lengthen the step, without altering the cadence. To *step short*, is to diminish or slacken the pace, according to the tactics. These phrases are frequently used in military movements when it is found necessary to gain ground in front, or to give the rear of a column, etc., time to acquire its proper distance. *Balance-step*, is so called from the body being balanced upon one leg, in order to render it firm and steady in military movements, etc.

In the United States Service, the length of the direct step, in common and in quick time, is twenty-eight inches, measured from heel to heel; and the cadence is at the rate of ninety steps per minute for common time, and one hundred and ten steps for quick time. The principles of the direct step are taught by means of the *balance-step*; during its execution the Instructor requires the recruits to keep the body, shoulders, arms, and hands in the position of a soldier.

The Instructor commands: 1. *Balance-step*, 2. *Left foot*, 3. FORWARD, 4. REAR, 5. HALT. At the command *forward*, bend slightly the left knee, and carry the left foot, without jerk, about fourteen inches to the front, the knee straightening as the foot is brought forward, the toe turned out and slightly depressed, the sole of the foot about three inches from the ground the body balanced firmly on the right foot, and inclining slightly forward. At the command *rear*, carry the left foot, without any jerk, to the rear, the knee slightly bent, the toe on a line with the right heel, and inclining slightly downward. The steps may be continued by alternating the commands, *forward* and *rear*. At the command *halt*, given after the command *rear*, plant the foot by the side of the other. The balance-step with the right foot is similarly executed. To execute the balance-step, gaining ground to the front, the Instructor commands, 1. *Balance-step*, 2. *Left foot*, 3. FORWARD, 4. GROUND, 5. HALT. At the command *forward*, advance the left foot as previously explained, at the command *ground*, plant it without shock, the foot advancing as the weight of the body is brought forward, the left heel twenty-eight-inches from the right; the right foot is then advanced without command to the position of *forward*, and similarly planted at the word *ground*. The movement is continued by the command *ground*, until the command *halt*, when the foot in advance is planted and the one in rear brought to the side of it. The command *ground*, is at first given in very slow cadence to allow each recruit to balance himself on the foot that is planted, and is afterward gradually increased to common time.

The principles of the balance-step being thoroughly understood, to march in the direct step, the Instructor commands: 1. *Forward*, 2. *Common time*, 3. MARCH. At the command *forward*, throw the weight of the body upon the right leg without bending the left knee. At the command *march*, move the left leg smartly, but without jerk, carry the foot straight-forward twenty-eight inches from the right, measuring from heel to heel, the sole near the ground, the toe a little depressed, the knee straight and slightly turned out; at the same time throw the weight of the body forward, and plant the foot without shock, the weight of the body resting upon it; next, in like manner, advance the right foot, and plant it as above; continue the march, without crossing the legs or striking one against the other, keeping the face direct to the front. The Instructor indicates from time to time the cadence of the step by calling out, *one, two, three, four;* or *left, right*, the instant the left and right foot, respectively, should be planted.

Being in march, to shorten the step, the Instructor commands: 1. *Short step*, 2. MARCH. At the second command the length of the step is reduced to fourteen inches, the squad resuming the full step at the command: 1. *Forward*, 2. MARCH. Being in march to mark time the Instructor commands: 1. *Mark time* 2. MARCH. At the second command given the instant one foot is, comingto the ground, continue the cadence and make semblance of marching, without gaining ground, by alternately advancing each foot about half of its length, and bringing it back square with the other. To resume the direct step the Instructor commands: 1. *Forward*, 2. MARCH. Being in march, to change step, the Instructor commands: 1. *Change step*, 2. MARCH. At the command *march*, given the instant the right foot comes to the ground, the left foot is advanced and planted; the hollow of the right is then advanced against the heel of the left, the recruit again stepping off with the left. The change on the right foot is similarly executed, the command *march* being given when the left foot strikes the ground. Being in march, to march to the rear the Instructor commands: 1. *To the rear*, 2. MARCH. At the command *march*, given as the right foot strikes the ground, advance and plant the left foot: then turn on the balls of both feet, face to the right about, and immediately step off with the left foot.

Being at a halt to side step, the Instructor commands: 1. *Side step to the right* (or *left*), 2. MARCH. At the command *march*, carry the right foot six inches to the right keeping the knees straight and the shoulders square to the front; as soon as the right foot is planted, bring the left foot to the side of it, and continue the movement, observing the cadence, until the commands: 1. *Squad*, 2. HALT. Side steps are always executed in quick time, unless common time be specified. Being at a halt to back step the Instructor commands: 1. *Backward*, 2. MARCH. At the command *march*, step off smartly with the left foot fourteen inches straight to the rear, measuring from heel to heel, and so on with the feet in succession till the commands: 1. *Squad*, 2. HALT. At the command *halt*, bring back the foot in front to the side of the one in rear.

The length of the double step is thirty-three inches; the cadence is at the rate of one hundred and sixty-five steps per minute. To teach the principles of the double step, the Instructor commands: 1. *Double step*, 2. MARCH. At the first command, raise the hands till the forearms are horizontal, fingers closed, nails toward the body, elbows to the rear. At the command *march*, raise the left leg to the front, bending and then elevating the knee as much as possible, the part of the leg between the knee and instep vertical, the toe depressed; replace the foot in its former position, and execute the similar movement with the right leg. The Instructor, placing himself seven or eight yards in front of the recruit and facing him, indicates the cadence by the commands, *one, two*, given alternately as the left and right foot touch the ground, beginning in common time, and increasing gradually to double time. The alternate movement of the feet is continued till the commands: 1. *Squad*, 2. HALT. At the command *halt*, bring the foot, which is raised, by the side of the other, drop the hands, and resume the position of the soldier.

The recruit being established in the principles of the step the Instructor commands: 1. *Forward*, 2. *Double time*, 3. MARCH. At the command *forward*, throw the weight of the body on the right leg; at the second command, raise the hands until the forearms are horizontal; at the command *march*, carry forward the left foot, the leg slightly bent; the knee somewhat raised, and plant the foot, the toe first, thirty-three inches from the right; then execute the same motion with the right foot; continue this alternate movement of the feet; throwing the weight of the body upon the foot in advance and allowing a natural swinging motion to the arms. The double step under urgent circumstances may be increased to one hundred and eighty steps per minute. At this rate a mile can be passed over in ten or eleven minutes. The recruits are also exercised in running, the principles being the same as for double time.

In marching in double time and at the run, the men breathe as much as possible through the nose, keeping the mouth closed; experience has proved that, by conforming to this principle, men can go much farther with less fatigue.

Recent and interesting experiments in cadence and step have been made at West Point by Colonel H. C. Hasbrouck, U. S. Army. The Cadets at the Military Academy are arranged according to size throughout the battalion; the files on the outer flanks of the flank companies are over six feet, and on the inner flanks of the center companies about five feet in height.

Measurements of the cadence and length of step were taken many times for each company and under all circumstances, in column of fours and platoons, with right and left in front, in line, maneuvering, and marching in a straight line over a measured course of 300 yards, and at quick and double time; also with and without music by the Academy Band. As it was supposed possible that a step that was suitable and natural for the active but not yet fully developed young gentlemen that compose the Corps of Cadets might not do for the soldiers of the Army, measurements of the cadence and length of step of a Company of Engineers, a very well instructed and fine appearing Company were also taken.

The results obtained were as follows:

Battalion of Cadets.	
Average length of step, quick time	30″.2
Slowest cadence, quick time without band	115
Shortest step, quick time	28″.6
Longest step, quick time	31″.3
Slowest cadence, quick time, without band	109
Fastest cadence, quick time, without band	119
Average cadence, quick time, with band	120
Average length of step, double time	37″.2
Average cadence of step, double time, without band	184
Shortest step, double time	35″.5
Longest step, double time	38″.9
Slowest cadence, double time, without band	181
Fastest cadence, double time, without band	188
Average cadence, double time, with band	180
Company of Engineers.	
Average length of step, quick time	31″.5
Average cadence of step, quick time	120
Average length of step, double time	37″.
Average cadence of step double time	178

It will be noted that the shortest step taken in quick and double time is longer than the step prescribed in the Tactics. The slowest cadence viz., 109, was made in marching against a very high wind. It is believed that an increase in the length and cadence of the step, in both quick and double time, is desirable. Probably, a length of 30″ and cadence of 120 for quick time; and a length of 36″ and cadence 175 for double time, would be a great improvement and would prove practicable and suitable for all the men in service.

STER HYDRAULIC PRESS.—A press in which a powerful hydrostatic pressure is obtained by introducing into the cylinder of a hydraulic-press already filled with liquid, not an additional amount of liquid by successive impulses, as in the case of the hydraulic-press, but a solid substance, usually a solid cord, by a steady, uninterrupted movement.

STERRO METAL.—An alloy used in gun-making. It derives its name from the Greek word signifying "firm." It consists of copper and spelter, with very small portions of iron and tin; and to these latter its peculiar properties are attributed. It has a brass-yellow color, is close in grain, is free from porosity, and has considerable hardness, whereby it is suitably adapted to bearing-metal, or to other purposes, where resistance to friction is needed. *Sterro-metal* possesses another quality, which, in reference to its application for guns, is regarded as more important than its high tenacity, namely, great elasticity. The inventor proposes that, in heavy ordnance, the interior should consist of a tube of *sterro-metal*, and, over this, wrought or cast-iron should be shrunk from the breech to beyond the trunnions. The following is the composition, as given by Baron Rosthorn, of the Imperial Arsenal, the inventor:

Copper	55.04	or	57.63
Tin	0.83		0.15
Zinc	42.36		40.22
Iron	1.77		1.86

It differs from *Keir's metal*, mainly in having a small quantity of tin.

STETSON MAGAZINE-GUN.—This rifle has a fixed chamber closed by a movable breech-block, which slides in the line of the barrel by indirect action, being moved by levers from below. The arm resembles externally, in its operation, and in many of its features, the Winchester. It is locked in the act of closing the lever-guard, by a projection on the bolt being thrown upward in front of a shoulder in the upper portion of the frame. The empty shells are ejected through the same lateral opening by which the magazine is charged. It is provided with a cut-off for the magazine, by which it can be reserved for an emergency while the arm is being used as a single-loader.

STICKLER.—A sidesman to fencers, or second to a duelist.

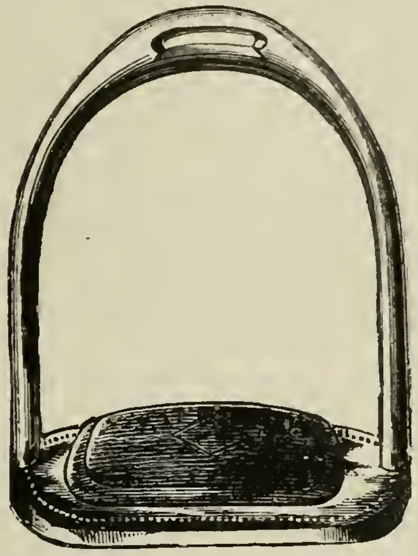
STILETTO.—A small poniard which came into use during the Middle Ages, and which is of common use even at this day. The blade is round and pointed.

STILLMAN MAGAZINE.—The comb of the butt-stock is counter-bored for four musket cartridges. They are kept in place by a lid swinging backward, which is kept open when raised, and shut when closed by a flat spring which bears on corresponding flat surfaces on the hinge. When the lid is raised the cartridges are kept from accidentally falling out by copper bushings, as in the *Benton magazine*. This magazine has been modified so as to allow the lid to swing sidewise in opening.

STINK POT.—In warfare a shell, often of earthenware, charged with combustibles, which, on bursting, emit a foul smell and suffocating smoke. It is useful in sieges for driving the garrison from their defenses; also in boarding a ship, for effecting a diversion while the assailants gain the deck. The stink-pot is a favorite weapon of the Chinese. Under the more elegant title of Asphyxiated-shell, the French and other modern nations have experimented considerably on this mode of harassing the enemy. Also written *Stink-ball*.

STIRRUP.—The iron hoop fastened to the saddle by a leather strap, to enable the rider to mount and dismount, and support his foot while in the saddle. The present English stirrups are similar to those attached to a hunting-saddle. The stirrup-irons are made of shear-steel. The lance-stirrup has a leather bucket attached to it, for the butt of the lance. The stirrup was not used till the 14th century. Its shape has varied very much, according to the time and the people. At first it was only a strap, to which was subsequently added a flat piece of wood or metal; and afterwards it was of a triangular shape, as may be seen in the frescoes of the Cathedral of Brunswick. The stirrups used in battle in the 15th century, which took the place of the *soleret*, were closed at one end so as to prevent the passage of the foot.

The drawing represents the Whitman stirrup, which



possesses the advantage of keeping the rider's foot in place by means of a solid rubber mat. See *Saddle*.

STOCCADO.—A push or thrust with a rapier.

STOCK.—1. A term variously applied in ordnance to signify the nave of a wooden wheel, the handle of a tool, the whole of the wooden part of a rifle or pistol, a part of the gun-carriage, etc. 2. The usual neck-gear of a soldier in some armies, generally made of black leather, answering the double purpose of keeping the cold out and the soldier's head up. The stock is not worn by the enlisted men in the United States Army, but is worn by Cadets. See *Cravat* and *Gun-stock*.

STOCKADES.—A line of stout posts or trunks of trees firmly set in the ground, in contact with each other, and arranged for defense. A stockade is used principally when there is plenty of timber and little or no danger of exposure to artillery fire. It is frequently used to close the gorge of a field-work, and to guard against the work being carried by a surprise, by bodies of infantry attacking the work in rear. The timbers of a stockade may be either round or square. When round, they are hewed to a flat surface on two of the sides so that the posts, when placed in position, shall have a close contact of at least four inches. The top of a stockade should be at the least eight feet above the ground on which it is placed, and it should have the upper ends of the timbers sharpened (Fig. 1), arranged with spikes, or fixed in some way to offer an obstruction to climbing over the top. A stockade is arranged for defense by cutting loop-holes, which can be used by a soldier when firing. The height of the loop-hole may be just four feet and six inches above the ground, or higher. In the former case, the soldier stands upon the natural surface of the ground in the act of firing; in the latter case, he stands upon a banquette of earth or some temporary arrangement which raises him to the proper height. The exterior opening of the loop-hole should be not less than six feet above the ground on which the enemy may stand when he is close to the stockade, so that he can not make use of the loop-hole. Some obstruction must therefore be placed in front of the loop-hole, keeping the enemy away from it; or the ground immediately in its front should be deepened by digging a trench. If the loop-hole can be placed six feet above the ground, it will be practicable to arrange the loop-holes so as to furnish a double tier of fire.

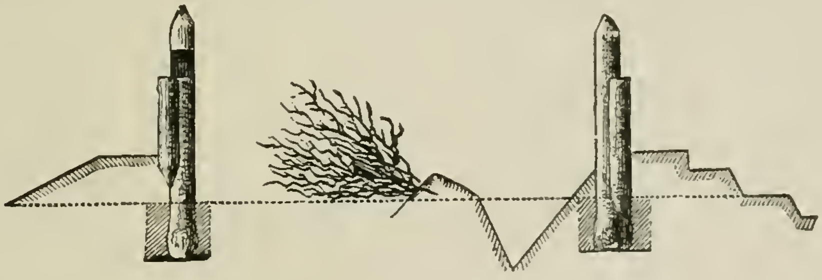


Fig. 1.

The loop-holes of the lower row should be arranged so that they cannot be used by the enemy. They should not be higher than eighteen inches above the ground on the outside; on the inside, the ground must be cut away or a trench dug in rear of the stockade, so as to allow the use of the loop-holes by the defense. The stockade is frequently strengthened by a second row of timbers, as shown in Fig. 2. In this drawing, is seen the method of making loop-holes, by cutting away a strip from two adjacent posts, leaving an interval through which the men can fire. Loop-holes are usually made about two feet and six inches apart. See *Accessory Means of Defense*.

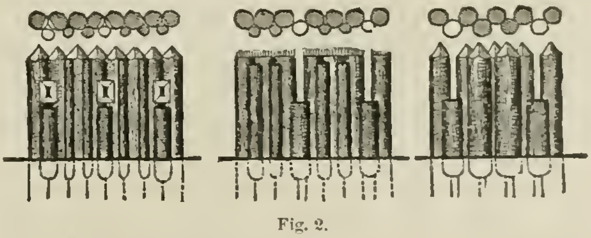


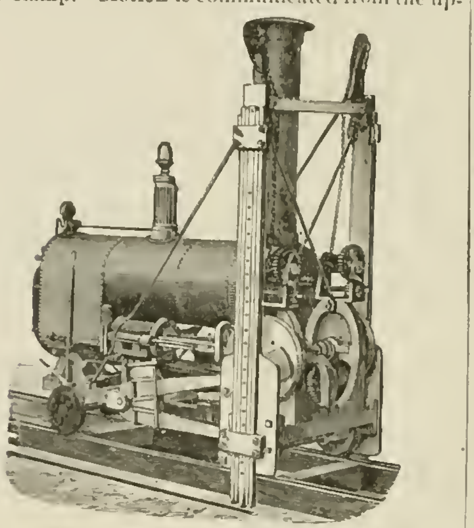
Fig. 2.

STOCK-PURSE.—In the British Service, a certain saving which is made in a corps for regimental purposes.

STONE-BOW.—A cross-bow which was formerly used or designed for throwing stones.

STONE-CUTTING.—The plans as at present adopted by Military Engineers, for constructing permanent fortifications, require a thorough knowledge of the art of stone-cutting. Stone, as employed for military purposes, is a substance which in none of its varieties is easily operated on by machinery, owing chiefly to its brittleness, its unequal hardness, and the natural cracks which so frequently impair its solidity. Accordingly though many ingenious machines have been invented for working stone, it is as yet only in some of the plainer kinds of work that they can be said to have entirely superseded hand operations. Some stones and slates are soft enough to be cut with ordinary toothed saws much in the same way as wood is cut. More generally, however, the sand-saw is employed, which we shall presently describe in noticing marble cutting. For the cutting of common kinds of stone, which are not to receive a fine polish, a machine, which promises to be very efficient, has been recently patented by Mr. George Hunter, of Maentwrog, Caernarvon, and is now in operation at various large quarries, both of stone and slate. The cutting portion consists of a circular disk, round the circumference of which a number of pointed steel tools are fixed into sockets, thus giving it the appearance of a large toothed saw. This machine will cut sandstone at the rate of 5 to 6 in., slate at 3 in., and soft limestone at 3 in., per minute, supposing these to be in blocks each 2 ft. thick.

The American Wardwell double-gang machine, extensively used and adapted for every kind of stone, except grit-sandstone, is represented as mounted upon a steel rail track on the bed of the quarry. The frame which supports the boiler, engine and other machinery consists of one piece of forged iron, weighing nearly a ton, thus furnishing great durability. The engine is of six horse power, its shaft carrying a balance wheel on each end to which is attached an adjustable wrist-pin plate. The levers which operate the gangs of cutters are pivoted at their rear ends to an extension of the frame. The free end of the upper lever passes through a sliding-stirrup, or swivel attached to the wrist-pin plate (not shown) giving an up and down motion to that end of the lever, as the balance-wheel revolves. The free end of the lower lever passes through a mortise in the back side of the lower clamp. Motion is communicated from the up-



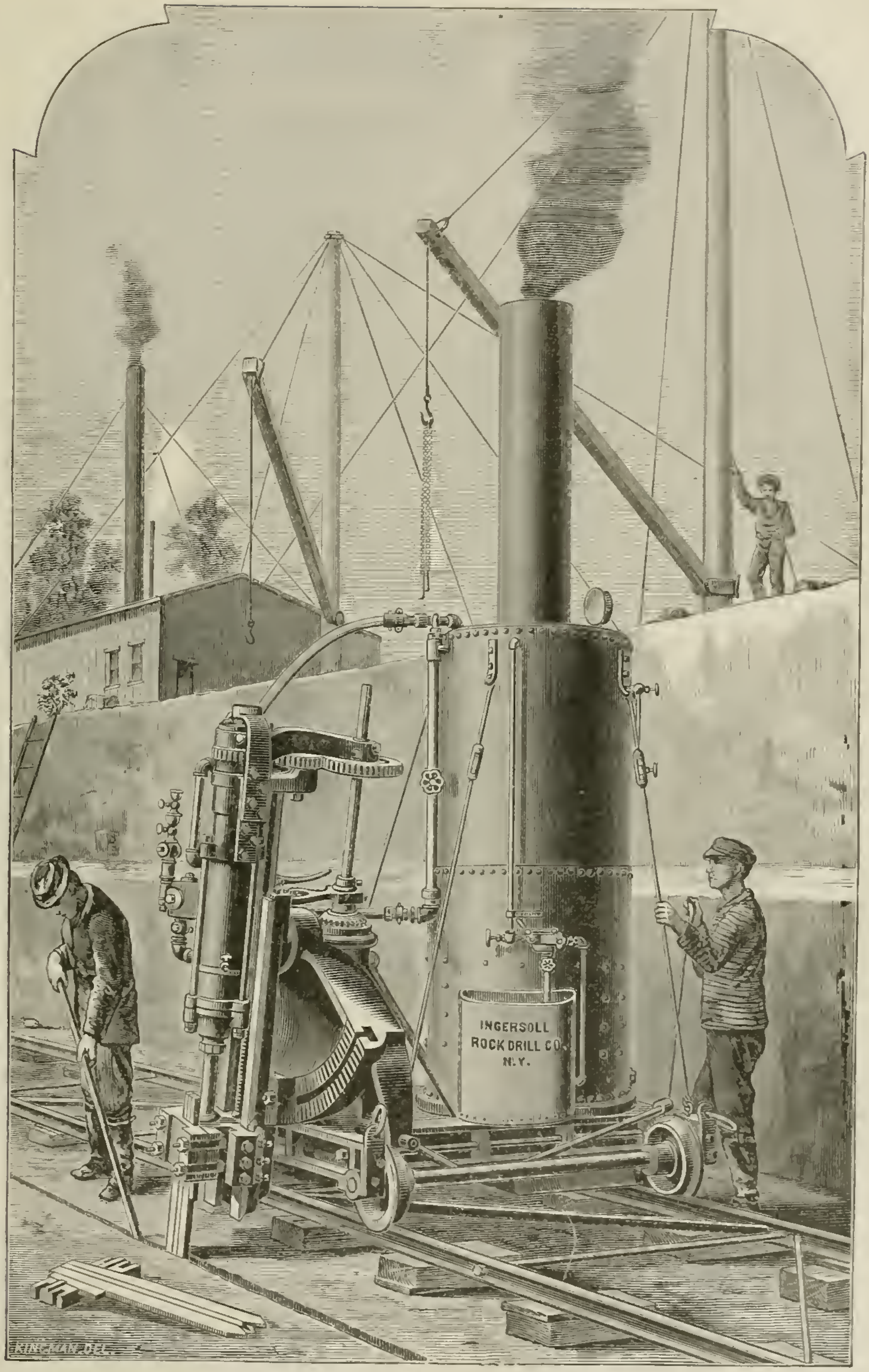
Wardwell Double-gang Machine.

per to the lower lever by means of clasps, between which the rubber springs are placed, as shown in the drawing. The free end of the lower lever actuates the gang of cutters, which consists of five bars of the best cast-steel, sharpened at their lower ends, and clamped together by head and foot clamps; the whole sliding freely on the standard. Of the five cutters, two have diagonal cutting-edges and three have their edges transverse. The center cutter extends the lowest and they altogether form a stepped arrangement each way from the center; thus when the machine is moving forward the three cutters, which includes the center one, operate, and while moving in the opposite direction the other two with the center one perform the work. The object of the diagonal cutting edges is to insure an even bottom to the channel. These bars of steel are from seven to fourteen feet in length, according to the depth of the channel to be cut. The upper end of these bars are grooved to match corresponding grooves in the head clamp, for the purpose of preventing displacement of the cutters. The worm on the main-shaft actuates the worm-gear upon the feed-shaft. The feed-shaft extends diagonally downward to the rear of the machine, where it terminates in a bevel-pinion: upon the rear axle are placed two bevel-gears. By means of the lever shown, either of these bevel-gears may be thrown into action with the pinion. It will be readily understood that the motion thus communicated, serves to turn the axle either backward or forward, according to which wheel engages the pinion. When the machine is required to be stationary these bevel-gears are so placed as not to engage with the pinion. The short lever locks these bevel-gears in either of the desired positions. The windlasses on each side of the machine are for changing the gangs.

So far as sawing or slicing of stones is concerned, the great tendency of late years is to rely on the use of the diamond—the black variety which is of no use as a gem. Some American stone-cutting machines have saws with teeth set with these diamonds, and are said to cut ordinary sandstone at the rate of 75 sq. ft. per second for each saw. Machines for dressing the face of stones by means of a series of chisels, in imitation of the handiwork of the mason, have recently been tried and have given fair results. It is considerably more than a century since machinery for sawing and polishing marble were first established at Ashford, near Bakewell, in Derbyshire, that country being still the seat of the principal marble manufacture of England. Marble is cut into slabs by means of a series of thin plates of soft iron used like saws, but having no teeth. The saw-blades are fixed into a rectangular frame, to which a reciprocating horizontal motion is given. The block of marble to be cut rests on a carriage below the frame, and a small rill of mixed sand and water is constantly falling into the saw-cuts. After the marble has been sawn into slabs it is cut up into narrow pieces, when so required, by means of small circular saws with smooth edges, sand and water being employed as above. The sawn slabs are next submitted to the grinding process. This, for pieces of moderate size, is usually done upon a large circular cast-iron plate, called a *sanding-bed* or *grinding-bed*, mounted upon an upright spindle, and supplied with sand and water. The workman places the piece of marble with its face downward upon the grinding-bed, and exerts the proper amount of pressure. The marble is held in its place by means of guide-rods stretched across the plate. Slabs too large to be manipulated in this way are ground with plates of iron operating upon their surface.

Cylindrical objects, such as columns or vases, are first formed roughly into shape with a hammer and chisel, and then turned, with a pointed steel tool, upon a lathe, to which a slow motion is given. When thus brought to an accurate form, a rapid motion is given to the lathe, and the tool-marks ground away by the use of coarse, and then fine, and still finer sandstones—the polishing being completed with emery and putty-powder while the object is still upon the lathe. Machinery is also applied to the production of flat objects with curved and molded outlines. The machine for this purpose operates by the use of a rotatory cutter, which is guided in its action by a template formed accurately to the intended shape of the article. The cutter is of steel or stone, and is attached to the lower end of a spindle driven by beveled wheels. There is a flange which allows the cutter to penetrate the marble till it reaches the template and no further. In the process of cutting, the marble is constantly drawn up against the cutting-tool by two weights, the one pulling the table in one direction, the other the carriage on which the table rests, in a direction at right angles to the former, thus compelling the cutter to follow the outline of the template. The shape of the cutting-tool is, of course, exactly the reverse of the moulding to be formed.

In the cutting of granite, the machinery and processes are so nearly the same as those employed for marble, that it is unnecessary to describe them separately. Suffice it to say, that all objects to which the sawing apparatus cannot be applied, require to be worked to shape with great care by means of steel chisels and iron mallets, which only remove a small

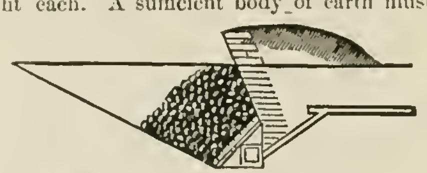


Improved Ingersoll Stone Channeler.

portion at a time. Owing to the great hardness of the material, any defect in the chiseling greatly increases the labor of polishing. So slow, indeed, are the operations with granite, that a saw-blade will not cut through one inch in depth during a whole day, and a good-sized sawn slab will take a week to polish.

A most important operation in the quarrying of stone is that known as "channeling," by which is meant the process of cutting long, narrow channels in the rock for the purpose of freeing the sides of large blocks of stone. Formerly this work, like all other operations of quarrying (excepting the hoisting and loading), was performed by hand; but of late special machines have been devised for the purpose, which are rapidly finding their way into use. When the proper number of channel-cuts have been made around a block of stone in the quarry, it is necessary to undercut the blocks in order to raise them. This is done by drilling,or "gadding," a series of holes at varying distances apart, according to the nature of the stone, along the bottom of the block, and releasing it by the splitting action of wedges. The large illustration exhibits an improved form of channeling-machine recently introduced by the Ingersoll Rock Drill Company. The machine is self-contained, and mounted upon a carriage which is made to traverse a tramway laid alongside of the cut about to be made. The boiler is of an improved design, with submerged flues, and has a water-tank attached. The engine is unusually powerful for the work required. It is the well-known Ingersoll rock drill, provided with channeling-cutters in place of the usual drilling-bit, and operates by percussion, as in the usual form of the drill. It is provided with a steam-cushion, by which the force of the blow is completely controlled. The framing by which the engine is attached to the carriage is made amply strong to secure the requisite stability for channeling in hard and tough stone, and by means of suitably disposed gearing the machine can be adjusted to a desired angle in a vertical plane. The stability of this machine has been fully tested and demonstrated by successful work in all kinds of stone. One of the machines has been doing successful work during the season on the massive green serpentine rock of Hartford County, Maryland, and has not cost a cent for repairs. This rock is as hard as fluorspar (harder than granite). The makers give the record of their machine as follows: In sandstone, 260 feet channel in 10 hours; in oolitic limestone, 230 feet.

STONE-FOUGASSES.—A stone-fougass is made by excavating a shaft 6 feet deep, inclined to the horizon at an angle of about 45°. At the bottom place a charge of 55 lbs. (a cubic foot) of powder, then a strong shield of wood at least 6 inches thick, in front of the charge, and over the shield throw in three or four cubic yards of pebbles, of not less than half a pound weight each. A sufficient body of earth must be



placed vertically above the charge and retained over the upper part of the shaft, near the edge, by a revetment of sods, to insure the effect taking place in the right direction. Fougasses are usually fired by means of an augot, or casing tube, containing a hose or saucisson, etc., led up the side of the pit or shaft, and then parallel to the surface of the ground, at a depth of two or three feet; or they may be fired, at the proper moment, by means of a loaded musket with its muzzle in the powder, and a wire or string fastened to the trigger. See *Fougasses*.

STONE MORTAR.—A mortar designed to project stones a short distance, not exceeding 250 yards; it also threw 6-pounder shells up to 150 yards. The stones which were used in this mortar were put into a basket fitted to the bore and placed upon a thick oak plank, which covered the mouth of the chamber. This plank had a number of holes bored through it, to allow the passage of the flame. When shells were fired, they were laid in beds with their fuses placed outwards, and cut to burn 15 seconds. The mortar was primed with a piece of quick-match long enough to allow the cannoneers to get out of the way of any fragments which might fall in the battery. When firing stone, the angle of elevation was 60°; but, with shells, this angle was about 33°, to prevent the shells from having too great a force when falling, by which they would be buried in the ground, and their explosion become less effective.

STONE SHOT.—Shot used with guns up to the sixteenth century. The class of ordnance from which they were discharged was comparatively weak as compared with that of the present day, and consequently the projectiles were of no great size. Stone shot were also discharged from mortars.

STOP IRONS.—Pieces of iron at the ends of the side-pieces of a platform to prevent the carriage running off it.

STOPPAGE OF PAY.—When by report of the Second Comptroller of the Treasury, or of any Bureau of the War Department, it is ascertained that an officer of the Army has been overpaid, or is indebted to the United States for money, property, or supplies, or has failed properly to account for the same, the Paymaster General notifies the officer of the charge.

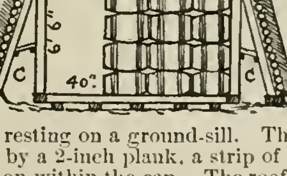
If a refundment or satisfactory explanation be not made within a reasonable time, the Paymaster General, on the order of the Secretary of War, gives notice of the stoppage of the officer's pay until the overpayment or indebtedness is satisfied. Should the officer in his explanation appeal to the Secretary of War, the Paymaster General submits the case for decision before enforcement of the stoppage. The notice of stoppage of officers' pay takes the form of a monthly circular to all Paymasters, advising them of stoppages in force at its date. This circular is submitted to the Secretary of War for his approval prior to publication. When an officer's name is borne upon this circular, no payment of salary is made to him which is not in accordance with the stoppage entry in the case. Paymasters disregarding this requirement in any case are held liable for the amount of the stoppage. Overpayments to an officer are deducted on first payment after notice of stoppage, even if the pay accounts have been assigned. The assignee takes the account subject to all risks of stoppage. The officers against whom the pay is stopped may demand a suit, and the agent of the Treasury is required to institute a suit within sixty days thereafter.

STOPPAGES.—Certain deductions in the British Service made from the pay of officers and men, in consideration of supplies made to them, or in aid of certain institutions. These stoppages were formerly more numerous than now. Thus, every officer and man had to pay toward Chelsea and Greenwich Hospitals, and a soldier had to pay for his own kit by a stoppage from the bounty. These stoppages have been remitted. Those at present remaining are, under usual circumstances, limited in the Navy to payment for slops (*i.e.*, clothing) when issued to men, or for willful damage: in the Army, for forage, 8½d. each ration by cavalry officers, and 6d. for artillery officers (though their horses eat the same); for messing on board ship; for diet in hospital, if sick through the man's own fault; for cost while in a prison; for damages to barracks: and as a fine for drunkenness.

STOPPER.—1. A plug placed in the muzzles of muzzle-loading small-arms, not in breech-loaders, to keep the bore free from rust, and to prevent dirt from entering into the barrel. It is made of cork or India-rubber, having a brass-top. To make it thoroughly serviceable, the cork or India-rubber should be covered with serge or flannel. 2. A gasket or short piece of rope used to keep any weight suspended, or to take the strain off a rope, one end being always attached to some fixed object. It must be stronger than the rope it has to hold.

STORAGE MAGAZINE.—The magnitude of the storage magazine will depend upon the number and caliber of pieces in the work and the number of charges to be kept for each. This data being known, the amount of storage room required will be determined by allowing 5,780 cubic inches for each barrel containing 100 pounds of powder. Projectiles and cartridges for siege and field-guns are put up in boxes, and are stored in magazines kept especially for this kind of ammunition. Each box of siege-gun ammunition contains four projectiles and four cartridges, and it measures about 2,950 cubic inches. Each box of field-gun ammunition contains ten projectiles and cartridges, and measures about the same. From this it is easy to obtain the storage capacity required for any amount of these kinds of ammunition. The dimensions of the interior of the magazine should be so regulated as to entail no unnecessary loss of space in storing its contents. The exterior dimensions of a powder barrel are: Length, 20 inches; diameter at bilge, 17 inches. With the barrels stored in the usual way, on the side, a magazine 6 feet 6 inches high would afford space for four tiers, leaving 8 inches on top for handling room. A magazine 10 feet wide will give room for four rows, leaving 40 inches for passageway; therefore each 17 inches of length of a magazine 10 feet wide by 6.5 feet high will contain 16 barrels. A magazine of this height and width and 30 feet long would store 400 barrels and leave a space of about one yard in width, extending across it, at the entrance. At the rate of 100 rounds for each 15-inch gun, a fair allowance for such guns in any field-works, a magazine of the foregoing dimensions will give storage for a supply of powder for four pieces. The number of rounds per gun should increase as the caliber diminishes. It would, however, seldom be necessary to have more than 300 rounds for any caliber above 100-pounders. An ordinary packing-box containing the number of rounds previously specified measures, in exterior dimensions, 19 inches in length, 13.5 inches in width, and 11.5 inches in height. These dimensions allow the boxes to be compactly packed in a magazine of any ordinary shape, and it requires only a very small calculation to determine the storage-room required for any given number of rounds for the guns of these calibers. It is best not to exceed, for any one magazine, the dimensions above laid down, namely, 30 by 10 by 6.5 feet. When greater storage room is required, two or more should be constructed. Precautions to secure drainage are of the utmost importance. Generally the ground is sufficiently undulating to effect this by means of a covered drain leading from the bottom of the magazine. Where this is not practicable, the bottom of the excavation must be formed so as to collect the water at one point, whence it may be removed by pumping or bailing.

The drawing illustrates the best method of constructing a storage magazine. The sides of the interior of the magazine are formed of 12 inch logs, either square or round, placed vertically in juxtaposition, and resting on a ground-sill. These are capped on top by a 2-inch plank, a strip of the same being spiked on within the cap. The roof is formed of 15-inch logs, laid across, in juxtaposition, each having a shoulder of 3 inches to fit it to the cap and inside strip. Longitudinal logs with varying diameters are laid on these, so as to give a proper pitch to the roof. Earth is solidly packed upon the top and between the roof logs, receiving the proper slope for the roofing boards. These boards, carefully joined, are laid on in two thicknesses, each being covered with a coating of asphalt or coal-tar; and upon these boards rest the covering of earth. The flooring is of joists and boards. The sides of the magazine are all surrounded with an air-chamber formed of inclined



logs supported on a ground-sill and resting against the top logs; these are placed at three or four feet apart, each one being braced at the middle to resist the flexure from the pressure of the earth. The air-chamber is covered in by saplings laid upon each other horizontally. Ventilators are placed between the magazine and the air-chamber, near the top, and also between the latter and the external air, the two not being opposite, and the usual precautions to guard against sparks, by covering the mouth with wire cloth or perforated tin, are taken. The whole is covered with earth, the thickness of which will depend on the character of the enemy's artillery. In no case should it be less than 14 feet on the exposed side; 10 feet will be sufficient for the other sides and the top. The entrance may be either upon an end or side, depending upon how the magazine has been located with reference to the enemy. In all cases the entrance must be on the side from the enemy, and should be secured by a bomb-proof covering. The magazine-chamber should, if practicable, be placed at least two-thirds of its height below the surface of the ground. In this and in all similar structures railroad iron is a highly serviceable material for roofing, the bars being laid in juxtaposition in place of the logs before mentioned. See *Powder Magazine*, and *Service Magazine*.

STORE-HOUSE.—Every post furnished with heavy artillery has one or more store-houses for the preservation and safe-keeping of equipments, implements, and such machines as should not be exposed to the weather. They should be light, dry, well ventilated, and furnished with shelves, racks, and tables for the accommodation of the stores kept therein. The articles are sorted according to their natures and arranged in appropriate places. These places are distinctly labeled, and, furthermore, each article, as far as possible, should be marked, so that under no circumstance there may be mistakes or confusion.

Cartridge-bags are preserved from moth by packing them with an hydraulic press; by enveloping them in paper bags hermetically sealed, the paper being similar to that used for preserving army clothing; or by heading them up in tight casks. A mild infusion of colocynth will preserve them from the moth. The bags are steeped in it, afterwards dried, and then packed away. *Sponges* are preserved from moths and packed away in the same manner as cartridge-bags. They should not be kept on the head of sponges in store, as they are then always damaged by rats and moths. Sponge-covers should never be put on the sponge-head unless both are clean and dry; after using, the sponge should be washed clean and dried, and then the cover put on. *Sponges, rammers, worms*, and *ladles* are generally placed on racks, with supports, not over three feet apart, to prevent the staves from warping.

Articles composed of brass are spread on shelves, and are kept clean and free from verdigris. It is forbidden by the regulations to use oil or grease upon them; alcohol or vinegar, with rotten-stone and afterwards whiting, are the most suitable polishing materials for them, and all scouring should be avoided. A good lacquer for brass rticles is composed of: Alcohol, 95 per cent., 2 ounces; seed-lac, 1 ounce. Put the mixture in a glass vessel for five or six days, exposed to the light; shake well once each day, and apply with a brush while the article is as hot as it can be made without injury.

Steel or iron implements should be painted black or kept bright, according to the use for which they are intended. For polishing, use crocus-cloth, oil, and rotten-stone; after which, oil with sperm oil. For the preservation of the bright parts of machinery, elevating screws, etc., when not in use, the following preparation is used, viz.: One pound white-lead and 0.25 pound tallow or lard oil, heated and mixed together. This is applied warm with a brush or cloth. It is removed by rubbing off with the cloth, using a little turpentine.

Leather equipments are hung on pegs in a cool, airy place. Those of russet leather should be taken down three or four times a year and brushed off to prevent accumulation of mould. Those of black leather should once or twice a year be washed with castile soap and water, well rubbed, and before thoroughly dry oiled with a mixture of neat's-foot oil and tallow; lamp-black may be added to the oil for blacking. *Fuses*, *friction-primers*, and *water-caps* are kept, as far as possible, in their original packages, and are stored in the driest and safest place in the store-house.

Pulley-blocks are hung up or piled where they have free circulation of air; those of wood are occasionally oiled with raw linseed oil. The *hooks*, *checks*, and *partitions of iron blocks* are painted black. *Journals* should be coated with black-lead, or if this is not available, lubricating oil must be applied before using. The greatest care must be observed to keep them free from sand or other gritty substance. *Rollers*, *maneuvering blocks*, *shifting-planks*, *chocks*, *cradles*, *capstans*, and *capstan-bars* are stored in dry places. They should not be painted, but are occasionally oiled with raw linseed oil.

Gins are painted olive, with the iron parts black. The windlass, however, should never be painted, but oiled with linseed oil. As strict uniformity is not observed in the construction of gins, each one should be numbered and its parts so marked that if parts of different gins become mixed they may be readily separated. Each gin should be placed by itself, the braces fastened to the legs by their bolts and keyed up; the clevis and clevis-bolt are left on the pry-pole.

Trunnion-rings, *sling-chains*, etc., are hung on pegs and preserved from rust by a thin coat of black paint.

Hydraulic-jacks should be kept filled. The ram or piston and the journals are frequently oiled to prevent rusting, but when used the head of the ram, to prevent slipping, should be free from oil or grease. The outside of the jack may be painted.

Gatling guns are kept in dry store-houses, and require the greatest care to preserve them from rust. The use of emery-cloth or any other scouring material must be avoided. They must be kept covered, and well oiled with a mixture of about equal parts of good sperm and kerosene oil. Every two or three days they should be wiped off, a rag passed through the barrels, and fresh oil applied. The journals are oiled through the oil-holes in the breech-casing. The carriages, limbers, and caissons are painted and cared for as other wooden carriages.

Gun-lifts are painted olive and when not in use are kept under cover. *Hand-carts*, *sling-carts*, *garrison-trucks* and *wagons* are painted the same as siege-carriages, and should be kept under sheds. The small sling-cart, being entirely of iron, excepting the pole, is painted the same as iron carriages.

Paints, *turpentine*, *oils*, *lacqueurs*, etc., are kept in a room separate from other stores; a cellar or casemate is preferable. The floor should be covered with two or three inches of fine sand, which should be renewed occasionally. Sawdust should *never* be used for the floor. *Volatile oils*, such as kerosene or benzine, must never be kept stored in the paint and oil room, but in such place that the least possible damage will arise from it should it take fire.

Paint brushes, when new, and before using, should be wrapped, or, as painters term it, bridled with strong twine, and soaked in water to swell them. After using, they should be cleaned with spirits of turpentine and put away in a vessel containing water to keep them from drying and becoming unpliable.

STORES. All public stores taken in the enemy's camp, towns, forts, or magazines, whether of artillery, ammunition, clothing, forage, or provisions, shall be secured for the service of the United States; for the neglect of which the Commanding Officer is to be answerable. See *Military Stores*.

STORE TRUCK.—An efficient vehicle for removing single packages of a considerable weight; the bar in front being insinuated under the box, for instance, which is then tipped so as to balance back slightly against the bed, in which position it is transported upon a pair of heavy wheels of small diameter. It is an indispensable assistant in the armory, arsenal, and packing-rooms. The term truck is sometimes applied to certain hand-carts and two-wheeled barrows. It is not easy to make the distinction in some cases, and is perhaps not very important. The store-truck is used mostly in the United States Service for moving boxes, and in embarking and disembarking stores, is quite light and has two strong rails rounded at the ends for handles.

STORE WAGON — A wagon consisting of a body and limber, employed to carry the various stores of a field-battery, such as the wheelers', collar-makers', and farriers' stores.

STORM. To storm is to make a vigorous assault on any fortified place, or on its outworks. The storming-party is a select body of men, who first enter the breach, and are, of course, imminently exposed to the fire of the enemy.

STORM FLAG.—In the United States Army, the storm flag is the National flag. It is eight feet fly and four feet two inches hoist, is furnished to all occupied military posts and National Cemeteries, and is hoisted in stormy or windy weather. This flag is also used as a recruiting flag. See *Flags*.

STORM GAS CHECK.—This invention consists of a loose tubular lining, which fits into the barrel of the weapon, and covers the junction between the barrel proper and the breech-piece; and being capable of an endway movement, by reason of the expansive force of the ignited powder, will completely seal the joint between the breech and barrel. The gun may be smooth-bore or rifled, and shot or shells of any suitable construction may be used. See *Gas-check*.

STOVE BARRELS.—A variety of barrels used when carrying powder from one manufacturing department to another.

STRAGGLERS.—Individuals who wander from the line of march. It is part of the rear-guard's duty to pick up all stragglers.

STRANGLES —A contagious eruptive disorder peculiar to very young horses. It is ushered in by sore throat and cough, muco-purulent nasal discharge, and the eruption of a swelling in the space between the branches of the lower jaw. In about ten days this swelling comes to a head, bursts, and in favorable cases, the patient is soon well again. From exposure to cold, poverty, or other causes, the swelling, however, occasionally appears in less favorable situations, as about the glands lying within the shoulder, in those of the groin, or even in those of the mesentery. Such irregular cases are apt to be protracted, accompanied by much weakness, and sometimes prove fatal. Bleeding, physic, and irritant dressings are always injurious. Good food and also the best nursing, with fomentations to the throat, and steaming of the head, favor the healthier maturation of the swelling. When there is debility, coax the animal to eat by offering him at short intervals small quantities of scalded oats, malt, bran, or green food, and allow him several times daily a pint of sound ale.

STRAPPADO. A punishment formerly inflicted upon foreign soldiers by hoisting them up with their arms tied behind them, and then suddenly letting them down within a certain distance of the earth.

STRAPPED AMMUNITION.—In large field-howitzers, it is not convenient to unite the cartridge bag and projectile, on account of the difficulty of packing them in the ammunition-chests; the bag and projectile are, therefore, carried separately. The projectile is attached to a sabot without grooves; and, to give a proper form to the cartridge-bag the mouth is closed with a *cartridge-block*, which resembles a sabot; hence the name *strapped ammunition*.

Straps are made of sheet-tin. For shot there are two straps crossing at right-angles, one passing through a slit in the middle of the other; for shells there are four straps fastened to a ring of sheet-tin and pierced with four slits, through which the ends of the straps are passed and folded down on the under side. The sheet of tin is first cut to a length equal to that of the straps, and, if the straps are for shot, a line is drawn dividing it into two equal parts, to mark the place for the slit. The straps are cut with circular shears. If such be not at hand, the width of the strap is marked on the sheet, cut with tinner's shears, and straightened on a bench with a mallet. The slits are made with a cold-chisel on a block of lead, and a strap not slit is passed through and set flat by a blow of the hammer.

The following implements are required to strap shot and shells: One *bench*; 2 *pans*, containing *nails* .55-inch long, with strong, flat heads .2-inch diameter; *boxes* and *barrels*, for straps and sabots; 4 *hammers*, for strapping; 1 *common hammer*; 4 *punches*; *shot-gauges*, of each caliber; 1 *gauge* for each caliber, .04 in. greater than the largest shot-gauge, through which the shot should pass after it is strapped; *tow* or *rags*, for wiping the balls; 1 *wheel-barrow*; 1 *paulin*, if the shops have not a plank floor.

A helper knocks off the scales from the balls with a hammer, cleans and dries the interior of the shells, if requisite, wipes the balls, and gauges them, both before and after they are strapped. The workman sitting astride the bench, places the shot or shell in the cavity of the sabot, the roughest part of the shot down, the fuse-hole of the shell on top, in the axis of the sabot. The ball should rest on the bottom of the cavity (it can be told from the sound, by striking on the bottom of the sabot with a hammer); if it do not the sabot is rejected. The workman places the junction of the straps in the axis of the sabot, or the ring concentric with the fuse-hole of the shell; beginning with the strap which is not slit, he forces the end of it into the groove of the sabot with the back of the hammer, punches it, and nails it; he then draws the other end tight, punches it, and nails it, in the same manner. He disposes the other strap perpendicular to the first, nails it to the sabot as he did the first, cuts off the superfluous length, and with the hammer and side of the cold-chisel sets the straps in close to the ball at the top of the sabot.

The boxer mode is as follows:—Bore a hole, 2 inch in diameter, .15 inch deep, in the shot; enlarge the hole at bottom. Take a copper rivet, .2 inch in diameter, hollow out the end, leaving the length of the rivet .25 inch greater than the least thickness of the sabot; bore a hole in the center of the sabot for the rivet, with a countersink for the head; place the shot in the sabot, the hole down; insert the rivet in the sabot, making it enter the hole in the shot: strike the head of the rivet a blow with a hammer to upset the end of the rivet and fasten the sabot.

If tin or sheet iron cannot be procured, straps may be made of strong canvas, 1 inch wide, sewed at the point of crossing. The part of the ball which is to be inserted in the sabot is dipped in glue; the straps are also glued to the ball; the ends are doubled into the groove and secured by 2 nails in each end. Another method is to wrap round the ball a band of canvas 1 inch wide, one-half of which is glued to the ball, the other to the sabot; or the shot may be kept in place by merely tying the cartridge-bag over the top of it.

When strapping shells for siege and garrison service, the straps are cut and made as prescribed for shot for the field-service, changing their dimensions. Two rings or loops of tin, .38 inch diameter, are attached securely to the slit strap of the howitzer and columbiad shells, for the purpose of attaching a handle made of cord .15 to .25 inch thick. A slit is made in the strap through which the ends of the tin loop are passed and soldered on the under side of the strap. For the handle, pass a piece of marline through both loops and tie the two ends together, leaving such a length that the hand can embrace both branches. The shells are placed in the sabot, and the straps put on in such a manner that the fuse-hole may fall in one of the angles, between two straps, and that the axis of the fuse-hole may stand at an angle of about 45° with that of the sabot. The eyes of the shell should not be covered by the straps. The straps are fastened at each end with 2 nails in the side and 2 in the bottom of the sabot. In loading the piece care must be taken to place the fuse-hole in the upper part of the bore. See *Ammunition*, *Field and Mountain Ammunition*, and *Siege and Garrison Ammunition*.

STRAPS.—Decorations made of worsted, silk, gold, or silver and worn upon the shoulders, without epaulettes.

STRATAGEM.—In war, any scheme or plan for the deceiving and surprising of an army, or any body of men.

STRATARITHMETRY.—The art of drawing up an army, or any given number of men, in any geometrical figure, or of estimating or expressing the number of men in such a figure.

STRATEGICAL FRONT.—The portion of the theatre of war in front of any position occupied by an army as it advances, is termed the *front of operations*. That part which is directly in front of an army, or which can be reached in two or three days, forms simply a *front*. When the whole extent lying between the two hostile armies is considered, the term *strategical front* is applied. See *Strategy*.

STRATEGICAL LINES.—The lines followed by an army in making a strategical movement. Temporary lines of operations, or maneuver lines, therefore, are strategical lines. *Lines of operations* are important strategical lines. In general, lines connecting two or more strategical points, which lines can be used by an army, and which allow of easy communication between these points, are strategical lines. A base of operations is a strategical line. See *Strategy*.

STRATEGICAL MARCHES.—Marches made in the theatre of war, near an enemy whose position is not exactly known, having in general for their object the completion of some strategical combination. They are used to conduct an army to a position from which an attack can be made on the enemy, or to a position in which the army can remain and receive an attack, in other words, to a position immediately in the presence of the enemy. The marches are either *ordinary* or *forced*, and are used principally to mass troops at some stated point on the theatre of operations before the enemy can make arragements to prevent it or can prepare counter-movements to weaken or nullify the effect of the movement. Secrecy, celerity, and good order are indispensable requisites for success in all marches of this kind. See *Marches* and *Route Marches*.

STRATEGICAL OPERATIONS.—It is by preparatory movements, by marches skilfully conducted, so as to throw our forces on the vulnerable point of the enemy's line, that all such grand results are obtained, which flow from a single victory. A battle gained is always a fine thing; but the consequences resulting from it may be very different, according as, by our previous measures, we are able to cut the enemy's line of communications; separate him from his base; disperse his forces, or simply force him to retreat without further loss than that on the battle-field. In the first case, victory is complete if the first success is promptly followed up. In the second, the enemy will soon be able to rally his forces, and offer a new battle. Vigor on the field and rapidity of pursuit should go hand in hand for great success. The latter is of as great importance as the former. Marshal Saxe was so thoroughly pervaded with this conviction, that he laid it down as an axiom, that "*military success resided in the legs of the soldiers*." A *dictum* that is ably enforced by all authentic military history.

A march, regarded as a strategical operation, may be either towards or from the enemy; either a *forward* movement, or one in *retreat*. In either case the army, if numerous, is necessarily divided into several corps, which move upon separate roads, either to subsist more easily, or to have all the space necessary for all deployments, and the other preparatory movements for delivering battle. The different columns of march should be kept the closer together, as the enemy is known to be the more bold and active in his movements. If there is danger of an attack, the columns should be kept in supporting distances of each other, and they should not be thrown into any position where an obstacle might prevent their being brought together at any desirable moment on the field of battle. At the same time discretion must be shown, so that so simple a rule may not be pushed to an absurd extreme, by keeping the various columns so close to each other that parallel roads will have to be made for them with the axe and pick, when those already in use cannot be turned to account. Any attempt of this kind would, except in rare cases, so greatly retard our movements that the least enterprising enemy would take advantage of it. Military history offers epochs where this circumspect course was pursued by armies, but no truly great General has ever submitted to such trammels. So long as a march is not made within cannon-range of the enemy, more or less interval can be left between the columns whilst executing the marches which are to bring them into position on the battle-field, according to the nature of the locality. The only limit to be fixed is, that the intervals shall not be so great as to prevent any corps reaching the battle-field on the day prescribed.

Each column should adopt all the usual precautions to prevent a surprise. Neglect in doing so has brought on some of the greatest disasters recorded in history. Of all marches, those which are most likely to produce the most splendid results are the ones that are concealed from the enemy, and therefore termed *secret marches*. Well-planned and executed, they enable an army to throw itself unexpectedly on the enemy's flank, threaten his base of operations, surprise his cantonments, etc. A country cut up with forests, water-courses, and like natural obstacles, lends itself best to the operations of a secret march; as these both conceal the movements of troops, and lead the enemy into fancied security from the character of the locality, and cause him to neglect the usual precautions to guard against a surprise. It cannot be too strongly impressed upon every soldier that, with his patience and a determined will, there is no natural obstacle that troops cannot overcome, when there is no enemy to interrupt our work. In this respect, in looking back on military history, it may with truth be said that nothing is impossible to a determined will.

Speed is one of the chief characteristics of strategical marches, as it is of the ordinary movements on the battle-field. In this one good quality resides all the advantages that a fortunate initiative may have procured; and by it we gain in the pursuit all the results that a victory on the battle-field has placed in our hands. By rapidity of movement, we can, like the Romans, *make war feed war*, by remaining so short a period in any one spot as not to exhaust the resources around us, however unequal to a prolonged sojourn. By this means, we disembarrass ourselves of those immense trains which are otherwise indispensable for the ordinary daily wants of an army; we carry along with us only what is indispensable, obliging the soldier to keep himself always supplied with a few days' rations of bread in his knapsack, driving along with the army herds of cattle in sufficient numbers to furnish the meat ration. In this manner, an army, freed from all of the *impediments* that might retard its motions, will be able to accomplish the most stupendous labors in marching and fighting. No great success can be hoped for in war in which rapid movements do not enter as an element. Even the very elements of nature seem to array themselves against a slow and over-prudent General. The Chevalier Folard has very well remarked, "that the slow and heavy in war will partake of as little of the glory of this world, as the lukewarm will of the glory of the world to come."

Under another heading in this work the advantages of interior lines of operation were pointed out. Marches which lead to this result deserve the close study of the General. If the enemy, for example, is moving on an extended front, upon our army, with the purpose of surrounding it, the true resource for safety is for us to move in mass upon some very weak point of his center, and, having thus separated his wings, beat them both in detail. In this manner we shall not only foil the enemy's plan, but scatter and force his forces on divergent lines of retreat; the more disastrous to him at the moment, and the less advantageous for his concentration later.

If the enemy's forces are concentrated, we may direct a movement of our army towards each one of his flanks, so as to induce him to separate in his center for the purpose of securing each of his flanks, when, having done so, we may reunite our separated forces and rapidly concentrate them on the one of his fractions the most accessible to us. A movement of this kind cannot be attempted with a prospect of success unless the topographical features are of such a character as to mark our movements. For example, supposing a river to lie between our force and that of the enemy, so as to prevent him from moving on our center, we might direct two fractions on the extreme right and left of the enemy's position, and, if he does weaken himself on his center to reinforce his wings, we might take advantage of this to cross the river rapidly on his center, everything having been prepared for it, and thus, holding a point between his wings, concentrate on either and overwhelm it before it could receive succor from the other. Here everything depends on rapidity of movement, and subsequent vigorous action. An hour's delay in such combinations may not only cause the failure of the best-laid plan, but entail disastrous results. A single hour may suffice for the enemy to gain the strategical point and overwhelm us with superior forces. If fortune is on the side of the heavy battalions, she also frequently grants her favors to superior activity and audacity.

From the preceding discussion, if based on sound principles, and historical precedents are strongly in its favor, it follows that to defend with advantage a frontier menaced on several points, the true rule is not to attempt to hold every point in force, but to watch every outlet by small corps, just of sufficient strength to check and delay the enemy, and to hold the chief portion of our forces concentrated at some central point, from which they can operate rapidly against any very considerable fraction of the enemy's forces. For example, let us suppose an army of 80,000 acting on the defensive against one of 120,000 separated into three corps of 40,000 each. To oppose to the enemy three corps of equal strength we should have but about 26,000 in each, and consequently we would find ourselves inferior in numbers on all points. If, instead of this, we opposed to each fraction of the enemy a corps of from 12,000 to 15,000, it would be sufficient to hold 40,000 in check, whilst our main body, consisting of from 35,000 to 40,000, holding a central position, could move on the point first menaced, and, being joined by the corps of observation, would offer to the enemy an effective force of about 50,000 combatants, which, with all other things equal, should beat the enemy. See *Strategy*.

STRATEGICAL POINTS.—The points of operation are also termed *strategical points;* and under this appellation are comprised not only those which may be regarded as the chief end to be attained, but also those by the occupation of which any army will receive incontestable advantages. The capital city of a country is in Europe regarded as a strategical point of great importance, chiefly from political considerations, arising from the influence which the seat of government exercises over the whole country. This, to a certain extent, is true of our own country; for although Washington city,in a military point of view, might have but little influence on the results of a war, and has no controlling influence over public opinion at home,still its loss would be regarded by Europeans in a European point of view,and hence its possession, whether by a foreign or domestic enemy,would have a damaging effect abroad, besides exercising a certain moral one at home.

A point is strategical that gives us entire control of several important roads,the course of a river,or which guards some important passage. In a flat country there are usually few strategical points. Those which hold this position usually owe it to fortifications by which they are surrounded, and by those various resources for military purposes which they can furnish. Wooden,hilly,and well watered regions present many such points. In high mountain ranges, strategical points are very restricted in number, but are usually of a very decided character. They are met with behind the narrow mountain passes at the points of junction of several valleys along which roads have been made. They are also found at elevated points where the ridges of several chains seem to come together.

Troops occupying such points can choose the roads by which they think best to descend from;their movements, in such a case, are from the center towards the circumference, whilst those of an opponent can only be made,with a prospect of success, by making wide circuits, to turn the spurs which obstruct any lateral movement. See *Strategy*.

STRATEGOS.—A series of American games of war, based upon military principles and designed for the assistance both of beginners and far advanced students, in prosecuting the study of tactics, grand tactics, strategy, military history, and the various operations of war.

Strategos is far more comprehensive than the German game "Kriegsspiel," or than its English version "Aldershot," both of which have now become so famous among foreign soldiers. Unlike these games, which have little in common with the ordinary soldier, the subaltern, and the private military student, and were designed for the almost exclusive use of the best-informed and most advanced members only of the military profession, the *American* game of war possesses an absorbing interest for those *of every grade* in the profession of arms; while in its most advanced application, Strategos embodies all the more valuable features of these foreign games,introducing also at the same time very many noticeable improvements upon both of them, and being thoroughly American even in its necessary similarities thereto.

Strategos begins with the novice at the very threshhold of *minor tactics*, and accompanies him upward through all its varying phases as applied to each of "the three arms." It yields readily to all the requirements of "dummy" instruction, and from the simple squad or detachment up through the company,battery squadron, and battalion,even to the army corps itself, considered as a tactical formation, it well affords a ready means of practical and unlimited elucidation never before offered to the military profession. This application of the outfit will prove of inestimable value in the practical study of tactical problems, its scope being such as to cover every possible demand for object study.

Advancing a step beyond this one, its elementary application, the same outfit may be most profitably employed by the student of *strategy* and *grand tactics* in his deeper studies. With it he can more readily,and understandingly master both definitions and principles of the science of war, and upon these as a foundation still further investigate the many considerations which affect and vary their application in the practical experience of campaigning. In this connection it may be stated that the topographical capacity of the outfit is such that it is an inexhaustible source of very ready illustration for every *text book* or authority—such as Jomini, Hamley, Wolseley, Halleck, Mahan, Wheeler, Dufour, etc., upon military principles and precepts, so that diagrams which are utterly beyond the scope of even such books can, with its aid, be realized in the simplest, most expeditious, and lucid manner.

Again the Strategos outfit will afford valuable companionship to those who are interested in the study of *military history*—battles and campaigns can be *analyzed* with its assistance, and followed step by step, and detail by detail, in a manner which it would be utterly impossible to realize even with the most extensive system of maps and diagrams. The power of *illustrating any military historical topic* will be limited only by the subject itself, while it surely will at the same time possess the peculiar advantages of both the tableau and the panorama, any and every feature of which may be modified at will. The above varied uses to which the outfit of this new game can be applied will appeal directly to the great majority of American military aspirants, and satisfy a want that has long been felt, especially in our country, *and one which the extremely complicated and advanced foreign games have utterly failed to appreciate.* With an outfit, therefore, of such elastic capacity, there can certainly be no difficulty experienced when representing the various ancient and modern armies in any of their phases of formation, either tactical, grand tactical,or as influenced by any topographical considerations,in accurately delineating the several orders of battle, and even of studying the latter over against each other either arbitrarily or according to the principles laid down under the head of the "Battle game."

The "Battle game" is an application by which a most entertaining and instructive *game*, based upon military principles and precepts,can be played. Upon the game board used in this application of the outfit, two armies of any size and organization can be represented with proper regard to lines, distances, and order of battle, by squadron, battery and battalion, and(the various pieces having special moves and powers, and the whole progress of the game being governed by carefully compiled rules)a miniature and bloodless battle can be fought, far less trying to ordinary patience than the "Advanced game," and yet gradually educating the players up thereto. The various features of the "Battle game" have been calculated with special reference to the subject illustrated ; the aim has been to make the rules, etc., *suggestive*; and although the game is necessarily far more extensive than ordinary parlor pastimes, it is yet simple enough to be fully within the capacity of any military student already even moderately familiar with the elements of the science of war, while a mere military novice cannot but be benefited, though seeking therefrom perhaps entertainment only for an evening. It is intended particularly—1, to give practice in organizing large forces, in making dispositions, and in forming lines and orders of battle; 2, to *familiarize* the player with the natural run of affairs during action; 3, to *sharpen* the *coup d'œil*; 4, to fix in the mind the *individuality* of each of the arms, their relative importance, and the necessity of their combined use; 5,to suggest practical and decisive *concentrations* at opportune moments; 6, to afford field and opportunity for comprehensive battle plans; 7, and finally, in a word, to inculcate *generalship*.

The several applications of the Strategos outfit thus far enumerated do not come within the scope of any game of war now known. By them, these applications are all completely overlooked in the haste to present an advanced and necessarily very complicated game *to those few* special students whose interest and professional studies may lead them to it. The *great mass* of American military students will thus always fail to find interest in these foreign games on account of their very complexity; and this fact, in no small degree, accounts for the extreme slowness with which Kriegsspiel, though now some seventy-five years old, becomes known in our own country even among all officers of the regular army, who alone perhaps as a class can afford to be constant players of it. But Strategos, having advanced thus far with the subaltern and the student, is not open to these objections; nor does it by any means neglect the special wants of the few whose extensive knowledge of the military art, science and history, and whose more than passing object in studying these matters, would demand the highest and most scientific application of the outfit. With such an application, embodying all that is valuable in the German and English games, and introducing many new and noticeable improvements in the matter of method, men, tables, adaptability to American requirements, etc., etc., the game of strategos may naturally and does appropriately terminate. Its "Advanced game" thus affords to the professional military man every opportunity that could be desired for pursuing studies *commenced in more elementary fields* to their legitimate termination.

In this, the last branch of the subject, therefore, all arbitrary assignments of values and moves is of course entirely out of the question, and improper. The whole game is required to base itself upon actualities, upon the results of careful investigations, and upon the tabulated statistics of experience, of actual practice, and of former battles and campaigns. Everything in such a game must be subjected to the most searching military scrutiny, and nothing is allowed upon the map which does not conform to the very best of military information possessed and attainable. Each of the essential elements of distance, time, and topography must have its peculiar weight duly considered, and throughout the directions, rules, order of procedure, tables, etc., etc., devoted to the playing of the "Advanced game," the constant endeavor will be seen to represent the mimic battle or campaign in all its features save the dreadful wastes of blood and iron.

The text-book contains all the rules for the use, and minutely describes the employment of the outfit in each of its several applications. It also serves as a sort of general military "hand-book," being replete with references, precepts, rules, suggestions, data, and tables, all of which have special and intrinsic statistical value over and above their mere uses in the game room. Considered by itself, it is, in fact, a study of the bearing of military statistics upon war, on field and map, and is a most comprehensive military work. See *Kriegsspiel* and *War Game*.

STRATEGUS.—The title of any Athenian General Officer. Also written *Strategos*.

STRATEGY.—In tracing out the movements of ancient armies, as far as we have the means of doing so, and from the often very obscure narratives of historians, it will be observed that in some features they conform very closely to those of modern armies, whilst in others they differ most essentially from them. Those in which this conformity is seen, and which pertain only to the general operations of a campaign belong to that branch of the military art which has received the appellation of *strategy*. Whilst those in which a marked difference is noticeable, such as the manner of conducting marches, dispositions for battle, the arrangements of encampments, etc., belonging to the domain of *tactics*. For example, the famous expeditions of Hannibal and Napoleon over the Alps present more than one point of resemblance in their general features; whilst the battles and combats which afterwards followed have no points of comparison. The reason of this is, that general operations are controlled by the topographical features of the seat of war; whilst those of a partial character, mere evolutions, or, in a word, tactical combinations, depend solely upon the weapons with which troops have been armed at different epochs. The study of military history thus becomes very instructive in a strategical point of view, whilst, on the other hand, in endeavoring to apply the notions, gleaned from the same source, on the tactics of the ancients, to our modern armies, errors of the most grave character might be committed. Every servile imitation in this latter case—an error which more than one man of talent has fallen into, from not having sufficiently weighed the enormous difference that exists between what are known, in the present day, as firearms, and the weapons for like purposes used by the ancients, and the consequences which must necessarily ensue from this cause in the arrangement of troops for combat—is greatly to be deprecated

From the forgoing remarks, it will be inferred that strategy is, in a peculiar sense, the science of Generals in command of armies; whilst tactics, in all its ramifications, from the elementary drill of the soldier to orders of battle, from the *bivouac* of an outpost to the encampment of an army, now belongs to officers of all grades. Yet with these marked differences, it is sheer pedantry to pretend to define the precise limits of these two prominent branches of the military art, as they present a multitude of exceptions in which they approach and run into each other. Tactics if we restrict its meaning to the evolutions and maneuvers of troops on the field of battle, may be taught with mathematical exactness, because every movement is accurately prescribed, and the more so the lower we descend the scale of this branch of military knowledge. But this is far from being true of strategy, because, in the calculations involved in its operations, a great many considerations enter which do not admit of exact computation, and thre upon which success or failure essentially depend; as time, the character of the roads over which the army has to move, the nature of the obstacles which lie between it and the enemy, the moral qualities and activity of the enemy's forces, etc., etc.

The following extracts from *Edmunds' Art and Science of War*, will give the reader valuable information concerning the main principles of *strategy* and their application in modern warfare:

A point is said to be *strategical* when it is so situated that its possession will be of decided advantage to an army. Cities at the junction of large rivers, or controlling the crossing of a river or a pass through the mountains, or at the meeting of several important roads, are good examples of this class of points. It is evident that these places are more numerous and of more consequence in a broken than in a level country. In the latter place a point might become strategical by being strongly fortified.

Owing to the extensive system of railroads now operated in nearly all countries, and to the great facility they offer for the movement of troops and supplies, a railroad center is now a point which it may be very desirable to occupy.

In our own country, New York, Philadelphia, Chicago, St. Louis, Vandalia, Cincinnati, etc., are all prominent illustrations of such points, and there are many others whose position will not apparently have much influence on a campaign, but by being brought by its accidents within the sphere of operations of an army, must be held at all hazards. In every country there are always some places which are more important than others, the possession of which by an opposing force would usually be decisive.

The following are some of the reasons why the occupation of great railroad centers in the theater of operations would be advantageous to the General in command of an army. They enable him to draw his supplies and re-enforcements from a great extent of country, to separate his troops for subsistence, and to concentrate them for battle; to gain rapid and early information of the enemy and his movements, for there are always telegraph lines along the railroads centering at a common point; to move his forces rapidly to any point threatened by the enemy, etc.

In a mountainous country, the strategical points, although few in number, are generally very prominent The junction of several valleys, or roads along the crests of several ridges, would naturally be of great value to an army occupying it, as the forces might operate in any one of the valleys or along any of the roads with an equal facility, while the enemy, once committed to one line, could not change to another without great labor and loss of time, necessitated by the retrograde movement resulting from the difficulty of crossing the intervening spurs or valleys.

In the campaign of 1796-97, in Italy, Bonaparte, by causing the redoubt which closed the pass of the Montenotte to be occupied by one thousand two hundred men, was able to interpose his army between the armies of the allies—Austrians and Sardinians—and whip them in detail. At this time the allies, numbering about sixty thousand men, were operating in three columns by three roads separated by very difficult mountainous country. Bonaparte, with about thirty thousand men, holding the middle road, the pass of the Montenotte, very successfully accomplished his plan of attacking in succession the columns of the enemy. The campaign was thus decided from its inception, and the redoubt of Montenotte, seconded by a small and brave garrison had great influence upon the final result.

The capital city of a country is usually a very important strategical point. This may proceed, not from its influence on the military operations of a campaign or from its position, but from the fact that it is the seat of government the occupation of which by the enemy may have a lasting and damaging effect in a political point of view. During our civil war great importance was attached to the capture of the city of Richmond, and all the campaigns of the Army of the Potomac were made with that city as the objective point, with the idea that its fall would put an end to the war. This was undoubtedly too much to expect; for the bulwark of the rebellion was not the city of Richmond, but the Confederate armies, and their capture or overwhelming defeat was necessary before the fall of the city would be a decisive cause of the close of the war. The supplies and re-enforcements of the Confederate army were nearly all drawn from the States south of Virginia, and as long as the avenues of supply remained intact the cohesion of the army was assured and it remained a menacing force.

War having been decided upon, it then becomes the duty of the Commanding General to determine and lay out a *plan of campaign*. In forming this plan everything the enemy may do should be foreseen, and measures should be taken to prevent the accomplishment of his plans. In an offensive war the plan of campaign consists in the selection of an objective, theater of operations, base, and lines of operations. The determination of the objective usually decides the theater of operations; for it will necessarily be that part of the frontier which is near the objective. The principles of strategy already laid down comprise all the considerations which will usually govern a General in making his selections of these different objects. Sometimes, however, there may be political questions which cannot be overlooked by the General when drawing up his plan.

In choosing an objective, which is usually the point first determined in the plan, the capital of the enemy's country is naturally the subject taken into consideration on commencing the work. Its possession will generally have such a decided effect, both upon the nation itself, and abroad, that its capture will become the primary object of the campaign. This statement is based on the fact that, when the capture of the enemy's capital becomes a matter of such great importance, it is presumed that the hostile army will make every exertion and sacrifice to prevent the accomplishment of this purpose: that it must be fought and conquered, before the capital itself is reached. In November, 1862, General Burnside assumed command of the Army of the Potomac, which at that time was concentrated in the neighborhood of Warrenton. General Lee's forces were scattered, one wing of his army being near Culpepper and the other in Shenandoah Valley, and separated by two marches. It was possible for General Burnside, by a single march, to interpose his forces between the two wings, and he was already in a position favorable to a decisive action. Instead of following this plan, which had been the purpose of General McClellan, his predecessor, he announced his intention of making a change of base to Fredericksburg and of making "a movement upon Richmond from that point." Swinton remarks as follows: "It would be difficult to explain this determination on any sound military principle; for while the destruction of the hostile army was, in the very nature of things, the prime aim and object of the campaign, General Burnside turned his back on that army, and set out upon a seemingly aimless adventure to the Rappahannock, whither, in fact, Lee had to run in search of him. If it be said that Richmond was General Burnside's objective point, and that, regarding this rather than the hostile force, he choose the Fredericksburg line as one representing fewer difficulties than that on which the army was moving (the line of the Orange and Alexandria railroad), the reply is, that an advance against Richmond was, at this season, impracticable by any line; but a single march would have put him in position to give decisive battle under circumstances eminently advantageous to him."

The marches of the troops necessary for concentration, the points where they are to assemble, and the arrangements for the needed supplies of all kinds, will also be considered in drawing up the plan. It is thus seen that it is only the general features that are settled upon in determining the plan of campaign: that the marches of each day, the place for camping, etc., are details which do not enter into this problem, but are decided upon as the time comes for their accomplishment or selection. In drawing up the plan the outline maps of the country are made use of; those that show only the boundaries, principal cities, rivers, mountains, and roads are the best for the purpose. The topographical maps are resorted to when indicating the minor details of the march and camp, and also in studying the natural features of positions where it is expected to deliver battle.

A thorough knowledge of the geography of a country is then indispensable, both in planning a campaign and in conducting the minor operations of the war. The Archduke Charles says: "It is by studying the theater of war, that the objective points are learnt, and the means which the nature of the ground presents for taking possession of and maintaining them. By the aid of this knowledge operations are combined, that is to say, the way is examined by which it is possible to arrive more certainly at the proposed end, and the result to be expected awaited." Frederick the Great fought the battle of Leuthen on ground with which he was thoroughly familiar, having previously hunted over it. It was thus possible for him to make dispositions by means of which, with a force of thirty thousand men, he disastrously defeated the Austrian Army of eighty thousand men. "In 1796, Moreau's Army, entering the Black Forest, expected to find terrible mountains, frightful defiles and forests, and was greatly surprised to discover, after climbing the declivities of the plateau that slope to the Rhine, that these, with their spurs, were the only mountains, and that the country, from the source of the Danube to Donauwerth, was a rich and very level plain. "In 1813, Napoleon and his whole army supposed the interior of Bohemia to be very mountainous, whereas there is no district in Europe more level, after the girdle of mountains surrounding it has been crossed, which may be done in a single march." The Union armies labored under very great disadvantages during the rebellion from not having a proper knowledge of the statistics and topography of the Southern States, and ignorance of these subjects was a fruitful cause of grave errors and great loss.

The plan of the campaign, in the case of an army carrying on a defensive war, is called the *plan of defense*.

The character of the war to be carried on by the defence will depend upon the national characteristics of the people, the nature of the country, the number and discipline of the troops, etc. All these points will receive attention when developing the plan of defence.

The question whether an army acting on the defensive will await the hostile forces within its own frontiers or carry the war into the enemy's country, will also be decided. In the first case the army can take positions for receiving battle which have been selected, studied, and strongly fortified before hand; the enemy is obliged to make large detachments from his forces to hold places that it might be dangerous to leave unoccupied in his rear; the people can be relied upon to give timely information of the enemy's movements; facilities are offered for obtaining guides and spies; the army can operate in any direction with the certainty of finding a base or strong points of support. In case of disaster the difficulties and dangers of retreat are much lessened, while for the enemy, under adverse circumstances, the perils are greatly multiplied. The great objection to this system is that it makes the country sustain all the burdens of the war.

In the second case these relative advantages and disadvantages will be reversed, but the consideration of making the enemy contribute the means of carrying on the war may outweigh all others, and cause this system to be adopted. Particularly will this be the case when your forces, although not equal in numbers to the enemy, are well disciplined, and not inferior in other respects.

In the plan of defense it will be determined whether to meet the enemy on the frontier and dispute his advance, or to allow him to penetrate into the interior, and then concentrating all energies, make the results of a defeat overwhelming. In the campaign of 1812, in Russia, Napoleon was drawn on towards Moscow, which place he found in flames and then began the horrors of that terrible retreat, which deprived him of a large proportion of that magnificent army with which he had started out only a few months before.

Positions that are to be held to the last extremity, or that are to be abandoned after a certain amount of resistance; roads that are to be kept ready for all emergencies; points on which to fall back in case of disaster; places where stores and supplies are to be accumulated; all these will be designated in the plan of defense.

The army should be kept well together, ready to assume the offensive at the first favorable opportunity; for a passive defence seldom leads to passive results.

Movements in war, whether offensive or defensive, must always be based upon a calculation of time and distance. But the applications of this principle are easier in defensive than in offensive war. In the latter the operations are vaster, the conditions more variable, the elements of the calculation more uncertain. At any moment one may be forced to change his part, to abandon an attack in order to defend himself and to escape great perils. There is needed, therefore, a greater genius, to be always ready to vary his projects, to execute new combinations. In a defensive war, the theater is more contracted; the operations are upon familiar ground, the nature of which may be exactly appreciated. The combinations being less in number, it is easier to arrange for them and to confront them. In an offensive war genius must supply the want of experience, and guess at the character of the country in which the operations are made; the points of support upon which we count, vary and sometimes disappear. In defensive war we act upon a field prepared and studied; we have fixed pivots of operation; everything may be calculated with precision. A superior genius is then more necessary for offensive war, while a great knowledge of the profession, the talent to choose judiciously the points of support, an extreme foresight, with indefatigable activity, may suffice for the needs of defensive war.

Nevertheless, this kind of war is far from being easy, because properly speaking, a General is only reduced to act on the defensive when the means at his disposal are inferior to the enemy. Now, in modern wars, with equality of arms, instruction and experience, numbers are of chief avail.

In a military point of view, the offensive has its good and its bad side. Strategically an invasion leads to deep lines of operation, which are always dangerous in a hostile country. All the obstacles in the enemy's country, the mountains, rivers, defiles and forts, are favorable for defence; while the inhabitants and the authorities of the country, so far from being the instruments of the invading army, are generally hostile. However, if success be obtained, the enemy is struck in a vital point; he is deprived of his resources and compelled to seek a speedy termination of the contest. For a single operation, which we call taking the *initiative*, the offensive is almost always advantageous, particularly in strategy. Indeed, if the art of war consists in throwing the masses upon the decisive points, to do this it will be necessary to take the initiative. The attacking party knows what he is doing and what he desires to do; he leads his masses to the point where he desires to strike. He who awaits the attack, is everywhere anticipated; the enemy falls with large forces upon fractions of his force; he neither knows where his adversary proposes to attack him, nor in what manner to repel him. Tactically, the offensive also possesses advantages, but they are less positive, since, the operations being upon a limited field, the party taking the initiative cannot hide them from the enemy, who may detect his designs, and by the aid of good reserves cause them to fail. The attacking party labors under the disadvantages arising from the obstacles to be crossed before reaching the enemy's line; on which account the advantages and disadvantages of the tactical offensive are about equally balanced. Whatever advantages may be expected either politically or strategically from the offensive, it may not be possible to maintain it exclusively throughout the war; for a campaign offensive in the beginning may become defensive before it ends.

The offensive confers, at the outset, the power of concentrating on the flank or center of the enemy's line of defence, and so turning or breaking it. The defender must either oppose the enemy with an inferior force at first, or abandon territory in order to assemble his forces at some point further back. On the other hand, offensive war demands great resources, and success itself, if not absolute and decisive, entails fresh difficulties on the invader. And when he has penetrated very far within the defender's territory, the situations of the antagonists differ greatly, inasmuch as the army on the offensive is bound to its base, be that base wide or narrow, while the defensive forces may base themselves on any portion of the territory which will supply them and which their front protects.

It is evident, that when one belligerent power feels secure behind an unassailable frontier, and holds many issues into the enemy's territory, either by command of the sea or otherwise, it can assemble its forces unknown to its antagonists upon some point selected by itself, from whence to make an eruption into the theater of war. And if the belligerents be divided only by a frontier line—a river such as the Rhine or Potomac, or a mountain range such as the Alps—the army that passes it will nearly always find itself immensely superior to the force that can immediately interpose. For the defender's army has by the conditions of the defensive been spread so as to guard all possible avenues by which the attack might be made. Thus, in the Waterloo campaign, Wellington and Blucher, being on the defensive, were guarding all the roads from the French frontier into Belgium, along a front of a hundred miles. Napoleon suddenly assembled his whole army upon the center of their line, and, on first entering Belgium, was greatly superior to any force which the opposing General could interpose between him and his object, Brussels. During the American civil war, Richmond being the point arrived at by the principal Northern army, the Federals could, behind the screen of the Potomac, concentrate their forces and advance either from the Upper Potomac down the Shenandoah valley; from Washington along the Orange railroad to the Rappahannock; from Acquia Creek by the Fredericksburg and Richmond railway; by the peninsula between the York and James rivers adopting either stream as a base; or from the south side of James river by Petersburg. They used all of these lines, and frequently advanced at first with numbers greatly superior to those which the Confederates could assemble to oppose them. Thus, the great advantage conferred by the offensive, is the *power of concentration*.

A defensive war is not without its advantages when wisely conducted. It may be passive or active, taking the offensive at times. The passive defence is always pernicious; the active may accomplish great successes. The object of a defensive war being to protect as long as possible the country threatened by the enemy, all operations should be designed to retard his progress, to annoy him in his enterprises by multiplying obstacles and difficulties, without, however, compromising one's own army. He who invades does so by reason of some superiority; he will then seek to make the issues as promptly as possible; the defence, on the contrary, desires delay till his adversary is weakened by sending off detachments, by marches, and by the privations and fatigues incident to his progress. An army is reduced to the defensive only by reverses or by a positive inferiority. It then seeks in the support of forts, and in natural or artificial barriers, the means of restoring equality by multiplying obstacles in the way of the enemy. This plan when not carried to an extreme, promises many chances of success, but only when the General has the good sense not to make the defensive passive; he must not remain in his positions to receive whatever blows may be given by his adversary, he must, on the contrary, redouble his activity, and be constantly upon the alert to improve all opportunities of assailing the weak points of the enemy. This plan of war may be called the *defensive-offensive*, and may have strategical as well as tactical advantages. It combines the advantages of both systems; for one who awaits his adversary upon a prepared field, with all his own resources in hand, surrounded by all the advantages of being on his own ground, can with hope of success, take the initiative, and is fully able to judge when and where to strike.

At the commencement of a campaign, to *advance* or *not to advance* is a matter for grave consideration, but when once the offensive has been assumed, it must be sustained to the last extremity. However skillful the maneuvers, a retreat will always weaken the *morale* of an army, because in losing the chances of success, these last are transferred to the enemy. Besides, retreats always cost more men and *matériel* than the most bloody engagements; with this difference, that in a battle the enemy's loss is nearly equal to your own, whereas in a retreat the loss is on your side only. We will suppose an army taking the field; the first care of the Commander should be to agree with the head of the State upon the character of the war; then he must carefully study the theater of war, and select the most suitable base of operations, taking into consideration the frontiers of the State and those of its allies. The selection of this base and the proposed aim will determine the zone of operations. The General will take a first objective point; he will select the line of operations leading to this point, either as a temporary or a permanent line, giving it the most advantageous direction, namely, that which promises the greatest number of favorable opportunities with the least danger. An army marching on this line of operations will have a front of operations and a strategic front. The temporary positions which the *corps d'armée* will occupy upon its front of operations, or upon the line of defence, will be strategic positions. When near its first objective point, and when it begins to meet resistance, the army must either attack the enemy or maneuver to compel him to retreat: and for this end it will adopt one or two stragetic lines of maneuver, which, being temporary, may deviate to a certain degree from the general line of operations, with which they must not be confounded. To connect the strategic front with the base as the advance is made, lines of supply, depots, etc., will be established. Strategical points and lines are inseparable, and exist conjointly; a point is not decisive for military operations unless accessible for all armies, and a line is not considered as being advantageous, so much as the object to which it leads. The frontiers of States, are either large rivers, or chains of mountains, or deserts. Of all these obstacles to the march of an army the most difficult to overcome is the desert; mountains come next, and large rivers occupy the third place.

Some authors have represented that high ranges of mountains are. in war, inaccessible barriers. Napoleon, on the contrary, in speaking of the Rhetian Alps, said that, "An army could pass wherever a man could put his foot." Generals no less experienced than himself in mountain warfare have united with him in this opinion, in admitting the great difficulty of carrying on a defensive war in such localities, unless the advantages of partisan and regular warfare can be combined; the first to guard the heights and to harass the enemy, the second to give battle at the decisive points—the junction of the large valleys. When you are occupying a position which the enemy threatens to surround, collect all your force immediately, and menace him with an offensive movement. By this maneuver you will prevent him from detaching and annoying your flanks, in case you should judge it necessary to retire. It is an approved maxim in war never to do what the enemy wishes you to do, for this reason alone, that he desires it. A field of battle, therefore, which he has previously studied and reconnoitered, should be avoided, and double care should be taken where he has had time to fortify or intrench. One consequence deducible from this principle is, never to attack a position in front which you can gain by turning. Previous to the battle of Austerlitz, Napoleon put in practice this rule, which he himself gives in his memoirs: "When you have resolved to fight a battle, collect your whole force, dispense with nothing. A single battalion sometimes decides the day." Napoleon had carefully arranged for the concentration of forty thousand men at Vienna, or sixty-five thousand at Brunn, according as circumstances should permit. The Russians, on the contrary, attacked the French without waiting for General Essen, who was only a few days' march distant, and who was bringing with him nearly ten thousand men. The allies did exactly what Napoleon had wished. No force should be detached on the eve of a battle, because affairs may change during the night, either by the retreat of the enemy or by the arrival of large re-enforcements to enable him to resume the offensive, and counteract your previous dispositions.

With the purpose of dispersing the forces of the enemy, we must harass him particularly upon those points essential to his safety, and promplty seize the moment in which he has yielded to our feints, to attack him upon a weak point with *superior* numbers. This is just what is called a feint in fencing phrase, with the sword in hand, when in single combat. Two or three slight partial advantages open the way for the more considerable ones which decide the fate of the campaign. It is thus clearly seen how extremely important it is for a General to assume the *initiative* in all of his movements; thus he overrules the design of his enemy, and a first success frequently gives an ascendancy which is never lost. But the favorable moment must be clearly discerned. Too great a disproportion in the force and in the various means, would be an insurmountable obstacle. We should wait until the confidence of the enemy leads him into error.

Profiting diligently by the occasion when offered, the skillful General may always obtain an advantage which will permit him to turn the tables on his adversary, and to pass from defensive to offensive.

This is what happened, remarkably, in 1796, in the immortal campaign of Italy. The French army, having arrived at the frontiers of the Tyrol, and in a defensive position, found itself much inferior to the Austrian army, augmented as it was by the re-enforcements led by Wurmser in person. The enemy's General, when attacking, had divided his force; the French General reunited his own, and soon a first success enabled him to assume the offensive in turn. Afterwards a series of victories succeeded in combats where the French army was almost always superior in numbers upon the field of battle. To sum up, all in one word, this division of the art of war which applies to the general movements of armies, it should be observed, that it is always founded upon a calculation of time, distance, and celerity of movement.

During the late civil war in North America, General Jackson was quartered in the Shenandoah valley with about fifteen thousand or twenty thousand men. Opposite to him was a Northern army entering the valley from Harper's Ferry, under General Banks; another army under General Fremont, on the west side; and another army, under General Siegel, just on the east side of Manasses Gap. General Jackson descending the valley rapidly, first encountered the head of General Fremont's column near this point. General Jackson retreated rapidly for a day or two, until he had drawn the head of Fremont's army away from the main body, and then he fell on that and defeated it. The two Generals, Milroy and Schenck, were beaten and fell back on Fremont, who had just sent off despatches to Washington announcing a victory, but who was very glad to get over the mountains and make his escape. He was disposed of for a few days. Jackson proceeded down the valley, and moving rapidly on Manasses Gap, fell on a detachment of General Banks troops, and defeated them. General Bank's, who was down at Winchester, hearing of what had happened, came up speedily, and tried to support his unfortunate detachment. He met with Jackson under disadvantageous circumstances, and was beaten on the two days following, and was driven right over the Potomac into Washington.

During the Continental war, in 1866, like the two invading armies in Bohemia, so the two foes of Austria—Prussia and Italy—on a great scale, were assailing her on a double line. In all circumstances the rule must hold, that the defender in such a case ought not, except with forces superior to both, to attempt to make head against both attacks. The policy of retarding the attacks of one enemy, and operating in force against the other, is the only decisive mode of operation. For this reason Colonel Hamley maintained, before hostilities began, that Austria should at first have taken that step which circumstances afterwards forced on her, and, withdrawing all the forces disposable for the field, should have held only the fortresses and mountain passes, secure that, when once she had crushed her German foe, she could always, by Verona, issue upon the Italian army in Venetia and drive it over the Po.

Battles have been stated by some writers to be the chief and deciding features of war. This assertion is not strictly true, as armies have been destroyed by strategic operations without the occurrence of pitched battles, by a succession of inconsiderable affairs. It is also true that a complete and decided victory may give rise to results of the same character when there have been no grand strategic combinations. The results of a battle generally depend upon a union of causes which are not always within the scope of the military art; the nature of the order of battle adopted, the great or less wisdom displayed in the plan of the battle, as well as the manner of carrying out its details, the more or less loyal and enlightened co-operation of the officers subordinate to the Commander-in-Chief, the cause of the contest, the proportions and quality of the troops, their greater or less enthusiasm, superiority on the one side or the other in artillery or cavalry, and the manner of handling these arms; but it is the *morale* of armies, as well as of nations, more than anything else, which makes victories and their results decisive." When the march of an army has been so conducted, that, when it meets the enemy on the field of battle, it has a decided advantage over him, the battle which follows will usually be more decisive than in the contrary case. A single battle well fought under the foregoing condition, has frequently been decisive of the whole campaign, and even of the war. The battle of Jena gave Napoleon advantages, which, vigorously followed up in the manner so peculiar to him, soon placed the kingdom of Prussia at his feet, and left him free to turn his attention to the Russians.

Battles are classed as offensive, defensive, and as a combination of these two, viz., offensive-defensive or defensive-offensive. *a.* In an offensive battle, the army moves to attack the enemy wherever found. "It must be admitted that the assailant generally has a moral advantage over the assailed, and almost always acts more understandingly than the latter, who must be more or less in a state of uncertainty." *b.* In a defensive battle, the army selects a position in which to receive the enemy, and does not leave it. Gettysburg was, for the Union troops, a strictly defensive battle; for the Confederates, it was an offensive battle. *c.* When, in the first case, the army leaves its position at any time during the battle in order to attack the enemy, it then fights a defensive-offensive battle; while for the enemy, the battle is offensive-defensive. The battle of Chancellorsville was offensive-defensive for the Union troops, and the reverse for the Confederates. In the same manner that a nation may be restricted to a defensive war, a General may be required to fight a defensive battle. Owing to inferior numbers, having troops inferior in discipline to the enemy, or armed with an inferior weapon, a General may be constrained to take a position and await the attack of the enemy. By taking a strong position, this inferiority may be counterbalanced; and, by assuming the offensive at the proper time, he may gain a great advantage over the enemy, which, properly followed up, may give him the victory. The Austrians were restricted to the defensive at the battle of Königgratz, because they were armed with a muzzle-loading rifle, and were inferior to the Prussians in numbers and discipline; the latter were armed with the breech-loading needle-gun. A pure defence can never win a battle, it may perhaps enable the troops acting on the defensive to preserve their position, but the most that can be hoped for from a pure defence is a drawn battle, not a victory. The improvements in modern arms have undoubtedly added much to the power of the defence, but the attack has been advanced also.

At first sight, it would appear that the defence would gain more from the peculiarities of improved fire-arms than the attack. An army acting on the defensive, may have it in its power to choose such a position, as to oblige the enemy to cross an open plain; it will also probably have time to ascertain the distance of certain fixed points, so as to produce the greatest effect from its fire. On the other hand, the advantages that an attacking force possesses are also very considerable. As its Commander has only to consult his own judgment, he regulates his movements according to the disposition of the enemy. He, being the assailant, has a definite object before him, and chooses his own way of obtaining it; while the defender has first to find out his adversaries intentions, and then to make the best arrangements for frustrating them. On the one side, confidence and resolution, on the other, uncertainty and anxiety. The defender, if he wish to bring about a decisive result, must eventually himself become the assailant; but here the question arises, whether before advancing to attack, he should not exhaust all the material advantages to be gained from stationary fire, by employing it to the very last moment.

When two armies come in contact the one that acts on the offensive or takes the initiative has the power of selecting the point for attack, and of arranging against that point a superior force. The defender does not know where he will be attacked, and has to provide for several possible, nay probable contingencies. He is liable to be deceived, induced to disseminate his force, and seek to be strong at all the threatened points, while the assailant need be strong at one and that the decisive point. Increased range and accuracy in weapons have given the attacker the power of selecting far more advantageous positions for covering and supporting his attack than formerly. Ground which in the days of old artillery might be simply ignored must now be held by the defender, thus compelling him to extend and therefore weaken his whole line; or it must be abandoned to the enemy, who will quickly make use of it as a *point d'appui* for an attack; and as the area operated over has thus increased at a much quicker rate than the actual effective range of the weapons, the assailant benefits considerably.

When the enemy's line is found to be equally strong along the entire front, so that no favorable point of attack can be found the possession of which will carry with it advantages proportionate to the losses which would follow upon its capture, then the better plan would be to flank or turn the enemy, and compel him to abandon his position. The attack is seldom confined to one point, but, having selected the place where the great effort will be made, endeavor to mislead the enemy by one or more *false* or *feint* attacks, to keep him in doubt as to your real intentions, and to prevent him from concentrating his troops to meet your forces making the main attack. Tactical and strategical considerations both enter the problem of determining the point of attack; the consideration which will govern in any particular case will depend upon the results which are expected to

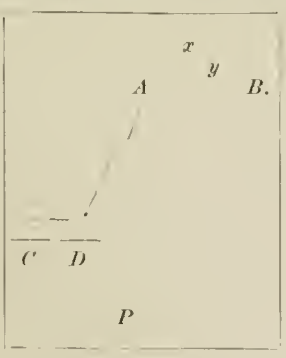


Fig. 1.

follow the defeat of the enemy, or the risks to be run in attaining these results. The tactical considerations relate to the advantages which can be gained on the field of battle; and the strategical to the consequences of victory. The strategical conditions are more important than the tactical, unless the difficulties of the ground are too great, and the results expected to follow do not justify the risks to be taken.

Let the army *P* in Fig. 1, find the enemy in the position *AB*, with one flank resting on a hill and the other on a river, with an impassable marsh in front. The point *A* is both the strategical and tactical point of attack; for its capture would command the field of battle, force the enemy from his line of retreat, *xy*, and throw him back on the impassable obstacle opposite the left flank. *AC*, with the right re-enforced would be a better position for the assailed to take, as in this case an attack at *A* would compel the assailant to fight with an obstacle at his back, and an attack at *C* would give the assailed the full benefit of the height. The position *AC* is also objectionable, as it presents a salient *D*, always a weak point in a line, because it renders both faces liable to be enfiladed.

Suppose an army, acting on the defensive, to have the position *XY*, Fig. 2: its right uncovered, and its left resting on an impassable obstacle. The strategical point of attack is *Y*; for, if the left is forced back, the line of retreat *AB* is exposed. But the selection of *Y* as the point of attack, forces the assailant to fight with his back to the obstacle *Z*, which would be very dangerous unless greatly superior to the enemy. Rather *X* select as the point of attack, and depend upon vigorous fighting and pursuit for great results. Combined attacks, like combined marches, cannot be relied upon for success. They should only be undertaken when the natural features of the country are such that the enemy can easily be checked if he attempts to make a counter-attack,

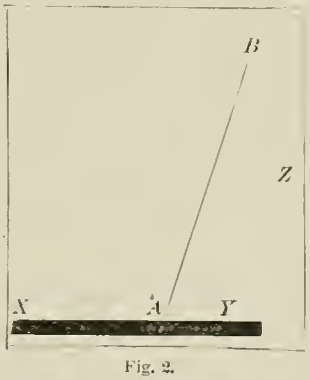


Fig. 2.

and when the preliminary movements of the troops are concealed from his view. When the features of the country are such that the detachments can, by taking up naturally strong positions, hold the enemy in check, the main body can operate with safety against the flank; for, in case of repulse, its main line of retreat would not be compromised. Much depends upon the character of the opposing General; if he be alert and always ready to act promptly and vigorously, any extended movements would be dangerous, although it might under other circumstances be successfully carried out. Movements may be made with troops that are superior in numbers or in discipline, which would be very rash when the opposing forces are nearly equal, or the Commanders of the same capacity.

There are really but two ways in which a battle can arise. *a.* When one army is on the defensive, and holds a strong post, the other moving forward to attack it. *b.* When the two armies meet, both being in movement. Auerstadt, Solferino, Mars-La-Tour, are all examples of this latter kind of battle, but in every case the *rôle* of attacker or defender falls to one side, sometimes to each alternately, and it may vary in different portions of the field, the same army being on the defensive in one place and on the offensive in another. However a battle may actually come about, the order of march of the troops forming the army must be intimately connected with the action of the troops in the line of battle; consequently the order of march must be invariably detailed so as to allow of the armys first required being near the head of the column. If the way in which battles begin is considered, it will be found that the cavalry of the advanced-guard usually find the enemy and report his position; if he is in a defensive position, they report the circumstance; if on the move, they report the force immediately in front of them. In all probability they will be driven in on the main body of the advanced-guard, the Commander of which must then take up the best defensive position he can, to cover the deployment of the troops in his rear. If the enemy are holding a defensive position, he will not be very much troubled, because few Generals will like to leave a carefully prepared position and to give up too soon the advantage of acting on the defensive, or to move until the plans of the attacker have declared themselves. In such a case the Commander of the advanced-guard, knowing that the enemy is to be attacked, must take up such a position that he may protect and cover the advance of the main body to the attack.

If the enemy are not holding a defensive position, he will in all likelihood be hardly pressed, and have some difficulty in maintaining a *point d'appui* on which the troops in rear are to form up to the right or left, such as Hassenhausen, held by Gudin at the battle of Auerstadt. Consequently it follows that those arms of the service which can best facilitate the formation, should be near the head of the column. Hence there is a very close connection between the tactical action of troops on a field of battle, and their order of march, and it is essentially requisite that the order of march, be subordinated to the deployment of the army into line of battle, and this becomes all the more important as the troops approach the actual point of collision. As they do so, the number of roads on which they are moving must be reduced, by the mere convergence of the columns, and hence, the order of the troops in those columns becomes of the utmost importance. It is further manifest that there should be no definite order of march, but the actual order in which the troops stand should be regulated by the work to be done, and the nature of the country.

It is manifestly the object of the officer commanding the advanced-guard to find a position such as will compel the enemy to develop a considerable force to attack him, and at the same time enable him to make head against such an attack. Such a position can generally be found; it is often desirable to occupy a small village or town, loop-hole some houses or buildings, or form some trenches, which will enable the advanced-guard to remain in possession of the ground. It is requisite in many cases to open passages to the right and left for troops to move through and facilitate the formation; a strong body of engineers should therefore move with the advanced-guard. If the enemy is in position, and does not show any inclination to attack, a portion of the engineers may be detailed to remove obstacles, form any small bridges that may be required, such as those that were needed for the passage of the Bistritz and Sauer, and facilitate the advance of the troops beyond the position taken up by the main body of the advanced-guard. But as the line of advance of an army acting on the offensive will, if defeated, be generally its line of retreat, it will be always well to strengthen some points which in case of disaster may afford a rallying place to troops that are worsted. But no position can be properly defended without artillery, consequently the Commander of the advanced-guard should have a strong force of artillery with him, which he must use boldly, to search out the enemy's position, compel him to unmask his guns, and declare himself. The Commander of the artillery of the advanced-guard has a very responsible office thrown on him. He must not only find positions for his own guns, but he should, from the fire of the enemy, be able to select places for the corps batteries as they come up; and to facilitate this object he should place his batteries so as to leave room for others to come up in support of them.

The battle of Mars-La-Tour offers an excellent example of the action of an advanced-guard on a large scale, when meeting an army on the move. The object of the Germans was to hold the French fast, and prevent their retreat on Verdun, while the remainder of their army came up. Thus the troops that first attacked the French were really acting like all other advanced-guards, they were covering the front and giving time for the deployment of the army. The German General, Alvensleben, learning from his reconnoitering officers that the French were encamped between Vionville and Rezonville, determined to attack them with his own corps, the third, and what other troops were near. At nine A. M., the Germans established between Tronville and the road by which the French were retreating, four horse-artillery batteries and three cavalry regiments, which surprised the French encampments, compelled the French to retire and deploy, facing west across, and at right angles to the Verdun road. At eleven o'clock Vionville was taken by the Prussian infantry and immediately strengthened by two companies of engineers, and it at once became a *point d'appui* round which the whole Prussian line pivoted throughout the day. The four horse-artillery batteries were soon supported with four batteries, which fired on the French infantry masses, causing them to suffer severely; soon, however, the German ammunition columns began to be exhausted, and the ammunition columns left at Gorge, although ordered up in time, could only come up the ravine with great difficulty and under a shower of French shells. Then the corps artillery came into action to the east of Tartleville. The operation was no easy one. Once in position it was received with a terrible infantry fire from Flavigny. But the batteries held their ground, being shortly supported by four more batteries, which extended the line of guns to the left towards Vionville. The fire of the French infantry, at nine hundred to one thousand two hundred yards, caused great loss, covering the batteries with a rain of bullets. The eight batteries in position near Vionville, and the seven near Flavigny, now concentrated their fire on Flavigny and the Cistern wood; these fifteen batteries completely cleared that important position, which fell to the Germans about twelve o'clock without any serious infantry fighting. The second French corps, shaken by the terrible artillery fire, called on its cavalry for support, and a sharp cavalry action ensued, under cover of which nine of the fifteen German batteries advanced beyond the Flavigny road so as to embrace that place in the German line of battle; three other batteries advanced almost simultaneously along the main road between Rezonville and Vionville; but these movements were only executed at the cost of heavy losses; some batteries losing all their officers, others many of their horses.

It will be seen by this abridged account, that the German guns were not advancing in line with or following in rear of the infantry. But the movements of the artillery, so far from being rigidly tied down to conform to the rules of the infantry, were tactically independent, that is to say, both the arms were working each according to its own special peculiarities for the attainment of one object. Long before the Prussian infantry could come on the ground in any force, the artillery was in position, preparing the way for it, protected on its flanks by cavalry and a small force of infantry. The manner in which the German artillery was used to extend the line of battle, fill up a great gap in its center, and so not only occupy a longer front themselves, but attack their enemy over a larger front, is well worthy of notice: they were working tactically together with the cavalry and infantry to debar the French from the Verdun road, and give time for the deployment of the German army. The attack of the French cavalry on the German batteries was at once met by the German cavalry, and the fire of the guns being then masked, both as regards their own, and to a certain extent their opponent's fire by the cavalry fight, the batteries seized the opportunity and dashed to the front. At one o'clock the Prussians had two cavalry divisions, one corps, and twenty-one batteries in action, the French had one cavalry division, two corps, and twenty-six batteries. The whole of the Prussian guns were really in three batteries, of nine, seven, and five guns respectively, while the French guns were scattered about. After one o'clock the French took the offensive, and drove back the Prussian wings; the center, however, held fast to Vionville. In this action the use made of artillery and engineers to check the French and gain time, the action of the artillery especially, in seizing advantageous places, and rapidly bringing up fresh batteries, and in concentrating masses of fire on certain points, are well worthy of close examination. If the guns had not been with the advance, the same result could never have been obtained. It is worth noticing where the guns marched. The artillery had no special escorts, one battery marching with the cavalry brigade forming the advanced-guard, and the other three with the main body of the division; all the divisional artillery of the third corps marched between the brigades of the leading division, the corps artillery between the divisions. Notwithstanding the eighth Prussian corps hardly came into action at all, a large number of its batteries coming in towards the close of the day, supported the exhausted artillery of the tenth and third corps. We have said that no matter how a battle may begin, the *rôle* of attacker and defender will usually fall to one side, and perhaps change several times during the course of the day, depending on the number of men engaged at one place, the strength of the positions, the mode of handling the reserves, and the number of men defending the position.

To conduct a retreat successfully in the presence of a victorious or superior enemy is the most difficult operation in war. This is owing to a great extent to the effect produced on the *morale* of the troops as soon as their backs are turned on the enemy. The magnitude of the distances and the nature of the country to be traversed, the resources it offers, the obstacles to be encountered, the attacks to be apprehended, either in rear or in flank, superiority or inferiority in cavalry, the spirit of the troops, are circumstances which have a great effect in deciding the fate of retreats, leaving out of consideration the skillful arrangements which the Generals may make for their execution. It is upon the rear-guard in retreats that the safety of the army depends, and the efforts and sacrifices made by it should be unlimited when necessity calls for them. The officer to command the rear-guard should be selected with regard to his coolness in emergencies, his prudence and judgment in making dispositions. "He should be feared and respected by his enemies." A retreat is always a necessity after a lost battle or after an unsuccessful enterprise. When a retreat is inevitable, the troops engaged must first be withdrawn. This, when possible, should be done by alternate lines, the movement being protected, as much as possible by the artillery, a portion of which remains with the line nearest the enemy for this purpose. A *rear-guard* of the freshest troops is organized as soon as possible; the pursuing enemy is checked or forced to deploy, when the retreat is stopped and the troops reorganized, and order restored. The army is then again in condition to confront the enemy. The sooner all this can be accomplished, the less will be the losses from the consequences of defeat. The losses in battle are small when compared to those of a disorganized, routed army on the retreat. The nature of the retreat will depend entirely upon the nature of the pursuit. A vigorous enemy, following up his advantage with energy, will soon entirely disperse or capture a defeated army. At the commencement of a retreat it frequently becomes necessary to decide whether a forced march will be made, or whether the retreat will be conducted by regular marches. With a large army it may be set down as a general rule that short marches should be made, placing the main reliance for safety upon the rear-guard. A forced march with a large army is a very difficult operation under the most favorable circumstances, but when made by a beaten, dispirited, disorganized army, it may lead to the most disastrous results.

There are five methods of arranging a retreat: The first is to march in a single mass and upon one road. The second consists in dividing the army into two or three corps, marching at the distance of a day's march from each other, in order to avoid confusion, especially in the *matériel*. The third consists in the marching upon a single front by several roads, nearly parallel, and having a common point of arrival. The fourth consists in moving by constantly converging roads. The fifth, on the contrary, consists in moving along constantly diverging roads. A retreat conducted in accordance with the first method would evidently be a dangerous operation with a very large force, and especially so if the enemy should make a vigorous pursuit. The danger would arise from overcrowding, which might soon convert the retreat into a rout. The second method might be followed when the enemy does not push the retreating army too hard. When the roads are good the fourth method would be most excellent, for the army, as it marches onward in retreat, is constantly concentrating, a very desirable object to attain. In regard to the fifth method there are only two cases in which divergent roads can be followed: 1st. When an army has experienced a great defeat in its own country, and the scattered fragments seek protection within the walls of fortified places. 2d. In a war when the sympathies of the whole population are enlisted, each fraction of an army thus divided may serve as a nucleus of assembly in each province; but in a purely methodical war, with regular armies, carried on according to the principles of the art, divergent retreats are simply absurd.

Usually a retreat should be regulated by the same rules as a forward movement, viz., the different corps of the army should move on parallel roads within mutual supporting distances. This is a point of the greatest importance, for the army should always be prepared to meet an enemy ever on the alert for a favorable chance to attack. The crossing of a large stream by an army on the retreat is usually an operation of extreme difficulty. The trains should first be crossed, and well cover their passage the army should take a strong position some distance in advance of the point selected for the crossing. The march of the rear-guard should be so regulated that it will reach the point intended for it to cross just after the last of the main body has passed. After the rear-guard has crossed, the bridge should be destroyed. A retreat conducted parallel to a frontier may often lead to very decisive results. As this operation usually exposes a flank to the enemy, it can only be resorted to with safety when the natural features of the country greatly favor it. When the line of retreat is along a large river, or along a mountain, the bridges and defiles of which are under the control of the retreating army, the advantages are very great. When this line of retreat is through the enemy's country, the army can subsist at his expense, and cause him to bear the full weight of the war; and when the army's line of retreat is within its own frontier, the enemy is drawn on without gaining ground towards the interior, is forced to expose his flanks to attacks from those directions, and is forced to march through a hostile country, the inhabitants of which are always ready to assist his opponent.

After a battle is gained the defeated army should be pursued unceasingly. You have won a great battle, and the enemy are in full retreat: run after him; hammer him with guns, charge with cavalry, above all things pass round his flanks, and keep pushing him and hitting him from morning until night. His forces will soon cease to be an army. The French after Waterloo, when well beaten by the English, and pursued without intermission by the Prussians, flocked back across their frontier a disorganized mass without arms. The General who, in pursuit, acts with precaution, who maneuvers instead of charging, will never inflict much harm upon an enemy: caution is out of place when you have a beaten army before you. This conduct, which by some may be termed reckless, may at times occasion losses to the pursuer, but unless it is practised, you can never expect to crush a retreating enemy. This is the time for cavalry and mounted infantry, if you have any of the latter. When the pursuit is vigorously made many risks may be taken, for it is safe to presume that the enemy cannot in this case make a decided stand, or turn on the offensive with very much prospect of success. The communications of the defeated army should be seized, if possible, because when they are gained the whole *matériel* of the enemy is at your mercy, and a position may be taken to bar his further retreat or attack him in flank. The latter operation will usually be the safer one, because the efforts of a desperate foe may accomplish much in the former case. A great effort should be made to separate the forces of the retreating army, as in this case a larger fraction of it may be destroyed or captured, while in the contrary case little damage would be inflicted. A road parallel to that taken by the retreating forces offers many advantages to the pursuing army; for, by following this road, opportunities may be presented of making a flank attack. A retreat, from its moral effects, always gives certain advantages to the pursuing force, even when made by an army in good condition.

A description of Soult's retreat, after leaving Oporto, is taken to illustrate the difficulties which may be surmounted in operations of this nature. The 15th, Sir Arthur reached Braga. Murray was at Guimaraens on his right, and Beresford, who had anticipated his orders, was near Chaves, having sent Sylveira towards Salamonde, with instructions to occupy the passes of Ruivaens and Melgassy. But at this time Soult was fifteen miles in advance of Braga, having, by a surprising effort, extricated himself from one of the most dangerous situations that a General ever escaped from. To understand this, it is necessary to describe the country through which his retreat was effected. We will observe that the Sierra de Cabirera and the Sierra de Catalina line the right bank of the Tamega; but, in approaching the Douro, the latter slants off towards Oporto, thus opening a rough but practicable slip of land, through which the road leads from Oporto to Amarante. Hence, the French in retreating to the latter town had the Douro on their right hand and the Sierra de Catalina on their left. Between Amarante and Braga, which is on the other side of the Catalina, a route practicable for artillery runs through Guimaraens, but it is necessary to reach Amarante to fall into this road. Thus, Soult, as he advanced along the narrow pass between the mountains and the Douro, rested his hopes of safety entirely upon Loison's holding Amarante. Several days, however, had elapsed since that General had communicated, and an aide-de-camp was sent on the morning of the 12th to ascertain his exact position. Colonel Tholosé, the officer employed, found Loison at Amarante, but neither his remonstrances, nor the after-coming intelligence that Oporto was evacuated, and the army in full retreat upon the Tamega, could induce that General to remain there, and, as we have seen, he marched toward Guimaraens on the 13th, abandoning the bridge of Amarante without a blow, and leaving his Commander and two-thirds of the army to what must have appeared inevitable destruction. The news of this unexpected calamity reached Soult at one o'clock on the morning of the 13th, just as he had passed the rugged banks of the Souza river; the weather was boisterous, the men were fatigued, voices were heard calling for a capitulation, and the whole army was stricken with dismay. Then it was that the Duke of Dalmatia justified by his energy that fortune which had raised him to his high rank in the world. Being by a Spanish pedlar informed of a path that, mounting the right bank of the Souza, led over the Sierra de Catalina to Guimaraens, he, on the instant, silenced the murmurs of the treacherous or fearful in the ranks, destroyed the artillery, abandoned the military chest and baggage, and loading the animals with sick men and musket ammunition, repassed the Souza, and followed the Spanish guide with a hardy resolution. The rain was falling in torrents, and the path was such as might be expected in those wild regions, but the troops made good their passage over the mountains to Pombeira, and, at Guimaraens, happily fell in with Loison. During the night they were joined by Lorge's dragoons from Braga, and thus, almost beyond hope, the whole army was concentrated.

If Soult's energy in command was conspicuous on this occasion, his sagacity and judgment were no less remarkably displayed in what followed. Most Generals would have moved by the direct route upon Guimaraens to Braga; but he, with a long reach of mind, calculated upon the slackness of pursuit after he passed Vallonga, that the bulk of the English army must be on the road to Braga, and would be there before him; on that, at best, he should be obliged to retreat, fighting, and must sacrifice the guns and baggage of Loison's and Lorge's corps in the face of an enemy—a circumstance that might operate fatally on the spirit of his soldiers, and would certainly give opportunities to the malcontents; and already one of the Generals (apparently Loison) was recommending a convention like Cintra. But, with a firmness worthy of the highest admiration, Soult destroyed all the guns and the greatest part of the baggage and amunition of Loison's and Lorge's divisions; then, leaving the high road to Braga on his left, and once more taking to the mountain paths, he made for Carvalho d'Este, where he arrived late in the evening of the 14th, thus gaining a day's march in point of time. The morning of the 15th he drew up his troops in the position he had occupied just two months before at the battle of Braga; and this spectacle, when twenty thousand men were collected upon the theater of a former victory, and disposed so as to produce the greatest effect, roused all the sinking pride of the French soldiers. It was a happy stroke of generalship, an inspiration of real genius! Soult now re-organized his army; taking command of the rear-guard himself, and giving that of the advanced-guard to General Loison. Noble, the French historian of this campaign, says, "The whole army was astonished"; as though it was not a stroke of consummate policy that the rear, which was pursued by the British, should be under the General-in-Chief, and that the front, which was to fight its way through the native forces, should have a Commander whose very name called up all the revengeful passions of the Portuguese. *Maneta durst not surrender;* and the Duke of Dalmatia dexterously forced those to act with most zeal who were least inclined to serve him; and, in sooth, such was his perilous situation, that all the resources of his mind and all the energies of his character were needed to save the army.

From Carvalho he retired to Salamonde, from whence there was two lines of retreat. The one through Ruivaens, by which the army had marched when coming from Chaves two months before; the other, shorter, although more impracticable, leading by the Ponte Nova and Ponte Miserella into the road from Ruivaens to Montalegre. But the scouts brought intelligence that the bridge of Ruivaens, on the little river of that name, was broken, and defended by one thousand Portuguese, with artillery; and that another party had been, since the morning, destroying the Ponte Nova on the Cavado river. The destruction of the first bridge blocked the road to Chaves; the second, if completed, and the passage well defended, would have cut the French off from Montalegre. The night was setting in, the soldiers were harassed, barefooted, and starving; the ammunition was damp with the rain, which had never ceased since the 13th, and which was now increasing in violence, accompanied with storms of wind. The British army would certainly fall upon the rear in the morning; and if the Ponte Nova, where the guard was reported to be weak, could not be secured, the hour of surrender had certainly arrived. In this extremity, Soult sent for Major Dulong, an officer justly reputed for one of the most daring in the French ranks. Addressing himself to this brave man, he said, "I have chosen you from the whole army to seize the Ponte Nova, which has been cut by the enemy. Do you choose one hundred grenadiers and twenty-five horsemen; endeavor to surprise the guards, and secure the passage of the bridge. If you succeed, say so, but send no other report; your silence will suffice." Thus exhorted, Dulong selected his men, and departed. Favored by the storm, he reached the bridge unperceived of the Portuguese, killed the sentinel before any alarm was given, and then, followed by twelve grenadiers, began crawling along a narrow slip of masonry, which was the only part of the bridge undestroyed. The Cavado river was in full flood, and roaring in a deep channel; one of the grenadiers fell into the gulf; but the noise of the storm and the river was louder than his cry; Dulong, with the eleven still creeping onwards, reached the other side, and falling briskly on the first posts of the peasants, killed or dispersed the whole. At that moment, the remainder of his men advanced close to the bridge; and some crossing, others mounting the heights, shouting and firing, scared the Portuguese supporting posts, who imagined the whole army was upon them; and thus the passage was gallantly won.

At four o'clock, the bridge being repaired, the advanced-guard of the French commenced crossing; but as the column of march was long, and the road narrow and rugged, the troops filed over slowly; and beyond the Ponte Nova there was a second obstacle still more formidable. For the pass in which the troops were moving being cut in the side of a mountain, open on the left for several miles, at last came upon a torrent called the Miserella, which breaking down a deep ravine, or rather gulf, was only to be crossed by a bridge, constructed with a single lofty arch, called the *saltidor*, or leaper; and so narrow that only three persons could pass abreast. Fortunately for the French, the *saltidor* was not cut, but entrenched and defended by a few hundred Portuguese peasants, who occupied the rocks on the further side; and here the good soldier Dulong again saved the army; for, when a first and second attempt had been repulsed with loss, he carried the entrenchments by a third effort; but at the same instant fell deeply wounded himself. The head of the column now poured over, and it was full time, for the English guns were thundering in the rear, and the Ponte Nova, was choked with dead. Sir Arthur Wellesley, quitting Braga on the morning of the 16th, had come, about four o'clock, upon Soult's rear-guard, which remained at Salamonde to cover the passage of the army over the bridges. The right was strongly protected by a ravine, the left occupied a steep hill; and a stout battle might have been made, but men thus circumstanced, and momentarily expecting an order to retreat, will seldom stand firmly; and, on this occasion, when some light troops turned the left, and General Sherbrooke, with the guards mounting the steep hill, attacked the front, the French made but one discharge, and fled in confusion to the Ponte Nova. The French reached Montalegre on the 17th. Sir Arthur, with the main body of the army, halted that day at Ruivaens. The 18th he renewed the pursuit, and a part of his cavalry passed Montalegra, followed by the guards; the enemy was, however, drawn up behind the Salas in force, and no action took place. Sylveira, indeed, had entered Montalegre, from the side of Chaves, before the British came up from Ruivaens; but instead of pursuing, he put his men into quarters; and a Portuguese officer of his division, who was despatched to Marshal Beresford with orders to move from Villa Perdrices upon Villa del Rey, loitered on the road so long that all chance of intercepting the French line of march was at an end; for, though Beresford, on the 19th, pushed Colonel Talbot with the Fourteenth dragoons as far as Ginjo, Francheschi turned in force, and obliged that officer to retire, and thus the pursuit terminated.

Soult, on the 19th, entered Orense, but without guns, stores, ammunition, or baggage; his men exhausted with fatigue and misery, the greatest part being without shoes, many without accouterments, and in some instances even without muskets. He had carried fifty-eight pieces of artillery into Portugal, and he returned without a gun; yet was his reputation as a stout and able soldier nowise diminished. When General Loison abandoned Amarante, he relinquished all claims to military reputation, as a simple statement of facts will prove. The evening of the 12th he wrote to Soult that one regiment had easily repulsed the whole of the enemy's forces; yet he, although at the head of six thousand men, cavalry, infantry, and artillery, that night, and without another shot being fired, abandoned the only passage by which, as far as he knew, the rest of the army could escape from its mighty perilous situation with honor. The marches and encounters, from the 14th to the 17th, were excellent on both sides. Like the wheelings and buffeting of two vultures in the air, the generals contended, the one for safety, the other for triumph; but there was evidently a failure in the operations of Marshal Beresford. Soult did not reach Salamonde until the evening of the 15th, and his rear-guard was still there on the evening of the 16th. Beresford was in person at Chaves on the 16th, and his troops reached that place early on the morning of the 17th. Soult passed Montalegre on the 18th, but from Chaves to that place is only one march. Again, Marshal Beresford was in possession of Amarante on the 13th, and as there was an excellent map of the province in existence, he must have known the importance of Salamonde, and that there were roads to it through Mondin and Cavez shorter than by Guimaraens and Chaves. It is true that Sylveira was sent to occupy Ruivaens and Melgacy; but he executed his orders slowly, and Miserella was neglected. Major Warre, an officer of the Marshal's staff, endeavored, indeed, to break down the bridge of Ponte Nova and Ruivaens; and it was by his exertions that the peasants, surprised at the former, had been collected; but he had only a single dragoon with him, and was without power to execute this important task. The peasantry, glad to be rid of the French, were reluctant to stop their retreat, and still more to destroy the bridge of Miserella, which was the key of all the communications, and all the great markets of Entre Minho e Douro; and therefore sure to be built up again, in which case the people knew well that their labor and time would be called for without payment. It is undoubted that Soult owed his safety to the failure in breaking those bridges; and it does appear that if Major Warre had been supplied with the necessary escort and materials he would have effectually destroyed them. "Sylveira did not move either in the direction or with the celerity required of him by Beresford; there seems to have been a misunderstanding between them; but allowance must be made for the numerous mistakes necessarily arising in the transmission of orders by officers speaking different languages; and for the difficulty of moving troops not accustomed or perfectly willing to act together." Instructive lessons may also be learned from the following: Soult from Spain in 1814 (parallel retreat); Frederick the Great from Moravia in 1758 (parallel retreat); Napoleon from Moscow in 1812 (parallel pursuit); Grouchy after Ligny in 1815 (pursuit); retreat of the Austrian army after Koniggratz in 1866; retreat of the English army from Quatre Bras on Waterloo in 1815; Johnston's withdrawal before Sherman's advance through Georgia in 1864; Lee before Grant in Virginia the same year, etc.

The conduct of the advance-guard and the manner of executing the marches will always materially influence strategical operations. The strength of the advanced-guard will depend upon the nature of the country, the strength of the main body, the quality of the troops, the season of the year, and upon the duty required of it. If an attack is expected, or it is required to take or hold a certain position, it will be stronger than under the ordinary conditions of march. As a rule its strength will vary from *one-fifth* to *one-third* the total force. The fact that, when very strong, the duty would recur so often as to greatly fatigue the men, and if too weak, it might become an object to the enemy to make an attempt to cut it off from the main body and capture or destroy it, should also be considered when determining the strength of the advanced-guard The duty should be so regulated that it will fall in turn to all the different divisions of the army, in this way simplifying the details of the service, familiarizing all the troops with the duty, and keeping them under the command of their proper officers, which will have a good effect on the discipline of the command. The plan of making details for this duty from the different regiments tends to relax discipline by bringing men under officers with whom they are not accustomed to serve. The composition of an advanced-guard is usually the same as that of the body of troops which it is designed to cover and protect. The advanced-guard of an *army* is generally composed of the three arms, viz.: infantry, cavalry, and artillery; the relative proportion of each depending upon the nature of the country and the resistance it may be required to make. Following the general rule, the cavalry will predominate in an open country; in fact in such a country, nearly all the cavalry of an army on the march should be thrown well to the front and on the flanks, thus affording the best protection from a surprise, gaining information of the enemy's movements and designs, and covering those of its own army, enabling the General to make any desirable dispositions without the enemy's knowledge. In a broken or rugged country the *main force* will consist of *infantry*, such ground being best adapted to the movements and methods of fighting of this branch of the service. The cavalry in this case should be employed in scouting, and in conveying information to the rear.

The principle of the formation of an advanced-guard is that it is made up of a number of detachments, increasing progressively in strength from the front to the rear. The object of each of these detachments is to guard against surprise the stronger body which follows immediately in rear, and to give the latter time to prepare for attack. This consideration regulates the distances to be preserved between strong detachments. When the detachments are small, the distances need only to be sufficiently great to prevent the possibility of the rear detachment being suddenly brought under fire without notice. The advanced-guard should be divided into the *advanced party* with its *support*, the *reserve* of the advanced-guard. The strength of the *reserve* should be from *one-third* to *one-half* of the whole advanced-guard. The remainder will make up the *advanced party* and its *support*, being in the proportion of about *one-third* for the *advance party* to *two-thirds* for the *support*. "The extreme front of the advanced-guard

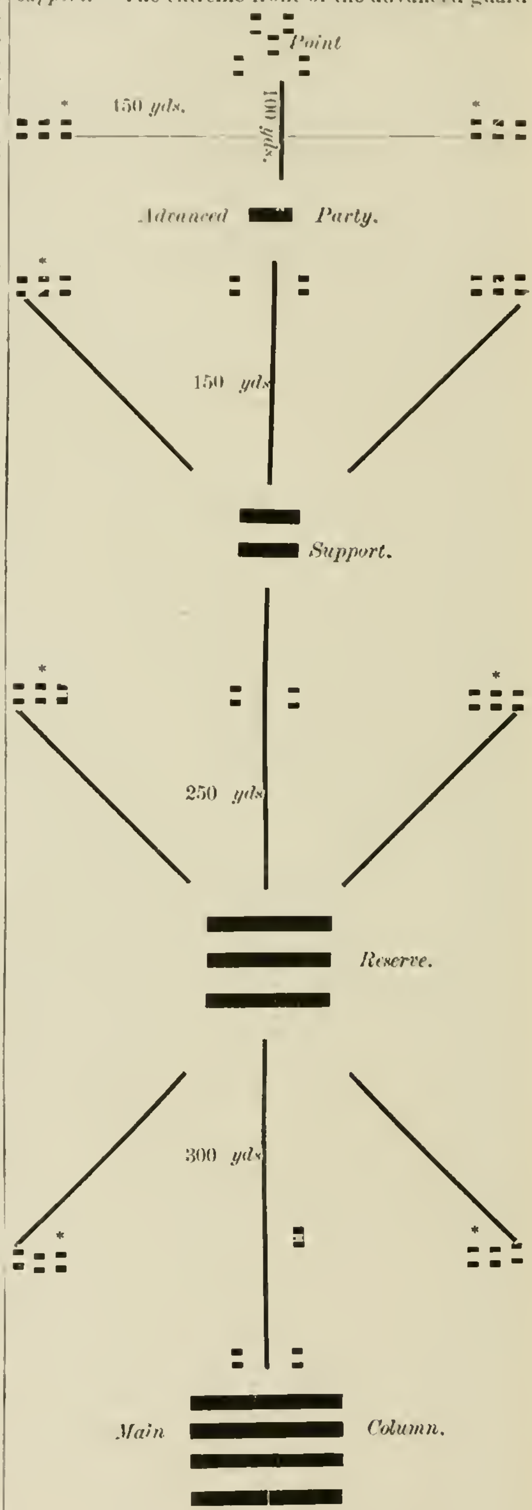


Fig. 3.

will always consist of a leading group, or point, of three or four men, under a Non-commissioned Officer if possible, sent forward from the advanced party."

To illustrate the general dispositions of an advanced-guard—which are about the same for all, whatever their strength and purpose—the manner of arranging a guard of one hundred and fifty men, infantry, will be taken. First,—Fig. 3—a leading group of four men under a Corporal, flanked by two groups of three or four men each to the right and left rear, not more than one hundred and fifty yards off the main route. The remainder of the advanced party follows at one hundred yards from the point. At one hundred and fifty yards, a connecting file between, the support follows, detaching, when required, two small flanking groups, to support and keep in sight the flankers of the advanced party. At two hundred and fifty yards, connecting files being between, the reserve follows, consisting of half the force. It may detach to either flank, when desirable, one group of men thrown forward, and another group thrown rather back supporting the former. None of these flanking groups should extend their distance laterally from the main route over four hundred yards, under ordinary conditions. A distance of three hundred yards separates the reserve from the main body, which is thus eight hundred yards, or nearly half a mile, from the leading group of the advanced-guard.

In the case of an advanced-guard or cavalry of about the same strength as the foregoing, the lateral distances would be increased to two hundred, three hundred, or even a greater number of yards, depending upon the nature of the country; and the distances between the different portions of the guard would be increased in proportion, until the total distance from the point of the advanced-guard to the *main* column would be one thousand five hundred or two thousand yards or even more in a very open country. The Commander of the advanced-guard remains with the reserve. It marches on the main route always ready to move quickly to the front or flank if required. When possible, flanking patrols from the reserve move on each flank. They are to examine houses, farms, etc., standing back from the route, and preserve connection with any columns that may be advancing on other roads to right and left. Should there be any fighting it is done by the reserve. The advanced parties, feel, observe, and reconnoiter, but when it comes to pushing home an attack the reserve must be brought up as quickly as possible. This does not mean that the advanced parties will not usually be able to sweep back the enemy's feelers and scouts if they are encountered. So much they will doubtless be able to effect, but should more serious resistance be met with, it is their duty, even at the cost of delay, to obtain re-enforcements, or to fall back on the larger body in their rear, so as either to ensure the advance being pushed successfully, or that such obstacle to the enemy's nearer approach be offered, as shall give the main body time to prepare for action. The principle on which such rules for action are based is that it is the essence of the duty of an advanced guard to be *successful* in repulsing the enemy or in holding him back a sufficient time. The distance of the head of an advanced-guard from the main column varies according to circumstances, and cannot be dictated by rule. It may, however, be fairly remarked with reference to the principal duty of the advanced-guard, that if the main body requires to be afforded a long time to prepare for the engagement—in other words, if the column of the main body be deep, and would take much time to form up—the distance of the head of the advanced-guard must be a long way in advance. But if the country is difficult to traverse, and the enemy's advance can be easily retarded, the head of the advanced-guard need not be so far in front as if the country is open, and the advances of the enemy would be uninterrupted. Or, if the advanced-guard is strong, and can hold the enemy, it need not be so far in advance as if it were weak, and liable to be driven rapidly back. Again in thick or foggy weather, or at night, the distance in front of the head of the advanced-guard, would be reduced, as would also the breadth of front of the scouts, or flanking parties. Under such circumstances a long extended advanced-guard would be useless, and the proper direction of march might be lost. The enemy could also easily pass through a widely extended front, undetected, in a dark or foggy state of the atmosphere.

A very rough rule is sometimes followed of ascertaining approximately what the distance should be from the head of the advanced-guard to the head of the main column. The distance is to be equal to the length of the column of the main body *en route*, on the assumption that the rear of the column would then have time to form up for action, before the enemy could pass from where he encountered the head of the advanced-guard, to the position taken up by the column to receive the attack.

The division of the advanced-guard into advanced party, support, and reserve, admits of a sub-division of duties which is very desirable. The nature of these duties leads us naturally to fix the position in the advanced-guard of the several arms when combined. Mobility is undoubtedly necessary for the advanced files, and reconnoitering their duty, cavalry must therefore be at the head; and not only at the head but to reconnoiter to the flanks, for infantry employed on this service, to any distance, would delay the advance, and the men be soon exhausted by the extra fatigue. The advanced party, and also the leading portion of the support, would therefore, be *cavalry*. But cavalry should not compose the whole of the support, as cavalry meeting hostile infantry would naturally be checked. The support, then to fulfill its complete mission, should include infantry. A few engineers should accompany the support, in order to be near at hand when required to repair a broken bridge or assist in removing an obstacle to the advance. The pioneers of infantry would also march with the support, to render like service. The reserve would be composed of all the three arms, in order to withstand the enemy and fight him. Infantry at the head, followed by the artillery, then by more infantry, and finally by the remainder of the cavalry not employed in the advance. The engineers not with the support, would bring up the rear of the advanced-guard. The circumstances under which guns would require to take a more forward place in the march of an advanced guard are of rare occurrence. In a mountainous or hilly country, much enclosed, a few guns might perhaps accompany the support. In such a country they would be comparatively safe from sudden attack or reverse, the enemy being hampered in his movements by the ground, and they would be close at hand when required for any special service, such for instance as silencing the enemy's guns brought to bear on points which must be passed by the advanced-guard. A couple of guns are also sometimes of use with the support, in order to clear the road in front without loss to the infantry.

Marches are of two kinds. 1. Those made beyond striking distance of an enemy, called *route* marches. 2. Those made in the immediate vicinity of the enemy, called *strategical* and *tactical* marches the latter being in sight of the enemy. Marches of the second class are termed *strategical* because they are usually made in connection with some *strategical* combination. In marches of the first class the comfort of the men is an object of the first importance, unless there is some urgent reason for rapid concentration, when every other consideration must give way to it. In the second case comfort must give way to security. In both cases the marches should be so conducted that the troops will arrive at their destination with as little fatigue as possible. Great care should consequently be exercised to see that the troops are not obliged to make any unnecessary movements. Particularly discouraging is a counter-march without any object accomplished, as when caused by false information; it is fatigue endured without return. Success in war will depend in a great degree upon the manner in which the marches are conducted. The General, who at a given time, can have the greatest number of troops at a given point and in the best condition for fighting, is bound to be successful. General Wolseley says: "Let me see two armies on the march, and I believe I could tell you the respective fighting value of each. The fitness of troops for the great final struggle, when they at last meet their enemy, must ever depend greatly upon the manner in which their marches have been arranged. Men overmarched, or whose health and comforts have not been duly attended to whilst on the march, can never be expected to go in at an enemy whose men have been well cared for by an able staff administration." One general principle should be followed in all marches, viz., to have as many columns as possible and march them upon the greatest possible front. This will be decided by the number and nature of the roads leading in the desired direction. The greater the distance from the enemy the more closely may the above rule be followed; as the enemy is approached, the more nearly should the marching approach the battle front. Several roads, sensibly parallel, and but a few miles apart, fulfil this condition most favorably.

The following general rules should be observed in all marches: 1. The several branches of the service should afford each other mutual protection, and their position on the line of march should depend on the nature of the country. 2. The order of march should be such, that by short, simple, and rapid movements, it can become the order of battle. 3. That at no time, and under no pretext whatever, should the slightest deviation from the strictest discipline be permitted. The march of an army corps over a single road is a very tedious and fatiguing operation. The march of the several divisions should be so regulated that they will not interfere, and so the short delay of one will not affect the others. Let us suppose the case of an army corps of thirty-five thousand men, marching on a single road, and see what space would be taken up by it. The advanced-guard—consisting of a brigade of cavalry, four regiments of infantry, two batteries of horse artillery, a company of engineers, and a pontoon train—from the extreme front to the extreme rear, would cover about four miles of road; the main column about thirteen miles; the train four miles. Allowing an interval of one mile between the advanced-guard and the main column, and twenty per cent. for opening out on the march, and the corps will cover about twenty-five miles of road. The rear-guard would have to make a forced march in order to reach the extreme head of the column in one day. General McClellan, referring to the disadvantages arising from the use of a single road for the march of a large army, says: "If I had marched the entire army (about one hundred thousand men) in one column along the banks of the river instead of upon five different parallel roads, the columns with its trains would have extended about fifty miles, and the enemy might have defeated the advance before the rear could have reached the scene of action."

A march is said to be *forced* when it is longer than the ordinary marches, and is made for the attainment of some particular object. Forced marches are very fatiguing, and they should therefore be resorted to only in cases of urgent necessity, and then but few such marches should be made in succession. On the eve of a battle they are frequently necessary in order to facilitate the concentration of troops. Especially will this be the case with the large armies of the present day, which cover a great extent of country while on the march. Depending upon the condition of the roads and weather, and the size of the column, infantry will march from one to two and one half miles an hour. Allowing ten hours as the limit of the greatest ordinary march, and time for the necessary halts—which should be made for at least five or ten minutes each hour—infantry can march from ten to twenty miles a day. The latter distance will therefore be the longest ordinary march for troops of this branch of the service; a longer march than twenty miles will then be a forced march. Cavalry at a walk will usually march three miles an hour; moving at a trot it can make five miles for a few hours. Forced marches, continued for several days, are more severe for cavalry than for infantry. When it is possible, cavalry and horse artillery should march by a different road from the infantry, as it is very fatiguing to horses to keep pace with men on foot. If this cannot be done, large intervals should be allowed between the mounted and dismounted branches of the service when on the march. Unless the country is deep or very much cut up by canals, cavalry can generally make its way across the fields, having a detachment of mounted sappers with tools carried on pack-horses for the purpose of opening ways through and over obstacles. The pace at which the troops at the head of a long column march is far from being a matter of indifference; it should be uniform and slow. If the rate of marching at the head of the column is not uniform, the troops in rear will be unnecessarily fatigued, as they will be obliged to go alternately fast and slow in order to keep the proper distances. If the rate is too fast, the column will be drawn out and the number of stragglers greatly increased.

Route marches become marches of *concentration* when made for the purpose of bringing different bodies of troops together at a specified place or places at a time fixed upon before hand. *Strategical* marches become marches of *maneuver* when so made that they render untenable the position occupied by the enemy, forcing him either to abandon it or to accept battle under adverse circumstances. In this class of marches secrecy, celerity, and good order are the first essentials of success. The campaign of 1805 furnishes a most notable example of these two classes of marches. At the opening of the campaign, Napoleon's entire army was distributed from the Texel to Brest along a front of about five hundred miles. By most admirably planned marches of *concentration*, he brought the first and second corps—thirty-seven thousand men—from Hanover and Holland to Wurtzburg, between September 18th and 20th; the third, fourth, fifth, and sixth corps and the reserve—one hundred and thirty-eight thousand men—from France to the Rhine, between Manheim and Strasburg, between September 21st and 24th. The seventh corps was to reach the Rhine at Strasburg after the others. With the corps in these positions the marches of *concentration* were completed. Each corps moved in three divisions on three consecutive days. The Austrians, at Ulm, expected Napoleon to make a front attack, by passing through the defiles of the Black Forest. Their grounds for this belief were based upon the operations of previous campaigns. But Napoleon's plan of campaign was entirely different from any that had previously been followed. The main body of the French force being on the right helped to fix Mack, the Austrian Commander, in his error. Napoleon, making a strong demonstration in front of the Austrian position, pivoted on his right, and concentrated his entire force on the Danube, between Donauwerth and Ingolstadt, in the rear of Ulm, thus separating the Austrians from the Russians who were already coming up the Danube to their relief. Ulm was thus rendered untenable and Mack was so compelled to capitulate. The marches of the French army from the Rhine and Wurtzburg were marches of *maneuver*, aiding by their direction a strategical combination.

A *flank* march is one whose direction is parallel, or nearly so, to the enemy's position. Such a march, when made in the immediate presence of the enemy, is usually a very delicate operation to successfully accomplish, and should rarely be resorted to. As the distance from the enemy is increased the difficulties of a flank march diminish, and when they are made at a distance of several marches from him, with good protection for the exposed flank, they will not differ from ordinary marches. One of the most brilliant examples of a successful flank march in the presence of the enemy, was that of the rebel general Stonewall Jackson, made during the battle of Chancellorsville, May 2d, 1863. General Hooker determined to fight a defensive battle and strengthened his position for this purpose. General Lee, Hooker's opponent, finding a front attack on his position impracticable, sent General Jackson with about twenty-two thousand men to attack Hooker's right and rear. The position of the Union forces is shown in Fig. 3, also the direction of Jackson's flank march. The column on the march was at no time more than two miles from the Union lines, but was concealed from them by intervening timber. It is said that General Lee, previous to the battle, had a road cut through the timber from Jackson's position to the Brock road, with a view of making this maneuver. The full effect expected from this flank movement was not realized, owing to the loss of General Jackson, who was mortally wounded and taken from the field just as he was about to follow up the advantage given by his new position in the line of battle. This march and the subsequent attack had, however, a decided influence on the fight, and, in connection with other events, determined General Hooker to withdraw his forces across the Rappahannock river. The Union force controlled by General Hooker numbered about one hundred and twenty thousand men; the Confederates had about fifty thousand men.

Combined marches are those made for the purpose of attacking two or more points of the enemy's position at the same time; or, they may be undertaken in order to have several corps, marching from different directions, reach a certain point at a fixed time. The nearer this point is to the enemy the more difficult will be the operation, owing to the opportunities offered of attacking the separated corps in detail. These operations are open to the same objections as diversions, their object frequently being defeated by similiar causes. Marches through obstructed country depends for success upon the manner in which they are conducted. The difficulties to be encountered by the advanced-guard will in this case be increased, and upon its efficiency will depend the safety of the army. Forests, streams and mountains will have to be crossed and defiles traversed. The disposition to be made for the accomplishment of these objects will depend upon the circumstances in each particular case; whether the enemy is present in strength, is strongly posted, and the opposisition that he will probably make. It is the province of the advanced-guard to develop all these facts, so that suitable arrangements may at all times be made by the Commanding General. The general rule is not to compromise the safety of any considerable body of troops in such positions, and therefore they should not be entered until the country has been thoroughly scouted in every direction. Each division should act as a support to the one that precedes, and the march should not be resumed until all the troops have traversed the dangerous zone. The safety of the trains pertaining to an army on the march is a consideration of the first importance. In a forward movement they follow the columns of march, and if the flanks of the army are protected they may follow either indifferently, or both. Under other circumstances they should follow the flank which affords the best protection, otherwise they should be placed in rear of the center. On a retreat the trains will be in advance of the army. Night marches with large forces are very difficult operations for obvious reasons. They are, however, a necessity in certain cases, as on the retreat in order to gain a march on the enemy, when making diversions, etc.

In moving an army it is desirable, if possible, that only one division should march by each road. The largest unit that can at all conveniently march by one road in a continuous column is an army corps; but its pace will be very slow, and great fatigue will be entailed upon men and horses. Orders for a march should contain: 1st. General direction and object of march. 2nd. Date, hour, and order of the march, and the roads to be followed by each division, etc. 3d. Formation of advanced or rear-guards, and special instructions for flanking parties and detachments of all sorts. 4th. Instructions for field hospitals, reserve ammunition, engineers, pontoons, and military portion of the train generally. 5th. Instructions for supply of troops and orders for baggage and provision columns. 6th. Position of General on the march, and of headquarters for the night. It is quite evident that as the success of strategy is mainly dependent on accurate calculation of the powers of marching, the most brilliant conceptions, and the most profound combinations, must fail if the troops do not move over the distances calculated on, and do not occupy the prescribed relative positions to each other. Similarly, when the head of a column is attacked, the most skilful tactics will not help it, if the artillery, cavalry or infantry that are required for any particular action cannot be found, if the roads are blocked, and re-enforcements cannot be brought up, or ammunition be got at; consequently the art of marching forms a most important portion of the science of war. The increased power of weapons enables a small body of men, who know they will be supported, to hold a position longer than formerly, this enables an advanced-guard to check an enemy, compel him to deploy, and bring up his artillery before he can make an impression; consequently the distance apart of columns on the march, or the front of an army moving in proximity to an enemy, may now be enlarged to an extent that formerly would have been unsafe. It is a matter of no little importance as affecting rapidity of marching and punctuality of supply.

The functions of outposts are to hold an enemy in check until the army is prepared for action and is ready to receive him; to enable the army to rest by securing it from surprise by the enemy; and to prevent the enemy's reconnoitering parties from approaching sufficiently near the position of the army to gain any information concerning it. Armies in actual presence of each other form order of battle, and in this case outposts cease their function. Armies at a distance from each other, when the nature of the country and their means admit of it, cover their front and flanks with cavalry, one or two or more marches in advance; and in this case, since these troops would give notice of the enemy's movements and time for preparation, the other outposts behind these would, for the moment, find their uses limited to preventing the passage of deserters on the one side, spies on the other, and to giving protection from sudden raids of parties of the enemy which might break through the cavalry cordon. It is when the cavalry line does not exist, or has been withdrawn, while armies, though not in presence, are within striking distance, that outposts assume their full value. The withdrawal of the cavalry may follow either from the force of that arm on one side being overmatched, or because one army awaits the other in position. In this last case, when the opposing lines of cavalry covering their respective armies come into collision, the cavalry of the army which takes position, even though for the moment victorious, must in the end give way; because the advancing army will push on troops of all arms, while the stationary army cannot do so, seeing it intends to fight elsewhere, and cavalry alone cannot oppose a combination of arms. The army in position therefore, places its outposts, and its cavalry retires through them. The enemy's cavalry is checked by the outposts. The enemy thereupon either proceeds at once to reconnoiter and attack the position, or himself takes position, covered by *his* outposts, with the intention of attacking next day, or at a more convenient time, or of maneuvering. To observe his (the enemy's) approach from a distance, and to recognize, if possible, its true character; to resist up to a certain practicable point, and then fall back in concert and good order, continuing to retard the enemy, —such are the functions which are demanded from a line of posts extending across valleys and over ridges, sometimes in wooded ground, sometimes in enclosures, sometimes in an open country, sometimes along a front the issues of which are close defiles—each variety of the conditions calling for an appropriate disposition; while the whole attenuated line, which thus opposes itself to the onset of an army, is to maintain concentrated action throughout.

The arrangement of the different component parts of the outposts is similar to that of the advanced-guard, and their duties have much the same character, differing, however, essentially in matters of detail and mode of execution. In order to perform these duties properly, efficiently, and with the minimum amount of fatigue, the combined action of the two arms, infantry and cavalry, is absolutety necessary. The infantry is required to resist the enemy's advance, and the cavalry to watch him, obtain information of his movements, and to promptly transmit the knowledge gained to the rear. The relative proportion of these two arms in any case will be determined by the nature of the country in which the army is operating. If the country is level and open the cavalry can be employed to the best advantage, and it would therefore be largely used, especially during the day, but at night it should be replaced by infantry as far as practicable. In a rough, close, or broken country infantry would be principally employed at all times. Infantry and cavalry on this duty should never be placed together in the same line, on account of the danger which would result from a flank attack on the former, rendered possible by the latter being forced back from its position. Owing to the similarity of the two duties—advanced-guard and outpost—it is desirable that the names of the component parts should as far as practicable be the same for each. In many instances, after the day's march is finished, the advanced-guard, when not too much fatigued, is also required to perform the duties of outposts, in which case very little change would be necessary in its formation in order to adapt it to its new service. There are two systems of outposts, viz., the *cordon* system and the *patrol* system. In the first system a line of sentinels is so arranged that the enemy, either singly or in parties, cannot by any possibility pass it; in the second case constant patrols are made, which are expected to detect parties of the enemy attempting to pass, without calculating to entirely bar the way to individuals. When the weather is clear and the country comparatively open, the *cordon* system is very effective, but in a very broken country, or when the weather is stormy or foggy, the large number of men required to properly perform the service makes the duty very arduous. The *patrol* system under these circumstances would probably be preferred, sentinels being placed on all the avenues of approach, and a thorough system of patrols being employed to prevent the enemy from penetrating the lines. Under all conditions of country and weather, a combination embracing the best qualities of each system might be devised. To illustrate the manner of arranging and placing outposts, let us suppose that an army corps has taken position in fairly open ground, and the necessary arrangements are to be provided for its security. For this purpose the troops detailed for outpost duty will be posted in four lines, as follows: 1. *Sentinels.* 2. *Pickets.* 3. *Supports.* 4. *Reserve.*

Each picket furnishes a chain of double *sentinels* to watch the country in front, and to connect with the neighboring pickets. No more posts should be established than are absolutely necessary. In fairly open ground by day they may be from two hundred to four hundred yards apart for infantry, and up to six hundred yards for cavalry mounted sentries called *vedettes.* Sentries should not be more than four hundred yards in advance of their pickets. Vedettes may be as far as six hundred yards from their pickets. Sentries or vedettes should have clearly in view all the men of the posts on each side of them, and no ground in front of the two adjoining posts should be unseen by the sentries of both posts. At night, sentries should be placed so as, if possible, to bring any advancing person against the skyline, they themselves remaining in shadow; but, as it is impossible to continue the cordon system with strict effect at night, sentries would in general be only placed on the roads, and other lines of approach. Vedettes would be withdrawn altogether at night, unless there were no infantry available, in which case they would then be placed on the roads or the passages through which an enemy is most likely to advance.

The strength of a picket will be determined by the number of posts for which it furnishes sentries or vedettes, in addition to the men required for detached posts, and for patrolling duties. The picket acts as a support, or a sort of anchor, to the sentries, vedettes, or detached parties which it furnishes. It is therefore posted in their rear, if possible centrally, and on a main route or thoroughfare. A mounted orderly or two should be attached to an infantry picket. Patrolling duties must always be allowed for, the number of men required being determined by the Commander of the outposts according to circumstances; with cavalry pickets the proportion would generally require to be large, about *one-fourth* to *one-third* of the whole picket. Detached parties are of a strength proportioned to the duty upon which they are sent. From two to four double sentries are quite sufficient for an infantry picket to furnish and two to three double vedettes for a cavalry picket. It follows that the infantry picket would observe from six hundred to eight hundred yards of front, whilst the cavalry picket would watch a front of one thousand to one thousand five hundred yards. The pickets themselves may be from four hundred to eight hundred yards from their supports in the case of infantry, and from one thousand two hundred to two thousand yards in the case of cavalry. Infantry pickets would thus be from six hundred to eight hundred yards from one another, whilst cavalry pickets would be from one thousand to one thousand six hundred yards apart.

These figures are of course purely approximate, as the nature of the ground and other circumstances must immensely affect the dispositions in any particular case; in a perfectly open country, in clear weather, for instance, the distance and intervals would no doubt be much increased. The principles however, by which they should be calculated are simple, and ought to be borne in mind. The pickets, whilst being placed centrally as regards their sentries, should be close enough to aid and support one another in retreat, an efficient flanking fire being mutually provided for in the case of infantry. They should not be too close in front of their supports, as the latter might in such case be demoralized by the pickets being suddenly driven in upon them, nor, on the other hand, too far distant to prevent the supports from advancing in time, to aid the pickets when hardly pressed. From twenty-five to fifty men for infantry, and from twenty to thirty for cavalry, are generally sufficient for ordinary pickets. Where large detached parties are furnished by a picket, its strength must be proportionally increased. A picket should be, if possible, posted on the route by which the enemy will probably advance, and a cavalry picket should have ground in advance of its position favorable for action, in case it may be necessary to take the offensive in order to check the enemy. The position of the picket ought to be so far concealed that the enemy can only discover it by attacking; but, there must be free movements in all directions, and especially easy means of communication, both with the flanking pickets and the supports in rear. In all cooking, eating, feeding, and watering arrangements, *two-thirds* of a picket of either arm must always be ready for immediate action, and none of the men should stroll at a distance from the arms.

The line of resistance—that is, the line where the first important stand is to be made—having been decided upon in the first instance, the supports are also placed at convenient positions thereon, as centrally as subdivision, therefore, in the one case, would be, for the reserve one-third, for the support one-third, for the pickets one-third; in the other case, for the reserve one-half, for the support one-fourth, for the pickets one-fourth, of the whole strength. The reserve ought to be placed out of sight of the enemy, occasionally divided into two parts, on a principle route or routes of retreat to the main body. Its functions are to move to the re-enforcement of the supports if necessary, or to occupy a good defensive position for the troops to fall back upon if required. The distance from the line of supports must vary considerably according to circumstances, but would range

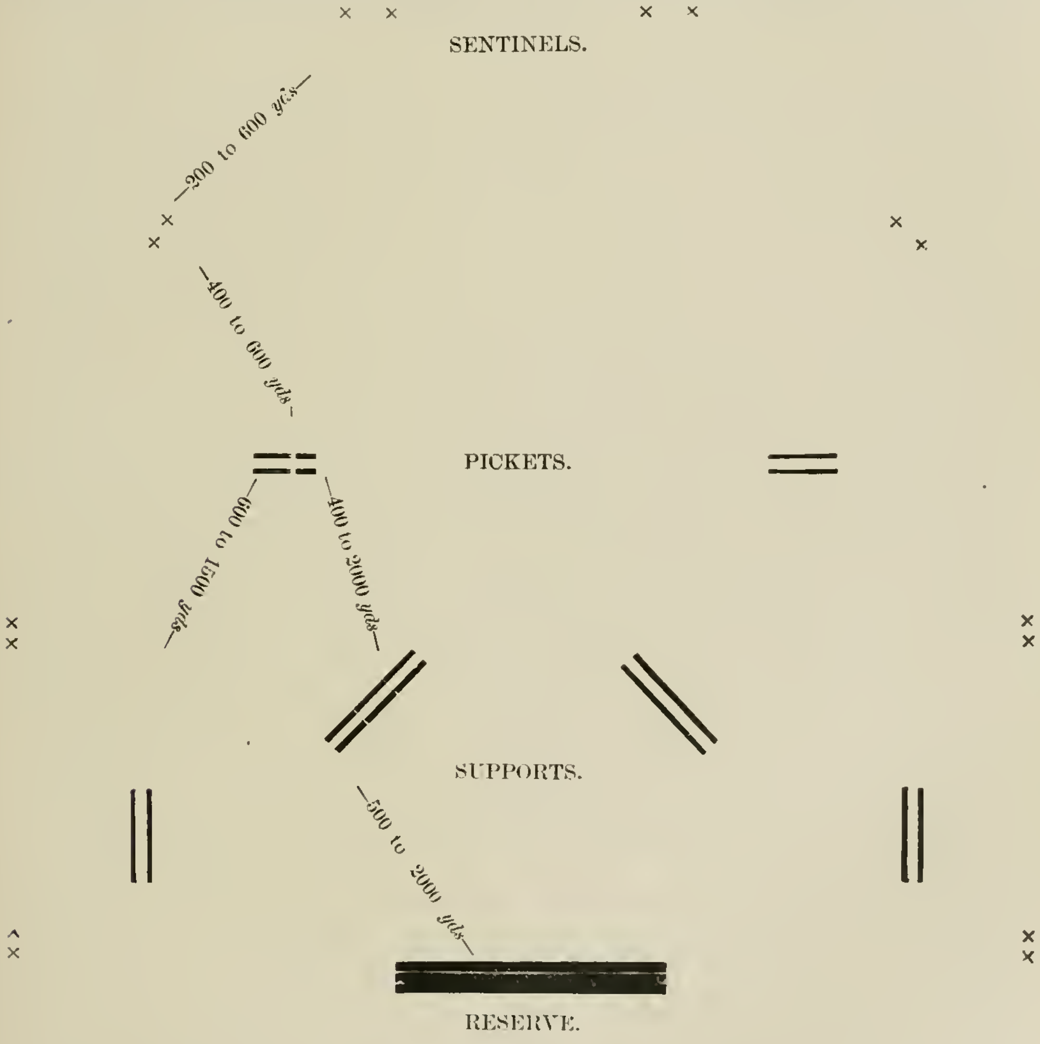


Fig. 4.

possible to their own group of pickets in front, and close to or on the main avenues of approach. Supports should be of a strength equal to all in front of them, and one support to every two or three pickets will be sufficient. The strictness of routine laid down for the pickets may be somewhat relaxed in the case of the supports; but they must be always ready to march, day or night, at a moment's notice to any point required, or to stand on the defensive.

The reserve is intended as a general support to the lines of pickets and supports. It consists generally of from one-third to one-half of the whole strength of the outpost. This leaves, for the supports and pickets, either two-thirds or one-half the whole. The under the more ordinary conditions from five hundred yards to one thousand yards for infantry and from one thousand two hundred to two thousand yards for cavalry. The reserve may bivouac, rest, cook, eat, and smoke, but should always be ready to act at the shortest notice. Fig. 4 represents the outposts arranged in accordance with the foregoing principles.

When the enemy is able to bring his artillery into action the attack may be considered to have commenced. As it is the duty of the supports to hold the enemy in check until the army is ready to receive him, it follows that they must be placed beyond effective artillery range of the position, which may be taken as two thousand five hundred yards. The line of sentinels would then be from three thousand three hundred to three thousand seven hundred yards in the case of infantry, and from four thousand three hundred to five thousand one hundred yards in the case of cavalry, in advance of the main body. No rule can be determined which will regulate these distances for all occasions and under all conditions. The distances in all cases will also depend upon the nature of the country, the objects to be obtained by the outposts, and other peculiar circumstances always attending each particular case. Changes in the position of a portion of the outpost line will usually become necessary at night. They should be carefully arranged before dark, and put into execution just as the light is failing so as not to be observed by the enemy. Bridges, main routes, and obligatory points of passage should be occupied by the pickets, the supports being pushed close up to them. Advanced sentries being of little use during the dark hours, except on the roads, footpaths, and other avenues of approach, the number of double sentries in a close country can usually be reduced at night. If extra men are thus set free they should be employed on patrol duty, which must be more frequent in front of the line as the double sentries are fewer in number. On the other hand, in a comparatively open country, the number of approaches to be watched may even exceed the number of day posts. Here there would be no saving of sentries, but the patroling would probably not require to be so incessant. In order to make these dispositions it may become necessary to contract the outpost line, but in such case the original posts would be resumed on the approach of daybreak. This should, however, be effected with as much care and preliminary examination of the ground as at the previous occupation.

With a mixed force cavalry would usually be withdrawn from the front at night. This would be especially the case in a difficult or enclosed country. But should it be necessary to retain them during the night on account of the absence of infantry to replace them, they must undergo a thorough change of position. The posts with wide extended view suitable for the cavalry vedette by day are valueless at night, and stationary mounted men can only watch roads or defiles after dark.

Cavalry pickets which have been in open ground during the day must now be placed on the roads, where they can have free movement from front to rear, double vedettes being immediately in front of the pickets advanced a short distance up each approach. Principal reliance must be placed upon the watchfulness of the patrols, which are kept constantly in motion during the night. The enemy can only himself move in any force upon the roads; and if these are vigilantly watched and examined for some distance to the front during the dark hours, a certain amount of security against surprise is thereby obtained.

Patrols from outposts are of three kinds: 1. Visiting patrols. 2. Reconnoitering patrols. 3. Strong patrols. *Visiting patrols* consist of an Officer, or a Non-commissioned Officer, and one or two men. They are sent out from each picket between reliefs, and their duties consist in keeping up the communication between the picket and its neighboring pickets, as well as with its support in rear, and with its detached parties in advance. Visiting patrols are especially necessary in a close country and in bad weather. In an open country, with clear weather, they may be much less often sent out during the day.

Reconnoitering patrols are sent forward a limited distance, not exceeding from half a mile to a mile for infantry, in advance, to examine ground which cannot be watched by the sentries, and to give notice of the enemy's approach. They commonly consist of an Officer or Non-commissioned Officer, and two to four men. Cavalry may be safely despatched to a much greater distance than infantry. The Germans and French call the smaller of these patrols by names which signify crawling or creeping in the case of infantry, and secrecy in the case of cavalry. *Strong patrols* are of the same character as the last, but of larger force and not necessarily secret. If of greater strength than a dozen men they would be furnished from the supports or reserve. Sometimes a company or troop, or even a larger body, would be despatched on such duty. They should not proceed farther than about a mile for infantry, from the line of sentries, and even then with mounted orderlies attached, for the purpose of conveying information rapidly to the rear. The object of strong patrols would generally be to obtain early information of the enemy's movements when he is at a distance, to ward off his patrols, and to prevent surprise; sometimes to engage a post, in order to ascertain the enemy's strength, thus acting on the offensive. Above all things, strong patrols should avoid unnecessary firing. Firing signifies, to those in rear, that the patrol has not only seen the enemy, but that the enemy has seen the patrol, and is advancing. An incessant fire, kept up in retiring, intimates that the enemy is in force and is pressing the pursuit, but this signal should be abstained from unless it is necessary to arouse the troops in rear; the outpost line must be most careful not to occasion false alarms, which are hurtful to the *morale* of the army. As a general rule, it would be best to retire steadily, if possible unperceived, as soon as the enemy is touched upon; but sometimes, if opportunity serves, a prisoner or two may be captured, in order to obtain information.

Artillery with outposts. Artillery, if added, would usually be with the reserve, when the guns should be posted so as to cover the retreat of the advanced portion of the outposts, or else be held in readiness close to a main route to proceed at once to any required point as the attack of the enemy develops itself. Guns are, however, occasionally more to the front, when, without unduly risking their safety, they can be placed so as to command ground which must be passed by the enemy in his advance. The enemy may thus be forced to lose time by deploying when still at a considerable distance. The guns posted near the front line should be safe from surprise, and either out of range of the enemy's effective rifle fire, or protected from it by skirmishers thrown out in advance of the guns. With proper precautions an artillery outpost may often be placed in an advanced position, probably on a flank, where, being well covered by the guns of the main body, it need not retire until it has accomplished its object, supporting the infantry as they fall back from point to point. For this and other purposes of delaying the enemy, however, advanced guns must avoid taking position within artillery range of ground which the enemy's batteries could reach and take post on unperceived. Horse-artillery acting with cavalry may sometimes, if well supported, be pushed still farther to the front, for the purpose of making the enemy develop his attack early in the day.

The chain of outposts should cover not only the front of an army, but should also extend well around the flanks, in order to guard every avenue by which the enemy might by any possibility approach. When the army remains in one place for any length of time it is advisable to strengthen the outposts by means of abattis, slashings, etc. All the heights from which the enemy could obtain a commanding view of the country in the vicinity of the army should be included within the chain of outposts, and if this is not practicable, then should such heights be occupied by detached bodies of troops to prevent the enemy from making use of them for the purpose of reconnoitering. When an army has to withdraw at night from the presence of the enemy it becomes an object to conceal the movement as long as possible, and for this purpose the outposts are usually left in position until daylight. Under these circumstances the sentinels should be particularly on the alert, and patrols should frequentlymade to prevent spies o ber deserters from giving the enemy information of the movement. The troops should constantly be prepared for an attack, which would certainly follow should the departure of the army be discovered. It also becomes a part of the duty of the outposts to keep the fires burning as usual so that the suspicions of the enemy may not be aroused.

Fig. 5.

Particular care should be taken not to post troops on any point from which they cannot reach the enemy with their fire, and from which they cannot move to the assistance of the troops at other points. Nor should troops be placed in advance of the general line where they might be liable to be cut off by the enemy, without providing for their safe retreat by holding with a strong force all the roads leading to the position. To illustrate the dangers almost certain to result from an improper arrangement of troops in position, reference is made to the battle-field of Gettysburg, Fig. 5. The result of the Confederate reconnaissances was to fix upon the ground opposite Longstreet—that is, the left and left center held by Sickles' corps—as the most practicable point of attack. * * * In the original ordainment of the line of battle, Sickles' corps (third) had been instructed to take position on the left of Hancock, on the same general line, which would draw it along the prolongation of Cemetery Ridge, towards the Round Top. Now, the ridge at this point is not very well defined, for the ground in front falls off into a considerable hollow. But at the distance of some four or five hundred yards in advance, it rises into that intermediate crest along which runs the Emmetsburg road. General Sickles, thinking it desirable to occupy this advanced position—which he conceived would, if held by the enemy, make his own ground untenable—assumed the responsibility of pushing his front forward to that point. The motive that prompted General Sickles to this course was laudable enough, yet the step itself was very faulty; for though to superficial examination the aspect of this advanced position seems advantageous, it is not really so; and prolonged to the left, it is seen to be positively disadvantageous. It affords no resting place for the left flank, which can be protected only by refusing that wing, and throwing it back through low ground, towards Round Top; but this, in turn, presents the danger of exposing a salient in a position which, if carried, would give the enemy the key-point to the whole line. General Sickles' disposition of his troops had precisely this character. * * On this obtruding member, General Lee determined to make his attack; for, as he states: "It appeared that if the position held by it could be carried, its possession would give facilities for assailing and carrying the more elevated ground and crest beyond." This eccentricity in the placing of Sickles' corps did not become known to General Meade until about four o'clock, when he arrived personally on the field; and though he then saw the danger to which that corps exposed itself, it was thought to be too late to correct the error; for just at that moment, Longstreet, under cover of a powerful artillery fire, opened his attack, and all that remained for General Meade was to support Sickles as far as could be done in the emergency. The final result of this attack was to carry the position occupied by General Sickles, after serious losses and a stubborn resistance on the part of the Union troops; but there then remained the line which should have been occupied in the first instance, and the efforts to carry which resulted in Lee's defeat.

Rivers, like mountains, strengthen the relative defence; but one of their peculiarities is, that they are like implements of hard and brittle metal, they either stand every blow without bending, or their defense breaks and then ends altogether. When the river is very large, and the other conditions are favorable, then the passage may be absolutely impossible. But if the defense of any river is forced at one point, then there cannot be as in mountain warfare, a persistent defense afterwards; the affair is finished with that one act, unless that the river itself runs between mountains.

The other peculiarity of rivers in relation to war is, that in many cases they admit of very good, and in general of better combinations than mountains for a decisive battle. Both again have this property in common, that they are dangerous and seductive objects which have often led to false measures, and placed Generals in awkward situations. Positions may be selected near rivers either for the defensive, to prevent an enemy from passing, or for the offensive, to force a passage. In selecting a position to guard a river or an extended line of frontier, when menaced by the enemy, it will not be advisable to divide the army into several equal portions and endeavor to watch each point suitable for crossing, or each pass by which the enemy may *débouche* ; but, placing the main body in a central position, watch the different bridges and passes with strong detachments, and, when the enemy has developed his point of attack, advance with the main body to meet him and dispute his passage. For example, let us suppose an army of eighty thousand acting on the defensive against one of one hundred and twenty thousand separated into three corps of forty thousand each. To oppose to the enemy three corps of equal strength, we would have but about twenty-six thousand in each, and consequently would find ourselves inferior in numbers on all points. If, instead of this, we opposed to each fraction of the enemy a corps of from twelve thousand to fifteen thousand, it would be sufficient to hold forty thousand in check, whilst our main body, consisting of from thirty-five thousand to forty thousand, holding a central position, could move on the point first menaced, and, being joined by the corps of observation, would offer to the enemy an effective force of fifty thousand combatants, which, all other things equal, should beat the enemy. The principle is not the less true, and the rule not the less imperative, even when the disparity of force is far greater. It may happen that, with every effort, we may not succeed in obtaining the preponderance of numbers on any point; still the only chance of success lies in concentrating all we can, and trusting to skill, promptitude, vigilance, and audacity, to do the rest. History furnishes brilliant examples of what a great General can accomplish, even under apparently the most discouraging state of things, by promtitude and rapidity of movement in throwing his reserve first on one and then on another of the enemy's fractions. Napoleon's campaign of 1814, in France, fully illustrates the application of these principles.

The passage of an unfordable river in the presence of an active enemy is an operation of the most difficult nature. A crossing may be forced, or stratagem may be resorted to for the purpose of deceiving the enemy as to the point selected, and thus the undertaking may be successfully accomplished before the enemy can concentrate to vigorously oppose it. As on the defensive, it is not best in this case to separate the army into several corps in order to force a passage at several points, but menacing several, to select one or two, and then by a rapid march to endeavor to reach them and effect the passage before the enemy is fully prepared to prevent it. In selecting a point to cross a river, it is well to bear in mind that in the bends the current is not so rapid as elsewhere ; also that small islands are generally located there, which may greatly aid the crossing and the construction of the bridge.

The following general rules embrace nearly all the points to be observed in the passage of a river in the vicinity of the enemy :

1. It is essential to deceive the enemy as to the point of passage, that he may not accumulate an opposing force there. In addition to the strategic demonstrations, false attacks must be made near the real one, to divide the attention and means of the enemy. For this purpose half of the artillery should be employed to make a great deal of noise at the points where the passage is not to be made, whilst perfect silence should be preserved where the real attempt is to be made.

2. The construction of the bridge should be covered as much as possible by troops sent over in boats, for the purpose of dislodging the enemy, who might interfere with the progress of the work ; and these troops should take possession at once of any villages, woods, or other obstacles in the vicinity.

3. It is important also to arrange large batteries of heavy caliber, not only to sweep the opposite bank, but to silence any artillery the enemy might bring up to batter the bridge while building. For this purpose it is convenient to have the bank from which the passage is made somewhat higher than the other.

4. The proximity of a large island near the enemy's bank gives great facilities for passing over troops in boats and for constructing the bridge. In like manner, a smaller stream emptying into the larger one near the point of passage, is a favorable place for collecting and concealing boats and materials for the bridge.

5. It is well to choose a position where the river makes a re-entering bend, as the batteries on the assailant's side can cross their fire in front of the point where the troops are to land from the boats, and where the end of the bridge is to rest, thus taking the enemy in front and flank when he attempts to oppose the passage.

9. The locality selected should be near good roads on both banks, that the army may have good communications to the front and to the rear on both banks of the river. For this reason those points where the banks are high and steep should be carefully avoided.

The rules for preventing a passage, follow, as a matter of course from those for effecting it, as the duty of the defenders is to counteract the efforts of the assailants. The most important thing is to have the course of the river watched, without attempting to make a defense at every point. Concentrate rapidly at the point threatened, in order to overwhelm the enemy, while a part only of his army shall have passed.

A long line of river cannot be successfully defended against the passage of an enemy who is provided with a sufficient pontoon train. On this account the army defending the river should be well concentrated, with its line of retreat well secured, and inflict as much damage as possible on the enemy at the point of crossing. The passage of a large river by an army on the retreat, when hardly pressed by the enemy, is one of the most difficult operations to be performed in any war. The points selected for the passage should present the most favorable features to enable a small body of troops to hold a larger body in check for a considerable time, so the enemy cannot press too hard upon the troops that have to pass last. Every precaution should be taken to deceive the enemy as to the point of crossing, which, when once selected, should be reached as soon as possible. The march should be so arranged that there shall be no crowding at the crossing, each body of troops reaching the designated place when the bridge is clear.

The passage of the Douro, by Wellington, May 12, 1809, illustrates all the details of such an operation, and shows with what small means it can be successfully accomplished. The passage of the Douro, by Sir Arthur Wellesley, 12th of May, 1809, was immediately after the river had been passed by the French, under Soult, continuing their retreat, and destroying the bridge across it from Villa Nova to Oporto. Soult, at Salamanca, would be more formidable than Soult at Oporto, and hence the ultimate object of the campaign, and the immediate safety of Beresford's corps, alike demanded that the Douro should be quickly passed. But, how force the passage of a river, deep, swift, and more than three hundred yards wide, while ten thousand veterans guarded the opposite bank? From the summit of the height of Sarca, the English General searched all the opposite bank and the city and country beyond it. He observed horses and baggage moving on the road to Vallonga, and the dust of columns as if in retreat, and no large body of troops was to be seen under arms near the river. The French guards were few, and distant from each other, and the patrols were neither many nor vigilant ; but a large unfinished building standing alone, yet with a short and easy access to it from the river, soon fixed Sir Arthur's attention. This building, called the Seminary, was surrounded by a high stone wall, which coming down to the water on either side, enclosed an area sufficient to contain at least two battalions in order of battle; the only egress being by an iron gate opening on the Vallonga road. The structure itself commanded everything in its neighborhood, except a mound, within cannon shot, but too pointed to hold a gun. There were no French posts near, and the direct line of passage from the height of Sarea, across the river to the building, being to the right hand, was of course hidden from the troops in the town. Here, then, with a marvellous hardihood, Sir Arthur resolved, if he could find but one boat, to make his way, in the face of a veteran army and a renowned General. A boat was soon obtained; for a poor barber of Oporto, evading the French patrols, had, during the night, come over the water in a small skiff; this being discovered by Colonel Waters, a Staff-officer of a quick and daring temper, he and the barber, and the prior of Amarante, who gallantly offered his aid, crossed the river, and in half an hour returned, unperceived, with three or four large barges. Meanwhile, eighteen or twenty pieces of artillery were got up to the convent of Sarea; and Major-General John Murray, with the German brigade, some squadrons, and two guns, reached the Barca de Avintas, three miles higher up the river, his orders being to search for boats, and to effect a passage there, also, if possible. Some of the British troops were now sent towards Avintas, to support Murray; while others came cautiously forward to the brink of the river. It was ten o'clock; the enemy were tranquil and unsuspicious; and an officer reported to Sir Arthur Wellesley that one boat was brought up to the point of passage. "Well, let the men cross," was the reply; and upon this simple order an officer and twenty-five soldiers entered the vessel and in a quarter of an hour were in the midst of the French Army.

The Seminary was thus gained without any alarm being given, and everything was still quiet in Oporto; not a movement was to be seen; not a hostile sound was to be heard. A second boat followed the first, and then a third passed a little higher up the river; but scarcely had the men from the last boat been landed, when a tumultuous noise of drums and shouts arose in the city; confused masses of the enemy were seen hurrying forth in all directions, and throwing out clouds of skirmishers, who came furiously down on the Seminary. The citizens were descried gesticulating vehemently, and making signals from their houses; and the British troops instantly crowded to the bank of the river: Paget's and Hill's divisions at the point of embarkation, and Sherbrooke's, where the old boat bridge had been cut away from Villa Nova. Paget himself passed in the third boat, and mounting the roof of the Seminary, was immediately struck down, severely wounded. Hill took Paget's place; the musketry was sharp, voluble and increasing every moment as the number accumulated on both sides. The enemy's attack was fierce and constant; his fire augmented faster than that of the British, and his artillery, also, began to play on the building. But the English guns, from the convent of Sarea, commanded the whole enclosure around the Seminary, and swept the left of the wall in such a manner as to confine the French assault to the side of the iron gate. Murray, however did not appear; and the struggle was so violent, and the moment so critical, that Sir Arthur would himself have crossed, but for the earnest representations of those about him, and the just confidence he had in General Hill. Some of the citizens now pushed over to Villa Nova with several great boats; Sherbrooke's people began to cross in large bodies; and, at the same moment, a loud shout in the town, and the waving of handkerchiefs from all the windows, gave notice that the enemy had abandoned the lower part of the city; and now, also, Murray's troops were seen descending the right bank from Avintas. By this time three battalions were in the Seminary: and Hill, advancing to the enclosure wall, opened a fire upon the French columns as they passed, in haste and confusion, by the Vallonga road. To the left, General Sherbrooke, with the brigade of the guards, and the Twenty-ninth regiment, was in the town, and pressing the rear of the enemy, who were quitting it. In the center General Hill, holding the Seminary and the wall of the enclosure, sent a damaging fire into the masses as they passed him; and his line was prolonged to the right, although with a considerable interval, by General Murray's Germans, and two squadrons of the Fourteenth dragoons. The remainder of the army kept passing at different points; and the artillery, from the height of Sarea, still searched the enemy's columns as they hurried along the line of retreat. The passage of the Douro, at Oporto, would, at first sight, seem a rash undertaking; but, when examined closely, it proves to be an example of consummate generalship, both in the conception and the execution. The careless watch maintained by the French may, indeed, be called fortunate, because it permitted the English General to get a few men over unperceived; but it was not twenty-five, or twenty-five hundred soldiers that could have maintained themselves, if heedlessly cast on the other side. Sir Arthur, when he so coolly said, "Let them pass," was prepared to protect them when they had passed. He did not give the order until he knew that Murray had found boats at Avintas, to ferry over a considerable number of troops, and, consequently that that General, descending the Douro, could cover the right flank of the Seminary, while the guns planted on the heights of Sarea could sweep the left flank and search all the ground enclosed by the wall around the building. If General Murray's troops only had passed, they would have been compromised; if the whole army had made the attempt at Avintas, its march would have been discovered; but in the double passage all was secured; the men in the Seminary by the guns, by the strength of the building, and by Murray's troops; the latter by the surprise on the town, which drew the enemy's attention away from them. Hence, it was only necessary to throw a few brave men into the Seminary unperceived, and then the success was almost certain; because, while that building was maintained, the troops in the act of passing could neither be prevented nor harmed by the enemy. To attain great objects by simple means is the highest effort of genius.

Other celebrated examples of the successful passage of rivers in the presence of the enemy are given below. It is the details of these operations which should be particularly studied, in order to render the lessons derived from them instructive and useful. Passage of the Rhine at Tholhuys, by Louis XIV, in 1672; the Rhine at Kehl, and the Danube at Hochstadt, in 1800; the Danube at Essling and Wagram in 1809, by Napoleon; the Beresina at Borisov in 1812, by Napoleon; the Danube at Satonnovo, by the Russian army, in 1828; the Rappahannock at Fredericksburg, by Burnside, in 1862; the Rapidan, by Grant, in 1864, etc., etc.

With respect to the proportions of the different arms of the service of which every army is composed, regard is had to the relative importance of each. Infantry is placed first in order, and usually comprises about four-fifths of the entire strength. The proportion of cavalry depends upon the nature of the country in which the army is to operate, being larger in an open country, which is favorable for its action, than in a broken or wooded country. It generally forms about one-fifth the entire force. Artillery, ranked third in the order of importance, is in the proportion of about three guns to one thousand men. An army, therefore, of one hundred thousand men, would consist of eighty thousand infantry, twenty thousand cavalry, and three hundred guns. The proportion of artillery depends upon the character of the troops, and the nature of the country in which they are to be employed. The greater the efficiency of the troops, the less may be the number of guns. The proportion would also be less in a wooded or broken, than in an open or level country; the former being less advantageous for the efficacy of the artillery. The proportion of light to heavy guns is also regulated by similar causes. When operating in a country with but few good roads, the former should predominate, otherwise, the heavy guns will vary in number from one-third to one-half the total. In the campaign in Bohemia, in 1866, the Prussian army was constituted as follows: Elbe army, forty thousand men and one hundred and thirty-five guns; first army, eighty-one thousand men and two hundred and seventy guns; second army, one hundred thousand men and three hundred and sixty guns.

A careful reconnaissance is important in both tactical and strategical operations. A general reconnaissance has for its object the obtaining of detailed and accurate information of countries and their armies that will be of assistance in case of war. It comprises within its scope our own as well as other countries, for the data obtained may be used in prosecuting military studies, and as an aid to a General in drawing up his plan of operations, which includes the movements of troops necessary for concentration as well as their employment after this has been accomplished and they are ready to meet the enemy. Tables of statistics, giving population, manufactures, industries and concerning the roads, railroads, canals, rivers, important improvements, head of cattle, and the sections of country where they are most numerous, etc.; geographies, general and military; reports, of all kinds, etc., will all be found of great assistance in compiling the required information. But, however complete and exhaustive these sources of information may be, officers of the army should frequently be sent to different countries to examine and report not only upon their military systems, but upon any subject which may become important in a military point of view. This method not only serves to retain possession of much that might be of great utility in planning military operations, but it enables officers to gain personal experiences of peoples and their customs, which might be invaluable to them and to their country, in the event of war. In a reconnaissance of this nature great care should be taken to particularly notice those subjects which cannot be found in published reports, statistics, etc., and to make the examination and report most thorough in these respects. The course of study preparatory to those journeys necessarily imposed upon officers to fit them for the duty, would also be of great assistance in the training proper for their profession. Canada and Mexico being contiguous to our frontiers, we might derive great benefits from a thorough knowledge of these countries.

Special reconnaissances are made with reference to the actual military situation at the time, and a report of them is usually made at once, frequently upon the spot. They are divided into two classes, viz., *topographical* and *armed*.

Topographical reconnaissances are undertaken for the purpose of obtaining accurate and detailed knowledge of the theater of operations. This knowledge obtained, the General in command is enabled to arrange his troops on the march with the condition of mutual support fulfilled; to select positions for giving or receiving battle, when acting on the offensive or defensive; to select suitable camping places; and to prepare the means for passing or avoiding those obstacles which are always to be found on the line of march of an army, as rivers, marshes, etc. It is important that officers should follow a regular system in preparing reports of reconnaissances, otherwise, what would be perfectly clear and intelligible to them at the time, might mislead the person who is to depend upon them for information. For this reason the following definitions are given:

1. *Ground.* By the word ground is meant the surface of the ground, as far as its nature or character in a military point of view is concerned. Ground may be divided into the following kinds: *Even ground*, the nature of which offers no obstacle whatever to any kind of formation or movement of troops; *cut up ground* would be precisely the reverse of this. *Open ground*, the nature of which offers no obstacle to the vision in any direction; *concealed ground* is the reverse of this. *Passable ground*, or ground the nature or character of which offers no obstacle to the passage of troops; *impassable ground* is the reverse of this. It is evident that these definitions have not only an absolute but a relative meaning as well, when applied exclusively to the different arms. *Level ground*, in a mathematical sense, does not exist at all; the expression, however, is used to designate ground in which there appears to the eye to be no perceptible change from rise to fall, which does not affect the action of the three arms, and which prevents the formation or movement of troops under cover. A *hill*, an isolated elevation of ground, with slight slopes. *Heights*, or *ridge of heights*, extensive elevations, with slight slopes. A *mountain*, an isolated elevation of considerable height over the surrounding country. A *plateau*, an extensive elevation of the ground, having a summit with a nearly flat surface. In reconnaissance reports it is desirable that either absolute or relative altitudes should be given. Depressions in the ground are the reverse of elevations, and may be classed as a *depression*, *gorge*, *ravine*, and *valley*, and should be especially described, both as regards their dimensions and steepness of slope. *Hilly ground* belongs to a flat country or where a flat country merges into a mountainous one; the elevations in the ground are slight both as regards height and steepness of slope, and affect the movements of troops only to a small extent, but at the same time enable troops to be formed and moved up under cover. The action of the three arms is similarly affected, inasmuch as by choosing certain elevated points a greater field for the action of firearms may be obtained. *Mountainous country* affects the movements and action of troops to a very great extent by high elevations on the ground, steep slopes, and the rugged character of the surface, and very often restricts troops to the roads or to the patches of passable ground found here and there in the valleys. There is also great difficulty in housing and feeding troops on the country, and in very high mountains (over three thousand meters) it is only possible in the case of small detachments. Large bodies of troops would have to depend almost entirely on supplies brought from a distance, especially as regards food. As regards the nature of the surface of the ground, it is usually described as having a rocky, clayey, loamy or sandy sub-soil, which is generally covered with a layer of mould of variable thickness, on which vegetation takes place. Ground is described as *rocky* when the rocks protrude beyond the surface uncovered with earth or soil, and as *stony* when the surface is covered with a layer of loose stones. *Soft* or *wet* ground may be described as ground not having a firm surface. The marsh, bog, or swamp are to be considered as tracts of ground left in their natural state; they may generally be looked upon as tracts of wet country that are impassable.

2. *Slopes.* Slopes may be either gentle up to 5°, steep over 20°, and very steep over 30°. Slopes are best given in degrees. Gentle slopes offer no obstacle to the movement of troops. A slope of 10° has a considerable effect on the movements of infantry in close formation; cavalry cannot charge downhilll, and only wtih difficulty uphill; artillery can only move uphill with difficulty, and the drag or brake has to be applied going downhill. The movements of cavalry and artillery cannot be carried out in an orderly manner on any slope of 20°, except as single horsemen. Slopes of 30° may be considered as impassable for the infantry in close formation; on the steeper slopes, *i.e.*, up to 45°, single men can only

climb up with the very greatest difficulty, if at all.

3. *Water.* Water as belonging to the natural features of a country, is also important in a military point of view. Water may be either *running* or *still.* Running water may be classed according to the size and importance of the stream, as *river, rivulet, stream* or *brook.* Still water may be classed as *sea, ocean, bay, lake, pond,* or *pool,* and as parts of the sea, as *gulf, bay, harbor,* or *roadstead.*

4. *Roads, etc.* Among the artificial features of a country land communications are of special importance, especially railways, which may be classed as *railways* or *tramways.* The military importance of the latter is almost *nil;* but, on the other hand, the former are of the very highest importance. Next come the *high-roads* of a country, *i.e.*, the roads that have been scientifically constructed and have been regularly kept in repair. The expressions, *country-roads, cross roads, forest roads,* and *meadow roads,* all convey their own meaning, inasmuch as all of them serve for some particular purpose, which their names indicate, and do not directly join two important towns or villages. *Paths* or *tracts,* that can only be used by foot passengers, may be styled *foot-paths.* A *hollow road* is a road, the level of which is sunk below that of the adjoining ground. A *pass* may be considered as the road over a chain of mountains joining the two countries or tracts of country divided by such chain. A *defile,* as generally accepted, means the contraction or narrowing of passable ground, such as a mountain defile, the defile over a dam, over a bridge, etc. *Rivers,* etc., are crossed by means of *bridges, ferries,* or *fords.* The former may be classed as permanent or floating; and again, according to the materials they are constructed of, and the plan of construction. Ferries vary according to the nature of the floating means of conveyance and method of transit from one bank to the other. *Land* may be classed as park, garden, meadow, plough, grazing, or uncultivated land, and woods or forests. Woods that have been regularly planted and laid out are called forests. *Habitations* may be classed as either towns, market towns, villages, or hamlets, and as single houses. *Fortifications* may be classed according to the size and the particular object of the work, as *battery* (intended for guns only), *redoubt* (a field-work intended chiefly to be used by infantry), *fort,* a closed permanent work of small dimensions, *fortress* (a permanently fortified town). The expression *before, behind, this side of, that side of,* etc., should always, if possible, be avoided, as the meaning they convey almost invariably depends on the position of the observer at the time. In by far the greater number of cases it is advisable to use geographical expressions (such as north, south, etc.) instead. But on the other hand, in the case of a water-course running, for instance, from east to west, the expressions north bank and south bank should never be used, but invariably the words *right* and *left* bank, as well as the expressions above and below. Similarly, in speaking of a ravine, the expressions right side and left side of the ravine should be used. In this case the observer should invariably fancy himself at the highest point of the stream or valley, and facing towards the mouth or opening, when using these expressions.

The following are the main points which should be considered by officers making reconnaisances for the guidance of a General in command of an army:

ROADS.

Their classification and length; their breadth, which will regulate the front of the column of march, and any contraction, or enlargement of the road should be noted; the nature of the road-bed, stating whether the necessary materials for repairs can be found in the vicinity; the inclines, stating the gradient and whether difficult parts of the road, can be avoided: the defiles, their nature, length, breadth, etc., and in the case of bridges, the materials of which they are constructed, the weight they will safely bear, the nature of the stream they cross, etc.; whether bordered by fences—stone or wood—ditches, hedges, etc.; the nature of the country on either side of the road, whether open, wooded or cultivated, and the nature of the crops; the distance between prominent points, both in miles and the time required on the march; good positions for the defensive, and the probable number of troops that can be placed in them to advantage; towns, etc., through which the road passes; points where other roads cross or join; their direction and condition, etc.

RAILWAYS.

1. The *line.* Whether single or double throughout, or double for certain distances; the location and length of the sidings; general condition of the road-bed, class of rails used, and length of time constructed and worked, which will determine the weight of the trains that can be safely run; the bridges, tunnels, and crossings on the line, giving the materials of which they are constructed, the width and height of each in the clear. The construction of important bridges and tunnels on the line should be considered in connection with the question of how long their destruction, either intentionally or by the enemy, would interfere with the working of the road. The *guage.* Whether broad or narrow. *Gradients.* State the length and difference of level of each. The gradients will affect the size of the trains that can be safely run over the road, and the traction power required to haul them. *Curves.* The radius of each curve should be given. The number of sharp curves on the line will influence to some extent the speed of trains. *Distance between stations.* On single lines only those stations will require attention which are provided with sidings where trains can pass. On double lines the distance between telegraphic stations will regulate the intervals between consecutive trains.

2. *Stations.* Number of tracks from which cars may be loaded or unloaded at each station; number and location of turn-tables and switches; platforms available for loading or unloading supplies and troops of all arms, or facilities for making platforms, and spaces suitable for forming troops while loading; number and capacity of storehouses, and their location with respect to the lines of the road; extent and location of water supply, and whether available for men and animals; places where refreshments can be procured, etc.

3. *Means of carrying on the traffic.* The watering stations with the means and quantity of supply; fuel stations, with kind and quantity of fuel usually kept on hand; number and location of construction and repair shops; location and capacity of the engine houses; system of telegraphs and signals, with the number of lines available for military purposes.

4. *Rolling stock.* Number, condition and power of engines; number and condition of cars of all kinds suitable for carrying troops of all arms, supplies and animals; materials for repairs, etc.

5. *Administration.* Personnel of the stations, lines, engines and trains.

6. *Division of the line.* Give the usual runs of the engines, stations where the personnel of the engines and trains is changed, and where the trains pass under the control of other lines.

7. *Duties.* The personnel of day and night service; the roster, and length of the tours of duty; order of duties and extra duty: ordinary and extra traffic, etc.

When railroad lines are to be used for military purposes, it is very desirable that the personnel of the roads should be continued in service; that the management of the lines should not be changed except when absolutely necessary: for in this way will the assistance of those who are accustomed to the duties be secured to the best advantage.

RIVERS.

1. Length of the portion of the river to be reconnoitered, the general direction, and any very great deviations from it.

2. Breadth, viz., the average breadth and the breadth at passages over the river and at towns or villages of importance.

3. Depth in deepest places in the stream, average depth, as well as the depth at points of special importance (as mentioned under 2).

4. The banks, height above mean level of the river, slope and peculiar character, embankments or artificial banks.

5. Bed and character of the bottom, whether rocky, stony, gravel or mud. Periodical changes in the bed.

6. Islands, whether cultivated or passable.

7. Fall and rapidity of the current per second. The fall is *slight* if the rapidity of the current is from 11.8 to 27.5 inches, *moderate* if from 2.2 to 3.2 feet, *rapid* if from 3.2 to 6.5 feet, and *very rapid* if 9.8 feet or more per second.

8. Whether navigable for ships or boats, together with data on the waterfaring population, boats, ferries, and ships, especially steamers, and purposes for which used. Any alteration in the volume of water according to the time of year should be noted and given.

9. Artificial arrangements such as sluices, dams, weirs, etc., giving their position and construction and the effect they have on regulating the volume of water in the river.

10. Tributaries should, if necessary, be similarly described.

11. *The valley of the river.* The depression and extent, whether passable or crossed by roads; cultivated towns and villages, especially those situated on the banks of the river, stagnant pools or creeks, and marshy places; elevations on the ground, dams and dykes, should be especially noted. Sides of the valley, distance from the river and from each other, relative heights, nature of the ground, whether steep or passable; roads and cultivation.

12. *Permanent bridges.* Materials (wood, stone, brick or iron; construction, on piles, arches, girders, etc.); breadth, length, and height of roadway above mean water-level; whether any part can be temporarily drawn up or removed; the weight the bridge can support, and whether passable for the different arms; the approaches on either bank, whether easily destroyed and restored.

13. *Floating bridges.* Such as bridges of boat, pontoons, or rafts, giving size, construction, and weight the bridge is capable of supporting, the number of boats, etc., the bridge is formed of, and the time taken in opening and closing the bridge.

14. *Ferries and flying bridges.* Weight the ferry or bridge can support, giving the time taken in crossing, together with the number of men, horses and guns that can be taken over at a trip.

15. *Fords.* Giving position, direction, depth, bottom. A ford 3.28 feet deep is passable for infantry, 4.71 feet deep by cavalry, and 2.85 feet deep by artillery.

16. *Favorable positions for throwing military bridges.* Giving approaches on either bank, construction, and whether assistance could be obtained on the spot in the way of bridging materials, workmen or transport.

CITIES, TOWNS, VILLAGES, ETC.

Inhabited places are of importance as points of *d'appui* in fighting, and as places where troops may be housed, fed, or equipped. Large towns or villages are important in the latter sense, whereas small places are more so for fighting purposes, because the latter only are so situated (though rarely it is true) as to command all the surrounding country. Large places are generally situated in valleys, and moreover, require a large force to be effectually held. It should also be stated in a reconnaissance of a place whether it is suited for defense, and more especially independent defense; *i.e.*, if the intended garrison could hold out unassisted for any considerable time against a superior enemy. As regards the latter question, the following points should be considered:—

1. Buildings (stone, wood, mud).
2. How enclosed (walls, hedges, banks and ditches).
3. Entrances (number and description).
4. Streets and squares (extent and position as regards each other; any obstacles to communiation).
5. Large solidly constructed buildings, well adapted for reduits, such as churches, etc.
6. Weak points in the defense, and how far capable of being remedied.
7. The surrounding country, whether favorable to the attack or defense. The number of troops considered necessary for an obstinate defense of the place, or the distribution of troops for the same, would not be given unless required by special order.

As regards giving the troops the use or benefit of the place, the following points should be considered: 1. Number of houses, with the number of men, etc., they would contain. 2. Number, occupation, and trades of the inhabitants. 3. Stores, depots, factories, bakeries, mills. 4. Facilities of transport by rail, river, road, or canal.

WOODS.

The following points should be considered in making a reconnaissance of woods: 1. Position and extent. 2. Nature and configuration of edges. 3. Roads, paths, tracks, and vistas. 4. The kinds of trees and undergrowth, with thick and clear spaces, clearings. 5. Nature of the soil with reference to the ground being passable off the roads, etc. 6. Obstacles to movements, such as streams, water, marshy places, etc. 7. Villages, etc., in the woods, with any clear spaces round them.

VALLEYS, AND LOW LYING GROUND.

A reconnaissance report on the above should give information as regards: 1. Situation and extent. 2. Nature or character of the ground, whether cultivated; peat-bogs, marshes, ditches, etc. 3. Roads, paths and tracks. 4. Whether the ground off the road, etc., is passable for the different arms, and how far the state of the ground varies at different seasons of the year.

MOUNTAINS.

The reconnaissance of mountains is a very difficult undertaking, inasmuch as the vision is generally much obscured, especially when the mountains are wooded. Good maps are consequently indispensable. Very particular attention should be paid to places where troops can to a certain extent deploy for action; otherwise the chief points to be considered are whether or to what extent troops can be moved, housed and fed. The reconnaissance report should furnish information of the following points:

1. Position, extent, shape and relative heights. Main and secondary ridges or spurs, plateaus, chief and secondary valleys should all be considered, giving the steepness of the various slopes.

2. Surface. The actual surface or covering of the mountains (rock, stones, debris, earth, etc.), marshy or rocky places, cultication (forest, ploughland, meadows,) towns, villages, etc., with the resources they contain.

3. Water, lakes, rivers, streams, etc.

4. Roads, tracts, paths and passable ground, especially noting ground where troops in formation could move off the roads, etc., (generally only found in valleys, or on ridges).

5. Special military considerations, such as positions, places for bivouacking, or where defiles, passes, etc., could be blocked, etc.

FORTRESSES.

1. The past history of the fortress should be thoroughly studied, especially that of its constructions, and of any sieges that it may have undergone, certain of the most important details of which should be given in the reconnaissance report.

2. Next, general geographical and strategical questions should be gone into and examined. This entails a reconnaissance of the surrounding country, which

should be made from an intending besieger's point of view, that is the best way of obtaining a correct insight into the defensive properties of the place, at least as regards how far an enemy's approach can be best observed, the ground round the fortress commanded, and an investment prevented or obstructed.

3. Next, in the reconnaissance of the interior of the place, the general system of defence, the *enceinte* with its ditches, outworks, advanced works, detached forts, and covered communications, should all be considered, both as regards plan, section, and system of fortifications. Casemated covers, caponnières, powder magazines, reduits, casemates for the garrison, bomb-proof hospitals, arsenals, and stores for provisions, have of late years gained much in importance.

4. Next the sluices belonging to the place regulating the level of the water in the ditches and ground near the works, the system of counter-mines if any, the entrenched camp, whether partially formed or projected, together with any works of defence that would be undertaken to give additional strength to the place were a siege expected, should be gone into and described, giving the time the latter would require with the labor and materials available on the spot. Similarly the artillery armament of the place should be examined and described.

5 Finally, the town itself surrounded by the fortifications should be examined separately by itself as a place of habitation, and any considerations which might affect the defense of the place, either advantageously or disadvantageously, should be studied and described; also, whether with due reference to all the above considerations, the proposed garrison of the place appears sufficiently strong.

6. In conclusion, a general *résumé* should be made, showing the advantages and disadvantages presented by the works of the place, and the neighborhood of the fortress, in the case of investment or blockade, attack "*de vive force*," by surprise or escalade, bombardment, artillery attack, or regular siege with breaches and assault, with special reference to the weak fronts of the fortress.

LARGE TRACTS OF COUNTRY.

1. In the reconnaissance of large tracts of country, the first object should be to examine and describe the general character of the country for military purposes.

2. For this purpose a country has very often to be divided into sections according as the latter are favorable or otherwise to military requirements, as regards the marching, fighting, quartering, feeding, etc., of troops. The country should be considered both as regards its orography and hydrography, paying special attention to important rivers, etc., and the general character and configuration of the ground (mountainous, hilly, and flat country).

3. Next, the communications both by land and water should be carefully examined, *i. e.*, railways, highroads and navigable rivers and canals. The state of cultivation of a country is also of importance and large tracts of forests or woods, valleys and low-lying ground, etc., should be specially reported on. Finally, the inhabitants (numbers, nationalities, religion, occupation, characteristics, etc.) should be considered, together with the towns, villages, etc., with population of each, paying of course, special attention to fortified places or points otherwise of military importance.

STATISTICAL RECONNAISSANCES.

1. Statistical reconnaissances complete the detailed series of reconnaissances just given. But it would be a mistake to fancy that the necessary information for the same could be collected during a tour from observation only. Consequently a preparatory study, going thoroughly into the question by collecting information from every kind of book and printed matter, must first of all be undertaken.

2. Work of this description is nowadays rendered comparatively easy by the publication of certain works on statistics, but as a rule, the information thus obtained has generally to be differently grouped to be of value for military purposes. The following points should then be considered.

3. *Quarters and camps.* Number and description of the towns, villages, etc., giving the number of inhabitants and the number of fireplaces in each; the public buildings and supplies of wood and straw should be noted in each separate place.

4. *Provisions.* Produce of cultivation and meadows, head of cattle, stores, mills, industries and trades, especially bakeries, breweries, distilleries, wine and tobacco produce.

5. *Clothing and equipment.* Linen, cotton, cloth, and leather factories.

6. *Sanitary establishments.* Hospitals, infirmaries, and baths.

7. *Means of transport.* Rolling stock of railways, horses, mules, and yoke oxen; description of carts and carriages with draught; navigation.

8. *Arms and warlike stores.* Small-arm factories, iron foundries, stores of metal and timber, powder-mills.

9. *Money.* Monetary system, duties and taxes.

10. *Inhabitants.* Military system and organization, any special organization for the defense of the country, such as national guards or local rifle clubs; degree of education and political feelings.

11. Reconnaissances made without preparatory work can only be useful as a means of verifying military considerations of high importance, or completing our existing stock of information. As regards the latter, it is worthy of remark that documents and maps, made for local use only, and consequently but little known elsewhere, are often to be obtained on the spot itself, and afford much valuable information.

REPORT.

As regards the general form of making a reconnaissance report, it is generally advisable to make it in as abstract or even tabulated form as possible. For instance, it should not be necessary when seeking for information on a given point, to have to wade through the whole report to the end; a short index of the contents as well as a logical arrangement of the subjects facilitates the work of rapidly examining the report. It is, moreover, desirable to have a great deal of important data or information without arguments or reasoning, as the latter can only be made on definite suppositions. A report which is not definite in its information is but little better than none at all; to make an incorrect or false report amounts to a military crime; and a report which is larger or more voluminous than is necessary, often fails to fulfill the object desired. A report should be as brief as possible when it accompanies a map or sketch as "explanations." Further, it should always be borne in mind that every reconnaisance report is an official report, and that, consequently, the officer making the reconnaissance is responsible for the accuracy and truth of his personal observations. The latter should therefore be kept quite distinct from that part of the report which has been compiled from the information and observation of others.

ROUTE SKETCHING.

There is a branch of topography, which, from the importance sometimes assumed by it, should be mentioned under the subject of topographical reconnaissance, in connection with which it is frequently used, viz., route sketching. The object of route sketching is to represent the route passed over by an observer, together with so much of the country in the immediate vicinity and within view, as may in any way affect military operations. The sketch is usually accompanied by notes giving explanations of any features that strike the observer as being of particular importance. Information gained in this manner may frequently be found of great assistance in arranging the details of a campaign or of a battle. It is not proposed to treat of the subject in this work, but the details of the duty, as well as those pertaining to reconnaissance, will be found in a book entitled "Military Sketching and Reconnaissance," by Lieut.-Col. Hutchison and Captain MacGregor, of the British service.

The officer selected for the duty of conducting a reconnaissance, should be one who has been specially instructed for the purpose. The duty requires an officer who has a particularly good military judgment, and who has previously made a thorough study of the subject. He should have a mind that can readily grasp details and retain them; he should be familiar with the different arms of the service, their placing for mutual support, and their adaptability for action under the varying features of ground. The faculty of correctly estimating distances by the eye will be of great assistance to an officer in performing this duty. This faculty, although natural to some, may by practice be acquired by all. The officer should be provided with all the materials necessary for making and recording his observations; good maps of the country to be examined, a field glass, writing materials, etc.; good guides—the best will usually be found among that class of people whose duties take them about the country—a good escort, preferably cavalry, as offering the necessary essential of moving quickly, and of furnishing the means of forwarding rapidly the information obtained.

An officer familar with the duties prescribed should be able to make a general sketch of the country, giving the details set forth, during the temporary halts necessarily made on the march for the purpose of resting his escort and obtaining information. The great value to an army, of officers who are thoroughly conversant with these duties, and the great assistance to the General in command that the information gained by them is in carrying out his plan of campaign, are fully illustrated by the events of the wars of 1866, and of 1870-71. The Prussian staff was most thoroughly organized, and the influence the officers composing it, exerted in bringing the campaign to a successful issue, is readily apparent after a careful study of the detailed operations of these wars has been made.

An armed reconnaissance, when made with a small force beyond the outlaying sentinels of an army, for the purpose of obtaining information of the enemy, is usually termed a *patrol*, *scout*, or *secret, reconnaissance*. The best hour for the troops to set out on this duty is about dusk, or sometime during the night. They can at this time more easily pass between the outposts of the enemy, and when daylight comes they will then be on the ground which it is desirable to examine. Again, if the departure of the detachment is discovered by the enemy, another route can be taken during the night. The officer selected for this duty should be daring, courgeous and capable of enduring great fatigue; he should be a good horseman have good eyesight, a mind quick to grasp all details, be prompt to act, and he should have a retentive memory. He should be familiar with sketching, so as to be able to represent any portion of the enemy's works or position, or to convey a good and intelligent idea of the ground which it may be the intention to occupy. He should be provided with a good field glass, with maps, and with all the materials necessary to record the information gained. A good guide is also indispensable, one who is thoroughly acquainted with the country, the byways, short cuts, etc. The officer should be given full instructions, in writing, if necessary, of the object of his scout, and he should entirely understand them before starting out on his mission. He should know the distance taken up in column by the sub-divisions of the different arms of the service, so he can readily estimate the strength of any force of the enemy which may come under his observation. He should be furnished with a detail suitable for the work required of him. If the country is open, the escort should be composed of cavalry; if it is broken or rugged, infantry should be taken. The men should be selected from the best material the army affords, their qualifications being similar to those of the officer in charge of the party. As a general rule, the detachment should be small, as a few men can conceal their march and presence from the enemy much better than a troop or company under similar circumstances.

Great care should be exercised when approaching any place favorable for an ambuscade. Such points should be carefully examined by one or more men, detached for the purpose, before closing in on them with the party. All renconters with the enemy should be carefully avoided, as the main object is to gain knowledge of his forces, positions, and movements, without exposing the presence of the party making the scout. Even very small parties of the enemy should be allowed to pass, as the main object of the scout might be lost by an attempt to capture them, by the escape of some one member of the party, out of sight or overlooked for the moment. The detachment should avoid the traveled roads, keeping near them, however, by moving along the byways, through the woods and fields. It should be very careful about making any noise, should not be allowed to build fires or the men even to smoke at night, when in the immediate vicinity of the enemy. It keeps well together, depending upon a few men in advance, marching in dispersed order, to give timely notice of anything suspicious in the vicinity. If any considerable force of the enemy is discovered, the detachment should be entirely concealed from view, but in such a position that all the enemy's movements may be seen, and his exact composition, direction of march, and numbers determined, when a detailed statement of the information obtained should be made in writing and sent to the commanding General by two of the most reliable men of the party. General Pope, during his campaign in Northern Virginia, received accurate information in regard to the flank march of General Jackson, from Colonel J. S. Clark, of the staff of General Banks. That officer remained all day in a perilous position, within sight of Jackson's moving column, and counted its force, which he found to be thirty-six regiments of infantry, with the proper proportion of batteries, and a considerable cavalry force. If the object be to gain information of the enemy's presence or strength at a certain place, the officer, when he has reached the immediate vicinity, will conceal his detachment in the best manner possible, and taking two or three of his best men, will approach as near as he can without discovery, to gain the desired end. If essential to send information speedily, a few men may be left at intervals along the line of march, to in turn take the message and forward it. Upon the return of the officer to his station, he should make a report in writing of his scout.

A reconnaissance in force is generally made just before a battle, for the purpose of forcing the enemy to develop his strength and dispositions. The time selected is usually late in the day, in order that night may be depended upon to put an end to the fighting, and to give the commanding General an opportunity to make any change in the arrangement of his troops which the facts gathered from the reconnaissance may have rendered necessary. The enemy should be threatened in such a manner as to lead him to suppose that a real attack is intended, and to force him to discover his strength and position. During the advance reconnoitering officers should be well to the front, seizing upon every point of advantage for a good lookout, noting the details of the enemy's position, marking where his troops and guns are placed, and estimating distances. The reports and notes (rapid outline landscape sketches sometimes added) of these officers, when put together on return, will afford valuable information to the General commanding. Care must be taken that the movement does not lead to a general action for which the force is not prepared. By advancing for the reconnaissance late in the day, even should it be difficult to withdraw, darkness will enable the Commander to put a stop to the fight.

A *reconnaissance in force* may be made under the immediate supervision of the General-in-Chief, or by a detachment of troops of all arms, selected for the purpose, and under the direction of a subordinate commander. In the first case, there would be a general advance of the whole line, as if for the purpose of bringing on a general engagement, showing a strong line of skirmishers in front. The forward movement may be preceded by a charge of cavalry for the capture of some of the enemy's outposts or sentinels, from whom information of a very valuable character may sometimes be obtained, especially when they are from differennt fractions of the enemy's forces. The artillery should be brought into action in order to cause the enemy to open fire with his own, thus revealing the general disposition of his forces, key points, etc. The General follows the movement, taking station where he can most readily overlook the enemy's line, and, having gained his object, causes the troops to be withdrawn to their position. Care should be exercised that any success obtained at any point of the line, be not so closely followed up as to prevent the withdrawal of the troops at the proper time. Or, if during the movement, it is found that an important position has been gained, owing to the failure of the enemy to properly guard it, and which it may be desirable to hold, dispositions should at once be made for that purpose, by sending re-enforcements forward, causing the troops to entrench, etc. An operation of the second class is more difficult, requiring great tact and good judgment on the part of the officer in command. Depending upon the nature of the country and the object to be gained, the detachment will be formed of one or more arms of the service. The troops selected, usually a division, or perhaps the advanced guard of an army, will be handled as in the first case, the additional precaution being taken to see that the line of retreat to the main body of the army is in no way compromised. To render this secure, the flanks of the attacking body of troops should be well protected by patrols of cavalry and by skirmishers.

Minor operations made by small parties and usually called *patrols*, are continually carried on, both within and beyond the line of advanced sentinels of an army. In the first case, to examine well the ground between the sentinels, also the ground between the line of sentinels and their respective outposts. In the second case, to examine the country between the lines of the two armies, to ascertain what changes may have been made during the night. In this way small affairs of detached parties are brought on, the object being to take prisoners and thus gain information. The great objection to a *reconnaissance in force* is that, as the troops are used to unmask the enemy and make him develop his position and forces and then withdraw, the operation partakes of the nature of a retreat, and is liable to have a somewhat demoralizing effect upon them. From commanding ground, or before an enemy who is negligent in covering his front, much may be learnt by a practical General without making an actual attack. Napoleon spent part of the day before Austerlitz at the outposts, while in his front, the valley of the Goldbach, and the opposite slopes, were covered with cavalry skirmishers, amidst whom rode experienced officers, from whose observations, joined to his own, the Emperor deciphered accurately the movements and designs of the adversary.

Marmont says, "Nothing should be neglected by which we may obtain exact information; and the surest method is always to be in contact with the enemy by means of light troops, frequently to have small engagements, and to make prisoners, whose answers are almost always simple and sincere. More is learned through them than by means of the most faithful spies. The latter often confound the names of corps and of Generals, and form very inexact estimates of the strength of the troops, concerning whom they report."

"Two Prussian officers of the staff of Prince Frederick Charles, the afternoon before the battle of Königgratz, boldly approached the Austrian lines, observed the positions of the Austrian troops, and, though both pursued and assaulted by cavalry, got safe home, and brought to their General certain intelligence, which allowed him to frame the combinations which resulted in the morrow's victory."

"The eyes of the Austrian Army on more than one occasion during the campain (1866) failed. Their patrol system was very much inferior to that of the Prussians. Its inferiority seems to have been due to the want of military *education* among the officers to whom patrols were entrusted. In the Prussian Army special officers of high intelligence were always chosen to reconnoiter. The Prussian system never failed, never allowed a surprise. The Austrians were repeatedly surprised and taken unprepared."

When an enemy is at a distance and his movements are unknown, he is often more to be feared than when close at hand and under observation. He must not therefore be lost sight of because he is some way off; but on the contrary he must be watched in such a manner as to observe his movements closely with a view to estimating his designs, and at the same time to prevent his attempts at reconnaissance with like intentions. A fatal mistake is too often made by cavalry, in supposing that it is sufficient to reconnoiter the enemy and return with a report, or even to reconnoiter in a certain direction and report that no enemy is seen. It is not only necessary to find the enemy, but when found, to keep him under constant observation. For this purpose detached bodies of cavalry should be advanced to the front of an army, interposing between their own troops and the enemy a veil or screen, behind which there is immunity from surprise, and in the extreme front of which feelers, or reconnoiterers are actively employed, collecting intelligence for transmission to the rear.

These duties would be either performed by the "divisional cavalry" or else by the "cavalry division," according as the operations are on a small or on a large scale. By the former is meant the cavalry attached to a division. If several divisions are acting together, the cavalry of each would cover the immediate head of its own column on the march, reconnoiter the country to its front and flanks, and link the column to others, just as in action it would fight on the flanks of its own division, crown its success or cover its retreat. By the latter is meant the division or brigade of cavalry, which is an independent tactical body, having relations to the whole army of a similar nature to those borne by the divisional cavalry to its own division. It therefore furnishes the advanced cavalry for screening and reconnoitering duties, when several columns are moving forward in combination. Should a division or smaller column of three arms be acting by itself, a portion of its cavalry would generally be detached to the extreme front for a similar purpose.

A force of considerable strength is usually employed on this important service. The principle adopted is that of retaining a support in rear, from which smaller parties are detached to the front and to the flanks, these parties in their turn sending out smaller fractions, until the whole assumes the form of an open fan, upon the outer edge of which the patrols are reduced to a strength of some eight or ten men, which in their turn may be covered in extreme advance by groups of scouts of two or three men together. This action of the cavalry may perhaps be best appreciated by its being described as a moving outpost chain. A regiment of cavalry may thus be sent out to a distance, varying, according to circumstances, from ten miles to one or two days' march, in advance of the army it serves to cover. One squadron moves still farther to the front, one to each flank, while the remaining squadron acts as a reserve to the others. Each of these squadrons now in extreme advance sends patrols to its front and flanks, as required by the nature of the ground and supposed position of the enemy. A support, consisting of from one-third to one-half the squadron, remains in each case in rear, moving along a central route. The patrols in their turn detach scouts so that every part of the ground may be thoroughly examined. The distances to which the advanced squadrons should proceed from the squadrons in reserve, and also the intervals to be preserved between the squadron in advance, must depend so much upon the nature of the country and upon the position of the enemy, that it would be hard to frame any absolute rule on the subject.

It is, however, suggested that, while the advance should be extended as much as possible in order to avoid employing too many men upon the service, care should invariably be taken that all the bodies in front be able to fall back securely upon their supports, in case of the enemy being met in force. It is recommended that the distance to which each patrol may detach itself from its immediate support be restricted to four or five miles, or as much ground as can be passed over in one hour in ordinary country. On occasion, however, a patrol may be despatched on independent service for much longer distances, relying entirely upon its own resources. It frequently becomes necessary for scouts to be sent to considerable distances from their supporting body; but each group, though out of sight and hearing of the next, should always know the general position of the groups on either flank of its own patrol, and of the squadron from which the patrol is detached.

CONNECTING POSTS.

In proportion as a reconnaissance is pushed further to the front the necessity for maintaining some system of constant communication with the rear becomes more apparent. It must be regarded as a first essential condition, that the intelligence procured by a reconnoitering party be transmitted at once to the main body. It is also needful that a detached patrol should be in a position to receive orders from the rear as quickly as possible. Hence arises the necessity for connecting posts, when reconnaissances are being carried on at some distance in advance of the main body. The posts are placed on the main routes, generally at positions which can be found easily, such as bridges or remarkable or well-known buildings, and they are established by each advanced party as it proceeds to the front. The posts should be two or three miles apart, or the distance an orderly could, in case of necessity, pass over at a gallop without pulling up. A post should not consist of less than three men, one of whom must always be ready to mount at an instant's warning, whenever a messenger is seen approaching, for the purpose of carrying on the despatch to the next post. The orderly who brings in a message returns to his post after a short rest, and takes back with him any orders for the advanced party. The pace at which an orderly should ride, the exact place, and hour of despatch, should be written on the outside of the message.

STRONG RECONNOITERING PARTIES.

A strong reconnoitering party would be detached, either from the main body, or from the reserve of the advanced covering detachments, *i. e.*, from the reserve of the advanced-guard on the march, or from the reserve of the outposts at the halt. The Commander would receive before starting the most precise instructions as to the object to be effected. He might be ordered, for instance, to search for the position taken up by the enemy, and to ascertain the numbers of his troops by such indications as may come under observation without disclosing his own proximity; or he might be directed to feel for the enemy in a particular quarter until he should hit upon him. Or else he might be directed to report on the resources of the country, the facilities and obstacles it presents for advance, and the general lines of communication.

Strong reconnoitering parties may push their reconnaissance far beyond the zone of the smaller reconnoitering patrols. They are generally ordered out by the General or Brigadier, their force and composition depending much on the nature of their mission and of the country, and on the necessity or non-necessity of concealing the march of the party. A troop of cavalry is often sent on such a duty, a staff-officer accompanying the force. If the country is close, hilly, and wooded, infantry may be selected in preference, a few mounted men being attached as orderlies; but more usually still in a varied country, infantry is joined to cavalry as its support. The infantry would accompany the cavalry to certain points, past which the horse must fall back in retiring. These points the infantry would hold to secure the retreat of the cavalry, which latter would then advance rapidly to the front to complete the reconnaissance. The cavalry in its turn would cover the retreat of the infantry across any open ground.

The addition of infantry gives to such reconnoitering parties a strength and power of resistance which cavalry can never attain by itself. The employment of artillery tends towards a similar end, and the especial mobility of horse-artillery renders it most appropriate for such service. Artillery is nevertheless seldom added to an ordinary reconnoitering party, its use being generally confined to a reconnaissance in force, or a special reconnaissance. But although guns are not much employed upon this kind of duty, there may still be occasions where artillery would prove a useful addition to the other arms, as, by its assistance, woods or other suspicious places, within range, could be effectively examined or cleared of the enemy's presence, without the necessity of a close approach. Guns can also cause the withdrawal of parties of the enemy from small defensive positions by acting on their flank.

Whenever the several arms are combined in a strong reconnoitering party, cavalry is always well to the front in the advance, so long as the ground permits. The infantry in rear takes up successive positions favorable for defense, as it advances, so that if at any moment the cavalry is driven back it will be protected in its retreat by the infantry. In the return march the infantry takes the lead, unless hardly pressed in a close country, when the cavalry is sent on in front.

Troops are usually drawn up, or formed in two ways, viz., *a*. In *column*; the habitual disposition when on the march, and for facility of movement and maneuver. *b*. In *line*; which is now as a rule the order on the field of battle. The formation in deep columns of attack, formerly employed with such great effect on the battle field, will now very rarely be used. This change in the manner of handling troops is due entirely to the great improvement in the fire-arms of the last twenty years.

INFANTRY.

It may be said of infantry that it is by far the most important factor of an army. Cavalry and artillery certainly render important and essential service at some period of every campaign, or during some phase of every battle; but good infantry is absolutely necessary for the accomplishment of any great operation in war. Infantry is undoubtedly the main stay and the backbone of all armies, whether it be viewed in the light of numbers, or its action on the field of battle. Its fire is more deadly than that of artillery, its action is sure, while that of cavalry is fitful. On the infantry of an army the brunt of the fighting falls, it suffers more in action and more on the line of march, and to it the action of all other arms is subordinate. Artillery fire but to pave the way for an infantry attack, or to check an infantry advance. Cavalry charge but to confirm an infantry victory or to check a pursuit, engineers open roads and make bridges, to allow infantry to pass; they strengthen positions, and throw up earthworks, but to protect and cover the infantry, or to enable a small body to check a superior force. On infantry tactics the whole superstructure of military operations must be built. But it must be borne in mind that in any tactical action, one arm of the service without the other is really incomplete, and the true function of tactics, is to so apply the action of each arm, that not only its special power shall be developed, but that it shall be developed at the time and place requisite for the support of the other arms.

The Austrian infantry has always proved inferior to that of other powers with which it has recently been matched. The excellence of the other branches of the army has never been able to atone for this one fatal defect. The infantry of an army is its mainstay. A battle, it is true, may occasionally be decided by the vigorous action of cavalry, as was the case at Marengo; sometimes be influenced by the happy concentration of artillery, as was seen at Wagram and Solferino; but success can never be confidentially relied upon in war, unless the fighting powers of the infantry may be fully trusted.

The infantry by its fire disables the enemy and prepares the way for the efficient operations of the cavalry and artillery; the infantry by its charges wins battles, carries and defends positions. Infantry has great powers of endurance, is capable of giving or receiving battle in almost any position, and is peculiarly free from those casualties, which in unforseen emergencies frequently paralyze the other arms. The essential qualities of a good infantryman are: coolness under all circumstances of danger, self-reliance and independence in action, judgment in deciding when to take advantage of cover, and when to leave it in order to move forward again; he should be a good marksman, as the main reliance of infantry is the efficacy of its fire; he should know when to husband his amunition, and when to deliver his fire with the greatest rapidity; for rapidity and accuracy of fire at the proper moment are now of supreme importance in the decisive phase of a battle. The genius of the Commanding General is the greatest aid in winning a victory, infantry ranks next. The cavalry and artillery render important service on the field of battle, and in the retreat and pursuit; the infantry often finds itself in positions and under circumstances that would be most disastrous, if not supported by these arms; and by their aid successes gained by the infantry are often made complete. Infantry can win a battle, but calvary and artillery are necessary to destroy the enemy by a vigorous pursuit. The history of all wars and of all nations confirms these conclusions.

Infantry acts defensively by its fire and offensively by its charges. On the field of battle it is invariably employed in one of these ways, or in both combined. On the field of battle two bodies of infantry will seldom come into actual contact. In making an attack the assailant will either be repulsed and driven back by the effect of the fire of the assailed, or, when the former reaches a certain point in its advance, the latter will abandon its position. Infantry on the field of battle, when stationary, should always lie down; it is thus always to a certain extent concealed from the enemy's view and protected from his fire. The introduction of breech-loading rifled arms has radically modified the tactical formations of infantry; this being particularly true for offensive movements. Formerly, the fire from troops in a body was mainly relied upon to produce telling results; now, the main object is to develop to the fullest extent the independent action of each individual soldier and the fire from each rifle. It appears, therefore, that both in defensive and offensive fighting tactics, one great object is to develop the individual action of the man, whether in the use of his weapons or as a unit. For officers this development of independent action is the power of leading and handling small groups or bodies of from ten to two hundred men; but while this independence is developed, it must be held in hand and directed, it must be freedom, not license. It must be carefully watched by a Commander who has reserves in hand to support it, either by completing the victory or checking defeat; and above all it necessitates most careful training on the part of the soldier.

The first troops that come into contact with one another before battles are fought, are small detachments. Military history necessarily passes over much that is done by these small bodies; but there can be no doubt that the correct leading and handling of these small bodies, conduce greatly to bringing the action of larger bodies to a successful conclusion. At the beginning of any great battle, there are numerous struggles for important points, indeed great battles are often brought about by the necessity for supporting small detachments seeking thus to obtain some advantageous ground. Now it is undoubtedly one of the consequences that flow from the use of modern arms, that troops once actually engaged can rarely, if ever, move to the right or left. Maneuvering under fire, always difficult, may now be deemed almost impossible: once troops are really engaged it would appear that their movements must be either forward or backward. Fresh troops may be brought up from the rear to feed the fight in front, but such movements as those made by Massena at Wagram, are at the present day impossible.

The actual success of operations in war must primarily rest on the action of small bodies; good previous strategical movements, a correct formation of the order of battle, a proper selection of the points to be attacked, will make the success, when obtained, of far greater importance; but the actual success must ultimately depend on the correct handling of small bodies of men. The question how a small body of men should be handled in actual fighting has now become of far greater importance than formerly. Important as affecting the individuals concerned, perhaps more so, as reacting on larger bodies. This is one of the features of modern fighting, and one which must be carefully considered. A battle under existing circumstances is a series of small battles or fights in which bodies of troops, perhaps not greater than a brigade, are engaged, and each of these bodies must be tactically complete, must work for one object, and seek to carry one point.

It has been said that for the future no direct attack can possibly be made on troops occupying a position, and that all attacks must be made on the flanks; but experience shows that attacks on the flank, unless supported by a strong front attack, can always be met and defeated. The battle of Wagram, and perhaps still more, the counter-strokes delivered at Rossbach and Salamanca, show, that unless front attacks are made at the same time, flank attacks are unlikely to succeed; consequently, however difficult and dangerous such attacks may be, yet it is requisite that they should be made, in order that the change of front, which any well-disciplined army can make if unopposed, may be prevented.

We said that on the German side the intention was generally evident of attempting to turn the enemy. But the fight often developed itself in such a manner that, after preparing the way by artillery fire, the Germans made a vigorous attack upon the French center, without waiting for the effect of the movement on the flanks. This mode of action has often been criticised, and attention has been called to the enormous sacrifices which it has generally entailed; but these critics forget that, when you wish to force the enemy to fight, a fairly sharp attack in front is necessary to hold him fast, otherwise he would avoid the turning movement which is meanwhile going on, either by a timely retreat, or by throwing himself upon the turning column and attacking it, whilst executing its movement.

The offensive. In order that a force on the offen sive may be able to develop with effect its maximum of attacking power, and make use of it to the utmost, it should adopt a formation favorable, as far as possible, to the following requirements: *a.* To the very greatest mobility. *b.* To the greatest possible security from the effects of the enemy's fire. *c.* To the greatest possible development of its own fire.

For troops acting on the *offensive*, the great object to be attained is, to devise some means by which they can, with some degree of organization remaining, reach a point sufficiently near the enemy's position, to enable them to carry it by a grand and concerted rush forward. To contend that this result can now be obtained by troops in the old formation in column, or even drawn up in two ranks, is contrary to all the teachings of the past few years; which leads us to conclude that such an operation would be attended with the most disastrous results. The results of recent wars teach that the proper formation for troops acting on the *offensive* is in successive lines of skirmishers. The intensely effective and continuing rolling fire of the Chassepôt made it clear to all our Commanders that a strong deployment of skirmishers was absolutely necessary, so as to answer the enemy's fire in an effective manner, not to expose too strong supports to its effects, and at the same time prepare the way for our attack. In the course of a long conversation on this subject, General Skobeleff expressed himself as follows:

"The only formation in which troops can successfully assault intrenched positions is in successive lines of *skirmishers*. The division General must be perfectly thoughtless of his own comfort or safety, and put himself between the skirmishers and the reserves where he can feel the pulse of the battle and have his troops in his own hand, and judge of the moment when the sucessive battalions in reserve should be sent forward. There are in every command a small percentage of cowards who will slink away at the first opportunity, a certain number of men of rash bravery who will go too far forward and get killed, and the great majority of men of ordinary courage, but liable to waver as the fight gets hot The reserves must be sent in at the moment when the reasonably brave men have been long enough engaged and met with enough resistance to begin to feel nervous, but before they have actually begun to retreat; and it is in deciding upon the opportune moment for sending forward his reserves that the art of a division Commander consists. Such are the opinions of the General who made more open assaults than any other in this war, and who never failed in any one of them to carry the works which he was ordered to attack.

The expression "loose order" has been often employed to describe this mode of attack, but the expression is an inaccurate one. The attack is not loose, which rather means a careless haphazard action, but it is the *individual* action of the soldier fighting in extended lines; the real facts being that such a method of fighting demands not only greater individual exertion and intelligence, but far higher and more complete instruction on the part of both officers and men.

It appears generally that troops formed for attack should be formed in at least three bodies, and that these bodies should under one direction work for one object, and be closely linked together, and be of such strength, that each shall be a considerable force. We thus arrive at the formation of a skirmishing line, a supporting line, and a main body. Taken together these three form the first line. It further appears that the men placed in the skirmishing line should be extended so as to diminish loss, increase accuracy and rapidity of fire, while at the same time a heavy and destructive fire is maintained. The functions of the skirmishing line being to crush and overwhelm the enemy with bullets. The objects of the supports being to fill up gaps among the skirmishers, and so sustain the intensity of their fire. The duty of the main body being to advance the moment the enemy is sufficiently shaken, and to drive him out of his position.

The distance between these three bodies must be governed partly by the work they have to do, partly by the trajectory of the arms in use, partly by the ground; to effectively support the skirmishers, that is to say, to be able to feed them with fresh men, the supports should be two hundred to two hundred and fifty yards in the rear. The main body must be able to cross the interval that divides them from the skirmishers in about five minutes, or they must be five hundred to six hundred yards off. Consistent with the due performance of these functions the supports and main body may be in any formation that from the shape of the ground, or other circumstances, will protect them best from loss, whether that formation be extended order, line, or columns, and they must change from one formation to another as quickly as possible. The principles which govern the formation of troops for attack can only be given, their application must depend on the knowledge and ability of the Commander in adjusting his formation to suit the ground he is working over. Thus the more cover there is to take advantage of, naturally the smaller will be the loss, and consequently the supporting body, whose functions are to supply the losses of the skirmishers, may be reduced, and the length of the skirmishing line increased, at the same time that the intervals between the lines may be diminished. But the original question embraced more than the formation of the troops. It was, how shall the shot-swept zone be crossed?

Putting irregularities of ground out of consideration, this zone is swept by fire of different kinds, in different places. *a.* The artillery fire, which may be said to begin at about two thousand five hundred yards. *b.* The unaimed or random fire of the infantry, which may begin to tell at about one thousand one hundred yards. *c.* The aimed fire of the infantry, which will begin to tell at about six hundred to seven hundred yards. Artillery employed in defending a position do not fire so much on advancing infantry in the early stage as on the attacking artillery, in addition to which the actual loss by artillery fire in action is comparatively small, being from one twelfth to one fourteenth of the loss caused by the musketry fire. Hence it may, speaking in general terms, be disregarded. The unaimed infantry fire produces many losses, and it appears that the effect of such fire may be mitigated by observing where it falls most, and avoiding those places.

The fire that causes heavy losses, and checks advancing troops, is undoubtedly the aimed or directed fire of infantry. The sooner and quicker the space between, where the deployment of the troops takes place, and the enemy's position is crossed, the better; but if crossed at the double, one of the objects of the skirmishing line, crushing the enemy with bullets, would not be accomplished, hence, such a method of advance, even if it were possible to run over the two thousand yards without stopping, would be undesirable. But it seems desirable that the first one thousand yards should be crossed without firing, and as rapidly as possible. It will be shown hereafter, that the attacker's artillery usually fires on the enemy's infantry, not on his guns, hence, until the attacking troops reach the zone of dangerous infantry fire, or about one thousand one hundred yards from the position if possible, they should advance without firing, and as quickly as they can, without being disordered, once the dangerous zone of infantry fire is reached, not only will they begin to suffer, but the power of inflicting loss on the enemy by means of their own fire begins, and about this stage of the advance the skirmishers must begin to fire. How should they then advance? Bearing in mind that the function of the skirmishing line is to keep up a continuous rain of shot on the enemy, and expose themselves as little as possible, or to develop the offensive power of the breech-loader, while reducing the destructive effect it has when used on the defensive. Bearing this in mind, it appears that the advance may be made in a succession of short rushes, lying down, firing rapidly, and again running on. This maneuver may be performed in several ways ;the whole line may so act, or alternate men may so act, or alternate portions, sections, subdivisions, or companies may so act. The first method entails the disadvantage of there being a time, however short, yet a small appreciable time when the fire ceases. The second method has this objection, that the party in advance are sure to mask the fire of those in rear more or less, and that soldiers are peculiarly apt to be discouraged by losing men from their comrades' fire, and that the men are apt to get out of hand, and the officers find their control reduced. The rush forward of an extended line invariably draws the enemy's attention, and consequently his fire on that portion; this is the moment for the other portion to seize and rush on too, hence there is an advantage in the alternate rush of portions.

For what distance should these rushes be made? They should be of such a length that the men should not be exhausted and out of breath after making them, even when the distance is run over as rapidly as possible; for this reason, it would appear that these rushes should not exceed about sixty yards, but should be adjusted so as to obtain cover; if cover exists, the rush should be from cover to cover. Before advancing, the officer commanding the body about to make the rush should select the place he is going to, point it out to his subordinates, and at a given signal he should dash to the front, his subaltern and men following; on getting into his new position he will get his men under cover as quickly as possible, kneeling, lying down, or standing, as may best cover them, and will open fire at once, and fire steadily and deliberately until the company on his flank is rushing, when he should fire a few rounds as quickly as he possibly can, to cover its advance. It should be a standing rule that when any body of skirmishers is rushing to the front, those on its immediate flank should fire rapidly to cover its advance and reduce the effect produced by the cessation of its fire.

It is the function of the supports to fill up the gaps in the skirmishing line, hence, companies must get mixed up together, it is perfectly impossible to prevent it. But it is possible, by careful training to obviate, or rather to mitigate, the evils that might ensue. Meanwhile the German line of skirmishers was approaching the enemy by a succession of rushes. This was either done by taking advantage of cover,or else they would advance about a hundred paces at a run, throw themselves down, and then run on again. In this manner the line of skirmishers got part of it within four hundred paces, part to within from one hundred and fifty to three hundred paces of the enemy, according to the nature of the ground, seldom without suffering great and inevitable loss. This advance would occasion separate strokes and counter-strokes, which naturally caused the tide of battle to roll backward and forward. At this period the fight would attain its highest pitch of intensity. The fire of the breech-loaders on both sides resounded unceasingly, and the work of commanding became the more and more difficult. (The distances which we here give are modified of course by the nature of the ground and other circumstances). As a general rule the German infantry had their sharpest musketry fighting at from about five hundred to one hundred and fifty paces, under peculiar circumstances even at closer quarters.

These were doubtless the right tactics and suited to the present arms, because one should use the offensive power of the breech-loader before attacking an enemy in position. An immediate rush against such a position, even if made by strong lines of skirmishers, would as a rule fail. If fresh detachments come up from the rear during a stationary musketry fight, whether to strengthen the line of fire or to make an attack, it was necessary to double these up with the old skirmishers, because closing the latter to a flank was usually not to be thought of; thus men of many different battalions and regiments were intermingled.

Companies *will* get mixed up. Long range weapons compel an advance in extended order for long distances, and do what officers may, men under such circumstances, exposed to a heavy fire, do get out of order. There is no use blinking this fact; it is impossible that it can be otherwise, so long as human beings possess different physical and moral endowments. Some men will be eager and anxious for the work, others will hang back, and their courage gradually ooze away. Some can be influenced by example and encouragement, others cannot; some are stronger and better able to keep up than others, consequently we must expect such a mixing up of companies amongst the skirmishing line. It is better to foresee and provide by training that an evil which *will* take place may be as little of an evil as possible, than attempt to guard against what all experience shows cannot be guarded against. No army ever went into action with better drilled or steadier troops than the English did at the Alma; they were the results of years of careful drill and the finest and most perfect organization and system that any army ever had, and yet what was the force that first carried the battery at the Alma but a mob, composed of various regiments, brigades and divisions mixed up together, and such must ever be the case where a rapid advance under a heavy fire is made by a body of troops for any distance. The wisdom of introducing any complication, with the object of preventing companies being mixed, is at least questionable.

The principles on which troops should be formed, and which govern their advance, being such as have been described, it is desirable to endeavor to realize as clearly as possible the circumstances under which, and the reasons why an attack is made at the present day possible. At a distance from the enemy's position, varying according to the nature of the ground, and the state of the atmosphere, but perhaps lying within the limits of two thousand five hundred to three thousand yards, troops will have to deploy and quit the close order in which they have previously been formed. *Now an attack on an enemy presupposes a superiority of force at the place where the attack is made.* War, whether viewed tactically or strategically, is but the art of being the strongest at the right place at the right time. This superiority of force may be numerical, moral, or local, or it may be composed partly of all three, but for an attack to have a reasonable hope of success, *the attackers at the point the attack takes place must be superior.*

Now, when the first deployment takes place the attacker's infantry will suffer but slightly from artillery fire. But the assailant's artillery will shake down walls of villages, farms or houses in which the defenders are posted, thus driving the infantry out. Their artillery will consequently become the object for the defender's guns to fire at,as it will be stationary, or only advancing occasionally,and in masses of several batteries. Hence the infantry will, in this first stage, suffer but little from the direct or aimed fire,although a few losses may be occasioned by stray shots. As the infantry advances, a large portion of the artillery will advance also,not together,but by alternate batteries, or brigades of batteries; so that a fire will be always kept up. It will probably advance thus, until it gets near to the extreme range of the infantry fire,or about one thousand to one thousand four hundred yards from the enemy's position. The moment the first or skirmishing line of the infantry comes near enough to the enemy's position to become a mark for its aimed or direct fire,say about six hundred to seven hundred yards, the troops in rear, that is to say,the supports and main body,will suffer but little, except from the unaimed or random fire. The fire of the assailant's artillery and the fire of his skirmishing line will have the effect of drawing on them both the enemy's artillery and infantry fire, *and hence it becomes possible to bring up the main body, in a much closer formation than is often supposed.*

Now here is one of the strong points of the attack, and *vice versa* one of the weak points of the defense. The defenders, do what they will, instinctively fire on the troops that are doing them an injury, and consequently the main body of the attack escapes, or nearly escapes, from all but the unaimed or stray shots that have missed the skirmishing line. Hence in every attack the fire both of the artillery supporting the attack, and of the infantry skirmishing line, must be continuous, carefully directed, and brought to bear on the portion of the enemy's position, where an entrance is to be forced. But no fire, however heavy, well-directed, and continuous, will drive good troops out of position. A heavy cross-fire of musketry and artillery may shake the *morale*, and disorganize the defenders, may kill and wound many, may induce many of the less brave individuals to leave the position, but still the really brave men will remain to fight it out. So long as they have ammunition these men will hold their position, and it is only the advance of superior numbers that will finally compel them to retire.

The attack of an enemy's position is based entirely on the science of the attack of a fortress. A mass of artillery fire is concentrated on certain points; under cover of that fire the infantry advance until checked by infantry fire. Again the infantry fire is subdued by the infantry fire added to the artillery fire of the attackers, a breach is made in the enemy's position, and through that breach a formed body of men is pushed, who make a lodgment there. Such in general terms is the attack of a fortress, such in general terms is the attack of a position, with this difference, the former is the work of days, the latter that of hours. The necessity of bringing up a sufficiently strong body formed, in hand and under control, to drive out the defenders, occupy their positions and reap the results of the fire is manifest and the question arises, how shall this body be brought up? It must conform more or less to the movement of the skirmishers; at what distance from them should it be, and in what formation? The three distinct zones of fire, through which troops must pass in moving to the attack, have been already described; these zones must govern the formation of the main body. When entering the zone of artillery fire which may be said to begin at from two thousand five hundred to three thousand yards from the enemy's guns, the main bodies should be so formed as not to offer a mark sufficiently large to induce the enemy to turn his guns on them. The great object of the defense is to retard the attack, and as the attacking artillery will at this, the first stage, be partly in action, partly moving up with the skirmishing line, the defenders must, if this force be, as it should be, a powerful one, direct all their attention to it and not to the main body. Formed in such a way, and kept at from five hundred and fifty to six hundred and fifty yards behind the skirmishers, the main body may advance and experience but little loss. On arriving at from one thousand two hundred to one thousand four hundred yards, the unaimed fire of the infantry will begin to tell, and at this point the formation of the main body may be again extended. The formation requires to be such as will enable the men to advance with speed without being demoralized: and this appears to be more likely to be attained by small columns than by either a line or extended formation.

The action of the supports during the time that elapses from the troops coming under fire should be now considered. The duty of the supports is essentially to keep up the fire of the first line, and fill gaps. It is not so much for re-enforcing the skirmishers that they are requisite, the skirmishing line should originally consist of a "sufficient number," their function is to keep that line up to "the sufficient number," feeding it to fill up the gaps caused by the enemy's bullets. Hence the officer commanding the supports, must watch the front, or skirmishing line, and send up men when he sees they are requisite. The nearer to the skirmishers the supports are the more they will suffer, but if too far off they will cease to act as supports. It appears that the supports will suffer less, that is to say, they will attract the enemy's fire less if they advance in small groups. The distance at which the supports are from the skirmishers must be left chiefly to the officer commanding those supports, but then it should rarely exceed three hundred yards. As the skirmishing line advances towards the enemy, and begins to get into the zone of aimed fire, or some six hundred to seven hundred yards from the enemy, the supports must be freely pushed on, and take their places in the skirmishing line, and as the advance of the skirmishers will, from the fact of their moving in successive rushes, be somewhat slower than that of the supports, the latter will close on them, and the main body will also close somewhat on the supports (as it will experience less loss, and consequently be less retarded).

The Commander of the supports must during his advance seek to find out the places where his assistance may be most usefully sent. The best points for the attack may be found when about eighty to one hundred yards from the enemy. As the fire is kept up the main body will advance, and when it comes near the line of supports the latter should rush to the front and join the skirmishers. The following rule should become absolute, the moment the main body arrives near what is left of the line of supports. They should dash to the front and join the line of skirmishers in order to give the impulsion requisite to cross the last and most dangerous zone of all, and finally give the assault.

If an attempt be made to realize the state of affairs at this period of the attack it will be seen that the skirmishers, re-enforced by the supports, are within two hundred and fifty to three hundred yards of the enemy: that the main body is some three hundred yards in rear of the skirmishers; the divisional artillery perhaps some one thousand two hundred to one thousand four hundred yards off, supported by a portion of the corps artillery occupying advantageous places up to two thousand yards off, and all bringing a heavy cross-fire on the enemy's position; the second line of troops following up in the rear of the main body of the first line, and perhaps some five hundred to six hundred yards in rear of it, a tremendous fire being maintained by the now thickened skirmishers, and the whole front covered with clouds of smoke. Such a state of things cannot last long; the skirmishers may get a hundred yards nearer, and the main body getting closer to them, must prepare to carry the position; gradually converging, the various portions of the main body must push rapidly to the front and drive the enemy out. While the second line seeing the advance and hearing the cheers that accompany it, should push rapidly on also, ready to support the attack, meet the enemy's reserves, and confirm the success. What should the skirmishers do when the main body advances? The skirmishers, who have borne the heaviest part of the fighting, will undoubtedly have got much excited, and heated; they will have been brought close up to the enemy's position, and by that time all the men whose heart is not in the work will have disappeared. officers and men who have worked through the zones of fire that have been described, who have seen comrades and friends dropping, will be in such a state of nervous excitement that the cheer and advance of the main body, will, no matter what orders are given, carry them to the front. The idea of leaving skirmishers lying down is contrary to the fundamental principle of the attack, which is that all the disposable forces should be applied; and leaving them behind really leads to nothing This line left behind cannot fire effectively on the enemy, it cannot collect and reform the *débris* of the troops crushed by the enemy's fire, it will have done enough, and suffered too much already for that. Judging by all experience, what it must do, is to push on with the rest. To leave it lying down is in the most favorable case a useless theoretical course to pursue, generally it will be a dangerous one.

The moment the position is carried every effort must be made to hold it. The troops should be reformed. A heavy fire should be poured on the enemy as he retires, and the second line following rapidly, must endeavor to occupy the ground, and coming up in regular order can do so far better than troops whose nerves have been wrought up to the highest pitch of excitement by a successful attack.

The nature of the attack described is illustrated by Figures 6, 7, 8, 9, and 10; but although such sketches are useful as giving expression to ideas, it should be clearly understood as regards the supports and main body, that there can *by no possibility be any definite or fixed formation*. The formation to be adopted should be entirely suited to the ground, thus one

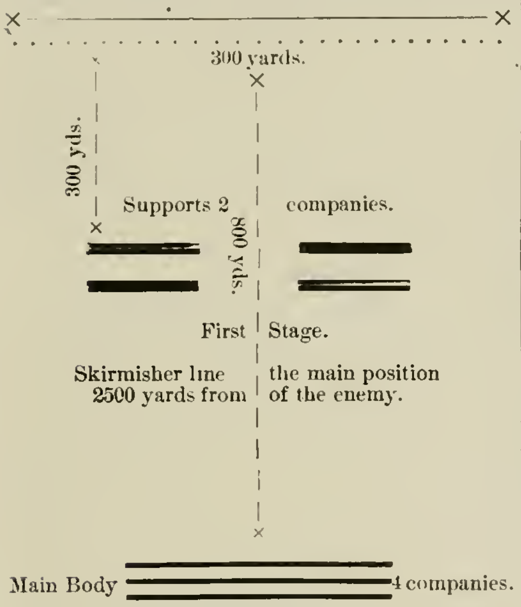


Fig. 6.

company of the supports may be in column, another in line, and after advancing one hundred yards the formations may be entirely altered, the company in column being extended, and that formerly in line now in column; similarly for the main bodies.

Von Scherff divides the attack into three stages, and lays down certain general rules to govern the formation and conduct of the troops during the progress of the attack. Every attack has to go through three stages: *a*. The period of preparations. *b*. The moment of accomplishment, and of the greatest strain on the faculties, and *c*. The period of reaction and of recovery.

The preparatory stage. This expression does not mean the same as "opening of the fight." The latter implies the several acts of reconnoitering the enemy and the ground, of gaining time for deployment, of coming to a determination upon the object to be fought for, and upon the means to be employed: that is to say, of making your dispositions and giving out your orders. In the observations which follow, we will look upon this period as passed by, and will treat of the "preparation" simply as the first step of an attack, the direction of which, and the means to be employed in making which, have already been quite settled.

1. In order to prepare the way effectively it is necessary to bring up your skirmishing line to between two hundred and four hundred paces of the enemy's position, and to overwhelm with a concentrated and uninterrupted fire the particular part of it on which you intend to direct your assault.

2. In order to do this, the attacking force should be divided into an *advance* and *main body*.

3. These two bodies should be in such proportion to one another that from one-fourth to one-half of the total strength should be alloted to the *advance*.

4. The advance is again divided into skirmishers and supports; the former bringing as many rifles into play as the nature of the ground will allow, the latter being intended to make good the losses of the former, must, on open ground, be of equal strength to them, but under favorable circumstances need only be half as strong.

5. The better the cover afforded by the ground the greater may be the extension of the skirmishers during their advance. The limits to be assigned to this extension depend on the necessity which exists of ensuring unity of command throughout the attack, and of being able to concentrate the skirmishers' fire upon one point. The front of one thousand men will range between three hundred and five hundred paces.

6. For the sake of unity of command it will be advisable for every battalion taking part in the attack to form its line of skirmishers with one company and its supports with another.

7. The skirmishers should advance from the extreme range of the artillery fire bearing upon them as far as the *extreme* effective range of the enemy's infantry fire in one body. The company which furnishes them should always be extended in one line before it becomes a target for the enemy's fire, even if at first it had formed some supports. This advance from one thousand two hundred to eight hundred, if possible, to six hundred paces of the enemy, takes

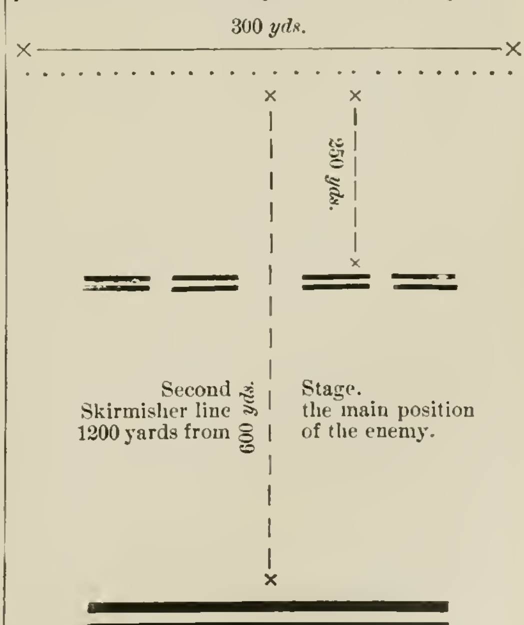


Fig. 7.

place as long as may be without opening fire, individual firing by word of command being only allowed when you can no longer dispense with its animating effect, or when special reasons for it arise (such as the necessity of driving in advanced parties of the enemy, etc.). As soon as the line of skirmishers reaches the zone of loss from *aimed infantry fire* it changes its mode of progression to that of the alternate *rushing forward* and *lying down* of separate fractions. As far as it is possible (the nature of the ground and the advantage taken of particularly favorable moments forming exceptions), these rushes are made by whole divisions, and not over more than from fifty to eighty paces at a time; whether in succession from a flank or chequer-wise is immaterial. Each time, the divisions which are halted and lying down cover by a steady, well-directed fire the advance of the others. Only when the skirmishers have advanced to within the most effective range of the enemy—say from four hundred to two hundred paces—will an unmistakable command or signal be given, upon which a *rapid independent fire*, as much concentrated as possible upon a point previously indicated, will be opened and will be maintained until the moment of the actual assault.

8. The distance of the supports from the skirmishers and their mode of advance, will be regulated as provided for the portion of the attacking force, which remains in close order.

9. The skirmishers will be re-enforced by the supports, as far as practicable, by doubling in separate fractions between separate fractions of the front line; but the details of execution will always be subordinate to producing the best possible effect upon the enemy.

The stage of execution. Whilst it was the task of the *preparation* to pave the way for the attack, the work of breaking the enemy's power of resistance by employing the greatest possible amount of striking power, devolves upon the *execution*. The conditions for successfully carrying out an attack, as far as they depend on the Commander's dispositions may be summed up as follows:

1. Every independent body of troops intended to take part in an attack should have a distinct objective assigned to it by superior authority, and should direct its efforts against this point, without cessation, with its whole strength, and in the most direct way.

2. The troops must be deployed for the attack as soon as they come within reach of the enemy's artillery. They should be divided into a main and advanced body, the former keeping within five hundred paces of the advanced skirmishers; in open ground, and under favorable circumstances, nearer to them.

3. The support of the advanced skirmishers should as soon as it becomes a mark for the enemy's guns, assume by degrees a more and more extended formation behind the skirmishers, first deploying from column into line, then spreading out so as to leave intervals between the divisions, and finally making each division expand into an open *line*. The Captain of the support will use his own discretion as to the re-enforcement of the skirmishers, both with regard to time, place, and amount, establishing himself as close as possible behind them with whatever parts of his company remain in hand, and finally throwing himself with these remnants into the line of skirmishers to take part in the heavy firing, when the main body has approached within eighty or one hundred paces.

4. The main body may get over the ground from first coming into action until reaching the zone of unaimed infantry fire, that is, until within one thousand five hundred or one thousand two hundred paces of the enemy, in little columns, if the attention of the defender's artillery is so much occupied by that of the assailant, or by his advanced skirmishers, that it cannot direct its fire on the main body.

5. From this point onwards, when either the mass attracts the fire of the enemy's guns or begin to catch his rifle balls, it should resolve itself into company columns, with intervals of from forty to eighty paces, in which formation as near an approach as possible should be made to the advanced skirmishers, say to within from six hundred to four hundred paces of them. During this advance each company may, at the discretion of its Captain, either deploy or else when wished form *open line* from division columns.

6. As soon as the main body has arrived within about fifty paces of the line of skirmishers, now re-enforced by the whole of the supports, the commanding officer gives the signal for the assault, which will be made by both advanced and main body together in double time, as lively a fire as possible being at the same time kept up by the advanced troops during the movement, which continues thus to within about twenty or thirty paces of the enemy, then terminating in a rush at full speed with a cheer, and the position is carried. The advanced troops will generally make it a point to envelop the point of entry whilst the main body converges upon it and breaks in.

7. The troops which force the position must aim at gaining the further border of it, so as to be able from thence to pursue the retreating enemy with their fire, and every portion of the attacking force will try to do this without regard to their original subdivision into advanced and main body. It will not signify if at this stage portions of the main body companies pass beyond or mingle with fractions of the advanced companies, which may yet be engaged with the enemy within the limits of the post which has been forced. An immediate rush forward beyond the border of the position is altogether inadmissible. The assailant will do much better if he at once prepares the point which he has captured for defense. As soon as the success of the attack may be considered complete, every officer must do his utmost to restore order as quickly as possible in his immediate neighborhood, and by degrees throughout the whole mass, in spite of the over-excitement or reaction which will probably prevail.

The third stage of the attack. We hardly require theoretical argument or a graphic desetription to prove that troops which have made an attack, as it necessarily must be made, in the manner above described, will have expended almost all their power for a certain time, and require a period of repose which should, at least, last until the disorder which, as we have already asserted and still confidently maintain, is inseparable from such operations has been to some extent remedied. This third stage has at all times been an extremely dangerous period for the assailant, a period in which the laurels which have been won at the price of blood, have often been again torn from the victor by a counter-attack of the enemy. Hence it has always been the aim and the task of the Commander when making his general dispositions for the attack to provide for this moment of depression, and in examining this part of the question we come to this difficult point, the subdivision of the force into separate *lines of battle*.

The following principles will be sufficient to regulate their general employment in the attack, in reference to the third stage now discussed.

1. An attacking force of more than two or three battalions must needs be formed in more than one line of battle, so as to be able to meet any counter-attack of the enemy, the possibility of which must be kept in view.

2. A second line of battle becomes necessary when the front of attack is so wide that a charge made against it cannot be met directly by the wings of the assailing force, namely, if the front exceeds the range of a rifle-ball, say from eight hundred to one thousand two hundred paces. A third line of battle is requisite to help the advanced troops to tide over the weak moment of reaction through which soldiers who have met with stubborn resistance will naturally pass, and of which the defender is likely to take advantage for making a counter-attack either on the flank of the stormers as they advance, or on the position which they have just carried. Therefore, while a second line of battle is only necessary under certain conditions, a third line can never well be dispensed with; that is to say, we shall always find it advisable to keep back a certain portion of the line to follow after the fashion of a third line.

3. From a quarter to one-third of the total force will usually be sufficient for the third line, and the second may be much weaker. The former will meet the enemy's counter-strokes by acting on his flanks, and, according to circumstances, will serve as an "outer" reserve after the position has been carried, or will undertake the pursuit; the latter will fill up accidental gaps in the front line, oppose a purely defensive action to the attempts to break through, or clear out his stragglers after the position is won.

4. The usual distance of the second line of battle from the main body of the first line will be three hundred paces, so that it may not share the losses of the latter, while the third will follow at the distance of from eight hundred to five hundred paces, so regulated that it may be at hand when its support is required. While the corps composing the second line of battle will, in accordance with the duties required of them, be disposed so as to cover the intervals of the first line, those of the third line will also be most advantageously posted on the flanks with a view to the part assigned to them, which, however, does not prevent them from being at first kept together in the center so as to be available for use on either side. But anyhow they must be drawn to a flank in the extreme case, of having to cover the retreat of the first line after its repulse.

5. The combined action of the second and third lines of battle with the first will depend too much upon circumstances to become the subject of regulation. It will generally be convenient to place the corps

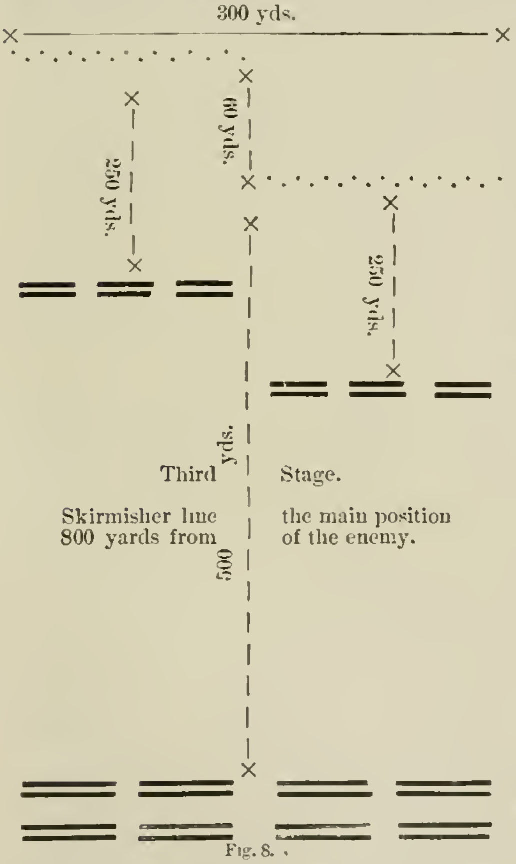


Fig. 8.

in second line, under the same command as those in front of them in the first line, while the third had better form an independent command: but the Commander of the whole force must have full discretion in the matter.

The defensive. The improvements made in fire-arms during the past thirty years seem to carry with them the conviction that the *defensive* has greatly gained in strength thereby, and this, too, at the expense of of the *offensive*. Theoretically this deduction seems natural enough, but the result of recent wars teach us conclusions entirely different. Fire-arms and gunpowder first rendered the *defensive* possible for an army operating against another in an open country. Previous to these inventions, the weaker party was forced to take refuge in walled cities and there await the enemy: and the latter was then forced to resort to siege operations. In the open field both parties took the offensive: for, had either side concluded to stand on the defensive, it would have inevitably been beaten.

In 1859, the Austrians, provided with rifled small-arms, stood on the *defensive*, and were beaten. It is true that in this war the French had rifled cannon, but their infantry was generally armed with the smooth-bore musket.

The French have usually followed the *defensive-offensive* system; that is, they have stood on the *defensive* until the enemy fully developed his plan of attack, and then, at the proper time, assumed the *offensive*, with results that are well known. The first Napoleon reaped his greatest success by following this system. Austerlitz is a brilliant example of a battle fought on this plan. In 1870, the French stood on the *defensive*—contrary both to their nature and traditions—and were beaten. In 1878-79, the Turks also stood on the *defensive*, and they in turn were beaten. Of course in all these cases there were certain causes which contributed to the choice of the *defensive*, other than the advantages supposed to be inherent in it; but still, confining the mind to the simple question of *improved weapons*, it is somewhat singular that the side which assumed the presumably stronger system, the *defensive*, was invariably beaten.

Before entering into the subject of the tactics to be followed by infantry holding a *defensive* position, it is proposed to make a simple calculation illustrative of the relative powers of the breech and muzzle-loading rifles on the defense. Let us suppose a force of two hundred infantry manning the interior crest of a redoubt. With the present breech-loading rifled musket this number of men can deliver eight thousand shots in four minutes, allowing six seconds per shot for loading, adjusting sight, and aiming. This number of shots can be delivered while the enemy is passing over a distance of about six hundred yards—limit of effective fire of the *muzzle* loading smooth-

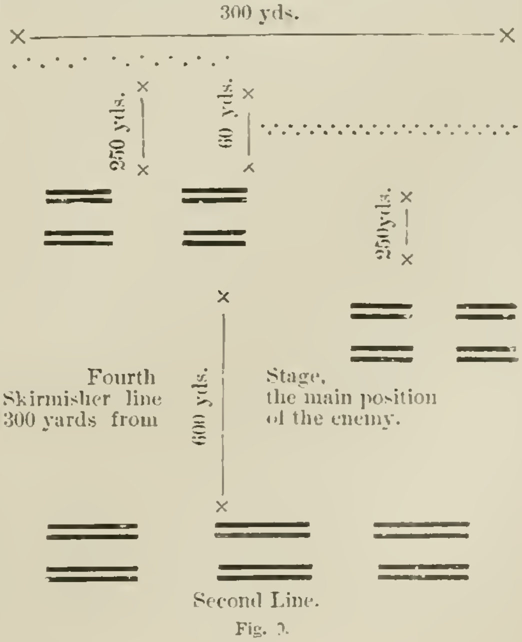


Fig. 9.

bore musket at the double time, and without any halt or delay, and under the most favorable conditions of ground. The same number of men, armed with the *muzzle*-loader, can deliver one thousand two hundred shots—allowing three shots in two minutes—under the same conditions. Supposing that one shot in twenty-five is effective, we will have three hundred and twenty men hit in the first instance, and forty-eight in the second. Then remembering that the breech-loader will prove fatal at three times the effective range of the muzzle-loader, and some idea may be formed of the great superiority of the former arm, especially when employed in positions where the distances had been previously measured and marked on the ground. We can thus see good reasons for the open order indicated for troops acting on the *offensive*, and are also enabled to form an idea of the tactics that should be followed by the *defense*.

This change in the conditions of infantry fire has reversed the relative defensive value of ground. Formerly ground that most abounded in cover was regarded as very strong, while the reverse was held of ground that was level, open, and easily approached. Now, the latter requires but comparatively few men to hold it, for no troops could live to cross it under a heavy musketry and artillery fire. The former is now the place that requires most defenders, for it is the locality where the opposing troops can find that cover so essential to protect them from the heavy fire of troops in position and protected from return fire by the works that forces on the defensive now invariably shelter themselves behind.

The power that improved arms have given to the defense is that of keeping the attackers for a longer time under a heavy fire than formerly; it is also stated that the defenders derive much advantage from the following causes: *a*. Their fire is delivered by men in position, who can take a better and more correct aim. *b*. That the force acting on the defensive may be better covered and protected than that acting on the offensive, suffer less loss, and consequently be cooler and less excited. *c*. That the ground may be better studied by the defensive than by the attacking force, and not only can advantage be thus taken of its conformation, but also additional force may be obtained by removing men from where they are of no use to important places.

If, however, these advantages, or supposed advantages, be analyzed, they will be found to have hardly the importance that they at first sight appear to possess. With reference to the first, it must not be forgotten that the assailants move rapidly and by rushes of alternate fractions, which tends to disconcert the aim of the defenders, who are ever firing at a running target, while the attackers are firing at a fixed target; therefore the superiority of the defense in this case does not seem to be very great. With reference to the second it appears that the concentration of fire on one spot so demoralizes a defender that he can be neither cool nor calm. The fire of the attacker is always convergent, that of the defender divergent. Further, the advance of troops takes them away from the dead and wounded, who are left behind. The defenders must remain in one place, and the dead and wounded can with difficulty be removed, hence the *morale* of the defenders will suffer most. With reference to the third, there can be no doubt that the defense will benefit greatly from its superiority in this respect; and it is not only in its fire, but the power to bring that fire to bear on proper places, that the defender owes his superiority.

It would appear that for the correct holding of a defensive position, arrangements should be made to bring a very heavy artillery and infantry fire on the attackers at the very beginning of the action, and to hold a few powerful reserves in hand, to attack and drive out any troops that may obtain a lodgment within the general line. The assailant to have a reasonable hope of success must be superior at the point where the attack is made. Now to counteract this superiority there must be on the side of the defense large reserves kept ready in hand to be moved the moment the attacker's project is developed, and sufficiently near to be brought up in time to drive the enemy back; not merely to check his advance after he has penetrated the position. Such reserves must be in the hands of the Generals commanding the divisions and corps, rather than those of the General-in-Chief, and hence it follows that these bodies should each form its own reserve.

On the defensive it may fairly be questioned if a deployed line is now requisite. The breech-loader enables an extended line to deliver more fire now than a closed line in former days. It will perhaps be wiser, therefore, to keep a large portion of the first line until the attack has developed itself, and then to use it in thickening the line of skirmishers where most threatened. Such a method gives much additional power to the men who see themselves supported by those behind, and who feel that they are not left alone to cope with the attackers. The sudden increase of the defender's fire, by a large reenforcement of the supports, has a powerful effect in checking the enemy's advance. It appears, from the testimony of all continental writers, to be the experience of recent war, that volley firing cannot be used, and that independent firing, which enables each man to judge its own time and aim, is far more effective.

It would appear, therefore, that in holding a defensive position, the skirmishing line in front should be supported exactly as in the attack, and this all the more so, as in most defensive positions, the supports which feed the front line may be much closer than in the attack. In occupying any defensive position, small bodies of troops of all arms should be told off at favorable places to make an advance on the enemy and check his movement. Such a force advancing a short distance from the main position disconcerts the assailant, compels him to direct his fire on

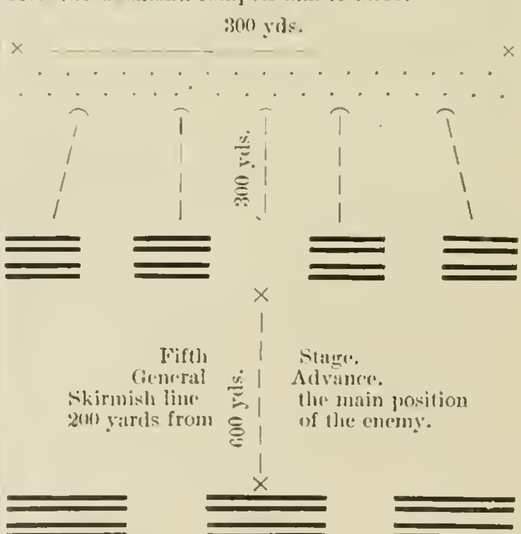


Fig. 10.

the new opponent, relieving the actual defenders from fire, and enables them to act with renewed vigor. For this purpose small posts in front of a position are of great value, but they should not be surrendered or evacuated at the first attack, they should be firmly held, and to do this they must be supported from the rear.

There is a tendency on the part of the assailants to avoid the center of the defender's position as being that where usually the fire is heaviest, and to turn off to the flanks, and to cover their advance by seeking out the places unswept or only partly swept by fire. Such movements must leave gaps in their line, and these gaps, if not filled up from the supports at once are the very points favorable for the defenders to attack, and by so doing threaten the assailant's advance on the flanks. But in making such forward movements, the greatest care is requisite that the main position be not lost, and hence arises another necessity for reserves. Generally, both supports and main body may be much nearer the skirmishing, or firing line, than when attacking. The only thing is to place them so that they shall escape fire as much as possible; but especially in the defense it must be remembered a small reserve that arrives when it is wanted, is infinitely superior to a strong one that arrives too late. Early deployment and a long march over ground, in extended order, exhausts an assailant; the defender should therefore seek to make the attacker deploy as soon as possible. But it is questionable if this should not be rather done by bodies of cavalry and artillery, pushed well out to the front, and supported by infantry, who, using the containing power of the breech-loader, will make the attacker deploy; rather than by long shots from the main positions which are not efficacious, and mark the position held, better perhaps than anything else.

The basis of a pure defense should be to fight the attack only at the distance where its fire produces the greatest effects. But though this is so, it is requisite to profit by the extreme range of arms and by the aid of small detachments entrusted to selected officers, to keep up a fire on the general advance of the enemy. The first line (*skirmishing or firing line*) will seek, by means of the most rapid fire, to keep the last halt of the enemy's skirmishers or that preceding the assault, as far off as possible. All the intensity, all the power of the fire, will be developed against the actual assault for three hundred to four hundred paces. The defense should be convinced, that despite its fire, it may become necessary to use the bayonet, and that this resort is less dangerous than a retreat.

The defensive-offensive. All defensive action which aims at a decisive result is composed of two elements; resistance and counter-attack. The *defensive-offensive* aims at the same end as does the *offensive*, but in a different manner. Whilst the latter begins by shattering the enemy's powers of resistance so as next to destroy his capacity for fighting, the former attempts to obtain the same result by previously breaking the enemy's powers of attack. The *defensive* holds it to be easier to break the power of attack than that of resistance, and therefore begins by only warding off the enemy's blows; but if it desires to smash its adversary, it is obliged at length to make use of its own powers of offense, in place of those of defense which have hitherto been called into play.

Principles of the passive defense. 1. The *passive defense* must, in order to reserve as much force as possible for the decisive offensive return, endeavor to perform with a minimum of strength the double task of shattering the enemy and holding the position.

2. Whilst the choice of position has much to do with the successful performance of this task, the mode of occupying it will also affect the result.

The troops employed in the *passive defense* should be concentrated at points previously recognized and indicated as keys of the position, unity of command being preserved at each of these points, whilst the intervening space should only be observed.

3. The principle of the line-formation will govern the disposition of the troops at each point occupied, *i. e.*, as many rifles as possible will be brought into action in first line. One man to a pace in this line of skirmishers will best meet this demand, and a line of supports half as strong as the first line, and approaching as close as practicable to it will be sufficient, as it is assumed that both lines are well under cover. Upon these two bodies, forming together the first line of the *defense*, and which should also invariably be under one Commander, devolves the task of shattering the assailant's power of attack.

4. So as under all circumstances to be able to hold a position once occupied, this first line needs a reserve (main-body), varying in strength, according to circumstances, from equal to down to one-third or one-fourth of its own numbers; this reserve serving *passively* to garrison a *reduit* or to furnish active support, under one and the same, or under separate command, according to which part it plays, but never more than from three hundred to four hundred paces in rear.

5. Unity of command in the direction of depth is desirable as long as the reserve is visible from the position of the first line, whilst in the direction of width its extent depends upon the unity of the work in hand, which again chiefly depends upon the nature of the ground.

6. The value and necessity of a second line of battle are much more evident for a defensive than for an attacking force; but its strength, and the manner in which it is drawn up and handled, depend entirely on the nature of the ground, according to which it will come into action either as an 'inner' or 'outer' reserve, for the latter of which offices a third *line of battle* will often become necessary when the numbers are large; and its operations will be conducted almost entirely on the principles of the offensive return (the more so, the larger the dimensions of the forces engaged), even when it does not of itself attempt to produce a decisive result. Above all, an infusion of the offensive element should never be wanting in the *passive defense* even in the smallest particulars.

7. It should be a principle of the *passive defense* to open fire on the enemy only when he comes within the most effective range. All the same it will be necessary to take advantage of the extreme range of the arm by detaching small parties to fire, under the control of their officers, on the enemy's general line of approach, as far as it is known. The first line will by a lively fire, and eventually by *rapid independent firing*, keep the enemy's skirmishers at as great a distance as possible when they are taking up their ground previous to the assault, for the defense will be best served by their being hindered from establishing themselves firmly at this moment. Every fire-arm should be brought into play to the fullest extent against the actual assault at from four hundred to three hundred paces. The defenders must be convinced that it may be necessary, after all, to have recourse to the bayonet, and that this would be less dangerous to them than to give way.

8. From the very nature of the work, a defensive action can only be carried through in *extended order*, to adopt which, from the very first, both supports and reserves may easily be forced. Still even with troops thus extended, the power of concentrating fire must be preserved, although it will rarely now be able to take the form of a volley. The intermixture of skirmishers with supports will, for the *defense* as for the *attack*, be generally the only form of re-enforcement possible, although exceptions to this rule may occur in the earlier stages of the fight, exceptions always to be made use of.

The principles which present themselves to us as a consequence of this study of the second stage of the *defensive-offensive* are pretty much as follows:

1. The *defensive-offensive* must carefully separate the troops intended for the two purposes of defense and counter-attack; allotting to the former as far as possible a minimum of force, if the position be favorable.

2. The strong main body is intended to deal the counter-stroke best of all on the enemy's flank just as he is advancing to storm the position; otherwise, at least as soon as possible after the assailant has forced his way in; only as an exceptional case, when the assailant makes gross mistakes or shows timidity, should the counter-attack be made before the fire of the defense has had its full effect.

3. The counter-attack as an act of offense is governed entirely, both as to form and execution, by the same principles which regulate the attack, that

is to say, it should be quick, concentrated, and energetic.

4. The position chosen for the body of troops intended to make the counter-attack, is one of the most difficult as well as the most important problems which a Commander has to solve. Being entirely dependent on circumstances for time and place, the offensive return can only produce a decisive result if made at the right moment. This consideration must guide the Commander in selecting a position, and also in deciding upon the further dispositions and orders which are certain to be required. The only principle which can be laid down is to keep the troops concealed under cover, if possible behind a flank.

5. The combination of defense and counter-attack, and the necessary transition from one to the other are of such direct and decisive consequences to the *defensive-offensive*, that this form of action is only to be recommended if the Commander be thoroughly competent and the troops extremely fit to maneuver.

CAVALRY.

The use of cavalry for grand charges in mass, as illustrated by the battles of Napoleon, is now passed. To attack with cavalry, troops in good condition and armed with the modern weapon, would be a useless sacrifice; still, circumstances might arise, when this sacrifice should be made in order to avoid a greater, or to accomplish a result which could not be otherwise obtained. At Mars-la-Tour, August 16, 1870, the German cavalry charged the French infantry in order to check the latter until re-enforcements could come up. This object was gained, but at a great sacrifice; it could be gained in no other way. The German infantry engaged was inferior in number to the French, was greatly exhausted, and its ammunition was giving out. Time must be gained to allow the German re-enforcements to reach the field and deploy. The cavalry charge accomplished this object, and victory was rendered possible by their efforts.

It appears that the action of cavalry on an actual battle-field must now be generally limited to watching the flanks, checking the action of the hostile cavalry, attacking broken and repulsed infantry. There are, however, many instances when an able cavalry leader can seize opportunities to use his arm with great effect. Such opportunities do not often occur, but when they do, the success achieved will generally be very great. The reason for this restricted action of cavalry will readily be perceived when the great increase of range and rapidity of fire of the modern arm, both of the infantry and artillery, is considered. The dangerous zone of infantry fire is from three to four times as wide as formerly, while the rapidity of fire is almost infinitely greater. The same may be said to a great extent of artillery fire. Cavalry requiring open, level ground for its movements, it labors under great disadvantages; for these are the conditions most favorable for artillery and infantry fire.

Cavalry in the field requires more care than the other arms and is less easily handled. Its efficiency is dependent upon the condition of the horses; it requires ground favorable for its action; it becomes dispersed readily, and is hard to hold in hand. An attack of cavalry on infantry should, if possible, be made upon the flanks; in combats of cavalry against cavalry, front and flank attacks combined will usually offer the best chances of success.

A reserve is a very important feature with cavalry; for, whatever the success gained by the first line it soon becomes disorganized, and then the side which can bring fresh troops into the action will usually win. Success to be lasting should be promptly followed up; cavalry is weak immediately after a successful attack, for its horses are blown, it becomes scattered, and in the confusion orders are seldom heard or heeded. Under such circumstances the attack should be followed up by a reserve of fresh cavalry, or better still by infantry, or the results will be but temporary. The enemy's broken troops would soon be able to rally under the protection of the reserves and again show a firm front. Cavalry should never await a charge at a halt; when it is found that the enemy is about to charge, your cavalry should at once charge to meet him.

When cavalry is obliged to charge over unknown ground the line should be preceded at some distance by a few horsemen to give warning when an obstacle is met. Neglect of this precaution has frequently led to disaster. At the battle of Leipsic, in 1813, Murat made a grand cavalry charge on the allied center, capturing twenty-six guns; he carried everything before him until he reached the village of Gulden Gossa, in the vicinity of which the ground had not been reconnoitered, and the nature of which could not be seen from a distance. At this place the French were suddenly checked by a great hollow, full of trees, buildings and ponds. The allied infantry, favored by this cover, opened a destructive fire upon them, and the Russian cavalry suddenly charging them in flank, they were driven back with great loss, leaving twenty of the guns they had captured.

The true uses of cavalry are the following: to watch the enemy and gain information of his numbers, position and movements; to protect the formation of infantry by charging when first the army comes into the presence of the enemy, holding him in check until the infantry is well in position and can act; to charge troops that have been repulsed in an attack; to follow them up and reap every advantage from the success gained; or the reverse, to cover such troops until they can reform and hold their own against a counter-attack of the enemy; to furnish the means of protecting the front, rear and flanks of an army, guarding it from surprises, gaining information which will lead to its success, and preventing the enemy from obtaining knowledge of its movements; to charge the guns of an isolated battery when the latter is not provided with the requisite infantry supports, operating for this purpose by the flanks.

Recent events have shown that the duties of cavalry, not only as covering the advance of an army, as outposts or reconnoiterers, but also on the actual field of battle, are perhaps more brilliant than ever. True it is that the qualities and knowledge now required of cavalry are different from what they were, or to put it more correctly, the same qualities and a great deal more besides are needed. Quickness, coolness and gallantry are now as always requisite in a cavalry soldier. But more still is needed, knowledge of country, knowledge of what the requirements of the troops are, power of observation and description, ability to seize instinctively the object of the Commander-in-Chief, a certain acquaintance with engineering, all these are now necessities for a cavalry officer. His sphere is greatly enlarged, and to fill it properly his military knowledge must be far more extensive than that involved in leading a squadron and keeping it effective, all important as the latter is, as the basis of everything else. Far from doing away with cavalry, modern events have clearly shown that there is no arm of the service from the correct management of which the army can reap more benefit. If its action be paralyzed, from any cause, there is none the want of which will be more severely felt.

Even before crossing the frontier the cavalry divisions in the center of the army were pushed to the front. Their mission was above all to pursue and keep in contact with the enemy. They threw forward strong detachments which everywhere forced the enemy back, and sought to discover the direction of his march or his new position. If they found the way clear before them, they sent on officers' patrols, with orders to push forward at any risk until they came upon the foe. These parties were despatched in all directions and performed their duties generally with equal ability and determination. It is they who spread the fear of "les Prussiens" many miles in front of the army corps' advance-guards: to them cities like Nancy opened their gates without an attempt at resistance; and if here and there a cavalry patrol some days' march in advance of the division was dispersed or cut off, one or two horsemen generally made their way back to give intelligence which was what was wanted. Requisitions and foraging excursions were made to great distances, magazines were destroyed, railways and roads rendered impassable, telegraph wires cut, in one word, the communications of the French Army rendered insecure.

As an additional result of the use to which our cavalry was put, we may mention the perfect security and tranquillity enjoyed by our army corps on the march and in camp, in rear of the cavalry divisions pushed forward half or a day's march to the front. The army corps had not, as a rule, to trouble themselves with outpost duty, but only to provide for the immediate security of the bivouac or cantonment. The infantry was therefore relieved of much hard work, being in great measure exempt from the wearisome and harassing picket duty. The cavalry divisions were kept in advance as long as possible, and were often only withdrawn at the moment we advanced to the attack on the day of battle, if the ground appeared too unfavorable for horses. Before Sedan our cavalry divisions were close to the enemy, and prevented him from getting certain intelligence of our movements. Under cover of these same divisions the operation of surrounding the French was partly accomplished, and the German Commanders would hardly have got information at the right time of MacMahon's departure for Rheims and Chalons had the cavalry masses not been pushed far to the front.

Cavalry should always be posted on ground where it can operate freely and be protected from the enemy's fire as much as possible. A large proportion of cavalry should be held in reserve, as it is thus fresh for any emergency. It can also be used to great advantage in deciding the conflict when the enemy has exhausted all his means; for the General who can at this time bring fresh troops into action is sure to win and reap the greatest results from his victory. The formation of cavalry for the attack should be in line, as it is thus less exposed to the sweeping fire of artillery and infantry.

Celerity being one of the main features of good cavalry, its value in the pursuit is incalculable. It can keep close on the flanks and rear of the retreating enemy, compelling him to remain constantly on the alert; it can take advantage of every opportunity to rush in and capture his disorganized forces, operating for this purpose on the flanks, where it is less exposed to a direct fire. In the pursuit, cavalry usually has associated with it horse-artillery, which, continually harassing the flying and disordered enemy by its demoralizing fire, prepares the way for the efficient action of the cavalry.

Provided with the breech-loading fire-arm one valuable feature of cavalry is the ease with which it may be used as mounted infantry. Moving with great rapidity to a threatened point it can be dismounted and take position to receive the enemy's attack, in this respect being nearly the equal of the best infantry; while the facility with which it can be deployed and moved, may, by being used at just the time fresh troops are needed, decide the action in favor of the General sending it forward. General Sheridan, in his operations in the Shenandoah valley, in 1864, used his cavalry as a mask, behind which he formed his infantry and concealed its movements until it fell with great effect upon the enemy's flanks.

On March 31st, 1865, at Five Forks, having dismounted the cavalry and placed it behind temporary breastworks, Sheridan was able to repulse an attack made by the Confederate infantry; the cavalry was armed with carbines. On April 1st his cavalry drove the enemy into their works at Five Forks, and held them there until the infantry came up and turned their left flank, an operation which resulted in the defeat or capture of nearly one-third of General Lee's entire force. On April 6th, at Sailor's Creek, General Sheridan, with his cavalry, cut Lee's line of retreat and held Ewell's corps in check until the infantry came up, when the Confederates threw down their arms and surrendered. Acting thus in a double capacity the cavalry contributed in a great measure to the successful termination of the campaign. Moving rapidly as cavalry to intercept the line of retreat, then dismounting and acting as infantry to hold the enemy in check until the infantry came up, the result did not long remain doubtful.

The question of how flanks are to be protected during an attack in extended order is one that continually crops up, and one to which as yet, no satisfactory answer has been given. This weak point of the infantry attack is precisely that on which the cavalry should fasten, and it is that where knowledge of ground, quickness and decision will continually afford to young officers in command of small bodies, an opportunity of performing brilliant feats. The action of cavalry supported by horse-artillery on the flanks of an army will be of the greatest importance by extending the line occupied by the troops on the defensive, the enemy, if he attempts a flank movement, must consequently be thrown further off, and compelled to make a longer march. And the action of a powerful cavalry supported by artillery on the head of the columns moving to a flank will at all times delay their progress, and give time for the army acting on the defensive to maneuver. But to work cavalry and horse-artillery in this manner it is requisite that they should be boldly used, and advantage taken of the rapidity of their movement, they must not be kept close to or hanging on the infantry for support, but must act boldly, seek to find out the enemy's flank movement, and once those movements have declared themselves, the cavalry must act on the head of his columns; whenever troops move to outflank an enemy in position they must always move in long columns, for they attack to a flank and not to their front. Hence, the front being narrow, they themselves may be over-lapped and taken on the flank.

No army that is able to maneuver, and the cavalry of which is properly posted, and does its duty, should ever, under any circumstances, be surprised by a flank attack. The position of cavalry should be on the flanks; that is to say, there should be no mass of cavalry on the roads, following or leading the army, but the whole country should be filled with horsemen, working on a broad front, pushing on at all times, if checked simply halting, while those on the right and left turn whatever stops the advance. In the rear of those feelers must be the supports on which they retire, and again in rear the main bodies. All information from a wide front is brought into the main bodies, there collated, tabulated, and telegraphed back to the directing head in rear. Thus the cavalry of an army resembles more than anything else the feelers of some insect, pushed out in front, and conveying impressions to the animal, which guide its movements. To accomplish this duty thoroughly and completely the cavalry soldier must be trained as an individual, not merely as a unit of a large mass. His individual knowledge and ability must be continually improved and also strengthened while at the same time his power of acting as a fraction in large masses should be kept steadily in view. Thus, the cavalry soldier requires to be all he has ever been, together with a great deal more he has hitherto not been. There are but few things more remarkable than the contrast of the French and Prussian cavalry during the recent war; the former guided entirely by old rules and ideas, the latter guided not only by new ideas suitable to altered circumstances, but with those ideas carefully based on the old customs.

The gallant charges made by the French cavalry against the Prussian infantry when the latter were not disordered were perfectly useless and effected nothing, although the fact that the German cavalry did succeed on one occasion shows that the successful attack of cavalry against breech-loaders and rifled artillery, although exceedingly dangerous, is by no means impossible. On the 16th of August, the French army was seeking to retreat on Verdun from Metz, a small portion of the Prussian infantry only was up on the south of the Verdun road, and it became a matter of the utmost necessity to pin the French to the ground and keep them there until the remainder of the Prussian army could come up. The French first line was extended into a long line of skirmishers. Several brigades charging on various points at full gallop and with the most reckless bravery, overwhelmed the first line; then coming upon the supports broke several battalions, and rode through several batteries, were at length repulsed by the masses which they encountered further on, and, being attacked by French cavalry, retired under a fearful fire. The French, surprised by the impetuous onset of the German squadrons, paused in their advance, time was gained; the German re-enforcements, which eventually decided the victory, came into line. The attack had a great effect on the fate of the day. Our cavalry sacrificed a third, some regiments, indeed, half their men, to bring the French to a stand-still. But here lies the difference between this charge and the great cavalry attacks of former days, that the latter themselves decided the victory. The duties of cavalry in the field may be divided into two classes. These duties, although similar, are sufficiently distinct to produce a real division. 1st. The duties of the cavalry attached to a division of the army. 2d. The duties of the cavalry division. In the Prussian army a regiment of cavalry is attached to each division. The duties of this cavalry are to cover the head of the division, examine the country, provide small parties to look out for the enemy in various directions, feel for and communicate with troops marching on roads parallel to that its own division is marching on, keep up the communication with troops in front and rear, and thus link the component portions of the army-corps together, and, lastly, to provide orderlies and escorts. The duties of the cavalry division are similar, but on a far larger scale; it has to keep the army acquainted with every movement of the enemy, to harass him and to conceal the movements of its own side by keeping a strong curtain of posts constantly in advance, so that the enemy shall know nothing of what goes on within that curtain, to connect the various army-corps moving together, and keep each informed of the action of the other.

ARTILLERY.

The introduction of rifled artillery and breech-loading arms has caused considerable modifications in the action of artillery in the field. These modifications are based partly on the nature of the infantry fighting, partly on the peculiarity of the rifled gun itself. It is undoubtedly true that rifled artillery is far more powerful in accuracy and effect at long ranges than smooth-bore guns. But at short ranges it is very questionable if such advantages exist, and this is all the more the case that at short ranges the effect of rifles on artillery is now very greatly increased.

With smooth-bore guns, the accuracy of laying at short ranges was hardly required, the gun even badly laid was sure to produce a good effect. With rifle projectiles this is not the case; to produce the full effects of a rifled artillery, careful attention is at all times required, and this attention can hardly be given at short ranges, when the gunners are suffering much from infantry fire. Two things follow from this: 1st. That if the full value of rifled artillery is to be brought out, it must come into action much sooner than formerly, it must continue in action much longer. 2nd. That it must move about far less than formerly. Mobility is an essential for good artillery, as it is for all arms, but it is the power to move rapidly when required, not continual movement, that is necessary. Artillery when moving is useless, suffers injury, and does no good. Breech-loaders have enabled infantry to advance firing if required. Such is not the case with artillery, which can only fire when halted.

If the problem of the proper use of artillery on the field of battle be considered, it becomes at once apparent that its chief function is to pave the way for an attack. It may be accepted as an axiom that the success of an infantry attack, on a body of infantry favorably posted, is, with anything like equal numbers, very doubtful. The position taken up by the troops on the defensive is sure to be always more or less difficult of approach, and there are sure to be houses, walls, farm-yards, villages, used as points of support; in such places, or behind even the smallest shelter-trench, or in rifle-pits, an enemy usually suffers but little from the fire of attacking infantry, and at the same time can inflict loss all the more that he is sheltered and preserves coolness and can use his weapons deliberately.

It is then the province of artillery to drive the defenders out of such places, and shake their *morale* by a heavy concentrated fire, which will enable the infantry to advance to the attack. If it was wished to open the battle in earnest, no time was lost in deploying a strong force of artillery, which generally took post in a connected line at the distance of from two thousand to three thousand paces, endeavoring by its fire to cover the deployment of the main body and to shake the enemy. The division artillery and the greatest part of the corps artillery of the army corps engaged, were usually employed for this purpose. The German artillery was employed on the largest scale in this manner at Gravelotte and at Sedan. Long lines of guns kept up a fearful fire upon the French positions, shattered their formations, and silenced their batteries.

One of the most important facts gained from the experience of recent wars is that artillery fire cannot be maintained against infantry fire at a much less distance than one thousand yards. When, therefore in action, artillery is subjected to infantry fire within this distance, and at the same time the cannoneers are not hidden from the enemy's view by the natural features of the ground, or otherwise protected from his fire, it must be withdrawn beyond that range, or it will soon be destitute of gunners and means of moving or fighting. In action artillery usually begins the fight by opening fire to cover the deployment, formation, and advance of the infantry. The experience gained from the war of 1866 shows that artillery was of great importance for supporting and covering the more important movements of other troops.

There is nothing which tends to produce so great a moral effect as a heavy cross-fire of artillery. The best troops in the world get shaken and demoralized by such fire. Loop-holed houses or walls rapidly become untenable, and the shells search out the trenches or rifle-pits. The effect of a given number of guns placed so as to bring a converging fire on a portion of the defender's position is very much greater than if they merely brought a direct fire. A direct fire may be more or less guarded against, but a cross-fire on a position produces the moral effect of an attack both on a flank and in front. There are therefore two general rules for the use of artillery; it must act in large bodies, and must seek to bring a converging fire on the point aimed at. On a field of battle every effort should be made to get large numbers of batteries into line under one command, especially during the earlier stages. The strategical employment of artillery in modern warfare will be more fully noticed in the article WAR. See *Artillery*, *Cavalry*, *Infantry*, *Tactics*, and *War*.

STREAK.—The tires of the wheels of the wooden artillery-carriage are composed of six short pieces of iron, called streaks, each of which is placed over the junction of two felloes, and secured with four bolts and two nails. By using a *streak* instead of a ring-tire a wheel can be repaired in the field, for as the streaks are of small size,they can be transported with a battery,and heated in the ordinary field-forge.

STREAMERS.—Small paper cases filled with a composition consisting of 2 parts of niter, 1 part of sulphur, 16 parts of fine mealed powder, and 4 parts of charcoal. The cases range from .2 to .4-inch diameter, and from 2 to 4 inches long, made of 4 turns of No. 7 paper. One end is closed, and the case is charged and primed like that of a lance. A number of streamers produce the effect known as rain of fire. See *Compositions* and *Fireworks*.

STREET FIGHTING.—In an enemy's country the subject is much simplified; a town so occupied is all inimical, and under the most desperate state of opposition; consequently in the attack there is no respect to person or property. If the houses are combustible, a ready means of subduing the place is within reach; and if not, it is forced in different directions by siege operations, as practised by the French at Saragossa.

On occasions of internal dissensions and insurrectionary movements, the case is different; the efforts of the troops and of the well-disposed citizens are greatly impeded by the difficulty of distinguishing between friend and foe,or of the premises or property with which it may be justifiable to interfere. This, and the very natural and proper anxiety to avoid bloodshed and injury to one's own countrymen, frequently lead to a habit of temporizing with the circumstances, and by this indication of timidity and weakness give such confidence to the rebels as to enable them, and perhaps with comparatively insignificant numbers, to gain in moral effect as the others lose; by degrees the wavering and the timid are led to join them; the troops themselves imagine that there is declared power manifested that is not to be opposed, and thus the former obtain a complete ascendency, which the exertion of more firmness and system at first would effectually have prevented.

The best institutions of any country become endangered by such a bad state of things; but a remedy may be found in a more systematic manner of proceeding. The troops should never be brought into the presence of the insurrectionists until fully authorized to act—the consequence would be that the very appearance of the soldiers would be a warning to every one of the immediate consequences of prolonged opposition, which would prevent further conflict, or make it very short. In order to promote the power of vigorous action by the military, and to prevent the innocent from suffering ,the most solemn warning should be issued, in case of tumult, against the presence in the streets of all women, children, and persons who do not join in the troubles, intimating that the consequences of any bad result from their being thus incautiously exposed must rest on themselves. These are necessary preliminaries to the consideration of the means of attacking an insurrectionary force. When disturbances are to be put down in a town, cavalry, artillery, and infantry can act with full effect, and with every advantage of organization, so long as their opponents occupy the open streets. If barricades are constructed across them, the cavalry become unserviceable; the infantry, however, have still force; for one side of an ordinary barricade is as good as the other, and the infantry can cross any of them without difficulty.

But when it is found that the insurgents have had recourse to the most determined means of resistance, by occupying the interior of houses in support of barricades, the mode of attack must be adapted to the circumstances. The operation should be conducted under due deliberation, nor would any triumph be conceded by care being taken that the use of a cover shall not give the impression of defeat. It will be readily ascertained what part or parts of the town are so occupied as to render the movement of the troops through the open streets unadvisable. An endeavor should be made to isolate those portions by detachments of troops posted at all the approaches to them. This of itself would throw the rioters into a most uncomfortable and false position; they would find themselves shut up without any internal organization to enable them to act to any useful purpose, or to make any combined,forcible effort for their release; or, indeed, if they could do so, it would have all the effect of *an escape* instead of a victory.

Nor would it be necessary, under such circumstances,that these detachments should be at all large, numbers of them being supported by some general reserve. Active measures,however,might at the same time be carried on against any portions of the houses that it may be considered advisable to force, for the purpose of confining the resistance within narrower limits,or for subduing it at once altogether. Although in towns the attack of a mass of houses is formidable, and almost impracticable to troops unprepared for such an operation, it will not present much difficulty to a systematic proceeding. One great defect for defense in a house or street is its want of a flanking fire, although every part may obtain a support from the opposite houses in the same street. If, therefore,only one side of the street is occupied, individuals or parties moving close along that side are in security, except from the chance missiles that may be blindly thrown down from the windows. Nothing of that kind could prevent two or three soldiers, under cover of a partial fire of the windows, from passing up and breaking open the doors; by which means, the troops being admitted,possession of the entire building would soon be obtained.

When, however, from any peculiarity of the building, or of others contiguous,or from the circumstance of both sides of the street being occupied in force, such a mode of proceeding would be too hazardous, the soldiers might make an entrance into the nearest available house in the same block of buildings, and, supported by detachments of troops,work their way, through the partition walls, etc., from one house to another; or by the roofs or the back premises, where the defenders will be quite unprepared to oppose them, or, if they make the attempt, would not have the same advantages as in front; small parties, if necessary, keeping up a fire on the windows from the walls of the back yards, or from the opposite houses, would effectually cover these advances of the troops. To carry on such approaches,the men should be provided with an assortment of crowbars, sledge-hammers,short ladders, and,above all,some bags of powder not less than 5 or 6 lbs. weight.

In these desultory operations in the defiles of streets and houses, the troops should not be in heavy columns, but in small detachments well supported; and by acting thus in order,and on system, the effect will be the more certain, as a popular movement is, necessarily, without subordination or unity of action, and peculiarly subject to panics at any proceeding differing from what had been anticipated. See *Riot*.

STREITAXT.—The battle-axe among the Germans. When the handle was greatly lengthened and when it was used by foot-soldiers, it was called *Fuss-streitax*.

STRENGTH.—The term *strength*,as applied to a cannon-metal, should not be confined to *tensile* strength alone, which expresses the ability of any substance to resist rupture from extension produced by a simple pressure, as a weight, but should embrace a knowledge of its *elasticity*, *ductility*, and *crystalline structure*, which affect its power to resist the enormous and oft-repeated force of gunpowder—a force which resembles a blow, in the rapidity of its application. It has been shown by experiment, that the feeblest strains produce permanent elongation or compression in iron; and the same is probably true of all other materials. Perfect elasticity cannot, therefore, be found in solids, although different substances possess it in different degrees. It follows that each discharge, however small, must impair the strength of a cannon, and an ordinary discharge repeated a sufficient number of times, will burst it. In the selection of a durable cannon-metal, it is very necessary to know, not only the ultimate rupturing force, but also the relation between lesser forces, and the extension and compression produced by them, and the permanent extension which always remains after these forces are withdrawn, or what is technically known as the "permanent set." This knowledge will be useful in regulating the charge of a cannon to suit the required endurance. Of two metals that possess the same tenacity and elasticity, it is evident that it will require more "work" to rupture the one which possesses the greatest amount of ductility. The size and arrangement of the crystals of a metal, have an important influence on its strength to resist a particular force. This arises from the fact that the adhesion of the crystals, by the contact of their faces is less than the cohesion of the particles of the crystals themselves, and that consequently, rupture takes place along the larger, or the principal crystalline faces. A metal will be strongest, therefore, when its crystals are small, and the principal faces are parallel to the straining-force, if it be one of extension, and perpendicular to it, if one of compression. The size of the crystals of a particular metal depends on the rate of cooling of the heated mass; the most rapid cooling gives the smallest crystals. Practically, there is a limit to the rate of cooling of certain metals; cast-iron, for instance, is supposed to change its nature by losing a portion of its uncombined carbon, when suddenly cooled, as in iron moulds. The position of the principal crystalline faces of a cooling solid, is found to be parallel to the direction in which the heat leaves it, or in a direction perpendicular to the cooling surface. The result of this arrangement of crystals is to create planes of weakness where the different systems of crystals intersect. See *Cooling*, and *Strength of Materials*.

STRENGTH OF MATERIALS.—The strength of materials will depend upon their physical constitution—viz., their form, texture, hardness, elasticity, and ductility. The resistance of materials in all engineering works is tested in reference to various strains; such strains are—1. Extension or tension; 2. Compression or crushing; 3. Transverse or cross-strain; 4. Shearing-strain; 5. Torsion or twisting-strain.

Extension.—When a rod is suspended vertically, and a weight attached to its end tending to tear it asunder, all its fibers act equally, and its strength evidently depends on the strength of the individual fibers and their number, that is, the area of cross-section of the rod. The following table gives the resistance to *rupture* of some of the most common materials:

	Per Sq. In.
Fine sandstone	200 lbs.
Brick	300 "
Common lime	50 "
Portland cement	210 "
Deal (timber)	5 tons.
Cast-iron (ordinary)	6¼ "
" Stirling's toughened	12¾ "
Wrought-iron, boiler-plate	20 to 24 "
" bars	25 "
Cast-steel	60 "

Ropes (hemp), four-fifths ton per pound weight per fathom.

With regard to the elongation of materials under tensional strain, it has been observed that up to a certain limit, which is different for different substances, the elongation is proportional to the extending force, a physical truth the promulgation of which is due to Hooke; up to this limit also the body nearly recovers its original form on the removal of the force; this limit is called the limit of elasticity. When this limit is passed, the permanent elongation or destruction rapidly increases until rupture takes place. The extension of wrought-iron is about $\frac{1}{10000}$ of its length per ton of strain per square inch, and that of cast-iron $\frac{1}{5000}$. The limit of elasticity of wrought-iron is attained under a strain of 12 tons per square inch; and in the case of American pine 1⅛ ton per square inch.

Compression or Crushing-strain.—The strength of pieces of stone, wood, or iron, whose height is small in proportion to the area, and which absolutely crush under the strain, is proportional to the area of their horizontal section. The following table gives the resistance to crushing of some of the more common materials:

Cast-iron	50 tons per square inch.
Wrought-iron	16 " " "
Brickwork	30 tons per square foot.
Sandstone	200 " " "
Limestone	490 " " "
Deal	450 " " "
Oak	650 " " "

Up to a certain strain, which is called the limit of elasticity, the diminutions in length of the body are proportional to the compressing force; and are practically the same in amount as the elongations in the case of tensional forces. In the case of wrought-iron the limit is 12 tons per square inch; after that strain, its shape and proportions become permanently altered; and where these are of consequence, as in most practical cases, we come to the limit of its utility, which is reached when the load is about 16 tons per square inch. It then oozes away beneath an additional strain, as a lump of lead would do in a vise. The mode of ultimate failure of cast-iron is quite distinct from that of wrought-iron. It crushes suddenly by the sliding off of the corners in wedge-shaped fragments, being a crystalline mass, without sufficient ductility to allow of its bulging horizontally; the angle of rupture at which these wedges slide off being tolerably constant, and varying from 48° to 58°. The limit of elasticity is attained in cubes of deal under a compression of about 100 tons per square foot; and in those of oak, 150 tons per square foot.

Pillars, round or square, may be divided into three classes—1. Those whose height is not more than 5 times their diameter; 2. Those whose height is between 5 and 25 times their diameter; 3. Those whose height is at least 25 times their diameter. The first always follow the same laws as cubes or pieces of small height above discussed, and are absolutely crushed; their strength almost invariably being proportional to their cross-section. The second are broken across, partly by crushing and partly by bending. The third give way purely from bending as with a transverse strain, and their strength is found by experiment to be directly proportional to the fourth power of their diameters, and inversely proportional to the square of the lengths. Thus in the case of two long pillars of equal length, but of which one has its diameter just double that of the other, the strength of the former will be just 16 times that of the latter; from which will be apparent the advantage of the tubular form for pillars, as it gives a large diameter, combined with lightness. In the case of long columns having lengths 25 or more times their diameter, if we represent the strength of a long cast-iron column of any dimensions by 1000, the strength of a wrought-iron column of the same dimensions will be 1750; of cast-steel, 2500; of Danzig oak, 110; and of red deal, 80.

Transverse or Cross-strain.—When a beam fixed at one end is loaded with a weight at the other, it is bent from its original form, and takes a curved shape. The fibers on the upper or convex side of the beam are extended, and those on the under or concave are compressed; while at the middle of the beam, there are fibers which are neither extended nor compressed, where the compression ends and the extension begins; this surface of fibers is called the neutral surface. As long as the beam is not strained beyond the limit of its elasticity, the extensions and compressions for a given strain are nearly equal, and therefore the neutral surface passes through the center of gravity of the cross-section of the beam. If we strain the beam beyond this limit, and approach the breaking-strain, the extensions and compressions are no longer equal, and therefore the position of the neutral surface is not readily determined. For example, in the cases of stone and cast-iron, the amount of compression is much less than that of extension, and in the case of timber greater. Also the extensions and compressions are no longer proportional to the strains. From these causes the position of the neutral axis, and the amount of strain on the different parts of the cross-section at the moment of rupture, cannot be determined by theory. Different theories have been proposed to determine the relative strength of similar beams, while their absolute strength is left to experiment. That of Galileo consists in supposing the beam incompressible, and that it gives way by extension turning round lower edge, each point of the section giving an equal resistance before rupture. That of Mariotte and Leibnitz supposes the beam in like manner to turn round its lower edge, but considers that the resistance given out by each point of the section is proportional to its distance from that edge. The theory now generally adopted consists in supposing the extensions and compressions to continue up to the point of rupture proportional to the strains, as is actually the case up to the limit of elasticity, and therefore, that the beam turns round a neutral axis, passing through the center of gravity of the cross-section, the force given out by each point being proportional to its distance from the neutral axis. This last theory is found to give the best results in the case of timber or wrought-iron, especially wrought-iron arranged in the forms usual in girders. The second represents nearly the method of failure of stone, and the first that of cast-iron. Though none of these theories give accurate results, they yet give us means of determining, from particular experiments, the strength of any other beam whatever. For example, these theories agree in giving the strength of any rectangular-beam to be proportional to the area of cross-section multiplied by the depth, and inversely proportional to the length of the beam, since the strain increases directly as the length. This, when expressed mathematically, is

$$W = C\frac{bd^2}{l} \qquad (a.)$$

Where W = breaking weight in tons.
b = breadth of beam in inches.
d = depth of beam in inches.
l = length of beam in inches.
C = a constant number for beams of the same material, to be determined by experiment.

This result is borne out by experiment—that is to say, the constant C being determined by experiment on one beam, the strength of any other is found by multiplying its breadth by the square of its depth and by the constant C, and then dividing by its length. In the case of a beam supported at each end and loaded by a weight in the middle, the strength is also given by the formula,

$$W = c\frac{bd^2}{l} \qquad (b.);$$

but c, in this case, is 4 times the value of C in the formula for a beam loaded at one end. The truth of this may be seen from the consideration that the beam may be treated as if it were two beams, each fixed at the middle point at one end, and pressed upward by the reaction of the supports at their other ends. This reaction is evidently equal to $\frac{W}{2}$: so that the breaking weight of the whole beam, supported at both ends, resolves itself into that of a beam of length $\frac{l}{2}$, acted on by the weight at one end $\frac{W}{2}$: this by formula ($a.$) is,

$$\frac{W}{2} = C\frac{bd^2}{\frac{l}{2}}$$

$$\text{or, } W = 4C\frac{bd^2}{l} = c\frac{bd^2}{l};$$

therefore, $c = 4C$ or $C = \frac{1}{4}c$.

Experiments on the transverse strength of beams are generally made by loading in the middle beams supported at both ends. The following table, from experiments by Mr. Barlow, gives the value of c for beams supported at each end and loaded in the middle:

	Tons.
Cast-iron	$13\frac{1}{2}$
Wrought-iron	12
English oak	$2\frac{1}{?}$
Red pine	$2\frac{1}{5}$

These numbers when substituted in the formula give the breaking-weight, one-third of this will be the safe load in practice. The transverse strength of cast-iron is considered so good a test of its value, that in specifications of iron-work, it is generally required to be of such a quality that a bar of it, of certain dimensions, will bear a specified weight at the center; for example, "that a bar of it, 42 inches long, 2 inches deep, and 1 inch wide, set on bearings 36 inches apart, shall bear, without breaking, 30 cwt. suspended in the middle." If a beam be loaded uniformly over its length, it will bear twice as much as if the load be condensed at the center. Also if the load be placed some distance from the center, the load it will bear is to the load borne at the center inversely as the rectangle of the segments into which the beam is divided by the point of application of the load are to one another, from which it follows that it will bear a less weight at the center than at any other point. Since the strength of a rectangular beam is proportional to the square of the depth, multiplied by the breadth, it is evident that by increasing the depth and by diminishing the breadth we shall, up to a certain limit, increase the strength of the beam without increasing its weight; for an example, let A and B be the sections of two beams, of which A is 2 inches broad and 2 deep, and B 4 inches deep and 1 inch broad, they are of the same sectional area—viz., 4 sq.in., but the strength of B is to the strength of A as $4^2 \times 1$ is to $2^2 \times 2$, or as 16 to 8, that is 2 to 1, that is to say, B is twice the strength of A. Hence arises the advantage of the double T-forms so generally used in iron girders, the strength of which forms are proportional to the area of the top or bottom plates multiplied by the depth. For a beam of this form loaded at the center, the following formula will give the breaking-weight:

$$W = C\frac{ad}{l}$$

Where a = the area of the top or bottom flange in sq. inches.
C = 4 times the destroying load per sq.in. of the material, under direct tension or compression in tons.
d = depth of the beam in feet.
l = length between supports in feet.
W = breaking-weight at the center in tons.

For cast-iron beams, when the area of the bottom flange is made 6 times that of the top, which has been found by experiment to be the best arrangement, and the strength is measured by the tensional-strain, supported by the bottom flange, that is, $6\frac{1}{2}$ tons per sq. inch.

$C = 6\frac{1}{2} \times 4 = 26$ tons.

For wrought-iron beams,

$C = 4 \times 20 = 80$ tons for the lower flange,

and $C = 4 \times 16 = 64$ tons for the upper flange.

In beams supported at both ends, the strain is greatest in the middle; girders are therefore usually made strongest in the middle, and taper toward the ends.

Shearing Strain.—This force is seen when a plate is cut by shears, or when a riveted or bolted joint is torn asunder, in which case the rivets are sheared across. The effect of it is to cause the particles in one plane to slide over those in another; this is resisted by their mutual coherence, and the magnitude of the resistance depends on the number of the particles, that is on the area of cross-section of the body sheared. The following laws are the result of experiment:—1. The ultimate resistance to shearing is proportional to the area of section of the bar sheared. 2. The ultimate resistance of any bar to a shearing-strain is very nearly the same as the ultimate resistance of the same bar to a direct longitudinal strain.

Torsion.—If one end of the shaft or axle of a wheel is immovably fixed, and a power also acts at the circumference of the wheel (or at the end of a lever or a winch), the power may be so increased as to twist the shaft as sunder at its weakest point. If a shaft A has twice the diameter of another shaft B, there will be four times as many fibers in the section of fracture of A, to resist the twist, as in that of B. But as the separation takes place by the one end of the fracture turning round upon the axis of the shaft, making the ends of the separating fibers describe circles, those fibers that are furthest from the center will have the greatest power of resistance, and the sum of their moments, or their united effect, will be in proportion to their mean distance from the center. This mean distance in A is twice that in B; and, therefore, the resistance in A is 2×4, or 8 times the resistance in B. Generally, *the strength of shafts to resist torsion is as the cubes of their diameters.* The torsive strengths of shafts 1 in. diameter, and with weights acting at 1 ft. leverage, being found by experiment for different materials; the strength of shafts of other dimensions is found from these "constants" by multiplying by the cube of the diameter, and dividing by the length of the lever. It is evident that the torsive strength of a hollow shaft will be greater than that of a solid one of the same quantity of material, on the same principal that its transverse strength is greater. The rule used by Boulton and Watt for calculating the diameters of their wrought-iron shafts was as follows:

$$\text{Diameter of shaft in inch.} = \sqrt[3]{\frac{120 \times \text{horse-power.}}{\text{Revolu. per minute.}}}$$

This is found to make the shafts rather too light; and the following variation gives safer practical results:

$$\text{Diameter of shaft in inch.} = \sqrt[3]{\frac{240 \times \text{horse-power.}}{\text{Revolu. per minute.}}}$$

See *Testing-machine.*

STRETCHER.—A portable litter for carrying a sick or wounded man off the field of battle. It is so called from cross-pieces or *stretchers* keeping the poles separate and the canvas stretched, thus producing a firm but soft surface for the disabled man to lie upon. The requirements of a good field-stretcher are: Firm, but not hard support for the patient, and one easily cleaned of the blood and dirt; lightness, to facilitate carriage by bearers and strength, to resist shocks and rough usages of war; simplicity of construction, combined with capability of folding into a small compass for packs. There must be no detached pieces, which are liable to be lost. Provision should be made for keeping the patient off the ground when the stretcher is once laid down. The latest pattern consists of a tarred canvas bottom, attached to two ash poles which are kept at the required distance apart by two jointed galvanized-iron rods. It is filted with four short iron legs, and has a pillow secured to the head. The Indians make a good stretcher as follows, Fig. 1. Three cross-pieces are well lashed to two elastic

Fig. 1.

poles, eight or ten feet long. This frame-work is then supported over the wounded man as he lies on his blanket or canvas and the latter is securely fastened to the frame. One cross-piece is in front of the feet, another behind the head, and a third one being over the man, will steady him in the transport. Small twigs may form a frame-work, which, covered with a blanket or coat will protect the sick man from the sun, wind or rain. After a fight the Indians carry their wounded great distances, palanquin fashion. If horses can be spared they may transport a litter instead of the stretcher. In this event the poles should be very elastic, about eighteen feet long, united by cross-pieces three-and-a-half feet long, the ends being firmly secured to the sides of the animals by very strong fastenings. The Indians often use one horse with this litter, allowing only one end to trail on the ground. When only one animal can be spared, great caution must be exercised in passing over broken and rocky ground. Assistant Surgeon A. Hartsuff, United States Army, has furnished the details of an improvised stretcher and travee. The drawing, Fig. 2, shows the manner of its construction and use. When detached from the mule it forms a very convenient stretcher, being made of light poles, usually the Indian *teepe* poles. Carrying the stretcher on the shoulders should be avoided; if necessary to do so, the front and rear bearers of the stretcher should be "out of step," a man of equal height, strength, and length of step, so far as may be practicable, should be selected. The sick or wounded man should then be carried with his face toward the direction in which he is moving. In crossing ditches, dikes, hollows, fences, etc., the stretcher should be kept horizontal.

The following stretchers may be readily extemporized:—Roll a small stone or any other hard object into each corner of a blanket, and thus form projections which will prevent the slipping of the strings or thongs with which the blanket may be made fast to a frame of poles (or rifles lashed together). Strips of the blanket may be used as strings. This stretcher may be still further simplified and less material required when two corners of the blanket are fastened to a short cross-piece at the head, while the other end is gathered up and tied together to the main pole. The pressure of the pole on the shoulder (most readily borne on the shoulder) when bearing the stretcher, may be diminished by a short pole or gun held lever-wise over the other shoulder, so as to take some portion of its weight. Fig. 3.

Four rifles and two coats, in a great emergency, may be made into a stretcher. The sleeves of one coat are turned into the inside. The rifles are then passed through the sleeves (muzzle to muzzle) and firmly lashed together, when each coat is buttoned through the front. For a man who can sit up, one rifle through the sleeves of a coat,and the coat-tail lashed to another rifle, will form a good stretcher. The sick man may bear against one of the bearers and let his legs hang down. A stretcher may be made by suspending an ox, mule or horse hide between two poles, or by interlacing the belts and gun-straps. Even the knapsack may be fastened between the poles or rifles so as to form a good transport. When it is possible to transport a wagon, a stretcher made of belts, ropes, etc., may be hung from its sides within,or better the bottom of the body of the wagon may be filled with blankets,very small branches covered with straw, hay, ferns, rushes or any soft material. A person who is unable to walk, but who can sit and practically support himself, may be transported by two men, who either support him on a short pole held

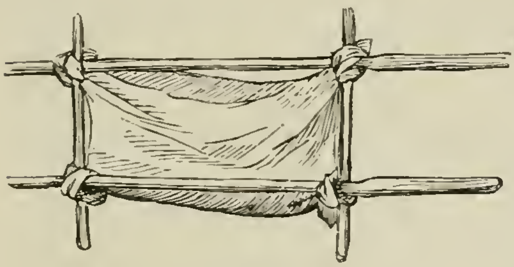


Fig. 3.

between them, with his arms upon their shoulders, or form a seat with their hands and arms like the chairs made by children in their games, Fig. 4. In case of great emergency, after knotting together the ends of a blanket, two men could be laid in the bights and transported, one on each side of the horse, the cen-

Fig. 4.

tral part of the blanket being laid across the horse's back and secured. The Indians frequently transport their children in this manner. See *Litter* and *Travee*.

STRETCHER-BEARERS.—Men of the British Army Hospital Corps whose special duty in war time is to carry the wounded from the battle-field, to the ambulances, wagons, or field-hospitals. The ambulance Committee has recommended that 150 of these men should be attached to each division, and 36 to each brigade of cavalry.

STRIKE.—There exist several definitions of this word, but the most common is to touch or to hit. *To strike a blow*, in warfare, is to make such an impression on the adversary as probably to insure victory. *To strike a tent* means in castrametation to loosen the cords of a tent which has been regularly pitched. The duty of *striking tents* is performed by the soldiers who inhabit them, and is carried out in accordance with rules bearing on that subject. *To strike a gin.*—To dismount or take down a gin. *To strike a camp.*—The act of breaking up the camp. This is perform-

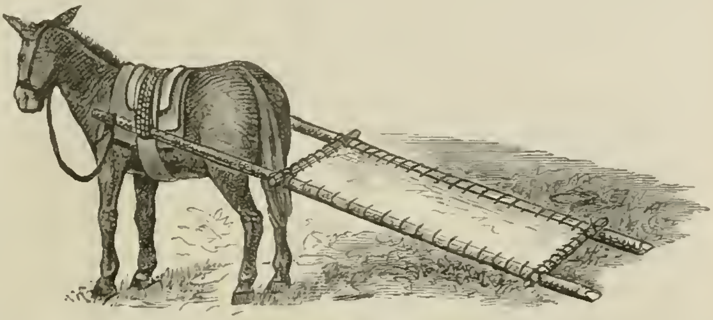


Fig. 2.

ed according to orders issued over night, which detail the hour for assembly, and the hour for reveille, as it is very desirable that the men should not be disturbed sooner than is requisite. Immediately after the reveille has sounded, the cooks should prepare coffee for the troops; whilst this is being got ready, the men pack up their blankets, and place them in the wagons. When they have finished their breakfast, fires should be extinguished, and tents struck and rolled with their bags. All trenches and latrines should be filled up before the men leave the ground.

STRIKER.—1. A species of steam-hammer, striking in a manner similar to the trip-hammer,but operated directly from the engine, the cam-wheel being dispensed with. It may be adjusted to strike either vertically, or horizontally, or at any angle, and is designed as a substitute for the blacksmith's assistant, known as the *striker*, on heavy work. 2. A term commonly applied to a soldier-servant.

STRIKING EFFECT.—The term penetration, when used in connection with a projectile, means the resistance it is capable of overcoming at the time of striking an object. The resistance overcome is the work performed, and is made manifest by the crushing effect of the blow, or by the penetration of the projectile. It implies both pressure and motion,and is expressed in foot-pounds, which for convenience, are reduced to tons of 2 240 pounds each. It is the *living force* of mechanics, expressed mathematically by $\frac{w v^2}{2g}$; in which w=weight of projectile in pounds; v=velocity of projectile in feet; g = gravity, which in the latitude of New York, is equal 32.16. To apply this formula, suppose a projectile weighing 500 pounds strikes the side of an ironclad with a velocity of 1,000 feet,

we have $\frac{500 \times (1000)^2}{2 \times 32.16} = 7773631.8$ foot pounds; by dividing 2240, gives 3470.35 foot-tons as the force or energy of the blow.

It has been ascertained by experiment that the resistance offered by armor-plates to penetration by a given weight of projectile,the energy of which is constant, varies directly as the diameter or circumference of the projectile;hence, in order to find the penetrative power of a shot, it is customary to divide its energy by the number of inches in its circumference, and when projectiles are compared in this way they can be classed as regards their power of penetration. It will be seen that because a shot has great energy it does not necessarily have great penetrative power, the latter depending so largely on its diameter. For obtaining the penetration in wrought-iron, Captain Noble's formula is used; which is—$F = a x^2$

$F = \frac{w r^2}{452617 \times a}$; in which F=number of foot-tons per inch of the projectile's circumference, d = diameter of projectile in inches, a = 1,384. x=depth of penetration.

STRIKING VELOCITY.—The velocity which a projectile has on impact.

STRINGHALT.—A peculiar catching up of a horse's limbs, usually of one or both hind limbs. It is most noticeable when the animal is first brought out of the stable, when he is excited, or made to turn suddenly round; it is a variety of chorea or St. Vitus's dance. Although a serious eye-sore, it does not interfere with usefulness, and is quite incurable.

STRIP.—A technical term applied to the accident of a projectile issuing from a rifled gun, without assuming the spiral turn.

STRIPES.—A term sometimes applied to the chevrons on the coats of Non-commissioned Officers.

STRUT.—A term employed to express the obliquity of the lower or working spoke of a wheel of a gun-carriage. See *Wheel.*

STUB.—1. A kind of iron formed from old horse-shoe nails. It is used especially for gun-barrels of superior quality. The stubs are put into a tumbling-box to brighten them, removing all rust and dirt. They are then combined with from 12 to 50 per cent. of steel in blocks of the same size as the *stubs.* The combined metals are puddled, hammered, heated, tilted, and rolled into ribbons, to be wound in coils around mandrels, heated to a welding heat, *jumped,* and finished by a hammer on the anvil. 2. A stationary stud in a lock which acts as a detent for the tumblers when their slots are in engagement therewith.

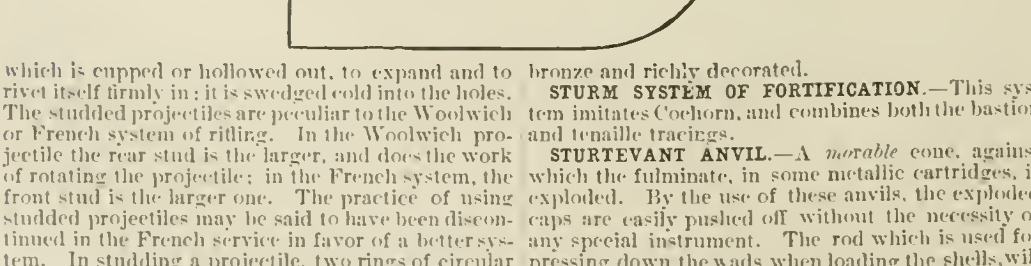
STUD.—A place where horses are bred or kept. In England, the Government does not, under this name, possess any such establishment. Horses, when wanted, are purchased in the market, and distributed to the different regiments of the mounted branch of the service. In India, on the Bengal side, the Government of that country possesses stud depots at Ghazeepore, Buxar, and Kurrentadhee, in the Central Provinces, and two in the North West Provinces, at Haupper and Saharunpore. They are under the control of officers of the Army specially appointed, belonging to the *Stud Department.* When the studs do not produce a sufficient number of horses, they are purchased either in the country or in the Colonies.

STUDDED PROJECTILES.—The studs of this class of projectiles are usually of ronze, the proportions of the alloy being from seven to ten parts of copper to one of tin, which is sufficiently soft to enable the stud to be attached to the projectile by pressing it into under-cut holes in the latter, causing the end, which is cupped or hollowed out, to expand and to rivet itself firmly in; it is swedged cold into the holes. The studded projectiles are peculiar to the Woolwich or French system of rifling. In the Woolwich projectile the rear stud is the larger, and does the work of rotating the projectile; in the French system, the front stud is the larger one. The practice of using studded projectiles may be said to have been discontinued in the French service in favor of a better system. In studding a projectile, two rings of circular holes are usually cast in the walls, the number of holes in each ring corresponding to the number of grooves in the gun. The weakening of the walls by so many holes, and the concentration of the effort of rotation at these points, seriously affects the endurance of the projectile. The system of studding to accommodate the increasing spiral, may be readily understood by a reference to the following diagram, showing Palliser's differential studding and in which EE, DD represent the groove at the seat of the projectile; and AA, BB represent the groove at the muzzle. O and O are studs. The object sought is to combine a double bearing with an accelerated spiral. The difficulty lies in the fact, that since the angle at which the grooves are inclined is continually increasing, the gun would be trying to turn the fore part of a rigid projectile faster than the hinder-part, which would be impossible. To overcome this difficulty, the rear stud is made larger than the front one. Thus, at starting, the three rear studs do all the work of turning the projectile, since EE is the driving-edge of the groove when it commences to move. This work is inconsiderable, as the angle of the twist at first is zero. But as the projectile travels along the bore, the friction will wear down the rear studs, and the assistance of those in front will be gradually called into play.

The rear studs are made large enough to fill the grooves; the size and position of the front stud is thus determined. Draw AA tangent to the larger stud at C, and making an angle AAH = final angle of rifling. From O, the center of the rear stud draw OO, making OOH = ½ AAH. It will readily be seen that a circle described with any point O as a center along the line OO, and the perpendicular OP fall upon BB as a radius, will touch DD, and that the projectile will freely enter the gun, and that the bearing-edges of the stud will all press equally on the driving-edges of the grooves as the projectile approaches the muzzle.

The front stud touches the driving-edge on entering the bore, and the loading-edge when well home; and the reverse action occuring in firing, the share it takes in the work of rotation is very small, for until the driving-edge meets it, the whole pressure is on the rear studs. Its chief use appears to be to steady the projectile.

These projectiles must be handled and stored with great care to prevent the studs being bruised and injured so as to jam in the bore, or fail to grip on the grooves in firing. They are liable to break up in the bore if fired a second time, and the studs are liable to sheer and thus prevent the centring of the projectile. See *Palliser Projectiles, Projectiles,* and *Scott Projectile.*



STUIC.—An Irish war-born, commonly made of bronze and richly decorated.

STURM SYSTEM OF FORTIFICATION.—This system imitates Coehorn, and combines both the bastion and tenaille tracings.

STURTEVANT ANVIL.—A *movable* cone, against which the fulminate, in some metallic cartridges, is exploded. By the use of these anvils, the exploded caps are easily pushed off without the necessity of any special instrument. The rod which is used for pressing down the wads when loading the shells, will also answer for pushing off the exploded caps.

STYLET.—A small poniard or dagger; a stiletto.

SUB.—A familiar abbreviation used in the British army to signify a Subaltern, or any Inferior Officer.

SUBAHDAR.—Under the Mogul Government, the title of a Governor of a Province. It now designates a native officer, holding a rank equivalent to that of Captain under European officers.

SUBAHDAR-MAJOR.—The native Commandant of an Indian regiment of infantry.

SUBALTERN.—A Commissioned Officer below the rank of Captain. But strictly speaking every officer is a subaltern to the grades above him, as the Captain is subaltern to the Major, and so upward.

SUB-BRIGADIER.—An officer in the Horse Guards who ranks as Cornet.

SUB-CALIBER PROJECTILE.—A projectile for cannon or small-arms, of smaller diameter than the bore of the gun from which it is fired, but having a sabot large enough to fill the bore, allowing the usual windage; or with an expanding sabot, which is forced out so as to fill the bore when the gun is fired. This description of shot is intended for punching armor at high velocities. In its simplest form it is a steel projectile, covered with wood simply to center it; and is attached in the rear to a piston the full size of the bore, so that its weight is very small compared with the full-caliber projectile of equal length, while the area upon which the powder acts is the same for both. The projectile is rotated by a brass disk attached to the rear—a modification of the *Reed system*. The *sub-caliber* system will not allow the use of the most effective shells or projectiles; and this modification does not reduce the area of the shot to the air, as well as to the target. The wood covering is torn off when the shot enters the armor.

SUBDIVISION.—The part of a regiment on parade distinguished by a second division. Thus, a company divided forms two subdivisions.

SUBDUR.—In the East Indies, a term signifying a Chief.

SUBMARINE-BLASTING.—There are two methods of submarine-blasting in common use in the United States, where all the most notable instances of large work have taken place. The first method to be noticed is by the shaft and tunnel plan. In this case a shaft is sunk very near or through the water, then by driving tunnels from the shaft, enough space is excavated to give opportunity for the distribution of the explosive. Holes are drilled in the roof or pillars, or both, and the disruption of the rock is produced by a simultaneous discharge of the explosive charges. After the explosion follows the dredging the *débris*. The other method is by drilling vertical holes from the floating scow, on which the drilling-machines are placed, charging the line of holes, withdrawing the scow a suitable distance, firing the charges, and dredging the *débris*. The operation is repeated by drilling another line, and then firing the charges. Still another method of breaking rock under water has been practiced, although not in common use, except to break isloated rocks of moderate dimensions,and as an adjunct to the plan of shaft and gallery and simultaneous explosion of a large number of holes, where the proximity of valuable buildings to the scene of the explosion requires the use of the smallest practicable amount of explosive material, to thoroughly shatter the rock, and to break the larger pieces afterwards by the explosion of "high explosives" on top of the masses which are too large for convenient handling by the dredging-machine.

The history of the submarine work in the United States shows but little done until after the close of the Civil War, and that chiefly by the last mentioned method of "surface blasting." The operations have been under the direction of the officers of the Engineer Corps of the Army and highly creditable to them in every case. In this article an attempt will not be made to trace all of the earlier efforts to break and remove rock under water, but to give an explanation of the methods used in the most notable instances,and to add that prior to the blasting of "Blossom Rock" in San Francisco Harbor in 1870,the work has been confined to small masses which had been disrupted either by surface blasting or by drilling of holes from a platform or scow from the surface, under the manipulation or direction of a diver below. Some of these operations had been carried on by General Foster in Boston Harbor in 1867 and 1868, on two rocks which lay directly in the channel. These rocks were drilled from the surface by means of a novel apparatus,a tripod being let down on the rock and the drill-bar raised by a chain from the vessel. After the holes were drilled they were cleaned with a composition of chlorate of potash known as "Oriental Compound" and fired by a friction exploding machine. 600 cubic yards in one of these rocks cost about fifty dollars per cubic yard, and occupied 290 days in drilling and blasting. Blossom Rock was an obstruction in the harbor of San Francisco about 4,500 feet from land, and was entirely submerged. Mr.Alexander W. Von Schmidt, C.E., undertook its removal by a tender to complete the work for a definite sum of money, which was accepted by Colonel R. S. Williamson, Corps of Engineers U. S. Army, the Engineer in charge of the Department on the West Coast. His proposition was to remove it so as to leave 24 feet of water at low tide over it. A crib was made and floated over the rock, and ballast put in it around the center compartment which was to be used as a shaft for the entrance of men,and removal of material. A boiler-iron tube rested on top of the rock in the center of the crib,and sand bags and cementing material around the tube kept the water out. The rock was not hard and was to a large extent picked and pried out, although some blasting was done. After the shaft was sunk 31 feet 6 inches an excavation was made 140 feet long by 60 feet wide, and 12 feet high. In this excavation and near the outer edge were placed 38 barrels having an average capacity of 60 gallons each,and seven old iron tanks each filled with blasting-powder. The barrels and tanks contained in all 43,000 lbs. of Soda Powder, which was fired by means of electricity. In order to make the combustion of the Soda Powder more certain, a long tube filled with fine rifle powder was placed in the center of the barrels, and the electric exploder was placed in the middle of that. The explosion took place on the 23d day of April,1870, and threw a column of water, estimated at 200 feet in diameter, to a height of 200 feet. On measuring the depth of water,it was found that there was not space enough excavated to hold the broken rock and timbers, and it was estimated that it would have required an excavation 10 feet deeper to have accomplished that result. The timbers in this case, as in all others since, have been great barriers to the settlement of the broken rock into the excavated space,as the timber under water is very little injured by an explosion except where the explosion comes in direct contact with the timber. Another fallacy was exposed when the current of water failed to carry away the small broken débris,and the work required dredging,which was done in a crude way with heavy iron rakes hauling the débris off into deep water. In this,as in other cases, the cleaning up of the bottom so that no isolated stone should project enough to reduce the depth of water below 24 feet at low tide, was expensive, and the contractor was obliged to go over the work the second time, after his conclusion that he had fulfilled his contract. The liability of missing a few stones in dredging to a line is very great, and is the cause of much expense in submarine operations.

The next submarine excavation of note under the shaft and tunnel system, was at Hallets Point,in New York Harbor, and it attracted much atttention all over the world. The point was a dangerous one for vessels in passing from Long Island Sound to the Harbor of New York, and its successful removal was a part of the general system of harbor improvements designed by Gen. John Newton, Corps of Engineers, U. S. Army, under whose charge this work came in

Fig. 1.—Explosion at Hallets Point, Sept. 24th, 1876. Area exploded, simultaneously, $2\frac{3}{4}$ acres. Explosive used, $49,879\frac{1}{2}$ lbs. Dynamite.
Camera located 2,125 feet North-west of Explosion.

1869, and by whom the plan has been patiently and persistently followed, under very discouraging conditions, ever since, with rare thoughtfulness and skill. A shaft was sunk near the edge of the water, to a depth of 37 feet below the surface of the rock, and galleries were driven radiating therefrom, leaving pillars to support the roof. The area of excavation was about $2\frac{3}{4}$ acres. The roof averaged about 10 feet thickness. The roof and pillars were drilled and charged with dynamite, (in this instance a composition of nitro-glycerine and nitrate of soda or saltpeter was used, commonly called Rendrock, Vulcan, Giant Powder, or Dynamite No. 2.) The following is a statement of quantities of explosive, and number of holes.

Area of excavation, about	$2\frac{3}{4}$ acers,
Cubic yard of excavation, about	47,461
Cubic yards in piers,	5,900
Cubic yards in roof,	56,860
Cubic yards broken by blast,	62,760
Total explosive used in pounds,	$49,879\frac{1}{2}$
Number of brass primers (exploders)	3,680
Number of feet of leading wire,	150,000
Number of feet connecting wire,	100,000
Number of cells in firing battery,	960

exploder, which was done by the three year old daughter of General Newton on the 24th day of September, 1876, and a column of water and dirt was sent to a height estimated at 114 feet by one photograph taken. It is probable that the column was thrown higher than shown in the potograph. The shock was felt in the city of New York very perceptibly, and as many people had been seriously apprehensive of the results by shock, great relief was felt when it was over. The shock was noted at a distance of many miles, and was especially noted because of its novelty. While no serious damage was done, the shock was sufficent to indicate that great caution was to be used in increasing the amount of explosive, to be used to the cubic yard of rock in future operations in localities near buildings. The rock was thoroughly shattered, but some surface blasts were necessary to prepare some of the larger masses for the dredge. The dredging was done under three contracts, made at different times during the years from 1876 to 1882. All of this work of excavtion was done by day's work, under the direction of General John Newton, who was assisted by Capt. W. H. Heuer and Capt. James Mercur. See Fig. 1.

The next work of similar character done by sub-

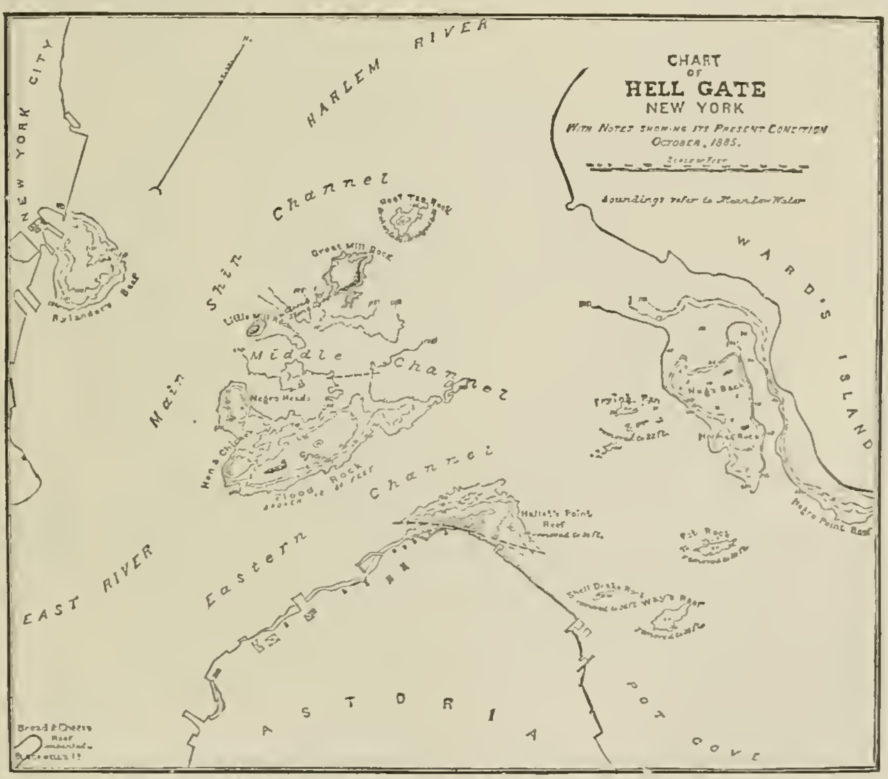


Fig. 2.

The explosive was placed by the contractors in tin tubes, having a screw metal cover with rubber packing, and the cartridges were shipped from the factories in that condition. Much care was exercised to keep the outside of the cartridges face from nitro-glycerine, and to prevent leakage, because the fluid, being explosive by itself, might fire the charges if the net portion of the cartridges happened to come in contact with a rock by falling during the operation of loading. The loading was successfully performed, and the connections by gutta-percha covered wire were made. The fuses or exploders used were made by the Laflin & Rand Powder Co., and are known as the "platinum fuses." The electro motive force was created by a 960 cell battery. The circuit was closed by firing an stantially the same system, was Flood Rock, which was exploded Oct. 10, 1885. This is the second important step in the plans of General Newton for the improvement of the Harbor of New York, and the execution of the work has been so accurately and happily described by Lieutenant Geo. McC. Derby, Corps of Engineers U. S. Army, and assigned to this important work,—in a paper printed in the Sanitary Engineer of December 3, 1885, that it is copied here as the best description that can be given. The importance of clearing this channel was early recognized, and many attempts were made to afford relief. The first work was done under the direction of Mr. E. Merriam, in 1851, and subsequently by Major Fraser, Corps of Engineers. By firing large charges of powder on the surface of the rocks, they succeeded in breaking off the ragged points and blowing them into deep water. But, once the reefs were reduced to comparatively smooth surfaces, this method became of little avail. By 1867 many thousands of dollars had been expended, and while the removal of the highest points of Pot Rock, Frying Pan, and Way's Reef had undoubtedly been of great relief to vessels of light draft, the total volume of the obstructions had been but very little reduced. At this time the work was put in charge of General John Newton, Corps of Engineers, U. S. Army, who submitted the same year to the Chief of Engineers the first complete and practicable scheme for the improvement of Hell Gate. He proposed the removal of all the dangerous reefs to a depth of twenty-six feet at mean low water, and submitted detailed estimates of the cost of the work and the required time to complete it. This project which was at first only approved in part on account of its magnitude, was, after the successful demolition of the reef at Hallet's Point, adopted in its entirety. The first appropriation became available July 31, 1868, and a day's work. On Way's Reef the results were equally unsatisfactory. The contractor failed completely in removing the rock to the required depth, though he succeeded in collecting under the contract $69,000 for taking the top off it. After these costly failures, the contract system was abandoned, and the work proceeded on General Newton's plans under his own management. He proposed to remove the large reefs by tunneling under them, and for use on the smaller reefs he designed a large scow, built to withstand collisions, carrying heavy drop drills working through pipes to avoid the current, and operated by means of flexible connections by engines on the scow. This machine has been collided with as often as four times in one day, with sufficient force to break her 1⅜-inch anchor chains, and has succeeded in accomplishing her work, though not at figures comparable with the cost of such work under ordinary circumstances.

Work was commenced on this project in July, 1869, and according to the estimate it should have been completed in ten years at a cost of $5,139,120. Six-

Fig. 3.

General Newton began work by advertising for proposals to remove Frying Pan, and certain other small reefs under contract. These resulted in contracts being made for the removal of Frying Pan in twelve months at $17.80 per cubic yard, and Way's Reef in eighteen months at $44.28 per cubic yard.

After eleven months' delay in preparation, the contractor erected on Frying Pan an elaborate drilling plant, consisting of a cast-iron ring thirty feet in diameter, weighing many tons, mounted on adjustable legs, and carrying a number of steam rock drills. Similar means have since been used almost everywhere for breaking the rock under water; but in Hell Gate the very violent currents, combined with the tremendous traffic, render unavailable any sort of machinery that will not yield to a forcible collision without breaking. The plant on the Frying Pan was run into and wrecked before it had done a teen years have now elapsed and there is still three years' work to be done, all progress having been repeatedly cut short by the failure of appropriations, and the funds having at no time been furnished by Congress with sufficient liberality to admit of the work being prosecuted regularly, rapidly, and economically. The cost of the work has been largely increased by this policy, but thanks to the improvements in machinery and explosives, and to rigid economy in expenditures, the original estimate is not likely to be exceeded. The results that have been achieved so far in Hell Gate are shown in the sketch Fig. 2. Way's Reef, Shell Drake, and Hallet's Point have been entirely removed, and Pot Rock, Frying Pan, and Hell Tap so far reduced as to cease to be obstructions to any but the largest vessels. Flood Rock, including the dangerous reefs known as the Gridiron, Hen and Chickens, and Nigger Heads, was

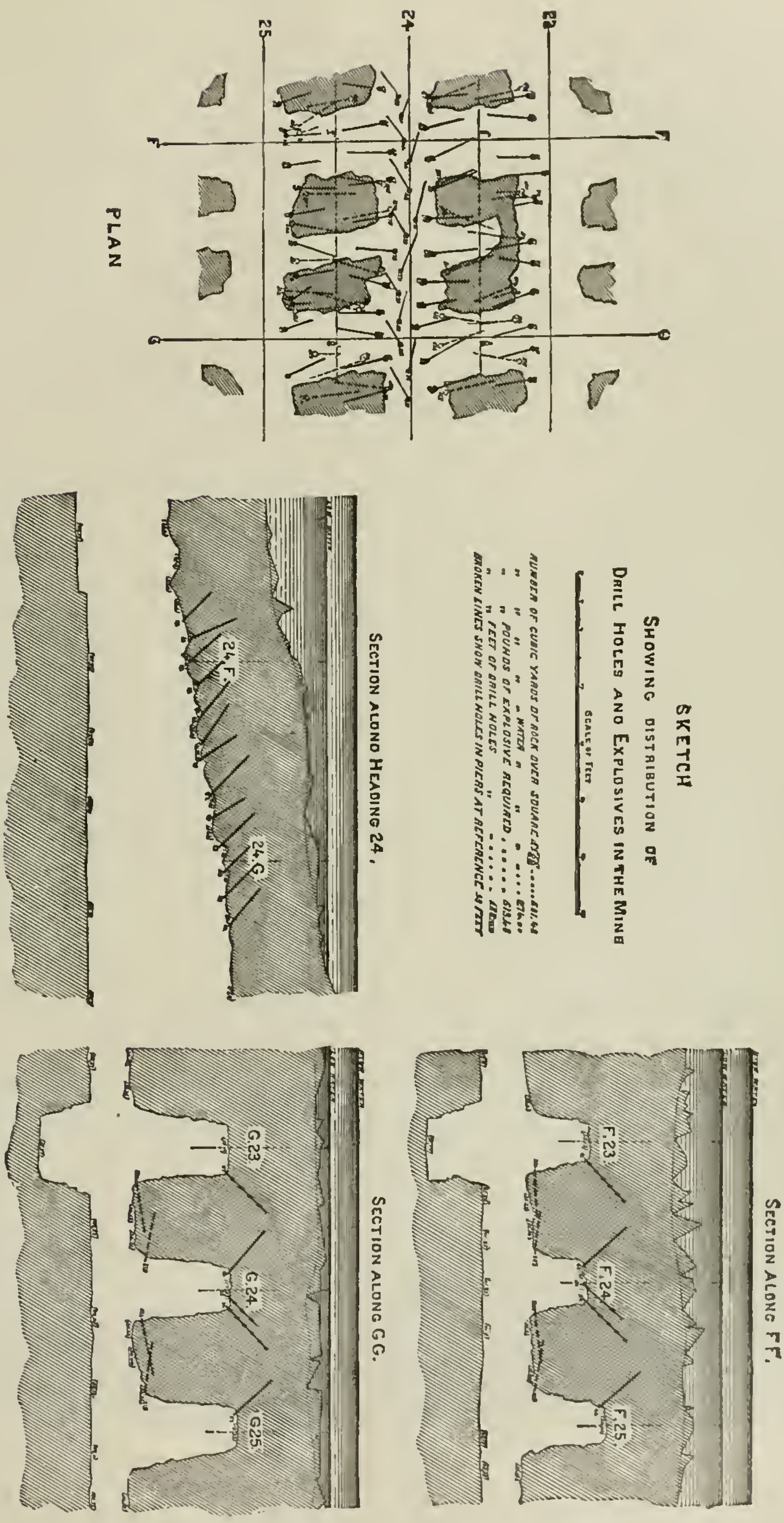


Fig. 4.—Distribution of Drill Holes and Explosives at Flood Rock.

Fig. 5.—Flood Rock. Interior view of Tunnel, showing the location of holes and method of loading them with the explosive contained in thin copper cases. The Illustration shows two men carrying the loaded cases, and one man pushing them in the holes. After the holes are filled with Rackarock within a few inches of their mouths a short case of Dynamite is inserted and left projecting to assist in producing explosion by "sympathy." The upper portion of the Drawing gives a sectional view of the Tunnel, taken by Harper Brothers.

on October 10 broken up to a depth of thirty feet at mean low water, and the work of removing the *débris* is in progress. Loaded ships drawing twenty-six feet of water pass through Hell Gate without danger, and wrecks on the rocks are now of very rare occurrence, and with great care may be avoided entirely.

The methods pursued by General Newton at Flood Rock were substantially those that he had tested with such success, though on a comparatively small scale, at Hallet's Point. Two shafts were sunk on the ridge of the reef, and from them two sets of parallel galleries were run at right angles to each other, undermining the whole nine acres of reef, and leaving it standing on pillars about fifteen feet square and about twenty-five feet apart from center to center (Fig. 3). The roof in the cross galleries was then blasted down, leaving it as thin as the character of the rock and the location under the river-bed would permit, as shown in section (Fig. 4). The cross-galleries were run at right angles to the stratification, so as to reduce the amount of timbering to a minimum: accidents from falling rock being inadmissible on account of uncertainty as to the character of the roof above and the proximity of the river. The average thickness of the roof was 18.8 feet, far more than was desirable, but as the penalty for cutting it too thin was the probable loss of all hands and work worth nearly $1,000,000, no unnecessary risks were taken. The least thickness was ten feet. Though the soundings on the reef were very close, and taken with great care, they would not distinguish between solid rock and loose bowlders bedded together and overgrown with shells. On this account, and the danger of breaking into large seams, the galleries had to be carried forward with great caution, only small charges being used and generally only one drill-hole at a time being fired. The effect of this is that 2.3 pounds of explosive and 11.97 feet of drilling were required per cubic yard excavated; the galleries averaging 10 × 10′ in cross-section. Far cheaper work could have been done had it been considered desirable to fire larger charges and several at the same time. One seam broken into was over ten inches wide and 100 feet long, with nothing but mud and sand in it to keep the river out. Such seams were always walled up solid with Portland cement as fast as they were opened out. Another seam, from one inch to four inches wide, was found to extend from one side of the reef to the other, a distance of over 400 feet. By tapping it with drill-holes the stream of water in it was found to be 350 gallons a minute. It being impossible to go around it or under it, it was decided to cut through it. As it was large enough to carry thousands of gallons, means had to be taken for protecting the completed part of the work in the event of the water coming in with a rush when the blasts were fired, breaking into the seam. This was accomplished by building across the gallery where the experiment was to be tried, a heavy door capable of standing the pressure of the river, and of being closed by a long line leading to higher ground. After crossing this seam a succession of others was encountered, that gave constant trouble seemingly without end, until the whole work was finished.

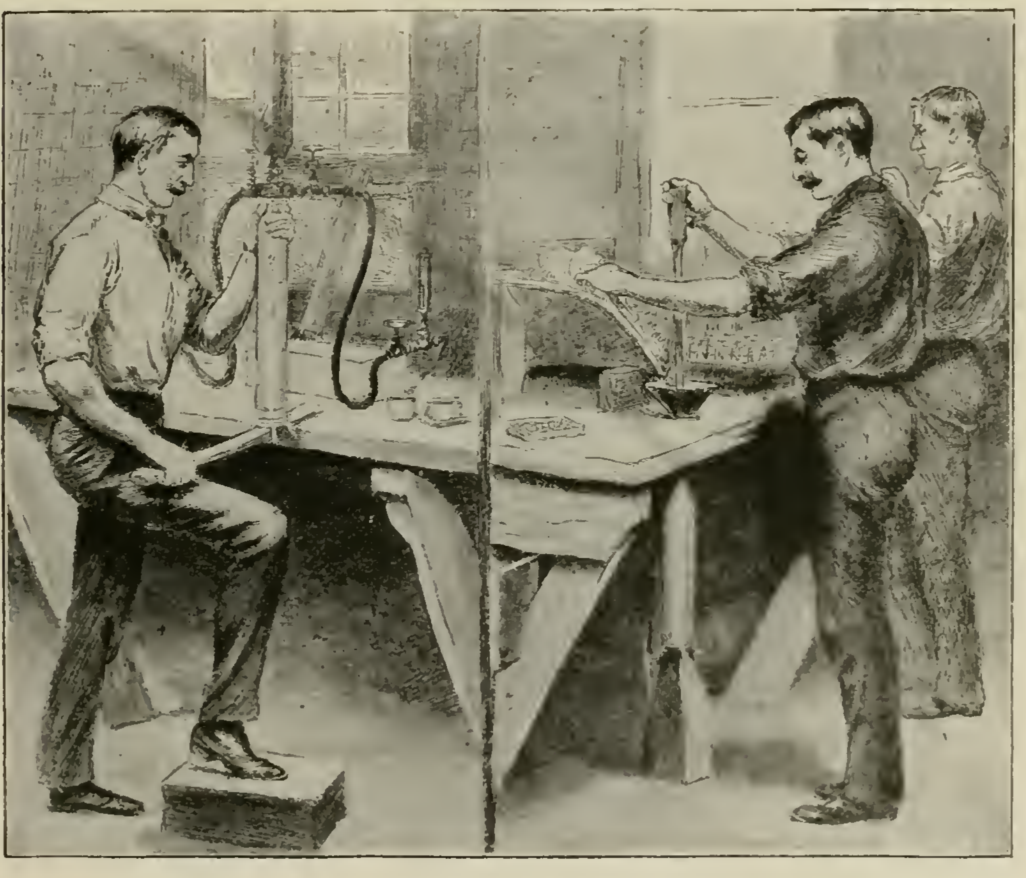


Fig. 6.

The precautions necessary, and the delays to all hands caused by so much water, combine to make this class of work far more costly than ordinary tunneling, but one of the fruits of the precautions is found in the fact that at Flood Rock 21,669 feet of tunnels were diven, 80,232 cubic yards of rock excavated, and about 480,000 pounds of high explosives consumed, with the loss of only one man. We are all familiar with the great cost in human life of all the great tunneling operations in this country, a cost which probably reached a maximum at the St. Gotthard Tunnel, where the mortality ran up to 377 lives lost. Before work was commenced at Hallet's Point it was intended to excavate a cavity sufficiently large to receive the *débris* from the roof, and leave a depth of 26 feet at mean low water immediately after the final blast; but on account of the extra expense of timbering and the fact that it requires 1.45 cubic yards of space to contain one cubic yard of roof after it is broken, this part of the project was modified, as it was believed that the required depth could be obtained more economically by dredging a portion of the *débris*. Experience at Hallet's Point proved the correctness of this view, and at Flood Rock the principle was carried still further, the rule there being to run just as few galleries as possible consistent with the proper distribution of the final charge. It was this policy, which is nevertheless unquestionably the correct one, that caused so much disappointment among those who expected to see Flood Rock disappear from view entirely when the mine was fired. It is a matter of some suprise that so many should have expected such a result, as it had been repeatedly published that no such effect was looked for or intended by those in charge.

After the completion of the galleries, the roof and the pillars to a depth of thirty-three feet, mean low water, were drilled with holes enough to contain 0.79 of a pound of No. 1 dynamite for every cubic yard of rock, and every 7,000 pounds of water overhead, amounting to 1.04 pounds per cubic yard of rock broken. The holes slanted upward at angles of 60° and 45°; the former, along the center of the gallery, were eight feet deep; the latter ten feet, to reach as far over the pillars as possible. These lengths were often reduced by the drill cutting into seams open to the river. The holes were of such a diameter as to receive *a rigid 2½-inch cartridge* throughout their entire length; 113,102 feet of such holes were required, and owing to their unusual size, and their upward inclination, they were only drilled efficiently after radical improvements were made in the best rock-drills in use elsewhere.—See Fig. 5. The average charge per hole was 22.5 pounds, which permitted a reduction in the amount of drilling required from 0.93 of a foot per cubic yard broken at Hallet's Point to 0.42 of a foot. Drill-holes of such large caliber are not generally used in this country; probably because the rock-drills in use are not adapted to drilling them. Most remarkable results were, however, obtained at Aarlberg Tunnel with holes of this diameter. By taking advantage of progress made in mining machinery and explosives, and making the improvements in methods outlined above, General Newton had been able to reduce the cost of preparing the mine for the reception of the final charge from $7.92 to $2.69 per cubic yard to broken as compared with his work at Hallet's Point. To secure an equally satisfactory result on the cost of the blast itself, an elaborate set of experiments was planned and carried out in the early spring to obtain more simple methods of firing the mine and to extend the list of the available explosives, which was then practically limited to dynamite or other nitro-glycerine compounds.

These experiments resulted in proving beyond question that all the electrical connections between the drill-holes and the battery could be entirely dispensed with, as the explosion of a ten-pound charge of dynamite would fire with absolute certainty, under water, another charge of dynamite packed in a thin elastic envelope at a distance of twenty-seven feet. They also proved the efficacy of means previously discovered at Flood Rock, of firing long narrow charges of rackarock, an explosive so inert (but consequently so safe to handle) that a pistol bullet may be forced into it at short range with impunity. See *Rackarock*. This explosive was afterward adopted for the great blast, its strength under water being somewhat greater than that of No. 1 dynamite, its cost but little more than half, and it having the very great advantage that any quantity could be kept in store without danger to New York City, as it need only be made explosible just before being taken into the mine. The total cost of the final blast at Hallet's Point was $81,092.24; at Flood Rock it was about

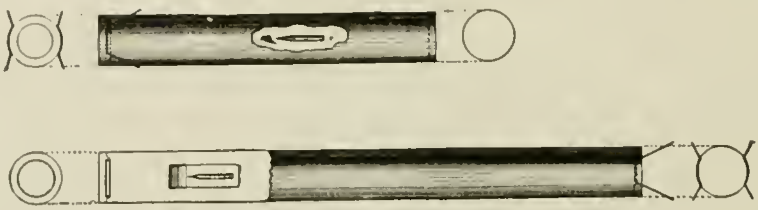


Fig. 7.

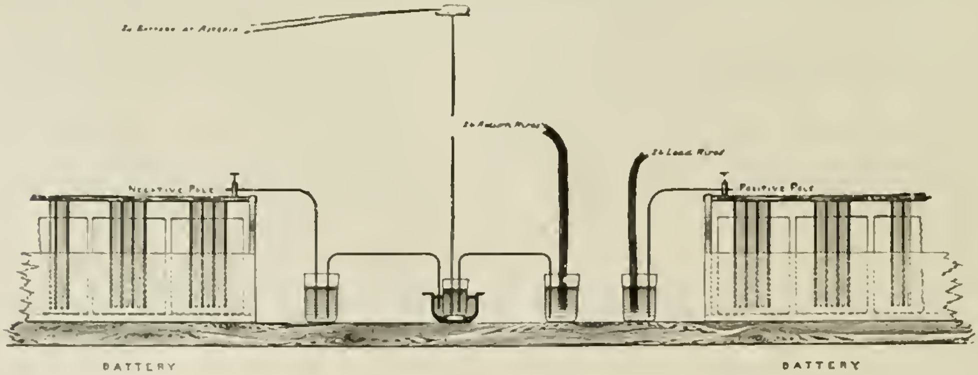


Fig. 8.

$106,509.93, though the blast was 5.6 times as large. The loading of the mine was commenced July 30, the Contractor having already delivered at the works 100,000 pounds of rackarock to begin on. The explosive, consisting of 79 parts of finely ground chlorate of potash and 21 parts of di-nitrobenzole, was mixed in small batches in a leaden trough and packed at once into cartridge cases $2\frac{1}{4}$ inches in diameter, and 24 inches long, made of copper 0.005 of an inch thick (Fig. 4). Into each cartridge was inserted a small exploder containing 30 grains of fulminate reinforced by one ounce of dynamite. The dynamite was not essential, and was only used on account of the hesitancy of the manufacturers to produce a larger primer of fulminate of mercury, this latter doing all the work of maintaining and transmitting the detonation. The cartridge being loaded, its lid was securely soldered on by a method devised at Flood Rock, using an alloy melting at 160° Fah., and a soldering-iron heated by blowing through it a jet of wet steam; 42,528 cartridges were thus soldered without accident. See Fig. 6. The boxes for carrying the cartridges to the mine contained twenty each, and were removed as fast as filled: so that the amount of explosive on hand above ground was never enough to do more than local damage in case of accident.

All the loading in the mine was done by a gang of twenty picked men, who worked from eight to twelve hours a day, from July 30 to October 9, putting the cartridges into the drill-holes. They showed no timidity and did not become reckless; their caution and steadiness were most commendable, as the accidental explosion of a single cartridge would certainly have resulted in the drowning of all who were not blown up. They only dropped one cartridge, which is very much to their credit, as the galleries varied in height from four to thirty-three feet, upward of 9,000 feet requiring scaffolding to reach the holes. The scaffolds used were made in sections that could be bolted together, and built to any height; they were mounted on the mine cars, and moved along on a portable track. The cartridges were kept from sliding out of the drill-holes by stout brass wires, which are shown in the sketch, Fig 7. In all cases the last cartridge put in was dynamite, which, in addition to being held in place by the wire springs on its sides, was securely wedged in the hole with wooden wedges. About six inches of it were allowed to project to receive the shock from the initial charges connected with the battery. Every dynamite cartridge contained a thirty-grain fulminate exploder, experience having shown the value of such an exploder in preventing an explosion of the second order. The copper cartridges were only 0.005 of an inch thick, tinned on the inside. They had been tested by submersion in the river for three months, and by standing for a like period loaded with *rackarock* in a warm room. Nevertheless, a considerable number of cartridges in the mine showed signs of corrosion some weeks before the blast. Fortunately, where this occurred, the odor of the *rackarock* and other indications made it known at once. The cause was soon found to be sulphur in the water running in certain drill-holes, which in a few cases was so strong as to completely destroy the copper in a couple of weeks. Fortunately, the number of such holes was not large, and the cartridges were safely withdrawn before any great number were damaged, and protected by being dipped in a wax made of rosin, beeswax and tallow. The holes were particularly bad under the ground made to receive the buildings and machinery, which was largely composed of ashes. Many coal-barges have been lost on the reef at various times, and may have caused the trouble in other parts of the work. This was the only unforseen difficulty that arose during the loading. It was remedied at small cost, but it caused great inconvenience at a very trying time. The number of pounds of *rackarock* put in drill-holes was 240,399; of dynamite, 42,331; total, 282,730 pounds. There were 11,789 drill-holes in the roof, and 772 in the pillars. The total amount of rock to be broken by the final blast was 270,717 cubic yards, covering an area of about nine acres.

The primary charges, whose office was to fire those in the drill-holes, were placed along the galleries at intervals of twenty-five feet. They consisted of two $24\times2\frac{1}{4}$-inch thin copper cartridges filled with No. 1 dynamite, solidly packed, lashed upon a horizontal timber at a height above the floor, varying from three to twelve feet according to the height of the gallery. On top of these was lashed a rigid brass shell, 8×2 inches, containing about one-half pound of dynamite put in loose, and a platinum fuse connected by wires with the battery on the surface at the head of the shaft. In the first case the dynamite was packed tight so that it should explode by sympathy in the event of its own fuse failing; and in the second, put in loose so as not to be affected by water should the brass shell be imperfectly corked. As far as practicable, in all cases adjacent charges were put on different circuits, so that if any circuit failed from any fault in the connections, its charges would still explode, both of the adjoining charges being within sympathetic range and on two different circuits. There were 591 of these primary charges arranged in 21 circuits of 25 each, and three circuits of 22 each, all coming together at the poles of the battery. Some of these circuits were nearly a mile long.

The fuses made especially for Flood Rock had a resistance of 1.73 ohms cold, and 2.76 ohms at explosion. They only required 0.205 ampères to fire a single fuse, or 0.615 ampéres to fire a series. A factor of safety of two was used, and double this current was sent through every fuse at the final blast. The battery was a most excellent one. Each cell had an electro-motive force of 1.95 volts and an internal resistance of only 0.01 ohms. The plates were six inches by nine inches—four carbon and three zinc in each cell, separated by only one-quarter of an inch. The ordinary bichromate solution was used. There were sixty cells, all coupled in one series, two large mercury cups constituting the poles. The twenty-four lead wires dipped into one of these cups, and the twenty-four return wires terminated in a third. Between this third cup and the remaining pole of the battery stood the circuit-closer, (Fig. 8). It consisted of a stout iron cup containing mercury, in which sat a thin glass tumbler, also partially filled with mercury. Two large strips of copper connected the mercury in the iron cup with one pole of the battery, and that in the glass with the cup containing the return wires. It is evident that to close the circuit through the fuses it would only be necessary to break the tumbler so as to let the mercury in it mix with that in the iron cup. To do this at the proper moment, a $\frac{1}{4}$-inch iron rod four feet long, terminating at the top in a small round disk, stood with its point in the bottom of the glass. It was long enough to pass through the roof of the battery house. An ordinary 30-grain platinum fuse connected with a small battery at Astoria was laid on the disk and stuck on with a lump of wax. It had been previously determined by experiment, that the blow struck by this fuse on exploding and transmitted by the iron rod, was so sharp as to reduce the tumbler to dust without splashing the mercury so as to risk closing the circuit imperfectly. This disk being a foot or more above the roof, there was no danger of the explosion of the fuse cracking the battery-jars or doing other damage to the connections inside the battery-house. The mine was flooded by two syphons, one twelve inches and the other sixteen inches. They were started at noon October 9, and the mine was full at 3:30 A. M. October 10.

General Newton set the time for the explosion at 11 A. M., but it did not occur until about 11:13. This delay was due to the electrical arrangements for firing the mine not being ready by 11 A. M.; though work was commenced at 4:30 A. M., running the torpedo cable from the rock to the Astoria shore, all the preparations could not be made and everything tested any sooner than they were. The mine was fired as soon as the battery and connections were ready. The explosion occurred over the whole area of the reef, as shown by ranges on shore, together with several instantaneous photographs taken from all sides. Though all the charges exploded at the same instant, the effect above the water-surface varied in point of time as well as in appearance with the strength of the rock and the depth of the water. There was no loud report and no dangerous shock through the earth, though a slight vibration was observed as far away as Cambridge, Mass. A few panes of glass were broken in the neighborhood, a number of loose ceilings came down, and several bricks were shaken from the chimney of a house near the water's edge in Astoria. This was all the damage done, but it was enough to show that the amount of explosive fired was quite as large as ordinary prudence would warrant. Several handsome engravings, made from photographs taken at the time of the Flood Rock explosion, may be seen at the close of this Volume among the illustrations under *High Explosives*.

When the water subsided the surface of the river was covered with a thin mist of reddish fumes. It has been suggested that these fumes indicated an explosion of the second order. Lieutenant Derby, however, reports that he has often observed them on a small scale when firing either dynamite or rackarock under water, when there was no reason whatever for suspecting anything but a complete detonation. If they are not properly one of the products of the reaction in an explosion of the first order ordinarily, it is probable that they are caused by the action of some of these products at a high temperature on the finely-divided water.

A diver was put down on the reef as soon after the explosion as possible. Wherever examined it was found shattered and cracked; the surface-blocks very large, but in good shape to be dredged with a reasonable amount of surface-blasting. More could not have been expected. Proposals were advertised for at once, and a contract let October 21 for the removal of 30,000 tons, at $3.19 per ton, the contractor to do his own surface-blasting. The first contracts on Hallet's Point were let at $2.40 and $2.29, but the Government agreed to break up the large blocks. When the third contract was let, on the same terms as to surface-blasting as the Flood Rock contract, the price was $3.19. It is considered therefore that $3.19 for Flood Rock is, on the whole, a very satisfactory price for the first contract, as the removal of the top layer is by far the most difficult part of the work. As before stated, the cost of running tunnels under a river-bed, keeping as *close* to the water as possible, cannot be compared with that of tunneling under ordinary circumstances, particularly when the engineer is required by law to pay the same wages for eight hours' work as a contractor would pay for ten, and the same munificent Government supplies the funds at such a rate that only two years in ten can he work his whole plant, and three of the remaining years must stop altogether, while such items as pumping, superintendence, and care of plant run on, work or no work.

Comparing the results at Flood Rock with those at Hallet's Point, however, where the circumstances were much the same, we find the cost of mining a cubic yard of rock has been reduced 34⅝ per cent; showing at least as much improvement in such work during the last decade as has occurred in tunneling generally. The total cost of the work so far done on Flood Rock amounts to $2.99 per cubic yard of the total amount of rock broken $5.66 less than the cost of breaking at Hallet's Point. A considerable portion of this gain will, however, be expended on the proportionately larger amount of dredging to be done. The net result, however, will show us an improvement of not less than thirty per cent, and probably more. Pending the awarding of the contract for dredging, a large scow belonging to the Government was set to work removing the broken stone as soon after the explosion as possible. The large blocks are slung with chains by divers, and hoisted out. From fifteen to thirty tons of rock are thus removed daily at an expense to the Government of a little *less* than the amount paid the contractor. The contractor has two large grapples at work and is averaging just about 120 tons per day. General John Newton, though lately promoted to be Chief of Engineers, United States Army, still retains the improvement of Hell Gate in his own hands. The pleasant duty of assisting him has at different times since 1867 fallen to the lot of Captain W. H. Heuer, Captain James Mercur, Colonel Walter McFarland, and Lieutenant Derby, Corps of Engineers.

To the admirable paper of Lieutenant Derby should be added a description of the special bit invented by him, and used in making holes with less reduction in diameter than with the ordinary X-bit. The work of drilling holes in the roof, and to a small extent in the columns for the charges of powder for the final blast, was commenced with the ordinary X-bit. As it seemed necessary to use metallic cartridges a variety of diameters (of cartridges) were used on account of the holes being so much smaller at their ends than at their mouths. Although the first X drill-bit was 3¼ inches, it seemed impossible to use a cartridge larger thon 2 inches diameter at the end of the hole. This fact lead to experiments on the part of Lieutenant Derby, which lead to most happy results in the production of what is known as the tubular-bit. In this bit the cutting surfaces are so distributed as to utilize the power applied with a greater economy. As used at Flood Rock, the drilling-bar was hollow, having a cutting-tool on its end also hollow. The cutting-tool had six cutting-points, and in its operation a little core was formed, which disappeared, however, under a slight blow from the end of the drill-rod. The débris were washed out as fast as made, and consequently little force was spent in pulverizing the rock after it was broken off. The result of this was the drilling of $73,984\frac{79}{100}$ feet of holes for the final blast, 59.5 per cent. faster than with the X-bit, and making the holes of at least 25 per cent. greater area at the bottom. This permitted the use of cartridges 2½ inches diameter and in many of the holes even 2¾ inches could have been used, although the bit at the start was only 3½ inches in diameter. The experiment to determine these comparative results continued through months, and an average is made on 39,119 feet drilled with the X-bit and 39,200.75 feet with the tubular. The total number of feet drilled for the final blast, which was done entirely by the Little Giant drills, was $113,101\frac{78}{100}$ feet. Very much of this work was done in the roof, which in most places was too high to be reached except by placing the column on the top of a temporary staging erected for the purpose. As but few holes could be reached in one setting of the staging (generally two) much time of the eight hour shift was occupied in moving.

The ordinary forms of bits are forged on the ends of steel bars of different lengths, the diameter on each additional length decreasing slightly to conform to the wear on the shoulders of the preceding bit. On the opposite end a head is turned or forged to fit into the drill-chuck. In very loose, seamy rock a Z-shaped bit is sometimes used to advantage. Any blacksmith can dress and, in a short time, make the bits. *Much depends upon their being properly dressed and tempered*, and their form and manner of cutting secures a greater saving as compared with hand-drilling where both ends of the steel are worn away rapidly. See *Rock Drill*, *Submarine-drilling*, and *Submarine Mines*.

SUBMARINE-DRILLING.—Previous to the invention of power-drills submarine drilling had many costly limitations. It is very doubtful if many of the operations now undertaken for the removal of submerged reefs would ever have been successful had it not been for that valuable auxiliary, the steam-drill, and the useful appliances that attend it. When, in 1832, Congress made an appropriation for the removal of the rocks at Hell Gate, Major Frazer, of the Engineers, began operations according to the methods suggested by Maillsfort; and the result was an expenditure of eighteen thousand dollars in knocking off the jagged points of the rock by surface-blasts. When the smoother top of the ledge was reached surface-blasts had no effect, and in order to make further progress it was necessary to drill the rock for the insertion of explosives. The problem admitted of two methods of solution. First, drilling through the water nto the rock. Second, going under the rock surface with a network of mines and galleries, and breaking up the roof and its supports by a simultaneous explosion of the whole mass. The first-named system was considered impracticable at that time, and it doubtless was. The steam-drill had not been adapted to submarine work. The chain-drill involved the assistance of divers who could not work in the swift current of Hell Gate. Under favorable circumstances progress with these clumsy appliances was slow, and the fleet of barges which must be employed over the rock was in constant danger of collision with passing vessels. These were the main reasons which induced General Newton to adopt the system of submarine-mining. It is doubtful, in view of the improved appliances which have been successfully introduced, subsequent to the beginning of operations on Hell Gate, if the under-mining system will ever again be resorted to. We look upon the stupendous operations of Hell Gate with wonder and admiration, but we can learn nothing, so far as the general system is concerned, that will guide us in the future. Hell Gate, therefore, does not come under the title of submarine-drilling; the process employed there differs in no important feature from all the general systems of mining and trenching employed throughout the United States. It is scarcely necessary to add that mining at best is far more expensive than open-cut work, and is only resorted to where open-work, or the bench process, is impracticable.

The United States steam-drilling scow was first introduced in the spring of 1869, for the removal of reefs in New York Harbor. At the time of its conception little was known of the use and adoption of the steam-drill in submarine work. The drilling-scow consists in the main of an enormous barge with a well through its center into which is fitted a metallic dome. This dome is lowered to the rock, and drilling progresses through tubes inserted in the surface of the dome. Perhaps the most successful work accomplished by this scow was the removal of Way's Reef in New York Harbor, in 1874. Following is a full report of the operations:

When drilling was first commenced the maximum length of Way's Reef measured 235 feet and its maximum width 115 feet within the 26-foot curve, and its maximum depth was 17.4 feet at mean low-water. The reef runs in a north-easterly direction, and consists of gneiss, vertically stratified. While the scow was undergoing repairs, (the dome being provided with a new set of enlarged drill-pipes for allowing the use of larger drills, and the hull of the scow being stiffened by means of two keel-logs,) during the month of July, 1874, the character of the tidal currents was then investigated, and some soundings were taken off Way's Reef. The results of these observations were: 1st The ebb-current runs swifter than the flood-current over Way's Reef. 2d. That the velocity of tidal currents gradually diminishes from the channel-end of the reef toward the shore-end. 3d. Maximum ebb and flood currents set in nearly opposite directions, the angle of the divergence being 20°. 4th. Ebb-current assumes near the northeastern extremity of Way's Reef a velocity of over three nautical miles per hour during the mean tides. 5th. The change of current happens near the stands. 6th. Mean rise and fall of tides is in Pot Cove 6 feet. 7th. About 400 feet to the eastward of the reef the water reaches a depth of 65 feet at mean low-water, and to the westward of the reef the depth of water is about 49 feet. Ranges were established for locating the center-anchors with regard to this condition, favoring the direction of the stronger ebb-current, and allowing about 450 feet of chain for the (east) forward center-anchor and 350 feet for the (west) aft center-anchor. The (south) port-anchors were carried close in shore, in order to take advantage of the less disturbed waters of Pot Cove for change of position of the scow when it is moved off the charged drill-holes. The chain then employed did not allow a large scope; still it was found necessary to change the position of the anchors but four times. Independent of the center-anchor ranges, seven signals for sextant-observations were erected along the Astoria shore, and additional sets of ranges for indicating the center-line and the two ends of the reef. A large tide-gauge staff, which could be read from the deck of the scow, was set up, to secure a constant and reliable reference to mean low-water.

The average working force of the United States steam-drilling scow, while engaged on Way's Reef, numbered thirty-seven men, consisting, besides the reporter, of one mechanical draughtsman, two divers, one chief carpenter, two carpenters, one engineer, eight drillers, one blaster, one blacksmith and two blacksmith helpers, twelve sailors, two firemen, one time-keeper on the dredge, and one tide-gauge keeper on board of the scow. This crew was divided into two gangs. The day-gang, thirty strong, commenced operations at 7.30 a. m. and continued work, under ordinary circumstances, until 4.30 p. m. The running of anchors, placing the scow in position, lowering the dome, charging and firing the drill-holes and surface-blasts, and the survey of the open frame were committed to their charge. The night-gang consisted of one diver and four sailors, making submarine surveys, and marking, with weights, the points for drilling. If drilling continued at night, the force of the night-gang was augmented by the required number of drillers and firemen, taken from the day-gang. They also connected the plugs which stop each drill-hole with plug-lines and hoisted the dome. Every week the *personnel* of the night-gang was changed. Each position of the dome was located during the drilling operations, by means of sextant observations, both in reference to the center and the center-line of the dome. These positions were plotted, and finally transferred upon the drill-hole sheet, upon which each separate hole, as actually drilled, charged, and exploded, was carefully laid down. Whenever ledges of rock occurred drawing less than the required depth, the dome was lowered upon them and drilling instituted. Small rocky points projecting above the 26-foot curve were surface-blasted. Advantage was taken of the knowledge of tides and tidal currents to work nearer the shore-end of the reef during spring-tides, and the channel-edge was visited during and near neap-tides. This management had the additional advantage of reducing the force as well as the number of collisions. Three collisions happened, nevertheless, while anchored over Way's Reef, but all of them without noteworthy damage to the colliding crafts. Tin cans of conical shape, allowing about three-eighths inch play with the sides of the drill-holes, and in length equal to the depth of the hole, were used to contain the charges of nitro-glycerine. In shattered rock, where a filling of the drill-hole could not be prevented by the use of the wooden drill-hole plug, an empty cartridge was inserted into the hole directly after the withdrawal of the drill. A second cartridge, well charged with the explosive, equal in length to the first, but of smaller diameter, was afterward inserted in the empty tin tube. A stopper made of old rope "shakings" was forced into and secured to the muzzle of the filled cans, in order to prevent the spilling of the explosive fluid in lowering the charges. Cylindrical and prismatic cartridges were used for surface-blasting. The form and dimensions of the shells were suited to the configuration of the bottom, projecting above the 26-foot curve, and subject to removal. These charges were provided with weights and lines, to secure close contact to the rocky surfaces. The nitro-glycerine was furnished by the Messrs. Mowbray, Gilbert & Warren. It stood well all qualitative tests. The nitro-glycerine was stored in the magazine on Flood Rock until the floating ice interfered with communication between the rock and the scow. From this time out, from the end of December, 1874, the nitro-glycerine was carefully secured on board the scow. The frozen nitro-glycerine was warmed in a large wooden tank, filled with water not exceeding in temperature 85° Fahrenheit. The tins containing the explosive were placed directly in the tank. This manipulation was commenced about four hours before charging the holes. Previous to the explosion of the charges the remaining stock of nitro-glycerine was sent off about 600 feet from the reef in a row-boat, in order to remove it without the sphere of explosion by concussion. The drilling-scow was withdrawn a distance of 150 feet for charges below one hundred and seventy-five pounds, and a distance of about 250 feet for charges upward and to five hundred pounds. These distances were all exceeded whenever the holes were drilled into the more projecting part of the reef, and particularly whenever the direction of a hole, owing to the "canting" of the dome, made a "blowing-out" in the direction of the scow probable.

During the month of September, 1874, experiments were made with the fuses offered in the market, to test their capacity and merits in exploding frozen nitro-glycerine. These investigations resulted in the construction and adoption of two improved fuses, one frictional and one for voltaic electricity, which are safe to handle, are impermeable to water, and fully reliable to explode frozen nitro-glycerine. Said fuses contain in the bottom of a stout copper cap twenty-five grains of fulminate of mercury, which effects the initial explosion of the nitro-glycerine charge. The fulminate-charge itself is fired by Brown's No. 4 composition in the fuses for friction-batteries, and by the ignition of gun-cotton in the fuses for voltaic electricity. In the first case, the electric spark, jumping across between the ends of the connecting-wires, decomposes the priming; in the second case, fine platinum wire, heated by the voltaic action, fires the gun-cotton priming. In both fuses the priming is contained in hollow cylindrical wooden cases. Paper disks cover the priming and press it to the wires. These wooden priming-cases act as plugs for the stout copper caps into which they are forced. The water-tight union between cap and plug is secured by indenting the former into the wood of the latter. In addition, the fuses are steeped in a mixture of beeswax, rosin and tallow. Smith's friction battery and Bunsen's trough-battery were employed for igniting the fuses used as motors in exploding the nitro-glycerine charges. Gutta-percha-covered wires formed the connection between battery and charges. Much wire was saved by the substitution of under-ground conductors in the place of a continuous-wire circuit. Owing to the close proximity of the shore-line, limiting the maximum charge to about 500 pounds of nitro-glycerine, the number of holes simultaneously fired was reduced to nine. Not one misfire happened. The blasted rock was taken up by Messrs. Morris & Cuming's dredge, which was set to work when the *débris* of the blasts had spread over the greater part of the reef.

The effect of an average blast on this reef is to cover with *débris* the rock within a circle of about 40 feet diameter. Owing to an increase in the diameter of the drill-holes by the introduction of 5½-inch bits in place of the original 3½-inch bits, while retaining the primitive distance between the drills, the rock was well broken up by the blasts. Thus a vital point was gained in submarine-dredging. Care was taken to keep both dredge and scow steadily busy. In the beginning, and until more favorable arrangements could be made, the dredged *débris* was dumped by the scow-force, with permission of riparian owners, within the established bulk-head line of 1857, along the Astoria shore. Afterward the Commissioners of Public Charities and Correction made application to take loaded scows away, and used the dredged material for filling in at Blackwell's Island. The scows had an average capacity of two hundred and fifty tons. The Commissioners, in discharging or dumping this material, frequently exposed the scows to hard rubs, and the owners declined to have them further employed in this manner. They were afterward unloaded with the working force of the scow, until Morris & Cumings, for the sake of using the stone, undertook this labor at their own risk and expense. After the grapple-machine had nearly cleared the reef of the *débris*, it was transferred to the Harlem River, where it was employed in the removal of the old bridge-abutments obstructing navigation between East One hundred and Fourteenth Street and Ward's Island. A stone-rake attached to the steamer Geneva was now employed to complete the removal of the blasted rock by sweeping it into deeper water on both sides of the center-line of the reef.

Between the time of the arrival of the scow over Way's Reef, at 12.15 p. m. August 4, 1874, and to the date of the successful removal of the reef, 4.30 p. m. January 20, 1875, about 134 hours were occupied in the systematic survey and re-survey of the whole reef, by means of divers, following a horizontal bar to be dragged over the rock and lowered to the required depth, corrected for the stage of tide by reference to the tide-gauge reading. This horizontal bar, a 3-inch iron pipe, 18 feet long, was fastened at its extremities to two wrought-iron uprights graduated in feet and halves. The whole frame could be raised and lowered to any depth by means of windlasses secured to two coupled pontoons. When sweeping with this "sounding-machine" the uprights were held by guys in a vertical plane. Each time the frame struck, the character of the obstruction was thoroughly examined. Loose stone was either hoisted on deck or rolled into deeper water by the divers. Imbedded rock was submitted, as the case seemed to call for, either to drilling and blasting or to surface-blasting processes. An additional verifying sweep was made after this operation. If the result was not entirely satisfactory, the attempts to complete the removal were continued until the frame passed freely over all previous obstructions. In all, the dome was lowered sixty-five times for drilling purposes. Drill-pipes were sometimes shifted in position with a view of producing a larger number of sound-holes. Sometimes the dome was shifted in position for this purpose also. In addition to the 65 drill-hole blasts, 16 surface-blasts were exploded

The following is a *résumé* of the drilling, dredging and blasting operations: Total number of holes drilled, 262; total number of feet drilled, 2,130.4. The total amount of explosives used were—For 65 drill-hole blasts, 15,308 pounds 12 ounces nitro-glycerine. For 16 surface-blasts, 1,484 pounds nitro-glycerine and 38 pounds 8 ounces dynamite. Cubic yards of rock removed, 3,029. Total time of dredging, 86 days, 10 hours, 21 minutes; total time of stone-raking, 58 hours, 35 minutes. Average number of feet of drilled holes to each cubic yard, 0.7. Average number of pounds of nitro-glycerine to each cubic yard, 5.54. Average number of feet of holes drilled by each machine per shift of 8 hours, 6.5. Average depth of holes, 8.13 feet. Average cost of linear foot of hole drilled, including placing of scow, lowering dome, expenses for drilling, cost of sharpening drills, expenditure of steel hoisting up dome after drilling operations, and heaving off scow, $2.05. Average cost of sharpening a drill, $1.41. Average number of feet drilled to each sharpening, 8.13. Expenditure of steel to each foot of hole drilled, 2 pounds 7 ounces. Average cost of dredging and dumping one cubic yard of *débris*, $4.29.

RESUME OF OPERATIONS.

Total amount of explosive used for 65 drill-hole blasts	15,308 lbs. 12 oz.
Total amount of explosive used for 16 surface blasts	1,484 lbs. 3 oz.
Total number of holes drilled	262
Total number of feet drilled	2,130.4
Cu. yds. of rock taken up by dredge	3,029
Total cost of 1 cu. yd. rock removed	$18.26

The U. S. steam drilling-scow was built at a cost of several hundred thousand dollars, and has outlived its usefulness. Simpler and more effective means are now employed which give by far more economical results.

In the year 1877 an interesting work was carried on in Lake Superior for the removal of the reef obstructing the entrance to Eagle Harbor, Michigan. Following is a report of the work:

After the approval of the project as submitted by Maj. F. U. Farquhar, Corps of Engineers, U. S. A., and the purchase of machinery and supplies to carry the same into operation, the work of drilling and blasting commenced July 15, 1875, and continued until November 1. Upon the re-opening of the harbor, May 15, 1876, the work was resumed, essentially upon the same plan as of the previous season, and continued until the closing of the harbor in November. Upon May 24, work was resumed, and continued until September 15, 1877, at which date the removal of the rock was completed. Upon the resumption of work in 1877 about one month of drilling and blasting was necessary to complete the progressive part of this division of the work; this was at once undertaken, and arrangements made for the employment of a dredge to remove the broken rock. After a careful examination of the dredges obtainable, and propositions from their owners for their use and operation, selection was made of a modified "Otis" machine, owned and operated by Messrs. Williams & Upham. The equipment was to consist of a dredge, tug, and stone-scows, fully manned by experienced crews; the owners to pay all expenses of operating and keeping the equipment in repair, and assuming all risks to their property. The contractors were guaranteed not less than 600 hours' work, provided the equipment was at all times adapted to and capable of performing the work to be done. The whole to be under the supervision and direction of the Engineer in charge. For such service the following rates were to be paid in full of all demands, viz, $13 per hour for time actually engaged in removing rock, and $5 per hour for time (otherwise working time, and not to exceed 10 hours in any one day) during which the condition of the lake was such as to prevent work, or for such time as the Engineer in charge should for any cause, elect that no dredging be done.

The dredge used was well adapted to the work, its double engines giving strength and rapidity of movement, and its short length, 65 feet, allowed it to withstand the almost constant swell, permitting work in a sea such as would have forced a longer dredge to stop.

It could be quickly moved from one position to another, which was an important consideration, since the area worked over was large when compared with the quantity of rock to be removed. Arrangements were perfected with Messrs. Williams & Upham early in June, but necessary changes in the machinery prevented the beginning of dredging before June 26. This was nearly one month later than had been previously estimated, and delayed the completion of the work nearly a month beyond the expected time. The dredge completed its service on September 6, having been engaged through an interval of 33 days, or 3 days in excess of the previously estimated time, removing 3,000 cubic yards of rock and 200 cubic yards of bowlders. This gives an entrance into Eagle Harbor of 130 feet in width, with a depth of 14 feet below low-water of February, 1868, which is in accordance with the project as approved. In carrying into effect the project as originally submitted, experience suggested but slight modification of the details while in the general plan no change has been suggested which would have added to the value of such original plan or the economy of putting it into operation. It may be of value to examine the operations of drilling, blasting, and dredging in detail, and make therefrom such deductions as seem to be justified.

The great obstacle in drilling was the deposit of gravel, sand, and bowlders covering the surface of the rock. It was nearly overcome by the use of drill-pipes, as described in the report of 1876. During the season of 1875 the drilling was pushed far ahead of the blasting. The unexploded holes were protected from filling with sand and gravel by wooden plugs with weights attached. These were torn out by the storms and ice of the winter of 1875 and 1876, and the holes thereby lost. This is the cause for the discrepancy between the number of holes drilled and blasted in 1875. During the seasons of 1876 and 1877 nearly 90 per cent. of the drilling was utilized; a large part of the 10 per cent. lost was due to the abandonment of the holes, soon after starting the same, on account of the presence of small masses of copper, which prevented the further advance of the drill-steel. This dissemination of copper through the rock threatened at one time nearly insurmountable difficulties. It occurred where a vein, and laterals thereto, intersecting the rock, carried large quantities of copper. A single mass of pure metallic copper weighing over 600 pounds, together with over 1,000 pounds in masses varying from a few ounces to several pounds, were removed from an area of about 200 square feet. In holes having an average depth of 7.3 feet, about one-half the cost of labor in drilling belonged to the first 2 feet. The entrance of the drill-pipe was generally secured at this depth, protecting the hole from further danger of filling. It was this experience which led to increasing the distance between holes and drilling to a greater depth. The change of practice in this respect will be seen by an inspection of the table on page 314.

The following is taken from the final report of Mr. L. Y. Schermerhorn, Assistant Engineer, on the removal of the rock obstructing the entrance to Eagle Harbor: A *résumé* of operations during the three last seasons may be of interest, the details having been given in the reports of 1875 and 1876.

During the last season the holes were drilled to 20 feet below the surface of the water, or about 4.5 feet below the bottom of the intended excavation. It was expected that as dredging progressed further drilling and blasting would be necessary, both in breaking up masses of rock too large to be removed by the dredge and in reducing points above the bottom. This division of the drilling and blasting required 65 additional holes, with an aggregate depth of 390 feet. Thirty holes in this latter drilling were expended on rock broken in two large masses, while the remaining 35 holes were to reduce points which the dredging showed to be above the bottom. In drilling these holes the platform hitherto employed was replaced by a single tripod conveniently arranged. Upon the platform of this tripod the drill was placed, and the tripod and drill together easily and quickly moved from point to point by the derrick of the hoisting-scow. This arrangement occupied but little space, and could be placed with certainty over the points where drilling was required. It might well be used in drilling isolated bowlders obstructing river-beds or harbor-entrances; the entire cost was less than $25.

In nearly every case where reduction of high points was required it was for less than 1.5 feet in depth. A notice of the sketch showing the location and extent of points requiring redrilling and blasting, shows it was nearly confined to that part of the ledge which consisted of amygdaloid-trap, traversed by seams of chlorite in both vertical and horizontal planes, which caused the rock to fracture in small cubes, and more like rotten shales than trap. In this particular rock the explosives throw out quite limited craters, leaving high points between the holes. This peculiarity in fracture was not recognized until developed by the dredging; had it been known earlier the holes would have been placed with less distance between them. The tendency of the explosive to simply throw off the collar of the hole was shown in the inner part of the reef, which consisted of a belt of sandstone and conglomerate. This difficulty was at once obviated by placing the holes nearer together (about 5 feet each way) and using quite light charges of the slower explosive, or No. 2 dynamite. In the crystalline trap the rock was in all cases broken to the bottom, and without doubt of the satisfactory results. The holes might have been placed at greater distances apart or the quantity of dynamite might have been slightly reduced. In the matter of explosives, the action of the No. 2 dynamite was more satisfactory than the No. 1, in that the former, for the same amount of nitro-glycerine, produced a fracture of the rock extending to greater distances from the hole. The No. 1 dynamite broke in much smaller pieces, but the action was confined to the immediate vicinity of the hole. The No. 1 and No. 2 were generally used together, placing about one-half of the No. 1 in the bottom of the hole; this was followed by the No. 2, while upon the top was placed the remaining quantity of No. 1, in one of the cartridges of which was placed the exploding-cap. The energy of the final explosion seems to depend, within certain limits, on the character of the initial explosion, *i. e.*, a strong initial explosion producing a more complete resolution of the nitro-glycerine into its gaseous constituents. For this reason the exploding-cap was placed in a cartridge of No. 1 dynamite (which is perceptibly quicker in explosion than No. 2,) securing the explosion of the No. 2 dynamite by the action of the upper cartridges of No. 1. There are now offered a large number of explosives, in all of which nitro-glycerine is the essential explosive agent. Competition has led to a considerable reduction in prices, which may be easily obtained by the omission of a part of the nitro-glycerine they previously contained. Since the value of the explosive depends entirely on its nitro-glycerine, some means should be had of easily determining this amount. It is claimed by the manufacturers of dynamite that it contains the following proportions of nitro-glycerine, viz: No. 1, 75 per cent.; No. 2, 33 per cent.

The following tabulated statement shows the details of drilling and blasting by the seasons in which the work was done:

the low-water plane of February, 1868. The reading of the gauge during the time dredging was done was from 1.3 to 1.5 above this plane. An examination of the gauge-readings, taken at Superior City and Marquette, establish this plane at least 0.3 below the lowest water had in 15 consecutive years during the season of navigation. The dredging passed over the area of work in cuts having a width of 20 feet, and in direction parallel to the center-line of the entrance. The dredging was carried to the full depth wherever the rock was sufficiently broken. When extremely high points or improperly broken rock was met with, the dredge thoroughly removed all superposed fractured rock. This was imperative, since further drilling became nearly impossible until the broken rock was removed from the surface. In this the dredge had to be frequently moved and changed in position. These high points, although singly occupying small areas and containing small volumes, occurred at such frequent intervals as to require the second passage of the dredge over a large part of the entire area. The rock had an average weight of 169.4 pounds per cubic foot. The rock was carefully measured by the scows' displacement of water; a memorandum of volumes occupied in the scows by the broken rock and solid rock therein contained, shows that one cubic yard of solid rock made 1.83 cubic yards when dumped in scows. The larger masses of rock were chained by the diver and removed by the hoisting scow; they were usually much less than one cubic yard in volume. The rock dumped in scows averaged less than one cubic foot pieces. The dip of the rock was towards the north, and at an angle of 30° from the horizontal; this required the progressive movement of the dredge with the dip, so that advantage might be taken of the tendency of the dipper to follow the stratification, and thus work below the bottom. At the same time the position of the beds and planes of cleavage constantly tended to leave the bottom of the excavation serrated in section, and against these projections the dipper was constantly abutting. The dredge was obliged to advance from the inner to the outer part of the reef, for the reason previously given, and also since by so working the almost constant swell was met by the bow of the dredge. Any other position would have permitted work only during the smoother condition of the lake.

The cost of dredging rock depends—outside of the adaptability of the dredge to the work to be done—upon the following conditions:

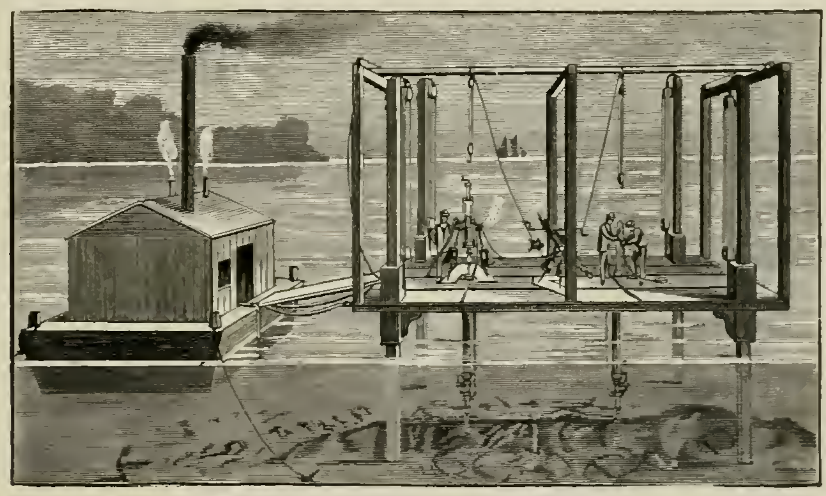
1st. Degree of rock-fracture.
2d. Position of rock-beds and stratification.
3d. Depth of rock to be removed.
4th. Protection against sea and wind.

The first depends on the details of drilling and blasting. Within limits it is cheaper to expend in thoroughly breaking the rock into comparatively small masses

Season.	Number of holes drilled.	Aggregate depth.	Average depth.	Average distance between holes.	Number of drills sharpened.	Number of hours drilling.	Average rate drilled per hour.	Amount of steel used.	Number of holes exploded.	Average dynamite used per hole. No. 1.	Average dynamite used per hole. No. 2.	Contained nitro-glycerine.	Aggregate dynamite used. No. 1.	Aggregate dynamite used. No. 2.
		Feet.	*Feet.*	*Feet.*				*Yds.*		*Pds.*	*Pds.*	*Pds.*	*Pds.*	*Pds.*
1875	392	2,099	5.35	5.0	656	890	2.36	51	147	0.51	3.0	1.37	75	441
1676	309	1,945	6.3	7.7	132	727	2.67	40	275	2.8	11.9	6.0	775	3,260
1877	183	1,343	7.34	8.5	88	609	2.26	32	154	3.89	12.33	7.0	600	1,899
	884	5,387	....	....	876	2,226	....	123	576	....	....	....	1,450	5,600

DREDGING.

The rock was removed to a depth of 14 feet below than to economise in drilling and explosives and expend in dredging the extra amount of time required in removing too coarsely broken rock. The second, or position of rock-beds, presents the best condition when thin stratification and horizontality exists, and the most unfavorable when the beds are tilted at an angle something less than 45°, or when stratification does not exist. Yet even then these advantages largely disappear when the fracture is carried well below the intended bottom of the excavation; and for this reason it seems better to carry the drilling rather excessively than otherwise below bottom. It would have been better at Eagle Harbor to have pushed the drilling to greater distances below bottom than it was. The increased depth (see table page 314) of 1877 gave better results than those obtained from even 1876. Where horizontality of bed obtains this is not so essential, since advantage in dredging is had from the floor-like bottom then obtainable. The third condition, or depth of rock to be removed, depends upon the fact that the time occupied by the dipper in descending, moving along the bottom, ascending and dumping, is the same whether the depth of the rock to be removed will entirely fill the dipper or only in part. This depth is limited by the dimensions of the dipper, and if it have a capacity of about a cubic yard, its depth will be about 3.5 feet. It is manifest that a less depth of broken rock than 3½ feet will then require nearly as much time in removal as the depth stated. A greater depth than 3½ feet would allow the formation of a bank before the dipper, through which it, in the ascent, could readily obtain the material to fill it to its entire capacity. Again, as the depth to be removed falls below 3½ feet, the dredge must be moved frequently, adding to the time practically lost. It then seems permissible to say that under circumstances otherwise similar, if the cost of the removal of rock having a depth of 3.5 feet be taken as 1, then the cost for all depths less then 3.5 feet will be nearly equal to 1, and for depths greater than 3.5 feet about proportionate to the increased volumes moved. This presupposes the rock to be fully broken to the required depth.



Modern Plant for Submarine-drilling and Blasting.

The fourth condition, or protection against sea and wind, is beyond comparison, except in any one location, and all that can be said is that from the experience of the seasons of 1875-'76-'77 the most favorable time for such work on Lake Superior is in the months of June, July, and August, during which time it is not safe to allow a smaller amount of lost time through bad weather than about one-sixth, and it may in any one season be as much as one-fourth.

The following summary shows the details of the dredge-work:

Working-time, actual	$576\frac{5}{60}$	hours.
Lost time, bad weather	$100\frac{25}{60}$	hours.
Possible time from June 26 to September 6, inclusive	63	days.
Days and parts of days dredge was working	47	days.
Average time made per day	$12\frac{25}{100}$	hours.
Used in making repairs in otherwise working-time	83	hours.
Used in making repairs in bad weather	46	hours.
Rock removed by dredge	3,000	cubic yards.
Bowlders removed by dredge	200	cubic yards.
Rock, coarsely broken, removed by aid of diver and hoisting-scow	150	cubic yards.
Average depth of rock removed	$2\frac{6}{10}$	feet.
Maximum depth of rock removed	5.0	feet.
Area of excavation	35,000	square feet.
Average amount of rock removed per hour by dredge.	$5\frac{53}{100}$	cubic yards.

The cubic yard of rock herein mentioned means prism measurement. The material removed, reduced to scow measurement, becomes 5,964 cubic yards.

In the removal of rock in the Detroit River and elsewhere, along the Lakes, Messrs. Dunbar employed a scow held in place by spuds and anchors. Upon the face of the scow were mounted four Ingersoll drills which were guided by ways. This system has given good results, although it would not apply in rough waters, or where there is much rise and fall of tide. Besides, the drills being fixed in place, holes cannot conveniently be placed in angular positions; and even if arranged to be so placed, a rise or fall of tide would cause the drill steel to bind at the collar of the hole owing to the change of the current. The most formidable obstacles in the way of the removal of submerged reefs are: 1. Sand, mud, or gravel overlying the rock. 2. Swift currents. 3. Rise and fall of tides. 4. High winds and rough water. 5. Danger of collisions with passing vessels. To overcome these difficulties, Mr. William L. Saunders, has designed and quite successfully applied the submarine plant as illustrated and here described.

This plant consists in the main of a barge containing boiler, blacksmith's shop, diving apparatus and pump, floatable platform or drill-stage, provided with spuds by which it is elevated above the surface of the water; two or more steam-drills, mounted upon an "A" frame or platform to facilitate moving them about the deck; and cylindrical conically tapering tubes, with an ejector device attached; these tubes being let down to the rock through trunk-ways in the deck of the platform, and the process of drilling and the charging being carried on through the tubes.

The barge may be of any ordinary design, and is moored in position by four anchors, one at each corner. The drill-stage is made of very strong timbers, bound together underneath.

The spuds are free to slide through trunk-ways fixed to the platform. Heavy pully-blocks at each spud-top serve to raise the platform above the surface of the water. There are three gallows-frames, one at each end, and one in the middle of the platform; these serve to hold a pipe which is free to roll about in a horizontal position over the top of the frames. To this pipe are hung blocks and tackle which command any position over the deck, and serve to lift the drill-steels, etc. The drill-stage is made floatable by means of empty barrels or water-tight tanks placed underneath.

The barge is moored to within fifteen feet of one end of the drill-stage, and the two are connected by a gang-plank, steam-hose, etc. The ejector-tubes are made telescoping so that they may be adjusted to various elevations of the rock. These tubes consist in the main of two telescoping cylindrical sections, made of No. 8 boiler plate. On the lower end of one of these sections is attached a casting tapering conically to a four-inch opening into which is inserted a piece of four-inch tubing; this tubing forms the lower end of the apparatus or that nearer the rock. Where there is an accumulation of material over the rock a common ejector is attached to the side of the conical casting, and is connected directly with the interior of the tube. By forcing a stream of water through this ejector the overlying material is pumped from underneath the tube, allowing it to readily sink until it rests on the surface of the rock. The steam-drill being placed over the mouth of the tube, a drill-steel is here inserted, and a hole drilled to the required depth. The lower end of the conical attachment serves to guide the steel in starting a hole, and prevents "stepping." When the drill has been driven the length of the feed of the machine, an extension piece is inserted over the shank of the steel; the machine is wound up again to the top of the screw-feed, when the chuck being clamped on the top of the extension piece, the drill is driven further on till the required depth is attained; the drill is then removed from the tube, and a graduated plunger, or ram-rod, inserted to ascertain the exact depth of the hole. Dynamite enclosed in tin cans is then suspended into the tube, and pressed down to the bottom of the tube by means of the plunger. The connecting wires are then attached to a piece of cork and thrown down into the drill tube, which is next lifted on deck, and the floating cork with wires picked up, led to the battery and fired. The progress of drilling is very materially facilitated by feeding down into the hole and through the drill-tube, a length of one quarter-inch pipe, at the upper end of which is attached a hose, which connects it with a pump; then a stream of water is fed upon the drilling-bit, preventing the accumulation of cuttings under the bit or in the shape of a collar just above it. This small pipe follows alongside the drill-steel, but is not injured by it, except it be allowed to get underneath the bit.

The drill-stage, being elevated above the surface of the water, is not affected by winds or tides, nor is it necessary to remove it before blasting. A severe blast will only break a spud, which can readily be replaced. In submarine-blasting pieces of rock are seldom thrown above the surface of the water. The upheaval of the water has no injurious effect upon the drill-stage, but with a barge the effect would be disastrous in springing leaks in her timbers and injuring the machinery. With such a plant as this, in connection with the ejector-tubes, all the difficulties encountered in submarine-drilling may be overcome. Holes can be drilled charged, and blasted through as much as six feet of overlay of material. Swift currents will not affect the platform, and as no divers are employed, it is only necessary to secure the tubes in position, when the state of water enclosed within will admit of free working of the drill-steels, and free charging of the holes. The tides rise and fall underneath the stage without affecting the position of the drills. High winds and rough weather within certain limits are not antagonistic to the operations. In the event of a collision with any passing vessel the spuds of the side-stage act like spring-piles in a ferry slip, and the most serious result would be to break all the spuds, which might be replaced at but slight expense. It is no exaggeration to say that the Hell Gate rocks might have been removed with such a plant as this one at one-third the expense and in one-quarter the time of that involved in the present methods of undermining.

Following is a report of the operations on Black Tom Reef, New York Harbor:

Date of beginning of operations	May 2d, 1881.
Actual working days	344.
Days lost in equipment of Barge No. 4	26.
Days lost through winter and storms	35.
Lineal feet of hole drilled	17,658.
Lineal feet of effective drilling	16,567.
Number of holes drilled	1,736.
Number of holes charged	1,629.
Number of holes blasted	1,542.
Average depth of hole	10 $\frac{17}{100}$ ft.
Average distance between holes	4 ft.
Area drilled over	32,100 sq. ft.
Rock removed	5,136 cu. yds.
Explosive used (dynamite)	20,461½ lbs.
Number of exploders used	1,844.
Number of drilling-machines used	3.
No. of steels used (octagon 1½ in. diam.)	18
Longest steel used	28 ft.
Shortest steel used	16 ft.
Largest diameter of bit	3¾ in.
Smallest diameter of bit	2½ in.
Greatest depth drilled without change of the steels	12 feet.
Average depth drilled to each dressing of steel	9 feet.
Average loss of gauge per 1 inch feet drilled	0.03 in.
Total loss of steel by abrasion and dressing 59½ feet	394.48 lbs.
Greatest lin. ft. drilled in 1 day, Nov. 14, 1881	169 feet.
Expenditure for coal, 200.19 tons	$828.03
Expenditure for water	500.55
Expenditure for hose	491.18
Connecting wire used, 77¼ lbs	52.08
Rubber tape for covering connections, 7 rolls	12.25
Expenditure of steel to each lineal foot drilled, 0.36 of an oz	$0.00 32-100
Explosive used to in each lineal foot drilled, 1.16 lbs	0.53
Rock removed, to each lineal foot drilled	0.29 cu. yds.
Cost in labor to each lineal foot drilled	0.52
Cost in coal and water to each lineal ft. drilled	0.07½
Cost in repairs to plant to each lineal foot drilled	0.09
Cost in repairs to drills to each lineal foot drilled	0.00 53-100
Cost in repairs to ejector pipes to each lineal foot drilled	0.01½
Cost in hose to each lineal foot drilled	0.02 8-10
Cost in wire and tape to each lineal foot drilled	0.00 3-10
Average cost per lineal ft. of hole drilled	1.26 95-100
Expenditure of steel to each hole charged, 0.24 lbs	$0.03 36-100
Average explosive used to each hole charged, 12.56 lbs	5.80
Average rock removed to each hole charged	3.15 cu. yds
Average exploders to each hole	1.13

	(Price in explosive.)	
Average cost of the labor to each hole charged	5.65	
Average coal and water to each hole charged	0.81	
Average repairs to plants charged	0.96	7-10
Average repairs to Ingersoll drills	0.05	7-10
Average repairs to ejector pipes	0.16	4-10
Average repairs to hose to each charged	0.30	1-10
Average repairs to wire and tape	0.03	9-10
Average cost per hole charged	13.82	8-10
Average depth drilled to each cubic yard of rock removed. { whole	3.44	lin. ft.
{ effective	3.22	lin. ft.
Average explosive to each cubic yard of rock removed, 3.98 lbs	$1.84	
Expenditure of steel per cubic yard of rock removed, 1.22 oz	0.01	8-10
Cost in labor cu. yd. of rock removed	1.79	
Coal and water	0.25	
Repairs to plants	0.30	6-10
Repairs to drills	0.01	8-10
Repairs to ejector-pipes	0.05	2-10
Repairs to hose, cubic yard	0.09	5-10
Wire and tape, cubic yard	0.01	2-10
Cost per cubic yard	4.37	36-100

COST OF PLANT, INCLUDING ALTERATIONS, ADDITIONS, ETC.

Barge No. 4, hull and equipment		$6,640.00
Drill-float No. 1		4,095.70
Drill-float No. 2		4,987.40
Store-room account including repairs, alterations, coal and water, cost of machinery, etc		5,663.49
		$21,386.59
Expenditure in labor	9,203.88	
Expenditure in explosive	9,461.00	$18,664.88
Total expenditure		$40,051.47
Cost per cu. yd. on total expenditure		7.79

OPERATING EXPENSES.

Labor	$9,203.88
Explosives	9,461.00
Actual repairs to plant. (breaks, loss, etc).	1,575.57
Repairs to Ingersoll drills	93.31
Steam and water hose	91.18
Repairs to ejector-pipes	267.54
Wire and tape used	64.33
Coal and water	1,323.53
Operating expenses	$22,430.39
Cost per cubic yard	4.37
Pay-roll per day	$26.76
Coal, 0.58 tons	2.39
Water	1.45
Explosive, 59.48 lbs	27.50
Actual repairs to plant per day	4.58
Repairs to drills, per day	0.27
Loss of steel, per day, 1.15 lbs	0.16
Repairs to ejector-pipes, per day	0.78
Losses in hose, per day	1.43
Losses in wire, per day	0.15
Losses in tape, per day	0.03
Average cost per day	$65.50
Average cu. yds. rock per day	14.93
Average cost per cu. yds	4.33

The contract price for removing this rock by dredging was $1.95 per cubic yard. Many items in this report, notably the cost of plant, are very much higher than they need be. The prices given include all the experimental work done prior to the introduction of the improved methods of operation. This rock was situated in New York Bay, near Bedloe's Island. It was of granite formation, varying in texture from a soft muddy pyrites to a hard mixture of hornblende and quartz. The surface was covered by a deposit of mud, sand, and gravel, which at first interfered with the progress of the work to such an extent that but little headway was effected. After the use of the ejector-pipes no further difficulty from this source was experienced. See *Blasting*, *Rock Drill*, *Submarine-blasting*, and *Tunneling*.

SUBMARINE MINES.—The term *torpedo*, when employed in a military sense, designates those contrivances for producing explosions calculated to act destructively against an enemy coming into their immediate vicinity.

They are chiefly used for obstructing rivers and entrances to harbors, and are either stationary or capable of movement. When stationary they are called *submarine mines*, leaving the term *torpedo* for all offensive and movable combinations of this nature. The use and application of the latter fall more particularly to the province of the Navy, the former to the Army, and, employed as an auxiliary to shore batteries, constitute a branch of service naturally belonging to or intimately connected with the artillery arm.

Submarine mines are applicable to almost any situation liable to be attacked by ships, but in every instance they should be so arranged as to be covered by the guns of forts or detached batteries, so that, while acting as outworks of these latter, they will be protected from destruction by boats from a hostile fleet. The comparatively small cost of this species of defense allows of its extensive use as an agent to deter an enemy from approaching a fortified position, and to cause him to begin the tedious and dangerous operation of clearing the channel, or to land and attempt the capturing of the place without the aid of his ships. This in most cases would enable the defenders to hold out until the arrival of a relieving force. Submarine mines may be classed under two heads, viz.: *Mechanical*, those which depend for explosion of the charge on mechanical means, such as the simple percussion of a vessel coming in contact with them; and *Electrical*, those which are fired by electrical agency, either by the vessel closing the circuit, or at will from the shore.

The former class, or mechanical mines, are capable only of very limited use. When once placed in a channel they make it equally impassable to friend and foe. They are, therefore, only applicable to certain cases; as, for example, when it becomes necessary to block up a channel completely, that is to say, to render it altogether impassable until the mines have been removed. They might, however, be employed on a flat beach, dry at low water, to cover the flanks of electrical mines defending the navigable channel. In such case they could be planted or removed at low water with comparative security. The number of electrical cables, etc., required would be reduced by such an arrangement. Mechanical mines are not applicable to harbors of refuge, in which merchant ships might run to avoid an enemy. It would, furthermore, be absolutely necessary to make some arrangement by which they could be exploded at will, as the most effectual way of getting rid of them when it became necessary to clear the channel, as the process of removal in the ordinary way, by boats, would be far too dangerous an operation to undertake. On the other hand, submarine mines of this description possess the advantage of capability of being kept in store and ready for use at short notice: they require no knowledge of electricity in their management, and they might be used with advantage in certain cases where electrical submarine mines are not obtainable.

The second class of submarine mines, those to be fired by electrical agency, admit of a much larger field for their employment. They may be fired either at will by an observer, who, judging from the position of the vessel, closes the circuit, so that the charge may be exploded at the right moment: or that the vessel herself may be made to complete the circuit, causing a current to pass and fire the charge. The disadvantages of electrical submarine mines, as compared with those fired mechanically, are the multiplicity of wires required and the necessity of having a certain number of especially trained men. This number, however, is comparatively small. The advantages of electrical mines are, that they are always absolutely under the control of the observer in charge of them. By simply detaching the battery used in firing them they become perfectly harmless, so that all friendly vessels may pass over them with safety, which is not the case with those arranged for mechanical ignition. Again, they can be rendered active at a moment's notice by re-connecting the battery. By means of electrical contrivances, arrangements are so effected that vessels passing over mines give notice of their presence without exploding the mine. In this respect electrical submarine mines are a great safeguard against attack by surprise, and against vessels passing at night, or in a fog. Nor can they be tampered with by an enemy without its being immediately known, and exactly what mine. In the electrical system, when a mine is exploded, or becomes ineffective from any cause, another can be laid down in it place, and without danger, by simply making the neighboring mines inactive for the time being. Another important advantage of this system is the power of testing electrically, without going near it, the condition of each separate charge at any time after submersion, and of ascertaining, with almost absolute certainty, whether it can be fired or not. None of these advantages appertain to mines of the mechanical system.

The following general rules govern in selecting sites for these mines: 1st. They may be used in combination with floating obstructions, as booms, or with grounded obstructions, as sunken vessels, etc., or without them. 2d. They should be placed in such positions that the explosions will not injure any passive obstructions combined with them, or destroy the electric cables of adjoining mines. 3d. At least two, and, where practicable, more, rows of mines should be arranged across the channel to be defended. In deep water, it is more necessary to employ several lines of mines than in shallow, because in the latter case a vessel sunk by a mine would herself offer an impediment to others following; but in deep water the explosion of a mine leaves a gap, through which there is a safe passage. 4th. Submarine mines should be placed in the channel through which large vessels only can pass; the shallower places being, in all cases where such a course is practicable, rendered impassable by passive obstructions resting on the bottom. 5th. Submarine mines should be placed in the narrowest part of a channel. The advantages of such a position are evident, as a smaller number will answer the purpose. 6th. When the depth of the water and other circumstances admit of it, a submarine mine should always rest on the bottom. Under such circumstances, all complications originating in mooring arrangements are avoided; its position is more easily defined, and it is not so easily displaced by accident, or discovered and destroyed by the enemy. 7th. No indication of their position should be allowed to appear on the surface of the water. Under certain conditions it may be impracticable to conceal them altogether; as, for example, where there is a large rise and fall of tide. 8th. When, from the depth of the water, the charges cannot be placed on the bottom, they should be so moored as to float from 15 to 40 feet below the surface. In places where there is a considerable rise and fall of tide, special arrangements would be necessary for this. 9th. The place in which the batteries and other instruments connected with the ignition of electrical submarine mines are arranged, should be in those portions of the defensive works which are likely to be held longest, so that a command may be kept over the mines to the latest possible moment in the defense. 10th. The position of the mines should be well covered by the fire of the guns of the forts or shore batteries of the place to be defended, to prevent destruction by boats.

The object to be obtained in arranging any system of mines for the defense of a channel, is to place them in such a position that a vessel passing along that channel must, at some one moment, whatever course she may take, come within a radius of destructive effect of one of the mines. This would be easily attained by placing these mines in one single row across the channel, so that their circles of destructive effect may at least touch each other. To this simple arangement there are, however, practical difficulties; among which is the danger of entanglement between mooring cables of adjacent mines, or their electrical cables, especially when there is an ebb and flow of the tide. When mines are very close together, it is impossible, with the most perfect mooring arrangements, to prevent entanglements of this nature, particularly when laying down the mines and when arranging the gear in connection therewith. The difficulty of grappling for, and raising a mine for examination is greatly increased by this very close approximation. Again, when mines are very close to each other the explosion of one is very likely to injure its neighbor; or, where an electrical system is adopted, to disturb the particular mechanism of the system. It becomes necessary, therefore, to allow some latitude, in order to obviate these difficulties and at the same time to preserve the theoretical precision and closeness of a single line. This is effected by placing the mines in two or more lines, at a distance from each other something greater than the radii of destructive effect of the mines. This arrangement overcomes the great objection that attaches to a single line, which, in case a breach is once effected, affords a safe passage until repaired. It likewise makes it more difficult for an enemy to discover the limits to the area of danger, and consequently weakens the efforts of the enemy by the moral effect of uncertainty. The arrangement in lines is the best, both for facility in laying the mines so as to space the area with certainty, and for finding their positions when it becomes necessary to raise them for examination. It also affords facility in determining what particular mine it is necessary to explode to strike a vessel attempting the passage. So much depends upon local circumstances—such as the nature of the channel or roadstead to be defended, the probable means of attack at the disposal of an enemy, and the draught of water of the vessels of a hostile fleet, etc. that a great deal must be left to the officer commanding the defense. The size, strength, and character of the vessels to be guarded against will determine the power of the mines to be used.

Neither experiments nor observations in actual warfare have yet determined, except approximately, the size of charges necessary to perform the work required of mines under the various circumstances that would arise in service. The stronger the vessel, the greater, manifestly, will be the charge required to destroy it. As a general rule, the strength of vessels increases according to their size; likewise does their draught; therefore a mine of sufficient power to destroy a large vessel will evidently destroy a smaller one, and this notwithstanding the charge be placed at a depth suitable for the larger vessel and of the consequent intervening cushion of water. The depth of water in a channel decides very closely the character of vessels that can pass; this, for war vessels, may be placed at 15 feet for the minimum. Furthermore, it has been decided that a charge of 2,000 pounds of gunpowder, if properly placed, is sufficient to destroy the largest vessel. This, therefore, is laid down as the maximum charge to be used in any one mine. A rule for approximately determining the charge for depths of water from 15 to 40 feet is, that the square of the depth in feet gives the quantity in pounds of gunpowder required. Gunpowder being the most common and best known of the explosives, is taken as the standard. So far as is known, the explosive effect of gun-cotton, when used for submarine mines, is about four times, and that of dynamite about ten times that of gunpowder, weight for weight. The character of the bottom on which submarine mines are planned has considerable effect on their destructive power, a yielding, muddy bottom, being much less favorable than a hard and resisting one. In the foregoing rule, about ten per cent. should be added to the charges when the bottom is soft, or when the mines do not rest on the bottom. The distance apart at which two mines on the same line may be placed so that the explosion of one will not injure the other, depends upon the size of the charges employed. For the maximum charge—2,000 pounds—this interval should not be less than 200 feet; for charges not exceeding 500 pounds the interval may be reduced to 100 feet. This necessary interval between the charges in a line is one reason which renders the employment of two or more lines of mines essential to a proper maintenance of the defense. It also sufficiently explains the object to be attained in placing them in such a way that the charge in the second line shall cover the intervals in the first, and those in the third shall cover the intervals in the second, and so on.

For mechanical mines various contrivances have been used. All those constructed on the principle of the gun-lock have, however, been found to soon become worthless from oxidation and incrustation of the more delicate parts. A very simple form is the nipple, upon which is placed a percussion-cap, but this is apt to become damaged when immersed. Another kind is the well-known sulphuric-acid fuse, formed on the principle of ignition by sulphuric-acid dripped upon a mixture of equal parts of chlorate of potash and loaf-sugar. The sulphuric acid is placed in a small glass globe, which is so arranged as to be broken by the blow given on touching the side of a vessel, andthe acid set free, falling upon the mixture of chlorate of potassa and loaf-sugar, produces the required ignition. The ignition produced by this means is comparatively slow; it has, however, been found that an addition of one-third of ferro-cyanide of potassium to the mixture of equal parts of chlorate of potash and loaf-sugar produces an ignition as rapid as that of gunpowder. The glass globe is best inclosed in a lead tube, which, by bending or being crushed by the blow, breaks the glass. This is the fuse sometimes used for land torpedoes. To secure the fuse and charge from moisture, a composition made of 1 part of tallow, 8 of pitch, and 1 of beeswax will be found good. To this may be added a little gutta-percha, which will have a tendency to harden it. This composition, when softened by heat, is pressed around the fuse-plug. The great superiority of electrical fuses over mechanical, causes the latter to be employed only under exceptional circumstances. The universal use of the electric telegraph makes it easy to obtain all material and apparatus necessary for firing submarine mines; even fuses are an article of commerce, and there is no difficulty, if required, in obtaining the services of electricians or other operators capable of arranging and manipulating all parts of it.

The efficiency of a system of mines will depend upon the accuracy and certainty with which they may be discharged at the proper moment. This may be done at will,or the vessel herself may be so made as to strike a circuit-closer. When the mines are placed in position, accurate bearings of each one are taken from two secure points of observation. These stations should be within the defensive works, and selected so that the lines passing from them over each mine shall intersect in such a manner as to give as nearly as possible a right angle, or at least an angle not too acute. The mines have each a number, and the intersecting lines are correspondingly numbered: it is therefore obvious that when a ship is observed from both stations to be upon a line having the same number, she will be at the intersection of the two lines, or over the mine having a like number. The simplest form is where one of the stations is on the prolongation of the line of mines, as at A, (in Fig. 1), and the other directly in rear of the mines, as at B. C represents the galvanic battery, from which runs a conducting-wire through the station A to station B, and connects at the latter point with a series of keys, through which the current can be closed to each of

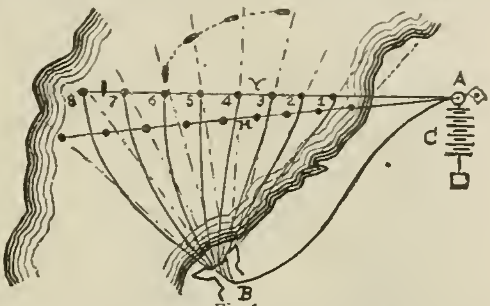


Fig. 1.

the mines 1, 2, 3, etc. Till the key at A is pressed down, no current can pass from the battery, C, past the station A; but directly it is pressed down, the circuit is so far completed and the line is charged up to the station B. From the station B is a series of electric cables (B 1, B 2, B 3, etc.) attached to a series of contact-points, perfectly distinct and carefully insulated from each other; these cables pass to the mines (1, 2, 3, etc.) through the fuses in connection with them and to the earth. At the second station, B, we have, therefore, a second break in the electrical current, and it is easily seen that in order to pass the current through, and fire any particular fuse, both these breaks must be bridged over, under which circumstances the current of the battery will be completed and the mine fired. Let it now be supposed that a vessel is approaching this line of mines. As her bow passes across the prolongation of the line B 7 the observer at B puts down key No. 7 in connection with mine 7; but as the ship has not come on to the line from A passing through the line of mines, the observer at A does not put down his key, a break still exists in the circuit, and no current can pass to fire the mine 7. When the vessel passes the line B 7 the observer at B allows the key to spring up and break the connection. As the vessel passes the line B 6 the observer at B presses down key No. 6, but as she is still not on the intersection of the lines B 6 and A 6, the same result as before is obtained, and the mine 6, will not be fired. Let it now be supposed that she passes on in her course till she arrives over the mine 3; in this position she is on the intersection of the two visual lines A 3 and B 3; the observers at A and B in this case both put down their respective keys simultaneously, the current of the battery is completed through the mine 3, and that mine will be fired. As before mentioned, it is advantageous to have all of the lines of mines directed on the one point (A). The mines of the second and third lines are connected to the station B precisely as are those of the first line. In the case of a vessel passing through an interval of any two mines of the first line,at such a distance as to be out of the radius of destructive effect of either of them, as, for instance, at the point Y, between 3 and 4, it is easily seen that at the moment of passing the first line of mines, when the observer at A would have his key down, she would not be on the prolongation of any of the visual lines from the station B to any of the first line of mines, and as the observer at B would not under such circumstances press down on any key,she would pass on to the second line and run upon the mine at A, which would be exploded as just explained. Instead of having the wire and key at A, as above explained, an ordinary signal flag may be used for transmitting preconcerted signals. This, however, would require the observer at B to have an assistant to look out for the flag, and is altogether inferior to the former method. It likewise has the disadvantage of informing the enemy of the position of the lines of mines.

As in many cases it would not be practicable to have a station on such a position as A, so far advanced towards the point of attack, with the corresponding danger of being cut off by an enemy, another combination becomes necessary; this is shown in Fig. 2. Two stations, A and B, well within the de-

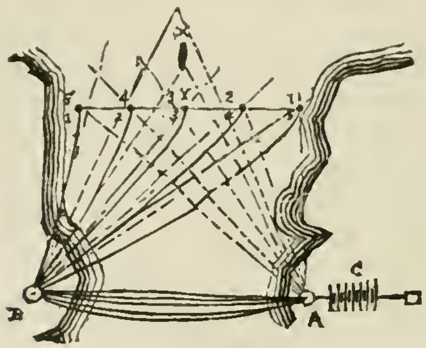


Fig. 2.

fensive works, are selected in such a position that the lines passing from them over the mines shall intersect in such a manner as to give a large angle. When the mines were placed in position, accurate bearings were taken to each from both of these stations. The galvanic-battery is placed at A, one pole being connected to the earth, while the other is connected with a center from which radiate a series of contact-keys. From the contact-points of these keys a series of cables, corresponding in number to the numbers of the mines, pass to the similar contact points of a like set of keys at station B, and from the pivots of the keys at B an electrical cable passes to each charge. In this case, therefore, each mine has a separate key at station A as well as at station B, each perfectly distinct from any other and well insulated therefrom, but the whole culminating at A in the single battery C. In each circuit, corresponding to any particular mine, there are, therefore, two breaks, one at its particular contact-key at station A, and the other at its corresponding key at station B, and till these breaks are bridged over, by pressing down the contact-keys simultaneously, the circuit of the battery will not be closed and the mine will not be fired. In this way it is easily seen that if key No. 1, for example, is put down at station A, and key No. 2 at station B, there still remains a break in each of these circuits; in circuit No. 1 at B and in circuit No. 2 at A, and neither of these mines will be fired. The object of this arrangement will be seen by tracing the course of the vessel (×) approaching the line of mines. She first arrives on the line of 5 from station A, and simultaneously on that of 1 from station B; the observer at A puts down key No. 5 and the observer at B key No. 1, without, of course, firing any mine. Again, as she reaches the position Y, the observer at A puts down key No. 4 and the observer at B key No. 2, without any circuit being closed. When she arrives at 3 both observers put down keys No. 3 simultaneously, and the mine is fired and the vessel struck. In carrying out the system above described, it has been found that with a series of very small wooden pickets, placed in a radiating form from a central point of observation, at a distance of about 20 feet, and with pieces of twine passing from the center over the pickets in the direction of the mines to indicate the bearings more accurately, a very good practice has been obtained. The observer, with his eye at the central picket and his hand on the contact-keys, puts the corresponding one down as the object passes the bearings of each. A man soon learns by practice the distance he may allow on one side or other of the bearing-line, and with ordinary care and nerve is soon able to make contact at the right moment. The system of pickets might probably be used effectually up to half a mile, but at greater distances a more accurate means of obtaining the intersections becomes necessary; the pickets have, moreover, the disadvantage of being easily disturbed and difficult to replace in an accurate position if once moved. In order to obviate as far as possible these defects, an instrument has been devised having a telescope, with cross-wires, mounted in connection with a series of contact-points and a movable key. It consists of a heavy cast-iron stand, on which is placed an iron upright arranged to carry the telescope, allowing it a horizontal motion around the upright; it has also a vertical motion. Concentric with the upright is a circular arc, described with a radius of about 18 inches. On this arc are arranged the contact-points for the cables running to the mines or to the other station. Attached to the upright, below the telescope, is a horizontal arm, which moves around with the telescope. To this arm is attached a contact-key, adjusted to touch the contact-points on the arc. The arc is graduated into divisions, by means of which the position of the contact-points may be registered, so that in the event of their being accidentally displaced they may again be fixed in true relative position with facility.

The arrangement of a system of submarine mines in lines possesses the disadvantage that if the enemy has once ascertained the position of one mine of a line, whether by explosion or by any accidental circumstance, he would know within what limits the others were to be looked for. In order to obviate this disadvantage, it would always be necessary to scatter a few mines in irregular intervals in front of the advanced line—to set them as skirmishers, retaining the mine formation for the main defense. These advanced mines might either be simply electro-self-acting, or arranged for ignition on the same principle as those of the main system, as circumstances required. As it is not advisable to expend heavy charges against small boats, these advanced mines should be comparatively small, so as to be used against the boats of an enemy seeking for the mines and circuit-closers.

The first object of an enemy would be to clear a passage of sufficient width through the system to enable him to pass freely in; and for this purpose he could employ drifters, with or without dragging-grapnels, for the purpose of either firing some of the charges by striking the circuit-closers, or grapling and destroying the electrical cables and other gear. These drifters may be boats allowed to float in with the tide or wind. In order to stop such a system of attack, a light boom or strong fishing-nets would be useful, and should be employed whenever circumstances permit. To stop drifters with dragging-grapnels, it is a good plan to lay three or four heavy chain-cables at intervals across the channel, in advance of the system of mines. The grapnels would catch in these, and the weight of the chains would be sufficient to bring up the drifters before arriving at the mines.

The night would unquestionably be the safest time for the enemy to carry on operations of this nature, and it would be necessary to employ boats to row guard in order to watch his proceedings. The mode of communication with these boats is a matter of considerable importance, and some means of rapidly transmitting intelligence is absolutely necessary. This can, of course, be done by the system of flashing signals, but the lights in such case would be a disadvantage, as they would indicate to the enemy the position of the guard-boat. In order to obviate this, a system has been devised by which a boat-rowing guard can be put in electrical telegraphic communition with a fort or guard-ship, by simply paying out an insulated wire attached to a telegraph instrument in the fort or ship, and carrying a second instrument on board the boat. Should the guard-boat be pursued, it would only be necessary to detach the electric cable from the instrument and to throw it overboard, with a buoy and line attached, and pull away.

Several systems have been devised for illuminating channels at night by means of the electric light, the Drummond light, magnesium light, etc., and there is no doubt that, when practicable, such devices should always be used. See *Case*, *Electric Cables*, *Mooring*, and *Torpedoes*.

SUBORDINARY.—In Heraldry, a name given to a certain class of charges mostly formed of straight or curved lines. Heralds vary a little in their enumeration, but the following are generally held to come within this category: the bordure, the orle, the tressure, the flanche, the pile, the pall, the quarter, the canton, the gyron, the fret, the inescutcheon, the lozenge, the fusil, and the mascle. Also written *Subordinate Ordinary*.

SUBORDINATION.— Subjection to the will of another; under command; readiness to submit one's self to the orders of superiors. In the Army, this feeling cannot be too deeply instilled into all ranks. Without it, no body of men could work together; like discipline, it is the mainspring of order; and unless it reigns supreme in every regiment, confusion and every imaginable evil must ensue. In effect, as James, in his "Military Dictionary," states, it is *subordination* that gives soul and harmony to the Service; it adds strength to authority and merit to obedience, and, while it secures the efficacy of command, reflects honor upon its execution. It is *subordination* which prevents every disorder, and procures every advantage to an army.

SUBSIDIES.—A term in politics, used in two different senses: 1. It is applied in English political history to taxes levied not immediately on property, but on persons, in respect of their reputed estates in lands or goods; or customs imposed on any of the staple commodities in addition to the *costuma magna et antiqua*. Thus, 30,000 sacks of wool were granted to Edward III. in 1340, in aid of the war with France. Subsidies were granted on various occasions to James I. and Charles II. 2. The same word is used to denote money paid by one State to another, in order to procure a limited succor of auxiliary troops, ships of war, or provisions. In the time of the war with the Revolutionists of France and Napoleon I., Great Britain furnished subsidies to foreign powers to a large extent, in order to engage them to resist the progress of the French. In questions regarding subsidies, it is held that the State furnishing the succor does not thereby become the enemy of the opposite belligerent; it may remain neutral in all respects, except as regards the auxiliary forces supplied. Such, for example, was long the attitude maintained by the Confederate Cantons of Switzerland; while giving troops to the various European powers, they were in the habit, at the same time, of preserving a rigorous neutrality. The service of Swiss regiments abroad is no longer sanctioned. The Federal Constitution of Switzerland, of Sept. 12, 1848, prohibited the conclusion of military capitulations; and on July 30, 1859, a proclamation was issued by the Federal Council, forbidding any Swiss subjects from taking service under a foreign Power without the authorization of the Council.

SUBSISTENCE DEPARTMENT.—The Subsistence Department, under the direction of the Secretary of War, provides for the purchase, issue, and sale of subsistence supplies, and such articles, for sale to officers and enlisted men, as are from time to time designated by the Inspector General of the Army, and the distribution and expenditure of the money appropriated by Congress for the subsistence of the Army.

As soldiers are expected to preserve, distribute, and cook their own subsistence, the hire of citizens for any of these duties is not allowed. When bakeries are not managed by the Subsistence Department, their expenses for hops, yeast, furniture, sieves, cloths, the hire of bakers, etc., are paid *from the post fund*, to which the profits then accrue. Subsistence supplies comprise: 1. Articles composing the ration, or authorized to be issued in *lieu* of parts of the ration, those authorized to be furnished for sales to officers and enlisted men, and forage for beef cattle, etc., called subsistence stores. 2. The necessary means of issuing and preserving these stores, such as stationery, scales, measures, tools etc., called subsistence property.

Under sections 1144 and 1149, Revised Statutes, the Subsistence Department provides for sale to officers and enlisted men tobacco and certain other articles, in addition to the component parts of the ration, which may be designated by the Inspector General of the Army. Lists of these articles are from time to time issued from the office of the Commissary General of Subsistence.

The United States Subsistence Department consists of one Commissary General of Subsistence, with the rank of Brigadier General; two Assistant Commissary Generals of Subsistence, with the rank of Colonel; three Assistant Commissary Generals of Subsistence, with the rank of Lieutenant Colonel; eight Commissaries of Subsistence, with the rank of Major; and twelve Commissaries of Subsistence, with the rank of Captain. See *Commissariat*, and *Supplies*.

SUBSISTENCE MONEY.—An allowance granted for the subsistence of soldiers who, whilst in imprisonment in cells, or confinement in the guard-room, forfeit their daily pay. The regulated rate in England is 6d. a day.

SUBSTANTIVE RANK.—*Solid* or *permanent rank*, such as confers upon an officer the pay of his rank with the position and precedence attending it. Thus a Major drawing a Major's pay, and consequently enjoying a Major's position in his regiment, is an example of *substantive* rank. See *Rank*.

SUBSTITUTE.—In Nations where conscription is resorted to for the supply of soldiers for the Army, the lot often falls on those unwilling to serve in person. In such a case the State sometimes agrees to accept the services of a substitute who is of equally good physique. Unless the levy be very extensive, or the term of military service very long, substitutes are readily found among military men who have already served their prescribed period. Of course, the substitute must be paid for the risk he runs. His price depends, like all other saleable articles, on the demand and supply.

SUCCEEDANT.—In Heraldry, succeeding one another, following.

SUCCESSION OF RANK.—A relative gradation, according to the dates of commission.

SUCCESSION WARS.—Wars of frequent occurrence in Europe, between the middle of the 17th and the middle of the 18th centuries, on the occasion of the failure of a Sovereign House. The most important of these wars was that of the Orleans succession to the Palatinate (1686–97), closed by the Peace of Ryswick; of the Spanish succession (1700–13); of the Polish succession (1733–38), closed by the Peace of Vienna; of the Austrian succession (1740–48); and of the Bavarian succession (1777–79), called, in ridicule, the potato-war. Of these, the second and the fourth were by far the most important.

SUCCESSIVE FORMATIONS.—Successive formations include all those formations where the several subdivisions arrive successively on the line of battle; such as *front into line*, *the deployments of columns*, *formations into line by two movements*, *changes of front*, *etc*. In all successive formations, except formations into line by two movements, the Field-officer who is at the head of the column, or nearest the *point of rest*, establishes two markers on the line opposite the right and left files of the subdivision first to arrive on the line. The markers face toward the *point of rest*, that is, the point where the right of the battalion is to rest, if the movement be from right to left, or where the left is to rest when the movement is from left to right. If the formation be central, they are placed on the line, in front of the leading subdivision, facing each other. In all formations from a halt, the markers are established at the preparatory command indicating the direction in which the line is to extend: if marching, they hasten toward the *point of rest* at the preparatory command, and are established at the command *march*. In the formations, on right (or left) into line, the first marker is established subdivision-distance to the right (or left) of the head of the column. In the formations front into line, the markers are established subdivision-distance in front of the head of the column. In the deployments, they are established three yards in front of the head of the column, when the deployment is on the first subdivision, and six yards in front of the column, when the deployment is on a subdivision in rear. In changes of front, the first marker is posted company-distance to the right of the first or left of tenth company, according as the change of front is to the right or left. The line is prolonged, by the guide of each company who is farthest from the point of rest; the guides are assured, as they successively arrive, by the Field-officer who is at the head of the column or nearest the point of rest. If the formation be central, each Field-officer establishes the guide of his own wing. When the line is to be formed facing to the rear, the markers are so posted as to permit the leading subdivision to pass between them after which the second markers close to a little less than company-distance from the first; if the formation be central, both markers close toward each other. Each guide so posts himself that his subdivision may cross the line of battle between himself and the guide next in front, after which he closes to subdivision distance.

SUCCESS OF ARMS.—That good luck, or fortune, which attends military operations, and upon which the fate of a nation frequently depends. Success is indispensable to the reputation of a General. It often hallows rash and unauthorized measures.

SUEDOISE.—A species of light cannon which superseded the *leather-gun*. It was much stronger, but very light and suitable for mountainous country like Switzerland. It was provided with runnions and could be transported on a carriage when desirable.

SUISSES.—The Swiss soldiers who were in the pay of France previous to August 10, 1792. "Suisses" was also a general term used to signify any stipendiary troops.

SUIT.—In all cases where the pay or salary of any person is withheld, in consequence of arrears to the United States (and salary can be legally withheld from no other cause except by the sentence of Court-Martial), it shall be the duty of the accounting officers, if demanded by the party, his agent, or attorney, to report forthwith to the agent of the Treasury Department, the balance due; and it shall be the duty of the said agent, within sixty days thereafter, to order a suit to be commenced against such a delinquent and his sureties.

SUIT OF SPLINTS.—An armor composed of imbricated plates, and worn in the 16th century.

SULLAGE.—The scoria which rises to the surface of the molten metal in the *ladle*, and which is withheld when pouring to prevent porous and rough casting. When desired that a heavy casting (such as a gun of several tons) should be especially solid, it is always poured on end, and, in addition also to the length required, a continuation of the mould upward is made. In this piece the *sullage* rises, hence its name. When the casting is cold, the portion added is cut off, and with it, the impurities which floated up there are removed.

SULTAN—SULTAUN.—An Arabic word, signifying "mighty man," and evidently closely connected with the Hebrew word *shalat*, to rule. In the East it is an ordinary title of Mohammedan Princes, and is also used in private life as a title of courtesy for people of high rank. It is given, *par excellence*, to the Ruler of Turkey, who assumes the title Sultan-es-Selatin, or Sultan of Sultans. It is also applied to his mother and his daughters; the word in Turkish having no grammatical gender, and corresponding also to the Princess. The wife of the Sultan is not now entitled to the epithet Sultan or Sultana as in former times.

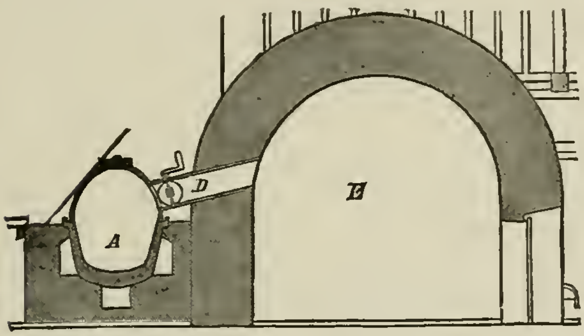
SULPHUR.—Sulphur, like saltpeter, is never found in a pure condition, but is mixed with earths, and is often combined with various salts. It is usually found in the vicinity of volcanoes, and large quantities are imported from Sicily. It is often found mixed with metallic ores, such as copper, iron, etc., but not to such an extent as would commercially justify its extraction. Sulphur is unfit for making gunpowder in its crude state, therefore it requires to be refined or separated from all foreign matter. This is done by a process of melting, and is completed in two distinct operations, namely, those of subliming and distilling. By the melting process, all earthy matters are left at the bottom of the retort or vessel in which the melting is carried on, and the pure sulphur, in the form of vapor, passes upwards, and is sublimed and distilled by condensation at two distinct periods of its temperature.

The refining-apparatus employed consists of a large pot of cast-iron, A, set in brick-work, the metal being very thick. Round the top-edge is shrunk a strong ring or tire of wrought-iron to prevent splitting by explosion. On the top is fitted a large dome-shaped cover, also of cast-iron, secured to the pot by three wrought iron tie-rods, which are secured by screw-bolts to a wrought-iron ring passing round the neck of the cover. At the top of the cover is a circular opening fitted with a heavy cast-iron lid, the weight of which is sufficient to keep it in its place during the refining process. In this lid is an iron plug-hole having considerable taper, through which the pot is charged. The cast-iron plug which closes it fits sufficiently tight to prevent escape of sulphur-vapor, particularly if a little sand be thrown over it; but at the same time it acts as a safety-valve, being lifted out if an unusual pressure of vapor is exerted inside the pot.

From the dome-shaped cover two good pipes proceed at right angles to each other, one to the subliming-dome, the other to the distilling-tank, or *receiving-pot*. The first pipe is furnished with a throttle-valve, D, which can be closed or opened by a handle from without. The other pipe is incased in a water-jacket, and can readily be closed or opened by means of a valve. When distilling, a constant flow of water is maintained through the water-jacket. An escape-pipe fitted to this jacket allows of the escape of the water when there is a sudden development of steam caused by the heat of the sulphur-vapor. The receiving-pot, C, is merely a large circular vessel of cast-iron, which is set on a frame inserted in small trucks. There is a large circular opening in the lid through which the melted sulphur can be ladled out when necessary. This opening is closed by an iron lid similar to that of the melting-pot, in which is also a small plug-hole through which the depth of the melted sulphur in the receiving-pot can be gauged with an iron rod. A small pipe leads from another opening in the lid of the receiving-pot into a square wooden chamber lined with lead to receive any new condensed vapor, and saves it to deposit its sulphur in the form of *flowers*. This chamber is provided with a tall chimney, also of wood, containing a series of steps or traps to catch as much of the *flowers* as possible.

The subliming-dome is a large dome-shaped building of brick, E. The pipe for the sulphur-pot enters it near the top. The chamber is lined with flag-stones, and the floor is covered with sheet-lead. It is provided with two doors, an inner one of iron, an outer one of wood lined with sheet-lead, both close fitting, through which passes a pipe to allow the escape of air. This pipe terminates in a vessel of cold water. If distillation alone is to be carried on, about 5½ cwt. of crude-sulphur are placed in the pot each morning. An extra hundred-weight must be put in if both distillation and subliming are to be carried on together. The fire being lighted, the conical cast-iron plug is left out of the hole in the lid of the pot, the passage into the dome is opened, and that into the receiving-pot closed. The heat is maintained for three hours till the sulphur is of a proper temperature for distillation. The vapor which first rises from the pot is of a pale yellow color, and as much of it as passes into the dome falls down condensed as *flowers of sulphur.* But at the end of three hours the vapor becomes of a deep reddish-brown color, showing that the temperature of the melted sulphur has reached the proper point.

The plug must then be inserted in the lid, the communication to the dome closed, and that leading to the receiving-pot opened, allowing the heavy vapor to pass through the pipe surrounded with the water-jacket, by means of which a constant circulation of cold water is kept up round it. In this way the sulphur-vapor is condensed, and runs down into the receiving-pot as a very clear orange liquid, resembling



molasses in color and consistency. The person who watches the operation knows, by gauging the depth of the melted sulphur in the receiving-pot, when the greater part of the material has distilled over. He then lowers the fire, opens the communication into the dome, and cuts off that leading to the receiving-pot, allowing the remaining sulphur to pass off into the dome as flowers. A low fire is maintained till the whole has been driven off, leaving the earthy residue quite free from it, and consequently loose like coal-ashes, so that it may be easily ladled out before re-charging the pot.

When both subliming and distillation are carried on at once, the first part of the process would be exactly as described above; but when the distillation was finished the fire would be maintained for the remainder of the day, but somewhat lower, to drive off the quantity required into the dome. And in this case the subliming process would be carried on for several days, and the pot and dome never allowed to cool down altogether until the required quantity of flowers of sulphur had been obtained.

It is of the greatest consequence that all the fires should be carefully regulated in all cases: for if the heat become too great and the temperature of the melted sulphur be allowed to rise to 836°, the vapor disengaged at that temperature is highly explosive when mixed with common air; and if the plug be driven out by the pressure of the vapor, or if air be drawn into the pot through some leakage in the pipes, an explosion invariably happens. When the distilled sulphur in the refining-pot has cooled down sufficiently, which it will do in the course of an hour or two, it is ladled by hand into wooden tubs, and allowed to solidify. These tubs are constructed of a number of loose staves held together by broad wooden hoops, which can be struck off when the sulphur has *set*, allowing the staves to fall asunder and leave it as a solid cylindrical mass.

The cold and solid sulphur is broken into lumps, and is ready for use in the manufacture of gunpowder. The vapor remaining in the retorts is now allowed to pass into the dome of the subliming chamber, until all is evaporated as "flowers," leaving nothing but the earthy matter behind in the retort. and this is afterwards cleaned out. These "flowers," of sulphur are unfit for making gunpowder, on account of the acid they contain, and unless required for firework purposes or compositions, they are returned to the melting-pot with a fresh charge of the crude-sulphur. The crystalline or distilled sulphur only is used in making gunpowder, and forms ten per cent. of it by weight.

To test sulphur, burn a small quantity on a piece of white porcelain, and, if fit for the manufacture of gunpowder, there should be scarcely any residue; or if dissolved in boiled distilled water, blue litmus paper, when dipped in it, should not be discolored. See *Gunpowder.*

SUMMERS.—Supports for the bottom boarding of the carriage-body, placed parallel to the frame-sides.

SUMMONS.—To secure the attendance of necessary and material witnesses before a General Court-Martial, the Judge Advocate should usually proceed as follows:

1st. If the witness is an enlisted man, and stationed in the particular Military Geographical Department, a summons should be addressed to his Post Commander, by whom an order should then be issued for compliance therewith. If the desired witness should be an officer so stationed, the summons is then sent him through his Post Commander, by whom orders should also be issued to enable him to attend; but in military *emergencies* the Post Commander should in either of these cases, first refer the matter to the Department Headquarters, with a view to obtaining a delay in compliance, so that an officer may be sent to supply the place of the one summoned, or, if this is not practicable, to invite the Court's attention to the possibility of taking the officer's deposition. Military or civilian witnesses at some distance, *without the State, Territory, or District* where the Court may sit, but within the particular Department, need not usually be summoned, in cases not capital, but the testimony taken by deposition, unless the Court should deem their presence indispensable or delay prejudicial to the service.

2d. The testimony of witnesses *without* the particular Department, and out of the State, Territory, or District, should, except in capital cases, be taken by deposition, unless the Judge Advocate is prepared to certify that, "under the peculiar circumstances of the case, and to administer justice, it is not practicable to take the desired testimony by deposition under the 91st Article of War." In such case the summons, or subpœna, as the case may be, and the application of the Judge Advocate, thus certified, should be sent through Department to Division Headquarters, to be forwarded to competent authority. This Article of War only makes provision for the use of depositions of witnesses provided they reside beyond the limits of the State, Territory, or District where the Court may be convened. Such depositions cannot be taken nor read in evidence where military offenders have been charged with the violation of an Article of War the penalty for which, as in the 21st, 39th and 42d Articles, may be death.

3d. Under the former Articles of War, the depositions of citizen witnesses residing within the State, Territory, or District might be taken on due notice, in cases not capital, even without consent of opposite party. This provision of the law has been repealed. When, however, the opposite side will freely consent "of record," the depositions, in cases not capital, of civilian witnesses who reside within the State, Territory, or District, may, in order to prevent a failure or delay of justice, be taken, with consent of Court, on interrogatories and cross-interrogatories prepared by each side. This would be more particularly the case where the witness is unable to travel by reason of old age, sickness, bodily infirmity, or imprisonment.

In order to subpœna a witness, it must be made to appear to the satisfaction of the Court that his testimony is "material and necessary," and the fact entered on the record. *Duplicate* subpœnas should then be sent to the nearest Post Commander for service, if the witness resides within the Department, or else to Department Headquarters, unless otherwise specially directed by the Department Commander. Service is made, under the laws of the United States, by delivering the subpœna to the witness; and *proof* of service, by returning the duplicate original to the Judge Advocate with an affidavit indorsed to the effect that, on such a day, date, and place, the affiant *personally* served the within-named witness, by delivering to him a subpœna, of which the within is a complete copy. Any military person, or civilian of competent discretion, can serve the subpœna; but service by mail is *not* a legal service. Military witnesses are, in practice, *summoned* by an official communication through the regular military channels. The attendance of a civilian is secured by subpœna in due form.

Should the witness fail to appear on due and reasonable notice, the Judge Advocate has, by section 1202 U. S. Revised Statutes, "power to issue like process to compel any witness to appear and testify at the Courts of criminal jurisdiction within the State, Territory, or District where such Court may be convened." This power includes also the power to execute such process through some officer, who shall be specially charged with its execution. The Judge Advocate should, therefore, present to the Court, and have attached to the record, and therein noted, the duplicate subpœna and affidavit of service, thereby showing—

1st. That the subpœna was seasonably and personally served on the witness. 2d. That the witness is a material one. He should then formally move the Court for a *writ of attachment* against the contumacious witness. If the motion is granted, depending on whether the witness has offered just excuse for a non-attendance, the record should show it; and the Judge Advocate should then, unless otherwise specially directed by the Department Commander, apply to the Post Commander nearest to the place of residence of witness, if within the particular Department, for the name of some military officer to serve the process, and formally direct the *writ of attachment* to him, and attach thereto a certified copy of the order convening the Court, and copies also of the original subpœna and charges and specifications. The Post Commander should thereupon furnish the officer a sufficient force for the execution of the process, whenever such force shall be actually required. If the witness resides without the particular Department, the Judge Advocate should trsnsmit the *writ of attachment*, with its annexed certified copies of *orders* convening Court, *subpœna*, and *charges* to Department Headquarters for transmission, properly signed and filled in, except as to the *name of the officer* who may be subsequently indicated to serve the writ. See *Court-Martial*.

SUMP FUSE.—A thick kind of fuse used for blasting under water. The fuse composition is enclosed in a hempen cord, which is twisted, overlaid with another cord, and varnished. The end is placed in the waterproof cartridge and tied; the end of the fuse is then dipped in pitch, and the protected fuse is ready for duty.

SUMPITAN.—A weapon like a *sabercane* and about seven feet long. It is quite effective at 100 or 125 yards. The arrow driven by this weapon is called a *sumpit*.

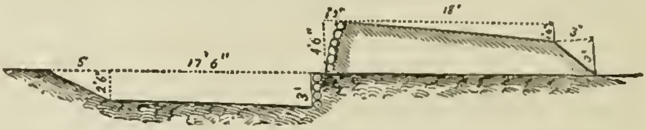
SUMPTER MULES. Baggage mules of early English armies were called *sumpter mules*. The term is obsolete now in the British, but is still retained in the American Army.

SUN-CASES.—Strong cases made much like those for rockets, and filled with a composition which burns more slowly than rocket composition. They are attached to wooden frames, to give long rays of sparkling light. The choke is sometimes made by driving clay in the end of the case, and boring a hole through it for the escape of the flame; or the clay is driven on a short nipple, forming the choke. Sun-cases are generally made from .75 inch to 1.5 inch interior diameter; their exterior diameter being quite double that of the interior. The length of the case may vary according to the time they are required to burn. The diameter of the choke is about ¼ the interior diameter.

To drive the case, set it on the nipple, and place it in a wooden mold; pour in a ladleful of composition and give it ten blows with the mallet; continue in the same way till the case is filled to the required height; put in a charge of rifle-powder, and over it drive a ladleful of clay. When the cases are filled, prime them by inserting in the choke a strand of quick-match doubled in the middle and secured by driving a little more composition on it with a lance-drift. Paste on each end of the case a strip of paper 5 inches wide, projecting 3 inches over the end of the cover, and forming an envelope to inclose the leaders. Sun-cases are fastened to the frames in the plane of the frame by means of iron wire, or with strong twine. See *Fireworks*.

SUNKEN BATTERY. A battery in which the platform lies below the natural surface of the ground. Such a battery possesses the advantage of being more quickly built.

The parapet of the battery and the embrasures are revetted either with gabions, fascines, or sand-bags; or with a combination of these The requisite slope is given to the gabions of the first tier by placing a row of fascines under them, along the foot of the interior slope. Another row of fascines is laid on the top of the tier, along the interior slope, on which the gabions of the second tier rest. The requisite height is given to the parapet either by placing sods on the top tier, or by earth alone. When sand-bags are used they are laid in single courses along the interior slope, and as headers and stretchers; the courses breaking joint. To give the bags greater durability they should be impregnated with tar before being filled. See *Batteries*.



Section of a Sunken Battery revetted with fascines.

SUPERANNUATED.—Incapacitated for all service, either from age or infirmity, and placed on a pension.

SUPERCHARGE.—In Heraldry, a bearing or figure placed upon another.

SUPERINTENDENT OF NATIONAL CEMETERIES. The Superintendents of the National Cemeteries are selected from meritorious and trustworthy soldiers, either Commissioned Officers or enlisted men of the Volunteer or Regular Army, who have been honorably mustered out or discharged from the Service of the United States, and who may have been disabled for active field-service in the line of duty. Applications for the appointment of Superintendent should be addressed to the Quartermaster General of the Army, and be accompanied by testimonials of responsible persons in support of the above requirements. They must be in the handwriting of the applicant, and must give his full name, length of service, the company and regiment he last served in, date and cause of his discharge, and his present place of residence. All applicants, before being appointed, are examined by a Board of Officers to be convened by orders from the Adjutant General's Office, in the Department where they may be residing or serving.

In view of the responsibility attached to the position of Superintendent, and his not being generally under the direct supervision of a Superior Officer, it is of great importance that none but men of excellent character should be appointed. Applicants for the position must therefore fulfill the following conditions: 1. They must have served in the Army of the United States, either Regular or Volunteer, and must have been disabled for active field-service *in the line of duty*, but *the degree of their present disability must not be such as to impair their efficiency in charge of Cemeteries*. 2. They must be of steady, sober, and correct habits. 3. They must have a fair degree of intelligence and education, and must be able to write legibly. An applicant having passed a satisfactory examination is, if selected for appointment, required to serve a probationary term of six months as an assistant at such Cemetery as the Quartermaster General may designate before being definitely appointed; but he is not placed in charge of a National Cemetery, temporarily or otherwise, during his probationary term of six months. Applicants thus selected are hired by the Quartermaster's Department, at the rate of $40 per month, and furnished with transportation from and to their homes.

If at the expiration of this probationary term the applicant has shown his fitness for the position, he is then eligible for appointment when a vacancy occurs. Should there be no vacancy at the end of the term, his employment will cease. He is then, in his turn, duly appointed as vacancies occur. The number of candidates on probation will at no time exceed four. The pay of Superintendents is $75, $70, $65, $60, per month, according to the grade of the Cemetery to which they are assigned, with quarters and fuel. Except under special authority from the War Department no leave of absence for a longer period than ten days can be granted Superintendents of National Cemeteries during the growing season, from April to September, inclusive. Superintendents of National Cemeteries are not liable to trial by Court-Martial under the Rules and Articles of War. See *Battle-ground Cemeteries*, *National Cemeteries*, and *Post Cemeteries*.

SUPERINTENDENT OF RECRUITING SERVICE.—A Field-officer detailed by the Adjutant General of the Army, and charged with the supervision of recruiting. As soon as a recruiting station is designated, the Superintendent sends the estimates for funds to the Adjutant General, and requisitions on the proper Departments (through the Adjutant General) for the clothing, camp equipage, arms, and accouterments. Subsequent supplies for the stations in his district are procured by the Superintendent on consolidated estimates; these are made as required for funds, and every six or twelve months for clothing, equipage, arms, and accouterments. The Superintendents make such transfers of funds, clothing, camp and garrison equipage, and accouterments to their officers as may be required. In all cases recruiting officers send their estimates direct to their Superintendent.

Branch or auxiliary rendezvous will be established only by orders from Superintendents. They should never be more than fifteen miles distant from the main rendezvous. Superintendents may order officers to visit their branch rendezvous not oftener than once a week. The Superintendents will report all Commissioned or Non-commissioned Officers who may be incapable or negligent in the discharge of their functions. When a recruiting party fails to get recruits from any cause other than the *fault* of the officer, the Superintendent recommends another station for the party. Whenever the number of recruits in any depot becomes too large, the Superintendent reports to the Adjutant General for instructions in reference to sending detachments to regiments, stating the number disposable.

When recruits are sent from a depot or rendezvous to a regiment or post, *a muster and descriptive roll*, and an *account of clothing* of the detachment, are given to the officer assigned to the command of it; and a duplicate of the muster and descriptive roll is forwarded to the Adjutant General by the Superintendent, who notes on it the names of all the officers on duty with the detachment, and the day of its departure from the depot or rendezvous. When a rendezvous is closed, the Superintendent gives the necessary instructions for the safe-keeping or disposal of the public property, so as not to involve any expense for storage. The Superintendents transmit to the Adjutant General consolidated monthly returns of the recruiting parties under their superintendence, according to directions on the printed blanks, accompanied by one copy of the enlistment of each recruit enlisted within the month. See *Recruiting*, *Recruiting Depot*, and *Recruits*.

SUPERINTENDENT OF THE MILITARY ACADEMY.—The Superintendent of the Military Academy, appointed by the President has the immediate command and government of the institution. He directs the studies, academic duties and field exercises, and renders to the General-in-Chief all required reports, returns, and estimates concerning the Academy. In the absence of the Superintendent, his authority and duties devolve on the next in rank who is eligible to command in the Army. See *United States Military Academy*.

SUPERIOR OFFICER.—Any officer of higher rank, or who has priority in the same rank, by the date of his commission, etc.

SUPERIOR SLOPE.—In fortification, the upper surface of the parapet. It is arranged so that a soldier behind the interior crest can reach with his fire a point near the crest of the counterscarp. This line of fire should pass within three feet of the crest of the counterscarp, and need not go below it. By this arrangement, the soldier can sweep with his fire all the ground beyond the ditch. By giving the superior slope an inclination of exactly $\frac{1}{6}$ it will be found that this condition will be fulfilled in an ordinary field-fortification. If the line of fire along this slope does pass more than three feet above the crest of the counterscarp, the inclination must be increased. The angle must be limited, because as it is increased, the weakness of the parapet near the interior crest is increased. The limit of this inclination is $\frac{1}{4}$.

If a slope of $\frac{1}{4}$ does not bring the line of fire within three feet of the counterscarp, the inclination cannot be increased. It is better in this case to construct a slight glacis, so as to bring the assailants under the fire of the parapet. Care must be taken that the upper surface of the glacis is kept at least five feet below the interior crest of the work.

It is well to state that a slope for the upper surface of the parapet is a necessary evil. It weakens the parapet by making it thin near the interior crest, and this thin portion wears away quickly under the action of the weather and the enemy's fire. Still, if it had no slope, it would mask the enemy when near the work. See *Field-fortification*.

SUPERNUMERARY.—A term signifying above the number, and, when applied to an officer in the Army, means that, on being detached from his regiment on staff or any other employment, he becomes supernumerary, and has his place and duties in the regiment taken by another officer, promoted from the next lower rank. Under these circumstances, the officer in staff employment is in excess of the regulated number of officers of that grade, and is shown in italics in his regiment as the same. After serving five years away from his regiment in the English Service he returns to it, and remains a supernumerary, until absorbed; or should his regiment be in India, or ordered home, he must then rejoin his regiment

SUPERSEDE.—To deprive an officer of rank and pay for any offense or neglect, or to place one officer over the head of another, who may or may not be deserving.

SUPPLEMENTARY TRIGGER.—A trigger of precision (*Steicher* in Germany) invented in the year 1543 at Munich. It could be fixed to wheel-locks.

SUPPLIES.—The departments of supply to the Army are 1. The Ordnance Department, which provides ordnance and ordnance stores; 2. The Quartermaster Department, which furnishes quarters, forage, transportation, clothing, camp and garrison equipage; 3. The Subsistence Department, which furnishes subsistence; and 4. The Medical Department, which provides medicines and hospital stores. The Ordnance and Medical Departments, requiring special knowledge for their peculiar duties, could not be relieved of any part of the duties belonging to them respectively; but the want of connection between the Quartermaster's and Subsistence Departments may in war be attended with serious inconvenience, and no good reasons whatever, it is believed, exist for not uniting the two departments in one. Under the command of one Chief in the field, acting, of course, in subordination to the Commander of the Army, such a Department might originate and direct such measures for the supply of the army as had not been provided for; control expenditures; insure a prompt and correct accountability for all disbursements and all distributions, and do away with all antagonism of interest caused by the requirement that one Department shall furnish subsistence stores, and the other transports. These with clothing and other supplies furnished by the Quartermaster, Ordnance, and Medical Departments, are the great wants of a soldier in active service. A well-armed and well-equipped soldier cannot dispense with food, transportation, and clothing, and the means of providing such necessities in war demand earnest thought.

We have seen military administration in times of peace conducted upon complete principles and regulations; services regularly organized, and efficiently supported by the natural resources of a fertile and industrious country; sufficient funds always available; the immediate supervision and protection of the war ministry; independence assured to the control of military expenditure and consumption by well-defined laws; nothing wanting, in short, to satisfy all the wants of the army, and to provide them with regularity, order, and economy. It is not so, it cannot be so, in a state of war. In the field the frequency of movements, the rapidity of marches, the uncertainty of events, the ever-varying chances, the imperfection of means, the insufficiency of resources —the time ever too short for all that has to be provided and done—embarrass, retard, and paralyze administrative action. Every emergency exacts its immediately appropriate measure, and the least foreseen accident may in a moment frustrate the most wise arrangement, and upset the surest calculations. The duties of administration now assume an entirely new character; they become immense in their extent, limited only, indeed, by the intelligence of the Administrator himself, who is charged with their execution. The first of all rules, that which the greatest Captains and the most enlightened Administrators have never failed to enforce in their writings, and of which experience has everywhere proclaimed the value, is the formation of depots beforehand, and to such an extent that the army may not only be subsisted during the opening of the campaign, but as long after as the interests of military operations may require, or as distances may permit. A certain mistrust of the country about to become the seat of war is indeed prudent, for it is generally a country unknown to administration, or perhaps scantily or ill-known, and which cannot fail to be opposed to its operations, since they are so apt to wound it in its interests or in its feelings. The subjects of which a knowledge appears the most important are: 1. The divisions of the territory into governments, provinces, counties, or departments; into districts, cantons, etc 2. The organization of its territorial, military, civil, and financial administration. 3. Its natural products. 4. The periods of seed-time and harvest of every description of grain, and the proportion between (local) produce and consumption. 5. The localities of large markets and fairs, the periods of these commercial gatherings, and the much more important objects of their traffic. 6. The subsistence which might most conveniently be substituted in lieu of those established by our regulations, and the relative proportion to be established in such substitution. 7. The different branches of commerce and industry. 8. The means of re-mount, both as regards cavalry and general transport. 9. The manufacture of cloth, leather, and other material, suitable for the preparation of clothing, equipments, harness, etc. 10. The articles of consumption drawn from other countries, the designation of those countries, and the objects of exchange in importations and exportations. 11. The weights, measures, and coinage, with relative value to our own. 12. The current prices of articles of consumption. 13. Barracks, quarters, hospitals, magazines, and other establishments of administration, and their capacities, throughout the various towns and fortresses. 14. The most convenient spot for forming temporary establishments. 15. The principal points of communication by land and sea, with the distances between them, distinguishing the different routes and indicating, as regards the roads, the spots at which they cease to be passable for carriages; and as regards rivers and canals, the places where they cease to be navigable. 16. In the large towns or fortresses the nature and quantities of the provisions stored therein, the means of grinding corn and baking, the principal mercantile firms, and the heads of large manufactories or workshops where it would be safe to deal for military supplies. One may easily conceive how useful such admirable statistics would be. On the outbreak of the war the Minister would feel no uncertainty at all either as to the nature or the extent of the arrangement he should have to make for himself, or as to the instructions to be given to his Commissary General. How many false moves would thus be avoided; how many useless and heavy expenses saved; how many unknown and lost resources would thus be discovered and employed for the benefit of the army and the relief of the country which has to support it. A commissariat should always regulate its arrangements on the double chances of presumed success or failure, according to the peculiar nature of the war to be undertaken. In the event of success, then in proportion to the advance into the enemy's country, it should form its depots in the rear of the army, and establish by stages, on the line of operations, bakeries, magazines, hospitals, convalescent stations, regular convoys, etc., always taking care to select localities with reference to the most favorable means of communication and of defense. In the case of a reverse, the army falling back upon itself will thus find its administrative services secured by means of the supplies which prudence shall thus have collected. The rights of war, which are always but the rights of the most powerful, tempered only by the interests of him who wields them, render an army, whatever it may be, absolute master of the provisions and other useful resources which exist, whether they have been provided as depots by the enemy, or destined for other purposes. Administration requires a numerous *personnel*, active, intelligent, and faithful, always ready to avail themselves of supplies for future use, for transmission elsewhere, or for immediate distribution to the troops, wherever they may be stationed. A commissariat requires an extensive and perfectly organized transport; this is the *sine qua non* to enable an army to subsist in the field. Transport is indispensable, and must be obtained at any price; it must, moreover, be *well adapted to the locality*, in order to be able to follow or rejoin bodies of troops in all directions. Thus it is to be understood that the country occupied must be expected to furnish a large proportion of the requisite transport. Although acting in the midst of a state of things essentially inimical to fixed regulations and established forms, the commissariat should prescribe for itself a strict and scrupulous system. In the face of so many pressing and urgent wants, which, if not supplied with regularity, may disturb the discipline and compromise even the honor of the army, it is not enough for the Administrator to prove himself both intelligent and economical in the dispensation of resources obtained with difficulty and labor; he should further, courageously attacking all abuses and repressing with severity all wastefulness and fraud, secure to himself the means of justifying his expenditure and distribution by authentic accounts, a duty but too rarely accomplished, but which should never be permitted to be neglected. War, it is said, should feed war; the axiom may be true if not just, but in no case should it be pushed to extremes; circumstances may occur, indeed, to render its application impolitic and dangerous. Under no circumstances, however, can the enemy's country under occupation be altogether relieved from the charges of war; it must inevitably bear a large share, even though its contributions may occasionally be considered as advances only. But whatever their nature, these exactions from an enemy's country should be imposed with discernment and moderation, with reference to the population and the nature of the produce, the geographical position and the wealth of the country and, when possible, with consideration for the feelings of the vanquished. Pillage a country and you reduce the inhabitants to misery, to despair, to flight, and thus not only deprive yourself of assistance, but in the day of reverse find implacable and cruel adversaries. All that can be done when a country yields nothing is to form depots wherever bodies of troops are quite likely to be stationed; to have the largest possible reserves at headquarters; and to be prepared with a sufficient land transport establishment to carry all requisite supplies in the event of an advance or a change in position. But this is an exceptional state of things; in general the country can be placed under contribution, either voluntary or coercive, for the supply of provisions and forage, and the Commissariat Officer then enters upon his legitimate functions. Several measures are then open to his adoption; he may avail himself of the enterprise of local contractors; he may make his purchases directly from the owners at the market price; he may fix an arbitrary rate for the different articles of supply; and lastly, he may levy contributions on the people and compel them to furnish according to their means the provisions required for the army. His own judgment must guide him in the choice of these measures. The employment of contractors, in times of peace undoubtedly advantageous, is attended with many objections during a period of war. Sir Randolph Routh says truly, "the best and surest contractor is the country occupied by the troops and its natural resources carefully and duly economized;" and he proceeds to cite instances within his experience of the inconvenience arising from the too great confidence in contractors "who swarm about an army when it is prosperous to prey upon its wants, but are the first to fly in the event of a reverse. The commissariat has to consult at once the wants of the army, the welfare and economy of the State, and the resources and feelings of the country where he may be acting. To seize supplies, unless from an enemy in arms, is to be deprecated; and to pay for them more than their value is equally objectionable; unnecessary force creates an ill feeling which may defeat the objects of administration; to submit to imposition enhances the difficulty of the Service; but a conciliation and fair dealing, backed by decision, will never fail to prove a good policy and enable the army to procure supplies without unnecessary expense to the public or uselessly exasperating the population. If the territory be that of a friendly or neutral power, every effort should be made by the commissariat to arrive at a just estimate of its resources in grain, cattle, fuel, and other articles of supply, to ascertain their current market value, and having obtained all possible information on these points, the people should be invited, either through the local authorities, or the agency of private individuals, to furnish whatever is required, with the understanding that the usual price will be paid for the supplies brought in, and that the headquarters of the army will prove a profitable market to them.

When confidence in the good faith of the purchaser has been once established, the population of a country occupied by a military force will be generally willing to sell, and should a disposition to hold back supplies in the hope of enhancing their value be shown, the interposition of the local authorities should be sought in preference to the adoption of arbitrary measures. Conciliation and firmness, temper and justice combined, will seldom fail to induce the inhabitants, even when their sympathies tend in another direction, to contribute to the extent of their means to the maintenance of the army quartered upon them. Amid a hostile population a conquering army should exercise its power with every possible regard to justice. Fair treatment may reconcile a people to the presence of a conqueror, and induce it to submit to superior strength. No effort should be left untried to produce such a result, since a resort to force, although it may provide for the immediate want, inevitably destroys the sources of supply. The best course to be adopted in levying supplies in an enemy's country is, having first ascertained the resources of the district, to demand, through the local authorities, the head men of villages, or other channels, that certain quantities of provisions should be brought at a given time to the headquarters of the army, care being taken that the demand be not beyond the means of the district, and a fair price should be paid whenever a disposition is shown to comply promptly with these requisitions. Such a measure will rarely fail of effect, and when the inhabitants feel certain that there is no alternative between selling their produce and having it seized, they will submit to the necessities of war in its least aggravated form, and yield to a compulsion which, though it do violence to their national feelings, consults their individual interests. Nor is it only in the supply of provisions that the theater of war should be laid under contribution; labor and transport may likewise be attained by means of judicious administrative arrangement. The stern rules of war justify the exaction of all the resources within its influence; it is for administration to render these exactions as little oppressive as possible when dealing with a class of people which, as a rule, is the most innocent of the causes of war, the most exposed to its ravages, and the least benefited by its results. In proportion as tact and moderation are displayed by the agents employed in levying supplies upon the population, so will the resources of the country become available and productive. Violence and wrong will convert the peaceable peasant into a desperate and implacable foe; conciliation and fair-dealing may make him, if not an ally, at least a profitable neutral. Interests far beyond the hour may be involved in the action of military administration under such circumstances, and the seeds of rancor or good-will, sown to-day on the scene of contending armies, may bring forth fruit to influence the destinies of nations long after the combatants themselves have ceased to struggle.

When it is necessary at established stations that a prompt settlement should be effected for all services rendered to the army, and that every engagement entered into by the commissariat should be most scrupulously complied with, how much more so is this the case in the field. The love of gain—that mainspring of human action under all circumstances, and in all places—is seldom appealed to in vain; but the feeling must be supported by confidence; for one man who will run a risk for a remote prospect of reward, a hundred will toil for a certain remuneration, and it should be one of the first aims of administration to inspire all classes among which it is called upon to act, with a full and entire confidence in its good faith.

A breach of faith involves more than immediate consequences: it permanently destroys *credit*.

SUPPLY DEPARTMENT. A branch of the Control Department, now abolished, and replaced by the Commissariat Department. This department has for its object, as its name implies, the providing of an army with food, whether in time of peace or war.

SUPPORT. An aid; a sustaining power. In military maneuvers, the term *supports* is given to a technical formation, being the second line in a battle, either in the attack or the defence.

SUPPORT ARMS. That position in the Manual of Arms executed as follows: The Instructor commands, 1. *Support*, 2. Arms. The piece is carried in front of the center of the body; grasp it with the left hand at the lower band, and raise this hand to the height of the chin; at the same time grasp the piece with the right hand, four inches below the hammer. (Two). Carry the piece opposite the left shoulder, barrel to the front; pass the left forearm extended between the right hand and the hammer, support the hammer on the left forearm, the left forearm horizontal, the wrist straight. (Three). Drop the right hand by the side. See *Manual of Arms*, Fig. 3.

SUPPORTERS.—In Heraldry, figures placed on each side of an armorial shield, as it were to support it. They seem to have been in their origin, a purely decorative invention of medieval seal-engravers, often, however, bearing allusion to the arms or descent of the bearer; but in the course of time, their use came to be regulated by authority, and they were considered indicative that the bearer was at the head of a family of eminence or distinction. The most usual

Supporters—Arms of Duke of Argyle.

supporters are animals, real or fabulous: but men in armor are also frequent, and savages or naked men, often represented with clubs, and wreathed about the head and middle. There are occasional but rare instances of inanimate supporters. On early seals, a single supporter is not unfrequent, and instances are very common of the escutcheon being placed on the breast of an eagle displayed. The common rule, however, has been to have a supporter on each side of the shield. The dexter supporter is very often repeated on the sinister side, but the two supporters are in many cases different; when bearer represents two different families, it is not unusual for a supporter to be adopted from the achievements of each. In England, the privilege of bearing supporters as now defined belongs to the Sovereign and to the Princes of the Blood, Peers and Peeresses, and the heads of a very few families not of the peerage, whose right is based on an ancient patent, or very early usage. No right is recognized by the College of Arms as belonging to the sons of peers bearing courtesy titles. Knights of the Garter and Knights Grand Cross of the Bath are dignified with supporters, which, however, are not hereditary. Supporters have also been assigned to the principal mercantile companies of London. In Scotland the use of supporters is somewhat less restricted. The distinction was much less wide than in England between the greater and the lesser Barons, and the right to supporters was considered to belong to the latter, so long as the baronial status conferred a right to sit in Parliament. The Act of 1587, which finally excluded the lesser Barons from the Scottish Parliament, and established a systematic parliamentary representation, was not held to interfere with this armorial privilege, and it is yet the practice of Lord Lyon to grant or confirm supporters to the representatives of all minor Barons who had full baronial right prior to that date. A limited number of heads of important families, including the chiefs of the larger Highland clans, apart from considerations of barony, participate in the right to supporters. Lyon is also considered to have it in his power to confer them *ex gratia*, a prerogative which is but sparingly exercised, one of the instances of such departure from strict rule having been in favor of Sir Walter Scott. Nova Scotia Baronets as such have no right to supporters, though many bear them in respect of baronial qualification. The lion and unicorn, familiar in the royal arms of the United Kingdom, were adopted, the former from the achievement of England, and the latter from that of Scotland prior to the uniting of the crowns. In the more modern Heraldry, supporters generally stand either on an escrol, containing the motto, or, more properly, on a carved panel of no definite form, which in Scotland is known by the name of a *compartment*. See *Heraldry*.

SURCINGLE.—A girth made of strap-leather and attached to the saddle. It consists of a long body and short strap, and is buckled with exactly the same degree of tightness as the girth, the buckle being placed so as just to touch the lower edge of the near flap of the saddle.

SURCOAT.—A tunic worn by Knights of the Middle Ages over the coat of mail; it was usually made of silk of one uniform color, but sometimes variegated, sometimes richly embroidered.

SURFACE.—In fortification, that part of the side which is terminated by the flank prolonged, and the angle of the nearest bastion; the double of this line with the curtain is equal to the exterior side.

SURFACE GAUGE.—An implement for testing the accuracy of plane surfaces. The hundreds of uses of the *surface-gauge* in modern armories make every improvement in its construction and adaptability of value to the practical, exact mechanic. One of the botherations of the ordinary surface-gauge has been that to set it exact, dependence has been made wholly on the adjustability of a set-screw, which demanded repeated trials on the "cut and try system." It is evident enough that it is possible to change this trial method to that where positive exactness shall be the rule, so that the carrying-arm of the gauge points shall be as easily adjusted to exactness as the jaws of the spring-calipers. The most approved pattern of this gauge is drop-forged of bar-steel, and it is finished in a thorough manner and hardened. It is much of the usual style, except the employment of two sliding-snugs, connected by a screw encircled by an open spiral-spring. The upper snug is split and is held in place at any position on the upright standard, by means of a simple thumb-nut that clamps the split snug on the standard. This snug is connected to one below by means of a screw encircled by an open spiral-wire spring. This lower snug supports the marking points, consisting of a piece of steel wire, which are held in the usual way by means of a thumb-nut on a clamping-screw.

In operation, any movement, up or down—along the line of the standard—or around its circumference, of the upper snug, will, of necessity, be accomplished by the lower snug in consequence of the connection of the screw; but the lower snug may be raised or be lowered by the connecting-screw acting with the spiral-spring, so that while the upper snug is held firmly in place by its binding-screw, the lower snug, carrying the points, may be carefully and exactly adjusted to surface measurements, and when in position the tension of the spring and friction of the screw will hold the points exactly where they have been adjusted.

The advantages of this gauge are not confined to its close adjustment after the principal snug is fixed as closely as possible to the surface to be gauged, but comprehend also a swinging around of the gauge points to reach surfaces out of one direct line without disturbing the standard. See *Gage*.

SURGEON.—A Staff Officer of the Medical Department. He has the rank of Major, but in virtue of such rank is not entitled to command in the Line or any Staff Departments of the Army. In the British Army, Surgeon is the grade in which an officer enters the Medical Department, and from which he is promoted in about 15 years to the rank of Surgeon Major. He may be attached to a regiment, or serve with a district hospital; pay and duty being practically the same in either case. The pay rises gradually from £182 10s. to £319 7s. 6d. a year; and the Surgeon ranks as a Lieutenant for six years, and afterward as Captain. In the Medical Department of the Navy, Surgeon is also the junior rank, reckoning for precedence as a Sub-lieutenant for six years, and afterward as a Lieutenant. The pay varies from £200 15s. a year to £310 5s. See *Medical Department*.

SURGEON GENERAL.—An officer with the rank of Brigadier General, charged, under the Secretary of War, with the administrative duties of the Medical Department. The medical supplies for the Army are prescribed in the Standard Supply Table, furnished by the Surgeon General, and issues are governed by it, except as to size of packages, which may be regulated by circumstances and quantities required. The Surgeon General requires sanitary reports from the various Medical Officers on duty, from time to time, and on the following subjects:

1. On the food of the Army, its quantity, quality, and mode of preparation. What is the character of the articles forming the regular ration as furnished to the post? What is the average amount of saving for post fund? What articles of food, and in what amount, are purchased by the post fund, obtained from post garden, or by hunting and fishing? Ice, how obtained, and in what quantities furnished?

How is the cooking done for the men? Give bill of fare for a week at different seasons. Is the food of the men inspected daily? How often is it inspected by the Medical Officer? Have any complaints been made by the men about the food, and have any cases of disease occurred which may be attributed to the food or its mode of preparation? If so, specify. Character of kitchen and bakery fixtures. Has any special apparatus, such as the Warren cooker or the felt box, been tried? If so, give results. Character and amount of extra articles furnished by the Commissary Department for officer's use. Diet of the sick and hospital fund. Remarks, suggestions, and recommendations.

2. Duties of Medical Officers in scouting parties and expeditions. Nature and amount of medical supplies required; how carried. Means of transportation for wounded. Remarks.

3. On military punishments and their effect on the health and morals of the soldier. Give instances, recommendations, etc.

4. Personal cleanliness of the men. What are the post regulations, if any, with regard to bathing? What facilities are afforded? How often are the men's blankets washed?

The above report must be forwarded promptly through the proper channel to the Medical Director on or before January 1st. Medical Directors will forward them through the Department Commanders, with their own observations and comments on the points above referred to. See *Medical Department*.

SURGEON MAJOR.—A Medical Officer who is attached to and in medical charge of a regiment. He is assisted by one or more Medical Officers subordinate to himself. As Senior Medical Officer, he remains always with the headquarters of the regiment when any portion of it is detached.

SURGEON'S CALL.—The signal for assembling the sick who are reported to the Surgeon. At Surgeon's call the sick then in the companies are conducted to the hospital by the 1st Sergeants, who each hand to the Surgeon, in his company-book, a list of all the sick of the company, on which the Surgeon states who are to remain or go into hospital; who are to return to quarters as sick or convalescent; what duties the convalescents in quarters are capable of; what cases are feigned; and any other information in regard to the sick of the company he may have to communicate to the Company Commander.

SURGERY.—It is impossible for any civilized nation to place too high an estimate upon this branch of the public service. Without the aid of a properly organized Medical Staff, no army, however well organized, could successfully carry on any war, even when it is one similar to our late Rebellion, or of a strictly civil character. No men of any sober reflection would enlist in the service of their country, if they were not positively certain that competent Physicians and Surgeons would accompany them in their marches and on the field of battle, ready to attend to their diseases and accidents. Hence military surgery, or, more correctly speaking, military medicine and surgery, has always occupied a deservedly high rank in the public estimation.

Dionis, a Surgeon far in advance of his age, in referring to the value of medical services to soldiers, exclaims, with a burst of eloquence: "We must then allow the necessity of chirurgery, which daily raises many persons from the brink of the grave. How many men has it cured in the army! How many great Commanders would have died of their ghastly wounds without its assistance! Chirurgery triumphs in armies and in sieges. 'Tis true that its empire is owned; 'tis there that its effects, and not words, express its eulogium."

The confidence reposed by soldiers in the skill and humanity of their Surgeon has often been of signal service in supporting them, when exhausted by hunger and fatigue, in their struggles to repel the advancing foe, or in successfully maintaining a siege when the prospect of speedy surrender was at hand. Who that is versed in the history of our art does not remember with what enthusiasm and resolve Ambrose Paré, the father of French surgery, inspired the souls of the half-starved and desponding garrison at Metz, in 1552, when besieged by 100.000 men under the personal command of Charles V.? Sent thither by his Sovereign, he was introduced into the city during night by an Italian Captain; and on the next morning, when he showed himself in the breach, he was received with shouts of welcome. "We shall not die," the soldiers exclaimed, "even if wounded: Paré is among us." The defense from this time was conducted with renewed vigor, and the French army ultimately completely triumphed, through the sole influence of this illustrious Surgeon. No man in the French army under Napoleon rendered so many and such important services to the French nation as Larrey, the illustrious Surgeon who accompanied that mighty warrior in his various campaigns, everywhere animating the troops and doing all in his power to save them from the destructive effects of disease and injury. His humanity and tenderness were sublime; and so highly was his conduct, as an honest, brave, and skillful Surgeon, appreciated by Napoleon, that he bequeathed him a large sum, with the remark that "Larrey was the most virtuous man he had ever known."

The injuries inflicted in war are, in every respect, similar to those received in civil life. The most common and important are fractures, and dislocations, bruises, sprains, burns, and the different kinds of wounds, as the incised, punctured, lacerated, and gunshot. With the nature, diagnosis, and mode of treatment of these lesions every Army Surgeon must, of course, be supposed to be familiar; and we shall therefore limit our remarks to a few practical hints respecting their management on the field of battle and in the ambulance. Most of the cases of *fractures* which occur on the field of battle are the result of gunshot injury, and are frequently if not generally, attended by such an amount of injury to the soft parts and also to the bone as to demand amputation. The bone is often dreadfully comminuted, and consequently utterly unfit for preservation. The more simple fractures, on the contrary, readily admit of the retention of the limb, without risk to life. In transporting persons affected with fractures, whether simple or complicated, the utmost care should be used to render them as comfortable as possible, by placing the injured limb in an easy position, and applying, if it need be, on account of the distance to which they have to be carried, or the mode of conveyance, short side splints of binders' board, or thin wood, as a shingle, or junks of straw, gently confined by a roller. For want of due precaution the danger to limb and life may be materially augmented. Permanent dressings should be applied at the earliest moment after the patient reaches the hospital. If the fracture be attended with splintering of the bone, all loose or detached pieces should at once be extracted; a proceeding which always simplifies the case, inasmuch as it prevents, in great measure, the frightful irritation and suppuration which are sure to follow their retention. When this point has been properly attended to, the parts should be very neatly brought together by suture, and covered with a compress wet with blood. As soon as inflammation arises—not before—water-dressings are employed. A suitable opening, or bracket, should be made in the apparatus to facilitate drainage and dressing.

Dislocations, accidents by no means common in all military operations, are treated according to the general rules of practice; they should be speedily reduced, without the aid of chloroform, if the patient is faint or exhausted; with chloroform, if he is strong or reaction has been fully established. The operation may generally be successfully performed by simple manipulation; if, however, the case is obstinate, pulleys may be necessary, or extension and counter-extension made by judicious assistants.

Bruises, or contusions, unless attended with pulpification, disorganization, or destruction of the tissues, are best treated, at first, until the pain subsides, with tepid water impregnated with laudanum and sugar of lead, or some tepid spirituous lotion, and afterward, especially if the patient be strong and robust, with cold water, or cold astringent fluids. If the injury be deep seated, extensive, and attended with lesion of very important structures, the case will be a serious one, liable to be followed by the worst consequences, requiring, perhaps, amputation.

Sprains are often accompained with excessive pain and even severe constitutional symptoms. They should be treated with the free use of anodynes and also with warm water-dressings medicated with laudanum, or laudanum and lead. The joint must be elevated and kept at rest in an easy position. Leeches may be applied, if they can be obtained; otherwise, if plethora exist, blood may be taken from the arm. By-and-by sorbefacient liniments and friction come in play. Passive motion should not be instituted too soon.

Among the accidents of war are *burns*, and, occasionally, also scalds. The former may be produced by ordinary fire or by explosion of gunpowder, casual or from the blowing up of a redoubt, bridges, houses or arsenals, and vary from the most trivial to the most serious lesions, involving a very great extent of surface or tissue, and liable to be followed by the worst consequences. Such injuries always require prompt attention; for, apart from the excessive pain and collapse which so often accompany them, the longer they remain uncared for, the more likely will they be to end badly.

Various remedies have been proposed for these injuries. Dr. Gross has always found white-lead paint, such as that employed in the arts, mixed with linseed oil to the consistence of very thick cream, and applied so as to form a complete coating, the most soothing and efficient means. The dressing is finished by enveloping the parts in wadding, confined by a moderately tight roller. It should not be removed, unless there is much discharge or swelling, for several days. If vesicles exist, they should previously be opened with a needle or the point of a bistoury. A liniment or ointment of glycerine, lard or simple cerate, and subnitrate of bismuth, as suggested by his friend, Professor T. G. Richardson, of New Orleans, is also an excellent remedy, and may be used in the same manner as the white-lead paint. In the milder cases, carded cotton, cold water, water and alcohol, water and laudanum, or solutions of lead and laudanum, generally afford prompt relief. Amputation will be necessary when there is extensive destruction of the muscles, bones, or joints. Reaction must be promoted by the cautious use of stimulants; while pain is allayed by morphia or laudanum given with more than ordinary circumspection lest it induce fatal oppression of the brain. In burns from the explosion of *gunpowder*, particles of this substance are often buried in the skin, where, if it be not removed, they leave disfiguring marks. The best way to get rid of them is to pick out grain after grain with the point of a narrow-bladed bistoury or cataract needle.

The subject of *wounds* is a most important one in regard to field-practice, as these lesions are not only of frequent occurrence, but present themselves in every variety of form and extent. Their gravity is influenced by numerous circumstances which our space does not permit us to specify, but which the intelligent reader can readily appreciate. In many cases death is instantaneous, owing to the shock, or shock and hemorrhage; in others it occurs gradually, with or without reaction, at a period of several hours, or, it may be, not under several days. Sometimes men are destroyed by shock, by, apparently, the most insignificant wound or injury, owing, not to want of courage, but to some idiosyncrasy. The indications presented in all wounds, of whatever nature, are—1st, to relieve shock; 2d, to arrest hemorrhage; 3d, to remove foreign matter; 4th, to approximate and retain the parts; and 5th, to limit the resulting inflammation.

1. It is unnecessary to describe minutely the symptoms of *shock*, as the nature of the case is sufficiently obvious at first sight, from the excessive palor of the countenance, the weakened or absent pulse, the confused state of the mind, the nausea, or nausea and vomiting, and the excessive bodily prostration. The case must be treated promptly: by free access of fresh air and the use of the fan, by loosening the dress or the removal of all sources of constriction, by dashing cold water into the face and upon the chest, by recumbency of the head; and by a draught of cold water, or water and spirits, wine or hartshorn, if the patient can swallow; aided, if the case be urgent, by sinapisms to the region of the heart, the inside of the thighs and spine, and stimulating injections, as brandy, turpentine, mustard, or ammonia, in a few ounces of water. No fluid must be put into the mouth so long as the power of deglutition is gone, lest some of it should enter the windpipe, and so occasion suffocation. Whatever the cause of the shock may have been, let the medical attendant not fail to encourage the sufferer by a kind and soothing expression, which is often of more value in recalling animation than the best cordials.

During an actual engagement, the Medical Officers as well as their servants, should carry in their pockets such articles as the wounded will be most likely to need on the field of battle, as brandy, aromatic spirits of hartshorn, and morphia, put up in suitable doses.

2. The *hemorrhage* may be arterial or venous, or be both arterial and venous, slight or profuse, primary or secondary, external or internal. The scarlet color and saltatory jet will inform us when it is arterial;

the purple hue and steady flow, when it is venous. When the wound is severe, or involving a large artery or vein, or even middle-sized vessels, the bleeding may prove fatal in a few minutes, unless immediate assistance is rendered. Hundreds of persons die on the field of battle from this cause. They allow their life-current to run out, as water pours from a hydrant, without an attempt to stop it by thrusting the finger in the wound, or compressing the main artery of the injured limb. They perish simply from their ignorance, because the Regimental Surgeon has failed to give the proper instruction. It is not necessary that the common soldier should carry a Petit's tourniquet, but every one may put into his pocket a stick of wood, six inches long and a handkerchief or piece of roller, with a thick compress, and be advised how, where, and when they are to be used. By casting the handkerchief round the limb, and placing the compress over its main artery, he can, by means of the stick, produce such an amount of compression as to put at once an effectual stop to the hemorrhage. This simple contrivance, which has been instrumental in saving thousands of lives, constitutes what is called the *field tourniquet*. A fife, drum-stick, knife, or ramrod may be used, if no special piece of wood is at near hand. The most reliable means for arresting hemorrhage permanently is the *ligature*, of strong, delicate, well-waxed silk, well applied, with one end cut off close to the knot. Acupressure is hardly a proper expedient on the battle-field, or in the ambulance, especially when the number of wounded is considerable. The rule invariably is to tie a wounded artery both above and below the seat of injury lest recurrent bleeding should arise. Another equally obligatory precept is to ligature the vessel, if practicable, at the place whence the blood issues, by enlarging, if need be, the original wound. The main trunk of the artery should be secured only when it cannot be taken up at the point just mentioned. Lastly, it is hardly requisite to add that the operation should be performed, with the aid of the tourniquet, as early as possible, before the supervention of inflammation and swelling, which must necessarily obscure the parts and increase the Surgeon's embarrassment, as well as the patient's pain and risk. Venous hemorrhage usually stops spontaneously, or readily yields to compression, even when a large vein is implicated. The ligature should be employed only in the event of absolute necessity, for fear of inducing undue inflammation. *Torsion* is unworthy of confidence in field-practice, and the same is true of *styptics*, except when the hemorrhage is capillary, or the blood oozes from numerous points. The most approved articles of this kind are Monsel's salt, or persulphate of iron and the perchloride of iron; the latter deserving the preference, on account of the superiority of its hemostatic properties. Alum and lead are inferior styptics. Temporary *compression* may be made with the tourniquet, or a compress and a roller. It may be direct, as when the compress is applied to the orifice of the bleeding vessel, or indirect as when it is applied to the trunk of the vessel, at some distance from the wound. Constitutional treatment in hemorrhage is of paramount importance. It comprises perfect tranquillity of mind and body, cooling drinks, a mild, concentrated, nourishing diet, especially when there has been excessive loss of blood, anodynes to allay pain, induce sleep, and allay the heart's inordinate action, fresh air, and a properly regulated light. Internal hemorrhage is more dangerous than external, because it is generally inaccessible. The chief remedies are copious venesection, elevated position, opium and acetate of lead, cool air and cool drinks. Exhaustion from hemorrhage should be treated according to the principles which guide the practitioner in cases of severe shock. Opium should be given freely as soon as reaction begins to quiet the tremulous movements of the heart and tranquillize the mind. When the bleeding is internal, the reaction should be brought about gradually, not hurriedly, lest we thus become instrumental in promoting or re-exciting hemorrhage. Secondary hemorrhage comes on at a variable period, from a few hours to a number of days; it may depend upon imperfect ligation of the arteries, ulceration, softening or gangrene of the coats of these vessels, or upon undue constriction of these tissues by tight bandages. In some cases it is venous, and may then be owing to inadequate support of the parts. Whatever the cause may be, it should be promptly searched out, and removed.

3. The third indication is to remove all *foreign matter*. This should be done at once and effectually; with sponge and water, pressed upon the parts, with finger, or finger and forceps. Not a particle of matter, not a hair, or the smallest clot of blood must be left behind, otherwise it will be sure to provoke and keep up irritation.

4. As soon as the bleeding has been checked and the extraneous matter cleared away, the edges of the *wound* are gently and evenly approximated, and permanently retained by suture and adhesive plaster, aided, if necessary, by the bandage. The best suture, because the least irritating, is that made of silver wire; but if this material is not at hand, strong, thin, well-waxed silk is used. The adhesive strips are applied in such a manner as to admit of free drainage. The bandage is required chiefly in injuries extending deeply among the muscles; when this is the case its use should be aided by compresses arranged so as to force together the deep parts of the wound.

5. When the wound is dressed, the next duty of the Surgeon is to moderate the resulting *inflammation*. For this purpose the ordinary antiphlogistic means are employed. In general, very little medicine will be required, except a full anodyne, as half a grain of morphia, immediately after the patient has sufficiently recovered from the effects of his shock, and perhaps a mild aperient the ensuing morning, especially if there be constipation with a tendency to excessive reaction. The drinks must be cooling, and the diet light and nutritious, or otherwise, according to the amount of depression and loss of blood. In the latter event, a rich diet and milk-punch may be required from the beginning. A diaphoretic draught will be needed if the skin is hot and arid, aided by frequent sponging of the surface with cool or tepid water. General bleeding will rarely, if ever, be required; certainly not if the injury is at all severe, or if there has already been any considerable waste of blood and nervous fluid.

Much trouble is, at times, experienced both in the civil and military practice, especially in very hot weather, in preventing the access of flies to the dressing. The larvæ which they deposit are rapidly developed into immense *maggots*, which, creeping over the wounds and sores of the patient, and gnawing the parts, cause the most horrible distress. The soldiers in Syria, under Larrey, were greatly annoyed by these insects, and our wounded in Mexico also suffered not a little from them. The best prevention is bran, or light saw-dust, with which the injured parts should be carefully covered. The use of cotton must be avoided, inasmuch as it soon becomes hot and wet—two circumstances highly favorable to incubation. The best local applications are water-dressings, either tepid, cool, or cold, according to the temperament of the patient, the tolerance of the parts, and the season of the year. Union by the first intention is, in all the more simple cases, the thing aimed at and steadily kept in view, and hence the less the parts are encumbered, moved or fretted, the more likely shall we be to attain the object. The medical attendant should have a constant eye to the condition of the *bladder* after all severe injuries, of whatever character, as retention of urine is an extremely common occurrence, and should always be promptly remedied. Attention to this point is the more necessary, because the poor patient, in his comatose or insensible condition, is frequently unable to make known his wants. Such, in a few words, are the general principles of treatment to be followed in all wounds; but there are some wounds which are characterized by peculiarities, and these peculiarities are of such practical importance as to require separate consideration. Of this nature are punctured, lacerated, and gunshot wounds.

Punctured wounds are inflicted by various kinds of weapons, as the lance, saber, sword, or bayonet. In civil practice they are most generally met with as the result of injuries inflicted by nails, needles, splinters, and fragments of bone. They often extend into the visceral cavities, joints, vessels, and nerves; and are liable to be followed by excessive pain, erysipelas, and tetanus; seldom heal by adhesive action; and often cause death by shock or by a hemorrhage. When the vulnerating body is broken off and buried, it may be difficult to find and extract it, especially when small and deep seated. When this is the case, the wound must be freely dilated, an eye being had to the situation of the more important vessels and nerves. In other respects, the general principles of treatment are similar to those of incised wounds. Opium should be administered largely; and, if much tension supervene, or matter form, free incisions will be necessary.

In *lacerated wounds* the edges should be tacked together very gently, and large inter-spaces left for a drainage. A small portion will probably unite by the first intention; the remainder, by the granulating process. All such wounds nearly always suppurate more or less profusely, and some of the torn and bruised tissues not unfrequently perish. The same bad consequences are apt to follow them as in punctured wounds. Warm water constitutes the best dressing, either alone or with the addition of a little spirits of camphor. Opium should be used freely internally, and the diet must be supporting.

Gunshot wounds, in their general character, partake of the nature of all lacerated and contused wounds. They are, of course, the most common and dangerous lesions met with in military practice; often killing instantly, or, at all events, so mutilating the patient as to destroy him within a few hours or days after their receipt. The most formidable wounds of the kind are made by the conical rifle and musket balls and by cannon-balls, the latter often carrying away the greater portion of a limb, or mashing and pulpifying the muscles and viscera in the most frightful and destructive manner; while the former commit terrible ravages among the bones, breaking them into numerous fragments, each of which may, in its turn, tear up the soft tissues in a way perhaps not less mischievous than the ball itself. The old round ball is a much less fatal weapon than the conical, which seldom becomes flattened, and which has been known to pass through the bodies of two men and lodge in that of a third some distance off. When a ball lodges it makes generally only one orifice; but it should be remembered that it may make two, or three, and even four, and at last bury itself more or less deeply. Such cases are, however, uncommon. Should the missile escape, there will necessarily be two openings; or, if it meet a sharp bone and be thereby divided or cut in pieces, as sometimes happens, there may be even three. The orifice of entrance and the orifice of exit differ in their appearances. The first is small, round, and often a little discolored from the explosion of the powder; the other, on the contrary, is comparatively large, slit-like, everted and free from color. These differences, however, are frequently very trifling, particularly if the ball be projected with great velocity and it do not encounter any bone. The opening of entrance made by the round ball is often a little depressed or inverted, but such an appearance is extremely uncommon in wounds made by the conical ball. It is often a matter of great importance to determine, when two openings exist in a limb, whether they have been made by one ball, which has passed out, or by two balls, which are retained. The question is of grave importance, both in a practical and in a medico-legal point of view: but its solution is, unfortunately, not always possible. Sometimes the openings of entrance and exit are materially modified by the introduction but non-escape of a foreign body, as a piece of breast-plate, belt, or buckle, along with the ball, which alone passes out, or by the flattening of a ball against a bone, or its division by a bone into several fragments, each of which may afterward produce a separate orifice. Generally speaking, the missile, at the place of entrance, carries away a piece of skin, and rends the skin where it escapes, the former being often found in the wound. Bullets sometimes glance, bruising the skin, but not penetrating it; at other times they effect an entrance, but, instead of passing on in a straight line, are deflected, coursing, perhaps, partially round the head, chest, or abdomen, or round a limb. Such results are most commonly caused by a partially spent bullet coming in contact with bones, aponeu-roses, and tendons; and the round is more frequently served in this way than the conical. Gunshot wounds bleed profusely only when a tolerably large artery has been injured, and in this event they may speedily prove fatal. During the Crimean War, however, many cases occurred in which there was no immediate hemorrhage, imperiling life, notwithstanding the limbs, lower as well as upper, were left hanging merely by the integuments. Under such circumstances, *intermediary* hemorrhage, as it is termed, is apt to show itself as soon as reaction takes place generally within a few hours after the accident. The pain is of a dull, burning, smarting, or aching character, and the patient is pale, weak, tremulous, nauseated, and despondent, often in a degree far beyond what might be expected from the apparent violence of the injury, and that, too, perhaps, when the individual is of the most undaunted courage and self-possession in the heat of battle. At other times a man may have a limb torn off, or be injured in some vital organ, and yet hardly experience any shock whatever; nay, perhaps be scarcely conscious that he is seriously hurt. The pain and prostration are always greater, other things being equal, when a bone has been crushed or a large joint laid open, than when there is a mere flesh wound. The gravity of gunshot wounds of the *joints* has been recognized by all practitioners, both military and civil, from time immemorial. The principal circumstances of the prognosis are the size and complexity of the articulation, the extent of the injury, and the state of the system. A gunshot wound of a ginglymoid joint is, in general, a more dangerous affair than a similar one of a ball-and-socket joint. The structures around the articulation often suffer severely, thus adding greatly to the risk of a limb and life. Of 65 cases of gunshot wounds of different joints, related by Alcock, 33 recovered; but of these 21 lost the limb. Of the 32 that died no operation was performed upon 18. Gunshot wounds of the smaller joints, even those of the ankle, often do very well, although they always require long and careful treatment. Lesions of this kind, involving the shoulder, are frequently amenable to ordinary means. If the ball lodges in the head of the humerus, it must be extracted without delay, its retention being sure to excite violent inflammation in the soft parts, and caries or necrosis in the bone, ultimately necessitating amputation, if not causing death. Gunshot wounds of the *knee-joint* are among the most dangerous of accidents, and no attempt should be made to save the limb when the injury is at all extensive, especially if it involves fracture of the head of the tibia or condyles of the femur. Even extensive laceration of the ligament of the patella should, I think, as a general rule, be regarded as a sufficient cause of amputation. In 1854, Macleod saw upwards of forty cases of gunshot wounds of the knee in the French hospitals in the Crimea, and all, except one, in which an attempt was made to save the limb, proved fatal. Of nine cases which occurred in India not one was saved. Guthrie never saw a patient recover from a gunshot wound of the knee-joint; and Esmarch, who served in the Schleswig-Holstein Wars, expressly declares that all lesions of this kind demand immediate amputation of the thigh. When, in bad cases of these articular injuries, an attempt is made to save the limb, the patient too often perishes within the first three or four days, from the conjoined effects of shock, hemorrhage, and traumatic fever. If he survives for any length of time, large abscesses are apt to form in and around the joint, the matter burrowing extensively among the muscles, and causing detachment of the periosteum with caries and necrosis of the bones.

Muscles, badly injured by bullets, generally suppurate, and are very apt to become permanently useless. Special pains should therefore be taken to counteract this tendency during the cure. Large shot and other foreign bodies sometimes lodge among these structures, where their presence may remain for a long time unsuspected. Cannon-balls often do immense mischief by striking the surface of the body obliquely, pulpifying the soft structures, crushing the bones, lacerating the large vessels and nerves, and tearing open the joints, without, perhaps, materially injuring the skin. A very terrible form of *contusion* is often inflicted upon the upper extremity of artillerymen by the premature explosion of the gun while in the act of loading; causing excessive commotion of the entire limb, laceration of the soft parts, and most extensive infiltration of blood, accompanied, in many cases, by comminuted fracture, and penetration of the wrist and elbow joints. The constitutional shock is frequently great. If an attempt be made to save the parts, diffusive suppuration, and more or less gangrene, will be sure to follow, bringing life into imminent jeopardy. An attempt in such a case to save the limb would be worse than useless, if, indeed, not criminal; amputation must be promptly performed, and that at a considerable distance above the apparent seat of the injury, otherwise mortification might seize upon the stump.

In the *treatment* of this class of injuries, the first thing to be done, after arresting the hemorrhage and relieving shock, is to extract the ball and any other foreign substance that may have entered along with it, the next being to guard against inflammation and other bad consequences. In order to ascertain where the ball is, the limb should be placed as nearly as is possible in the position it was supposed to have been at the moment of the accident. A long, stout, flexible, and blunt-pointed probe, or a straight silver catheter, when conveniently at hand, is then carefully passed along the track and gently moved about until it strikes the ball. In many cases the best probe is the Surgeon's finger. Valuable information may often be obtained by the process of pinching, or digital compression, the ends of the fingers being firmly and regularly pressed against the wounded structures, bones as well as muscles, tendons, and aponeuroses. Occasionally, again, as when the ball is lodged in an extremity, its presence is easily detected by the patient, who may make such an examination as he lies in bed.

The situation of the foreign body having been ascertained, the bullet-forceps, supplied all Surgeons in the field, take the place of the probe, the blades, which should be long and slender, being closed until they come in contact with the ball, when they are expanded so as to grasp it, care being taken not to include any of the soft tissues. If there be any loose or detached splinters of bone, wadding, or other foreign material, it should now also be removed; it being constantly borne in mind that, while a ball may occasionally become encysted, and is at all times, if smooth, a comparatively harmless tenant, such substances always keep up irritation, and should, therefore, if possible, be got rid of without delay. Although preference is commonly given to the bullet-forceps, properly so called, as an extractor, the polypus and dressing-forceps, as usually furnished Surgeons, generally answer quite as well, especially the former, the latter being adapted only to cases where the foreign body is situated a short distance below the surface, or where the wound is of unusual dimensions, admitting of the free play of the instrument. During the extraction, the parts should be properly supported, and if the wound is not large enough for the expansion of the instrument, it must be suitably enlarged. When the ball is lodged a short distance from the skin, it may often be readily reached by a counter-opening. When a bullet is imbedded in a bone, as in the head of the tibia, or in the condyles of the femur, and the parts are not so much injured as to demand amputation, extraction may be effected with the aid of the trephine and elevator. Sometimes a bullet-worm, as it is termed, an instrument similar to that used in drawing a ball from a gun, will be very convenient for its removal. The operation being completed, the parts are placed in an easy, elevated position, and enveloped in tepid, cool or cold water-dressings, as may be most agreeable to them and to the system. The best plan, almost always, is to leave the opening or openings, made by the bullet, free, to favor drainage and prevent pain and tension. If the track be very narrow, it may heal by the first intention, but in general it will suppurate, and portions of tissue may even mortify. Erysipelas, pyemia, and secondary hemorrhage are some of the bad consequences after gunshot injuries, the latter usually coming on between the fifth and ninth day, the period of the separation of the sloughs.

AMPUTATIONS AND RESECTIONS.

In endeavoring to decide so important a question as the loss of a limb, various circumstances are to be considered, as the age, habits and previous health of the patient, the kinds of injury, and the number, nature, and importance of the tissues involved. In military practice amputation must often be performed in cases where in civil practice it might be avoided. It may be assumed, as a rule, that young adults bear up under severe accidents and operations, other things being equal, much better than children and elderly subjects; the strong than the feeble; the temperate than the intemperate; the residents of the country than the inhabitants of the crowded city. The following circumstances may be enumerated as justifying, if not imperatively demanding, amputation in cases of wounds, whatever may be their nature:—

1st. When a limb has been struck by a cannon-ball or run over by a railroad car, fracturing the bones, and tearing open the soft parts, amputation should, as a general rule, be performed, even when the injury done to the skin and vessels is apparently very slight, experience having shown that such accidents seldom do well, if an attempt is made to save the limb, the patient soon dying of gangrene, pyemia, or typhoid irritation. The danger of an unfavorable termination in such a case is always greater when the lesion effects the lower extremity than when it involves the superior.

2d. No attempt should be made to save a limb when in addition to serious injury done to the integuments, muscles or bones, its principal artery, vein, or nerve has been extensively lacerated, or violently contused, as the result will be likely to be gangrene, followed by death.

3d. A lacerated or gunshot wound penetrating a large joint, as that of the knee or ankle, and accompanied by cominuted fracture, or extensive laceration of the ligaments of the articulation, will, if left to itself, be very prone to terminate in mortification, and is therefore a proper case for early amputation.

4th. Gunshot wounds attended with severe comminution of the bones, the fragments being sent widely around among the soft parts, lacerating and bruising them severely, generally require amputation, especially in naval and military practice.

5th. Extensive laceration, contusion, and stripping off of the integuments, conjoined with fracture, dislocation, or compression and pulpification of the muscles, will in general, be a proper cause for the removal of a limb.

Amputation is not to be performed, in any case, until sufficient reaction has taken place to enable the patient to bear the additional shock and loss of blood. As long as he is deadly pale, the pulse small and thready, the surface cold, and the thirst, restlessness, and jactitation excessive, it is obvious that recourse to the knife must be wholly out of the question. The proper treatment is recumbency, with mild stimulants, sinapisms to the extremities, and other means calculated to re-excite the action of the heart and brain. Power being restored, the operation, if deemed necessay, is proceeded with, due regard being had to the prevention of shock and hemorrhage, the two things now mainly to be dreaded. One of the great obstacles about immediate amputation is the difficulty which the Surgeon so often experiences in respect to the cases demanding the operation, and the uncertainty that none of the internal organs have sustained fatal injury; a circumstance which would, of course, contra-indicate the propriety of such interference. Cases occur, although rarely, where, notwithstanding the most violent injury, or perhaps, even the loss of a limb, there is hardly any appreciable shock, and in such an event, the operation should be performed on the spot. The results of the military surgery in the Crimea show that the success of amputations was very fair when performed early, but most unfortunate when they were put off for any length of time. This was the case, it would seem, both in the English and French Armies. Should amputation ever be performed in spreading gangrene? The answer to this question must depend upon circumstances. We may give our sanction when the disease, although rapid, is still limited, and when the patient, comparatively stout and robust, has a good pulse, with no serious lesion of a vital organ and no despair of his recovery, but a cheerful, buoyant mind, hopeful of a favorable issue. No operation is to be done when the reverse is the case; if it be, the patient will either perish on the table, from shock and hemorrhage, or from a recurrence of mortification in the stump. Lacerated, contused, and gunshot wounds are often of so frightful a nature as to render it perfectly certain, even at a glance, that the limb will be obliged to be sacrificed in order that a better chance may be afforded for preserving the patient's life. At other times, the injury, although severe, may yet, apparently, not be so desperate as to preclude, in the opinion of the practitioner, the possibility of saving the parts, or, at all events, the propriety of making an attempt to that effect. The cases which may reasonably require and those which may not require interference with the knife are not always so clearly and distinctly defined as not to give rise in very many instances, to the most serious and unpleasant apprehension, lest we should be guilty, on the one hand, of the sin of commission, and, on the other, of that of omission; or, in other and more comprehensive terms, that, while the Surgeon endeavors to avoid Scylla, he may not unwittingly run into Charybdis, mutilating a limb that might have been saved, and endangering life by the retention of one that should have been promptly amputated. It is not every man, however large his skill and experience, that is always able to satisfy himself, even after the most profound deliberation, what line of conduct should be pursued in these trying circumstances; hence the safest plan for him generally is to procure the best counsel that the emergencies of the case may admit of. But in doing this, he must be careful to guard against procrastination; the case must be met promptly and courageously; delay even of a few hours may be fatal, or at all events, place limb and life in imminent jeopardy. Above all, let proper caution be used if the patient is obliged to be transported to some hospital, or to a distant home, that he may not be subjected to unnecessary pain, exposed to loss of blood, or carried in a position incompatible with his exhausted condition. Vast injury is often done in this way, by ignorant persons having charge of the case, and occasionally even by practitioners whose education and common sense should be a sufficient guarantee against such conduct.

Little need be said here about the *methods* of amputation. In cases of emergency, where time is precious, and the number of Surgeons inadequate, the flap operation will certainly deserve a decided preference over the circular, and, probably, over every other. The rapidity with which it may be executed, the abundant covering which it affords for the bone, and the facility with which the parts unite are qualities which strongly recommend it to the judgment of the Military Surgeon. The flaps should be long and well shaped, and care taken to cut off the larger nerves on a level with the bone, in order to guard against the occurrence of neuralgia after the wound is healed. Whatever method be adopted, a long stump should be aimed at, that it may afford a good leverage for the artificial substitute. No blood should be lost during or after the operation, and hence the main artery of the limb should always be thoroughly compressed by a tourniquet, not by the fingers of assistants, who are seldom, if ever, trustworthy on such occasions.

Anæsthetics should be given only in the event of thorough reaction; so long as the vital powers are depressed and the mind is bewildered by shock, or loss of blood, their administration will hardly be safe, unless the greatest vigilence be employed, and this is not always possible on the field of battle, or even in the hospital. Moreover, it is astonishing what little suffering the patient generally experiences, when in this condition, even from a severe wound or operation.

In the war in the Crimea, the British used chloroform almost universally in their operations; the French also exhibited it very extensively, and Baudens, one of their leading military surgical authorities, declares that they did not meet with one fatal accident from it, although it was given by them, during the Eastern campaign, thirty thousand times at least. The administration of chloroform is stated by Macleod to have contributed immensely to the success of primary amputations.

The *dressings* should be applied according to the principles laid down under the head of wounds. The sutures, made of silver wire or fine silk, should not be too numerous, and the adhesive strips must be so arranged as to admit of thorough drainage. A bandage should be applied from above downward, to control muscular action and afford support to the vessels; the stump rest upon a pillow covered with oil-cloth, and the water-dressing be used if there is danger of over-action. Pain and spasm are allayed by anodynes; traumatic fever, by mild diaphoretics. Copious purging is avoided; the drink is cooling; and the diet must be in strict conformity with the condition of the patient's system. The first dressings are removed about the end of the third day; after that once or even twice a day, according to the nature and quantity of the discharges, accumulation and bagging being faithfully guarded against.

The following *statistics* of amputations, both in the continuity of the limbs and of the articulations, possess peculiar interest for Military Surgeons. They are derived chiefly from a review of Mr. Macleod's "Notes of the Surgery in the Crimea" in the North American Medico-Chirurgical Review for Jan., 1860.

The number of cases given by Macleod is 732, with a mortality of 201. Of these, 654 were primary, with 165 deaths, or 26.22 per cent.; and 78 secondary, with 36 deaths, or in the ratio of ·46.1. The mortality of the greater amputations—as those of the shoulder, arm, and forearm, and the hip, thigh, knee, and leg—was 39.8 per cent. for the primary operations, and 60 per cent. for the secondary.

The increase of mortality from amputations as we approach the trunk has long been familiar to Surgeons, and the results in the Crimea have not changed our previous knowledge. Thus the ratio of mortality of amputations of the fingers was 0.5; of the forearm and wrist, 1.8; of the arm, 22.9; of the shoulder, 27.2; of the tarsus, 14.2; of the ankle-joint, 22.2; of the leg, 30.3; of the knee-joint, 50.0; and of the thigh, in its lower third, 50.0, at its middle, 55.3, at the upper part, 86.8, and at the hip, 100.0. The limb was removed at the latter joint in 10 cases, all of which rapidly proved fatal. The French had 13 cases, primary and secondary, with no better luck.

Legouest has published a table of most of the recorded cases of amputation at the *hip-joint*, for gunshot wounds. Of these 30 were primary, and all ended fatally; of 11 intermediate, or early secondary, 3 recovered; and of 3 remote, one recovered. "Thus," says Macleod, "if we sum up the whole, we have 4 recoveries in 44 cases, or a mortality of 90.9 per cent." Some of the primary cases died on the table; and all the rest, except two, before the tenth day. In the Schleswig-Holstein war, amputation at the hip-joint was performed seven times, with one cure. Mr. Sands Cox, recording the experience of civil and military hospitals up to 1846, gives 84 cases, most of them for injury, with 26 recoveries. Dr. Stephen Smith, of New York, has published tables of 98 cases, showing a ratio of mortality of 1 in $2\frac{2}{3}$. In 62 of these cases, the operation was performed in 30 for injury, with a mortality of 60 per cent.

Amputation in the upper third of the *thigh* was performed 39 times, with a fatal result in 34. Of these cases only one was secondary, and that perished. Amputation of the middle third of the limb was performed in 65 cases, of which 38 died. Of these cases 56 were primary, with 31 deaths, giving thus a mortality of 53.3 per cent.; 9 cases were operated upon at a later period, and of these, 7 died, or 77·7 per cent. Amputation of the lower third of the thigh was performed 60 times, 46 being primary, with a mortality of 55 per cent., and 14 secondary, with a mortality of 71·4 per cent.

Amputation at the *knee* was performed primarily in 6 cases, of which 3 died, and once secondarily, with a fatal result. Chelius refers to 37 cases of amputation of the knee, collected by Jæger, of which 22 were favorable; and of 18 cases recorded by Dr. Markoe, of New York, as having occurred in the practice of American Surgeons, 13 got well. These cases, added together, afford an aggregate of 61, with a mortality of 21, or 34.4 per cent.

The *leg* was amputated 101 times, with 36 deaths, or a mortality of 35.6 per cent. Of these cases 89 were primary, with 28 deaths, and 12 secondary, with 8 deaths. Amputation at the *ankle-joint* was performed in 12 cases, death following in 2. Of these cases 3 were secondary, and all favorable.

The arm was removed at the *shoulder-joint* in 39 cases, with a fatal issue in 13, or 33.3 per cent., 33 being primary, with 9 deaths, and 6 secondary, with a fatal issue in 4. If we couple these cases with 21 that occurred during the previous period of the war, we shall have an aggregate of 60 cases, with 19 deaths, or a mortality of 31.6 per cent. The advantage of primary over secondary amputation of the shoulder has long been known to Military Surgeons. Thus, of 19 primary cases mentioned by Mr. Guthrie as having occurred between June and September, 1831, 18 recovered, while of 19 secondary cases 15 died. The experience of the late Dr. Thomson, in Belgium, is equally decisive.

Amputation of the upper *arm* was performed 102 times, with death in 25 cases, or a mortality of 24.5; 96 of these cases being primary. Of the 6 secondary cases one-half proved fatal.

The *forearm* was amputated primarily 52 times, and the hand at the wrist once, with only 1 death; while of 7 secondary operations on the same parts, 2 died.

Resection is one of the aids of conservative surgery, and military practice affords numerous occasions for its employment. The operation, however, is not equally applicable to all the articulations. Resection of the *shoulder-joint* has hitherto afforded the most flattering results. It is more especially applicable in cases of gunshot injuries, unattended by serious lesion of the vessels and nerves of the limb, or severe laceration of the muscles and integuments. A portion of the humerus, embracing, if necessary, from four to five inches in length, together with a part or even the whole of the glenoid cavity of the scapula, may be safely and expeditiously removed under such circumstances, and yet the patient have an excellent use of his arm.

Williams mentions 19 cases of gunshot wounds of the shoulder-joint in which resection was performed, of which 3 proved fatal. Baudens saved 13 out of 14 cases, and the British Surgeons in the Crimea lost 2 patients only out of 27.

Resection of the *elbow* has of late engaged much attention among military men, and although the results are less flattering than in the operation upon the shoulder, they are, nevertheless, highly encouraging. Of 82 cases which occurred in the Schleswig-Holstein and in the Crimean campaigns, only 16 died, or 1 in about 5.

The *wrist-joint* has seldom been the subject of excision; doubtless, cases not unfrequently occur in which it might be resorted to with advantage.

Dr. George Williams has collected the history of 11 cases of excision of the *hip-joint* for gunshot injury, 6 of which occurred in the Crimea. Of this number 10 died. Of 23 amputations at the hip-joint by English and French Surgeons in the East, all died.

Excision of the *knee-joint* for gunshot injury holds out no prospect of advantage, experience having shown that, when the articulating extremities of the femur and tibia are fractured by a ball, the proper remedy is amputation.

The *ankle-joint* has been resected in a few instances only for gunshot injuries, and the results have thus far been by no means flattering. When the joint is seriously implicated, amputation will undoubtedly be the more judicious procedure.

Resection of the bones in their continuity is seldom practiced in this class of injuries, and experience has offered nothing in its favor. The operation was performed several times in the Crimea, but proved invariably fatal.

The *after-treatment* in resection must be conducted upon the same principles as in amputation. The measures must, for the most part, be of a corroborating nature. The limb must be placed in an easy position, and be well supported by a splint or fracture-box, to prevent motion. The operation is liable to be followed by the same bad effects as amputations.

ILL CONSEQUENCES OF WOUNDS AND OPERATIONS.

The bad consequences to be apprehended after wounds, amputations, and other operations, are traumatic fever, hemorrhage, excessive suppuration, erysipelas, gangrene, spasm, pyemia, and tetanus.

a. Traumatic fever usually sets in within the first few hours after the injury, or soon after reaction has been fairly established. In camp practice its tendency generally is to assume a low typhoid character, especially if there is much crowding of the sick, with imperfect ventilation and want of cleanliness. Not unfrequently it displays an endemic or epidemic disposition.

The treatment must be exceedingly mild; the patient will not bear depletion, but will, notwithstanding his fever, probably require stimulants and tonics, with nutritious food and drink from the very commencement. A gentle anodyne and diaphoretic mixture, as morphia and antimony in camphor-water, may be needful, in the early stage, to quell the fictitious excitement or attempt at over-action.

b. The likelihood of *secondary hemorrhage* must be steadily kept in view in these cases; much may be done to prevent it by the proper use of the ligature at the time of the operation or dressing, but it is often unavoidable, especially in gunshot wounds, owing to the injury sustained by the coats of the vessels by the grazing of the ball. However induced, it should receive the most prompt attention, inasmuch as the loss even of a few ounces of blood may prove destructive to the already exhausted system.

c. *Spasm* of the muscles is not peculiar to amputations; it often exists in a most severe degree in cases of fractures and gunshot wounds. Anodynes in full doses, with a little antimony, the use of a moderately-tight bandage, and warm water-dressing, medicated with laudanum and acetate of lead, are the most appropriate measures.

d. *Profuse suppuration* may be looked for in nearly all bad wounds, whatever their character, and also in many of the amputations performed on the field of battle. The exhausting effects must be counteracted by supporting remedies, as quinine, iron, cod-liver oil, and brandy, with frequent change, of dressing, cleanliness, and ventilation. Bagging is prevented by counter-openings and careful bandaging.

e. *Erysipelas* usually manifests itself within the first thirty-six hours after the injury or operation; often assumes an endemic or epidemic character; is easily distinguished by the peculiar reddish blush rapidly spreading over the surface, together with the stinging or smarting pain and increased swelling; and should be treated with dilute tincture of iodine, or anodyne and saturnine lotions, quinine and tincture of iron, with nutritious food and drinks.

f. *Gangrene* is sufficiently common after severe lesions on the battle-field, especially that variety of it denominated hospital gangrene. During the Crimean war, this form of gangrene raged with extraordinary virulence and fatality among the French in the hospitals on the Bosphorus. It also prevailed about the same period within some of the hospitals in the south of France, and it is asserted that the "Euphrate," a transport ship, in her voyage to the Mediterranean was obliged, from this cause alone, to throw sixty of her men overboard within thirty-six hours! After the taking of the Quarries and the assault upon the Redan, during the heat of summer, in 1855, the English Surgeons lost a number of their cases of amputation of the thigh from moist gangrene of a decidedly rapid character, the system having been literally overwhelmed by the poison. When hospital gangrene is endemic, it attacks not only open wounds and sores, but also the slightest scratches, cicatrices, and stumps. Persons laboring under diarrhœa, dysentery, and scurvy are most obnoxious to it.

The proper remedies are sequestration of the patients, the free use of the nitric acid lotion, iodine to the inflamed skin, charcoal, port wine, or yeast cataplasms, and frequent ablutions with disinfecting fluids aided by opium, quinine, tincture of iron, lemon-juice, and other supporting means. Mopping the affected surface freely with strong nitric acid often answers an excellent purpose. The favorite remedy of Pouteau was the actual cautery.

g. *Pyemia*, the purulent infection of the French writers, is one of the greatest dangers after severe wounds and operations. It was the great source of the mortality after amputations, especially secondary, during the war in the Crimea. It usually comes on within from three to eight days after the injury, and is nearly always fatal. Its characteristic symptoms are rigors, followed by copious sweats, rapid failure of the vital powers, delirium, and a withered appearance of the countenance, frequently conjoined with icterode, tinge of the eye and skin. On dissection, the large veins leading from the stump or wound are found filled with pus, with redness of the lining membrane; and abscesses, usually small and filled with unhealthy fluid, are seen scattered through the lungs, muscles, and cellular substance, matter also occasionally existing in the joints. The treatment is essentially the same as in erysipelas.

h. *Traumatic tetanus* is not very common in military practice. It is most liable to show itself in tropical countries, in hot, damp weather, and in persons of a nervous, irritable temperament, occasionally supervening upon the most insignificant injuries, as, for example, a mere scratch. In India the disease is often provoked by unextracted balls, and both in that country and on the continent of Europe the operation which was most frequently followed by it, during the recent wars, was amputation at the shoulder-joint.

The effects of sudden vicissitudes of temperature in developing tetanus, are well known. They are most striking in tropical regions, when the change is from hot to cold, or from dry to wet. Larrey had repeated opportunities of observing the development of the disease under such circumstances, both in Egypt and Germany. After the battle of Bautzen, the exposure of the wounded to the cold night air produced over one hundred cases of tetanus, and a very large number suffered from a similar cause after the battle of Dresden. Like effects were witnessed at Ferozepore and Chillianwallah. Baudens, in his treatise on gunshot wounds, states that the influence of cold and moisture in developing the disease, during the French campaigns in Africa, was most striking. Of forty slightly wounded men, placed in a gallery on the ground floor, during the prevalence of a northeasterly wind, fifteen were speedily attacked with tetanus. Similar effects have several times been noticed in this Country. Thus, after the battle of Ticonderoga, in 1758, nine of the wounded, who were exposed the whole night after the action, in open boats upon Lake George, died of locked-jaw; and during our war with Great Britain, most of those who suffered on board the Amazon, in the engagement before Charlestown, were attacked with this disease a fortnight after, in consequence of a very sudden change of weather, the wind blowing cold and wet.

The extremes of heat and cold both favor the production of tetanus. In the East and West Indies, the slightest prick of the finger or toe is often sufficient to induce the disease, and the inhabitants of the Arctic regions not unfrequently suffer in a similar manner. Dr. Kane, in his memorable expedition, lost two of his men from this affection, and he adds that all of his dogs perished from a like cause. The *mortality* from traumatic tetanus is notorious. Hardly one recovers. Nearly all perish in two or three days from the attack. The most reliable remedies are opium, in the form of morphia or acetated tincture, in large doses, in union with camphor and antimony. The effects of Indian hemp are uncertain. Chloroform will mitigate pain and spasm. Amputation, except, perhaps, when the wound affects a finger or toe, will be worse than useless, as will also be counter-irritation along the spine. To prevent the disease should be our business, and to do this no wounded person should ever be exposed to the cold night air, or to currents of air at any time. *After amputations, however trifling, special directions should be given upon this point.*

DISEASES INCIDENT TO TROOPS.

The diseases which attend armies, or molest soldiers in camps, garrisons, and hospitals, and which so often decimate their ranks, and even at times, almost annihilate whole regiments, are the different kinds of fevers, especially the typhus and typhoid, dysentery, diarrhœa, and scurvy. These are emphatically, the enemies of military life, doing infinitely more execution than all the weapons of war, however adroitly or efficiently wielded, classed together. Pneumonia, pleurisy, and hepatitis, of course, slay their thousands, and various epidemics, especially cholera, not unfrequently commit the most frightful ravages. "War," says Johnson, "has means of destruction more formidable than the cannon and the sword. Of the thousands and tens of thousands that have perished, how small a proportion ever felt the stroke of an enemy!" Frederick the Great used to say that fever cost him more men than seven pitched battles, and it has long been a matter of history that more campaigns are decided by sickness than by the sword. The great mortality which attended our armies in Mexico was occasioned, not by wounds received in battle, but by the diseases incident to men carrying on their military operations in an inhospitable climate, badly fed, subjected to fatiguing marches and obliged to use unwholesome water. Thousands perished, during their absence, from fever, dysentery, and diarrhœa, and a still greater number from the effects of these diseases, after the return of the troops to their native soil. The latter affection, in particular, pursued many, like a relentless foe, to their graves long after they had been cheered by the sight of their homes and friends. In the war in the Crimea disease destroyed incomparably more soldiers than the sword, the musket, and the cannon. Typhus and typhoid fever, dysentery, diarrhœa, scurvy, and lastly, malignant cholera, annihilated vast numbers, both in the British, French, and Russian ranks. According to Dr. Macleod, whose "Notes on the Surgery of the War in the Crimea," are so well known to the profession, the proportion of those lost among the British by sickness to those lost by gun-shot and other injuries, was, during the entire campaign, as 16,211 to 1761, exclusive of those killed in action. The difference he supposes to have been still greater among the French and Russian forces. In December, 1854, and in January, 1855, not less than 14,000 French soldiers were admitted into the Crimean ambulances on account of disease, whereas, during the same period, only 1,500 were admitted on account of wounds. Of the whole number nearly 2,000 died. During the last six months of the campaign, in which the city was stormed and taken, the French had 21,957 wounded as an offset against 101,128 cases of disease. At Walcheren, in 1809, the British lost one-third of their troops by disease, and only 16 per cent. by wounds. In the Peninsular war, from January, 1811, to May, 1814, out of an effective force of 61,500 men, only 42.4 per 1000, says Macleod, were lost by wounds, while 118.6 were lost by disease. The number of sick that may be expected to be constantly on hand during any given campaign is estimated, on an average, at 10 per cent.; but this proportion must necessarily be exceeded, especially in an invading army, with raw, undisciplined, and unacclimated troops. This was eminently true even in the Crimea, in a climate comparatively healthy, within a few miles of the sea. We may well imagine what would be the effects of the climate of the South upon the Northern troops, if they were to pass far, during the hot season, beyond Mason and Dixon's line. Disease, in its worst form, would be sure to invade and thin their ranks at every step. Fever—typhoid, typhus, remittent, intermittent, and yellow—dysentery, diarrhœa, scurvy, pneumonia, and inflammation of the liver would accomplish more, infinitely more, for the Southern cause than all the weapons of war that could be placed in the hands of Southern people. Typhoid, typhus, and yellow fever, dysentery, diarrhœa, and scurvy would, in all human probability, soon become epidemic, and occasion a mortality truly appaling. The Southern soldier, on the contrary, thoroughly acclimated as he is, would suffer comparatively little.

The British in the Crimean War lost 5910 men from diarrhœa and dysentery, the whole number of cases having been 52,442, affording thus a mortality of 11.26 per cent. Cholera, of which there were 7575 cases, altogether, destroyed 4513, or in the ratio of 59.57 per cent. Typhus fever killed 285 out of 828 cases; fever, not typhus, 3161, out of 30,376. The French and Russian troops suffered in still larger numbers from these diseases. Macleod asserts that the former lost their men by typhus fever by thousands, and the latter by tens of thousands. The British suffered but little from intermittent fever, whereas this disease did great mischief among the French, causing serious mortality, either directly or indirectly, besides disqualifying large numbers for service. Scurvy was another dreadful enemy which the British and French troops were compelled to encounter in the Crimea. It prevailed more or less extensively for a long time, and served to impart its livery to the other diseases of the soldiery, masking their character, and remarkably augmenting their virulency.

Considering, then, the frequency of the occurrence of these diseases, and their excessive fatality, it behooves the Military Surgeon to use every means in his power to guard, in the first place, against their outbreak, by the employment of proper hygienic or sanitary measures, and, in the next, to treat them with all possible diligence and judgment when their development is unavoidable. It is, of course, impossible, in a work of this description, to enter into any details upon the subject; but there are several points which cannot, we conceive, be too forcibly impressed upon the mind of the military practitioner,—we refer to the great, the paramount importance of—1st, proper isolation of the sick, or, what is the same thing, the importance of not crowding them together; 2d, free ventilation; 3d, bodily cleanliness; 4th, little medicine; 5th, a good supply of fresh vegetables and fruits, especially oranges and lemons; 6th, careful and tender nursing. Painful experience has shown, in all parts of the world, that the crowding together of the sick and wounded is one of the worst calamities that can befall them. For want of this precaution, diseases, otherwise easily manageable, often assume an epidemic character, or, in the absence of this character, often baffle the best directed efforts for their relief. When the wounded are crowded together they frequently become the victims of erysipelas, hospital gangrene, pyemia, and phlebitis; occurrences which, under better regulations, might in many cases be entirely prevented. Of the propriety of constant and thorough *ventilation*, it is unnecessary to speak. If pure air is so essential in health, it is easy enough to see how important it must be in sickness.

Cleanliness of body should be regarded as a religious duty; it may be effected with the sponge and tepid, cool, or cold water, according to the exigencies of the case, and cannot be performed too frequently or too thoroughly, care being, of course, taken not to worry or fatigue the patient. In some instances the water may be medicated with common salt, potassa, vinegar, or Labarraque's solution. Nothing is generally more grateful to the sufferer, in the different kinds of fevers, than frequent sponging of the surface with cool or tepid water. The use of heroic *medicines*, or of any medicines in large doses, in these diseases, and also in cases of severe wounds, cannot be too severely reprobated. More men, there is reason to believe, have been killed in this manner in the armies and navies of the world than by the sword and the cannon. Let medicines, then, be administered sparingly. *Let the secretions be well seen to; but purge little, and use depressants with all possible wariness.* Give iced water, but not too freely, and lumps of ice when there is much thirst with gastric irritability and excessive restlessness. Mild diaphoretics and anodynes will, as a general rule, be highly efficacious, but the latter should be exhibited with great caution when there is cerebral oppression. Lemon-juice and potassa are indispensable in scurvy, or where there is a marked tendency to scorbutic disease. Quinine is one of the great remedies in most, if not in all, of these diseases, especially when, as is so often the case, they are associated with a malarious origin. The good average dose is from two to five grains, repeated from three to five times in the twenty-four hours. When marked debility prevails, the best stimulants are brandy, in the form of milk punch or toddy, and Madeira, port, or sherry wine. Immense suffering and loss of life are often occasioned for the want of fresh vegetables and fruits in military operations, as well as in the garrison and the hospital. A daily supply of these articles should, therefore, be provided at almost any hazard and expense. In all low states of the system, however induced, the strength can never be rapidly brought up without a diet which partakes more or less of this character.

There is a form of *dysentery*, very common in India, which is exceedingly apt, when large masses of troops are habitually congregated together, to assume an epidemic character; and it is for this reason that it has often been supposed to be contagious. For such an opinion, however, there does not seem to be any valid reason. Ballingall, who witnessed at least 2,000 cases of this disease, asserts that he never once met with a circumstance tending to create such a suspicion; and the views advanced by this eminent Surgeon are those now pretty generally, if not universally, entertained by the British practitioners in India. "The remote causes of dysentery in India are conceived to be heat, particularly when combined with moisture; the immediate and indiscriminate use of fruits; the abuse of spirituous liquors, and exposure to currents of wind and to noxious night-dews." Troops recently arrived from Europe are particularly prone to the disease.

Tropical dysentery presents itself in two varieties of form, the *acute* and the *chronic*. The first, which is an extremely fatal disease, is seated in the rectum and colon, the latter being often involved through nearly its entire extent, and it frequently commits very serious, if not irreparable mischief in these structures before the patient and the attendant are aware of its true character, owing to the absence of urgent pain and pyrexia. In general the attack is ushered in by the ordinary symptoms of diarrhœa, such as griping pain in the bowels and frequent calls to stool with excessive straining, the evacuations being, at first, thin and copious but without fetor and but little streaked with blood. The tongue, skin, and pulse are nearly, perhaps entirely, normal. Gradually the pain becomes more violent, as well as more fixed, and is felt in both iliac regions, or even along the whole track of the colon; the discharges consist chiefly of blood and mucous, or of a fluid resembling water in which fresh beef has been macerated; the tongue is covered with a white coat; the skin is either hot and dry, or bathed with clammy perspiration; and the straining is so excessive as to occasion prolapsus of the rectum. The pulse is, even at this stage, often but little affected, being, perhaps, only somewhat increased in quickness. Sometimes, however, it is very full, bounding, and vibratory, and without much velocity, and when this is the case it always, according to Ballingall, forebodes evil. Toward the close of the attack, the passages are frequently involuntary and intolerably fetid, gangrenous portions of the mucous coat of the bowel are sometimes extruded, and the surface of the body emits a peculiar cadaverous smell. The average period at which death occurs is about one week, but many cases linger on much longer.

The remedies upon which the India practitioners mainly rely in the treatment of this horrible form of dysentery consist of venesection, mercury, and opium, leeches, diaphoretics, warm bathing, blisters, and enemata being employed as auxiliaries. Venesection is always practiced early, and, even when the patient is not very robust, bodily, it being, apparently, regarded as the sheet-anchor of the physician's hope. Calomel is administered in doses of from ten to twenty grains, along with two or three grains of opium, twice or thrice in twenty-four hours; and, while profuse salivation is discountenanced, production of a slight ptyalism is generally aimed at. Such treatment as this seems altogether frightful to a modern American practitioner; and it strikes him as unnecessarily harsh, and as well calculated to augment the mortality of the disease. We might, in this Country, perhaps bleed, and that pretty freely, at the very commencement of an attack of dysentery; at all events, leech very copiously, but we would certainly draw blood sparingly if the attack had already made serious constitutional inroads, or if it was of an epidemic character; and, as to giving mercury with a view to ptyalism, however slight, few men would hardly be so fool-hardy. The India practitioners do not, it appears, employ quinine in the treatment of this form of dysentery; a remedy so extremely needful in many cases of this disease as it prevails in this country, especially in our Southern latitudes, where it is not unfrequently of a malarious origin.

The *chronic* form of India dysentery, termed hepatic flux, more frequently attacks persons who have been for some time inured to that climate, and is always associated with biliary derangement. "This flux, like the other, often assumes at its commencement the appearance of a common diarrhœa, and becomes afterward characterized by frequent and severe fits of griping, resembling colic pains, particularly urgent about the umbilical region. Each attack of griping is generally succeeded by a call to stool, and the evacuations are always unnatural in color and consistence, free from any admixture of blood, but generally of a yeasty or frothy appearance, and accompanied with large discharges of flatus; while in passing they are attended with a sense of scalding about the anus. The patient, after each evacuation, feels considerably relieved, and hopes to enjoy an interval of ease, but the recurrence of the griping, accompanied with a sensation of air passing through the bowels, and succeeded again by a call to stool, give him little respite. From the commencement of the attack, the patient complains of nausea, want of relish for his food, and preternatural thirst, attended often with a disagreeable taste in the mouth. The tongue is furred or loaded, and not unfrequently covered with a yellow bilious coat. The pulse is quickened and the skin parched."

Cholera morbus must, necessarily, in this Country, especially in our Southern latitudes, and during the hot summer months, be a more or less frequent attendant upon camp life, although much may be done, by a proper observance of hygienic laws, to prevent it. When the disease breaks out it cannot be arrested too speedily. The most appropriate remedies, particularly in its earlier stages, are perfect quietude, abstinence from drink, sinapisms to the epigastrium, and an efficient dose of morphia and camphor, or even morphia alone. If torpor of the liver exist, blue mass or a few grains of calomel may be advantageously combined with the anodyne. The swallowing of small lumps of ice will greatly assist in allaying the gastric irritability. A mustard and salt emetic will be indicated if the stomach is loaded with ingesta. The bowels are quieted with an anodyne enema; and, to relieve thirst and reduce heat of skin, the surface is frequently sponged with cool or tepid water. A combination of carbonate of potassa and acetated tincture of opium, with fresh lemon-juice, in peppermint or camphor water, will often act like a charm in relieving the gastric and intestinal irritability, the cramps, and other distressing symptoms.

The exposure of the soldier, both in the tent and on the field, renders him extremely prone to *rheumatism*, frequently attended with high inflammatory excitement and severe pain. Such an attack is often effectually put to flight if, at its inception, it be treated with a large anodyne and diaphoretic mixture, as fifteen grains of Dover's powder, a third to half of a grain of sulphate of morphia with a fourth of a grain of tartar emetic, or, what is perhaps still better, a drachm of the wine of colchicum in union with a full dose of morphia or black drop. When the disease has already made some progress, an active purgative should precede the exhibition of these medicines.

Sore throat, tonsillitis, and catarrhal affections, or, what in common language are called *colds*, are very common among soldiers, especially the raw troops just mustered into service, ill clothed, inexperienced, and unaccustomed to camp life. The moment such disease sets in, no matter how light it may be, the person should be compelled to report himself at the Surgeon's quarters, in order that he may receive the necessary attention and advice. Generally an attack of this kind will promptly yield to a trifling prescription, as a little hot drink, a mild aperient, or, better still, a quarter of a grain of morphia, a grain of opium, or a large dose of Dover's powder. In an army not under strict discipline, or where proper care is not observed in enlisting, *mania á potu* is very apt to show itself, much to the annoyance of the nurses and the physicians. If, in such a case, the patient be not well secured, he may, in his perverted military ardor, do serious mischief to himself and to his attendants. A moderately active mercurial purge at the outset of the disease will often go far in quieting the system and in abridging the attack. After the medicine has operated, a mild opiate and sedative treatment will generally be the most soothing. Alcoholic stimulants are, in general, to be withheld.

Nostalgia is another complaint liable to assail the soldier, even the hardiest, especially if he is a person of very strong domestic attachments, or engaged in an "affaire du cœur." It is most apt to show itself in soldiers enlisting for the foreign service, or in those who are forcibly expatriated, and is often attended with great suffering, terminating in confirmed melancholy. It is characterized by a love of solitude, a vacant, stultified expression of the countenance, a morose, peevish disposition, absence of mind, pallor of the cheeks, and progressive emaciation. Many of Bonaparte's troops, during the campaign in Egypt, suffered from this complaint; some in a very distressing degree. In this Country, nostalgia will not be likely to occur, at least not to any extent, as our people are essentially of a roving habit, and of an eminently social disposition. The treatment is rather moral than medical; agreeable amusements, kindness, gentle but incessant occupation; and the promise of an early return to home and friends constitute the most important means of relief.

Ophthalmia is one of the annoyances of the soldier's life. Liable to be occasioned by cold, it is capable of assuming several varieties of form, and sometimes prevails extensively as an epidemic. The granular and purulent, in particular, are to be feared, as they frequently destroy the sight, and even the eye, in a few days, occasioning intense suffering. To ascertain the condition of the parts, the lids must always be gently everted with a probe or the finger. The greatest cleanliness should be observed in these affections; the patients should, if possible, be sequestered; at all events not be permitted to use the same basins and towels; the light should be excluded from the apartment; and the general and local treatment should either be strictly antiphlogistic or of a mixed character, partly antiphlogistic and partly stimulant. The applications should be of the mildest description, especially those intended for the inflamed surface. The syringe is frequently used to wash away the secretions. Strong collyria generally do immense harm in all forms and stages of ophthalmia. Blood may be taken from the arm, or by cups or leeches from the temples, if the symptoms are unusually urgent and the patient plethoric. In rheumatic inflammation of the eye, colchicum and morphia, given freely at bedtime, will be of immense service. When *foreign matter* gets into the eye, or becomes imbedded in the cornea, speedy removal must be effected, and the parts afterward treated with rest, cold or tepid bathing, gentle aperients, and seclusion from light. Particles of steel and other sharp bodies are picked out with the point of a delicate bistoury, or cataract-needle. The effects of lime and other alkalies are neutralized by syringing the eye freely with a weak solution of vinegar; those of nitrate of silver, with a weak solution of common salt, a thorough coating of olive-oil being afterward applied.

Carbuncles, boils, and abscesses, which are of frequent occurrence in army practice, demand prompt attention, both on account of the suffering they induce and the disqualification they may entail for temporary duty. They should be opened early and freely, and no time be lost in amending the general health by gentle mercurial and other purgatives, alterants and tonics, particularly quinine and iron. The most appropriate topical remedies are tincture of iodine and warm water-dressings. In carbuncles the affected structures, after free division, will generally require the thorough application of some escharotic or detergent stimulant, as Vienna paste, nitric acid, nitrate of silver, or acid nitrate of mercury.

Frost-bite is extremely common among soldiers during the cold, wet weather of winter. Thousands of the French troops perished from this cause in Russia, during Napoleon's retreat from Moscow. Frost-bite was very prevalent among the English during their first winter in the Crimea, and the French suffered in still greater numbers, as well as more severely. The habit which the men had of sleeping in their wet boots, at one time almost universal, contributed greatly to its production, wet and cold combined diminishing the circulation and vitality of the feet and toes. On the 21st of January, 1885, when the thermometer stood at 5°, not less than 2,500 cases of frost-bite were admitted into the French ambulance, and of these 800 died, death in many having no doubt been expedited by erysipelas, pyemia, and hospital gangrene. Weak and intemperate persons are most apt to have frost-bite and to perish from its effects.

In the treatment, in incipient cases, cloths, wrung out of cold water impregnated with a little spirits of camphor or alcohol, should be applied, or the parts be covered for a few minutes with snow; or immersed in cold water. On no account must they be exposed to warmth, either moist or dry. Excessive reaction is controlled by lead and laudanum lotions, or dilute tincture of iodine. If gangrene occurs, the ordinary measures, local and general, are indicated. All rude manipulation in dressing the injured part greatly aggravates the disease. In general, spontaneous amputation is waited for, experience having shown that operative interference, even when the part is perfectly black, and attached only by a few living shreds, is extremely prone to be productive of excessive pain and constitutional irritation, often proceeding to an alarming extent.

Among the very great evils, both of civil and military practice, are *bed-sores*, which, unless the greatest possible precaution be used, are sure to arise during the progress of acute diseases and of severe accidents, necessitating protracted recumbency. The hips and sacral region are their most common sites, with the heel in cases of fractures of the leg. The earlier symptoms are a sense of prickling, as if the part were rubbed with coarse salt, or a burning, itching or smarting pain, with a brownish or livid discoloration of the skin, and slight swelling. Then gangrene ensues, followed by horrible suffering.

To prevent these sores, which often prove destructive to life, when there is already much exhaustion from previous suffering, the posterior surface of the body should be frequently examined, particularly if the patient is in a state of mental torpor, and pains taken to ward off pressure by the use of air cushions and other means. The parts should be sponged several times a day with some alcoholic lotion containing alum, or painted with a weak solution of iodine. If gangrene or ulceration occurs, a yeast or a port wine poultice is used, the separation of the slough is aided with the knife, while the granulating process is promoted by the usual remedies.

Ulcers of the leg are causes of disqualification in enlisting, but they sometimes occur after the soldier has entered the Service, from fatigue, injury, or undue constriction of the limb. However induced, they should be managed as any other forms of inflammation, recumbency with elevation of the affected parts, tepid water-dressings, a restricted diet, and cooling purgatives constituting the most important elements of the treatment. When the healing process has fairly commenced, the leg should be supported with the roller, or adhesive strips. As preventive of ulcers of the leg, the limbs should be daily washed in cold water, in Castile soap, and no soldier should be permitted to wear garters.

FEIGNED DISEASES.

Soldiers, influenced by a desire to quit the Service, to revisit their homes, or evade active duty, will not hesitate, at times, to play the part of impostors, feigning diseases, or even inflicting upon themselves more or less serious injuries, with the hope of accomplishing their designs. This deception, technically called malingering, would be of comparatively little consequence if it were always, or even generally, confined to a few members of a regiment; but when it is remembered that it is liable to become epidemic, spreading from individual to individual, it assumes a deep importance, well calculated to arouse the attention both of the Medical Officer and of the Military Commander. Its effects then become eminently demoralizing to the Service, which, if proper care be not employed to detect and punish it, might seriously suffer, especially when such an outbreak occurs on the eve of a battle. Great ingenuity is often displayed by malingerers, requiring no little vigilance and skill on the part of the Surgeon for its successful exposure, and yet it is not less necessary for his own credit than for the honor of the Service that he should not permit himself to be deceived. The number of diseases, imitated by this class of dissemblers, is surprisingly great, and there is also quite a list of self-inflicted injuries. Among the former are various mental diseases, as mania and imbecility; deafness; amaurosis; epilepsy; paralysis; hæmatemesis; hæmoptysis; gastritis; disentery and diarrhœa; affections of the heart; rheumatism; lumbago; wry-neck; contractions of the joints; incontinence of urine; bloody urine; and stone in the bladder: among the latter ophthalmia, opacity of the cornea, œdema of the limbs, wounds, and amputations of the fingers. Space will not permit us to enter into any details respecting this important subject. We shall, therefore, only present such facts as may be supposed to be of special practical interest.

First of all, the Medical Officer should weigh well in his own mind the nature of the disease for which a soldier applies for a certificate of discharge, or inability to perform duty. If the case is one of recent standing, it will be well not to come to too hasty a conclusion as to its diagnosis, it should be examined and re-examined before any definite opinion is given. Day by day new facts may be developed, revealing the true character of the affection. If the patient is really sick, or affected with some serious chronic disorder, his general appearance will hardly fail to afford some evidence of its existence. The pallor of the countenance, the functional disturbance of the suffering organ, the bodily prostration, the want of appetite, and the gradual emaciation will almost unerringly point to the nature and seat of the disease. When, on the other hand, the malady is simulated, all, or nearly all, the usual phenomena of disease will be absent. Imposters, moreover, are generally very zealous in talking about their disorders, or in obtruding them upon the notice of their Surgeons, whereas those who are really sick and suffering make comparatively little complaint. A malingerer may often be detected by carefully watching his movements, coming suddenly upon him when he is asleep or when his attention is directed to some one else, tickling his foot when he feigns paralysis, or pricking his back when he pretends to be laboring under lumbago. Sometimes a determined threat will promptly restore him to a sense of his duty, as the application of the actual cautery in incontinence of urine, rheumatism of the joints, or mental imbecility. Now and then the exhibition, in rapidly repeated doses, of a nauseous draught, answers the purpose. Whatever expedients be employed, the Surgeon cannot exercise too much address, otherwise he will be almost sure to be baffled.

Mental alienation, or *mania*, unless the result of inebriation and of acute disease, generally comes on gradually, being proceeded by a marked change in the moral character of the individual, loss of appetite and sleep, and other evidences of general disorder.

Genuine *deafness* is also gradual in its approaches, and, when fully established, is invariably attended by a peculiar listless state of the countenance with more or less change of the voice. Before a final decision is given, a careful inspection of the ears should be made, to ascertain whether there is any obstruction or appearance of matter. The unexpected discharge of a pistol, in a case of feigned deafness, might suddenly decide the diagnosis.

Amaurosis may be simulated by the internal use of belladonna, or by the direct application of this article to the eye, causing dilatation and immobility of the pupil. These effects are often accompanied by unnatural vascularity of the conjunctiva, and they generally disappear spontaneously in a few days. In genuine amaurosis, too, there is always a dilated condition of the vessels of the eye.

Feigned *epilepsy* differs from the real in the absence of lividity of the countenance, the want of froth at the mouth, and the partial character of the convulsions. The pupil does not contract as in the genuine disease, the general sensibility is much unimpared, the tongue is uninjured, the nails are not discolored, the hand, if opened, is again firmly shut, and the individual often watches with his eyes the impression the attack is making upon the by-standers. The application of a heated case-knife, or of a cloth wrung out of hot water, often speedily reveals the imposition.

Paralysis is frequently imitated, but is generally easily detected, simply by watching the patient, tickling his feet when he is asleep, or threatening him with the hot iron. The disease, when it attacks the lower extremity, is nearly always occasioned by apoplexy, and is then generally associated with mental weakness and difficulty of articulation. Partial paralysis of the upper extremity is frequently induced by lying upon the arm, by suppression of the cutaneous perspiration, and disease of the spinal cord.

Haematemesis may be simulated by swallowing blood, or an infusion of logwood, and ejecting the fluid afterward by vomiting. It should be recollected that the real disease is almost invaribly connected with serious organic lesion, as ulceration of the stomach, induration and enlargement of the liver, or visceral obstruction, and that the patient, consequently, will exhibit all the characteristics of a sick person. Soldiers sometimes counterfeit *hæmoptysis* by cutting the gums, or chewing substances impregnated with coloring matter. A case is related by Guthrie, in which a man, for this purpose, swallowed a piece of cork very full of pins. The immediate effect was hæmoptysis, and the remote one death by wounding the carotid artery.

Gastritis may be simulated by spontaneous vomiting, a faculty possessed by some persons, and by pretended pain in the epigastric region. The attack is in general speedily yields to a large sinapism and a brisk emetic.

Dysentery and *diarrhœa* are occasionally feigned by exciting, artificially, irritation of the rectum, by mixing blood with the alvine evacuations, or by borrowing the discharges of persons actually affected with these diseases. In genuine dysentery and diarrhœa there are always well-marked constitutional phenomena, which are of course absent in the spurious. Careful watching of the patient and compelling him to use a close stool will soon remove any possible doubt that may exist respecting the nature of the case.

Disease of the *heart*, in the form of palpitation, may it is said, be produced by the use of hellebore. Mr. Hutchinson, of England, refers to an epidemic of this kind among the members of the Marine Artillery. Organic cardiac disease could easily be detected with the stethoscope.

Rheumatism being a very common disease among soldiers, is often counterfeited; but the cheat is of easy detection when it is recollected that the real affection, especially the acute form, is attended with more or less swelling and constitutional disturbances.

When *lumbago* is made the subject of deception, the attack seldom long withstands the application of rash remedies, or the threatened use, if speedy relief do not arise, of the hot iron.

Contraction of the *joints*, a not unfrequent source of imposition, is easily detected by the use of anæsthetics, or simply by pricking the parts suddenly with a needle when the patient is off his guard.

Whenever *wry-neck* is simulated, both the sterno-cleido-mastoid muscles are rendered rigid by the effort at deception; whereas in the real disease the contraction is confined to one side.

MEDICAL, SURGICAL, AND DIETETIC FORMULAE.

In this connection we notice some valuable formulæ, or medical, surgical, and dietetic preparations, as given by Dr. S. D. Gross, in his *Manual of Military Surgery*, from which work the substance of this article has been taken.

1.—*General Remedies.*

Among the more simple *purgatives* may be mentioned the following: all drastic articles should, if possible, be excluded from the prescriptions of the Military Surgeon:—

R.—Massæ ex Hydrargy. gr. x;
Pulv. Ipecac. gr. i.
M. ft. pil. ii.

A mild laxative in dyspepsia and disorders of the stomach and liver.

R.—Extr. Colocynth. c;
Massæ ex Hydrargy.
Pulv. Rhei. v. Jalapæ, aa gr. x
Ant. et Potassæ Tart. gr. $\frac{1}{16}$.
M. ft. pil. v.

An active, antibilious purgative, from three to five being an ordinary dose. Calomel may be substituted for the blue mass, if there is much disorder of the liver and secretions.

The safest *emetics* are ipecacuanha, infusion of eupatorium, perfoliatum, and mustard and common salt, an even tablespoonful of each to half a pint of tepid water, one-half to be taken at once, the remainder, if necessary, in fifteen minutes. Sulphate of copper or zinc will afford the most prompt emetic effect in case of great urgency, as in poisoning.

The following formula will be found very serviceable in the earlier stages of most inflammatory affections, especially the cutaneous, articular, and traumatic, unaccompanied by disease of the alimentary canal:—

R.—Ant. et Potass. Tart. gr. iss;
Magnesiæ Sulph. ℥i;
Morphiæ Sulph. gr. ss;
Sacch. Albi. ʒii;
Aquæ Destil. ℥vi. M.

This is the antimonial and saline mixture of which repeated mention occurs in the preceding pages, and so commonly used in surgical as well as medical practice. It may be rendered depressant by the addition to each dose—which is half an ounce, repeated every two or three hours—of from three to eight drops of the tincture of veratrum viride; anodyne, or diaphoretic, by laudanum, or morphia; anti-periodic, by quinine; antigonorrhœal, by copaiba, gum-arabic being used, in the latter case, as one of the ingredients; and antirheumatic, by colchicum. If quinine be used, the addition of aromatic sulphuric acid will be required, which is also an excellent solvent of the salts.

R.—Vini Colchici Sem. ʒi;
Morphiæ Sulph. gr. ss;
Potassæ Carbon. gr. x;
Aquæ Destil. ʒss. M.

In rheumatic and gouty affections, taken at bedtime, and followed by a mild aperient next morning.

The following will be found to be pleasant and efficient *diaphoretics*:—

R.—Spirit. Mindereri, ʒiv;
Sp. Æther. Nitrici. ℥ii;
Morphiæ Acet. gr. i. M. S.

Tablespoonful every two or three hours. If there be much heat of surface, we may add to each dose the eighth, twelfth, or fifteenth of a grain of tartar emetic.

R.—Potassæ Carbon. ʒi;
Morphiæ Sulph. gr. i;
Sacch. Albi. ʒii;
Suc. Limonis recent. ʒii;
Aquæ Menth. v. Destil. ʒiiiss;
Sp. Æther. Nitrici. ℥ss. M. S.

Tablespoonful every hour or two.

The effervescing draught, so valuable in irritability of the stomach, is composed as follows:—

R.—Suc. Limonis recent. ʒji;
Sacch. Albi. ℥jiss;
Aquæ Destil. ℥ji. M.
R.—Potassæ Carbon. ℥i;
Aquæ Destil. ℥ji. M.

Put two tablespoonsful of the lemonade with one of the alkaline solution, and let the mixture be drunk while effervescing, repeating the dose at pleasure.

As *antiperiodics* quinine and arsenic are the main reliance of the modern practitioner. The former may be given by itself, in pill or solution, in doses varying from two to ten grains, according to the urgency of the case or state of the system. The usual dose is ten grains every eight, ten, or twelve hours, until the paroxysm is arrested. If the symptoms are unusually violent, we need not hesitate to administer fifteen or even twenty grains at a dose, being of course careful to watch the effects, which will generally be more pleasant if a little morphia be combined with the quinine.

In chronic, or frequently-recurring intermittent and neuralgic affections, arsenic forms a valuable, and, indeed, in many cases, an indispensable addition; also iron, if there be any evidences of anæmia. Many prefer the arsenious acid to Fowler's solution, convinced that it is much more efficacious and at the same time less apt to cause nausea and anasarca. The following formula will be found advantageous:—

R.—Acid. Arseniosi, gr. iss;
Quiniæ Sulph.
Ferri Sulph. aa ʒi;
Morphiæ Sulph. gr. i;
Extr. Nucis Vomicæ, ℈i.
M. ft. pil. xxx.

S. One every five, six, or eight hours.

Quinine is also one of the best *tonics*, and it may always be beneficially combined with other articles, as iron, gentian, quassia, nux-vomica, and capsicum. The fluid extracts and aromatic tinctures of bark and gentian will also be found useful. One of the best chalybeate preparations is the tincture of the chloride of iron, in doses of from twenty to twenty-five drops three or four times daily.

Expectorants constitute a large class of remedial agents, but they nearly all derive their active principles from the admixture of tartar emetic, ipecacuanha, or squills. They may generally be usefully combined with potassa and anodynes, being rendered palatable by syrup or sugar.

Nurses should be familiar with the manner of administering *enemata* or injections, as frequent occasions arise for their employment. They may be cathartic, as when they are designed to empty the lower bowel, or to promote the action of other remedies; stimulant, as in case of excessive exhaustion; nutritive, as when food cannot be taken by the mouth; anodyne, when it is wished to allay pain and induce sleep.

A *cathartic* effect may readily be induced by an injection of a pint and a half of cold water, or water in which a little ground mustard or common salt has been stirred, a mixture of warm water and castor oil; or an infusion of senna, or senna and Epsom salts. Turpentine is particularly indicated when the bowels are distended with flatus.

Stimulating injections may be made of brandy, alcohol, mustard, salt, or spirits of camphor or turpentine, mixed with more or less water; and they are often extremely serviceable in promoting reaction.

Nutritive enemata may be necessary in the low stages of fever, and in gunshot and other injuries attended with lesion of the gullet. The best ingredients are essence of beef, strong beef-tea, brandy, or brandy and milk, introduced in small quantity so as not to oppress and irritate the rectum.

Anodyne injections may consist of laudanum, black drop, morphia, hyoscyamus, or of belladonna, either alone, or variously combined, and administered with about two ounces of tepid water, or some demulcent fluid.

The best *syringe* now in use is the gutta-percha, which is not liable to be deranged, and which has the additional advantage of durability. It should be of various capacities, from eight to sixteen ounces, according to the intention to be fulfilled by it. The nozzle must be well oiled previously to its introduction, and care taken that no air be pushed into the bowel.

2.—*Topical Remedies.*

R.—Tinct. Iodinæ,
Sp. Vini Rectific. aa ʒj. M.

To be applied with a large camel-hair pencil, or cloth mop The pure tincture of iodine is seldom used for local purposes.

R.—Plumbi Subacet. ʒj;
Pulv. Opii, ℥j. M.

To be put in half a gallon of *hot* water, and the solution to be used warm or cold, as may be deemed best. Laudanum may be substituted for the opium.

R.—Pulv. Ammoniæ Hydrochlor. ℥j;
" Potassæ Nitrat. ℈ij;
" Opii, ℈j. M.

To be used as the preceding, being particularly valuable, in inflammation of the joints, and on unbroken surfaces.

The *warm water-dressing* consists of warm water, simple or medicated with laudanum, acetate of lead, or any other ingredient that may be desired, applied upon flannel or muslin cloths, properly folded, and covered with oiled silk, to confine heat and moisture.

The *cold water-dressing* is composed of cold water, also simple or medicated, applied with cloths, the parts being constantly exposed to the air to promote evaporation. The cloths are wet whenever they become heated or dryish, the water being pressed upon them from a sponge.

Water-dressing, if long continued, will occasionally cause irritation, itching, and pustulation of the skin, rendering it necessary to replace them with cataplasms, or other soothing remedies.

Among *poultices* decidedly the best, for ordinary purposes, are flaxseed and slippery elm. The former is made by mixing a suitable quantity of linseed meal with hot, or, what is still better, boiling water, and rapidly stirring it into a thick mush-like consistence. The mixture is then spread upon a fold of cloth, in a layer a third of an inch thick, when it is covered with bobinet or gauze to prevent it from adhering to the parts. A piece of oiled silk, larger than the poultices, is placed upon its outer surface, to retain heat and moisture. The elm, and, in fact, all other cataplasms, are prepared and used upon the same principles as the linseed. Like water-dressings, poultices may be simple or medicated, according to the object proposed. They should be changed at least twice, or, in warm weather, even three or four times in the twenty-four hours.

Adhesive plaster is cut, in the direction of its length, into strips of suitable length and breadth, warmed by holding the back against a smooth vessel, as a pitcher or tin case, and applied in such a manner as to bring the middle of each piece over the wound, the edges of which are, meanwhile, carefully supported by an assistant. A suitable space is left between the strips for drainage. If things progress favorably, substitution need not be made under three or four days. If the wound be large, only a few of the strips are taken off at a time, lest, all support being lost, the edges should be forcibly separated.

Before the soiled dressings are removed, everything intended for the new should be prepared, or put in its proper place. The strips of plaster should be removed with great gentleness.

If the injured parts are covered with hair, the surface must always be shaved before the application of the dressings.

Proper material for *sutures* should always be kept on hand, ready for use. The silver wire is the best, as it is less irritating than any other. Silk, however, answers exceedingly well; the thread should be rather thin, and be well waxed. Saddler's silk is the article used for the ligation of large arteries.

Among the more common and useful *unguents* for dressing wounds, burns, abraded surfaces, or fissures, are the following:—

R.—Pulv. Opii, ʒss;
Pulv. Rhei, ℈i;
Ung. Cetace ℥i, i. M.

To these ingredients may advantageously be added, in many cases of healing sores, or eruptions requiring a mild stimulus, a drachm of the ointment of the nitrate of mercury, a few drops of nitric acid, two drachms of ointment of acetate of lead, a small quantity of myrrh, or of balsam of Peru, or from six to eight grains of sulphate of quinine.

R.—Ung. Cetacei, ℥i;
Bismuth. Subnitr. ʒij. M.

Extremely soothing and valuable is the superficial excoriations, slight burns, and eczematous affections. Turner's cerate may be employed for similar purposes, but should always be considerably diluted.

The best *disinfectants* are chloride of soda, chloride of lime, Labarraque's solution, and the hypermanganate of potassa, of which an abundant supply should always be on hand in every hospital, free use of it being made, by sprinkling and otherwise, upon the dressings, as well as upon the bedding and the rooms.

The *sponges* about a hospital should be of the softest kind, perfectly clean, and always ready for use. The same articles should never be employed upon different persons, especially where there are foul or specific sores, as contagion might thus be communicated by direct inocculation, as has, for example, so often happened during the prevalence of hospital gangrene.

3.—*Dietetic Preparations.*

The diet of the sick-room has slain its thousands and tens of thousands. Broths, and slops, and jellies, and custards, and ptisans are usually as disgusting as they are pernicious. Men worn out by disease and injury must have nutritious and concentrated food. The ordinary preparations for the sick are, in general, not only not nutritious, but insipid and flatulent. Nitrogenous food is what is needed, even if the quantity taken be very small. Animal soups are among the most efficient supporters of the exhausted system, and every medical man should know how to give directions for their preparation. The life of a man is his food. Solid articles are of course withheld in acute diseases, in their earlier stages, but when the patient begins to convalesce they are frequently borne with impunity, and greatly promote recovery. All animal soups should be made of lean meat; and their nutritious properties, as well as their flavor, may be much increased by the addition of some vegetable substance, as rice or barley. If the stomach is very weak, they may be diluted, or seasoned with pepper.

Essence of beef, so frequently given in the low stages of fever, and in the exhaustion consequent upon severe injuries and operations, is prepared by cutting from a quarter to half a pound of lean beef into thin pieces, and putting it into a wide-mouthed porter bottle, corked tightly, and placed in a kettle of cold water, which is then heated till it boils. After it has been digested in this way for a few hours, the juice is decanted, and seasoned with salt and pepper, wine or brandy.

Beef tea, much less nourishing than beef essence, is made by putting a quarter of a pound of lean beef in a pint and a half of water, and boiling it for fifteen minutes, a few blades of mace being added during the process, and the fluid well skimmed.

To make *chicken broth* requires half a young chicken and a quart of cold water, with a teaspoonful of rice or barley, the whole being slowly boiled for two hours under cover, with proper skimming.

Chicken jelly is prepared by putting a chicken, cut up, all the bones broken, in a stone jar, closely covered, and retained in boiling water for three hours and a half. The liquor is then strained, and seasoned with salt and mace.

Vegetable soup is composed of two Irish potatoes, one onion, and a piece of bread, with a quart of water, boiled down to a pint in a closely-covered vessel, a little celery or parsley being introduced near the close of the operation. Salt and pepper are added at pleasure.

To form *rice jelly* a quarter of a pound of rice flour and twice that quantity of loaf-sugar are boiled in a quart of water until the whole becomes a glutinous mass, when the jelly is strained off and flavored.

Sago jelly is composed of four tablespoonsful of sago, one quart of water, juice and rind of one lemon, and enough sugar to render it agreeable. After the mixture has stood half an hour, it is boiled until all the particles are entirely dissolved, the mass being constantly stirred.

Oatmeal gruel is composed of two large spoonsful of oatmeal and half a pint of milk, stirred into one pint of boiling water, and allowed to simmer for thirty minutes, when it is strained through a hair sieve. *Cornmeal gruel* is prepared in a similar manner.

Arrow-root pap consists of a large tablespoonful of this substance made into a paste with a little cold water, which is then stirred into a pint of boiling water, and kept on the fire for ten minutes. The nourishing properties of arrow-root pap may be heightened by using milk instead of water in its preparation.

Milk toast is often much relished by the sick; and there is a very excellent jelly for invalids made of a thinly sliced and slightly toasted penny roll, boiled in a quart of water until it becomes a glutinous mass, when it should be strained upon a few shavings of lemon-peel.

The flavor and efficacy of the various dietetic preparations here described may be greatly increased by the addition of mace, lemon, wine or brandy. When salt, or salt and pepper are used, the patient's own taste should be consulted. Great care should be employed in making these compounds that they are not scorched. To prevent this a double boiler should be used.

Milk-punch, an excellent article when a stimulant is required in conjunction with a nutrient, is made by mixing good brandy with cold, fresh milk, in the proportion of about one ounce of the former to half a pint of the latter. Sugar and nutmeg may be added to make the mixture palatable.

Wine-whey, well made, may be rendered of great service to the sick. It is prepared by adding a pint of fresh milk, as soon as it reaches the boiling-point, as much good Madeira or sherry as will coagulate it. The mixture is then strained, and sweetened or flavored for use.

The best *wines* for the sick are Madeira, port, and sherry. In cases of gastric irritation, champagne sometimes produces a decided and excellent effect, quieting the stomach as well as the system at large.

Egg-nog consists of an egg, the white and yolk of which are beaten up separately; half a pint of cold water with a little loaf-sugar is then added, together with two tablespoonsful of brandy. See *Military Surgery*.

SURMOUNTED.—In Heraldry, the term used to indicate that one charge is to be placed over another of different color or metal, which may respectively be blazoned: Sable, a pile argent surmounted by chevron gules; and, argent, a cross gules, surmounted by another or. See *Heraldry*.

SURPRISE.—Surprises and ambuscades depend for their success upon the same point, that of being able to attack the enemy suddenly when he is not prepared to resist. The term *surprise* is applied to unexpected attacks upon an enemy's position: that of *ambuscade* where a position is taken for the purpose of falling suddenly upon the enemy when he reaches it. Secrecy, good troops, and a thorough knowledge of the localities, are indespensable to the success of either of these operations. In planning a surprise, the officer must spare no pains in ascertaining the face of the country leading to and in the immediate vicinity of the enemy's position; the character and disposition of his troops; and the state of preparation of the defenses of the position. Information may be obtained on these points from spies, deserters, inhabitants of the locality occupied by the enemy, good maps, etc. The troops to be employed in the expedition, as well as the other necessary arrangements, will depend upon the information gained on these points. If the position be an intrenched one, infantry will constitute the main force; cavalry and artillery can be of little other use than to cover the retreat of the infantry, and to make prisoners of those who may escape from the position. A body of engineer troops or of picked men used to handling tools, will accompany the infantry, and will carry with them such implements as may be requisite from the character of the defenses, as axes, saws, crowbars, small sealing-ladders, etc. If the position be not intrenched, as an open village, etc., cavalry may perform a very important part, by a sudden dash among the enemy, in creating confusion and alarm. As the success of the affair will greatly depend upon the secrecy with which these preparations are made, and the celerity with which it is conducted, all orders for collecting the necessary implements and assembling the troops, should be given at the shortest notice; no more troops should be taken than are indispensably necessary; and they should carry nothing with them but their arms, and the requisite amount of ammunition. Midnight is the best hour for small bodies of troops to carry out such enterprises; as they must effect all they desire to do and be off before daybreak. A few hours before daylight is the best time for large expeditions; as the dawn of day will be favorable to their retreat, by which time they will have been able to effect their purposes. The season of the year and the state of the weather should be taken advantage of. Winter and bad weather are most favorable, as the enemy's sentinels and outposts will then, in all probability, be less on the alert, and more disposed to keep under such shelters as they can procure. As our purpose may be divined by the enemy, measures should be taken against such a contingency. These will mainly consist, in securing by detachments all defiles and roads by which our retreat might be cut off; and by designating a rallying point, on which our force will fall back, if repulsed, which should be strongly occupied by cavalry and artillery, if they constitute a part of the force. In conducting the march, the troops will be kept well together; the greatest order and silence be observed. Instead of the ordinary precautions of an advanced-guard and flankers, reliance should rather be placed upon a few active and intelligent scouts, to gain timely notice of any movement on the part of the enemy. Concerted attack upon several points are good means of creating confusion and paralyzing the enemy's efforts, when they can be successfully carried out; but, as they may require some of the detachments to make considerable circuits to reach their points, much will depend upon chance as to their success. In such cases, some signal must be aggreed upon, to let the detachments, already in position, known when those, which are likeliest to reach theirs latest, are ready; but this may have the inconvenience of giving the alarm to the enemy. Rockets may be used for this purpose, and also to give notice to the troops to retire together. The retreat after a successful issue should be conducted with the same promptitude as the advance. Time must not be lost in waiting too long for all the detachments to come in at the rallying point, as the safety of the whole command might be compromised.

The following examples, taken from *Edmund's Art and Science of War*, are interesting in this connection:

HESSIANS SURPRISED AT TRENTON, 1776.

On the 25th day of December, 1776, a total effective force of not quite one thousand five hundred and fifty men constituted the garrison of Trenton. The command had six pieces of artillery, but contrary to the previous advice of Colonel Donop, there were neither field-works nor defense of any kind before the ferry or at any of the approaches to the town. One such work on the summit, at the fork of King and Queen streets, and one on Front street would have seriously endangered the American movement, especially under the circumstances of severe weather, which almost disarmed the assailants. It was Christmas, a holiday in great favor with the troops which composed the garrison. It is enough to state that military negligence was absolute. The disposition of the American Army for the attack was eminently bold and judicious. Griffin was expected still to occupy the attention of Donop, as if those demonstrations across the river were but the feverish action of local militia. A small center column under General Ewing, whose brigade reported but five hundred and forty-seven rank and file for duty, was to cross just below Trenton, to occupy the bridge across the Assanpink, and thus sever communication with Donop's corps at Bordentown. Still further down the river, as a constraint upon the possible movement of that corps to the support of Colonel Rahl (at Trenton), the right wing under Cadwallader, was ordered to cross at Bristol, below Bordentown, with view to a direct attack upon Donop from the south, and thus co-operate with the militia in that quarter. General Washington reserved for himself the conduct of the left wing, consisting of two thousand four hundred men, which was to cross nine miles above Trenton, at McConkey's ferry. Learning that Maidenhead was almost without garrison, except a troop of dragoons, it was the purpose of the American Commander also to include that sub-post within his raid. It was also expected that General Putnam would cross from Philadelphia, early on the 26th, with at least one thousand men. The plan embraced the deliverance of the left bank of the Delaware. The right wing landed a portion of its troops; but on account of the ice could not land the artillery, and returned to Bristol. The center of the column failed to effect a landing. The left wing of the army under Washington, accompanied by Greene and Sullivan as division commanders, formed evening parade under cover of the high ground just back of McConkey's ferry. It was designed to move as soon as darkness set in, so as to complete the crossing at midnight, and enter Trenton as early as five o'clock in the morning of the 26th. It was cold, snowy, and tempestuous. The landing of the artillery was not effected until three o clock, but the army did not march until four. Retreat could not be made without discovery, annoyance, and consequent disheartening of his troops, and late as it was the advance was ordered. Sullivan's division moved by the river road. Washington with Greene, took direction to the left, entered the Pennington road one mile from town. The pickets on both roads behaved well, but were quickly swept away by the force which now hastened to its achievement. Washington moved directly to the junction of King and Queen streets. Under his direction Colonel Knox placed Forrest's battery of six guns in position so as to command both streets. The Hessians in vain attempted to rally, the surprise was complete, and finding retreat cut off in all directions, surrendered to the number of about one thousand. The Americans lost three killed and three wounded. A few skillfully handled guns determined the action.

THE STORM OF KARS.

The storm of Kars during the Russo-Turkish war of 1877-78, is given as an example of the successful surprise and capture of a position defended by a large body of men. This was the final act of the campaign in Armenia, and one of the most remarkable exploits in military annals.

The fortifications consisted of a masonry citadel, and twelve detached forts. The various forts presented different *tracés* and different constructions. The forts ordered to be carried were the following: Fort Hafiz Pasha was a square redoubt, four hundred yards on a side, with bastions at the angles, ditch twelve by six feet, and a casemated barrack in three tiers closing the gorge. Fort Kanly consisted of two small square redoubts about one hundred and fifty yards on a side, and in rear of them a lunette with faces in the form of a bastioned front and closed at the gorge with a casemated barrack. The ditch was twelve by six feet. The development of the line of fire was over two thousand one hundred yards. Fort Stouvari was a simple lunette without ditches. Of the other forts, some had ditches, others not. The counterscarp of all the works having ditches was arranged with a banquette for infantry fire over the glacis. These works presented in general certain qualities advantageous to the defence, *i. e.*, they were (partly) on commanding ground, they were so near together and so constructed that their artillery lent mutual support, and the rocky ground precluded all idea of mining against them. The total armament of the place is about two hundred guns (303 were captured at the assault, including a large proportion of field-guns). The total development of the line of fire for infantry is about six thousand yards. Allowing two men to a yard and fifty per cent. in reserve, the proper garrison would be eighteen thousand infantry, and, with twenty-five men to a gun, five thousand artillery, or in all twenty-three thousand. This was almost exactly the strength of the garrison at the time of the assault. Thirty thousand infantry, with fifty-three squadrons and one hundred and forty-four guns were constituted the army of investment of Kars.

The train of reasoning which induced the assault is thus explained in the Grand Duke Michael's report: "Careful reconnaissances of the ground and of the defenses of the place, and the information gathered concerning the effective strength and morale of the garrison, and concerning its provisions, proved each day more clearly that, although the defeat of Moukhta Pasha's Army may have had a certain demoralizing effect upon the defensive strength of Kars, yet the capture of this town was none the less an extremely difficult exterprise. The excellent armament of the fortifications of Kars, the resolution of the garrison to fight to the last extremity, the well known firmness of Turkish troops in sieges, and the difficult conditions in which the troops of investment were placed, hardly permitted the idea of sitting down to a siege of which it would have been difficult to foresee the end. The only way to put an end to this state of affairs was to gain possession of Kars in open assault. The line of forts on the southeast, situated on the right bank of Kars river, Hafiz, Kanly, and Souvari, and the town itself, where all the depots and provisions of the garrison were concentrated, were chosen as the principal objective, partly on account of the conformation of the ground, and partly on account of the situation and relative strength of the defenses commanding the approaches of the place. It was at first thought that it might be possible to reduce the place by bombardment alone, but this was soon seen to be an illusion; the Turks began constructing new batteries. It was all the more necessary to hasten the end; the assault was decided upon. It only remained to fix the place and the means. In front of the line of the forts, which was to be the principal objective of the attack, the ground afforded within musket range of the works hardly any shelter, and not a single favorable position for field artillery. The enormous extent of the line of fire, flanked by several bodies of troops, successive rows of trenches and artificial shelters, the almost incredible range and intensity of the Turkish infantry fire on the defensive, threatened enormous losses in case of an attack by daylight. On the other hand, an attack in the darkness of a night without a moon might lead to a catastrophe. It was necessary to await the time when the moon, remaining nearly all night above the horizon, would light up the field so that there would be no danger on the one hand of making a mistake in the road, and on the other hand of revealing our movement to the enemy from a distance, and thus giving time to take his own measures and to direct a murderous infantry fire upon us. The greatest secrecy was observed, and the Turks do not seem to have had the least suspicion of what was going on. They had in fact concentrated over fifteen thousand men—two-thirds of their whole force—in their forts on the Shorak mountains, on the left of the river.

The orders giving the general direction for the assault, were as follows: 1. The troops investing Kars are to gain possession of Forts Souvari, Kanly, and Hafiz Pasha. 2. The attack must be made *unexpectedly*, and efforts must be made to take prisoner or else destroy the garrison of these forts, and to get possession of the guns in them. 3. At the same time as the attack of these forts, *demonstrations* will be made against other points of the enemy's line of defense, in order to distract his enemy's attention and the troops from the real point of attack. 4. These *demonstrations* may be converted into *real* attacks, taking advantage of the enemy's confusion or other favorable circumstances, but only by small bodies, as experiments, in order to avoid great losses. 5. Such attempts may be made also by the troops charged with the principal attack, after this latter has been executed; Fort Tchim and the wall of the town are specially indicated as the objects of these attempts. Under entirely exceptional circumstances, such for example as a case of complete panic on the part of the enemy, such an operation is authorized with reference to Karadagh, but without losing sight of the difficulties of its execution. 6. After having gained possession of Forts Souvaria, Kanly, and Hafiz, the first duty of the troops will be to establish themselves solidly there: they will not evacuate these works except in case it should be absolutely impossible to maintain themselves in them; and in this case they will bring away the prisoners and trophies, and will destroy, as far as possible, all the enemy's means of defense.

In order to carry out all these instructions, five separate columns of assault were formed and two columns of demonstration, and about five thousand men being held in reserve. The artillery was not to follow the troops, but was to remain, ready for action, near the reserves, until daylight or the receipt of further orders. The cavalry was to be stationed at important points and await orders. The concentration of the troops was to commence at dark, the forward movement at eight p.m. Profound silence was to be everywhere observed, and no smoking allowed. The 3d engineer battalion was divided up into small squads and distributed among the various columns, each squad carrying its ladders, dynamite-cartridges, and implements of various kinds. With each column was also a squad of artillerymen, with tools for spiking or dismounting the guns. On the evening of the 17th all the troops assembled at the points indicated, and about 8.30 p.m. the columns moved forward. A perfectly clear sky and the full moon, which had just risen, gave promise of a clear and calm night. A solemn and cold silence reigned in the air, and the most attentive ear could not have distinguished any noise in the least alarming. The dimly-seen line of our skirmishers was advancing prudently, step by step, followed by the troops for the assault, which at first marched in compact columns, then, as they approached the line of attack, formed in deployed order in company column. About nine o'clock some shots were heard at Turkish outposts, and then, as ours did not reply, they ceased. Only our batteries at Djavra, as a signal, opened a cannonade against the heights of Tekmass, attracting the attention and forces of the enemy towards this point. But not half an hour elapsed before a musketry-fire of the Turks burst forth along the whole line of attack, and after a few minutes the works and trenches of the forts which had been attacked began a continuous firing.

The little column of Prince Melikoff was the first to reach its destination. Advancing without firing a shot and capturing the Turkish pickets, it rushed into Fort Souvari about half-past nine p.m., almost before the Turks knew they were approaching; they then killed the Turkish garrison with the bayonet, spiked or dismounted the guns, and in less than half an hour left the work, broke through some Turkish cavalry which came to attack them, and rushed on to the bridge over the Kars river in order to attack Fort Tchim on its left flank and rear.

Grabbe's two columns, assaulting Fort Kanly, had more serious difficulties. They arrived in front of the work about ten p.m., and crossed, with some little difficulty and under a heavy fire, the obstructions in the shape of pits in front of the work. On the right, a few hundred volunteers swarmed over the parapet of the eastern redoubt, and as quickly as possible killed all the defenders who remained in it; they then rushed on the eastern flank of the main work, got possession of part of its parapet, and stayed there, awaiting the arrival of the rest of their column, but unable to get any further forward in the face of the superior force of the garrison. The rest of the column, however, seeing a redoubt occupied, inclined to the right to attack the trenches and a little lunette with four guns, situated between Kanly and Hafiz. Having gained possession of these trenches and the lunette, they began to reform and advance to the relief of their comrades who still held on upon the parapet of the eastern face. Meanwhile, on the left, Count Grabbe, led his column in person and on horseback, and passed around the flank of the western redoubt and attacked the main work, partly in front against the western face, and partly by turning its extreme western flank and endeavoring to enter the work in rear. The troops with great difficulty gained possession of the covered-way, reformed in the ditch, and at eleven o'clock portions of the 3rd Grenadiers and the 75th Regiment rushed over the parapet at the same time that a part of the Rifle Battalion entered the work from the rear. A fierce hand-to-hand fight then took place in this angle of the work, the traces of which were found in five hundred Turkish dead which lay in a small place there the next day. But although a good portion of the garrison was thus exterminated, the rest took refuge in the stone barracks at the gorge, which had two tiers of musketry fire, and several small mortars in barbette on top, and did great damage to the Russians at such close quarters. Colonel Belinsky then took some volunteers, passed round to the rear of the barracks, and tried to break down its doors; but they were of iron, and he made no impression on them. This attempt having failed, it became impossible for the troops to remain in the works under the rain of bullets which the Turks showered on them from the loopholes of the barracks, and they were therefore obliged to return to the ditch, leaving, however, a line of men lying down on the crest of the parapet, who gave the Turks a very warm reception whenever they attempted a sortie from the barracks. The barracks finally surrendered just after the Russian Commander was ready to blow it up with dynamite. Three hundred men were all that remained of Fort Kanly. With about the same details all the works upon the right bank of the Kars river passed into the hands of the Russians.

As daylight dawned about five A. M., the whole series of fortifications on the right bank of the Kars River was in possession of the Russians; but the commanding forts on the heights held out, and the Turks had still between twelve thousand and fifteen thousand men, somewhat demoralized, but still capable of fighting, on the left bank of the Kars. Massing these the Pasha determined to make an effort to break through in the direction of the villages of Samovat, Aravartan, and Bozgala, and thence winding through the mountains, gain the Erzeroum road. As the day dawned this movement became clearly defined, and Lieutenant General Roop, commanding on the left bank, took what measures he could to stop it, by disposing the cavalry, stationed near these villages, to take the columns in flank while his infantry retained them in front. The principal column of the Turks, near Bozgala, seeing itself surrounded, laid down their arms; but at Samovat and at Aravartan they broke through the Russian infantry and continued their march towards the mountains. "The Cossacks were after them with the utmost energy, and attacked them vigorously in flank, causing a loss of several hundreds of men among the Turks, and delaying them while another portion got on their road in front and headed them off. They surrendered here and there by batallions, until finally there remained but one detachment of about one hundred and fifty mounted men, flying in the direction of the Olti road. The Cossacks put after them, sabered about a hundred of their number whose horses were exhausted, and chased the rest for about fifteen miles. Then their own horses gave out, and they had to give it up. Kars was wholly in possession of the Russians. It was a good night's work—a fortified place of the first order captured in open assault with seventeen thousand prisoners, three hundred and three guns of various calibers, twenty-five thousand or more small-arms, and an immense quantity of provisions and material of all kinds. Two thousand five hundred Turkish bodies were found dead on the field. The Russian losses were two thousand two hundred and seventy-three.

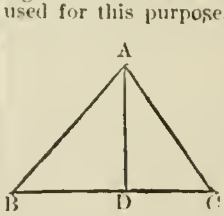
The campaign in Armenia, begun by the Russians with insufficient forces, and checked for a while finally ended in their complete victory and the overwhelming defeat and destruction of the Turkish forces. Its fate was decided by the battle of Aladja Dagh and the storm of Kars, and these are among the most brilliant feats in Russian military annals. The more the latter is studied, and the stubborness of the defense is considered, the more certain it appears that those who lay down as a proved principle of modern tactical warfare that fortifications defended by breech-loaders cannot be carried in open assault, have made a hasty judgment. Kars was stormed without any artillery preparation at all; its success was due to the skilful dispositions made beforehand, and to the individual courage and endurance of the men. In both cases hand-to-hand fights finally decided the battle. See *Ambuscade*.

SURRENDER.—To give up possession of anything. In battle, when unable to make good one's retreat, or in the case of a fortress being unable to stand out against the attack of the besiegers, to surrender is then to lay down arms and to give up the garrison as prisoners of war. Not by force of arms alone has a fortress to surrender; it may have to do so from being starved out by the besiegers. The greatest surrender of troops in the field that we are acquainted with in late years is that of the French Army at Sedan: of fortresses, that of Strassburg, of Metz, and others in France during the Franco-German war of 1870–71.

To surrender at discretion means to give oneself up, or to deliver up an army or a fortress, into the hands of a victorious General without stipulating any terms.

SURTOUT. In fortification, the elevation of the parapet of a work at the angles to protect from enfilade fire.

SURVEYING.—Land-surveying may be considered the earliest practical application of the art of geometry or earth measurement, and must have been in some more or less rude form coeval with agriculture and the division or appropriation of the soil. In Rome, surveying was considered one of the liberal arts, and the measurement of lands was intrusted to public officers who enjoyed certain privileges; and it is probable that the system of measurement practised by them was very similar to our plane-surveying with the chain and cross-staff of the present day, and has been handed down to us through the feudal period. An examination of ancient records and title-deeds will show that both areas and boundary-lines of the different inclosures forming fields, hundreds, townlands, etc., are often laid down with a considerable degree of accuracy. Land-surveying may be considered under the following heads: (*a.*) Plane-surveying with the chain, and without the aid of angular instruments, except the cross-staff or fixed angle of 90°. (*b.*) Modern engineering surveying, in which angular instruments are used. (*c.*) Coast and military surveying. (*d.*) Trigonometrical surveying. The fundamental rule of every description of land-surveying, from the humble attempt of the village schoolmaster to lay down an irregular garden-plot, to the trigonometrical survey of a large extent of the earth's surface, when the aid of the most refined improvement of modern science is indispensable, is simply to determine three elements of a triangle, and thence to calculate its area. In plane-surveying with the chain, the three sides of a triangle, ABC, are supposed to be accessible, and are carefully measured on the ground, and then laid down or platted to scale on paper, when an accurate figure of the triangle will be obtained, on which the length of the sides can be marked. To get the area, however, it will be necessary to determine the length of the perpendicular line AD, and this is usually done (when possible) on the ground by means of a simple instrument called a cross, which consists of two sights or fine grooves at right angles to each other, and being placed on the line BC (keeping B and C visible in one of the sights), nearly opposite the angle A, is moved gradually till the angle A is intersected by the other sight. The line AB can be also laid down on the drawing, and its length found by scale, and arterward verified on the ground, or it may be at once laid down on the ground by the use of the chain alone. An improved reflecting instrument, called an optical square, is also often used for this purpose. Any boundaries along the lines or sides of the triangle, ABC, can be determined by the use of offsets or insets, as they occur on right and left of the line. No matter what the form of the surface to be surveyed may be—polygon, trapezium, or trapezoid—it may thus be determined by a judicious subdivision into triangles; and when the survey is not of a very extended nature or character, and when no serious obstruction exists, chain-surveying is both accurate and expeditious, especially if the proof or tie-lines are properly introduced, for the purpose of testing the accuracy of the work. In every



description of surveying, it is best to make the original triangle as large as possible, and to work from a whole downward, rather than build up a large triangle by the addition of the several small ones, as is sometimes done.

Wherever buildings or any other impediments are found in the measurement of a straight line, they are generally passed by the erection of short perpendiculars sufficient to clear the obstacles, and a line parallel to the original measured as far as they exist, when the original line can be again resumed. Differences of level, occurring in measuring a line where no instruments are used, are generally compensated or allowed for by the judgment of the surveyor. In registering the dimensions taken on the ground, such as sides of triangles, offsets, intersections of roads, fences, etc., and everything required to make a perfect delineation or plan of the surface, surveyors use what is called a field-book, the mode of keeping which varies very much with individual practice. Some surveyors use hand-sketches or rough outlines of the form of the ground, and mark the dimensions on them, while others use the ordinary form of field-book, or combination of the two methods, which perhaps is the best when any difficult complications same. We give below the field-book of the assumed survey of the triangle ABC, with the different offsets and insets on its sides, and where the roads, fences, streams, etc., cross them, the detail of which can be obtained by subdividing the triangle into smaller internal ones. The figure can thus be laid down from the book, and its area calculated by the formula $\frac{AB \times CD}{2}$, and the offsets and insets calculated and added, or deducted.

Ponds, plantations, and enclosures of different kinds may be surveyed with a chain, especially if their form be such that they can be conveniently included in the area of a triangle, the correctness of which, being proved by proper tie-lines, the form, area, etc., may be ascertained by offsets or insets.

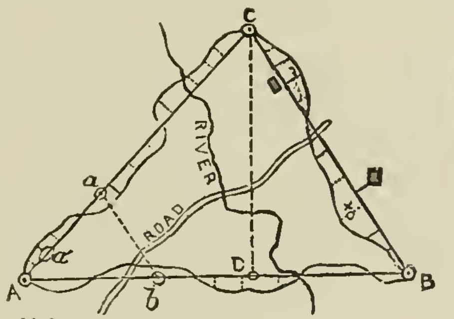
SURVEYOR GENERAL OF ORDNANCE.—One of the three great Officers of State in England, whose Department has the supply of all kinds of stores, transport, and quarters.

SURVEYS OF THE PUBLIC DOMAIN.—The records of the Land Office furnish a gigantic illustration of the evils of badly-directed scientific work. A large

PAGE 1.

		To cor. C	6	
		1500	13	
		1400		
		1200	20	
			12	
20 ▮▮	8	1000		
		900		
Fence.		800		
Road.		700		
	8	600	10	
	10	500		
Mill		400		
8 feet from	16	300		
line	8	200		
	5	100		
		0		
From B		L cor. B		go to C.

		To cor. B		
		2075		
		1950	12	
		1900	15	
		1800		Fence.
	9	1600		
	8	1500		
		1380		Fence.
		1360		Steam crosses.
		1300	6	Here perpendicular
		1275	8	D intersects.
		1100	12	
		1000	6	Fence.
		900		
		800		
	8	700	o	*b*, for proof.
		600		Road crosses.
	10	500		
		400		Fence.
		350	12	
		220	14	
From A		000		go to B.



PAGE 2.

		To cor. C		
		1274		
		500		Road.
		486		Stream.
From D on A		Cor.		to C.

		To cor. A		
		1800		
Here a gravel pit, *a*, 10 feet diameter.	o	1700	5	
		1600	4	
		1500	7	
		1400	6	
		1300		
	6	1200		
	8	1100		
	12	1000		
	9	900		
	8	800		
	6	700		
525 to *a*	o	600		Fence.
		500	18	
		400		Stream.
		300	5	
		200	6	
		100	9	
		000		
From C		L cor. C		go to A.

The line *ab* may be similarly booked and platted, and any lines intersecting shown.

happen on the ground, such as the frequent occurrence of buildings, enclosures, waters, etc., along the line. In the ordinary field-book, the center column, commencing from the bottom, represents the length of any line or side of a triangle; and the figures in the column, the distance at which the offsets to the right or left are taken, or where roads, streams, fences, etc., cross the line, or buildings adjoin the corps of surveyors has been employed for nearly a century. Forests, prairies, plains, and mountains have been traversed in many directions; millions of miles have been run with compass and chain; chart after chart has been constructed with great labor; folio on folio has been placed among the national archives, containing facts incoherent and worthless; and the record has been made that here are trees, there swamps, and yonder glades; that the lands surveyed are level, hilly, or rolling; that sandstones are found here, limestones there, or granite elsewhere; and so the records of useless facts have been piled up from year to year until they are buried in their own mass. That all of this labor and expense has been lost to science, may well challenge the attention of the learned men of America, and when properly understood, they will not be slow in demanding a reform. It is scarcely necessary to indicate a method by which these evils can be corrected in the future. There is one, and but one, adequate and inexpensive method. The initial points should be connected by a triangulation with a system of short base-lines accurately measured, the latter having their latitudes, longitudes, altitudes, and azimuths properly determined, and from the geodetic points established in this triangulation all the lines of the parceling surveys should be checked, and the datum points in the parceling surveys should be marked with imperishable monuments of stone or metal. By such a plan the boundary lines of parcels could be accurately and permanently fixed and easily identified. The corner-posts would not be immediately destroyed by natural agencies, and if lost by accident or removed by design, they could be easily and accurately replaced, and the whole basis of the system, in its geodetic points and triangles, would remain while hills and mountains stand and the stars shine. In this manner a proper parceling of the public lands would be made, and at the same time all other scientific purposes of a survey would be subserved. It is quite unnecessary to represent the importance of a good trigonometric survey for scientific purposes. It is rather of its utilitarian purposes that we would here speak, and especially of its importance to our system of surveys of the public lands. Not only would the use of a primary triangulation as the basis of land-surveying remedy the principal defects of that system, but it would be a means of great economy in the final cost, and would have the immense advantage of rendering much of those surveys both unnecessary and inexcusable, and would distribute the cost over the coming years in a manner least burdensome upon the revenue.

The relatively small proportions of the land remaining in the possession of the Government which is useful for industrial purposes has had, in the last few years, the effect of locating the incoming population of the far West upon scattered districts where water can be found, and these settlements are separated from each other by mountains or by broad expanses of barren plains which, for many years to come, will not be sold nor turned to any economic use except in very rare instances. And yet a survey is as essential to the title of the homesteader of Wyoming and Idaho as to the old settlers of Ohio and Illinois. To make that survey by present methods, and in conformity with existing statutes, it is necessary to run lines from standard meridians and parallels or from established township corners, and these lines must be "marked and measured" before the contractor can receive his payment. Connections of isolated districts must thus be made through a series of township corners. The futility of making such corners wherever they may chance to fall in the mountains and deserts, by such perishable devices as are authorized by law, needs no remark. The inaccuracy of such measurements in a difficult country is a consequence equally obvious. The whole system is one which from the peculiar character of the western region renders necessary a very large amount of surveying which serves no useful purpose except to connect isolated districts and such connections are from the nature of the case grossly inaccurate. To such a method the trigonometric method stands in the strongest possible contrast. By a judicious selection of natural and conspicuous geodetic stations scattered over the land, all superfluous surveying may be entirely avoided. The latitudes and longitudes of such stations being once determined, they may become the datum-points or origins of local surveys of all districts which lie in their vicinity. But while a trigonometric survey, if conducted with proper accuracy, is in one sense an expensive undertaking, there may be danger of overestimating its relative cost. It could not be more expensive than the present and surveys which yield such poor and perishable results. But even here it is well to remember that a triangulation, with a secondary and tertiary system of triangles, need not be at once extended over the entire domain, nor even over a very large proportion of it. Population in the far West has shown a tendency to cluster around a number of localities of relatively small extent, while the greater portion of the region is unoccupied. The primary points once determined in a few narrow belts, it will be practicable to expand a net of inferior triangles over those localities which need surveys while the barren wastes may be left until a survey is needed for them. It will always be practicable to regulate the extent of the triangulation, and to adapt it to wants as they arise.

The greatest economy of this method would arise from the fact that it would dispense with the unnecessary work of the present land surveys. Recalling here the fact that under the present method the work is done by contract, it obviously becomes the pecuniary interest of the deputy to survey as much land as practicable provided it will yield him a profit. To a considerable extent he has discretion in the selection of the districts which he has to survey, and being governed solely by considerations of profit, naturally, and quite lawfully, selects such lands as can be surveyed at least cost to himself without regard to their present or even probable occupation by settlers. Many millions of acres have thus been parceled without the slightest necessity, the lands being worthless, and the land marks have been allowed to perish, and all useful results have perished with them. We have but to contrast this prodigal and wasteful method with the permanent and ever-useful results of a triangulation in order to recognize the immense advantage of the latter. Throughout the Rocky Mountain region a great portion of the values of the public domain subsist in the mines of gold, silver, cinnabar, lead, etc. The surveys of these mining lands are carried on by methods even more poorly adapted to reasonable requirements than those of the agricultural lands. The tracts of mineral lands containing ores of precious metals, title to which are conveyed from the general government to individuals, are surveyed by methods so inaccurate that the surveys themselves are of little value in identifying parcels, and in the courts the records of such surveys are of no value, parol evidence being necessarily substituted; for in general the values of the mines exist within narrow horizontal limits and should resurveys the made following original records it would always be probable that sites thus obtained would not coincide with the original one but would be in part or in whole established on other grounds. Under the law the surveys of mineral claims are connected either with the corner posts of the land surveys or with "mineral monuments and this connection is made by lines run with compass and chain, and it should be remembered that the mines are in the mountains where the use of these instruments involves the greatest expense and secures the least accuracy. To this primitive and almost barbaric system of surveying the mineral lands may be attributed a large part of the disastrous litigation in which the mines of the Rocky Mountain region are involved. We need scarcely say that such surveys are so inaccurate as to be of no value whatever in determining the position of the claims themselves. It thus happens that when in a mineral district many claims have been surveyed, an attempt is made in the surveyor-general's office' or, in the General Land Office in Washington, to plot a number of such claims on a common chart, the several surveys are found to be inconsistent with each other, and overlap or fail to connect. The claims themselves should be plotted on properly constructed topographic charts and be connected with each other by triangulation, and the whole connected with the general system of triangulation which must be carried over the country. Every mineral district should have a thorough topographic survey, and at convenient points throughout the district monuments should be erected and their absolute and relative positions determined by fixing their angular relations to each other and to the geodetic points of the general triangulation, and thus every miner would have an accurate, simple, and inexpensive method by which the position of his claim could be fixed. But such properly constructed charts necessary for the identification of mineral claims and the proper recording of conveyances would meet all other wants. It would be a sufficient guide to the engineer, for all general purposes, in the location of highways and hydraulic works, and a sufficient map for all scientific purposes. If the work were properly done in the first instance, so as to be sufficient for all reasonable requirements, no duplication of the work would be necessary for any other purpose.

In the administration of the Land Office, there are important facts that should here be considered. The following classes of lands are recognized under the laws: 1. Agricultural lands or lands valuable for agriculture without irrigation or drainage. 2. Swamp lands. 3. Irrigable lands; lands valuable for agriculture only with irrigation and designated in the law as "desert lands." 4. Timber lands. 5. Live-oak and cedar lands. 6. Mineral-vein lands, or lands containing veins or lodes of gold, cinnabar, copper, lead, etc. 7. Placer lands, or lands containing placer mines of the precious metals. 8. Coal lands. (*Vide* Revised Statutes of the United States, 1878, title 32, chap. 6; title 32, chap. 10, secs. 2458-2468, inclusive; and title 32, chap. 11, secs. 2478-2490, inclusive. United States Statutes at Large, vol. 19, chap. 107. Statutes of the United States passed at the second session of the Forty-fifth Congress, chap. 151.) An examination of the laws thus cited will show that the classes of lands mentioned above are therein recognized, and in the administration of the laws relating to these lands those belonging to each specific class must be determined; but no adequate provision is made for securing an accurate classification, and to a large extent the laws are inoperative, or practically void; for example, coal lands should be sold at ten or twenty dollars per acre, but the Department having no means of determining what lands belong to this class, titles to coal lands are usually obtained under the provision of statutes that relate to other classes; that is, by purchasing at $1.25 per acre, or by homestead or pre-emption entry. An examination of the laws will exhibit this fact that for the classification contemplated therein a thorough survey is necessary, embracing the geological and physical characteristics of the entire public domain. The only provision under the General Land Office for such a survey is contained in the "Instructions to the Surveyors-General" (*vide* p. 18, and paragraphs under the head of "Summary of objects and data to be noted.") In the performance of those duties the deputy surveyors, who do the work under contract, fail entirely to provide the facts necessary to the proper administration of the laws, and, in practice, the facts upon which the transactions in the Department are based are obtained, not from experts employed as Government Officers and competent to perform the task, but on affidavits made by the parties interested, or by persons selected by them, and the history of the Land Office abundantly exhibits the fact that States and individuals have to a large extent obtained titles to lands from the general government under fraudulent representations. From the above statement it will be apparent that a thorough survey of the geology and physical classification of the entire domain is necessary to the administration of the laws relating thereto.

The importance of such a survey in the industrial interests of the country requires brief mention. The greater part of the lands yet remaining in the possession of the general government either needs protection on the one hand from overflow, because of excessive humidity, or irrigation on the other, because of excessive aridity. The utilization of all such lands depends upon the correct solution of great engineering problems. Large portions of the public domain on the Gulf coast are swamp lands; the great river valleys of the South are flood-plains, which must be protected from the waters which periodically flow over them; vast areas of swamp and lakelet lands exist in the region of the great lakes that must be redeemed by drainage; the western half of the United States is comparatively arid: in more than four-tenths of our national area, exclusive of Alaska, agriculture is dependent upon irrigation, and here the lands are to be used only by the utilization of rivers and minor streams that are chiefly fed by the snow-fields of the Rocky Mountains. The rapid migration which has been greater during the past ten years than in any similar portion of the history of the United States, is pushing, in middle latitudes, quite to the verge of possible agriculture without any irrigation, and soon all the lands in the humid and sub-humid region belonging to the general government will be exhausted and future settlers on public domain will be compelled to resort to the lands to be drained or to the lands to be irrigated. On the Floridain peninsula, millions of acres, valuable for the growth of sea-island cotton or sugar, can be redeemed by the drainage of Okeechobee Lake; on the Gulf coast, millions of acres of swamp-land can be redeemed by protecting them from tide-water; in the great flood-plains of the South, millions of acres of the richest land of the continent can be redeemed by protecting them from periodic river floods; in the region of the great lakes, millions of acres can be redeemed by the drainage of the swamp and small lakes; and in the Rocky Mountain region, very many millions of acres of land can be redeemed by spreading the rivers over the plains and valleys. Some of the engineering problems thus indicated have important mutual relations. The time must soon come when all the waters of the Missouri will be spread over the great plains, and the bed of the river will be dry. A large part of the Arkansas must also be taken out to fertilize the lands adjacent to its upper course, and still further south the waters of the upper ramifications of the Red River must be used. The utilization of these waters flowing during the season of irrigation, and the storage of the surplus, will have a most important effect upon the Mississippi, and will relieve the great Valley Plains to some extent from the devastating floods to which it is periodically subject. It has been pointed out, and it is well known to the scientific men of the country, that the present system of protecting these lands by levees is not only excessively expensive but entirely inadequate, and it has been further shown that it is practicable to redeem these lands by the storage of the waters.

The average cost of the land surveys, from the time they were instituted to the present, has been something more than twenty dollars per square mile. In the earlier years it was much less; in later much more, for obvious reasons. The mountainous region of the West presents many more difficulties than the plains, prairies, and level lands of the East. At present, these surveys cost from twenty-five to thirty dollars per square mile, and if the present system continues the cost must steadily increase because of increasing difficulties. After a careful consideration of this subject, and some familiarity with the methods and cost of land surveys and of the geographical and geological surveys of this country, and, to some extent, of those in Europe, we are of opinion that all necessary geographic surveys, including the parceling of the lands, could be made within the expense now incurred for the land surveys. Throughout the Western half of the United States all geographic work can be performed at a slight comparative cost, on account of certain physical conditions existing therein. Because of aridity the country is largely destitute of timber, and the presence of timber greatly increases the cost of this work; it is also a mountainous country, where salient points for triangulation are abundant, and from its numerous elevations the intervening valleys are readily commanded.

For the same reason, viz., excessive aridity, and the destitution of vegetation resulting therefrom, a geological survey can be carried on at a comparatively slight cost. Not covered by soils and vegetation, the whole country is an open book, where geological structure and distribution are plainly revealed, and the geologist is often able to discover at a single glance from some eminence what in regions favored with a greater humidity would be found out only after weeks or even months of patient toil. In comparing the cost of the surveys which should be made in this country with those made in Europe, the diverse purposes for which these surveys are made should receive attention. In Europe the areas to be surveyed, in comparison with the extent of population and natural wealth, are small: in America the areas to be surveyed, in comparison with the population and wealth, are great: in Europe, large standing armies are supported, and the several governments stand ever prepared for war; by those Nations which have or are executing the most elaborate surveys, the object is to prepare detailed charts of every possible battle-field within their dominion, which, in fact, embraces the whole area of their territory. The relation of the United States to adjacent Nations on the continent is such that our Statesmen do not think it necessary to support a large standing army, and in the organization of a survey of the United States it is not necessary to consider this military purpose. We need not construct maps on a scale so elaborate as we should were we compelled to consider the whole area of the country as a succession of battle-fields; but general charts, sufficiently elaborate for economic and scientific purposes, would serve all purposes of military strategy or the planning of campaigns.

In discussing geographic surveys, we may divide the subject-matter into two parts: first, the survey and representation of the natural features, which we may call the *nature* portion of the work; and, second, the survey and delineation of the more prominent works of man upon the surface of the earth, this we may call the *culture* portion. In the surveys made for military purposes this culture part receives relatively enormous attention. Again, in those countries of Europe where the most elaborate and expensive surveys are executed, the lands are in great part included in large estates which belong to the landed gentry; the few owners are all powerful in the administration of the several governments, and it is considered by them that the culture of every estate, its forests, its fields, its orchards, its walls, its hedges, its ditches, its buildings, etc., should be a matter of public record; that the extent, characteristics, and appurtenances of every estate should be thoroughly understood, in order that the position and importance of every great family in the social fabric may be clearly set forth. These reasons for an elaborate survey do not exist in this country, and in such a work, carried on by authority of the general government, should receive but slight attention. The position of towns, highways, etc., should be determined and marked, but the vast details of culture should be omitted. The nature part of the survey is permanent; the culture portion in this Country is rapidly changing, and if municipalities, townships, counties, or States should desire to prosecute detailed culture-surveys, the proper charts representing the nature portion would be furnished ready to their hands. In fact, these smaller units of our political organization do engage in these enterprises, and very many districts, townships, and counties have prepared elaborate charts of their areas; generally, however, neglecting almost entirely the nature of the work.

There are good reasons why ethnologic researches, or investigations relating to the North American Indians, should be fostered by the general government. The work is of great magnitude; more than four hundred languages belonging to about sixty different stocks having been found within the territory of the United States. Little of value can be accomplished in making investigations in other branches of the field without a thorough knowledge of their languages. Their sociology, mythology, etc., are not properly known until the people themselves are understood, with their own conceptions, opinions, and motives. The subjects of study are remote from the centers of civilization and culture, and thus inaccessible to the great body of American scholars. The field of research is speedily narrowing because of the rapid change in the Indian population now in progress; all habits, customs, and opinions are fading away; even languages are disappearing; and in a very few years it will be impossible to study our North American Indians in their primitive condition except from recorded history. For this reason ethnologic studies in America should be pushed with the utmost vigor. But there are other cogent reasons leading to the same conclusion. In the whole area of the United States, not including Alaska, there is not an important valley unoccupied by white men. The rapid spread of civilization since 1849 has placed the white man and the Indian in direct conflict throughout the whole area, and the "Indian problem" is thus forced upon us, and it *must* be solved, wisely or unwisely. Many of the difficulties are inherent and cannot be avoided, but an equal number are unnecessary and are caused by the lack of our knowledge relating to the Indians themselves. Savagery is not inchoate civilization; it is a distinct status of society, with its own institutions, customs, philosophy, and religion; and all these must necessarily be overthrown before new institutions, customs, philosophy and religion can be introduced. The failure to recognize this fact has wrought inconceivable mischief in our management of the Indians. For the proper elucidation of this statement a volume is necessary, but we shall have to content ourselves with some brief illustrations.

Among all the North American Indians, when in a primitive condition, personal property was almost unknown; ornaments and clothing only were recognized as the property of the individual, and these only to a limited extent. The right to the soil as landed property, the right to the products of the chase, etc., was inherent in the gens, or clan, a body of consanguinii, a group of relatives, in some cases on the male side, in others on the female. Inheritance was never to the children of the deceased, but always to the gens. No other crime was so great, no other vice so abhorrent, as the attempt of an individual to use for himself that which belonged to his gens in common; hence the personal rights to property recognized in civilization are intensely obnoxious to the Indian. He looks upon our whole system of property rights as an enormous evil and an unpardonable sin, for which the gods will eventually punish the wicked and blasphemous white man. From these opinions, inherent alike in their social institutions and religion, arises the difficulty which the Government has always met in obtaining the consent of the Indians to the distribution of lands among them in severalty. Tribes have been willing to receive lands and distribute them themselves among their gens. Among those Indians who have been longest in contact with the white man, as the tribes in Indian Territory and Minnesota, much property has been accumulated, and with the increase of their wealth the question of inheritance and individual ownership has at last spontaneously sprung up, and at the present time these tribes are intensely agitated on the subject; the parties holding radical sentiments are rapidly increasing, and it is probable that soon, among these tribes, the customs of civilization in this respect will be adopted. Among all other tribes the ancient customs are still adhered to with tenacity. In this matter, and many others of a similar character relating to their customs and belief, we must either deal with the Indian as he is, looking to the slow but irresistible influence of civilization with which he is in contact to effect a change, or we must reduce him to abject slavery.

The attempt to transform a savage into a civilized man by a law, a policy, an administration, through a great conversion, "as in the twinkling of an eye," or in months, or in a few years, is an impossibility clearly appreciated by scientific ethnologists who understand the institutions and social condition of the Indians. This great fact has not in general been properly recognized in the administration of Indian affairs. A few of the wiser missionaries, and a few officers of the Indian Bureau, have recognized some of the more important facts, but in general they have been ignored. Again, we have usually attempted to treat with tribes through their chiefs, as if they wielded absolute power; but an Indian tribe is a pure democracy; their chieftaincy is not hereditary, and the chief is but the representative, the speaker of the tribe, and can do no act by which his tribe is bound without being instructed thus to act in due and established form. The blunders we have made and the wrongs we have inflicted upon the Indians because of a failure to recognize this fact have been cruel and inexcusable, except on the ground of our ignorance. Within the United States there are about sixty radically distinct stocks of Indians. The history of the Country shows that no coalition between tribes of different stocks has ever been successful: a few have been attempted, but these have been failures. A knowledge of this fact, and the further knowledge of the extent of the several stocks as they have been classed by linguistic affinities, would be of great value in our administration of Indian affairs. In the late Nez Percé war much fear was entertained lest the Shoshones and Pai Utes of Utah and Nevada would join with the Nes Percés in their revolt, and the officers of the Army, as well as those of the Indian Office, were exceedingly anxious in regard to this matter; and the papers were filled with rumors that such a coalition had been made; the result proved, what has been confidently predicted, that no such alliance could be formed, and the Shoshones and Pai Utes were enlisted to fight the Nez Percés. See *Surveying*.

SUS KNAPSACK.—This is a combination of knapsack and shelter-tent. When the soldier does not pitch his tent, he can rest upon it on the ground. A portion of it being waterproof, shelters him from all dampness and ulterior sickness, while he can use the ends of the tent for a covering, and an inner pocket (intended to receive wearing apparel) for his pillow.

By a novel system of strapping the weight is supported from below. In fastening the small upper strap to the first hook the knapsack becomes so firmly placed on the shoulders that it cannot be forced down and made to touch the back. By connecting the higher and larger straps with the second hook the knapsack is brought higher upon the shoulders, and a constant change in the bearings of the weight can be produced, to the great relief and comfort of the soldier.

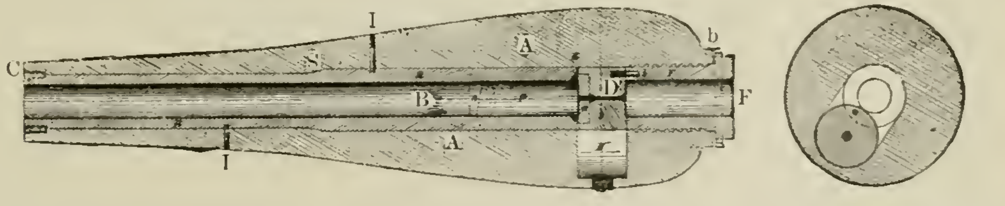
SUSPENSION BRIDGE.—A bridge made of rope or chain, and employed in military operations to effect a passage across an opening where no intermediate points are obtainable. Suspension bridges can be made also, in cases of emergency, of Jones' iron gabion bands, joined together by bolts and nuts, and used from one to four thicknesses according to the strength required.

SUSPENSION OF ARMS.—A short truce between hostile armies to enable them either to bury their dead or to treat with the view of making proposals for surrender, etc.

SUTCLIFFE GUN.—The 3″.15 breech-loading rifle field-gun devised for trial was procured by converting a 3-inch service wrought-iron muzzle-loader to a breech-loader, on the Sutcliffe plan, and adding such other alterations as to rifling and chambering as the character of the piece demanded. The breech mechanism is essentially the same as that described for the 9-inch Sutcliffe gun, the slight points of difference resulting chiefly from the lighter caliber of the field-piece, and from the fact of its being a converted gun—not a new construction. The gas-check is of the Broadwell pattern, single-lipped. The interior diameter of the breech-screw is sufficient to admit of the ready insertion of the cartridge and projectile. The rifling consists of eleven lands and grooves each, of equal width, 0″.45, the grooves being 0″.05 deep with edges parallel to a line passing through the center of the bore and the middle point of the groove. The pitch is uniform, and makes one turn in 11 feet.

The chamber of this piece is a powder-chamber merely, the projectile occupying no part of it when the piece is loaded. Its diameter is that of the bore plus twice the depth of the rifling: therefore the bottom of each groove may be said to be a continuation of the surface of the chamber. The cylindrical surface of the chamber is connected with the top of each land by a bevel 1 inch long, or having an inclination of one in each twenty. The chamber is 5½ inches long, (practically, 5 inches when the projectile it is inserted,) and will accommodate a 1½ pound charge of powder. There is no vent in the normal position on top of the piece.

The drawing shows a section of the Sutcliffe 9-inch breech-loading rifle. A, is the cast-iron body of the gun. B, is the steel tube, which, instead of the usual re-inforce of a jacket shrunk upon it, is simply made thicker or of greater exterior diameter throughout the lower half of its length. This tube is inserted from the rear and by means of hydraulic pressure. It is secured from being thrust forward under the action of firing by the shoulder S, formed by the beveled junction of the larger and smaller portions of the bore of the casting and by the steel muzzle-collar C, and is prevented from turning in the casting by crew-pins I I, which are tapped through the casing and a short distance into the tube.



The breech-mechanism works in the cast-iron casing, and is independent of the steel tube. It consists of a hollow steel breech-screw, F, working in a corresponding female screw cut on the interior of the breech, and having attached to its front face by means of a pin, *b*, a cylindrical steel breech-block D, of the same diameter as the screw between threads. The pin *b* is of steel, and is attached to the face and near the periphery of the breech-block, and about it, as a pivot, the block is free to turn. Only once during a revolution are the breech screw and block concentric. In this relative position they are inserted into the breech. Immediately in rear of the tube a slot or oblique pocket is cut in the casing for the reception of the block, when the breech is opened, and into which the block rolls as the breech-screw is reversed, thus exposing the powder-chamber. The interior diameter of the breech-screw is such as to admit of the free passage through it of the charge.

The screw is operated by means of a pinion attached to the breech and working in a toothed segment on the shoulder of the breech-screw. This segment is attached by means of set-screws, and may be removed at pleasure. A handle is attached to the pinion for the application of power. The front face of the breech-block is recessed for the reception of a hardened steel disk, called the obdurator plate, which abuts against the gas-check, a Broadwell ring, when the breech is closed. This plate is removable, and on being indented or bruised can be replaced. The gas-check projects 0''.5 beyond the face of the steel tube. The rifling consists of thirty-six lands and groves each, of equal width at the muzzle, but the lands gradually narrow toward the breech, until their junction with the chamber, at which point they are 0''.1 less in width than at the muzzle. The twist is one turn in 60 calibers, or 45 feet. The axis of the chamber is eccentric with that of the bore, being placed 0''.05 above it, in order that the axis of the projectile (in the operation of loading) shall be coincident with the axis of the bore. The diameter of the chamber is 0''.3 larger than that of the bore, which, in connection with the eccentricity, gives to the surface O, uniting the bore and chamber, the form of a truncated cone. The chamber is of a size sufficient to contain the cylindrical body of a 250-pound projectile, and a maximum charge of about 45 pounds of powder.

The gun has two vents, one in the normal position and the other through the center of the breech-block, either of which may be closed while the other is being used. The projectile for this gun is the ordinary lead-coated one, having a series of parallel ribs upon the surface of the coating. The coating may be attached mechanically, by being cast on and held by under cuts in the surface of the projectile; or chemically, by a soldering process, both methods being used. The diameter of the projectile between ribs is nine inches, the exact caliber of the gun, and the ribs project beyond this diameter 0''.2, being a little in excess of the depth of the rifling. The projectile, therefore, on being inserted in the gun, will slide forward until the front rib meets the rifling, where it will rest. Upon discharge, each of the lands plows a groove in the ribs, and this communicates the rotation due to the twist of the rifling. Weight of cored shot 260 pounds. The steel tube in this gun was manufactured by the Bochum Steel Company, Bochum, Prussia, and was forged from a single ingot. The steel breech-block and breech-screw were obtained from Firth & Sons, Sheffield, England, the screw being tempered in oil. The tube was made of such extra thickness as to admit of being bored up to 10 inches, should the experience gained in the proposed trial of 250 rounds, and with a caliber of 9 inches, warrant such a course. The gun was manufactured at the West Point foundry, and being of a larger model than any previously cast there, some time was consumed in making the necessary preparations of plant, etc.

The following are the principal dimensions of the gun:—

	Inches.
Exterior diameter of gun at muzzle	21.12
Exterior diameter 40 inches from muzzle	23.84
Exterior diameter 80 inches from muzzle	31.11
Exterior diameter of collar at breech	25.97
Exterior diameter 30 inches from breech	46.81
Exterior diameter, maximum	47.38
Diameter of bore	9.00
Diameter of chamber	9.30
Diameter of gas-check, exterior	12.50
Diameter of trunnions	13.00
Diameter of breech-block	16.50
Diameter of breech-screw, exterior, with its threads	18.00
Diameter of breech-screw collar	22.00
Diameter of vents	0.20
Thickness of tube (greatest)	3.75
Thickness of tube (least)	2.625
Distance between rimbases	48.10
Distance from face of muzzle to center of trunnions	118.70
Distance from face of breech to center of trunnions	66.70
Length of rifled portion of bore, including bevel	27.00
Length of chamber, exclusive of bevel on lands	120.50
Length of beveled junction of chamber and bore, top	3.50
Length of beveled junction of chamber and bore, bottom	1.75
Total length of bore	147.50
Length of breech-screw, including shoulder	28.50
Thickness of breech-block, in direction of bore	12.40
Number of lands and grooves	36
Depth of grooves	0.09
Width of lands, at chamber	0.2920
Width of lands, at muzzle	0.3920
Total weight of gun complete	44804 pounds.

See *Ordnance*.

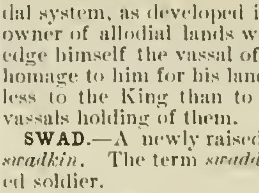
SUTLER.—A camp-follower who sells drink and provisions to the troops. In the British Service, the *sutler* is a vendor of provisions allowed by the Quartermaster General to follow an army in the field, for the purpose of supplying the soldiers with such luxuries as they can afford to purchase. Sutlers are under martial law, accompany the baggage on the march, and are narrowly watched, and severely punished if found guilty of any irregularities toward either the soldiers or inhabitants of the country. In the French Army a soldier in each regiment is licensed to act as sutler, and is called *vivandier*. See *Canteen* and *Post Trader*.

SUTTINGER SYSTEM OF FORTIFICATION.—This system was very similar to that of Rimpler, advocating the interior defense and suppressing the curtain. The ramparts are double throughout the system.

SUZERAIN. A feudal Lord. According to the feudal system, as developed in northern Europe, every owner of allodial lands was compelled to acknowledge himself the vassal of a Suzerain and do great homage to him for his lands. The term was applied less to the King than to his vassals, who had subvassals holding of them.

SWAD.—A newly raised soldier. Usually written *swadkin*. The term *swaddie* is applied to a discharged soldier.

SWALLOW TAIL.—In fortification, an outwork, differing from a single tenaille, since its sides are not parallel, like those of a tenaille; but if prolonged, would meet and form an angle on the middle of the curtain. Its head, or front, being composed of faces, forms a re-entering angle. The redan, shown in the drawing, delivers its fire over a part of a circle but has no front fire. If it be necessary to have a fire in the direction of the capital, it may be obtained by using the blunted redan, which is constructed by stopping the faces at points, as E and F, and connecting these points by a straight parapet.

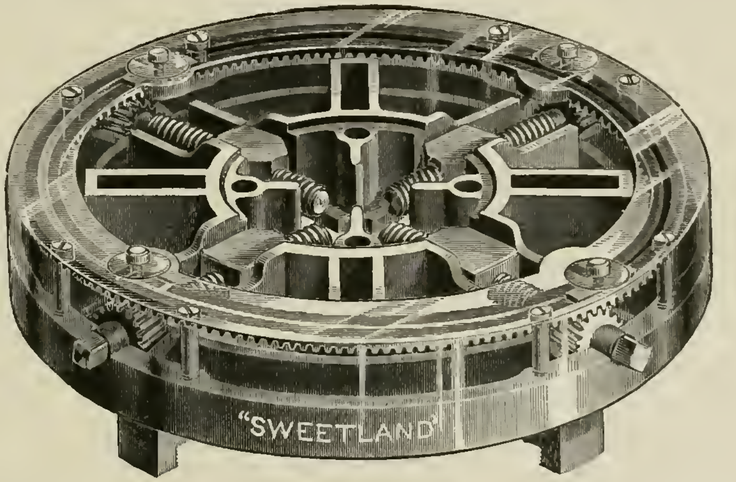


Two redans are sometimes placed side by side and joined to each other, making a work known as the double redan; sometimes the outer faces of the double redan are made much longer than the faces which are connected, in which case the work receives the name of priest-cap, or swallow-tail. See *Field-works*.

SWEEP BAR. A transverse horizontal bar which, in wagons, connects the hinder ends of the futchells together, forming with them and the splinter-bar a quadrangular frame.

SWEEP PLATE.—A flat, horizontal, ring of metal, affixed to the fore-carriage. The under surface of the *wheel-plate* rests on the upper surface of the *sweep-plate,* which latter sustains the weight of the front portion of the body. The two plates have their centers in the axis of the *main-pin.*

SWEETLAND CHUCK.—A form of chuck much used in arsenals and armories, being adopted for eccentric, concentric, or universal work. The drawing represents the entire mechanism of the device. The design of the improvement is to make the chuck independent as well as universal, thus combining two chucks in one. In the recess underneath the rack are the cam-blocks, beveled to correspond with the bevel recess in the rack. The cam-blocks are held in place by the convex spring-washers, which allow them to be moved to or from the center without disturbing the nuts, the friction being sufficient to hold them in place. When moved to the outer portion of the rack they connect the gearing, making the chuck universal; and when moved inward they disconnect the gearing, thus making each screw independent. The advantage of making each screw independent,



without disconnecting the others from the gearing, is a feature not combined in any other chuck, and is an improvement fully appreciated by the mechanic when adjusting the jaws for eccentric, concentric, or universal work. For instance, the chuck having been used independent, the workman wishes to change to universal, the jaws are moved inward until the outer end is true with the line on face of chuck; now, each screw can be engaged with the rack separately by sliding the cam-block inward. If one jaw is found to be out of true it can be disconnected and reset, leaving the others in mesh undisturbed. This chuck has a large hole in the center, and will allow a drill or reamer to pass through work without injury to the face of the chuck. See *Chuck.*

SWELL OF THE MUZZLE.—Inasmuch as the metal situated immediately at the muzzle is supported only in rear, it has been usually considered necessary to increase its thickness, to enable it to resist the action of the projectile at this point. This enlargement is called the *swell of the muzzle.* At present, the practice is to reduce the diameter of the swell of the muzzle of all cannon, and particularly that of heavy iron cannon, designed to be fired through embrasures. By a late order of the War Department, the swell is to be hereafter omitted from all sea-coast cannon. In field and siege-howitzers, the muzzle band takes the place of the swell. All projections on the surface of cannon, not absolutely necessary for the service of the piece, are omitted in cannon of late models. This omission simplifies their construction, renders them easier to clean, and obviates certain injurious strains that would otherwise arise from unequal cooling in fabrication. See *Cannon.*

SWIMMING.—The art of swimming is so exceedingly useful, not only as a bracing summer exercise, but as a means of preserving life, that it should be acquired by every military person. Considering the numerous risks run by all human beings, especially by the inhabitants of all maritime Countries, of being accidentally plunged into the water; and how greatly the chances of being saved are increased by the power of keeping one's self afloat for even five minutes, it is surprising that the art of swimming does not form an essential element of education among all classes. Of late years, this manly art has been made to form a part of the regular instruction at the United States Military Academy. Consult *Farrow's Military Gymnastics,* New York, 1881.

The first care of the intending swimmer is, of course, to find a proper piece of water in which to learn his first lessons. The very best water that can be found is that of the sea, on account of its saltness and bitterness, whereby two great advantages are obtained. The first advantage is, that, on account of the salt and other substances which are dissolved in it, the sea-water is so much heavier than fresh that it gives more support to the body, and enables the beginner to float much sooner than he can expect to do in fresh water. The other advantage is, that the taste of the sea-water is so nauseous that the learner takes very good care to keep his lips tightly shut, and so does not commit the common error of opening the mouth, which is fatal to all swimming, and is sure to dishearten a beginner by letting water get down his throat and half choke him.

Of course the salt-water floating-baths furnish the best means for a beginner. But where these do not exist there is nothing better than a sloping sandy shore, where the tide is not very strong. In some places the tide runs with such force, that if the beginner is taken off his legs he will be carried away, or at least will have great difficulty in regaining his feet. Take especial care of the holes, for there is nothing so treacherous. A hole of some six or seven inches in depth and a yard in diameter looks so insignificant when the water is out that few persons would take any notice of it; but when a novice is in the water, these few inches may just make the difference between safety and death. On sandy shores large stones are commonly the cause of holes. They sink rather deeply into the sand and form miniature rocks; round which the water courses as the tides ebb and flow, thus cutting a channel completely about them. Even when the stones are removed, the holes will remain unfilled throughout several tides.

The next best place for learning to swim is a river with a fine sandy bed, clear water and no weeds. When such a spot has been found, the next care is to examine the bed of the river and to remove very carefully everything that might hurt the feet. If bushes should grow on the banks, look out carefully for broken scraps of boughs, which fall into the stream, become saturated with water, sink to the bottom, and become fixed with one of the points upward. If human habitations should be near, beware of broken glass and crockery, fragments of which are generally flung into the river, and will inflict most dangerous wounds if trodden on. If the bed of the stream should be in the least muddy, look out for mussels, which lie imbedded almost to their sharp edges, that project upward, and cut the feet nearly as badly as broken glass.

As the very essence of swimming lies in confidence, it is always better for the learner to feel secure that he can leave the water whenever he likes. Therefore, let him take a light rope of good length, tie one end to some firm object on the bank, and let the rest of the rope lie in the water. Manilla is the best kind of rope for this purpose, because it is so light that it floats on the surface instead of sinking, as is the case with an ordinary hempen rope. If there is only sand on the shore, the rope can be moored quite firmly by tying it to the middle of a stout stick, burying the stick a foot or so in the sand, and filling up the trench. You may pull till you break the rope, but you will never pull the stick out of its place. If you are *very* nervous, tie two sticks in the shape of a cross and bury them in like manner. The rope need not be a large one, as it will not have to sustain the whole weight of your body, and it will be found that a cord as thick as an ordinary clothes-line will answer every purpose. On the side of a stream or pond, tie the rope to a tree, or hammer a stake in the ground. A stick eighteen inches in length, and as thick as an ordinary broomstick, is quite large enough. Hammer it rather more than two thirds into the ground, and let it lean boldly away from the water's edge. The best way of fixing the rope to it is by the "clove-hitch." Now, having the rope in your hand, go quietly into the water *backward*, keeping your face toward the bank. As soon as you are fairly in the water, duck completely beneath the surface. The learner should next accustom himself to the new element by moving about as much as possible, walking as far as the rope will allow him, and jumping up and down so as to learn by actual experience the buoyancy of the water.

Floating on the Back.—Take care that the cord is within easy reach, so that it may be grasped in a moment should the novice become nervous, as he is rather apt to do at first. Take it in both hands, and lay yourself very gently in the water, arching the spine backward as much as possible, and keeping the legs and knees perfectly straight and stiff. Now press the head back as though to force it between the shoulder-blades. When you are thus lying in the water, you will find that you are almost entirely upheld by its sustaining power, and that the only weight which pulls on the rope is that of your hands and arms, which are out of water, and which, therefore, act as dead weight. Now let your arms sink gradually into the water, and you will see that the weight on the rope is proportionately lessened; and if you have only courage to put them entirely under water, and to loose the rope, your body will be supported by the water alone. These are facts; but we may as well have reasons.

Bulk for bulk, any human being weighs considerably less than water, *i. e.*, at the temperature of ordinary sea or river water. Now, as the lighter substance will float on the denser, it follows that the human body will float in water. Suppose that a living person in a fainting condition, and therefore unable to struggle, were to fall into the water; some part of the body would remain above the surface. But as the head, which is one solid mass of brain, muscle and bone, is much heavier than water, it follows that the head would hang down and the shoulder-blades would appear above the surface, being buoyed up by the air-filled lungs. The hands and arms, of course, follow their natural inclination and fall forward, thus turning the body on its face. This, then, is the natural position of a living human being in the water, provided he does not attempt to struggle or alter his position. And the knowledge of this fact is the key to all swimming on scientific principles. A considerable part of the body remains above the water, but it is the wrong part, as far as the preservation of life is concerned. We want to breathe, and it is very clear that we cannot breathe through our shoulders. Therefore the first point in swimming is to reverse the natural order of things, and to bring the nostrils above the surface of the water. The mouth may be set aside altogether, because there is no necessity for that aperture in swimming. It is meant for eating and for talking, but was never intended for breathing, which is the only function that a swimmer regards.

Swimming, therefore, resolves itself into the ability to keep the nostrils above water; and the difficulty lies in the fact that the nostrils are set in the heaviest part of the whole body, and that which is absolutely certain to sink below the surface unless continual efforts are made to keep it in its right position. It is evident that the simplest method of attaining this object is to reverse the entire position of the body. Let, therefore, the learner be on his back, let him arch the spine in directly the opposite direction, and bend the head backward instead of letting it hang forward. The result of this change of posture will be at once apparent. The heaviest part of the body, the back of the head, will be partly supported by the water, and partly by the air which fills the lungs. The nostrils will then become the lightest part of the body, and will, of course, be above the surface when the remainder is submerged. Practically, the bather will find this result. If he will assume the attitude which has been described, and will be content to keep his lips tightly shut and his limbs perfectly still, he will find that when he takes an inspiration the face will rise almost entirely out of the water. At each expiration the face will sink as far as the eyebrows and lower lip, *but no further*, the nostrils being always left free for the passage of air to the lungs.

Anyone who will give this plan a fair trial will gain more real knowledge of swimming in an hour than can be obtained in a year by mere practical teaching. So powerful, indeed, is the buoyancy of the water, that if anyone, whether he can swim or not, will only lie in the attitude that has been described, and will not stir hand or foot, *he cannot sink if he tries*. A cork will sink as soon as he. So impressed are we with the extreme value of floating on the back, that we recommend our readers to practice it, and nothing else, until they feel perfectly confident that, when they lie in the proper attitude, the water cannot fail to support them. If the bather wishes to lie quite horizontally on the surface of the water, he can do so by stretching his arms as far as possible over his head. Their weight will counterbalance that of the legs, and will cause the toes to appear at the very surface. This position is sometimes called the *balance*. The directions which we have given are intended for those who are obliged to bathe in fresh water. Those who are fortunate enough to bathe in the sea will find the lesson much easier. The water supports the body so much more perfectly, that even during an expiration the face seldom sinks lower than the chin, while a fair inspiration raises the whole face out of the water.

Swimming on the Back.—When the learner has learned to lie on his back without moving hands or feet, let him gently paddle with his hands, keeping the fingers together firmly, and scooping the water, as it were, toward the feet. He must be careful to keep the hands below the surface, and the head well back. Most persons, when beginning this movement, are tempted to raise the head so as to see whether they are moving, or, if so, in which direction. Consequently, the water no longer supports the head; its weight is thrown on the body, and down goes the swimmer. When the learner can propel himself at a moderate pace head first, he should turn his hands round and scoop the water toward his head, thus propelling himself with his feet first. It will be found that the course can easily be directed, merely by using one hand rather more forcibly than the other. Having learnt this simple paddling process, the young swimmer now begins to use his legs. It is possible to paddle for a considerable distance by using the hands alone, and there are sometimes circumstances when this process is invaluable. If, for example, the swimmer should be seized with the cramp in his legs, he is certain to be drowned if he does not have recourse to this expedient. Of the cramp and other dangers we shall speak presently. Still, although the swimmer *can* propel himself, it is a very slow process, and he naturally would wish to get on at a faster rate. This is done by striking out the legs, with the feet wide apart, and then bringing them together again.

All these directions are simple enough; but something more must be mentioned. People generally fancy that the progress of the swimmer is only caused by the pressure of the soles of the feet against the water, and the usual opinion is that the fastest swimmer is he who has the broadest and the fattest feet. Of course, the pressure of the feet has something to do with it, but the chief part of the work is done, not by the feet, but by the legs. When the legs are spread, they inclose between them a mass of water of a wedge-like shape, and as they are drawn together, the body is urged forward, in much the same way as a vessel is propelled by a screw. In fact, the principle of the inclined plane comes into operation, and the swimmer is forced onward just as the sails of a windmill are driven round by the air, or the fan of a smoke-jack is turned by the ascending currents of the chimney. When a good swimmer is lying on his back and propelling himself as fast as he can, he always gives a kind of half-turn to the body, so as to obtain a screw-like action of the legs, thus increasing his speed without increasing the force of his stroke. Steering the course is easily managed by means of the legs. The left leg is allowed to remain still, and the right leg is used, when the body is to be driven to the left, and vice versa when it is desired to go in the opposite direction. The young swimmer must remember that when he brings his legs together they must be kept quite straight and the knees stiff. The toes should also be pointed, so as to offer no resistance to the water.

Swimming on the back is a most useful branch of the art, as it requires comparatively little exertion, and serves to rest the arms when they are tired with the ordinary mode of swimming. All swimmers who have to traverse a considerable distance turn occasionally on the back. They even in this position allow the arms to lie by the sides until they are completely rested, while at the same time the body is gently sent through the water by the legs. Let swimming on the back be perfectly learned, and practiced continually, so that the young swimmer may always feel secure of himself when he is in that position. The feet should be kept about twelve or fourteen inches below the surface of the water, for, if they are kept too high, the stroke is apt to drive the upper part of the head and eyes under the water.

Swimming on the Chest.—In order to begin with confidence, walk into the water until it is almost as high as the chest, and then turn toward the land, so that every movement may carry you from the deeper to the shallower water. Next place your hands in front of the chest, the fingers stiff and pressed together, and the thumb held tightly against the forefinger. Do not press the palms together, as some books enjoin, but hold the hands with the palms downward and the backs upward. Now lean gently forward in the water, pushing your hands out before you until the arms are quite straight, and just before your feet leave the bottom give a little push forward. You will now propel yourself a foot or two toward the land. Try how long you can float, and then gently drop the feet to the ground. Be careful to keep the head well back and the spine arched. Repeat this seven or eight times, until you have gained confidence that the water will support you for a few seconds.

Now go back to the spot whence you started, and try to make a stroke. Lay yourself on the water as before, but when the feet leave the bottom, draw them up close to the body, and then kick them out quickly. When they have reached their full extent, press them together firmly, keeping them quite straight and the toes pointed. This movement will drive you onward for a short distance, and when you feel that you are likely to sink, drop the feet as before. Start again and make another stroke, and so on until the water is too shallow.

At first you will hardly gain more than an inch or two at each stroke; but after a little practice you will gain more and more, until you can advance three or four feet without putting the legs to the ground. It is a good plan to start always from the same spot, and to try in how few strokes you can reach the land.

The action of the legs is very simple; to use the arms to best advantage, place yourself with the face to the shore, as already directed, and make the stroke according to the regulations. But just before the force of the leg-stroke is exhausted, spread the arms as widely as possible, turn the palms of the hands a little outward, and bring them toward the hips with a steady, regular sweep. This movement will have two effects. It will support the body, and it will continue the propulsive force which was just given by the legs. Be very careful not to hurry this stroke, and especially not to shorten it. Beginners generally make six or seven little strokes, keeping their arms bent during the whole time; but in correct swimming the arms should be sent forward to their utmost length, and the hands brought to the hips in a slow, uniform sweep. Let this be practiced over and over again, until it is perfectly learned.

When swimming on the chest, take particular care to avoid an error into which the beginner almost invariably falls. Being extremely anxious to keep the nostrils well above the surface of the water, the swimmer is apt to press his hands downward, so as to raise his head and neck, and often part of the chest, completely out of the water. Now, it is scarcely possible to make a worse mistake than this. By so doing, the swimmer actually supports a considerable weight *in the air*, and might just as well hang some four or five pounds weight of lead round his neck. In the second place, he tires his arms needlessly by forcing them to perform a wholly unnecessary action. They will have quite enough work to do in making the ordinary stroke, without adding to them the labor of supporting the head above water. The very principle on which all swimming is founded is that of making the water support the body, and, therefore, of supporting every part of the body by the water. If even a finger be lifted above the surface, the unsupported weight of that finger tends to press the body under water. So our advice to our readers is: First practice the stroke quietly and repeatedly, putting down the feet after each stroke is completed; then try to manage two strokes without putting the feet to the ground; then try three strokes, and so on until you can make some four or five strokes without distressing yourself. Having achieved thus much, make your mind easy: you have conquered the art of swimming. When you can make five strokes, you can make fifty, provided you do not hurry them. Should you feel yourself getting tired, or if a feeling of nervousness should come over you, the remedy is easy enough. Turn on your back and paddle along quietly until your arms are rested. Then turn over and proceed on your course.

In connection with the ordinary breast-stroke we must mention one very important point, namely, the manner of taking breath. If the swimmer lies, as he should lie, as low as possible in the water, he will find that at each stroke the water reaches to his lips, and will sometimes curl even over his nostrils. If, therefore, he were to take an inspiration while he is making the stroke, he would immediately draw some water into his lungs, and the only result would be that he would begin to choke and to cough, and would probably sink. But if he makes a habit of expelling the air from his lungs as he makes the stroke he need fear no danger of the kind, for the expelled air will drive away the water; and even if his nostrils should be covered, they would not take in one slight drop. It naturally follows that the proper time to take breath is while the arms are beginning to make the stroke, and when the force of the leg-stroke is almost expended.

Variations in Swimming. We now come to a few of the most useful variations in ordinary swimming. The first and most important of these, enabling the swimmer to last a long time, is the *side-stroke*, which is thus managed: The swimmer, lying, let us say, on his right side, stretches his right arm out as far as he can reach, with the hand held edgewise, so as to cut the water like a shark's fin; the left hand is then placed across the chest, with the back against the right breast, and the swimmer is ready to begin. He commences by making the usual stroke with his legs, the right leg, being undermost, doing the greater share of the work. Before the impetus gained by the stroke is all expended, the right arm is brought round with a broad sweep, until the palm of the hand almost touches the right thigh. At the same moment the left hand makes a similar sweep, but is carried backward as far as it can go. When the swimmer finds himself becoming tired, he turns over on his left side, and the change of action will rest the limbs almost as much as actual repose would.

Treading Water.—This is employed whenever the swimmer wishes to raise his head as high out of the water as possible, and is particularly useful if he is reconnoitering, or if he is trying to save a drowning person, or if he wishes to grasp a bough or a rope above his head. The best method of making the stroke is as follows: Keep the body perpendicular, and make precisely the same stroke with the legs as is done in ordinary swimming. This action will keep the head freely out of the water, and if assisted by the hands, the body will rise as far as the shoulders.

Swimming like a Dog. The swimmer lies on his chest and moves his hands and legs alternately, exactly as a dog does in swimming. The chief use of this stroke is that it affords a change of action to the muscles; and if the swimmer has to traverse any considerable distance, say a mile or two, he will find that a few occasional minutes employed in swimming like a dog will be very useful in relieving the strain on the muscles of both legs and arms.

Diving. It is, of course, a great thing to be able to support the body in the water; but the swimmer's education is only half completed until he knows how to dive. Many lives have been saved by the ability to dive; many have been lost from its absence. The first object is to keep the eyes open while under water. In order to do this, sink yourself well under the surface, hold your hand before your face, and try to look at it. Don't be afraid of water getting into the eyes. A chance drop of fresh water flirted into the eyes will make them smart, but you may keep your eyes open even in salt water as long as you like without the least irritation.

When the young swimmer has learned that he really can keep his eyes open under water, he should drop to the bed of the sea or river, where it is about four feet in depth, some white object—one of the well-known alabaster eggs used for deluding sitting-hens is as good an object as can be found; or a lump of chalk, or anything of a like nature, will do very well. Now try to stoop and lift the egg, and you will find two results. The first is that the egg will look as large as a hat, and the second is that you will find very great difficulty in getting to it. Now try another way of getting to the egg. Drop it as before, spring up as high as the waist, bend your body well forward, throw the feet in the air, and try to reach the egg head foremost. At first you will find this rather difficult, but after very little practice it will come easy enough. Be careful to stand at some little distance from the egg, or you will overshoot it. Next drop the egg, go back some eight or ten yards, swim toward the object, and dive for the egg from the swimming posture. This is not very easy at first on account of the difficulty in getting the chest below the surface. If, however, the legs are thrown well up in the air, the weight forces the body under the water.

The next object is to try how far the swimmer can proceed under water. Swimming under water is managed in nearly the same manner as swimming on the surface. But, in order to counteract the continual tendency upward, the swimmer must always keep his feet considerably higher than his head, so that each stroke serves to send him downward as well as forward. One of the chief difficulties in diving is to keep a straight course, because there is seldom anything under water by which to steer. In a river, when the water is clear, it is generally easy to look upward and watch the trees, posts or other objects on the banks; but in the sea it is a very different business, and the swimmer must have learned to make his stroke with great regularity before he can dive in a straight line.

After the beginner has acquired the art of simple diving he should try to achieve more difficult feats. He should learn to dive at a considerable distance from any object, swim towards it by guess, and try to bring it to the surface. He should throw two, three or more eggs into the water, and try how many he can recover at a single dive. When he has attained a sufficient mastery over the water, he should stand on the bank or in a boat, throw out an egg, dive after it, and catch it before it reaches the bottom.

The Header.—Next, the young swimmer should learn how to enter the water in a proper and graceful manner. It is as easy to enter the water gracefully as clumsily, and only requires a little care at first. Most beginners are dreadfully alarmed when they are told to jump into the water head first. They cannot rid themselves of the instinctive idea that their heads will be dashed to pieces. Consequently, when they try the "header," they only come flat on the water with a flop and a great splash, and hurt themselves considerably, the blow against the water having almost as stinging an effect as a stroke from a birch rod. It is advisable for the beginner to go to the bank of a river where the water is only a few inches below him, and there make his first attempt at a header. He should stoop down until he is nearly double, put his hands together over his head, lean over until they nearly touch the surface, and then quietly glide, rather than fall into the water. At first he will be sure to lose the proper attitude, but in a little time he will manage without difficulty. This should be done over and over again, and each time from an increased height.

Next, the learner should take a short run, and leap head first into the water from the place where he took his first lesson at plunging, so that the water is no great distance from him. He should then remain quite stiff, straight and still, and see how far his impetus will carry him. This is technically termed "shooting." At last he should accustom himself to leap from a considerable height, say from ten to twenty feet, and to do so either running or standing. In diving from a height, keep the body, arms and legs perfectly stiff, and all in the same right line. Any one who will do this can leap from extraordinary heights without the least fear of danger. The hands, joined over the head, form a kind of wedge, which cuts its way into the water and opens a passage into which the body passes. The head is so bent over the chest, that even the slight shock which ensues when the water is reached only effects the crown of the head, which is the part best able to bear it.

In Jumping out of a Boat, the best way is to go to the stern and leap over, as thus there is more resistance to the feet obtained than by leaping over the side; and in getting into the boat again, always come to the *stern*, never to the side. Swim toward the boat with the feet high. Grasp the stern with both hands, and kick the feet on the surface of the water, so as to keep them up; otherwise the legs will be sucked under the boat. Give a vigorous kick with the feet and a spring with the hands, and you will soon be lying on your breast over the stern; then to crawl fairly into the boat is easy enough.

Cramp.—Perhaps more good swimmers have been drowned by cramp than by anything else, and only those who have suffered from it can conceive its fatal power. Strong men and good swimmers, when seized with cramp, have been known to sink instantly, overcome with the sudden pain; and nothing can save the victim but the greatest presence of mind. The usual spot where the cramp is felt is the calf of the leg, just below the knee; and it sometimes comes with such violence that the muscles are gathered up into knots. There is only one method of proceeding under such circumstances. Turn on the back at once, kick out the leg in the air, disregarding the pain, and rub the spot smartly with one hand, while the other is employed in paddling toward shore. Draw the toes forcibly upward toward the knee. The causes of cramp are generally twofold. The principal cause lies in indigestion, for it is seldom that a person in really good health is attacked by this malady. The second is over-exertion of muscles that have been little used; and therefore too strong a leg-stroke should always be avoided.

Saving a Drowning Person.—Only experienced swimmers who have great presence of mind can hope to save a drowning person. The chief difficulty lies in the fact that a person who cannot swim feels, in deep water, much as if he were falling through air, and consequently clutches instinctively at the nearest object. And if he succeed in fixing a grasp upon the person who is trying to save him, both will probably sink together. Therefore every precaution should be taken to prevent such a misfortune, and the drowning man should always be seized from behind and pushed, as it were, in front. Should he succeed in fixing his grasp, the only remedy is to dive, when it will be found that he will loosen his hold on finding himself below the surface, and will allow his rescuer to take a better position.

Treatment of the Apparently Drowned.—When animation has become suspended, the body should be treated without delay, as follows:

1. *Position.*—Having sent for medical assistance, blankets and dry clothing, place the body in the open air, with face downward, whether on shore or afloat; expose the face, neck, and chest to the air, and remove all tight clothing from the neck and chest. The points to be aimed at are—first, the restoration of breathing; and secondly, after breathing is restored, the promotion of warmth and circulation. The efforts to *restore breathing* must be commenced immediately and energetically, and persevered in for one or two hours, if necessary. Efforts to promote *warmth* and *circulation*, beyond removing the wet clothing and drying the skin, must not be made until the first appearance of natural breathing; for if circulation of the blood be induced before breathing has recommenced, the restoration to life will be greatly endangered.

2. *To Restore Breathing.*—Place the body on the floor or ground with the face downwards, and one of the arms under the forehead. In this position all fluids will more readily escape by the mouth, and the tongue itself will fall forward, leaving the entrance into the windpipe free. Assist this operation by wiping and cleaning the mouth. If there be only slight breathing, no breathing, or if the breathing fail, then proceed to excite breathing.

3. *To Excite Breathing.*—Instantly turn the body on the side, supporting the head, and excite the nostrils with snuff, hartshorn, or smelling salts, or tickle the throat with a feather, etc., if at hand. Rub the chest and face warm, and dash cold water and hot water, alternately, on them. If there be no success, instantly endeavor to imitate breathing.

4. *To Imitate Breathing.*—Place the body on the face, raising and supporting the chest well on a folded coat or other article of dress. Turn the body very gently on the side and a little beyond, and then briskly on the face, back again, repeating these measures cautiously, efficiently, and perseveringly, about fifteen times in the minute, or once every four or five seconds, occasionally varying the side. [By placing the patient on the chest, the weight of the body forces the air out; when turned on the side, this pressure is removed, and air enters the chest.] On each occasion that the body is placed on the face, make uniform but efficient pressure with brisk movement on the back between and below the shoulder-blades or bones on each side, removing the pressure immediately before turning the body on the side. During the whole of the operations let one person attend solely to the movements of the head and of the arm placed under it. [The first measure increases the expiration—the second commences inspiration.] The result is inspiration, or natural breathing—and, if not too late, *life*. While these operations are being proceeded with, dry the hands and feet, and as soon as dry clothing or blankets can be procured, strip the body and cover or gradually reclothe it, but taking care not to interfere with the efforts to restore breathing. These efforts will generally prove successful in less than five minutes; if not, proceed at once to imitate the movements of breathing.

5. *To Imitate the Movements of Breathing.*—Stand at the patient's head, grasp the arms just above the elbows, and draw them gently and steadily upwards above the head, and keep them stretched upwards for several seconds. By this means air is drawn into the lungs. Then turn down the patient's arms, and with the assistance of another person, press them gently and firmly for two seconds against the sides of the chest. By this means, air is pressed out of the lungs. Repeat these measures alternately, deliberately, and perseveringly, about fifteen times in a minute, until a spontaneous effort to respire is perceived, immediately upon which cease to imitate the movements of breathing, and proceed to induce circulation and warmth.

6. *To Promote Warmth and Circulation.*—Begin rubbing the limbs upward, with firm, grasping pressure and energy, using handkerchiefs, flannels, etc. By this measure the blood is propelled along the veins toward the heart. The friction must be continued under the blanket or over the dry clothing. Promote the warmth of the body by the application of hot flannels, bottles of hot water, heated bricks, etc., to the pit of the stomach, the arm-pits, and to the soles of the feet. If the patient has been carried to a house after respiration and been restored, be careful to let the air play freely about the room. On the restoration of life, a teaspoonful of warm water should be given; and then, if the power of swallowing has returned, small quantities of wine, warm brandy, and water, or coffee should be administered. The patient should be kept in bed, and a disposition to sleep encouraged. This treatment should be persevered in for some hours until recovery is made.

7. *Precautions.*—Observe the following precautions: Prevent the unnecessary crowding of persons around the body, especially if in an apartment. Avoid rough usage, and do not allow the body to remain on

the back unless the tongue is secured. Under no circumstances hold the body up by the feet. On no account place in a warm bath,unless under medical direction,and even then it should be employed as a momentary excitant.

SWING.—The distance from the *head* center of a lathe to the bed or ways, or to the rest. The *swing* determines the diametric size of the object which is capable of being turned in the lathe. This limit is called the *swing of the bed*. The *swing of the rest* is the size which will rotate above the rest, which lies upon the bed.

SWING CRANE.—A very simple form of rotary crane, in which each member of the frame consists of a single iron beam,and in which the hoisting chain passes over a fixed sheave at the outer end of the jib, so that the only motions are those of hoisting and lowering, and of rotation. This construction is applicable to cranes of capacities from 100 to 1,000 pounds. For larger sizes it is usually preferable to employ a trolley. Each member of the frame of this crane consists of a single wrought-iron I-beam, suitably connected at their intersections. As the load is not to be removed inward upon the jib the latter is usually supported by a brace; although, where desired, a tension-rod may be substituted for the brace. The hoisting-gear consists of a pocketed chain-wheel, driven by spur-gearing,with frictional safety rachet upon the primary shaft, so that the load is always self-sustained in any position and cannot run down. Lowering is easily effected by reversing the motion of the crank, but ceases automatically whenever this motion is discontinued. Rotation is effected by simply pushing or pulling the suspended load, and the construction of the top and bottom pintles upon which the crane revolves is such as to reduce friction to a minimum. This crane is especially adapted to light work in arsenals, machine-shops, etc., and for use in loading and unloading in stations, wharfs, and warehouses. See *Cranes*.

SWING-SAW.—A buzz-saw hung on a pivot, so that it may be swung down to cut on blocks which, by reason of their weight or their shape, cannot be conveniently fed to the saw. This saw is well adapted to the general heavy and irregular work in arsenals. In most machines of this class, the swinging frames being hung directly upon the fast revolving shafts, cause excessive friction, resulting in loss of power and rapid destruction of the bearings. In the Pryibil machine, these disadvantages are avoided by hanging the swinging frame upon the outside of the bearings. The frame is of wood and the arbor of steel, running in adjustable boxes. This arrangement is now commonly used with saws up to eighteen inches diameter, or more. See *Band-saw Machine*.

SWISS GUARDS.—Troops first employed in the French Service in 1616. It was the policy of the Royal Family to render these Guards personally faithful to themselves, and estrange them from the other soldiers and common people. How well they succeeded was shown by the slaughter of 1792 at the Tuileries. The *Lion of Lucerne*, erected in 1821, commemorates their valor. The Swiss Guard also existed in France under Louis XVIII., and up to 1830. A body of Swiss Guards have long acted as the Pope's Guard at the Vatican.

SWIVEL GUN.—In artillery, a gun fixed on a swivel either on the back of an animal, such as a camel, or on a wall, or any commanding position.

SWORD.—A well-known weapon of war, the introduction of which dates beyond the ken of history. It may be defined as a blade of steel, having one or two edges, set in a hilt, and used with a motion of the whole arm. Damascus and Toledo blades have been brought to such perfection that the point can be made to touch the hilt and to fly back to its former position. In the last century, every gentleman wore a sword; now the use of the weapon is almost confined to purposes of war. In the Army, all officers and Sergeants, with cavalry, wear swords for cutting and thrusting. In the Navy, all officers wear similar swords; and the men in time of action, heavy-backed swords, called *cutlasses*. In the French Service nearly all the troops wear a combination of the sword with the bayonet,called a sword-bayonet. See *Broadsword*, *Cutlass*, *Fencing*, *Rapier*, *Saber*, *Scimiter*, and *Small-arms*.

SWORD BAYONET.—Short arms, like *carbines*, are sometimes furnished with a bayonet made in the form of a sword. The back of the handle has a groove, which fits upon a stud upon the barrel, and the cross-piece has a hole which fits the barrel. The bayonet is prevented from slipping off by a spring-catch; the sword-bayonet is ordinarily carried as a side-arm, for which purpose it is well adapted, having a curved cutting-edge as well as sharp point.

SWORD BEARER.—In Monarchial countries the title given to the Public Officer who bears the Sword of State. *Knights Sword-bearers* formed a community similar to, though much less distinguished than, the Teutonic Knights.

SWORD BELT.—A belt of suitable material, worn over the right shoulder of an officer, and supporting his sword. The sword-belt is little used at present, the sword being suspended from the waist-belt.

The following patterns of belts are prescribed for use in the United States Army:

For all Officers.—A waist-belt, not less than one and one-half nor more than two inches wide, with slings of the same material as the belt, with a hook attached to the belt on which to hang the sword. The sword and sword-belt are worn outside the coat, and, by all officers below the grade of Brigadier General, outside the overcoat.

For General Officers.—Of red Russia leather, with three stripes of gold embroidery.

For all Field-officers.—One broad stripe of gold lace on black enameled leather, according to pattern.

For all Officers of the General Staff, and Staff Corps, below the rank of Field-officers.—Four stripes of gold, interwoven with black silk, lined with black enameled leather.

For Company Officers of Cavalry, Artillery, and Infantry.—Four stripes of gold lace, interwoven with silk of the same color as the facings of their arms of service, and lined with black enameled leather.

For all Storekeepers.—Same as officers of the General Staff of the same rank.

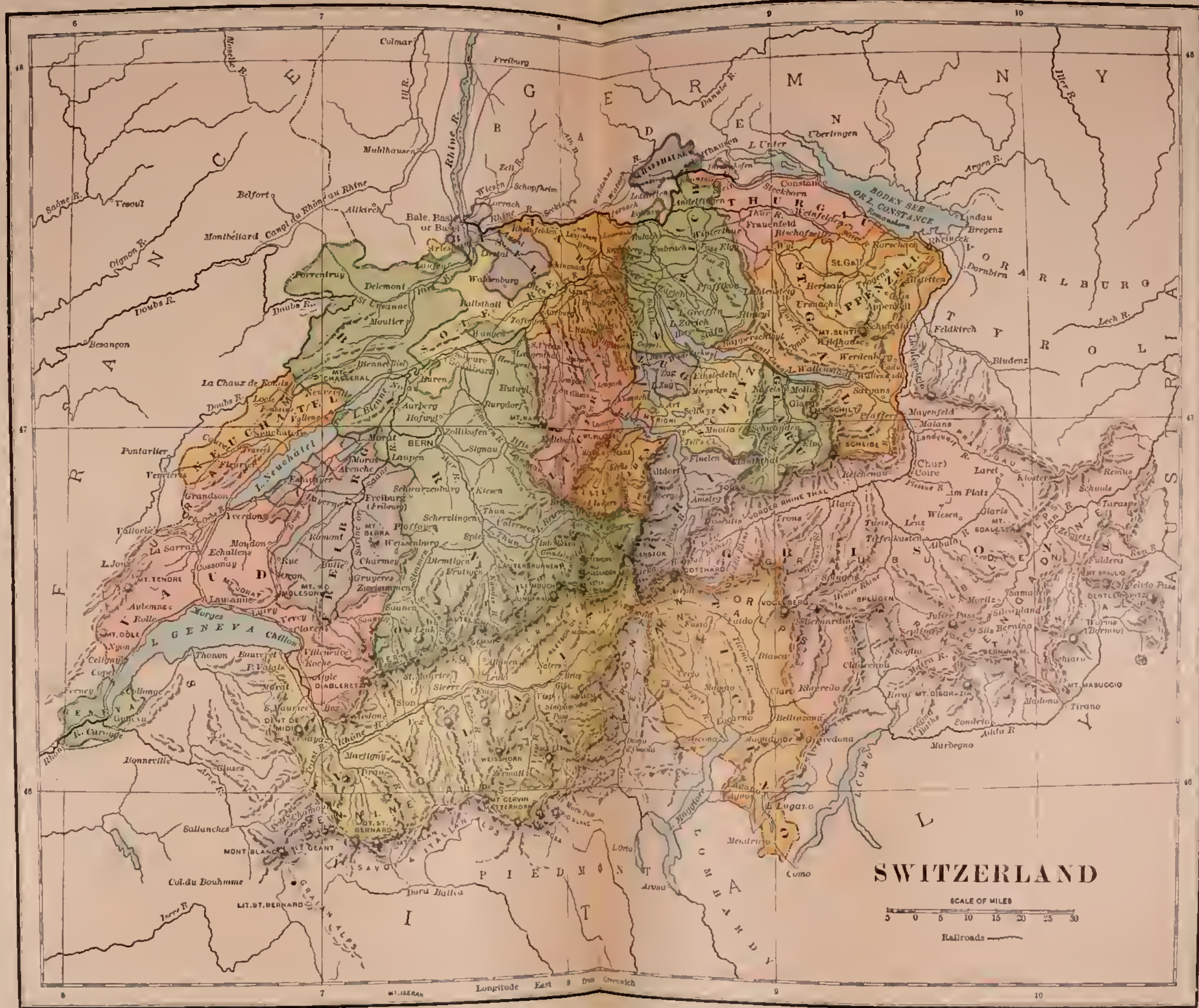
On undress duty, marches, and campaigns, officers may wear a plain black leather belt.

The sword-belt plate, worn by all officers, is gilt, rectangular, two inches wide, with a raised bright rim; a silver wreath of laurel encircling the "Arms of the United States;" eagle, shield, scroll, edge of cloud,and rays bright. The motto "*E pluribus unum*" upon the scroll; and stars of silver.

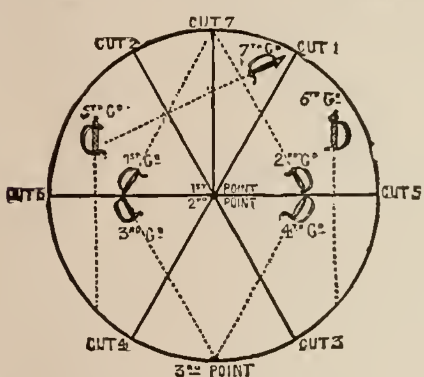
The sword and belt are worn upon all occasions of duty, except stable and fatigue. When not on military duty, officers may wear swords of honor, or the prescribed sword, with a scabbard, gilt, or of leather, with gilt mountings.

SWORD-BREAKER.—A peculiar weapon of the Middle Ages, intended to catch and break the adversary's sword.

SWORD EXERCISE.—Sword exercise differs from fencing with the foil; in that, the weapon employed has one cutting edge as well as a point, and is therefore intended to cut and thrust. The sword is the arm of all Officers in the Army and Navy, of many Non-comissioned Officers, and constitutes the sole mode of attack and defense for the officers of the British volunteers. A certain degree of proficiency in its use is therefore always serviceable. In practice, the usual substitute is a stout, straight stick,called a "single-stick," having a basket-handle to protect the knuckles. The position of the combatant is the same as that assumed in fencing with the foil; the lunge is similar, as are also the "advance" and "retreat," and other minor points. According to the instructions of drill


SWITZERLAND
SCALE OF MILES
Railroads
Longitude East from Greenwich
GERMANY
FRANCE
ITALY
TYROL
VORARLBURG
PIEDMONT
LOMBARDY
SAVOY
BODEN SEE OR L. CONSTANCE
L. GENEVA
L. Neuchâtel
Bale, Basel or Basle
Zurich
BERN
Lausanne
Freiburg
Mulhausen
Belfort
Besançon
Pontarlier
Colmar
Lindau
Bregenz
Feldkirch
Bludenz
St. Gall
Constanz
Luzern
Altdorf
Thun
Bellinzona
Lugano
Como
Tirano
MONT BLANC
Bonneville
Sallanches
Martigny
Zermatt
Lake Como
Rhine R.
Doubs R.
Aar R.
Rhône R.

masters, there are seven cuts, with seven corresponding guards, and three thrusts. The theoretical directions of all these are shown in the drawing, which represents a target placed opposite a pupil, so that he may see the motions he is expected to perform displayed before him. The center of the target is supposed to be in a line with the center of his breast. The cuts proceed from the circumference towards the center along the *thick* lines. Nos. 1, 3, and 5 are inside cuts, and attack the left cheek, left side, and inside of the right leg respectively; 2, 4 and 6 are outside cuts, attacking the enemy's right cheek, right side, and right leg on the outside. No. 7 is a vertical cut, aimed at the head. The dotted lines show the position of the sword in the several guards by which the cuts are opposed. The sword-handles illustrate the situation of the right hand with reference to the center of the body. The points or thrust are shown by the black circles. That towards No. 1 should be directed with the wrist and edge of the sword upwards to the right; towards 2, with the edge upwards to the left; and in the 3d point, with the wrist rising to the center, and the edge upwards to the right. The "parry" is an additional defensive movement, and consists in bringing the wrist nearly to the right shoulder; whence as center, a circular sweep of the sword is made from left to right. A considerable latitude is allowable in regard to the cuts, as to the part of the adversary's body at which they are directed, provided the general inclination of the blow be observed; similarly, the cut may at times be parried by a guard



other than that intended especially for it, according to the discretion of the fencer. In engaging, or joining swords, with the enemy, press the blades but lightly together, so that the hand and wrist may be readily susceptible of any motion. In making the guards, care must always be taken to receive, if possible, the feeble of the enemy's blade on the forte of your own, so as to offer the greater opposition. It should also be borne in mind that, in all cuts at the leg, when at proper distance, the shifting of your own leg, and delivering a cut at the same moment, becomes the most effectual and advantageous defense, particularly if you happen to be taller than your adversary, as you will then probably be out of his reach, while he is within yours. Contending with bayonet or pike, the most effectual guard is the 5th, which, if well timed, enables the swordsman to seize the musket or pike with his left hand, and then make the 6th cut at his opponent's neck. In an encounter with the rapier, the best cuts are Nos. 3 and 4, as they attack the enemy's arm, which must be advanced within reach before he can touch your body, and also constitute a defense against his thrust. If the enemy—no matter how armed—be on horseback, the dismounted swordsman (provided he have proper nerve and agility) has decidedly the advantage. Endeavor to place yourself on his left, where he has less power of defending himself or his horse, and cannot reach to so great a distance as on his right: an attack on the horse will probably render it ungovernable, and it becomes easy then to avoid the rider's blows, while he himself may be attacked with impunity in almost any direction. See *Fencing*.

SWORD-KNOT.—A ribbon tied to the hilt of a sword, serving as an ornament and to support the sword when it is drawn and dropped down at the side or front. In the United States, all General Officers wear a gold cord with acorn ends; and all other officers wear a gold lace strap, with gold bullion tassel. The enlisted men of cavalry wear a leathern strap with a bullion tassel of the same material.

SWORD PLAYER.—A fencer; a gladiator; one who exhibits his skill in the use of the sword. The term "Swordsman" is usually applied to a Professor of the Science of Fencing.

SYEF.—An Indian term meaning a long sword. *Syef-ul-Mulk* is the sword of the kingdom.

SYMBOL.—In a military sense, a badge. Every regiment in the British Service has its badge.

SYNCHRONOUS MULTIPLEX TELEGRAPHY.—The synchronous system of telegraphy is as important an improvement over the old quadruplex system as the quadruplex system was on the ordinary single wire system that it superseded. By means of the devices pertaining to the synchronous system with a single wire six distinct Morse circuits may be obtained, each of which is capable of operation up to the highest rate of transmission by the most expert operators. Twelve circuits are similarly obtainable, each one of which may be operated at the rate of twenty words per minute, or nearly equal to the average rate of transmission. Or by the employment of printing instruments, thirty-six messages may be transmitted simultaneously over one wire at a rate of speed which will be recognized as a fast circuit for this purpose; or seventy-two printed messages may be transmitted simultaneously over a single wire, at a rate equal to one hundred messages during the ordinary business hours of the day, and with either the Morse or the printing instruments these messages may be sent all in one direction or any number, within the limits named, in either or both directions at the same time. It is confidently expected that in the near future this system will be developed so as to far exceed these results. The advantages of the entire independence of these circuits one from the other, so that they may be worked in any direction that the business may require, will be obvious, since it frequently happens that the great bulk of the business originates at one end of the line.

There are Morse circuits worked in this Country at an average of fifty-five words per minute throughout the day; but twenty-five words per minute is considered a good average day's work. Allowing twenty-five words for each dispatch, including the date, address and the signature, an operator would transmit sixty messages per hour, or six hundred messages would constitute a day's work of ten hours. Applying to these messages the minimum rate of twenty-five cents each, the earning capacity of a Morse wire, affording but one circuit, would be $150 per day. If this wire were operated under the quadruplex system of the Western Union Telegraph Company, it *might* earn four times this sum, or $600 per day of ten hours, under the most favorable conditions. The Standard Multiplex Telegraph Company, with its synchronous system, will obtain from this same single wire six circuits, which can be easily worked at the rate of thirty-five words per minute; but placing the rate of transmission at a message per minute, the earning capacity would be $900 per day; or by operating twelve circuits over a single wire, and working each circuit up to its capacity of twenty words per minute, each of the twelve operators would transmit four hundred and eighty messages per day of ten hours, amounting to $120, or for the twelve operators, $1,440 per day of ten hours. As nearly all telegraph lines are occupied with business during the greater portion of the night, the foregoing estimate of earning capacity, based on ten hours' work, is below the possibilities; but the same comparison holds good so far as the systems of operation are concerned.

Beyond the Morse system of transmission, however, comparison between the synchronous system and the other methods of operation cannot be carried, since by no other system yet invented can a single wire be successfully divided into thirty-six or seventy-two circuits, each circuit being as separate and distinct from the others as if it consisted of an independent wire. It is ability to divide a wire into a large number of distinct circuits that will of necessity work a revolution in the telegraph business. Heretofore, by the quadruplex system, only two circuits could be rented to subscribers, so that each would be independent of the other, and for this service each subscriber was obliged to pay nearly the full price of a single wire in order adequately to remunerate the Company. If the subscriber's business would not warrant such an expenditure he could not be accommodated, as no more circuits were obtainable over the wire. In addition to the rental of the wire, the expense of skilled operaters has made the burden so great that but a few of the leading business firms in the large cities have been able to employ private circuits, and even have been compelled to pay for many times the capacity that their business required.

The adaptability of the synchronous system to all general demands will be readily recognized as highly advantageous. Should a party using the seventy-second part of a wire find that his business required greater facilities, he could be accommodated to any extent desired by increasing the capacity of his circuit. A merchant may find a circuit consisting of the seventy-second part of a wire sufficient for his business, but if he found it necessary to increase his facilities he may have a thirty-sixth of a wire and operate it by the Morse system. The new printing instruments may be operated by anybody, without experience or knowledge of telegraphy; and unlike the telephone, which admits of but one message at a time,—so that if thirty-six subscribers were accorded the use of a single wire one would use it to the exclusion of all the others, while his message was being transmitted,—the subscriber to the synchronous system would at all times be independent of the others, so that he could communicate instantly and to any extent necessary or to the full capacity of his circuit. In this way a Company having six wires between New York and Boston or between any other points, might rent out four hundred and thirty-two circuits, each consisting of the seventy-second part of a wire, or two hundred and sixteen circuits, each constituting the thirty-sixth part of a wire, or seventy-two Morse circuits of almost the capacity of ordinary Morse wires, or thirty-six Morse circuits, admitting of the fastest transmission possible by the most expert operator, and in all respects equal to thirty-six separate and independent wires. Each wire may also be readily divided into seventy-seconds, thirty-sixths, twelfths or sixths. One wire may be divided to accommodate twenty-four subscribers with the seventy-second facilities, twenty-four with thirty-sixth facilities; the Company retaining two Morse circuits for the transmission of general business. Between cities of about fifty thousand inhabitants one wire would accommodate a large number of subscribers and at the same time afford ample facilities for general business.

Even should the telephone become electrically practicable between cities widely separated, it could not compete with this system of dividing single wires among numerous subscribers, for in the case of the telephone one subscriber uses the wire to the exclusion of all the others, while with the independent circuits there is no delay, no publicity and a printed record is made of every word sent or received by each subscriber. The exchange system may be carried out between cities, so that a subscriber in New York may instruct the central office to disconnect him from his regular correspondent in Philadelphia, and connect him with any subscriber with whom he may desire to communicate in New York, Boston or Baltimore for such length of time as his business requires. Thus a subscriber in any city may communicate with all the subscribers in his own or in other cities within ordinary working distance. It is proposed, also, to introduce a new feature in telegraphic intercourse which has long been needed, but which could not be reached by Companies using the ordinary systems without too great cost.

The great success in the capacity of each single wire afforded by the synchronous system will admit of telegraphic *interviews* or *conversations* for any period of time desired at a very moderate cost. If a person in New York should desire to converse with a person in Boston, by applying at any New York office of the Company and giving the name and address of the party in Boston with whom it is desired to communicate, a messenger would be promptly dispatched from the receiving office in Boston to bring the party wanted to the most convenient office in Boston, where a circuit, equipped with printing instruments, which the interviewers may operate, would be furnished them; or, if preferred, a Morse circuit, duly equipped with operators, would transact the business in hand. For this service reasonable charge would be made by the minute, hour, or day. If on special occasions parties should want a circuit for a day, week, or month, they could be readily accommodated, the object being to bring the telegraph within the reach of everybody, and to adapt its facilities to the wants of all, either by the use of permanent private facilities, temporary facilities, affording opportunities for conversation, general transmission of messages, or by the exchange system, which will bring subscribers in the same or distant cities into as close relationship as is now enjoyed between telephone subscribers within the cities.

Congress is at the present time giving considerable attention to the subject of telegraphy, and there is scarcely a doubt but that in the near future the great bulk of correspondence will be done by telegraph, either under government control or by corporations.

Improvements in electrical apparatus are all in the direction of an increase of the capacity of wires, simplifying the operation and consequently lessening the cost. Therefore, it is but fair to predict that in the near future messages will be transmitted by telegraph almost as cheaply as they can be handled by the post-office. The following figures, to which criticisms of those best acquainted with practical telegraphy have been invited, prove conclusively that the multiplex telegraph system may be conveniently operated for the transmission of messages or correspondence at one-quarter of a cent per word between cities, say four hundred miles apart, and with profit to the Company. Telegraph experts agree that a telegram of ten words cannot be profitably transmitted and delivered over a circuit-to-a-wire system, for less than twenty-five cents. If the capacity of a single wire be increased sixfold the cost can be reduced more than half and still leave a larger profit. To show the working and earning capacity of this system over lines between New York and Boston,—all messages to be stamped, dropped in the post-office at either city and delivered by the carriers, as proposed by the Government,—the following estimate is predicted on a line of ten wires, the distance being in round figures, say two hundred and fifty miles:—

Ten wires, New York to Boston, constructed in the best manner and ready for operation, $2,000 per mile, ... $500,000

Equipment:—Five offices at each terminus, say $2,000 each, ... 20,000

Total cost line and office equipment, . $520,000

These ten wires would be capable of the different divisions as to circuits and capacity for each, either by Morse or the printing systems, as already set forth but by taking the most conservative estimate as a basis, that of six Morse circuits for each wire, and the ordinary rate of transmission, twenty-five words per minute for each circuit,as a basis,the results cannot fail to impress everybody with the fact that by multiplex telegraphy alone are cheap rates possible. Reserving one of the circuits for the conduct of the business,there would be under this organization fifty-nine circuits for public use. 59 circuits at 25 words per minute each, 1475 words per minute, and 88,500 words per hour: For 24 hours, 2,124,000 words, or per annum, 775,260,000 words, which at $\frac{1}{4}$ cent per word would yield, $1,938,150. Assuming that from interruptions to the wires, from lack of business to occupy them, or from any other cause,that the operation of these 59 circuits should be confined to 12 *hours* per day, the results would show a gross earning per annum of $969,075.

The outlay to accomplish this service on most liberal and comprehensive estimate, including interest on the cost of construction and equipment, and providing for adequate service throughout the entire twenty-four hours, would be as follows:—

	Per Year.
360 operators, 8 hours per day each, at $75 per month	$324,000
50 clerks, at $45 per month	27,000
25 linemen, at $75 per month	22,500
6 batterymen, at $75 per month	5,400
60 messengers, at $16 per month	11,520
Executive officers, Superintendents and Managers	28,800
Battery and material for repairs	15,000
Rents	12,000
Stationery	30,000
Interest on $520,000 at 6 per cent	31,200
Incidentals, taxes, etc	42,580
	$550,000

Showing total earnings	$969,075
Expenses	550,000

Here we notice a net profit per annum of $419,075, based upon *half* the capacity of the wires being occupied during the twenty-four hours; equal to over eighty per cent. of $520,000,the cost of construction. This estimate shows that by the synchronous multiplex system, messages of twenty words each may be profitably transmitted at five cents per message,with two cents additional for postal delivery. See *Field Telegraphy*, and *Telegraphy*.

SYNTAGMATARCH.—The syntagmata with 16 files, which was the army unit, and corresponds to our battalion, was commanded by a *Syntagmatarch*,who was stationed in front of his command, having an Adjutant on his left; a Color-bearer immediately in his rear; on the right a Herald-at-Arms, to repeat the commands; and on the left a Trumpeter,to sound the signals. In the rear of the syntagmatach was stationan officer who was the second in command. See *Lochoi*.

SYSTEM OF ARTILLERY.—The principal qualities to be observed in establishing a system of artillery are *simplicity*, *mobility* and *power*; and the improvements which have been made in artillery in the last four hundred years have had these qualities steadily in view. The American systems of field and siege artillery are chiefly derived from those of France. Toward the middle of the sixteenth century, the various guns of the French artillery were reduced to six. The weights of the balls corresponding to these calibers were 33¼, 15¼, 7¼, 2½, 1⅓, and ¾ lb. respectively. This range of calibers was thought to be necessary, for the reason that it required guns of large caliber to destroy resisting objects, while guns of small caliber were necessary to keep up with the movement of troops. Each of the five principal calibers was mounted upon a different carriage, and the ammunition, stores, and tools were carried on different store-carts. Three kinds of powder were used, viz.: large-grain, small-grain, and priming, which were carried in barrels of three sizes. The axle-trees, which were of wood, varied for the different wheels, as well as for the different guns. The gun-carriages were without limbers, and had only two wheels, the shafts being attached to the trails, which often dragged along the ground. No spare wheels were used, except for pieces of large caliber; and for facility of transportation there were put on an axle-tree, so as to form a carriage. With the exception of replacing injured wheels, all repairs were made on the spot, from the resources of the country, and no spare articles were carried with the train. There was no established charge of powder for the guns; although a weight equal to that of the shot was generally used. Such was the character of the artillery which accompanied the French armies up to the middle of the seventeenth century.

In the reign of Louis XIV., the calibers of cannon were gradually changed by the introduction of several foreign pieces. There were 48, 32, 24, 16, 12, 8, and 4 pdrs.:and those of the same caliber varied in weight, length, and shape. Uniformity existed in general in each district commanded by a Lieutenant General of Artillery, but the cannon of one district differed from another. Each district had (for six kinds of cannon) six carriages, with different wheels,and three kinds of limbers, with different wheels, making nine patterns of wheels, without counting those for the platform wagons used to transport heavy guns, the ammunition carts, the trucks, and the wagons for small stores and tools. Spare carriages were carried into the field, but those of one district would not fit the guns of another. There was but one kind of powder, and this was carried in barrels. The charge was usually two-thirds the weight of the projectile, roughly measured. Besides this,the powder often varied in strength according to the district from which it came.

In 1732, General Valière abolished the 32-pdr., as being heavy and useless, and gave uniformity to the five remaining calibers. Toward the end of the 18th century, mortars, or Dutch howitzers, were sometimes attached to field-trains: for the latter, a small charge, and caliber of 8 inches, were adopted. There were also light 4-pdr. guns attached to each regiment. Up to that time an army always carried with it heavy guns (24-pdrs.), and light guns (4-pdrs.), which were combined in the same park. Valière established a system of uniformity for cannon throughout France; but such was not the case with the carriages and wagons used with them. Great exactness was not then sought for, and there existed as many plans for constructing gun-carriages as there were arsenals of construction. The axle-trees were made of wood, the limbers were very low, and the horses were attached in single file.

In 1765, General Gribeauval founded a new system, by separating the field from the siege-artillery. He diminished the charge of field-guns from a half to a third of the weight of the shot, but as he diminished the windage of the projectile at the same time, he was enabled to shorten them and render them lighter, without sensibly diminishing their range. Field-artillery then consisted of the 12, 8, and 4-pdr. guns, to which was added a 6-inch howitzer, still retaining a small charge, but larger in proportion than that before used. For draught,the horses were disposed in double files, which was much more favorable to rapid gaits. Iron axle-trees, higher limbers, and traveling trunnion-holes, rendered the draught easier. The adoption of cartridges, elevating-screws, and tangent-scales, increased the rapidity and regularity of the fire. Stronger carriages were made for the lighter guns, and the different parts of all were made with more care, and strengthened with iron-work. Uniformity was established in all the new constructions, by compelling all the arsenals to make every part of the carriages, wagons, and limbers according to certain fixed dimensions. By this exact correspondence of all the parts of the carriage spare parts could be carried into the field ready made, to refit. Thus an equipment was obtained which could be easily repaired, and could be moved with a facility hitherto unknown. In order to reduce the number of spare articles necessary for repairs, Gribeauval gave, as far as practicable, the same dimensions to those things which were of the same nature. The excellence of this system was tested in the wars of the French Republic and Empire.

In 1827, the system of Gribeauval was changed by introducing the 24 and 32-pdr. howitzers, lengthened to correspond with the 8 and 12-pdr. guns, and abolishing the 4-pdr. gun and 6-inch howitzer. Afterward some important improvements were made in the carriages, chiefly copied from the English system; the number for all the field-cannon was reduced to two, the wheels of the carriage and limber were made of the same size; the weight of the limber was reduced, and an ammunition-chest placed on it; the method of connecting the carriage and limber was simplified, and the operations of limbering and unlimbering greatly facilitated; and the two flasks which formed the trail were replaced by a single piece, called the *stock*, which arrangement allowed the new pieces to turn in a smaller space than that required by the old ones.

In 1850, the Emperor of the French caused a long series of experiments to be made, at the principal Artillery Schools of France, to test the merits of a new system of field-artillery proposed by himself. The principal idea involved in this system was, to substitute a single gun of medium weight and caliber, capable of firing shot and shells, for the 8 and 12-pdr. guns and 24 and 32-pdr. howitzers, then in use. The caliber selected was the 12-pdr. The favorable results of all these experiments, and the simplicity of the system, led to the adoption of this, the Napoleon gun, as it is sometimes called, into the French Service; and others of similar principle were introduced into various European services, and also into our own. As this piece unites the properties of gun and howitzer, it is called the *cannon-obusier*, or gun-howitzer.

The past quarter century has been prolific in improvements in guns and all ordnance *matériel*. The principal ones may be summed up as follows: 1st. Introduction of guns of heavy caliber,constructed of cast-iron, wrought-iron, steel, or a combination of those metals. This increase in size has been rendered possible by the increase in knowledge of the physical properties of the metals,and consequent improvements in the methods of working, especially with large masses. Muzzle-loading smooth-bore guns of relatively small power have been replaced by heavy rifles, both muzzle and breech-loading, varying in weight from 18 to 100 tons, reaching a caliber of 18 inches, and firing projectiles weighing in some cases over 2200 lbs. At a distance of 1000 yards, these are capable of piercing armor-plates varying in thickness from 14 to over 27 inches. 2d. Introduction of special powders having a progressive action upon the projectile during its passage through the bore. 3d. Use of wrought-iron and steel for field, siege, and sea-coast carriages, and for covering ships of war. Many improvements in sea-coast carriages and the addition of mechanical appliances have been rendered necessary to insure rapid and easy handling of the heavy guns. 4th. Introduction of special shot and shell for the penetration of armor-plates, and in the field and siege services almost exclusive use of special shell and Shrapnel. 5th. Introduction of breech-loading small-arms of great range and accuracy, and of diminished caliber. The success of these arms rendered necessary the use of metallic-case cartridges. 6th Use of machine-guns and repeating small-arms. See *Artillery*, and *Ordnance*.

SYSTEM OF FORTIFICATION.—Although an infinite diversity of figures may thus be presented in the outline or plan of the enceinte,they may all be classed under four heads, to each of which Engineers generally have applied the term *system of fortification*. These four classes are, 1, the *circular system*; 2, the *polygonal system*; 3, the *tenailled system*; 4, the *bastioned system*. The term *method of fortification* is now usually applied to the manner of fortifying which is generally prevalent in any country, or to the mode adopted by an individual; as the *German method*, *Vauban's method, etc.* The *circular system* consists of an enceinte, the plan of which is circular or curvilinear. In the *polygonal system* the plan is either a polygon with salient angles alone,each side of which is flanked by a casemated caponniere, placed in the ditch,and midway between the two salients; or else each side of the polygon is broken inward at the center, so as to form a slight re-entering, to procure a casemated flanking arrangement for the caponnieres, which occupy these re-enterings, and also, in some cases,to flank works in advance of the enceinte. The *tenailled system* consists of a tenailled line, the re-entering angles of which are between 90° and 100°, and the salient angles not less than 60°. In the *bastioned system*, the bastions usually consist of two faces and two flanks, both extremities of the flanks being connected by curtains. See *Choumara System of Fortification*,*Cormontaigne System of Fortification*, *Enceinte*, *Fortification*, *German System of Fortification*, *Montalembert System of Fortification*,*Noizet System of Fortification*,*Polygonal System of Fortification*, *Tenailled System of Fortification*,and *Vauban System of Fortification*..

SYSTEM OF RIFLING.—An essential means of giving rotation to a projectile. The twist of the grooves, the length, diameter, or form of the projectile, must depend upon the purpose for which a gun is required, no matter upon what system it may be rifled. Inventors often claim principles which are as applicable to one as to another system. As regards precision of fire, one system will give as good results, for all practical purposes, as another, provided the conditions of charge, projectile, and twist of grooves are alike, and the rifling of the bore and the manufacture of the projectiles have been performed with the same amount of care and skill in both cases.

The conditions that are especially desirable in every system of rifling for ordnance are—1. Accuracy: 2. Perfect rotation, due to the twist, as indicated on the recovered projectile by proper marks of the rifling on the rotating device: 3. Steadiness or smoothness of flight, as indicated by smoothness of sound: 4. Absolute non-liability of the projectile to jam within the gun, either in loading or firing: 5. Non-liability to strip, either within the gun or during flight, even with the heaviest charges: 6. Must not injure the gun by breaking, nor produce unnecessary torsional strains of any kind by wedging, etc.: 7. Entire absence of balloting: 8. Maximum capacity for bursting charge: 9. Uniform and moderate pressures: 10. Uniform and high velocities: 11. Uniform and good ranges: 12. Absolutely safe to fire over the heads of our own men—a contingency constantly arising in both land and sea service: 13. So strong and safe in principle as to allow a wide margin for all errors of manufacture, and even inferiority of the materials: 14. Non-liability to injure in store, handling, or transportation: 15. Not too expensive. If an inferior quality of powder is employed, the pressures, velocities, and ranges will be irregular, and the accuracy correspondingly impaired; but none of the other conditions should be affected.

It will be observed that in many of the systems of rifling in use, one or more of these conditions have been sacrificed to some extent, to secure a closer compliance with others thought to be of greater importance, or of easier attainment. See *Compressive System of Rifling*, *English System of Rifling*, *Expansive System of Rifling*, *Flanged System of Rifling*, *German System of Rifling*, *Parrott System of Rifling*, *Scott System of Rifling*, *Vavasseur System of Rifling* and *Whitworth System of Rifling*.

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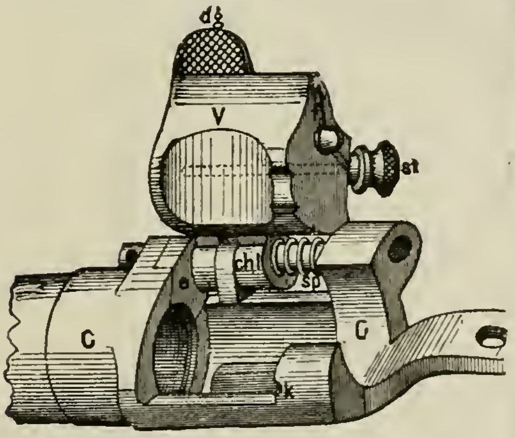
TAB.—The arming of an archer's gauntlet or glove.

TABARD.—A military garment in general use in the latter half of the 15th and the beginning of the 16th centuries, which succeeded the *Jupon* and *Cyclas*. It fitted closely to the body, was open at the sides, had wide sleeves or flaps reaching to the elbow, and displayed the armorial ensigns of the wearer on the back and front, as well as on the sleeves. About the middle of the 16th century the tabard ceased to be used except by the Officers at Arms, who have down to the present time continued to wear tabards embroidered with the arms of the sovereign.

TABATIERE GUN.—The French and English systems of altering small-arms to breech-loaders are substantially the same, the only difference being the relative size of the different parts. The French system is known as the "Tabatière" or tobacco system, and is represented in the drawing. The English system is named "the Snider," after its American inventor. The number and function of the several parts are similar. The receiver or breech-frame is represented by the letter C; the breech-block by the letter V. The breech-block is hinged to the receiver in such a way that it can be revolved at right angles to the bore in opening and closing the breech, and slid back and forth on the hinge pin to withdraw the empty cartridge-case. The lug c h l is the tongue of the breech-block hinge; the extractor is attached to the



axis of the hinge so as to move back and forth with the breech-block; when closed, the extractor fits into a recess in the receiver, with its point under the rim of the cartridge-head; the spiral spring s p forces back the breech-block and extractor to their places after the shell has been extracted to the position for closing the breech. The catch for holding the breech-block in place differs in the two systems. In the Snider it is a small pin, inserted well into the receiver and forced forward into the breech-block by a spiral spring. In the "Tabatière" system it is a flat spring, *f*, which is held in place by a screw at the rear end of the breech-block and fits into the small slot cut in the receiver. In the Snider system, the firing-pin s t is secured by a screw-nut worked by a wrench; in the French system the same piece is held in place by a thumb-screw nut. In both systems the breech-block is only locked at the moment of discharge, and then by the pressure of the hammer on the firing-pin. The Snider system was at one time exclusively employed in the British Army, and also in the armies of Servia, Montenegro, and Turkey, but is now being rapidly superseded by the Peabody-Martini system. The "Tabatière" system has been almost entirely superseded in the French Army by the Chassepôt, first as a paper-cartridge gun, and lately as a metallic-cartridge gun. See *Small-arms* and *Snider Gun*.

TABLE.—The eyes of some shells, as the Shrapnel, are divided into two parts. The larger portion on the exterior is called the eye proper, and the contracted portion, next to the interior, is called the *table*.

TABLE-MONEY.—An allowance granted to General Officers in the Army, and Flag Officers in the Navy, to enable them to fulfill the duties of hospitality within their respective commands. It varies according to the locality or importance of the appointment, £3 3s. a day being the maximum, except under very unusual circumstances.

TABLES OF FIRE.—The nature and purpose of a table of fire should be explained in connection with the subject of pointing cannon. A properly constructed table of fire, for a particular piece, contains the range and time of flight for each elevation, charge of powder, and kind of projectile. Its purpose is to assist the artillerist in attaining his object without waste of time and ammunition, and also when the effect of shot cannot be seen on account of the dust and the smoke of the battle-field. The first few shots generally produce a great effect on the enemy, and it is very important that they should be directed with some knowledge of their results, which, in the field, can only be attained by experience, or from the data afforded by a table of fire.

The following is the form of a table of fire for guns and howitzers:

KIND OF ORDNANCE.	POWDER.	PROJECTILE.	ELEVATION.	RANGE.	TIME.
	Lbs.	Lbs.	° ′	Yards.	Sec'ds.
Armstrong gun, 4-inch bore.	$3\frac{5}{8}$	29. (Solid.)	5° 0′	2099	7.5
			7° 0′	2894	9.1
			10° 0′	3700	11.6
			12° 0′	4196	14.2
			15° 0′	4776	17.1
			20° 0′	6070	21.4
			25° 0′	6580	25.
			30° 0′	7555	31
			35° 0′	9000	

The ranges in the foregoing table were determined at West Point, and are the mean of five shots for each angle of elevation. The ranges obtained with the best American muzzle-loading rifle-cannon compare favorably with these.

TABLETTE.—A flat coping-stone, generally two feet wide and eight inches thick, placed at the top of the revetment of the escarp, for the purpose of protecting the masonry from the effects of the weather, and also to serve as an obstacle to the besiegers when applying the scaling-ladders. It is always considered a matter of importance that the *Tablette* should be concealed from the enemy's view, as he would otherwise be able to direct his artillery against it; therefore, the escarp of all the works inclosed within the covered-way is submitted at least six inches to the crest of the glacis.

TABOR.—A small drum, played with one stick, in combination with a fife. It was formerly used in war, but has now given place to the kettle-drum. Also written *Tabour*.

TABORITE. A Roman soldier armed with a double-edged axe.

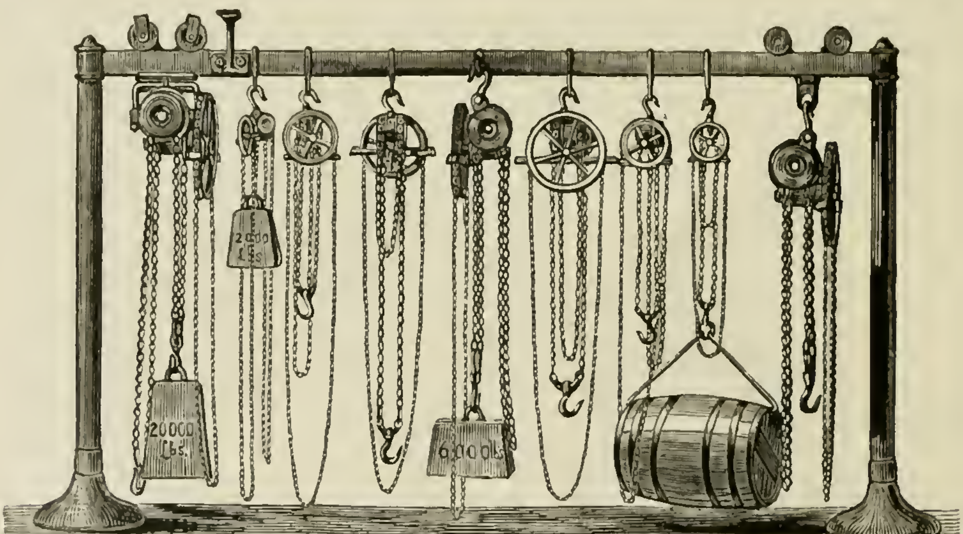
TABORS.—An intrenchment of baggage for defense against cavalry.

TACES. A species of kilt armor, or iron petticoat, formed of narrow plates, in their contour adapted to cover the figure, and so arranged that each one would slightly overlap the one below it. It was sometimes called *fandes*.

TACHOMETER. A kind of velocimeter for measuring the velocity of moving bodies. Waltmann's, for measuring the speed of flowing liquids, has several spiral vanes on a shaft carrying an endless screw, which turns a series of geared wheels. On being placed in a current, the vanes assume a position perpendicular thereto, and their rotation actuates the clock-work mechanism, which is graduated to indicate the velocity in miles per hour, or other units of measurement. See *Current Meter*.

TACKLES.—A tackle is a purchase formed by reeving a rope through two or more blocks, for the purpose of hoisting. The following are the more important tackles used in the movement of heavy guns and military stores: A whip is the smallest purchase, and is made by a rope rove through one single block. *A gun-tackle purchase* is a rope rove through two single blocks and made fast to the strap of the upper block. The parts of all tackles between the fasts and sheave are called the *standing parts;* the parts between sheaves are called *running parts*; and the part the eye of the hook and over the whole. This is a very quick-working tackle and a strong purchase. Used for hoisting entirely. When a very heavy weight is to be raised, the standing parts should be attached to the slings by a fisherman's bend, instead of to the block. The *size* of blocks is expressed by the *length* of the *shell* in inches; if ropes of unusual size are to be used, it should be specified in making requisition for blocks. Tackles are also designated by the number of sheaves employed; as *twofold* (two single blocks), *threefold* (double and single block), etc. *A mousing* is a seizing placed around a hook to prevent it from spreading or unhooking, and should always be applied as follows: Take several turns of yarn or spun-yarn around the point and back of the hook, and frap the ends around all the turns. The *bight* of a hook is the middle of the bend of the hook part.

A tackle is said to be "two blocks" when the entire fall is hauled through, so that the blocks are in contact. *To overhaul a tackle* is to separate the blocks. This is best done as follows: Hook the upper block firmly, or let one or two men hold it; let one or more men take hold of the lower block and haul, while one man lights the fall through the upper block by hauling the running part through it. If necessary, let another hand light the second part through. Rope should *always* be stopped up, either with the end or with rope-yarn stops, to prevent it getting into a snarl. When using ropes for hauling, they should never be dragged upon the ground. *To stop up a coil*



which is taken hold of in hoisting is called the *fall*. *A whip upon whip* is where the block of one whip is made fast to the fall of another. *A luff-tackle purchase* is a single and a double block: the end of the rope being fast to the upper part of the single block, and the fall coming from the double block. A luff tackle upon the fall of another luff tackle is called *luff upon luff*. *A watch tackle*, or *tail tackle*, is a luff-tackle purchase, with a hook in the end of the single block and a tail to the upper end of the double block. One of these purchases with a short fall is kept on deck, at hand, in merchant vessels, and is used to clap upon standing and running rigging, and to get a strain upon ropes. *A runner tackle* is a luff applied to a runner, which is a single rope rove through a single block, hooked to a thimble in the eye of a pennant. *A single Burton* is composed of two single blocks, with a hook in the bight of the running part. Reeve the end of your rope through the upper block, and make it fast to the strap of the fly block; then make fast your hook to the bight of the rope, and reeve the other end through the fly block for a fall. The hook is made fast by passing the bight of the rope through *of rope with the end*. Lay off two or three turns of the coil and take a clove hitch around all parts of one side of the coil. Do the same on the other side. If the rope should be rove in a tackle, run it "two blocks," and make the first hitch around the fall between the blocks. Before reeving a rope in a block, the turns should be carefully taken out to prevent twisting when the weight is lifted. This is done by stretching the rope out to its full length and turning it in the opposite direction to that in which it is laid up, until all the stiffness disappears. Blocks should be overhauled very often to see that the sheaves are working properly on the pin and that they work smoothly. If they do not, turn the pin end for end, and rub a little blacklead (graphite) on them to lubricate them, also on the sides of the sheaves where they rub against the shell. When hoisting with tackles they should never be allowed to twist. If they show a tendency to do so, insert a bar in the block or sling, and use it as a lever to hold it straight. It frequently happens that the men cannot apply their full strength in the direction in which it would be most effective. In such cases hook a single block to some object about two feet above ground and reeve the end of the fall through it, so that the men can add their strength to their weight and more men can apply themselves. Never trust the suspension of a weight to holding it by the unaided strength of men. If it is possible to get a turn around any fixed object, even in raising or hauling a weight, it is best to take a turn, as all that is gained is then saved. Always select such blocks that the fall will run freely through them, and not ride upon the edges of the sheaves. If it does, it will be certain to cut out. The rope should not quite fill the score or groove on the sheave. In this way excessive friction is avoided. The sailor's maxim is, "Small ropes and big blocks." The power gained by using tackles is as follows: Two single blocks, or gun tackle—nearly doubled; luff tackle (double and single block)—doubled. If the double block is movable—trebled; two double blocks—power $\times 3\frac{1}{3}$; double and treble blocks—power $\times 4$; two treble blocks—power $\times 4\frac{1}{2}$; whip upon whip, single Burton—trebled. When one tackle is applied to the fall of another, the power obtained is found by multiplying their respective values together. No advantage can be gained by using a greater number of sheaves than two treble blocks in one fall. See *Blocks*, *Cordage*, *Differential Pulley-block*, *Hooks*, *Knots*, *Pulley*, and *Rope*.

TACTICAL MARCHES.—Marches made in the immediate vicinity of the enemy, and so near him that they may be observed by him. Since these marches are so near the enemy, greater precautions are required to guard against an attack than are necessary in *strategical marches*. Tactical marches differ from *route* and *strategical* marches in the number and sizes of the wagon-trains accompanying the troops on the march. Both in *route* and *strategical* marches the troops are cumbered with long and unwieldy wagon-trains carrying the baggage and supplies of the army, whereas in a tactical march there are none, or the trains are reduced to a minimum. Since the enemy may attack the moving columns at any moment, everything is sacrificed to the important one of being ready to fight at short notice, and the army carries with it only supplies enough for a few days, and little or no baggage. Everything not essential for feeding the troops and not necessary for fighting is left behind the army while it is making a tactical march. See *Marches* and *Route Marches*.

TACTICAL POINTS.—All points on a field of battle which may impede the advance of an enemy to attack your position, or which may facilitate the advance of your army to attack the enemy's position, are *tactical points*, and should be occupied. *Tactical decisive points* are points on a field of battle which when occupied by an army, will enable it to make an attack on the enemy, whose success would be decisive on the issue of the engagement; and all points on a field of battle in possession of the enemy which will enable him to frustrate the attack on any part of his position, or which will enable him to impede or intercept the line of retreat, if repulsed, are *tactical decisive points for offense*. Reverse the conditions, and we will obtain the tactical decisive points *for defense*. The flanks and most advanced salients of the position are, in general, the most decisive points.

TACTICAL UNIT.—The term *tactical unit* is arbitrary, and might be used to apply to larger or smaller bodies of troops. Usually a battalion is a tactical unit of infantry, a squadron of cavalry, and a battery of artillery.

TACTICS.—Strategy is the art of maneuvering armies with a reference to the objects of the whole campaign—the securing of communications, the cutting off an enemy from his base, throwing him into a position where he must fight at a disadvantage or surrender, etc. Tactics has regard to the evolutions of an army in the actual presence of an enemy. It is the strategy of the battle field; the science of maneuvering and combining those military units which drill, discipline, and the regimental system have brought to the perfection of machines. It was admirably described by Napoleon as *the art of being the stronger*—that is, of bringing an overwhelming force to bear on any given point, whatever may be the relative strength of the entire armies opposed. The earliest records of battles are those of mere single combats, in which the chiefs, fighting either on foot or in chariots, performed great deeds; and the commonalty, who apparently were without discipline, were held in profound contempt. With the growth of democracy arose the organization of the phalanx, the advance of which was irresistible; and its firmness equally so, if charged in front. It, however, changed front with great difficulty; was much deranged by broken ground; and failed entirely in a pursuit, or if attacked in flank. Far lighter, and more mobile, was the Roman legion. Among Roman tactics was also the admirable intrenchment, which they scarcely ever omitted as an additional source of strength for their position.

Events reproduce themselves in cycles; and with the decay of Roman civilization came again the mail-clad heroes and cavaliers—mounted this time on horses—who monopolized the honors of battle, while the undisciplined footmen had an undue share of the dangers. Later in the feudal period, this disparity between knight and footmen was diminished by the employment of bodies of archers, whose shafts carried distant death. The adoption of gunpowder for small-arms altogether neutralized the superiority of the armored knight. This change brought infantry into the front place in battle, and threw cavalry into the status of an auxiliary. The French Revolutionary Wars tended much to the development of artillery as a field-weapon, and Napoleon employed this terrible engine to its fullest extent, a practice followed by the best modern Generals, who never risk a man where a cannon-ball can do the work. Frederick the Great was considered an innovator for fighting with infantry four deep. During the French war, the formation of three deep became general, and still obtains in several European armies. Before the battle of Waterloo, the British leaders had acquired sufficient confidence in their troops to marshal them in a double line. It is doubtful whether the advance in arms of precision will not soon necessitate the formation in a single line, or even a single line in open order. It is impossible, in an elementary article of this character, to give even an approach to an essay on modern tactics, which is an intricate science. We can only notice briefly a few of the more important principles.

The main idea apparent in the German tactics of 1870 was: A *front* attack is difficult, let us try the flanks. In the greatest battles of the war, those of Gravelotte and Sedan, the turning tactics came prominently forward. At Sedan the turning movement was complete. The losses of the tenth German division at Wörth prove what a serious matter it is to make a direct attack against the breech-loader. They amounted to about four thousand men. It was of course necessary to make vigorous attacks on some points of the French position, so as to take off their attention from the circular enclosing movement of the Germans. Although they (the Germans) were frequently obliged to make front attacks, the principle of the turning movement always asserted itself. In any case, however, a direct infantry attack should always have been undertaken in sufficient force. But this was too often not the case, so that weaker forces exposed themselves to suffer great losses in long-continued doubtful conflicts, gaining at the same time but little ground.

On the defensive the shooting-tactics of the Germans consisted simply in firing at short range, a practice which always had the best results. The main position selected was generally strongly occupied in first line. It was rightly judged that a strong development of fire at the commencement of an action was necessary and advisable. Separate strong masses in reserve, not a great many little reserves, were formed. If there was sufficient time, the position was divided into sections and prepared for defense as well as possible. On the approach of the enemy, the artillery was at once deployed into a connected line. The cavalry, having at first been pushed forward to check the enemy's advance, was then withdrawn behind the line of defense.

"The French opened their musketry fire at very long ranges, from about one thousand to one thousand four hundred paces. It is true that even at this distance we had men killed and wounded. The advance of the German infantry was never once checked in this way. Our infantry extended at least one "Zug" per company at once. This was, however, rarely sufficient when we came within effectual range of the Chassepôt, about five hundred paces. When at about four hundred paces from the French skirmishers, our men were obliged to seek cover, or if it was level ground, to lie down and to answer the fire, for which purpose the skirmishers were usually re-enforced by another 'Zug' per company, if this had not already been done.

To sum up the characteristic points of the infantry battle-tactics of 1870-71, it will be necessary in doing so to mention in the first place what we did *not* see. That is to say, *no* volleys in battle; *no*, or at least a very few, attacks by troops in close order; if, however, a compact body ever did attack, it was always a small one, never amounting to a battalion column. But we *did* see;—Great deployments of skirmishers on both sides; long continued gradually advancing musketry fights, often rolling backwards and forwards; at last, the flank of one party turned, or else one side exhausted; the other side pressing on in consequence, or a rush of dense clouds of skirmishers who endeavor at any price to dislodge their opponents; not forgetful that, in case of failure and retreat, they are *dead* men. On both sides great dispersion; intermingling of troops, and particularly in broken ground; hence the leader's control diminished. With the Germans—more steadiness, and the habit of reserving their fire. With the French—more hurry, and the habit of firing at long ranges. However great the effect of the artillery, however, enormous was the loss of the French by our shells, there was still no example of a really great result being due specially to artillery. Even the plateau of Floing, which was cannonaded from all sides, had to be stormed by infantry. And the same may be said of St. Privat. Single villages were set fire to by shells * * * and were in consequence evacuated by the French, but it cannot be said of such places that they were of primary importance. Almost always it was found necessary at last to wrest these positions from the enemy by means of infantry. In the forward marches of the German armies and of independent corps, we remark an advance-guard of all arms with cavalry at the head, even in broken ground. If they come on the enemy, a larger body of cavalry was often brought to the front to reconnoiter. The infantry of the advancing-guard was usually kept further back than in 1866."

To sum up the points remarkable in the tactics employed in 1870, we remark on the German side: *a*. The attack is directed on the enemy's flank, an assault on the center following this, sooner or later. *b*. In most cases, very powerful artillery fire to prepare the way. *c*. Extensive employment of skirmishers. *d*. Cavalry action restricted. On the defensive, the Germans show generally skilful choice of ground, concentration of artillery, and a proper system of firing.

On the French side: *a*. A strict defensive, maintained against flank attacks. *b*. Isolated counter-attacks without sufficient result. *c*. Likewise very strong swarms of skirmishers. *d*. Want of combination and superior direction in the employment of artillery. *e*. The cavalry behaves very well where it comes into play, but acts as if there were no such thing as a breech-loader. On the offensive; in the first period, gallant, impetuous advances of great swarms of skirmishers, who shoot too much, and thus retard their own movements, often opening fire at absurd distances. In the second period of the war: bad officers and inability to maneuver; hence attacks unskilfully made and soon checked. We may infer that the chief problem which the tactician has to solve in the present day is how to attack in the best form and manner; also how to train his infantry, the arm upon which he must depend for the assault, so completely, that its success will be facilitated, both by its formation for attack, and by the way in which it is handled in action.

The two direct front assaults made by Skobeleff's troops, at Plevna, September 11th, and in rear of Shipka, January 8th, were conducted in the following manner:

The troops were formed under shelter, between two thousand and three thousand yards from the Turkish lines, in battalion masses (double column of half companies on the center). In beginning the action the rifle company of each battalion was sent forward as a thin line of skirmishers, and one platoon (quarter company), in column of half platoon behind the line, at a distance of not more than fifty paces, and constantly replacing its losses.

About two hundred paces behind the skirmishers came in the first battalion, which moved forward in line, not touching elbows, but with intervals of about two paces, (or less) between the men—a strong skirmish line in fact—each company having three-fourths its strength in line, and one-fourth just behind it, in half platoon column, to replace its losses. The men moved forward preserving a general alignment, but each man taking advantage of any shelter that lay in his path, and firing from behind it, and then moving forward again. Another battalion followed in precisely the same order, and at a distance of about three hundred paces, so that the men could feel that there were supports coming behind them.

The remaining battalion of the regiment was held in hand by the division Commander until the fight developed itself, and it could be seen where the most resistance was met, whether the enemy was bringing any troops on the flanks, etc., the battalion was then directed on the point where it was most needed. The regiments on either side were sent forward in the same manner. Meanwhile the reserve regiment of the division, always under the control of the division commander was kept under shelter as near as possible to the line; as the troops already engaged, which had now merged into two lines (and at points where the resistance was greatest into one), began to move slowly, to waver, the reserve regiment or a portion of it was sent forward rapidly to the point where the fighting was hottest.

At the battle of Gorni-Dubnik, October 24th, eighteen thousand Russians attacked four thousand Turks occupying a redoubt of small profile with an outlying lunette and a few trenches. The artillery cannonade lasted only from nine to ten a. m. The infantry was formed on three sides of the redoubt, in two lines of company columns and a reserve. It moved forward to the assault in this order, preceded by a line of skirmishers. The lunette and trenches were carried, but the men could not reach the redoubt; they lay down in the ditch of the road and under other slight shelter, at distances varying from only one hundred to four hundred paces from the redoubt, and remained there, keeping up their fire whenever the defenders were visible. During the afternoon a second disjointed attack was made without success. Finally, about dark, a simultaneous rush was made from three sides, which gained possession of the work. The Turks had inflicted on the Russians a loss nearly equal to the total strength of their own force, and had themselves lost about thirty-five per cent.

The instances which have been given are the principal assaults in the first half of the war; they present many points of resemblance. In nearly every case the troops were drawn up in two lines of company columns and a reserve. The skirmishers were sent forward, the first line followed at one hundred and fifty or two hundred paces distance, and then the second line. In no instance, however, does it appear that there was more than one line of skirmishers; behind them the troops marched with dogged bravery, in solid line of two ranks, shoulder to shoulder, or in company columns with platoon fronts far inside the line of rapid effective fire; and they continued this march until the fire caused a break in their lines and a retreat, or until they reached the work after enormous losses, and held it as the result of a hand-to-hand fight. The skirmish line was so small in comparison with the main force that it really amounted to nothing, and the attack was in fact made in solid line. The attack and the forward movement were not distinguished. This *defective* formation was the principal cause of the heavy losses.

We next observe that, when attacks were made on two or more sides of a work, they were frequently made not simultaneously, but one after the other; so that the defenders were able to move from one side of their work to another and repulse the attacks in detail. We often notice that the reserve was sent forward, not just before the line began to waver, but after it was already in retreat. The effect of these dispositions was the same as if the attack had been made with only a portion of the force instead of the whole, since the new attack had to gain over again what had been gained (and lost) in the first.

In the latter part of the war, (and also in Skobeleff's attack at Plevna on September 11th), these faults, which experience had demonstrated, were not repeated. In all of Gourko's operations, during and after the passage of the Balkans, there was no instance in which a fortified position was assaulted in front; having a superiority of force, he threatened the enemy's front (occupied their attention with the fire of a skirmish line, with strong supports posted in the nearest shelter), and turned their flanks, compelling their retreat—the tactics in short of Sherman's Atlanta campaign.

The Commander of a force of the three arms acting independently, should have the clearest possible conception of the general objects which it is intended he should carry out, in order that when he comes in contact with the enemy he may form a correct decision as to whether he should attack or act on the defensive. Should his position and means at command be such as to allow of either course being pursued, the preference should generally be given to the attack, in order to secure the undoubted moral advantages which attend this course of action. But if the nature of his position and resources necessitate his assuming the defensive, he should seize upon the first favorable opportunity of turning the defense into the attack.

In offensive tactics we may consider three general modes of attack, one of which the Commander of a combined force must select, as the most suitable for his purpose. 1. *Frontal attack*, which would mean a direct advance upon the whole of the enemy's line or position. As a general rule, this form of attack is unadvisable, as even in case of success, the result is not decisive; the enemy's line of retreat being unassailed, he simply falls back to a position more to the rear. There may, however, be situations when the nature of the ground prevents any other mode of operation, or where the frontal attack may be made use of to feel the enemy and ascertain his exact dispositions, in preparation for a concentrated attack upon one of his weak points, as soon as they are discovered.

2. *Combined attack upon front and flank*. In this case the enemy is attacked in front at the same time that a portion of the force is directed at one of the flanks. An attack upon the flanks by itself unaccompanied by a front attack is not advisable, except in the case of small detachments acting against one another, or unless the attack can be effected by surprise, in which case the enemy is unable to meet it in time by a change of front. Were a strong force in position attacked solely on the flank, it would quickly form up its reserves to a new front, the troops of the original front coming up in support. For a flank attack therefore to succeed, it must, as a general rule, be accompanied by a frontal attack, sufficient to hold the enemy to his original position. An attack upon both flanks combined with a frontal attack can only be tried under circumstances of great superiority of numbers, without which it would become a most dangerous operation, enabling the enemy to give the counter-stroke at a weak point of a straggling line and beat the assailants in detail by cutting their force into two. In small engagements where the numbers are inconsiderable the flank attack may be made alone. In such cases a consideration may arise as to which flank it may be most desirable to attack, where one presents cover for concealing the movement, and the other, though offering no cover, is nearest to the enemy's line of retreat, which might thus perhaps be cut off. Surprise being here the element most essential to success, as carrying with it the greatest moral effect, the flank should certainly be chosen which affords the means of approaching unobserved, even though the result of action in this quarter may not be so decisive as it would be in the other. Should the attack be of greater dimensions, the element of surprise, and consequently the question of a covered approach, become of less importance. Here an attack upon the flank nearest the enemy's line of retreat would give best results, as being more decisive, so that other considerations being outweighed, this course of action would probably be adopted. The moral effect of threatening the enemy's communications would also in this case count for something. Sometimes the movement against a flank should constitute the real attack, that against the front being only sufficiently maintained to hold the enemy in position, and prevent his concentration on the threatened flank. Here the frontal attack has all the advantages of the defense together with the moral advantages of an expected diversion to be caused by the flank attack. The nature of the ground would influence the adoption of this mode of attack, but in any case it would be prudent not to follow it unless the attacking Commander, if unsuccessful, could still cover his line of retreat in falling back, or unless as may happen on occasion, he could still afford to retreat in a new direction and abandon altogether his old line of operations,

3. *Concentrated attack upon a weak point*, to break through the enemy's line or force his position. This mode of attack, if the most difficult of execution, is undoubtedly in case of success the most decisive, the enemy being broken into fractions which can subsequently be beaten in detail. The enemy's line of retreat may also thus be arrived at, and his communications cut before he can recover himself. The attack must always be made with force sufficient to resist a counter enveloping attack on the part of the enemy; which might otherwise be disastrous in its results. The increased range of modern guns and rifles has made this attack more hazardous than ever, for a concentrated fire-action can now be brought to bear on the assailant, not only from all parts of the defense in his immediate front, but in most cases from either flank as well. Unless therefore the ground covers the movement in a great degree it should not be attempted. In addition to the above primary modes of attack, a *turning movement* may also be considered. This might be looked upon as almost a form of flank attack were it not that it differs from it in some essential particulars. The turning movement is more often a *menace* than an *attack*, for it threatens the enemy's line of retreat so as to

force him to change front or shift his position before he enters the combat. The maneuver differs also from a flank attack inasmuch as it removes the scene of combat from the position held by the enemy, while the flank attack takes place on one of the flanks of the position itself.

The turning movement may be made, either with a portion of the force at command, or with its whole strength. In the first case, the conditions should render it improbable, if not impossible, that the enemy could act offensively in turn upon each fraction of the divided force. Otherwise the separate movement should not be attempted, as it must end in disaster. When the ground permits, or is favorable, cavalry and horse-artillery are specially suited to the turning movement. They should therefore nearly always form a portion and sometimes the whole of the troops employed in the service, both because they can by rapid advance produce the moral effect of surprise, and because they can more easily avoid destruction by a superior force. The relative proportion of the force detached, in such case, upon the turning movement, to that retained for the frontal attack, can only be decided by the circumstances. If the line of retreat of the assailants must necessarily be preserved in rear of the main body, the latter must keep the largest amount of force; if the retreat can be made equally well to the flank, the strongest force may be detached for the turning movement. It is evident this mode of attack, by which a portion of the force is detached from the main body, is not generally suitable for minor operations; there may be occasions, however, where a small force may with great advantage detach its cavalry and horse-artillery to threaten the adversary's communications. In the second case, if the turning movement be made with the whole force at command, it is clear that the former line of retreat must be abandoned altogether, or else there should be such complete probability of success that the line may for the moment be laid open to the enemy, for the sake of concentrating the whole force in the attempt to turn his position.

The above general principles being clearly understood, the Commander of a small force of the three arms should have no difficulty in preparing his plan of attack and issuing his orders, upon receiving reports of the strength and dispositions of the enemy, and of the nature of the ground upon which he must act. In ordinary cases when small forces are engaged, the cavalry reconnoiters in advance will bring in sufficient information for the purpose; but if the enemy should be covered by advanced troops, it may be necessary to make a special reconnaissance, sometimes supported by guns, in order to arrive at a knowledge of his strength and intentions. With large forces this would probably be carried out by the advanced-guard, the artillery of which, re-enforced where necessary from the main body, would take up what may be called a *preliminary artillery position*, and open fire at long range to cover the advance of the troops employed in the reconnaissance. The information required being obtained, the Commander would issue his orders. In the case of very small operations or of a sudden rencounter with the enemy these would be given verbally; under other conditions orders should, if possible, be written. Should the force, as it probably would, consist of detachments under various Commanders, it would be necessary that there should be a *general order* for all, and also a *special order* addressed to each Commander where separate action is required.

The general order should be clear, precise, and complete, and as short as strict compliance with these requirements will permit. It should contain:

1. The conditions or circumstances of the intended action, with what is known of the enemy.

2. The mode of action determined upon, and how to be undertaken: thus for instance, to attack the enemy when he is touched on in direct advance, or, to attack the whole, or a certain part, of a position.

3. The strength, composition, and general division of the attacking force, with names of Commanders; this may be given more in detail in the margin of the order if thought necessary.

4. The preliminary positions to be taken up by each distinct part of the force with their directions of attack.

5. The hours at which these positions are to be assumed, and at which the forward movement or attack is to be commenced.

6. The position where the Commander of the troops will be found during the action, to which all references or reports are to be made or sent.

These clauses would be sufficient for a small force, but, in operations of greater magnitude, it would be necessary to add:

7. The positions of the ambulance and field-hospitals, and the order of march of the trains of the various columns.

It must be understood that the dispositions of the troops thus indicated are only intended for the first phases of the engagement, for, until the enemy's counter-plans are developed, the final movements which depend thereon cannot be defined. The special orders addressed to separate Commanders should contain nothing that may tie their hands too much in matters of detail. As a rule, they should be told the thing to do, not the manner of doing it, and within certain safe limits, to be named, they should be allowed free action.

In apportioning the reserves for the different arms, the Commander of a combined force may accept the following as main principle, modifying its application according to the special conditions of the case. The various arms require reserves in exact proportion to their respective liability to fall into confusion during action. Therefore a reserve is most necessary for cavalry, next for infantry, especially when attacking, and hardly at all for artillery which has no shock action. But although a reserve of guns may not be required, the artillery should certainly have reserves of men, horses, and ammunition. With such aid the guns can be withdrawn from action in one part of the field, and sent rapidly to another as required.

During the progress of the earlier arrangements for the engagement, which may be said to constitute the first stage, and if no affair of advanced troops has taken place, the reconnaissance of the enemy and ground would be kept up by the cavalry, whose preliminary reports have enabled the Commander to decide upon his first course of action. Great care should be taken that there is no confusion in forwarding the reports of the patrols, and that their leaders clearly understand where they are to send them. The position of the Commander of the troops, as mentioned in the 'orders,' should therefore be impressed upon each patrol leader, whose duty it will be to see that every man sent back with a message distinctly understands where he is to deliver it.

The reconnoitering would be continued into the second stage, which would commence by the opening of fire by the artillery from its first position for attack. Should a preliminary position have been assumed by the artillery, it would probably have been under the circumstances above shown, or else necessitated by opening of the defender's fire at a long range upon the heads of advancing columns, in ground where they could not obtain shelter: in which case the advanced guns would at once have taken post to open fire in reply.

In either case, on the dispositions for infantry attack being made, this preliminary position would be quickly abandoned, and the guns moved on to the *first principal artillery position*. In its selection it must be remembered that the first part of the engagement has for its object the more complete discovery of the enemy's plans and strength, as well as to cause him as much loss as possible from the moment he can be brought under fire. The guns, accompanied by the necessary supports, should therefore be pushed well to the front, and come into action at a point selected with due regard to the direction of infantry attack, so far as known at the time, and at a range of from one thousand eight hundred to one thousand three hundred yards from the enemy's general position. The place chosen ought not to be such that the advance of the attacking infantry will soon mask the fire of the guns, and if the ground and the general form of the action permit, a position to a flank will be usually preferable. The artillery need only be protected by cavalry or a small force of infantry on its exposed flank. The especial danger to be feared would be the unobserved approach of the enemy's skirmishers or marksmen within effective range.

In the case of large forces, the guns would probably be massed in one or two strong batteries. No reserves need be kept back under ordinary conditions, but all the available guns, deducting any required for a flanking movement, should be quickly brought into simultaneous action. The object being to cover the advance and deployment of the infantry, and to draw the fire of opposing batteries, it follows that a sort of artillery duel will open and continue the engagement, until the attacking infantry comes up to effective rifle range of the enemy's position, and the third stage of the action is entered upon.

The tactics of the infantry would now, with a view to forcing the enemy to show his disposition clearly, be directed to covering much ground with as few men as possible in extended order, the main bulk of the force being kept in small columns. If, however, there are important points in advance of the position which it appears desirable to possess, they must be rapidly attacked by the infantry, without any preliminary demonstration of force. If any high ground, in the course of the advance, comes within reach, from which the enemy's dispositions can be seen, it should be immediately occupied by the assailants, even though not in the direct line of attack. In default of very high ground, which is not always to be found, a church-tower, a high-roofed house, or even a tree, may be turned into a post of observation by an officer. So far the original dispositions for attack may be probably followed without much deviation; but once the action can be said to have commenced, circumstances often compel the Commander of the troops to change his operations.

For the purpose of watching the phases of the combat, the position which the Commander should assume during the engagement ought, if possible, be on an eminence, from whence he can perceive the principal portion of the ground over which the troops are to work. He should not quit this post (duly announced in the "order") without exceptionally good reasons, and if he is obliged to do so, an officer should be left behind to direct all reports or messengers to the new station of the Commander. These injunctions are of much importance, as nothing could be more demoralizing, during an engagement, than to see officers and orderlies galloping about wildly to look for the Commander and asking everyone where he is to be found.

The orders which are necessarily transmitted during an action by the Commander of the troops are of much importance, and should be given with great care. They should, if possible, be in general harmony with the original plan of attack, although certain modifications may become necessary. They should not descend to details which are better left to Commanders of corps, nor should the Commander of the troops interfere in the execution of his orders, further than to assure himself that they are carried out. He should be satisfied on this point by means of constant reports and communications which must be kept up, without interruption during the action between him and the Commanders of separate corps and detachments. When the reports cannot be sent by an officer, they should be written, and in such case be numbered and dated with the exact hour and minute of despatch. Above all other matters it is most important that the Commander of the troops should be immediately informed, when circumstances render it impossible for a subordinate Commander to carry out the orders or instructions, as the failure to execute these may necessitate modifications and fresh orders to replace the former ones.

By the end of the third stage it may be presumed that the enemy has been forced to show his hand sufficiently for the purposes required of determining the best method of finally attacking him, and the Commander's main dispositions are either directed to be carried out in their original design or else modified to suit new ascertained conditions.

The artillery, which up to this time has continued from its first position to support the general advance, by endeavoring to silence the enemy's guns and to draw off his fire from the infantry, is now directed to concentrate its fire upon the intended point of attack in order to prepare the way for the infantry assault. The moral effect of this fire upon the defenders will probably be very great, even if the physical effect upon troops partly behind cover of ground and obstacles be comparatively trifling.

Whenever the ground will admit, the infantry are supported on the flanks by cavalry, which advances under cover in small columns, with strong supports close at hand, and losing no opportunity of attacking any advanced troops of the enemy and warding off adverse attacks in return. The very fact of the cavalry occasionly showing itself on the flanks, gives confidence to the attacking infantry and demoralizes the defenders, especially if they are themselves deficient or weak in that arm.

The fourth stage is now commenced, by the infantry being finally launched at the selected points of attack, and it comprises the whole of the real action up to the moment which immediately precedes final success or failure.

The infantry here plays the principal part. It is fairly committed to the fight, and having received its final impulse in the desired direction from the Commander of the force, no power can alter or recall it, for good, during the remainder of the engagement. Its developement of fire-action should rapidly increase as it nears the point of attack, for upon its weight of fire depends its success.

The cavalry on the flanks should be now on the watch, not only to protect the infantry flanks of its own troops extended in the advance, but also to seize opportunities of approaching unseen the flanks of the opposing infantry or artillery, and of throwing them into disorder or demoralizing them, if not inflicting serious injury. If repulsed and in its turn disordered, it must rally under the protection of the other arms, and again return to exercise similar functions. But cavalry at this stage can only play a minor part, unless the ground be more than usually favorable to its action; with the exception, therefore, of strong supports to the cavalry acting on the flanks, the remainder of this arm would still be kept in reserve, but not so far to the rear that it could not be brought up quickly if required to make a diversion or demonstration on either flank.

The artillery, which during the former stages, has been of first importance on account of its long range, now falls into the second place. The circumstances of the case must determine, whether it shall keep up its fire on the enemy's guns to relieve its own infantry, or whether it shall fire on the enemy's troops. As the rule to be followed, is, that it shall fire on that arm of the enemy which is for the time the most important, the enemy's infantry will, in all probability be now the object. In either case, a moment may arrive during this stage, when a second position more in advance is necessary for the guns, on account of their fire becoming masked by their own advancing infantry. If a portion or the whole of the guns can, in such case, be advanced rapidly and placed in a good position (especially on a flank, whence they can add their own fire to that of the advancing troops, which are at the moment absorbing the whole attention of the defending infantry), the proximity to the enemy's line, of this *second principal artillery position*, must not be too much limited by ordinary rules of caution. When the attack and defense are nearly matched, it is clear that the addition of a close artillery fire on either side may turn the scale, and compensate by decisive success for any loss sustained. As this close action of guns may in case of repulse lead to confusion, it would perhaps be advisable that the whole of the available artillery should not take up this second advanced position, but that a portion be held in reserve, massed in a favorable position, and kept in action all the time in support of the advanced battery. During this stage such portions of the reserves of the other arms are brought up as required, and any concerted flank attack carried out along with the frontal movement. The fifth stage is generally a success or a complete defeat, but may result in an intermediate issue between the two—a retrograde movement fighting: a retreat, in fact, in good order on the part of the assailants to the original position from which they had advanced. This stage commences by the final reserves which the Commander thinks fit to engage being ordered up. In great actions, a decisive blow might now, under favoring conditions, be given by the reserve cavalry; but in smaller affairs such as we are at present considering, this force would not come into play until the moment of pursuit or retreat. The reserves of infantry are thrown upon the decisive points, supported by the massed fire of the whole of the artillery. But little distance of ground or interval of time should be allowed between the successive attacks of freshly brought-up infantry. The fatal error of allowing a front line to be beaten back before a succeeding one arrives should be guarded against, and troops should be pushed on in rapid succession to carry out the forward movement, and to replace the enormous losses attendant in modern warfare upon a frontal assault; above all things, to keep up the *morale* of the attacking troops, by preventing a check in the front at this critical moment.

If the attack is successful and the enemy retires, either before the demoralizing influence of the last steady advance, or broken by actual assault, the position he occupied is quickly assumed by the artillery and a heavy fire brought to bear on the retreating troops. The reserve cavalry, which by this time has all been brought up from the rear, and probably posted on the weaker flank, is now launched in pursuit accompanied by horse-artillery, the superior mobility of both rendering their use peculiarly well suited to this service. The Commander of the troops would move forward from his station, and take his post upon the position lately occupied by the enemy, for further direction of the movements. The infantry meantime would recover from its first confusion, reform its ranks broken by the assault, and then furnish from its freshest troops, in all probability the reserves, a force to aid in the pursuit. The field-batteries will also push forward and harass the enemy with their fire, when he gets out of range of the position or becomes masked in his retreat by the interposing troops in pursuit.

If, on the other hand, the final assault of the position has been unsuccessful, the attacking force must retire, covered, in open ground by the cavalry and artillery, in close ground by the least disorganized portion of the infantry supported by the artillery. The latter arm now plays an important part. It must run every risk to enable the retreat to be safely effected, until a rear-guard can be organized to protect the movement. With this view, the first position where a stand can be made close to the field of action must be taken up by the freshest of the infantry, and the guns must be posted in such manner, as not only to support the infantry, but further, to cover all the necessary dispositions for conducting the retreat in good order.

Should a Commander of a force of the three arms decide to stand on the defensive, he should take up the position most suitable for his purpose without delay, as the superiority to be attained by this course of action must result in great measure from the advantages attendant upon choice of ground. A good position should be such, from a tactical point of view, that the different arms could be disposed for defense in the manner most suitable to their action, and that there should be facilities for concealing their strength, composition, and posts from the view of the enemy, and of preserving them more or less from his direct fire during the attack. It is also of the highest importance that the front of any position selected for defense should be clear for view and fire, as should also be the flanks, unless they rest on impassable obstacles.

Whatever may be the natural strength of a position its value as a point of shelter for passive defense, or as a point of temporary resistance for active defense, depends much upon the number and quality of troops which are to defend it. The extent of the position should not be disproportionate to the strength of the defenders, for, if too much ground is occupied, part or whole of the front must be weak, and if too little ground is occupied, the troops, being crowded, suffer greater loss under fire, while facility of maneuvering is impeded. By a rough rule it may be calculated that for each yard of front to be defended five men will be required, including all arms and reserves.

The Commander of the troops may thus in practice determine approximately what extent of position he should occupy, by knowing the strength of his force. If the position which appears to him best to hold, is not unsuited for his strength, he may occupy its full extent. If his force would thus be too much scattered, he must restrict the length of his line, defending only that portion of the position which presents the greatest natural advantages of ground, and which therefore, by its possession, will best enable him to carry out the purpose of his defensive action.

Should the force be large and covered by advanced troops, the preliminary proceedings will probably involve an affair of outposts, from which the Commander will be enabled to judge of the force and intentions of the enemy. In minor operations his front will also be covered by small reconnoitering parties, from whose reports he would arrive at the conclusions necessary for arranging the defense. When the enemy is reported to be advancing, the Commander, should the ground admit it, would probably employ his artillery or part of it in an advanced position, in order to cover the reconnaissance and enable it to be more active and daring, and to force the enemy to declare his intentions at an early period. In this forward position the guns would act much as in the preliminary position of the attack, and would in a similar manner be protected either by cavalry or infantry on the exposed flank.

When they have to retire it would usually be by a flank and under cover of the fire of the guns of the main position so far as already placed. During the early part of this stage the Commander would no doubt be able to complete his preliminary plans for defense, and would issue his orders thereon much in the same manner as if for attack. The mode of operations indicated in the second clause of the orders would probably be, in this case, to await the enemy in a certain position, and there to engage him with such and such intentions. In the fourth clause, the points to be defensively occupied by each fraction of the force would be detailed, and also the relative positions of each portion of the reserves.

The first stage of the defense which was commenced with the reconnaissance of the enemy, would thus comprise the selection and occupation of the position by the defenders, as well as the advanced action, if any, of the artillery, already alluded to. Upon the selection of the ground most suitable for the artillery of the main position, will in great measure depend the exact trace of the fighting line for the infantry, and there is some difficulty in approaching this part of the subject in detail, the positions for the guns so much depending upon the circumstances of each case, and more especially upon the configuration of the ground. The guns of the position should, however, if possible, be so placed as to bring the enemy's columns under fire at long range, and hence they ought to command every distant approach. They should also be able to pour a concentrated fire upon the probable positions which will be assumed by the attacking artillery, and be stationed so as to sweep the ground in front of the position from the earliest to the latest moment of attack. The defense of the flanks in the case of large forces must be specially provided for.

It would therefore appear, that, unless the ground is peculiarly favorable for posting guns in flanking positions, where without being exposed to enfilade they can bring a cross-fire to bear upon the main attack, and a flanking one to protect the immediate front, the required conditions can only be fulfilled by the guns being placed in the front line and preferably at the salients, should an irregular contour mark the front of the position. The general distribution of the infantry would probably be in three lines; the first or fighting line of defense, the special supports, and the reserves. If time for hasty fortification is permitted, some sort of entrenchment should be always prepared for the batteries, as even a low parapet of earth gives protection to the gunners. Great care should, however, be taken that the newly broken earth is concealed or covered in such manner from the enemy's view, that it shall not serve, as it has often fatally done, as a mark for their artillery more distinct than would otherwise be presented by the guns alone. Shelter-trenches may also be prepared for the infantry in the fighting and supporting lines. Neither the places prepared for the batteries nor the shelter-trenches should be occupied by guns or troops till the proper moment for action arrives.

In making these arrangements, it is of the utmost importance to secure the artillery of the main position against the fire of the enemy's advanced skirmishers or marksmen; and, with this view, the batteries ought to be covered in their immediate front by a line of extended riflemen, placed either in trenches or pits or behind natural cover, at a distance of from four to five hundred yards in advance of the guns which they defend. If the battery is on a flank, this protection should also be extended for a similar distance to the flank. The infantry thus posted would remain as long as possible in position, and only retire when, at the final stage, they are driven back by the overwhelming advance of the assailants. Besides their principal function, of keep-off the enemy's skirmishers from too early approach to the batteries of the defense, these advanced infantry could often bring an irritating fire to bear upon the attacking artillery at its first principal position, and perhaps serve to prevent the guns from approaching to the most telling ranges. This possible action would of course depend much upon the features of the ground. Sometimes the protecting duty of the infantry in advance of the defender's batteries would be rendered unnecessary, by one or more advanced posts being held in front of the position. The general trace of the positions having been sketched out, the entrenchments, if any, executed, and all dispositions completed, the troops would be held back under cover, in such order as to be readily moved up to their posts at the proper moment. The artillery would first take post, but not too soon. No advantage can be gained by the guns of the main position opening fire upon small and scattered advanced detachments of the enemy, and the position of the batteries of the defense would be thereby prematurely disclosed to no purpose. When the heads of the enemy's columns can be discerned and are within range, so that they can be forced to deploy by fire being opened upon them, the guns should move into position. The infantry, with the exception of the skirmishers in front of the guns, or detachments holding advanced posts, should not be brought up from under their cover in rear of the position. They can do no good at this juncture in the front line, and their moral tone will be much better preserved by their being saved from the effects of the preliminary artillery fire.

It is impossible to lay down any rule for the exact position of the artillery of reserve. High ground near the exposed flank, provided facility of movement therefrom in case of necessity is presented by its features, would often be suitable. The guns should, however, in any case be well up to the front, so as to lose no advantage of range from the commencement of their fire. A position in rear which entails, not only a sacrifice of some hundreds of yards range, but the necessity of firing over the heads of the defending infantry, greatly to their discomfort and demoralization, does not appear to present commensurate advantages of safety to the guns. It is evident that artillery so placed would be comparatively useless during the later stages of the defense, when once the attacking infantry has advanced so close that the fire of the retired batteries would be masked by the ground, or by the defending infantry lining the position. Guns so placed might be useful in defending an inner line, or for supporting a counter-stroke delivered inside the position after the assault has been made, but their action would be lost almost altogether during the period immediately preceding the final attack of the position. The previous knowledge of ranges and distances, possible to the artillery of the defense, presents a great advantage; but if circumstances have not permitted the gunners to ascertain them during the preliminary arrangements, by aid of range-finders or other means, the earliest portion of the artillery action must be utilized to obtain correct estimates of the ranges to all important points, by means of trial shots.

There are certain points or portions of all positions, the possession of which would assure the assailant the greatest tactical advantages. In many cases also the conformation of the ground appears to limit the movements of an enemy to certain lines of operation.

The defense should therefore occupy these parts of the position in force, with supports in close proximity, while still preserving the general line. Under the second condition, the force should be prepared to resist advance by rapid re-enforcements at any of the possible points of approach.

The reserves of the third line should be placed so as to be available for strengthening the most likely points of attack, and to be able to protect the line of retreat. Most of the cavalry, and some horse-artillery, if it can be spared, would be placed with the reserves. Sometimes a portion of this force is placed in the second line for the purpose of joining in forward movements and flank attacks upon the assailants, or of covering the retreat of the troops engaged in these counter-attacks if unsuccessful.

The second stage generally commences with the opening of fire at longe range from the main batteries of the position, upon the heads of the enemy's columns, which have already been similarly treated by the guns in the advanced preliminary position. The object of this fire is to force the enemy's infantry to quit its order of march and deploy. The attacking artillery will probably now reply from its first principal position, and as the artillery of the attack is at this time the most important arm it must be answered by the guns of the defense. In this artillery duel the defenders should have the advantage, as knowing accurately the ranges to the various points which must be occupied by the enemy in his advance, and as being moreover entrenched while the assailants are all comparatively exposed. During the second stage the infantry of the defense are brought up into position and open long-range fire (from one thousand to seven hundred yards) upon the advancing enemy with more or less effect.

In the third stage the advance to effective rifle range of the attacking infantry has forced the defense to show more clearly the positions of its troops, and the enemy commences his dispositions for the real attack, the direction of which it is now the object of the defending Commander to discover, by every means in his power. As the supports and reserves of the assailing infantry come clearly into view, they should receive the concentrated fire of part of the artillery of the defense

In the fourth stage the real point menaced by the attack being made clearly apparent, the Commander re-enforces it to meet the assailants with a superior fire, and the artillery of the defense is directed at the opposing infantry, which now has become the principal arm in the attack. Should a counter-attack be projected it takes place during this stage, unless it is to be delayed until after the assault. Resistance to a flank movement of the attacking troops would also now have to be made. In the case of a counter-stroke being delivered by the defense, part of the cavalry and horse-artillery might be employed in support of it. Cavalry also should generally move forward on the flanks at this part of the action to seek for opportunities of throwing the flanks of the attacking infantry into disorder, or of taking guns too rashly advanced.

The fifth or last stage comprises the final repulse of the attack upon the position, or the defenders' enforced retreat therefrom. In either case pursuit by the victors may ensue. Immediately before and during the final advance or assault every gun of the defense should concentrate its fire upon the attacking infantry, in order to check their advance, and should the assailants retire the guns must continue to fire upon them, until masked by interposing troops sent forward in pursuit. Should the defenders, on the other hand, be forced to fall back, guns must cover the movement and enable the infantry to disengage itself. In an open country the cavalry of the defense, (the reserve of that arm being probably quite fresh) would, with the aid of horse-artillery, assist in checking the pursuit; in a close country the service would be undertaken by infantry and artillery; in a varied country the duty would be shared by all three arms.

For a more detailed account of the subject of tactics, as recently employed by great Powers, and their application in modern warfare, consult *Edmunds' Art and Science of War*, from which the substance of this article is taken. See *Strategy*.

TAIL OF THE TRENCHES.—The post where the besiegers begin to break ground, and cover themselves from the fire of the place, in advancing the lines of approach.

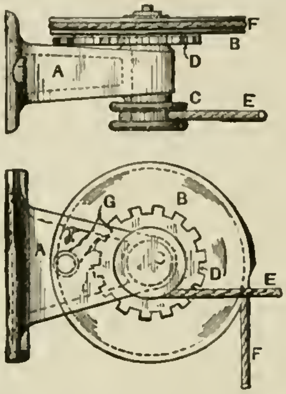
TAIL STOCK.—That head of a lathe which contains the non-rotating spindle, called the *dead-spindle*. At the other end of the lathe is the *head-stock*, in which is the *live-spindle*. The *tail-stock* is also called the *dead-head*, as containing the *dead-spindle*. See *Lathe*.

TAISHES.—A term applied to the armor for the thighs.

TAKE. in a military sense, to take is to make prisoner, or to capture. It has also a meaning in field movements, viz., to adopt any particular formation, as to "take open order." *To take ground to the right or left*, is to extend a line, or to move troops in either of those directions. *To take down*, is to commit to paper that which is spoken by another. *To take the field*, is to encamp, to commence the operations of a campaign. *To take up the gauntlet*, is to accept a challenge.

TAKEL.—An Anglo-Saxon term signifying the arrows which used to be supplied to the fleet.

TAKE UP.—In connection with the wire-rope system of bridge propulsion in cranes, it is found desirable to employ some means for automatically taking up the slack in fixed cables resulting from their gradual stretching. For this purpose the take-up shown in the drawing is employed, consisting of a bracket, A, securely attached to a wall or post at the end of the longitudinal tracks, and carrying at its outer end a short shaft, attached to one end of which is the small sheave, C, and to the other end the larger sheave, B. On one side of the latter is formed the ratchet wheel, D, and engaging with this is the pawl, G, pivoted to the bracket, A. E is the fixed cable for squaring and propelling the bridge of the crane, and F is a similar rope wound upon the sheave, B, and

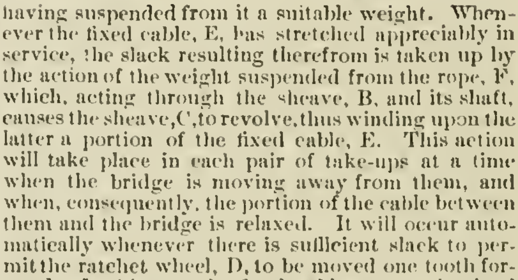


having suspended from it a suitable weight. Whenever the fixed cable, E, has stretched appreciably in service, the slack resulting therefrom is taken up by the action of the weight suspended from the rope, F, which, acting through the sheave, B, and its shaft, causes the sheave, C, to revolve, thus winding upon the latter a portion of the fixed cable, E. This action will take place in each pair of take-ups at a time when the bridge is moving away from them, and when, consequently, the portion of the cable between them and the bridge is relaxed. It will occur automatically whenever there is sufficient slack to permit the ratchet wheel, D, to be moved one tooth forward. In this way the fixed cables are maintained permanently at a proper tension to effectively perform their work. See *Cranes*.

TALON.—The heel of the blade of a sword.

TALUS.—1. The slope of an embankment or earthwork, in civil or military engineering. 2. The slope of a wall having a battering face. 3. A sloping heap of fragments at the base of an escarpment.

TAMBOUR.—In fortification, a tambour is a small work, usually a timber stockade, about 6 feet high, and loop-holed. Its object is to defend a gateway, the road into a village, or to afford flanking fire on a



bridge, etc. The tambour on the covered-way is the traverse which closes an entrance from the glacis.

A tambour, of timber-work and redan-shaped in plan, is frequently placed in front of a door or other opening, in a wall to be flanked. Sometimes it has several tiers of fire. It is constructed like a defensive stockade, with square or round timber six or eight inches in thickness. The general plan is that of a redan, or lunette, with a salient angle of 60°. A hole is made through the wall to communicate with the tambour, and loop-holes are made in the wall to flank the faces of the tambour. The drawing shows the plan of a wall A, flanked by a tambour, B. See *Machicoulis Gallery*.

TAMPEON—TOMPION.—A wooden plug of the diameter of the bore of the ordnance it is intended to fit. Tampeons are placed in the muzzles of ordnance to exclude dirt and wet from the bore, but they are no preventive against moisture, unless they are covered with serge. It is much better, therefore, if the precaution of binding them with serge is not taken, to leave the bores exposed to the circulation of the atmosphere. The cylindrical portion of the tampeon, which is made partially hollow for lightness' sake for heavy M.L.R.guns,is covered with woollen serge and strips of leather sewn upon it to fill the grooves in the gun. The tampeons of B.L.R.guns are somewhat different, the cylinders being solid, and having no leather strips. Tampeons for field-guns have two or three thicknesses of cotton cloth glued on the portions which enter the bore.

TAMPING.—Mines are tamped either with earth and sods: with earth and wood; or with sand-bags. To tamp any branch with sods and earth, the miner first fills the branch with sods for a length of 3 feet, commencing at the chamber. The sods are piled in regular layers, the precaution being taken to throw loose earth over each layer, to fill the voids between the sods. When this length is finished the miner fills in for an additional 3 feet with earth, which should be well packed. Another length of sods is laid of 3 feet, and so alternately through the entire branch. To tamp with wood and earth,a stout shield of thick board is first placed across the branch and firmly buttressed against the chamber, the branch is then filled with well packed earth, resting against the shield, for a length of 3 feet; billets of round or of square timber are then packed across the branch for a length, likewise,of 3 feet; another length of earth of the same thickness is packed in against the wood, and so on for the entire length to be tamped; finally, at the end of the tamping another shield is set up and firmly buttressed. Sand-bags for tamping are of the ordinary dimensions. To tamp with them a shield is first placed against the chamber and well buttressed. The branch is then filled up with sand-bags laid in regular layers, loose earth being thrown over each layer to close the joints. This is the best kind of tamping, as it can be removed most speedily after the explosion. The length of tamping is regulated by the line of least resistance of the mine: the part of the branch tamped should be equal to twice this line. This length must be measured in a right line from the chamber to the point of the branch where the tamping terminates, and not along the windings or elbows of the branch. As tamping is a laborious operation and requires considerable time to do it thoroughly, it has been proposed to insert a trough of 4 or 5 inches, section, in the branch or shaft leading from the mine chamber to the main gallery, or branch; and then to tamp in the usual manner around the trough. Prepared in this way, the charge made into cylindrical cartridges, or else the powder placed in successive portions in a cylindrical vessel, attached by a joint at its bottom to the end of a rod, can be shoveled forward through the trough and be thrown into the chamber in a very short time, and the mine be immediately afterwards exploded. See *Mines*.

TAM-TAM.—An Indian musical instrument, resembling the tamborine but larger and more powerful, and oval instead of round. It has been occasionally introduced into military bands.

TANCHIRT.—A richly damascened or inlaid armor, of the second half of the 16th century. The armet being joined to the cuirass by the gorget and collar, formed one solid piece, which piece, closing hermetically, left no possible hold for the sword of the enemy.

TANG—The projecting portion of the breech of a musket, by which the barrel is secured to the stock. Also, that part of a sword-blade to which the hilt is riveted.

TANGENT-HOOK.—A patch of metal in rear of the base-ring of ordnance, into which the tangent scale fits or slides.

TANGENT-RING.—All Armstrong breech-loading rifles, except the 7 in., are supplied with a wrought-iron *tangent-ring*, which is screwed on to the end of the breech. On each side of the tangent-ring is a socket, having a slot for the tangent-scale, and a boss projects beyond the socket, through which a screw passes to clamp the tangent-scale. The 7 in. guns have *sockets* instead of *tangent-rings*.

TANGENT-SCALE.—By means of this contrivance affixed to the breech of guns and howitzers, the requisite elevation may be given and the object seen at the same time. This scale has divisions of degrees marked on it, and can be raised (being fastened by a screw) to give the necessary elevation. Its divisions may be approximately found by multiplying the length of the piece in inches from the base ring to the swell of the muzzle, by .017455, and the product will give the length nearly of each degree or

TABLE OF TANGENT-SCALES FOR FIELD-GUNS AND HOWITZERS.

ELEVATION.	GUNS.		HOWITZERS.		
	6-pdr.	12-pdr.	12-pdr.	24-pdr	32-pdr.
	in.	in.	in.	in.	in.
1° 15′	0.256	0.333	0.252	0.28	0.331
2°	1.025	1.334	0.945	1.138	1.310
3°	2.051	2.670	1.870	2.271	2.618
4°	3.077	4.006	2.791	3.409	3.920

division on the tangent-scale; or, divide the radius by 57. By subtracting the dispart from the product, the length of the tangent-scale above the base ring for one degree of the elevation will be obtained. When there is no dispart sight, the scale can only be used for elevations above the dispart angle. See *Wood Tangent-scale*.

TANGENT-SIGHT.—This sight has the same steel bar as the *barrel-head sight;* it is graduated in the same way, and inclined at the same angle, but instead of the barrel-head it has a simple cross-head with sliding-leaf and clamping-screw, which is used to move the leaf to right or left. The cross-head is graduated like that of the barrel-head to give it ½° on each side, each ½° being divided into three spaces of 10′. Some of the tangent-sights have graduated elevating-nuts, and admit of being lifted out of the gun, and taken to the light for adjustment.

TANITE.—The trade name of a cement of emery and some binding material, used as a compound for grinding wheels, disks, laps, and in other forms.

TANNADAR.—In the East Indies, the Commander of a small fort or custom-house.

TAP.—A hardened steel screw with a square head, which can be turned by a wrench. It is grooved from end to end, and is slightly tapered. It is used for cutting a variety of internal screws, as that of a nut, etc.

TAPAJO.—A blind used by packers. It is formed of leather, with strings and loop of the same material. It should be used while packing or adjusting a disarranged load. When not on the animal's head, the *tapajo* will form a very convenient whip for the packer.

TAPE-FUSE.—A long, flexible, ribbon-shaped fuse, containing a composition which burns with great rapidity. By means of a fuse of this kind, a charge of powder may be exploded at the distance of several hundred yards, and apparently almost simultaneous with the communication of fire to the other end.

TAPE-PRIMER.—A narrow strip of flexible material, usually paper, containing small charges of fulminating composition at short and equal intervals apart, and covered with a water-proof composition, as the Maynard primer. It was never much favored in the service, and has been superseded by the plan of placing the fulminate within the cartridge. The tape-primer required a peculiar lock, having a recess for containing the tape and mechanism for advancing each primer successively to the nipple.

TAPER-RULE.—An instrument used in connection with the testing machine. It consists of a graduated steel wedge; the inclination of the wedge being 0''.01 in one inch. The graduation of the scale is in hundredths of an inch, so that each division actually represents an increment or decrement of 0.001 of an inch. A coarser graduation is sometimes employed, and the further subdividing performed by means of a vernier. In using this rule the space between the shoulders of the specimen is inclosed by a tube, excepting a space eight-tenths of an inch in width which is left between the top of the tube and the upper shoulder for the insertion of the rule. The tube is put on in halves, and held in position by bands. Where a vernier is used it is attached to the top of the tube, otherwise an index mark is made on the tube to serve as a zero for the scale. This method of measurement is more laborious and less reliable than with the self-indicating microscopic and vernier gauges. See *Microscopic Gauge* and *Vernier Gauge*.

TAPETS.—A term in ancient armor, synonymous with *laces*, to denote the flexible plates, which were hooked on to the skirts of the cuirass.

TAP-HOLE.—An opening at the base of a smelting-furnace for drawing off the molten metal. It is stopped by a plug of refractory clay, which is removed in the act of tapping.

TAPPET-RING.—The ring which is fitted on the octagonal part of the breech screw of an Armstrong gun, and is what the lever acts upon for working the breech screw. Should it be removed for any purpose, care must be taken that it is returned to its seat in the same position it occupied at first, for if fixed in any other way, the lever will not act on it in a proper manner. A separate ring called the *indicator* is placed in front of the tappet ring in the N.P. 40-pr. guns, and has an arrow cut upon it, which must correspond with a similar arrow cut on the gun to show that the vent piece is "home."

TAPPING-BAR.—A round bar with a sharp point, used for letting out the metal from the furnace into the ladles. Two such are generally used; the first a light bar with a chisel edge to clean away the unburned clay from the tap-hole.

TAPS.—A sound of drum or trumpet which takes place usually about a quarter of an hour after tattoo, and is an indication that all lights in the soldier's quarters will be extinguished, and the men retire to bed.

TAPUL.—A ridge which divides the breast-plate and cuirass into two compartments, and is carried out to a point, in accordance with the taste of the armorer, over the middle of the body.

TAR.—*Tar* is made by burning larch, fir, or pine, as though charcoal had to be made; dead or withered trees, and especially their roots, yield tar most copiously. A vast deal is easily obtained. It collects at the bottom of the pit, and a hole should be cleanly dug there into which it may drain. *Pitch* is tar boiled down. Turpentine is the juice that the living pine, or larch tree secretes, in blisters under the bark; they are tapped to obtain it. Resin is turpentine boiled down. *Tar* is absolutely essential in a hot country to mix with the grease that is used for the wagon-wheels. Grease, alone, melts and runs away like water: the office of the tar is to give consistence. A very small proportion of tar suffices, but, without any at all, a wagon is soon brought to a standstill. It is, therefore, most essential to explorers to have a sufficient quantity in reserve. Tar is also of very great use in hot dry countries for daubing over the wheels, and the wood-work generally, of wagons. During the extreme heat, when the wood is ready to crack, all the paint should be scraped off it, and the tar applied plentifully. It will soak in deeply, and preserve the wood in excellent condition, both during the drought and the ensuing wet season. It is not necessary to take the wheels off, in order to grease the axles. It is sufficient to bore an auger-hole right through the substance of the nave, between the feet of two of the spokes, and to keep a plug in the hole. Then, in order to tar a wheel, turn it till the hole is uppermost; take the plug out, and pour the tar in.

TAR BUCKET.—A bucket made of sheet-iron, and similar in its construction to the *sponge-bucket*. It is used for carrying grease or tar along with the pieces, for use on marches.

TARGE.—A circular shield, cut out of ox-hide or wood and strengthened by bosses, spikes, etc. It appeared as early as the 12th century. At the present day, at Toulon and Marseilles, the shield that the sailors use in naval sports is called a *targe*.

TARGET.—In its modern sense, the mark for aiming at in practicing with the cannon, rifle, or bow and arrow. In its more ancient meaning, a target or targe was a shield, circular in form, cut out of ox-hide, mounted on very light but strong wood, and strengthened by bosses, spikes, etc. Of modern targets, the simplest is that used for archery. With regard to rifle targets, the spread of the Volunteer movement and the numerous rifle-matches have caused ranges to be constructed over the whole country. The necessities are: a butt, artificially constructed or cut in the face of a hill, to prevent wide balls from scattering—a marker's shot-proof cell near the targets—and a range of such length as can be procured. In the United States Service, targets of seven different sizes, are used in turn according to the proficiency of the pupil; they are designated A, B, C, D, E, F, G. Target A is a rectangle, six feet high and four feet wide. Three concentric circles are described, with the middle point as a center and radii of 4, 13, and 23 inches respectively. The inner circle is black, and so are the lines marking the circumference of the middle and outer circles; the rest of the target is white. Target B is a square, 6 feet high. Three concentric circles are drawn, with the middle point as a center and radii of 11, 19 and 27 inches respectively. The inner circle is black, as well as the circumferences of the other circles; the rest of the target is white. Target C is a rectangle,

6 feet high and 12 feet wide. It has two concentric circles, described with radii of 18 and 27 inches respectively, the center being at the middle point of the target, and two lines drawn parallel to, and 3 feet from, each end. The target is white, except the lines just indicated and the inner circle, which are black. Target D is the same in size as C. The sizes of targets used by the British Army are as follows: for firing up to 300 yards, the target is 6 ft. high by 4 ft. broad, with a circular bull's eye 1 foot in diameter, and a center of three feet. Up to 600 yards, the target is six ft. square; bull's eye, 2 ft. diameter; center 4 feet. Up to 800 yards, the target is 6 ft. by 8; bull's eye, 3 ft. in diameter; and center, 5 feet. The marker signals the "hits" from his box, denoting a bull's-eye by a red-and-white flag, a center by a blue flag, and an outer by a white flag. If he show a red flag, it is to cease firing while he inspects the target. In scoring, the outer counts 2; center, 3; and bull's-eye, 4. A red flag should fly on the butt

during the whole time of practice, to warn passers-by to keep off the range. The targets used by the National Rifle Association at Wimbledon are not the same as those used by the army. According to the Wimbledon regulations of 1876, the target for the distance of 200 yards had a circle of 40 in. diameter, divided into the circular bull's-eye 8 in. in diameter, a center of 16 in. diameter, an "inner" of 28 in., the rest of the 40 in. being accounted "outer." On the target for 500 and 600 yards, the circle of 70 in. falls into a bull's-eye of 22 in. diameter, center, 38 in., inner 54 in., and the rest outer. The rectangular frame for 800, 900 and 1000 yards distance had a circular bull's-eye of 3 ft. in diameter, a center, 4 ft. 6 in., a square inner of 6 ft., the remainder of the target counting as outer. Of the ordinary Wimbledon targets for 1879 (as in 1878), that for 200 yards distance is divided into a bull's-eye 8 in. in diameter; "inner," 1 foot; "magpie," 2 ft.; and outer, the remainder of the target 4 ft. square. At 500 and 600 yards, the bull's-eye is 2 ft. in diameter; the inner, 3 ft.; the magpie, 4 ft.; and outer, the rest of the target of 6 ft. square. At 800, 900 and 1000 yards, the bull's-eye is 3 ft. diameter; inner, 4½ ft.; magpie, 6 ft. square; and outer, the rest of the target of 12 ft. by 6 feet. Previous to the inaugurating of the Wimbledon meeting in 1860, all the targets were circular, and made of iron. From that year till 1873 inclusive, they were square iron plates; but in 1874 targets of canvas stretched on an iron frame were introduced. See *Inner* and *Marksmanship*.

TARGET PRACTICE.—Under this designation is included in the United States measures taken to perfect the soldier in the knowledge of the power of his rifle, and to increase his accuracy of fire and consequent efficiency on the battle field. As thus employed the name is, however, a misnomer, implying, as it necessarily does, that the methods of instruction in target firing at all known distances, and under the restricted and inflexible conditions inseparable from such a system, can afford the soldier that experience and practical knowledge, in rifle firing, which, when he may be subsequently subjected to the test of battle, will find him best fitted to deliver under all the varied circumstances of modern actions the most effective fire.

A glance at the systems of musketry instruction in the armies of the leading military nations abroad shows that target practice, properly speaking, is universally considered as merely the preliminary step, deemed essential to be sure, when first commencing the education of the unskilled recruit, but giving place as soon as possible to methods far more practical in their nature, where the object selected for the soldier's aim, and the conditions under which he practices are made to resemble as nearly as possible those that would be found in war.

Between the instruction imparted and the use to which, in the opinion of the various nations the knowledge acquired will be subjected, an intimate relation may always be noticed. Thus the Germans, with whom individual long-range fire is not in favor, confine the target practice of the soldier to comparatively short ranges, and even when firing at distances as long as 500 or 600 yards employ a target representing a group rather than an individual. Their long-range fire is always entirely confined to volleys, the objective being generally bodies of men. This follows from their belief that in war the distance of 500 or 600 yards is the maximum limit of the deciding range of battle, and that much beyond that the simultaneous fire of a body of men offer much greater probability for effective results than the uncontrolled fire of the individual.

The French, too, though slightly increasing the limits both of individual and volley firing yet retain the same relative ranges for instruction and furthermore attach increased importance to the latter practice.

With the Austrians the class shooting is confined to the shorter ranges, while retaining the target representing the individual, and only when a group is arrived at does the distance exceed 400 yards. In these three countries an especial emphasis is laid upon the collective firing, not merely as an exercise in rifle firing, but mainly as a means of imparting to the men the requisite coolness and discipline, and a habit of trust and confidence in their officers, and to these latter a knowledge of the best methods of controlling and directing the fire of their troops. While from the ordinary drills and maneuvers and from the intercourse and relations of officers and men in every day life, the discipline of troops can be vastly increased. Yet these nations recognize that such measures alone are not entirely effective, when men are brought into practice under the excitement induced by rapid firing even without the detailed element of a hostile fire in return. Deeming fire discipline, as they term it, of the highest importance, without which a body of expert individual shots would in action be hardly more effective than so many untrained recruits, skirmish firing, especially in its more advanced form of field firing, constitutes one of the most marked features of their musketry instruction. Carried out under conditions bearing as close a resemblance as possible to those of actual war, both officers and men derive from it a benefit that could not be found in many days of mere drill, or as many practices at known distances upon targets with arbitrary divisions. This practical feature of the soldiers instruction, of which the importance though generally recognized is nowhere fully realized until its earlier exercises demonstrate its necessity, has lately been introduced in England, where until the last few years the influence of the expert target shot has unfortunately been paramount, and though as yet, long range target shooting holds a place in the education of the men, which its utility in war does not warrant, still the skirmish and field firing now forming part of the course will in a short period bear the full fruit.

In the United States, target practice until the year now closing (1885) formed the entire portion of the soldiers musketry instruction; this was perhaps a necessary consequence of the very limited share rifle firing in any shape, had previously held in the soldiers education, and was, moreover, necessary when the subject was first introduced, in order to awaken and sustain the interest of the men, and to foster the spirit of emulation both among them and their officers.

An enthusiasm on the subject was thereby introduced which greatly aided in the dissemination throughout the Army, of an accurate knowledge of rifle firing, under the conditions inherent to target practice. The time was then ripe for commencing the extension of the musketry course until it should finally embrace all the improved methods for perfecting the fire discipline of the company, and increasing the accuracy of the fire of the men under circumstances bearing some slight comparison to those that would obtain in war. But the conditions of service in the United States Army, the dissemination of the troops in small garrisons, the difficulties attendant upon collecting men in sufficient numbers, or of even sending them in small bodies for short distances to ground suitable for the advanced exercises, are so great, and with such difficulty overcome, that it became essential to introduce at first only such simple measures as could be readily carried out, without having to surmount obstacles, the interposition of which might be found to defeat the entire measure.

The past year has, therefore, been as a first step to the introduction of individual skirmish practice, the objective being first the figure of a standing man, then of a kneeling man, and then of a man lying down, and finally of the skirmish firing for the company as a body against a deployed line of these different forms. This latter practice has developed the fact before mentioned that even the old and presumably disciplined soldier, under the excitement consequent upon the collective firing, and the nature of the objective, bearing, as it does, a close resemblance to a hostile line in deployed and firing order, became difficult to control, and often fired too hastily. If the company skirmish firing had simply developed and demonstrated this fact, it would have subserved a most important end,but it has afforded a most efficient method of remedying the evil that it first made evident, and where it has been most successfully pursued has, besides developing an accuracy of fire under its practical conditions, also perfected its officers in controlling their men under circumstances somewhat similar to the necessities of modern actions. When in the future such measures may become possible, the introduction of field maneuvers embracing the concerted action of several companies or even battalions will have to be introduced and prosecuted before instruction in rifle-firing in all its manifold bearings to war, can be brought up to the standard reached in some countries abroad. A glance at the methods of the musketry instructions in Germany, France, Austria and England, and the more extended review of the system in the United States, which follows, will show the student of the subject that in the portion of rifle firing, relating only to target practice, the American soldier pursues a system which will make him a rifle shot second to none, and also that in the more practical part of the general subject the system is inaugurating methods that promise to bear in their complete development most satisfactory fruit.

GERMANY.

The annual course of musketry instruction extends over a period of from ten to eleven months, beginning after the close of the autumn maneuvers and continuing in its various branches throughout the year, and until the time of preparation for the next season's maneuvers arrives. During this period the firing is prosecuted with the greatest alacrity in the spring and summer, care being exercised after it has well commenced not to permit any extended interruptions in the soldier's training. During the winter months attention is devoted principally to the preliminary instruction with such a limited amount of range firing added as appears necessary to prevent deterioration on the part of the educated rifle shot. This is deemed so essential that even exceedingly cold weather will not put a stop to any contemplated firing. In the hands of the Captain of the company is placed almost entirely the instruction of his men. He calls to his assistance his Junior Officers and his Non-commissioned Officers, makes himself thoroughly acquainted with their attainments and adaptability as instructors, and is himself in turn equally the object of supervision on the part of the Battalion and Regimental Commanders. At some time during each year the officers of the regiment including even those who may be detached for staff duty in some garrison, are generally united for a course of the same preliminary drills and class firings in which the soldier participates, fulfilling the same conditions, and advancing from class to class; the object being not only to make the officers acquainted with the theory, but also expert in the practice of musketry. Great importance is attached to the ability of the officer to practically demonstrate that the soldier's failures on the target grounds cannot be ascribed to his weapon but rather to his lack of proficiency; officers, therefore, after a man's poor shot, often fire a shot from his rifle and making a fine score, thereby re-establishing the soldier's confidence in his piece. This knowledge also enables the officers to test rifles that are really defective and which require the attention of an armorer.

The course of instruction is divided into the preliminary drills; the class shooting, the field firing and the instruction practice; added to these at the close of the season is the inspection firing.

In the preliminary exercises is included the position and aiming drills, firing with miniature cartridges and judging distance drill. That the recruit may soon become accustomed to the rifle it is placed in his hands as soon as possible after his joining, and the instruction commenced with aiming drill, a small target or a special aiming apparatus being used. The Instructor first aims and explains the methods followed. The recruit then aims and has the errors he may have committed, as taking too fine or too full a sight, not centering the front sight properly in the notch of the rear sight, inclining the rifle to either side, etc., etc., called to his attention, and a correction required. At the same time he is shown how to grasp the rifle and how to place the finger upon the trigger. Position drills are conducted simultaneously with the aiming, and when the recruit can take readily and accurately erect, kneeling, sitting, or lying positions, the two drills are combined, using at first for the purpose a rest for the rifle—that usually employed being in the form of an inclined table with steps for the steady support of the piece. Practice in aiming at moving objects then follows. The Germans attach so much importance to these position drills that before commencing their range firing they are held with the soldier fully equipped in marching order and with knapsacks packed.

For the gallery or barracks practice the regular or service rifle is employed, but with specially prepared ammunition, consisting of a paper cartridge having about 50 grains of powder and a special lubricated ball smaller than the diameter of the bore; surrounding this paper cartridge is a bronze cylinder filling up the balance of the brass case. The range and penetration of the gallery bullet is so great that the customary preparations of range firing have to be observed when practicing with it. The cartridges are prepared by the soldiers themselves according to instructions contained in the manual. Considerable attention is given to this firing by the men when in barracks out of drill hours and it is found not only to amuse them but to develop a taste for shooting as well as to increase their proficiency in the range work. To accustom the recruit to the noise and recoil of the discharge, firing is afterwards practiced with blank cartridges, 30 being allowed annually. Aim is always taken at a target and the firing done from a rest.

Judging distance drill, though followed very carefully and the object of very great attention on the part of some officers, is yet looked upon with disfavor by many others, who do not carry the instruction beyond what is given by calling the soldiers' attention to the appearance of the markers at different distances, generally assigning as a reason for their omission of the exercises the caution in their service of limiting in action the individual fire to distances within 500 or 600 yards, up to which range the trajectory of the Mauser rifle is so flat as to neutralize all moderate errors that may be committed; and as moreover the rapidity of fire and excitement of action so greatly impairs the accuracy of the soldiers' judgment as to the distance of objects then presenting a very different appearance from that to which he was accustomed on the drill ground, that the time which may have been devoted to his instruction is but poorly repaid when the knowledge presumed to have been acquired is subjected to a practical test.

For the class firing 100 rounds of ball cartridges are allowed each Officer, Non-commissioned Officer, and man; it is required that half the weight of lead corresponding to this much ammunition be turned in—for lead turned in, in excess of this amount additional cartridges are issued, thus increasing somewhat the company's allowance. The entire company is divided into three classes; in the Third Class are those men who are in their first year's service, and the second year men who in the previous season failed to fulfill all the requirements for advancement to the Second Class. The Second Class is composed of the more expert men in their second year of the service and those men in their third year who failed to get into the First Class. In the First Class are only men who are in their third year of service. Thus for advancement to a higher class, proficiency is not alone requisite, but also a certain length of service, and no matter how fine a shot the soldier may be, he cannot reach the higher class until his third year.

In each class the firing is conducted in progressive exercises, which must be in succession fulfilled; the difficulty of each of these is continually increased either by changing the target, the degree of accuracy required or else the range at which practice is held. Particular attention is paid to short range firing, in the exercises for the first year the longest range with one exception being 200 meters (220 yards), and in the following years this is but little increased. As a consequence the thorough instruction of the majority of the men is limited to a distance of about 275 yards, and most of them have had no individual practice at the long ranges. At each practice the men always fire at least five cartridges of the eight or ten, and the conditions for advancement to the next exercise must be fulfilled in the last five shots fired. If in twenty consecutive shots on the same or successive days, the soldier fails in any exercises to hit the target four times he is put back to the preceding exercise and special attention given to him, but no man can be put down from a higher to a lower class. If his firing is generally so poor that he gives no promise of improvement, his case is brought to the attention of the battalion Commander, who may then exclude him from further practice. In the firing the men are not permitted any tents or shelters, and any alteration of the targets or the use of any thing by which the conditions of the course are altered in a sense unfavorable to the proper preparation of the soldier for war is absolutely forbidden.

The nature of the instruction is best indicated by the following tables giving the exercises in each class. In each case these are divided into the preliminary and principal practice; for advancement of a class the exercises of the principal practice, with the exception of the last two must be successfully accomplished with not more than 70 cartridges in the Third Class and not more than 55 inthe Second Class, but it is also a necessary qualification for advancement that all the other prescribed conditions and exercises of the lower class should have been fulfilled, but the number of cartridges is only limited by the total allowance. The sights on the Mauser rifle, alluded to in the tables, consist of a standing or fixed rear sight which is used for ranges up to 300 yards, a flap sight (the lower flap of the tables) which can be used up to 400 yards and the ordinary rear sight which is in two parts, one sliding up over the other and which gives an extreme range of 1750 yards, with 50 meter (55 yards) divisions. Aim is taken with a full sight and generally at the bottom of the target.

The company in successive detachmnents of ten or twelve men is always marched to the range in heavy marching order; the men upon arriving at the ground being permitted to take off their knapsacks and rest for about twenty minutes before being called up for firing. The firing squad is composed of five men at a time the balance of the company or detachment sitting or lying around and smoking.

During the target practice the Captain or one of the Subalterns supervises the practice of each man giving him the necessary cautions, instructions or encouragement. A single shot is fired in turn by each of the firing party until their practice is completed. The firing over, the detachment returns to the barracks, the Captain remaining to conduct the instruction of the succeeding detachment. The class shooting thus occupies six or seven hours of the officers time each day, and as the ranges are generally three or four miles, often more from the barracks, the detachments besides being occupied nearly an hour at the range will be about three hours marching there and back. This feature of the instruction is regarded with particular favor.

The field firing, which is carried out upon the conclusion of the class shooting, and is so arranged as to give the soldier practice under conditions more nearly similar to those that would obtain in war, is divided into the individual and squad firing. For the individual practice ten cartridges are allowed, and all the officers, Non-commissioned Officers and men of the three classes required to participate. The men are instructed in succession, as far as possible at unknown distances and over different varieties of ground, to take advantage of opportunities for cover, and of such accidents of ground as afford a rest for the rifle, to correctly judge their range and to be prompt in availing themselves of the limited period in which the targets are visible. The figure target and its different divisions, the head, breast, trunk and knee targets are used for the practice.

The principal object of the squad firing is to accustom the men to fire discipline, to practice them in the different stages of a modern combat and to develop and increase the ability of the officers to control their men in the disorder and excitement incident to action. The regimental or battalion Commanders generally take immediate charge, the companies are brought up to their war strength, different battalions being frequently combined, the exercise is given as far as possible some tactical idea and the situations so arranged as to give the leaders instruction and to test their ability in the selection of the proper lines for firing and the appropriate kinds to be delivered. Undulating or very broken ground, interposed with streams, trees or woods is chosen; this often necessitates the troops marching for several hours to the selected place; and the targets representing cavalry and infantry in position are located in the positions that would probably be taken up by a hostile force. Twenty ball cartridges per man are allowed for the engagement, the officers dividing to fire between volleys, and slow and rapid independent firing, and designating their men to special position of the presumed opposing troops upon which to direct their aim. The exercise is thus brought up to a close resemblance to a real action, an opposing fire being the only element lacking.

Instruction Firing. This is a class of firing to which in the German Army an attention is paid which is not shared by other countries. Its object is to teach the men all the properties of the weapon with which they are armed, and the degree of accuracy that can be expected from it; also the relations existing between the resulting dimensions of the shot group at different distances, and the size of the objective, thus throwing the probable limits of effective fire upon single men, groups and masses. Before the practical illustration, the soldiers are first instructed in the nature and effects of the influences which act on rifle firing, as laid down in their manual. These explain that even when firing the same rifle, under precisely similar conditions of weather and other circumstances, and with aim upon the same point, the variations necessarily incident to the ammunition and rifle, and therefore in a more marked extent in their relation to each other, are so diverse that the bullets, instead of striking the object at the same place, will in their points of impact cover a surface of greater or less size, which in its area and shape will depend upon its distance from the firer. Considering all the resulting trajectories, they are then deemed as composing a bundle or sheafe (called by the Germans "Gerbe"), uniting at the muzzle and then spreading out, more in a vertical than a horizontal direction as the distance increases, vertical sections of the sheafe will then be an ellipse or oval, and between this area, and the surface presented by different objects, should be some similarity in order that the fire may be most effective. To impress these facts upon the soldier, their manual (Schiess Instruktion für die Infanterie) illustrates the Gerbe and gives its dimensions, excluding a certain percentage of abnormal hits.

GERMAN COURSE OF CLASS FIRING.

THIRD CLASS.

No. of practice.	Range.	Position.	Target.	Sights to be used.	Conditions to be fulfilled.	
1	100 m. (110 yds.)	Standing, with rest	Stroke target	Standing sight.	5 hits, of which 2 in the stroke.	Preparatory practice.
2	100 m. (110 yds.)	Standing, with rest	Stroke target	Standing sight.	5 hits, of which 3 in the stroke.	
3	100 m. (110 yds.)	Standing, with rest	Infantry target	Standing sight.	5 rectangles, of which 4 looking-glasses.	
4	100 m. (110 yds.)	Standing, without rest	Infantry target	Standing sight.	5 rectangles, of which 2 looking glasses.	
5	150 m. (165 yds.)	Standing with rest	Infantry target	Standing sight.	5 hits, of which 4 in central third of target, 3 rectanglss, 2 looking-glasses	
6	150 m. (165 yds.)	Standing without rest	Infantry target	Flap sight	5 hits, of which 3 in central third of target, 2 rectangles, 1 looking-glass.	
7	150 m. (165 yds.)	Kneeling	Figure target	Flap sight	3 hits in figure, 2 of them rectangles.	
8	150 m. (165 yds.)	Lying down, rifle supported	Trunk target	Standing sight.	3 hits in figure.	
9	200 m. (220 yds.)	Standing, with rest	Infantry target.	Standing sight.	5 hits, 3 in central third, 2 of which rectangles.	
10	200 m. (220 yds.)	Standing without rest	Infantry target.	Flap sight	5 hits, 2 in central third, 1 of which rectangle.	
11	200 m. (220 yds.)	Lying down rifle unsupported.	Figure target	Flap sight	2 figure hits in figure.	
12	200 m. (220 yds.)	Lying down, rifle supported	Figure target	Flap sight	3 figure hits in figure, 2 of them rectangles.	
13	400 m. (440 yds.)	Kneeling	Section target	450 meters	3 hits.	
14	150 m. (165 yds.)	Standing, without rest, 5 shots at word of command.	Infantry target	Flap sight	4 hits.	

SECOND CLASS.

No. of practice.	Range.	Position.	Target.	Sights to be used.	Conditions to be fulfilled.	
1	100 m. (100 yds.)	Standing, with rest	Stroke target	Standing sight.	5 hits, of which 3 in stroke.	Preparatory practice.
2	150 m. (165 yrds.)	Standing, with rest	Infantry target	Standing sight.	5 hit, 4 in rectangles, of which 3 looking-glasses.	
3	150 m. (165 yds.)	Standing, without rest	Infantry target	Flap sight	5 hits, 3 in rectangle, of which 1 looking-glass	
4	150 m. (165 yds.)	Lying down without rest	Trunk target	Standing sight,	2 hits in figure.	
5	150 m. (165 yds.)	Standing, without rest	Infantry target in motion	Flap sight	5 hits, 2 in central third.	
6	200 m. (220 yds.)	Standing, with rest	Infantry target	Standing sight.	5 hits, of which 4 in central third, 3 of them rectangles, of which 2 in looking-glass.	
7	200 m. (220 yds.)	Lying down without rest	Infantry target	Flap sight	5 hits, 3 in central third, 1 of which rectangle.	
8	200 m. (220 yds.)	Kneeling	Knee target	Standing sight.	2 hits in figure.	
9	250 m. (275 yds.)	Lying down without rest	Infantry target.	Flap sight	5 hits, of which 2 in central third	
10	250 m. (275 yds.)	Lying down with rest	Figure target	Flap sight	3 hits in figure.	
11	500 m. (550 yds.)	Kneeling.	2 section targets together on their sides	550 meters.	3 hits.	
12	200 m. (220 yds.)	Kneeling, 5 shots at word of command.	Infantry target	Flap sight	4 hits.	

The gerbe illustrates aptly the advantages claimed by the Germans for their method of aiming at the bottom of the object. The densest portion of the gerbe shows the greater chances for the bullet striking nearly where aimed, the upper trajections show the impact for the shots going high, and the lower trajections indicate the probabilities of those bullets which fall short, yet reaching the mark through the ricochet. The manual also shows the effect of firing with a fixed sight upon objects at different distances, and hence the most advantageous adjustment for various positions of the enemy. When to the varia-

GERMAN COURSE OF CLASS FIRING.

FIRST CLASS

No. of practice.	Range.	Position.	Target.	Sights to be used.	Conditions to be fulfilled.	
1	100 m. (110 yds.)	Standing, with rest	Infantry stroke target	Standing sight.	5 hits, 3 consecutively, or 4 in stroke.	Preparatory practice.
2	150 m. (165 yds.)	Standing, with rest	Infantry target	Standing sight.	5 hits, of which 5 in central third, 4 of them rect angles, 3 of these in looking-glass.	
3	150 m. (165 yds.)	Standing, without rest	Infantry target	Flap sight	5 hits, of which 4 in central third, 3 of them rectangles, 1 in looking-glass.	
4	150 m. (165 yds.)	Lying down, with rest	Head target	Standing sight.	3 hits in figure.	
5	150 m. (165 yds.)	Standing, without rest	Figure target in motion	Flap sight	2 hits in figures	
6	150 m. (165 yds.)	Lying down, with rest	Disappearing breast target	Standing sight.	2 hits in figure.	
7	200 m. (220 yds.)	Lying down, without rest	Infantry target	Flap sight	5 hits, of which 3 in central third, of which 2 rectangles.	
8	200 m. (220 yds.)	Lying down with rest	Trunk target	Standing sight.	3 hits in figure.	
9	250 m. (275 yds.)	Kneeling	Knee target	Standing sight.	2 hits in figure.	
10	250 m. (275 yds.)	Lying down without rest	Figure target	Flap sight	2 hits in figure.	
11	600 m. (660 yds.)	Kneeling	2 section targets together on their sides	650 meters	3 hits	
12	300 m. (330 yds.)	Kneeling, 5 shots at word of command	Section target	Flap sight	4 hits.	

tions of a single rifle are added those consequent upon the collective fire of a greater number, the size and shape of the gerbe will be increased and altered, the effect of this fire and of that delivered upon the same object by a group of men, some using one adjustment of the sight and others a different one, is then also given. To show these features practically to the soldier, the best shots are selected, and fire from a rest upon targets placed at different distances, the targets are then placed one behind the other, the central points of the hits marked, and the shape and dimensions of the shot group called to their attention. A similar fire is conducted by groups of from 10 to 25 men each, all with the same sight, and also with the simultaneous employment of two or three different sights. An examination of the targets enables the men to form an idea of the area covered by their fire, and of the probable security that would be enjoyed by an enemy in close or extended order, and with the men standing, kneeling or lying. The comparative effects of independent and volley firing are also shown. All these results are then compared with the tables given in the instructions.

Inspection practice.—This is conducted by the brigade or regimental Commanders, and is held just before the autumn maneuvers, when the year's course of musketry inspection has been completed. The programmes, unknown by the troops until put into practice, are changed from year to year, but generally include tests of the firing of the best shots in the company without regard to class, tests of the best shots in each class, and of the firing of bodies. The ammunition used forms an extra allowance, and the targets and distances are such as will best determine the general state of proficiency that the better men have reached. As the particular nature of the firing cannot be anticipated, it ensures careful attention on the part of the officers to all the details of the course and to all the varieties of instruction.

Prizes.—Five money prizes are given annually in each company, one of \$1.50, two of \$1.12, and two of 37 cents; the highest of these to the first class shots, and one of each of the others to the second and third class. The distribution is determined by the results of the annual course, which must have been completed to render any one eligible. The two higher prizes can at the soldiers option be converted into silver medals. In addition to these money prizes, twelve badges are given to the best twelve shots among the men.

Targets.—For the class firings the stroke target, the infantry target, the figure target, and the section target, are used. The stroke or line target is 6 feet high and 4 feet wide, painted white with a vertical black band down the middle 4⅝ inches wide having at top and bottom two anchor marks 8 inches in total width; the lower of these marks is taken for the aiming point. This target is the first used in the firing of each of the classes, and is mainly intended to teach what the Germans consider of the first importance, that is, accuracy in direction. It shows the men the advantage of a good line shot which may be either too high, or too low, and yet reach the enemy with good effect, while but a slight error to the right or left would render it useless; it is used at only short range, 110 yards, the firing being standing and from a rest.

The infantry target.—This is also 6 feet high and 4 feet wide, and is divided into three vertical bands each 1 foot 4 inches wide; the two outer bands are painted blue, the inner one, called the "man's breadth," is left white. Through the middle of the "man's breadth" is drawn a horizontal black line, and with another horizontal line two feet below it forms the "rectangle" or "oblong." From the center point of the rectangle, three circles are described with radii of 3.9, 5.8 and 7.8 inches, forming "rings" Nos. 3, 2 and 1 respectively, the first two white, the third black; the three rings together form what is called the "mirror" or "looking-glass." The man's breadth is further bisected by a vertical black band 1.9 inches wide, with arrow-heads at top and bottom, for aiming points, the one nearest the mirror being used when with the fixed rear-sight of the rifle the mirror is as represented in the figure. When the lower flap of the rear-sight is used the target is reversed, bringing the mirror uppermost; what then becomes the lower arrow-head becomes the point of aim. This target is used up to 250 meters (275 yards), certain conditions, with respect to hits in the man's breadth, in the rectangle and in the looking-glass having to be fulfilled in the different exercises. The infantry target is in some exercises of the class shooting also used as a moving target, being drawn across the range at an ordinary walking pace, the time of transit being about half a minute: the soldier stands at a ready, waiting its appearance; a failure to shoot while it is in sight counts as a miss.

The figure target is 6 feet high and 16 inches wide, and has on it the figure of an infantry soldier, the trousers and accoutrements painted black. The figure is bisected by a horizontal line, the upper half forming the "trunk" target, the upper fourth of the entire target forms the "head" target, the upper third the "breast" target, and the upper two-thirds the "knee" target. The lower two-thirds of the trunk target constitutes what is termed the "rectangle." The figure target and its various subdivision is used for practice in the different classes, and up to 275 yards. Only hits in the figure counting, in some cases the outline is cut out to give a still greater resemblance to life; they are also used as movable targets in the same manner as for the infantry target. Four of the breast targets when placed on a horizontal axis, and made to revolve, by a system of pulleys and ropes, are also used on a disappearing target, the soldier firing when the target becomes visible; the period for aiming and firing is equal to that required to traverse a distance of twelve paces at quick time.

The section or group target is 6 feet high and 8 feet wide, and is divided into vertical bands 16 inches wide (the man's breadth), alternately blue and white, except that the extreme bands, both blue, are of only half this width. The target is used for the longer distances, the firing being held kneeling, and hits having an equal value in any position. These targets are all of canvas or card-board, the frame work being of wood.

The Musketry Instructions prescribe that for each regiment there shall be two ranges, one 600 meters (660 yards), one 400 meters (440 yards), and six of 300 meters (330 yards); longer ranges are also obtained when possible. Though the country is thickly settled, every regiment in service has its complement of ranges, but they have generally been compelled to take the woods or forests and to cut lanes through them, which are not usually more than twenty paces wide, and each range separated from the adjacent one by from 30 to 100 paces of woods. Under these circumstances it is rarely necessary to make any allowance for the force of the wind, and but little instruction is therefore given in this feature of aiming to which the Captains attach but little importance. When open ground is available for the ranges, rows of trees are often planted between them as a distinct mark of demarkation.

DIMENSIONS OF THE SHOT GROUPS AT DIFFERENT DISTANCES.

Distance.	Axis (inches).	Conjugat Axis (inches).	Per cent. of abnormal hits deducted.	Remarks.
100 m (110 yds.)	6.3	6.3	1	Smaller than a man's head.
200 m (220 yds.)	13.4	12.6	3	Smaller than a man's breadth.
300 m (330 yds.)	22.8	18.9	5	A little broader than a man.
400 m (440 yds.)	33.1	26.8	7	
500 m (550 yds.)	46.5	37.8	8	A little broader than a group of two men.
600 m (660 yds.)	62.2	49.6	9	The height of a standing man.
700 m (770 yds.)	83.5	66.1	10	
800 m (880 yds.)	110.2	83.5	11	
900 m (990 yds.)	148.8	103.9	12	More than twice the height and six times the breadth of a standing man.
1000 m (1100 yds.)	186.6	127.6	13	

Three men constitute the detail for marking, one of these raises a flag as soon as he hears a shot and keeps it visible until the other men, who meanwhile have been signaling the hit and plugging the shot-hole, return behind the shelter; the firing therefore is necessarily slow. Besides the record of the entire company kept by a Non-commissioned Officer, each soldier keeps a private target record book, which shows the nature of his failures, the exercises he has completed, and what yet remains to be accomplished for promotion to the higher class. Officers endeavor to sustain the soldier's interest in his progress by frequently inquiring as to his standing, and when he finally goes into the reserve the class he was in is noted on his papers.

In all the details of the German soldiers instruction in rifle firing, the feature which attracts the greatest attention is the fore-thought and thoroughness with which every step in his education is directed, the object to be attained being steadily kept in view and every effort made to fit him for the proper and effective use of his weapon in battle. At no stage of the practices are the targets those that would be best adapted for match shooting, and, though the exercises are of increasing difficulty, yet there are no scores, no sacrifice of useful instruction in a striving after a fictitious numerical excellence. To the class shooting, with even its very great and practical variety, is added the vitally important field practice with its volley and independent firing, its maneuvering and skirmishing, held over ground with all the accidents of hill and plain, stream and forest, on which troops would be likely to advance or retire in action. Nothing then is taught, but what would be most useful in war, but that is taught most thoroughly and with the most enlightened attention; as a consequence, the German soldier, if perhaps not as good a target shot as his brother in arms in some other countries is, yet in the effectiveness of the fire he would be able to deliver in each of the stages of an action fully equal to those of any other country.

FRANCE.

In the French Army the instruction of each regiment in rifle firing is placed under the general control of the Colonel, the details being arranged by the

Lieutenant-Colonel, and while the company Commander and his officers are considered as responsible for the instruction of their men, it is to a great extent placed in the hands of other officers selected for that purpose from among those who have passed successfully through one of the Schools of Musketry.

The officers so chosen.—a Captain for each regiment, a Lieutenant for each battalion, act as Instructors of Musketry for the organizations to which they belong. They are present at all the firing exercises of the company and supervise the instruction; they have general charge of the range, the targets, and all the accompanying material, and each year before the commencement of the course, conduct the preparatory exercises of the Lieutenants, and have charge of the theoretical and practical instruction of the Non-commissioned Officers, including elementary lessons upon the more important points of the general principles governing the employment of fire in action. At the conclusion of this course, the Colonel of the regiment, assisted by the Lieutenant-colonel and Majors, examine the Officers and Non-commissioned Officers, excusing those of the former who appear thoroughly proficient, and requiring instead of their attendance in future years, written essays on Musketry instruction; among the latter he gives the preference for promotion to those most conspicuous for their zeal and ability to instruct others. Great value is attached by the French to these regimental schools of instruction. The course of instruction is divided into the preparatory drills, firing with reduced charges, estimating distances, and the firing exercises.

In the first of the preparatory exercises (the aiming drill) use is made of a stand for the rifle by which direction can be given, with the line of sight at the proper and convenient height for the soldier when in the firing position. It is so arranged, that the but can be brought against the shoulder of the recruit and is of such stability that after pointing is completed the instructor can verify the aiming with accuracy. The soldier is first shown the points fixing the line of sight, and instructed to bring the top of the front sight up into the center of the notch of the rear sight, even with the upper edge of the slide and touching the bottom of the mark; this is first done by the instructor, then examined by each recruit in turn and afterwards done by the latter. This aiming is practiced with the rear sight adjusted for different distances, and the soldier cautioned to keep the plain of sight vertical. To verify the soldiers accuracy and to show him such irregularity as may exist, the rifle is directed at a large sheet of white paper, the marker then moves a disk until the soldier judges that it appears in the line of sight; its position is then marked, two repetitions of this aiming afford, by joining the designated points, a triangle of error which by its size and the position of its sides shows the soldier his lack of uniformity and the probable nature of his errors. After slightly altering the position of the piece the exercise can then be continued until the fault is overcome. By removing the bolt (or breech block) the relation between the line of fire and the various lines of sight, and the effect of canting the rifle to either side is then demonstrated. The men are also taught the manner of making allowances for the deflection of the bullet due to the wind, or for any fixed deviations peculiar to their own particular weapons. Position drills follow as soon as methods of sighting are understood; first with the soldier standing but only performing the motions of bringing the piece to the shoulder, then looking along the sights with various adjustments, but not at any mark, and finally with aim taken at some designated point and at the eye of the instructor. These exercises are performed in a similar manner from a kneeling and a lying position. After them the soldier is practiced in pulling trigger until he is thoroughly familiar with the amount of force necessary for discharging the piece. All these exercises are then combined, the men going through the different motions of aiming and firing at a mark, with various adjustments of the rear sight and from all varieties of position, at will and at word of command, as independent firing and also by volley. In the French instructions (Régiment sur l' Instruction du Tir) these different preparatory exercises are prescribed in great detail and great stress laid upon the necessity for their careful observance.

For the reduced firing a cartridge having about 6 grains of powder and a cylindro-ogiral lead bullet is used; the firing is conducted at 15, 30, and 45 meters (49, 98, and 148 feet), and upon targets 4 inches, 10 inches, and $17\frac{3}{4}$ inches in diameter, respectively, each hit counting one, and the following exercises being conducted :—

Number of Exercise.	Distance Meters.	Sight adjustment Meters.	Kind of fire.	Cartridges allowed.
1	15	200	Individual, Standing,	6
2	15	200	" Kneeling,	6
3	15	200	" Lying.	6
4	30	300	" Standing,	6
5	30	300	" Kneeling,	6
6	30	300	" Lying.	6
7	45	400	" Standing.	6
8	45	400	" Kneeling.	6
9	45	400	" Lying,	6
10	30	300	and at command.	6

The first four of these exercises are executed before the recruit is given any individual ball firing on the range, to which he is not advanced unless he obtains 16 points in the 24 shots; in case of a failure to make this score he is returned to the preparatory drills. As the allowance for the reduced firing is 100 cartridges, 40 will refrain from the preceding exercises which are used in volley firing and in individual practice at 15 and 30 meters, using lines of sight of 500 meters and above; in these latter cases the point aimed at is at certain fixed distances below the center of the target, depending upon the height of sight employed. Detailed reports of all these firings are made by the Captain.—Instructor of Musketry.

Probably greater attention is paid to instruction in estimating distances in the French, than in other armies, and they consider it a necessary complement to accuracy of fire. The course is divided into the preparatory exercises in measuring distances by pacing, and in estimating by sight and by sound. In pacing, the men are taught the relation existing between the length of their natural steps and one meter, the exercises being held over a distance of 100 meters, divided into ten meter intervals, first over level and then over other varieties of ground. The instruction is then continued over greater distances, and until the men do not commit errors in excess of two meters in every hundred.

In estimating by sight the company is divided into sections and half sections, and from each markers sent out who establish themselves in pairs at a distance of 200 and 400 meters. One marker stands fast, the other at a distance of 2 or 3 yards from the first, kneels or lies down going through the motions of firing. After the instruction has been repeated on different days, markers are sent out in other directions, their appearance compared with the established ones and an estimate and consequent adjustment of the sight required from every soldier. A Corporal accompanied by a trumpeter then paces the distance and the latter by previously arranged signals signified it to the squad. An examination of the sights and rectification of the soldiers errors then follows. This drill is continued in a similar manner between 400 and 600 meters (440 and 660 yards) and subsequently up to the latter distance without the aid of markers for comparison. When the locality is favorable the exercises are also held on uneven or broken ground with dissimilar back grounds and under various conditions of light and shade, as many of the practical difficulties of accurately estimating distances being introduced as possible. Battalion Commanders are required to instruct their officers in estimating distances with the aid of a fields glass up to 1,000 to 1,200 meters (1,094 or 1,312 yards) and by sound up to still greater distances depending upon the object whose distance is sought. In the case of a section firing the limit within which the determination can be considered as accurate, is about 3,000 yards or about the limit of unaimed infantry fire; the limit of artillery fire about 6,500 yards is considered as the limit of the application of this method to that arm of the service.

The firing exercises are divided into the individual fire, the collective fire, the field firing and the special firing. For the individual fire, 93 ball cartridges and seven blank cartridges are allowed, and for the collective fire, 9 blank and 27 ball cartridges distributed as indicated in the following tables.

rifles thought to have been defective, and any that he so considers are replaced by others. The preparatory firings afford a test of the soldier's weapons, and also an opportunity to the instructors to correct the more glaring errors of the men; they are not considered in the classification, but men who in the two firings do not make five points (the system of scoring will be described in connection with the targets) are put back to the preliminary exercises and also repeat the firing. If successfully accomplished the men are advanced to the instruction firing.

The object of this is to teach the man the value of his arm and to utilize its precision up to the limit of individual fire, and also to determine the relative accuracy of the individual soldiers.

The company is divided into as many squads as there are targets available for the practice, and these squads further sub-divided in the discretion of the officer. The fraction about to fire is formed at an order arms ten paces in rear of the firing point, the remainder 20 paces to their rear being permitted to break ranks. The officers fire first, then the man on

INDIVIDUAL FIRE.

Number of Exercise.	Distance.	KIND OF FIRE.	CARTRIDGES.		
			Blank.	Ball.	
		INSTRUCTION FIRING.			
1	200 m.—220 yds.	Kneeling } Preparatory	2	6	12
2	220 m.—220 yds.	Standing }		6	
3	100 m.—110 yds.	Kneeling	2	6	60
4	200 m.—220 yds.	Standing		6	
5	200 m.—220 yds.	Kneeling		6	
6	300 m.—330 yds.	Kneeling		6	
7	300 m.—330 yds.	Standing		6	
8	400 m.—440 yds.	Kneeling		6	
9	500 m.—550 yds.	Kneeling		6	
10	600 m.—660 yds.	Lying		6	
11	200 m.—220 yds.	Kneeling with bayonet fixed		6	
12	200 m.—220 yds.	Kneeling		6	
13	400 m.—440 yds.	Firing at command	3	3	
		APPLICATION FIRING.			
14	250 m.—275 yds.	Standing, upon Silhouettes of single men kneeling		6	18
15	325 m.—355 yds.	Kneeling, upon silhouettes of singlemen standing		6	
16	175 m.—190 yds.	In a shelter trench, with bayonet fixed, upon Silhouettes of men standing		6	
		COLLECTIVE FIRE.			
1	600 m.—656 yds.	Volleys by squads standing or kneeling	3	3	15
2	800 m.—875 yds.	Volleys by half-sections standing or kneeling	3	6	
3	1000 m.—1094 yds.	Volleys by sections	3	6	
4	Between 300 and 150 m.—330 to 165 yds.	Skirmishers standing fast and with 300 m. sight, upon silhouettes standing and kneeling at 1 m. interval between axes		6	12
5	600 to 400 m.—656 to 440 yds.	Skirmishers advancing upon line of silhouettes at 2 miles intervals		6	

Each day before commencing the instruction firing at either 100, 200 or 300 meters, the instructor of musketry fires 12 shots from a rest with a gun whose accuracy is known at a target of the same size as that to be used for the practice of the company, but divided into 400 small squares so that the center of impact of the group can be quickly determined, the point of aim and the center of impact when found are then marked on the target, and also on a regulation target placed on one flank of the line of targets to be used for the company firing, from which the men can determine the proper corrections in their sight adjustments for that day's practice. After the practice, the Instructor of Musketry prepares the report for the battallion Commander, and also tests by firing upon the special target above mentioned, all

the right steps out, loads, fires his six shots in succession, and moving by the left flank places himself five paces in rear of the firing party. He is followed by his rear rank file and in succession by the remainder of the party. During the firing the officers give to the men such cautions or instructions as may be necessary, advising them what sight to take, when to aim, etc.

Only the 60 shots fired in the 3d to the 12th exercise inclusive, are considered in the individual classification, which is made on the close of that practice in the month of August of each year. All, whether Non-commissioned Officers, old soldiers, or recruits, who have made in these practices at least 64 points for the 1st Class, those making 36 points but less than 64 form the Second Class, and those making less than

36 points the Third Class. The class which the soldier reaches determines the nature and amount of his subsequent practice for the year.

The individual fire at command(the 13th exercise), is conducted with but one man at a time, and in the same manner as the preceding exercises, except that the soldier only fires at the command: promptness is thereby inculcated and opportunity afforded the officers to judge the effect of variations in the methods of giving the commands upon the accuracy of fire.

All the instruction practices are executed as much as possible in favorable weather, it being considered essential that the firing should be under the best conditions, and that the soldier should abstain from all fatiguing exercises before coming to the firing point; they are therefore conducted in easy dress and without the knapsack.

The object of the application firing is to teach the soldier to fire in all positions upon special targets presenting an appearance similar to what would be met in war; figures of men standing and kneeling are therefore used, of life-size, and covered with black paper, and the firing is held as far as possible on other than the target grounds at known but yet such intermediate distances (for which the sight is not directly graduated) as will require careful judgment from the soldier. The silhouettes, five yards apart, are assigned one to each soldier, who at the signal advances to the firing point, takes the designated position, and fires his six shots, after which his target is examined and the hits counted, ricochets being given the same value (two points) as direct hits. The Lieutenants and Non-commissioned Officers participate in the entire course of individual firing.

When the soldiers have become familiar with the individual firing, they are advanced to the collective fire, which is divided into volley and skirmish firing. The volley firing is conducted at the ranges, at which it would be mainly used in battle and by squads of not less than 6 men, half sections of not less than twelve men, and sections not less than 24 men in strength, each under their appropriate Commanders. Its object is to afford practice to the officers in giving orders, and to the men the necessary coolness and confidence in their officers.

In the first of the skirmish exercises the targets are placed between 165 and 330 yards from the men, to whom the exact distance is unknown, they are required to use the battle adjustment of the sight (300 meters), and to aim at or slightly above the feet of the silhoutte targets according to their judgment of the true range. Two shots are fired rapidly in succession, sufficient time being taken for the aiming and firing, haste only being made in taking the proper position and in loading. In the second skirmish exercise, the firing line advances towards the silhouttes, the ranges fired over being between 656 and 440 yards, the men advance about 50 yards in each spurt, halt and fire two shots, three halts in all being made, in both of these skirmish firings the results are expressed by the per centage of the possible number of hits. It is laid down that before the practice which shall be held in marching order, a maneuver or march of some considerable duration shall have been executed, so that the troops shall be brought to the ground in the condition in which they would probably be when arriving upon a line of battle. It is further required that ground unknown to the men shall be used for the firing, such, moreover, being selected as presents considerable diversity of surface and will afford cover.

For the field firing, no particular rules are laid down, its object being mainly to instruct the troops in fire discipline, and in the varieties of fire to be employed in different stages of an action. The ground chosen is one in which entire freedom of fire is obtainable in all directions, and where the men can find cover. The firing is arranged to represent particular stages of an offensive or defensive action, thus obliging the officers to combine rapid execution of such movements as may be necessitated by unforeseen positions, with a judicious employment by different kinds of fire according to the distances, the variations in the ground and in the tactical conditions. Preparatory maneuvers are always executed, and the time when the action of the company engaged is presumed to commence is indicated by the officer having supervisory charge of the practice, as well as the time during which the objective is supposed to be visible. The first of the field exercises is held by the company raised to its war strength of 200 men, the second exercise, which is omitted when no suitable ground is available, is for the regiment, divided into two battalions, with all the companies at the war strength. A more important tactical idea is then developed than for the company firing. When practicable these exercises are held several times each year, the idea being changed on each occasion. The special firing is held only by those who have reached the first class and always from a kneeling position. The targets 200 meters distant, are for the first exercise, disappearing revolving ones, but whose place of appearance is known to the firer, this is in the second exercise varied by not informing the soldier from what point of the target-pit the target will appear: for the third exercise a silhouette of a standing man moving across the range is used; in the fourth exercise the range is increased to 400 meters and a rectangular target two meters high and one meter broad moved across the range; in all of these cases three cartridges are allowed for practice. In the fifth of the special exercises each man (of the first class) fires 10 shots kneeling, at 200 meters upon a square target two meters on a side, which is divided into 400 equal squares. The shots are not signaled, but upon the conclusion of the firing the target examined and the hits plotted upon a diagram, which is then properly attested and given the soldier as a testimony of his skill.

After the close of the annual course two competitive firings are held, one between the sergeants of the first class, and the other between the best eight corporals and men of the first class, in each of the companies of the regiment. A target is used in which the outer ring has the same diameter (39.4 inches) as in the regulation 200 meter target, but instead of a single interior ring, with two rings 12½ and 26 inches in diameter respectively. Hits in the innner ring are scored 3, and in the outer rings 2 and 1 respectively; hits in the target without the larger circle are not counted. The firing is at 200 meters (220 yards), each competitor being permitted two sighting shots (of which the results are signaled) and six scoring shots, fired either standing, kneeling or lying down according to the soldier's preference; these latter are not signaled, but the target examined and the hits scored after each man has fired his six shots. In cases of ties single shots are fired until a decision is obtained. For this firing three prizes are awarded to the successful competitors among the Sergeants, and ten among the Corporals and privates. The first prize becomes the property of the winners, and is worn during their service, or at any time when they may be called back into the ranks: the second class of prizes, embroidered hunting horns, worn upon the left sleeve of the coat, cannot be worn a second year unless the man remain in the First Class. Besides these prizes 37 others of somewhat similar nature are given to those men who have been most successful in the individual firing of the annual course. Furloughs of thirty days are also granted at the close of the Autumn maneuvers to all those who have won these prizes, provided they are otherwise deserving, and during the course, passes for a certain number of days to the Sergeants until midnight, and the Corporals and privates until 10 o'clock at night, to those who have distinguished themselves in their regular practice.

In adopting targets for the French Army, the desire to indicate accurately to the soldier the position of his misses, as well as his hits, when firing at short ranges has appeared paramount; the entire surface of the target is therefore made 6½ feet square for all ranges up to 500 meters (550 yards) inclusive.

For the individual firing at 100 meters, a circular band two inches wide and whose interior diameter is 19.7 inches is described, and within this circle a second circumference with a diameter of 9.8 inches. Hits within the smaller circle are scored two, outside of that but within the larger, one; hits in the target, but without the larger circle, are scored as misses, but their position indicated to the soldier. For 200 and 300 meters (220 and 330 yards) similar targets are used, except that at 200 meters the diameter of the circle is 39.4 and 19.7 inches, and at 300 metres 59 and 29½ inches. On each of these targets, in addition to the circles, are drawn two straight lines, two inches broad, one horizontal and the other vertical, and intersecting at the center of the target; these lines, however, are not considered in scoring hits.

The target for 400 meters (440 yards), individual firing, is without circles, on it the horizontal and vertical lines just mentioned are four inches broad, with, at equal distances to the right and left of the vertical lines other vertical lines four inches broad, thus forming with the upper and lower line of the target a rectangle 6½ feet high and 4 feet 11 inches wide on which all hits are scored, two; hits without this rectangle are considered misses. At 500 meters (550 yards) the target has only the two broad intersecting lines, and hits in any portion of its entire surface are scored, two. For 600 meters (660 yards) the target with the same two intersecting bands, is 6½ feet high and 9 feet 10 inches wide. These are all the targets used for that portion of the individual practice termed the instruction firing. For the application firing, silhouettes, representing single men standing or kneeling are secured to a frame work of the same size and outline, they, therefore, have to the figures almost the same appearance that a man would present at the same distance.

For the collective firing, the targets for the volleys of squads are panels similar to the rectangular target used at 600 meters, but 16 feet, 4 inches wide; for the volley firing of half sections, the panel target is 32 feet, 8 inches, and for that of sections, 65 feet, 5 inches wide; in all cases it is 6½ feet high; the score is expressed by the per cent. of the possible number of hits. For the collective skirmish firing the objective is composed of at least two lines of targets, of three where it is possible, representing the different echelons of a hostile company in order of battle: the first line representing the skirmishers, is formed of 14 to 28 of the silhouettes, alternately half-standing, half-kneeling, with the addition of a number of small rectangular targets, 19 inches wide and 30 inches high, or 19 inches wide and 6½ feet high, all covered with black paper. The second line, about 165 yards in rear of the first, is composed of two panels each 16¼ feet wide (separated when the ground will permit) on which are painted seven figures of standing men, similar to the silhouettes. The third line, which is always arranged when sufficient material and extent of ground can be obtained, represents a supporting section formed by a panel occupying a front of 65½ feet, on which 28 of the standing silhouettes are painted.

For the field firings, the objectives are necessarily varied according to the nature of the exercises to be executed. Lines of skirmishers are represented by silhouettes of men standing, kneeling, and lying, and their supports by panels, on which these figures of standing men are painted. Troops in column are indicated by several of these panels, one behind the other, with their depth not exceeding the normal depth of a column. Artillery in a similar way, is depicted by panels on which are traced silhouettes of guns, limbers, caissons and of the cannoniers and their officers, all being placed in the positions that an enemy would be most likely to occupy.

The French Musketry Instructions prescribe that the target ranges shall be located where an extent of ground, at least 700 yards long and 65 yards wide, can be obtained; the ground should be horizontal or with only a gentle slope and that preferably ascending; behind the targets the lands should be entirely unoccupied for about 2,700 yards, or else a butt 20 feet high should be erected. Five yards in front of the butt the line of targets is established, in front of them a covered trench for the markers. To avoid confusing the firers, not more than ten targets, five yards apart, are arranged in one line. If this does not afford facilities for the number of troops occupying the range, a second butt and line of targets is placed with an interval of about 200 yards on the flank of the first. On the line perpendicular to each target and at intervals of 100 meters, pegs are driven in the ground indicating the distance and the firing point for each particular target. At the entrance to the range a permanent building is erected, and a telephone line is run from it to the marker's shelter. The target frames are made of steel, and are covered with several layers of paper, and finally with a paper target.

Three men are required to each target for the duties of markers; one of these when a hit is made indicates by the manner in which he moves his signal flag, the divisions of the target in which the shot struck, while the second by means of a staff, on one end of which a small disk of paper is placed, stops up the shot hole; the third marker prepares these disks and places them on the staff. The markes are not permitted to leave their shelter except at the signal, cease firing.

The theoretical principles of rifle firing are explained with great detail and careful elaboration in their musketry instructions, and with them the Officers are required to be familiar, and the Non-commissioned Officers to have a fair understanding of their most essential features.

The various forces which act on the bullet, both during its passage through the bore and its flight in the air are fully explained, as also the causes which produce a deflection from the point aimed at. The influences inducing a dispersion of the bullet are recognized, and the resulting shape and size of the shot group at different distances is tabulated; the soldier is thus instructed in the size of the objective, which at various ranges the degree of accuracy of his weapon affords him a probability of hitting.

Distance.	Vertical.	Horizontal	Area of resulting Rectangle.
	Inches.	Inches.	Sq. inches.
100 m. (110 yds.)	7.2	6.3	
200 m. (220 yds.)	14.9	12.7	
300 m. (330 yds.)	22.6	19.3	
400 m. (440 yds.)	31.0	26.1	
500 m. (550 yds.)	39.6	33.1	
600 m. (660 yds.)	49.4	40.3	
700 m. (770 yds.)	58.3	47.8	
800 m. (880 yds.)	68.1	55.7	
900 m. (990 yds.)	79.5	64.2	
1000 m. (1100 yds.)	91.3	73.2	

The tables give the breadth of the indefinite horizontal band in which are concentrated the best half of the shots, considering only the variations in a vertical direction; and also the width of the corresponding vertical band, containing half the hits for which the horizontal variations are the least. The intersection of these two bands thus forms a surface on which one-fourth of the hits corresponding to those trajections which have been least influenced by the by the variations incident to the arm and its ammunition, are concentrated.

The vertical dimensions of this surface exceed its horizontal, and in a continually increasing proportion as its distance from the firer becomes more remote; for distances up to 1,000 meters they are given the foregoing table.

Dimensions of the surface of greatest concentration of hits (one-fourth of total number).

The trajectory corresponding to the center of this surface is called the mean trajectory, and upon its features are based the rules laid down for fire at different distances. The relations between the height of this trajectory above the line of sight, the angle of fall and the resulting dangerous space both on level ground, and on that sloping either up or down in the vicinity of the point struck, are elaborately discussed, and the probable effects of fire under such conditions carefully explained. To these are added instructions with reference to plunging and indirect fire, and to the proper times and distances for opening fire in action, the appropriate kind to be delivered, whether volley or slow or rapid individual firing, and the simultaneous use of several adjustments of the sight.

The French course of instruction, while in its practical details somewhat inferior to the German, yet in its skirmish and field firing affords its soldier a good training; but while perfecting its officers in the necessary control of their men, yet does not accomplish it in the same thorough manner so noticeable in the German Army.

AUSTRIA.

The course of musketry instruction in Austria is continued throughout the entire year, but receives during the summer months the greatest attention. In winter the practice is not entirely discontinued even in severe weather, but it is prescribed that on the coldest days, neither officers nor men shall be kept longer than two hours on the range.

The general direction of the instruction is made part of the duty of the commanding officers of battalions and regiments, who are required to ascertain personally as well as from an examination of the regular reports, that it is conducted strictly in accordance with the regulations. The actual instruction is placed in the hands of the company officers, though to each regiment is attached a Captain who is charged with a general superintendence of the course, and to each battalion a Lieutenant, who is a graduate of the School of Musketry, and who exercises a supervision over the instruction in both the theoretical and practical parts of the work. These officers make reports from time to time to the regimental and battalion Commanders, and call their attention to any departures from the authorized course. The company officers receive the same instruction as the men, particular attention being paid, in fact, to their target practice.

The course of instruction is divided into the preliminary drills, estimating distance practice, class shooting, practice shooting, and field firing.

The preliminary drills comprise exercises in aiming, in position drill, and in firing with reduced charges. In aiming, the soldier is first taught with the assistance of a rest, aiming at a small black disk between one and two inches in diameter, and also at the eye of the instructor. In the earlier drills, when the disk is used, the instructor verifies or corrects the accuracy of the soldier's work, afterwards he is permitted to practice independently and finally the regulation targets are used at their appropriate distances and aim taken upon them.

Position drill is taught standing, kneeling, sitting and lying down; and is then combined with the aiming drill; the soldier is also taught to aim from behind trees or low shelters, and at objects moving across the field of fire as well as towards or from the firer, the appropriate points for aiming under these circumstances being prescribed in the manual. It is required that the trigger shall be pulled by a steady pressure, and the rifle kept directed at the mark for three pauses of quick time after firing, so that any deflection of the piece may be detected. In aiming a full sight is taken and aim directed, as a rule, at the middle of the object to be hit.

For gallery practice a rifle is used, exactly similar in appearance to the regulation piece but of only about half the caliber, the bullet weighing only 24.7 grains. The targets are usually placed at about fifteen paces from the men, and so constructed as to have at that distance, the same appearance that the targets used on the range have at the full distance used for actual firing.

In the estimating distance practice it is desired to so perfect the soldier that he will be able to determine accurately distances up to about 350 yards; for Officers and Non-commissioned Officers proficiency is expected up to 1,000 yards. At the commencement of the instruction, soldiers (as markers) are placed one behind the other at intervals of 100 paces, but so that all can be seen from the position of the company; the attention of the men is then called to the comparative appearance of each of the markers, to their relative height, and to three articles of their dress that remain distinctly visible; they are also required to compare the apparent length of each of the 100 paces intervals. This instruction is first conducted on level ground; afterwards on rolling or on broken ground: with the markers in plain view, and also with them partly concealed behind trees, stones or other slight shelter. The influence of the period of the day, of the clearness of the atmosphere, of the nature of the intervening space and of the back ground, are all to be brought to the soldiers attention, and the exercises persued under all available varieties of these conditions.

In the class firing the squads do not exceed 15 men under the command of an Officer or Non-commissioned Officer. After the signal, commence firing, the name of the first man on the roll is read out, when he steps to the firing point, loads and fires. After firing and before the shot is signaled he calls out where he believes he has hit the target, or when this appears difficult, indicates this presumed position on a diagram of the target prepared for that purpose. After the shot is signaled, any errors in the soldiers estimate of his hit are called to his attention, and such cautions or instructions as may be deemed necessary given before the next shot. In this manner a score of five shots is fired, when the soldier after seeing that they are properly recorded gives way to the succeeding man. For the class shooting the second and third class men use 70 of the 110 cartridges allowed annually for practice. At the commencement all recruits are placed in the 3d. Class and begin practice on the target No. 1, at 125 yards continuing until in a score of five consecutive shots they make a total of 30 points (for method of scoring, see the description of the Austrain targets), when the range is increased to 166 yards, at which distance practice is continued until a score of 30 points is made. The soldier then fires on targets Nos. 2 and 3 at 250 yards, until he makes a score of 30 points at each, when he is transferred to the 2d. Class. To reach the Second Class, then it requires for the most expert 20 cartridges, but with the poor shot the expenditure of the 70 may still find them in the 3d. Class.

The 2d. Class practice at 333 yards, using No. 2 target; in two consecutive scores of five shots each, 30 points must be made in each score for the advancement to the 1st Class. Men who have reached the 1st class are called marksmen, and in succeeding years have no course of classshooting. Any ammunition that they may have saved from the 70 cartridges allowed for the class shooting when qualifying as marksmen, is expended as well as the regular allowance in the practice shooting.

The practice shooting is conducted by the marksmen and 2nd Class men, and those of the 3rd Class who with the expenditure of less than 70 cartridges have been advanced to practice at No. 2 target at 250 yards. These 3rd Class men then fire 10 shots at the whole figure target, at 125 and 166 yards. The practice firing for Marksmen in the year in which they attained that class is the same as for the 2nd Class: in following years they are allowed 70 cartridges, which are distributed in practice at the whole figure target at 166 and 250 yards, and at the disappearing target at 166 yards. At the one-third and one-fifth figure targets, at 125 and 166 yards, and at the head target at 125 yards. At the whole figure target in motion up to 166 yards, and at the moving cavalry soldier target up to 250 yards. At No. 2 target up to 416 yards, and at the group target from 500 to 1000 yards.

After the close of the class and practice shooting the whole command is exercised in the field firing, which is intended to instruct the soldier in the proper use of his weapon in action: it is first conducted by the classes firing separately, and then by all united. In the first of these exercises the 3rd Class are practiced up to 250 yards, the 2nd Class up to 333 yards, and the marksmen up to 500 yards. A section target, 12 feet 8 inches wide is used with a few figure targets placed in front and on each side, then for the 3rd Class all whole targets, for the 2nd Class half targets, and for the marksmen both whole, half, and third targets, some of these targets being arranged if possible so as to appear and disappear. The men advance towards and retire from the targets taking advantage of the variations of the ground for cover or rest, the practice being generally held more than once, but only fifteen cartridges in all being allowed. After the three classes are united, the firing is conducted in a similar manner up to 500 yards, five cartridges being allowed and the target being a section target 25 feet 4 inches wide, with the former addition of whole, half and third figure targets. In addition and for which ten cartridges are allowed, practice is held in the delivery of volleys and independent firing from closed bodies up to a distance of 333 yards.

The field firing by the three classes united is considered the most important part of the soldier's instruction, since without it, from the class-shooting, he may become a good target shot, but without any thorough knowledge of the use of his rifle under the conditions certain to arise in war. Special attention is therefore paid to it; it is required that it should be made as real as possible, that the men shall be in full marching costume,and that the companies should be brought up to their war strength. When possible it is conducted over ground with which neither the officers nor men are familiar, and that experience may also be gained in marching and bivouacking which is preferably at some considerable distance from their permanent station. The tactical idea or theme is therefore changed from year to year, as are also the allowances of ammunition for the purpose, the targets fired at and the distances covered by the action. No better idea can be conveyed of the thoroughness of the instruction in its various details, than that given in the following description of a late practice of two Austrian battalions. "The two battalions started from their respective garrisons (different points) at 2 o'clock of an afternoon in the month of August, in full marching order and with two days' rations; the day was very hot, the thermometer registering 104°. They reached their bivouac at 9 P.M.,after a march of about 14 miles, placed their outposts, lighted their camp-fires and bivouacked on the bare ground. The next morning they assembled at 7.30, and the two battalions, which were on the peace strength,were united so as to form one of war strength, the total number of men in ranks being 743. The ground over which the maneuver took place consisted of a valley between two far-projecting spurs. The enemy (the targets) occupied the upper end of the valley, the lower end of which was closed by a village. From the village to the position occupied by the defenders was a distance of about 2,500 yards, the slope for the first 1,000 yards being gentle and regular and for the remaining 1,500 yards undulating, thus affording good cover in places to the attacking troops,but,at the same time, often hiding the enemy from view, especially from that portion of the ground comprised between 670 and 840 yards from his position. The right flank and center of the defenders' shooting-line was also partially hidden by a row of trees in front of it. The northern space was clothed on its northern side with wood, which was of considerable tactical value in turning the defenders' flank. It will thus be seen that the position was one of an average character, such as might frequently be met with any day in actual war. The enemy which occupied it was supposed to be three companies strong, the shooting-line being about 170 yards long, and divided into five sections. It was represented by targets one foot high and of the requisite length. There were three supports represented by targets, 62 feet long and 3 feet high. The reserves were represented by disappearing targets, 54 feet long and of the full height of a man; these at intervals of three or five minutes were made visible for five or ten seconds.

The proceedings were conducted in strict accordance with a tactical idea laid down beforehand. At 8 o'clock the battalion commenced its advance towards the ground where the firing was to take place, at 10.10 A. M. the advance guards made out the position of the enemy, at 10.20 A. M. the fight commenced by the advanced guards, which was one-quarter of the fourth company, firing volleys, the distance being between 1000 and 1250 yards. When at about 900 yards from the defenders the shooting line was formed by the whole of the fourth company, the third acting as its support 250 yards in its rear, and the first and second companies being in reserve. One section of the third company and one of the first fired volleys over the heads of the shooting line, the nature of the grounds permitting. At 750 yards the shooting line was formed by the third and fourth companies with one section of the first, the remainder of the battalion being in reserve.

At 400 yards the first, third and fourth companies formed the front line, the second being in support. At 170 to 200 yards the second company joined in close order the right flank of the line of skirmishers, and the intention being to turn the enemies left flank, they and the right of the line prepared to advance covered by the rapid fire of the left, when the Commandant thinking that the object of the exercise was gained stopped the action." Throughout the advance the men were kept well in hand, the control of their officers and the discipline of the men being well illustrated by the fact that in a front extending over 300 paces the firing had twice been stopped, and several times the composition of the shooting line changed. Such an experience bearing as it does the impress of war is of exceeding value and a most necessary element of the musketry instruction.

The targets used in the Austrian service are so divided as to place before the soldier a representation of the space within which his bullet would have to strike in order to hit an adversary standing; this is accomplished either by a longitudinal marking of the target, or by painting upon it the figure of a man, and in both cases with certain other minor divisions, oval or elliptical in shape and with the longer axis vertical, the soldier that learns that it is not of so much importance whether he hits high or hits low, the prime object being to hit somewhere, and by thus dividing the target this fact is constantly brought before him and impressed upon his mind, the instruction is thus even in the class shooting, or target practice proper, directed in the manner which will render the knowledge acquired of the greatest practical benefit in war. Target No. 1 used only for the third class and for ranges up to 166 yards: it is 6 feet 4 inches high and 4 feet 3 inches wide and by vertical straight lines is divided into three longitudinal divisions, the outer ones each 16¼ inches wide are colored gray, the inner, 18½ inches wide being left white.

In the upper portion of this central part is carefully designated an oval about 28 inches long and 14 inches broad, whose center is 56¼ inches above the bottom of the target. Hits in the exterior or gray divisions of the target are scored two, in the center section eight, and in the oval ten. To assist the soldier in aiming a circular black aiming point 9½ inches in diameter is painted on the target, and as when in firing at 125 yards with the sight set at its lowest position, that for 166 yards, the bullet will strike 20½ inches above the point on which the rifle is directed, this aiming point is so placed that its lower edge shall be at that distance below the center of the oval. In scoring the hits no attention whatever is paid to the aiming point, the outline of the oval alone determining whether a shot in the central section shall count eight, or ten.

Target No. 2, used for ranges from 250 to 410 yards, it is of the same height and breadth as No. 4 target. The greater portion of the target is left white, but on its central portion is the figure of a man standing, six feet high and 22 inches wide, at its widest portion, painted gray with the outlines of an oval traced upon it. The oval which is of the same dimensions as in target No. 1, has its center three feet from the bottom of the target. Hits in the white portion of the target are scored two; in the figure, eight; and in the oval, ten. The aiming point for this target is at a black circle 14 inches in diameter, so placed that its lower edge (at which aim is taken) passes through the center of the oval; it is so placed that at all ranges at which the target is employed the sight can be correctly adjusted. The aiming point is not considered in scoring the hits.

Target No. 3. The same as target No 2, except there is no aiming point; it is used at a range of 250 yards; hits are scored as for target No. 2. These three classes of targets are made to pull up and down or to revolve, in which latter case two targets are arranged on opposite sides of a central axis so that while one is exposed in the firing position, the other is conveniently placed for the marker to cover the shot hole. The frame work of the target is generally of wood, though it may be of iron, covered with canvass or linen and then with a printed paper target. The figure target is a colored representation of a soldier standing, pasted on pasteboard and strengthened by a frame work; it is six feet high and every shot which strikes it is scored ten. The upper half and upper third are also used alone to represent a man kneeling, and the upper fifth, the head and shoulders to represent a man behind a shelter trench; for this latter purpose the head alone is also sometimes used. Besides the infantry figure target one representing a cavalry soldier is also employed, and both are used as movable and disappearing targets.

The group target is used up to ranges of 500 yards, it is 6 feet, 4 inches high, and 11 feet 10 inches wide, and has a white ground on which a number of infantry figure targets are pasted so as to form a group. When used at longer ranges several of these targets are placed side by side, or a number of No. 3 targets can be used for the same purpese. Special section targets, one foot high to represent men behind temporary field shelters, or three feet high to represent men kneeling, and of a length determined by the number of men whose positions it is intended to indicate, are also used for the field practice of the three classes united, as well as other targets representing cavalry and artillery.

On the ranges for the class shooting, the targets are placed on the same line, and in front of them a traverse of earth or a continuous wooden hut, covered with earth on the side furthest from the targets, is constructed. At some convenient point on the range a staff and flag are placed to indicate the direction and approximate the force of the wind. Shelters are also erected at the firing points from which the men practice. For communication between the firing party and the butt, a bell of telegraphic apparatus is used. The detail for marking is composed of two men, who as soon as a shot is fired on their target, of which they are informed by a ring on their bell, indicate its position and value by their disks 6 to 12 inches in diameter, differently colored and secured at the end of long wooden poles. For a miss the white side of the disk is displayed and held on the side of the target by which the bullet passed. A blue disk indicates a hit in the outer portions of the target, a black disk one in the figures on targets 2 and 3, or in the central section in target 1, and a red disk shows a hit in the oval. On the figure target a hit is shown by placing a white disk on the shot-hole, the disk being provided with a stack or spring which is pressed into the hole and retains it in position. For danger signals the markers use red and white flags. The marker's bell, with which most ranges are provided, besides announcing to the markers a shot on their target, which is only of much value when a miss has been made, also affords a ready mode, by means of a previously arranged code, signals of communicating to the target butt, the directions of the Commander of the firing party.

It will be noticed from this cursory examination of the Austrian method of instructing their soldiers in the use of their rifles, that throughout it, as has already been noticed in the German method, the object for which so much care and attention is given is steadily kept in view, and nothing taught that will not be useful in war. This is observed in the class and practice shooting, in the manner in which it is conducted and especially in the nature and shape of the targets used, but more particularly in the field firing by which the soldier is, in peace, familiarized in a most marked degree with the incidents of the modern infantry fight, and the officer educated as he can be in no other manner. in the habit of leadership, of coolness and prompt decision which it is so necessary he should acquire. The fighting value of troops so instructed and disciplined, and so led is thereby vastly increased.

ENGLAND.

The general officer commanding a district is held responsible for the musketry training of all the troops in his command. Of the progress of his men he is kept informed by monthly reports showing the daily drills and practices, summaries of the classification. and results of the range and field firings. In acquiring this knowledge he is assisted by an officer specially detailed for the purpose, who exercises a general supervision over the instruction of the troops, and makes the necessary arrangements for their training, keeping himself informed with reference to the ranges and facilities for practice at diffeient posts, and by personal inspection ascertaining the manner in which company Commanders, Subalterns and Non-commissioned Officers perform their duties, and their adaptability and efficiency as instructors.

The regimental Commander exercises over his companies and their officers a personal supervision; he is required to frequently visit the ranges where his men are firing, and to see that the practices are carried out in accordance with the regulations. He also arranges for extra drills and exercises in addition to those required, and for such special practices in estimating distances as may be possible.

The Company Commanders, who are expected to be in possession of a School of Musketry Certificate, exercise a constant supervision, especially in the preliminary drills, over the instruction as imparted to the different squads by their Non-commissioned Officers, carefully noting the fitness of these men for their duties; in the latter they are assisted by their subalterns.

The Adjutant and Sergeant-Major of each regiment must previously to their appointments, have obtained 1st Class certificates from the School of Musketry, in the case of regiments serving abroad they may be first appointed, subjeet to confirmation and to their obtaining the required certificate. The Adjutant examines the Non-commissioned Officers whom the

Captain proposes to detail as instructors, giving them a certificate to that effect, if he finds them competent. Without this they are not permitted to take any share in imparting instruction to the men. In each regiment a Sergeant who has been through the School of Musketry, is appointed "Sergeant Instructor of Musketry," who is chiefly engaged in the training of the recruits and in the preparation of the required records and reports. A Sergeant is detailed in each company who performs somewhat corresponding duties.

The course of training is different for the recruit and for the trained soldier, the preliminary portion receiving naturally much greater attention in the former instance. The recruits are divided into squads and an officer detailed to attend to their instruction, which comprises each day lectures upon the theoretical principles or lessons in the care of arms and ammunition, one aiming drill and two position drills—each drill lasting for half an hour; after this the men are taken to the range and practiced in firing under conditions similar to those described subsequently for the trained soldier, but at somewhat diminished ranges; those who complete this course between January 1st and October 31st are exercised as trained soldiers, during the current annual course, either with their companies or as casuals; the remainder are exercised in the ensuing annual course. The course of preliminary drills comprises instruction in the theoretical principles, and in the care of arms and ammunition and exercises in position and aiming drill, in judging distance drill and in blank firing, knowledge of theoretical principles of rifle firing is imparted in four lectures; in the first the fact that the barrel is rifled will be brought to the soldiers attention and its necessity and advantages explained to him; he is also informed of the force of gravity, and its effect in connection with the resistance of the air upon the path pursued by a bullet under the impulse of the explosion. The second lecture explains the theory of giving elevation, illustrating it by diagrams, the use of the rear sight in obtaining the elevation desired and the effect of inclining the sight to one side, upon the range obtained. The third lecture deals with the height of the trajectory above the line of sight, the dangerous space and the effect of errors in the determination of the distance of the objective upon the efficiency of the fire. The final lecture treats of the effect of variations in the winds, light, heat and other atmospheric conditions and in the ammunition itself upon the accuracy and uniformity of the practice. For the recruits these lectures are half an hour in duration and are given every other day, alternating with similar lessons in the care of arms and ammunition. Simultaneously with them the position and aiming drills are conducted. In the first practice the soldier goes through the motions of bringing the piece up against the shoulder in the firing position, but without looking along the sights or pressing the trigger; in the second exercise these latter elements are included, and in the third the aiming and firing at a definite mark are continued until a command cease firing. These exercises are conducted with the man kneeling and lying prone as well as from a standing position. For the aiming drill a tripod formed of three stakes tied at the top, or of the arms stacked, with scabbards on the bayonets, is generally used. The squads are not to exceed ten men at a time, formed in single rank about six paces in rear of the rest, one man placing his rifle on the rest, aims at the center of a mark, aligning upon it the middle of the top of the rear sight and the tip of the front sight. The aim is then examined by the instructor, who if it is unsatisfactory calls up another man to look along the sight and state what the error is, he then explains to the men what the consequences would be if an object were being fired at, the aim is then corrected by the first man. In the earlier exercises the object of aim is a bulls-eye eight inches in diameter, which is used at first at 100 yards, later increased to 300 yards. For longer distances a bulls-eye 2 feet in diameter is employed, and the distances successively increased up to 900 yards. The men are also taught to aim at moving and vanishing targets, dummy targets fulfilling these conditions being provided for every regiment or battalion, and used in the barracks yard.

The instruction in judging distances, in which all company officers are required to participate, markers are posted in pairs in echelon at every 50 yards; on the first day from 250 to 500 yards; on the second day from 550 to 800 yards. The squad forms opposite the first pair, and the instructor cautions the men to notice the size and appearance of the markers, taking into consideration at the same time the position of the same, the state of the atmosphere, and the nature and color of the background. He then points out the parts of the figure, arms, etc., which can be distinctly seen on the two men before him, and then questions the men as to the observations they have made, and endeavors to impress upon them the necessity of remembering the appearance of the men at this distance under the existing conditions. The squad then passes on to another instructor opposite the second pair of markers, and the preceding operation is repeated with the addition of comparisons between the appearance of the present and of the former markers. When these observations have been taken at each distance, the squads are marched to unknown ground and exercised in judging the distance of men within the limits prescribed above, but whose exact position is undetermined. In a more advanced portion of the course, larger parties are divided into two parts and mutually estimate their distance from each other, subsequently determining it with range-finders, or by pacing. In each drill eight answers or estimates are required from each soldier, and upon their degree of accuracy depends the class in which the soldier is placed in this exercise at the close of the season. The blank firing is conducted to accustom the recruit to the explosion of the charge and to give him steadiness before he uses ball and cartridges. Ten rounds are fired by each man from a standing position and the same number in independent firing in ranks; the front rank kneeling. For individual firing, kneeling and lying down, five rounds each are used, and five rounds each for volleys fired in the same positions. During all the firings especial attention is paid to the details of the different positions and to the manner in which the fire is executed, all errors that may be made being promptly corrected by the instructor. The target practice of the soldier is divided into range practice and field practice The course of the former is indicated in the following table, the different exercises taking place in the order in which they are enumerated:—

The regulations require that an officer shall always be present at the firing point, and that he shall supervise the work of the men; they may either fire singly or in pairs, as the Commander of the party directs. While no more than the number of shots above prescribed can be fired at each exercise and from them alone can the soldiers' classification be made; yet permission can be accorded for additional practice preceding the regular exercise, and thereby preparing the men for the official firing. No sighting shots are, however, allowed when firing for record.

The volley firing is as much for the training of Officers and Non-Commissioned Officers in the methods of giving the commands as for the benefit of the men. It is therefore always conducted by the proper Commander—whether the Officer or Sergeant, depending upon the size of the squad exercised. In the firing itself the sergeants never participate, but assist in superintending the practice when they are not themselves conducting it; they are similarly excused from the exercise in independent fire.

It is the object of the field practice to give a more practical form to the instruction of the soldier than

Range Practice.

Exercise.	Class of Target.	Distance—Yards.	Position.	Number of Rounds.	Remarks.
1	Third, except 6th bull's-eye.	150	Standing.	10	Individual practice; troops in dress of drill order.
2	Third.	250	Kneeling.	10	
3	Third.	300	Kneeling.	10	
4	Second.	400	Any Military position.	10	
5	Second.	500		10	
6	Second.	600		10	
7	First.	700		10	
8	First.	800		10	
9	Volley.	300 400	Front rank kneeling.	5 5	In helmets and knapsacks.
10	Volley.	600 800	Any military position in extended order.	5 5	
11	Independent.	400	Front rank kneeling.	10	In helmets and knapsacks.

can be given by the range firing; targets are therefore used which are intended to represent in some degree the appearance of an enemy either standing or behind some shelter, and moving or disappearing as well as permanently located; for the individual firing it is conducted according to the following plan, the poorer shots repeating any position of the range practice:

FIELD-PRACTICE (INDIVIDUALS).

Exercise	Class of Target.	Distance. Yards.	Position.	No. of Points.
1	Head and Shoulder.	200	Any Military.	10
2	Figure.	250 to 140	Kneeling.	10
3	Moving.	150	Standing, Kneeling, Lying,	3 4 3
4	Vanishing.	150	Standing, Kneeling, Lying.	3 4 3
5	Figure.	Advancing and retreating beween 400 & 200.	Any.	10

The object of the first of these exercises is to train a soldier to hit an enemy who may be exposing his head and shoulders above a parapet. The targets are placed at intervals of two feet, and as the figures on each target are two feet apart, this will be the interval between any two consecutive figures. Sixteen men practice at one time, drawn up in extended order opposisite the figures, one being assigned to each. No shots are signaled, but at the expiration of the practice the men are marched up to their targets and the hits counted. The firing can be repeated in the direction of the Commanding officer when ammunition is available, but only the first practice is counted in the aggregate on which the classification is made.

In the second practice, though the men advance from 250 to 140 yards, the adjustment of the sight is not allowed: but the one selected which corresponds to a range of 140 yards, and with which when aim is taken at the breast, a man standing will be hit up to 250 yards. Eight men practice at one time, they are first placed at 250 yards opposite their own targets, ten short advances of not less than 10, nor more than 13 yards are then made, and one shot fired at each halt. Hits are not signaled, but the men marched up to examine their targets upon the completion of the firing. For the practice at moving objects a target bearing a slight resemblance in its shape to the outlines of a man, but presenting only about half of such a surface, is employed. It is prescribed that the range shall not be less than 150 yards, but may be greater: the length of the "run" of the figure is about 25 feet. The soldier stands with his rifle loaded and at a ready, and must fire each time that the figure is run for him, a failure to do so is counted as a miss on his score. Practice is conducted with the figure passing both from right to left and from left to right. Hits either direct or ricochet are scored three, their number is signaled upon the conclusion of the practice.

The object of the practice at vanishing targets is to train the men in the fire required when engaging the enemy who are appearing and disappearing behind a shelter. The target consists of 16 figures, each similar to the one used in the moving target, and fitted to a central axle in sections or groups of four so arranged that alternate sections will appear and disappear together; this may be varied by arranging these sections in groups of two or even in single figures. The figures remain in view for five seconds, then disappear for ten seconds, and so on.

The men are formed in single rank in front of the targets, fire one shot each time the figure is exposed for them, and then, at the conclusion of the practice, march up and examine the targets. For the last of the individual firings of the field practice, the figure targets are placed not less than six yards apart and one assigned to each man. The squads are formed at a greater distance than 400 yards from the targets, towards which they advance until within that range, when they are halted and fire one shot. Four other halts, at intervals not exceeding 20 yards, are made on the advance, and one shot fired at each halt. The retreat is conducted in a similar manner. The men are allowed to take any position whatever, and also to avail themselves of any favorable irregularities of ground for obtaining rests for the person or rifle. Hits either direct or ricochet count three points; the targets are examined by the men themselves after the completion of the practice.

In addition to the preceding individual exercises in field practice, volley firing at long and extreme ranges is also conducted, and up to full range of the rifle. The targets are canvass screens representing infantry, cavalry, artillery, baggage trains, etc. The final exercise comprises field-firing by organizations of different strength, carrying out some tactical idea. As a preliminary measure, the troops must first be thoroughly trained in their respective duties in the drill and practice of the different maneuvers as laid down in the tactics. For troops thus prepared a hostile front or a more extensive or elaborate position depending upon the strength of the attacking force, is arranged. The defenders generally supposed to be equal in numbers to about two thirds of the organization practicing is represented by dummies distributed into fighting lines, supports and main body in the same manner prescribed in the tactics as a guide for troops when occupying a position. The preparation of these dummies is devolved upon the troops for whose practice they are intended, unserviceable tents, bags, pegs, sheeting, horse cloths, clothing or other articles from which figures or screens of the prescribed dimensions can be prepared being used.

For the brigade or for battalion field firing, officers from other corps are selected as umpires. In a similar way the umpire is chosen from another company when field firing is to be conducted. A chief umpire is also appointed. The engagement is then conducted by the proper Commanding Officer of the force presumed to be engaged, the subordinate officers and Non-commissioned Officers giving such commands as would be expected from them in action, and directing the fire of their men both in objective and in nature and amount. The distance at which fire is opened is left to the discretion of the CommandingOfficer, who also when the ground is favorable is expected to combine a flank movement with the main frontal attack. To estimate the value of the shooting at the several distances, the practice is stopped and the hits counted at certain intervals, for this purpose the action is divided into three stages, the first stage, from the time when first opening fire until the fighting line is reinforced by the supports; second stage, from the reinforcements by the supports until the reserve is brought into action and the third stage, from the reinforcements by the reserve to the termination of the practice. At the close of each stage the number of rounds fired by each company ascertained, thus affording means in connection with the number of hits, for a judgment of the value of the work.

In laying out ranges the targets are generally placed with an interval of 30 feet between their centers and at least 40 yards of available ground on their flanks. Except when intended for the use of a large body of men, two targets is generally the number established; in some cases instead of a greater number arranged in pairs with intervals between the pairs of 80 yards. All ranges are marked with the distance at intervals of 50 yards up to 800 yards, and a flag staff erected in a conspicuous place from which a large red flag is displayed as a signal that firing is being then conducted.

With the marking great care is exercised to obtain a correct record, it is required that a Non-commissioned Officer, preferably of another company, shall be present at the butt, who is held responsible that all shots are correctly signaled; he also keeps a record of all hits, with their value which is compared from time to time with the record kept at the firing point. The score at the firing point is kept by an officer or Non-commissioned Officer, all entries being made in ink; at the close of the day's practice, the Supervising Officer certifies on the "register that the practice was conducted strictly in accordance with the regulations; that he examined the target before and after the firing took place; that the points recorded were obtained by the men opposite whose names they appear and are the original entries made on the ground during the practice." For range practice in the British service, the targets are made up of slabs of iron, six feet long by two feet wide, and marked with six inch squares to facilitate painting the various divisions the targets are colored white, the lines on their surface being black.

The third class target is made up of two regulation targets, it is therefore 6 feet high and 4 feet wide, when used for practice at 100 and 150 yards the bull's-eye is 6 inches in diameter, for practice at 200, 250 and 300 yards, it is 12 inches in diameter, the center is 3 feet in diameter. Recruits fire at it, at 100 and 150 yards standing and 200 yards kneeling—the trained soldier at 150 yards standing and 250 and 300 yards kneeling. Hits in the bull's-eye count four; in the center, three; in the outer or the remainder of the target they count two.

Second class target is made up of three regulation target slabs and therefore 6 feet square, has a bull's-eye 2 feet in diameter and a center 4 feet in diameter, the remainder of the target constitutes the outer. Hits are scored as with the third class targets. The second class target is used by the recruit, firing kneeling at 300 yards and lying down at 400 yards; by the trained soldier at 400, 500 and 600 yards, firing in any military position, that is standing, kneeling or lying prone, the back positions not being allowed in regular practice, though they are allowed in certain matches.

First class target is made up of four regulation targets, hence 6 feet high and 8 feet wide; the bull's-eye is 3 feet in diameter, the center 5 feet in diameter. Recruits use the target for 500 yards practice lying down, the trained soldier for firing in any military position at 700 and 800 yards. Hits are scored as for the third class target.

For volley and independent firing six slabs forming a target 6×12 are used up to 400 yards, and eight slabs making a target 6x16 for practice beyond 400 yards. In each case a horizontal black band one food broad is painted across the center of the target.

Head and shoulders target, one regulation target placed on its side and blackened. Only hits on the black portion count, they are scored three; hits on the white portion of the target are scored as misses. Figure target is intended to represent a man standing. Hits in the black portion are scored three, in the white portion they are scored as misses.

At the close of the course a classification of the men is made, according to the results of the firing. For this purpose the individual practice of the range firing (exercises 1 to 8 inclusive) and the firing at the head and shoulders and the figure targets of the field practice (exercises 1 and 2) are now considered. It is understood to include the results of the firing at the moving and vanishing targets (exercises 3 and 4) as soon as the targets which are now being prepared are issued to the different garrisons.

In the range practice, eighty shots are fired by each soldier in the individual firing, the maximum possible, is therefore 320. In the first and second exercises of the field practice, twenty shots are fired by each man, the possible score is therefore 60. For qualification as a marksman 200 points (62½ per cent.) is required at the range practice, and 42 points (70 per cent.) at the field practice. For the First Class the total at the range practice is the same as for the marksmen, but is reduced to 33 points (55 per cent.) at the field practice. For the Second Class these totals are 50 (nearly 47 per cent.), and 24 (40 per cent. respectively). Men making less aggregate scores are in the Third Class. For cavalry, firing with the carbine, the totals required at the range practice for the different classes are about one-eighth less than for the infantry as given above, but for the field practice no reduction is made.

All marksmen wear as a distinctive mark, a badge of cross carbines or rifles worked in worsted on the left arm, and are besides eligible to compete for certain other prizes. To the best shot among the privates of a company composed of 40 men or upwards a prize of $12.50 and a marksmans badge worked in gold is awarded; if the company numbers less than forty the money prize is reduced to $10. These best shots and also the second best shot of the companies of each regiment then enter a competition, firing ten shots at each distance at a third class target at 200 yards standing; at a second class target at 400 yards kneeling; at a first class target at 800 yards in any military position, at the head and shoulder target at 150 yards, and at the figure target also at 150 (same as the first and second exercises of the field practice). The successful competitor receives a prize of $25 and a badge of cross rifles and a crown worked in gold and worn on the left arm, and the second man a prize of $15 and a similar badge, except that the crown is omitted. A prize of $15 and this same badge is competed for in each regiment by the best shot among the corporals from each company.

In addition to these prizes, marksmen to the number of 10 per cent, of the Non-commissioned Officers and privates of each company receive a money prize of $5.

No two of the above prizes can be retained by the same man, the next in order of merit always succeeding to the prize vacated by the winner of a higher prize.

As might have been inferred from the fact that every garrison is not yet provided with the necessary targets for all the exercises of the field firing, the nature of the instruction of the British soldier is yet in a transition state. These field firings have been but lately introduced, and the effort to make more than good target shots of the men, actually directing their musketry instruction so that as a first object their efficiency in battle may be thereby increased has hardly yet taken a definite form. Good results will undoubtedly follow when all the prescribed field exercises can be pursued, and when the final practices of the company or regiment in the maneuvers and firings incident to an actual engagement can be practically carried out as prescribed in the regulations.

The drawings illustrating the foregoing paragraphs will be found among the plates at the close of this volume. These illustrations are interesting and should be carefully studied by the student of foreign target practice.

UNITED STATES.

In the United States, as in the armies of other countries, no instruction of any importance was given the soldier in the use of his arms, before the introduction of the rifle-musket. The old smooth-bore in fact, in its method of sighting, actually stood as the exponent of the inaccurate firing of the weapons of its day; with no rear sight, the front sight alone did not permit of any accurate aim; yet sufficient perhaps for the very limited precision of the aim itself. When the rifle musket was generally issued in 1854, it was recognized that the army required careful instruction in its use before the capabilities of the arm could be properly developed; General Scott therefore published in General Orders in December of that year, for the information and guidance of the troops, a letter from the Chief of Ordnance, in which that officer stated, that as the sights were marked for ranges of 200, 300, 400, 500, 600 and 700 yards, he would suggest that the practice be held at those distances, five shots to be fired at 200 yards, seven at 300 yards, nine each at 400 and 500 and ten each at 600 and 700 yards. Other practice was recommended at intermediate distances for which it was suggested that the slide on the sight might be adjusted, or in case of slight difference, by the soldier taking a finer or coarser sight. That it was presumed that targets would be employed is evident from the letter, though as to their size, shape and any details of construction the order is silent. No method of instruction was prescribed, every detail being left to the discretion of the company officer, who in the general lack of knowledge on the subject was no better informed than the War Department. As might have been presumed under these circumstances very little instruction of any nature was imparted, and it soon became evident that further measures were necessary. Fifteen months later, or in March 1856, the General-in-Chief therefore issued a Circular stating that from the representations made to him of the lack of skill on the part of most of the men then in the ranks, and with a view to their improvement in firing with ball cartridge, he purposed ordering a more general practice in that important branch of military instruction. Officers were therefore required to communicate to him at an early day, their views on the subject, and to state whether in their opinion the practice should be weekly, monthly or quarterly; what number of rounds per man should be allowed under ordinary circumstances at each practice; under what regulation should the practice be conducted and what inducements to acquire skill should be held out, together with such further suggestions as their knowledge and experience should enable them to furnish.

The replies to this Circular, from their great dissimilarity, slight comprehension of the subject and paucity of practical suggestions, did not afford sufficient material upon which a system of instruction could be based, and no further progress was immediately made.

In May, 1857, Captain Henry Heth, 10th Infantry, was assigned to temporary duty in the Adjutant General's Office, in the following August appointed member of a Board for testing breech-loading rifles, and in October of the same year, after the adjournment of the Board, was directed to draw up a system of "Target Practice with Small-arms," the duty upon which it had been designed to employ him when first the detail for temporary duty was made. Captain Heth was furnished with the replies received under General Scott's Circular of the preceeding year, and with the different foreign publications on the subject. The system which he submitted was adopted by the Secretary of War, upon March 1st, 1858. In his preface Captain Heth states that his system is chiefly a translation from the French "Instruction provisoire sur le Tir," which in fact he would have recommended with little or no change if schools similar to the French schools of Musketry had existed in our Service. He also used the reports on the subject that had been rendered by Major T. Williams, Captain 4th Artillery and Brevet Major Fitz-John Porter, Captain Adjutant General's Department, and further acknowledged valuable aid and assistance from 1st Lieutenant Julian McAllister, Ordnance Department.

The methods prescribed contemplated, first, aiming and then position drills, subsequently firing with caps or candle practice, and finally estimatng distance, drill as all preliminary to regular target practice. For ball practice it was prescribed that the targets be placed at 150, 225, 250, 300, 325, 350, 400, 450, 500, 550, 600, 700, 800, 900 and 1000 yards, at all ranges; the surface fired at was six feet high, and either 22 inches wide or some multiple of that dimension, at 600 yards for instance being 110 inches (9 feet 2 inches) in width. The targets being divided by a horizontal and vertical line, of a width depending upon the distance at which they were used varying between 4 and 20 inches. Four rounds were to be fired at each distance. After practice at the first seven ranges, the company was to be divided into three Classes of about equal size, the First comprising those men who had hit the target the greatest number of times, the Second Class of those who came next in order, and the Third Class of the poorer shots. This division was finally to be remade when firing at all the fifteen distances had been completed.

Three exercises in skirmish firing were contemplated, ten shots being fired at each drill, five when advancing, and five when retreating. The number of targets was only limited by the circumstances of the ground; for the first practice they were 6 feet high and 22 inches broad and placed six yards apart, fire was opened when the company had arrived within a range of 350 yards, the point where the advance was to cease and the retreat commence was not stated. In the second practice the size of the targets was doubled and fire opened at 600 yards. In the third practice the width of the targets was increased to 88 inches, the company commencing to fire when at a distance of 800 yards.

Both file and volley firing were also required, and at the distances, 300, 400 and 500 yards, two cartridges being fired by file and two by volley at each distance.

At the close of the annual target practice, a company prize, a brass stadia, was awarded to the soldier who had hit the target the greatest number of times at the different prescribed distances, in case of ties it was provided that a competition should be held until a decision was reached. In competition for the regimental prize, a silver stadia, the company prizemen, each at their own station, fire 10 shots standing at 200 yards at a circular target 3 feet in diameter, having a black circle 8 inches in diameter in the center. The man having the shortest string, or the least aggregate for the distances of the several shots from the center of the target was pronounced the winner.

To the regimental prizeman making the shortest string was further awarded the army prize, a silver medal 2½ inches in diameter, and worn round the neck, suspended by a silver chain. The system thus prescribed was reprinted by the War Department in 1862, and under date of May 30th was again adopted for the instruction of the troops; no reference, however, being in it made to Captain Heth, who in the meantime had joined the Confederate Service; and until the adoption of Colonel Laidley's Rifle Firing, seventeen years later, it remained as the official course of rifle instruction for the army.

Though in other respects the system established was most admirable, yet it made no provision for reports of the progress made or success attained, or for any methods by which the instruction could be supervised and the results made known to the Army. Each Company Commander therefore conducted it with energy or not, according to his intelligence or enthusiasm, and lacking the spur of emulation now given by the figure of merit system the target firing, except in isolated instances, took no stronger hold upon the interest of the officers and men than the ordinary company drill.

The War Department recognized this condition of affairs by issuing, in May, 1869 (shortly after the introduction of the breech-loader), an order fixing the allowance of ball cartridges for target practice at ten per month, and requiring every Post Commander to designate an officer to supervise the practice, that officer to submit quarterly reports of the same to the Chief of Ordnance. In August, 1874, this was modified by requiring that the reports be made bi-monthly.

In carrying out these orders the Department Commanders issued supplementary directions as to how the practice should be held and the reports made out; the system and the targets continued as before to be those presented by Captain Heth.

In the interest taken in the subject and in the earnestness manifested accordingly, in his orders, General E. O. C. Ord, was particularly noticeable; he introduced the custom of announcing in the weekly Army Press the companies making the best monthly scores, and the names of the best shots, and took all possible measures to promote and further the education of his troops in the use of their rifles. About this time the influence of the National Rifle Association and of the International Matches, held under its auspices, became felt in the Army, and General Ord gave a great impetus to target practice by introducing, in September, 1877, the Creedmore target with its method of scoring hits. He also commenced publishing in monthly orders from his headquarters, a summary of the month's practice, giving not only the best, but the worst shooting of individuals, companies and regiments. The allowance of ammunition which in the meantime (October, 1877) had been increased from 10 to 20 rounds a month for each soldier, afforded ample opportunity for practice and improvement.

In the first prosecution of target practice, the army was greatly aided by the "Manual of Rifle Firing," of General Geo. W. Wingate, the General Inspector of Rifle Practice of the State of New York. General Wingate through his personal efforts succeeded in introducing rifle practice as a part of the military instruction of the National Guard, and his system, undoubtedly at that time the best extant, was very generally consulted throughout the Army. In some particulars it was not, however, deemed the best that could be devised for army use, and in April, 1879, the "Course of Instruction in Rifle Firing," prepared by Colonel T. T. S. Laidley in accordance with directions given by the Chief of Ordnance in September, 1877, received the approval of the Secretary of War, and by a General Order was in the following August announced as the system allowed in the Service for the instruction of the Army in the use of the rifle. The order further prescribed that the necessary aiming stands, targets, etc., were to be obtained from the Ordnance Department, and the labor and expense of setting them up and preparing the shelters, etc., borne by the Quartermaster's Department. Colonel Laidley's system placed the instruction of the men at each post in the hands of an Instructor of Musketry, aided by such Assistants as the size of the command required. Company officers, while required to be themselves instructed and to fire annually a number of cartridges, yet only participated in the education of their men as assistants to the regular musketry instructor. The course comprised exercises in which the soldier was taught successfully to take the best position for holding the rifle, to aim it accurately, hold it steadily and pull the trigger without deranging the aim; it contemplated the use of an aiming stand, which, however, was never supplied by the Ordnance Department, but also prescribed certain more limited exercises that could be held with a sand-bag rest for the rifle. In firing standing and kneeling, only the tactical positions were permitted, while for firing lying, the prone or tactical position was not alluded to, but a special side position required. For range practice the targets used by the National Rifle Association were adopted, and the practice commenced at 100 yards, each man firing five shots, or additional single shots in cases when each succeeding shot showed an improvement over the last. The most expert were then to be advanced to 200 yards, where firing was held in a similar manner. Each man was, however, prohibited from firing more than fifteen shots, or from practicing at more than two distances in any one day. The party firing were divided into squads of six men, the squad actively engaged being formed in single rank three paces in rear of the firing stand; when indicated by the instructor the file on the right stepped forward three paces, loaded, aimed and fired one shot, and immediately resumed his place in ranks, then at the command "next" from the Instructor the second file stepped forward, fired and returned to the ranks, the practice being continued in a similar manner until each man had fired his five shots. The instructions provided further that as the men became more skillful the instructor should increase the range and permit them to fire at 300 yards kneeling, and 500 and 600 yards lying down. Marksmen were further required to practice up to 1,200 yards. After the close of the firing for the year, the men were divided into classes according to their respective records, "those who had made 80 per cent. of the maximum possible at 200 yards, and 300 yards kneeling, and 70 per cent. at 600 yards, were to be classified as marksmen; those who made 65 per cent. at 200, 300 and 500 yards formed the First Class; those who made more than 50 per cent. at these latter ranges formed the Second Class, and all others the Third Class." The system not explicitly stating the number of shots to be considered in estimating these percentages, some departments in the first year made up a soldier's record from all the shots he had fired, some from only the best single score of five shots at the specified ranges and some from ten shots. The same uncertainty existing as to the proper methods of preparing the reports required, in some cases the scores were divided into scores of five shots each, and in others, where the whole fifteen shots permitted by the system had been fired at one range, any five consecutive shots were taken as a score. The complete lack of uniformity that thereby obtained, necessitated the issuing in May, 1881, of an order from the headquarters of the army, adopting a new blank form and specifying the proper methods for making the reports and for determining the classification. The same month also saw the issue from the same source of a very important order, establishing a system of competition for selected shots from each company in each Department, and the selection thereby of a team of twelve to represent it in a similar contest with the members of the teams from the other Departments in its Division. In addition to these competitions, provision was made for a contest every alternate year between the best twelve shots in the entire army. When first inaugurated each of these contests was decided by firing ten shots at each of the ranges, 200, 400 and 600 yards, hardly a test of sufficient magnitude to determine with any accuracy the most expert shots, but yet permitting a contest that awakened great interest throughout the army and gave a powerful stimulus to the whole subject of rifle firing.

To these and later orders, extending the system arranged by Colonel Laidley and clearing up doubtful points, as well as to the system itself, must surely be ascribed the very great advance made in but a few years in rifle instruction, and which quickly produced not only a few expert shots, but also greatly raised the general proficiency of the mass of troops.

Laidley's Rifle Firing, however, contained one omission that led to great lack of uniformity and devolved upon the Company Commanders, or rather upon the post instructor of musketry, the burden of determining the best manner of conducting the successive steps of instruction, in that it contained no provisions, except in most general terms, governing the advancement of the soldier from range to range as his proficiency warranted it. As a result at some posts in some companies in 1880 and 1881, the practice of all the men without much regard to their relative merit was restricted to 100 or 200 yards, while in other cases instruction would be given men at distances and under conditions for which their previous firing had not fitted them to profit.

The necessity for more definite rules governing this and other kindred portions of the subject, so impressed General Alfred H. Terry, then commanding the Department of Dakota, that he issued in March, 1882 an order requiring all company officers to practice with their commands, and also further requiring the presence for instruction of all the extra and daily duty men of the company. He prescribed that for all practice should begin at 100 yards, each one firing at least one score of five shots, firing in a similar manner was to be conducted at the other ranges, the soldier being advanced from range to range as he exhibited proficiency but not sooner. The percentages which as a general rule were to be considered as a necessary requisite for advancement were also established. In December of this same year General Terry in announcing to his command the result of the year's labors remarked as follows: "No one can doubt that the average capacity of the men to learn how to use their arms effectively is the same in all companies and at all posts. Nearly all the men enter the service without previous experience in the use of arms, and the number of those in any organization who have had previous experience is too small to affect its character. Moreover the experience of that small number is seldom such as to be of value in the prescribed course of rifle instruction. It cannot be supposed that there are any essential differences in the averages of either physical or mental qualification in the different parts into which the army is divided. This being the case the different results obtained in different organizations must be due to the officers who command them, and to the officers alone. Where officers are obedient and carry out in good faith the orders which prescribe the course of rifle practice: where they are intelligent and zealous; where they not only demand obedience from their men, but seek to awaken their interest in this the most important part of their instruction, and especially where they endeavor to excite emulation by practicing with their men and by becoming good shots themselves, excellent results will assuredly follow."

"But when officers are disobedient and fail to carry out with precision the orders of their superiors; when they are indifferent and lukewarm, when the instruction which it is their duty to give, if given at all, is given in a mechanical and perfunctory manner, without warmth or interest, their men will as assuredly fail to learn the use of their arms and under existing conditions of warfare they will be nearly worthless as soldiers."

"In these days of arms of precision and with the tactics which these arms have made necessary, the man who has not been taught to attain his mark with reasonable frequency, at distances much greater than one or two hundred yards, is an incumbrance rather than a helper on the battle-field."

"Moreover, offensive power in action is defensive power also. Indeed, there is no other defensive power except, perhaps, the power to run away, and, inasmuch as the Department Commander is sure that there is no officer in the Department who would contemplate that method of preserving the lives of his men, he is forced to the conclusion that those who habitually and persistently neglect the instruction of their men in the use of the rifle are thoughtless of—he trusts that they are not wholly indifferent to—the great responsibility which rests on those in whose hands the lives of the men are placed."

This admirable and effective statement of the necessity and advantages of a careful training in musketry instruction was widely circulated throughout the Army and exerted a very beneficial effect. In this same order General Terry adopted the Figure of Merit, proposed by his Department Inspector of Rifle Practice, for determining the relative proficiency in rifle firing of different organizations, this method which was in the following Spring adopted by the War Department for the entire Army, has since continued in effect. While undoubtedly leading to some abuses it has proved a most powerful influence for good, awakening the spirit of emulation, and bringing to the education of the men, not only their most enthusiastic endeavor but a similarly earnest interest on the part of their officers.

In March, 1883, General Terry modifying and amplifying his order of the preceding year, laid down more elaborate and detailed rules governing the soldiers target practice and the course of his successive instruction; this order being copied, in some cases with minor modifications, or still further details of elaboration, in three other Departments, provided about half the Army with a nearly uniform and easily understood system which had already in a previous year demonstrated its own advantages.

Still considerable dissimilarity existed, and the confusion was necessarily increased by the decisions emanating from the Headquarters of the Army and from the different Departments until the student of the authorized system was lost between the text book which had become in many cases a dead letter, and the numerous orders and decisions which were practically the ruling authorities on the subject.

Moreover, orders and decisions are always tersely expressed and can but prescribe methods, not explain them, or impress upon the rifleman their advantages, so that while at this time the general methods to be followed were distinctly enough stated and fairly well understood, yet in very many of the minor details, the instructor or the soldier himself was compelled to depend upon his own experience for the guidance and advice that a properly elaborated course of instruction would impart. The Chief of Ordnance, General Benét, being much impressed with the disadvantages in this respect under which the Army was laboring and the importance of remedying it possible the evil, addressed on October 30, 1883, a letter to the Secretary of War bringing these facts to his notice and recommending that Captain S. E. Blunt, of his Corps, be directed to prepare a new Manual, which should embody all the valuable experiences of the Army in target practice. This proposal receiving the approval of the Secretary the necessary instructions were transmitted to Captain Blunt then serving as Instructor of Rifle Practice of the Department of Dakota, who upon their receipt prepared and sent throughout the Army interrogatories and suggestions pertinent to the subject on which the opinions and recommendations of the officers addressed was solicited.

The topics of principal importance were with reference to abolishing the position of Instructor of Musketry which had in reality been but partly enforced, and of placing in the hands of the Company Commanders the education of their men.

With reference to the form of target, consideration was asked of the relative advantages of a target for range practice, with circular or elliptical dimensions, bearing in mind that the true object of rifle instruction for the soldier was not simply to enable him to hit a bull's-eye or to make large scores, but rather to so educate him that his fire in action would be most effective. For skirmish firing opinions were requested as to the advisability of adopting for a target, figures of men bearing as close a resemblance as possible to the actual appearance of an enemy. Suggestions were also made with reference to the Figure of Merit and the methods of computing it; and also many questions asked upon topics connected more or less intimately with practice and methods of instruction. Though in some instances the officers addressed neglected by failing to reply, to contribute their share to the desired advance and improvement upon the methods then in vogue, yet in the great majority of cases, the replies submitted were very full and of great value. Upon the proper form of target, the opinions, based upon extensive experience and a most intelligent comprehension of the requirements of military rifle instruction, were nearly unanimously in favor of a target with elliptical divisions, which should constantly impress upon the soldier the greater relative importance of accurate time shots. The wish for figure targets for skirmish firing was also universal.

With such accurate knowledge of the judgment and desires of the mass of the Army on these two important points, the duty of Captain Blunt was evident and the measures proposed were incorporated in the system prepared, which after examination by a Board of Officers finally received the approval of the Secretary of War in February and in March, 1885, was in General Orders announced to the Army as the authorized guide in all matters pertaining to the subject which it covered.

As compared with the former systems, the most marked features of that thus introduced, was the recognition it gave the Company Commander as the appropriate Instructor of his men, the definite rules prescribed for conducting the various steps of instruction from the recruit stage through all the phases of range firing up to that for the grade of sharpshooter, the incorporation of the most approved orders, the simplification of the reports and records, the adoption of targets both for range and skirmish firing, which would most promote the education of the soldier in the direction and for those purposes for which the knowledge acquired would prove most efficacious in war, and especially the measures taken to ensure careful attention to the skirmish firing and to further and increase the control of the officer over his men on the line of battle perfecting thereby that most essential of all the features of musketry instruction, the fire discipline of the company.

The provisions of the present system of "Instruction in Rifle and Carbine Firing for the United States Army" will be best understood by quoting from that work itself, and in the following review of the methods prescribed the language of the text has been generally followed, except where the limits of this article render an abridgement necessary in some particulars. The imperative necessity of extending beyond mere target practice the education of the soldier in the use of his weapons, is recognized and emphasized in the opening paragraphs of the Manual which specify that the object of instruction in rifle and carbine firing, is to develop in a body of troops such a state of discipline, such a knowledge of the capabilities of their weapons and such accuracy in their use, as will in battle render their fire most effective.

For the accomplishment of this end the exercises of the individual soldier directed to the attainment of proficiency in the use of the rifle or carbine in all varieties of weather, at different objects and distances, and over every possible variety of ground; and the training of the men as a body is conducted as to give them experience and instruction in the classes of fire they would employ in the different stages of modern actions, and to afford to their officers opportunities for acquiring a thorough practical knowledge of the best methods of conducting and directing their fire.

In each Department an Inspector of Rifle Practice, selected with reference to his special fitness and practical qualifications for supervising the course of instruction, is appointed, whose duty it is to examine the regular reports of firings, and from these reports, and from personal inspections, each post and target range being inspected at least once each year if practicable, to keep the Department Commander informed of the absolute and comparative degree of proficiency manifested by the troops of the various posts and companies in the Department.

For the amount of instruction received by their commands, and for the degree of proficiency which they manifest, Post Commanders are held primarily responsible, and it is expected that they will exact from the troops under their command the highest degree of proficiency attainable. It is their duty to inaugurate and conduct the instruction of their officers in the general theoretical principles of the subject, and by frequent supervision of the preliminary drills and exercises, and of the target practice of the companies, to assure themselves that the captains and their assistants are thoroughly conversant with all the details of the course, that they conduct the instruction of their men with energy and judgment, and where any deviations are made from the prescribed methods of instruction, that they are only those best adapted to secure the most favorable results.

Post Commanders are also required to exercise a direct supervision over all the practices of the company as a body, and particularly over the company skirmish firing. At large posts, however, where an additional field officer forms part of the garrison, the Post Commander may delegate to him this particular duty and also the general supervision of the instruction in target practice.

Company Commanders so conduct the instruction of their Non-commissioned Officers, both in the general theoretical principles of rifle and carbine firing, and in the different details of the course, particularly in the preliminary drills, that they may be enabled to render intelligent assistance in the instruction of the company.

The education of the men in rifle firing is placed under the immediate supervision of the Company Commander, assisted by his Lieutenants and Non-commissioned Officers. It is directed that the different steps in the general system of progressive instruction prescribed in the authorized course be carefully followed, but the details of the various methods may be modified by the Company Commander, if the particular circumstances of any special case appear to render a change advisable.

The course of instruction permits of three main divisions: 1. The preliminary drills and exercises.

2. Individual range practice. 3. Range or field practice of the company as a body. To these are added instruction in the estimation of distances and in the theoretical principles relating to rifle and carbine firing, and to its application in action.

After the soldier has been instructed in the nomenclature of the rifle, the precautions necessary for its care and preservation, and, at least to some slight extent, in the general principles governing the motion of projectiles, he is thoroughly exercised in the preliminary drills. This branch of the course of instruction comprises sighting drills, position and aiming drills, and gallery practice.

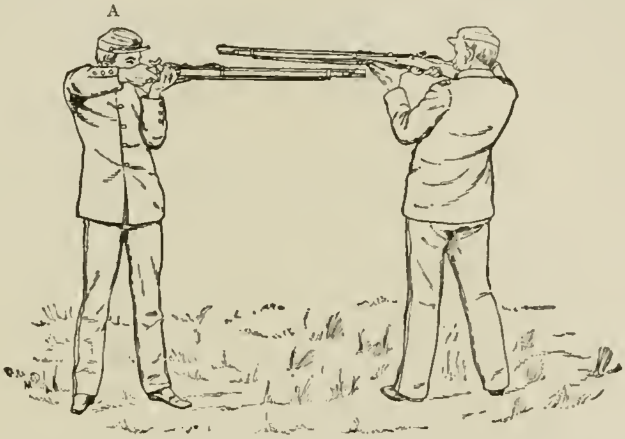


Fig. 1.—Firing Standing—Body Rest.

For the sighting drills, when a more permanent form of rest is not available, a tripod with a sandbag resting in the fork is employed; this affords a steady bed for the rifle. It is considered essential that the interest of the soldier be obtained and held. This it is prescribed can be best accomplished by limiting the duration of each drill to not more than 30 minutes, and by dividing the company into squads of 6 or 8 men each, and as the men become more proficient, by conducting in the different squads different steps of the gradual instruction, requiring the men to pass in succession from squad to squad

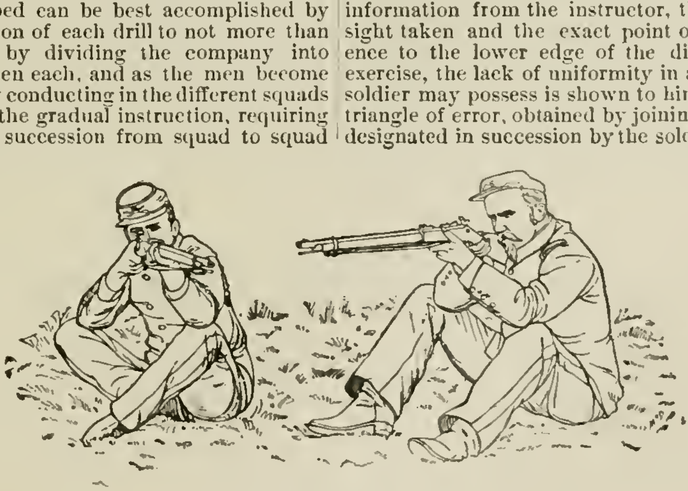


Fig. 2.—Firing Sitting Down.

as their individual exercises are completed. The squads should be taught by the Non-commissioned Officers, the Company Officers passing from squad to squad and examining and verifying the details of the instruction as it is imparted by their assistants.

The sighting drills are divided into four exercises. In the first, after the soldier has been shown the points determining the line of sight, the varieties of either full, fine or half sight that may be taken, and the effect of each explained, he is taught how to bring an object aimed at, and the line of sight, in the same straight line. For this purpose the sandbag rest being about 20 or 30 feet from the barrack wall, and the rifle directed at a large sheet of white paper on the wall, and about 5 feet from the floor, the instructor directs a marker to so move a small black disk as to bring its lower edge in the line of sight. The disk, by a pin or tack, is then to be attached to the paper.

The Instructor then informs the men that he has aimed at the lower edge of the disk, and whether with a full, fine, or half sight, and calling them up in succession, directs them to close the left eye and with the right, looking through the rear sight at the object, to notice the relative appearance of the black disk and the points determining the line of sight. This instruction is given with each variety of sight and with the rear sight adjusted for different distances up to at least 600 yards. The second exercise is a modification of the first, when the men themselves examine and determine without previous information from the instructor, the nature of the sight taken and the exact point of aim with reference to the lower edge of the disk. In the third exercise, the lack of uniformity in aiming which the soldier may possess is shown to him by means of a triangle of error, obtained by joining the three points designated in succession by the soldier looking three times along the line of sight, as those at which the rifle, steadily retained in the same position is directed. The instructor carefully explains to the soldier how the length and position of the sides of the triangle, exhibits the irregularity in his manner of aiming and by repetition of the exercise seeks to remove the cause of error. In the fourth exercise the effect of inclining the rifle and therefore the plane of the sights to either side is illustrated and explained

In the position and aiming drills which follow or are conducted simultaneously with the sighting drills, the soldier is first taught the correct position and exercised in taking it readily; the second exercise adds to the first accurate direction or aiming of the piece, and the retention of breathing and the third combines with the preceding the requisite steadiness of the rifle while pulling the trigger. These exercises are conducted standing, kneeling, sitting, and lying down, in each what is usually known as a tactical position, or one which could be readily taken in ranks is first taught, and then the men drilled in such varieties of these positions in which from the peculiar conformation of their body or from conditions inherent to the position itself, the instructor considers that they appear most at ease and most likely to be able to fire with the greatest accuracy. As a consequence many different positions are necessarily explained. For all off-hand shooting the Manual attaches particular importance to the standing position termed the body rest, Fig.1—A., which is assumed by the left elbow resting against the body and as far to the right as it can be placed with ease; the left hand grasping the rifle just in front of the trigger guard, with the little finger resting against the bottom of the thumb-piece of the cam-latch. The exact position of the left hand will, however, depend greatly upon the length of the upper arm. In some cases the first, or the first and second finger of the left hand, instead of grasping the piece, are extended forward under the barrel. Men with very short arms and neck may find it advantageous, while resting the left elbow against the body, to turn the wrist so as to bring the thumb against the trigger-guard, the fingers extending to the front under the barrel. This position, Fig. 1—B. while exerting a less strain upon the muscles than that first described yet brings the left arm more directly under the rifle. Several varieties both of kneeling and sitting positions are taught, though at these subsequent range practice the soldier is permitted at certain distances to either sit or kneel, as he prefers, to the exclusion of the other attitude. As however when sitting as illustrated in the accompanying drawing, Fig. 2, greater steadiness is obtained than in any kneeling position, the same has been almost universally chosen for firing. For firing lying down, the prone position is first taught the soldier with reference to which it is stated that although it does not afford to the person or rifle the same degree of steadiness that is given by some of the back positions; it is, however, the only one that has yet been subjected to the test of trial in action. It possesses, in a greater degree than other positions, the merit of adaptability to changes in the configuration of the ground; it enables the soldier to deliver fire over low breastworks or improvised shelters and rests, and affords him a better view over the ground which separates him from his mark, and a very much greater arc of fire without altering the position of the body, than can be obtained from any back position.

For target firing, lying down, the best results can generally be obtained by assuming one of the back positions. The particular one that should be adopted by the soldier depends greatly upon his conformation. Unless unusually stout, of small stature, or with very short arms, the position of Sergeant Tabler, 22d Infantry, usually known as the "Texas grip," and described, Fig. 3, should be taken. To do so pass the left foot and leg through the sling until the rifle rests just above the left knee; cross the left leg over the right at the knee and lie down on the back with both hips, both shoulders, and the right leg flat and firm on the ground; draw the piece to the rear, the stock below the guard-plate resting on the right shoulder well out from the head; place the left arm under the head, back of the hand up, fingers grasping the top of the butt, thumb behind the butt-plate near the head; rest the cheek against the side of the stock, and the head on the back of the left hand and wrist and press the stock firmly down on the shoulder; pass the thumb of the right hand as far as possible through the trigger-guard in front of the trigger, grasping the small of the stock with the fingers of the right hand back of the hand up, little finger in rear of the hammer, and the right elbow resting firmly on the ground.

In this position, to insure greater steadiness and to take up the force of the recoil, the rifle should be drawn strongly to the rear, bringing the gun-sling firmly against the left leg just above the knee; if the sling is not sufficiently lengthened, room will not be afforded for the fingers of the left hand on the butt; if made too long, the interposition of the trigger-guard will prevent the stock being firmly pressed against the shoulder, and the thumb of the left hand which generally serves to assist the fingers in correcting any canting of the rifle, cannot be placed behind the butt plate without constraint.

Care should be exerted that the muscles of the legs are relaxed, the left leg, or knee not being raised but extended at full length over the right. The muzzle can be depressed by withdrawing the right leg somewhat from under the left; it can be elevated by passing the right leg further under the left and by straightening the neck, thereby pressing the stock further down on the shoulder. The pull on the trigger should be given by gradually tightening the grasp of the right hand and pressing steadily against the lower part of the trigger with the base of the thumb. The well known Fulton position is explained, and also a modification of it obtained by placing the legs as shown in Fig. 4, the body being brought well upon the right hip, the right elbow resting upon the ground, the right forearm turned to the rear, the hand grasping the butt behind the ear, the left arm across the body with the thumb of the left hand upon the trigger, and the fingers over the small of the stock. In this position the right arm, if the elbow is placed far enough forward, experiences the recoil as a strain of tension and firmly sustains it, and by moving the rifle, when assuming the position, far enough to the front there will be no danger of the left hand striking the chin when the piece is discharged. Upon the importance of sighting and position and aiming drills great emphasis is laid, the instructions maintaining that when these exercises are carefully practised, the soldier before firing a shot at a target will have learned to correctly aim his piece, to hold his rifle steadily, to pull the trigger properly, and to assume that variety of position best adapted to the particular conformation of his body. Knowledge which cannot be successfully acquired upon the target ground alone.

After the soldier has been thoroughly instructed in sighting and in position and aiming drills, he is exercised in firing at a short range with reduced charges. As the object of the practice is simply to continue in a different manner the instruction of the preceding exercises, the firing is held both standing, kneeling, sitting, and lying down; and in order that the soldier may have experience in the appearance of the sight in its different positions, and practice in the consequent changes in the position of his head, when aiming, use is made of the rear sight adjusted for the different ranges, up to 600 yards.

The cartridge used consists of a round ball weighing about 140 grains and from 4 to 6 grains of powder, depending upon its quality and upon the length of the gallery, the amount being so regulated that with the sight at 100 yards, the bulls eye will be hit by the shot.

No effort is made to employ a target whose dimensions bear any particular proportion to those of the range targets, but the size of the bull's-eye and of the different divisions is determined by the length of the gallery range. For ranges of about 50 feet, the target is 7 inches high and 6 inches wide, with a circular bull's-eye 1 inch in diameter and two other circular divisions 3 inches and 5 inches in diameter respectively. If the gallery is 75 feet long these dimensions are increased one-half. When the gallery is 100 feet long, they are doubled.

When instruction is given with sight adjustments corresponding to longer ranges an aiming bull's eye is employed which is placed at such distance below the bull's-eye of the target that with accurate aim the latter should always be struck. The material for gallery practice, and the tools required for preparing the cartridge are supplied each company, the necessary labor being done by the troops themselves. As the allowance is exceedingly liberal, permitting about 300 shots per man, gallery practice occupies a very prominent place in the education of the soldier, to pointing and aiming drills the attention of the men soon languishes, while a gallery practice arouses and retains their interest; it also awakens the spirit of emulation in the soldier, without which any considerable degree of progress cannnot be made. The "Instructions" remark that to the instructor it affords the best opportunity for correcting the positions and errors of the men; and if carefully conducted the soldier who afterward practices on the range with full charges will, as soon as he becomes accustomed to the recoil, find it a simple matter to make scores which before seemed to him impossible.

Matches in gallery firing between the men, particularly the recruits, and between teams of the same or different companies, are to be promoted and encouraged. While increasing the interest of the men in their practice, they at the same time afford experience in the conditions of competitive firing.

The amount of estimating distance practice that the soldier receives is left mainly in the hands of the Company Commander. When very thoroughly conducted, it commences first with drills in which the men are taught the relation that exists between their usual step and a distance of 100 yards, they thus become enabled by counting the steps required to traverse any distance, to determine its extent with a considerable accuracy and great readiness. The instructions is most usually imparted by marking successive distances of 100 yards along the road taken by the company in passing from their barracks to the target ground, then when a squad reaches the first stake, they break ranks and pass one man at a time along the measured distances, halting and recording at each stake, the number of steps each has just taken. When a uniform habit is acquired and learned by the men, they are exercised in pacing distances on ground rolling or broken, and of a greater length than 100 yards, until each becomes conversant with the usual number of steps taken by him in traversing ground of varied configuration, thus acquiring knowledge that may at some time be of a practical advantage, as well as fitting them to perform with accuracy and facility the different duties of a marker in the more advanced exercises of estimating distance by sight. For these latter drills, of which the first stage is limited at 300 yards, it is indispensible that the soldier should have acquired the habit of applying to the interval separating him from the object observed, some unit of measure which he can easily carry in his mind; for this purpose, 100 yards, the shortest range at which target practice is held, and which in his range firing is constantly before the soldier's eyes, is employed; his attention is therefore frequently called to it, and as for estimating short distances this unit is too long for accurate use, he is cautioned to endeavor to divide it into equal parts as halves or quarters. In the preliminary instruction, markers are located at 50 yard intervals along a straight line, and the men posted at the origin directed to notice first the appearance of the nearest marker, and of those parts of his dress or accouterments that can be distinctly seen, and then to compare him with each of the others in succession. They are also directed to observe the divisions of the ground between them, and the marker at 300 yards into 50 yard inertvals as is indicated by the positions of the different markers, and to compare the apparent length of these successive intervals: these exercises are conducted in varisous conditions of the atmosphere, with different back-grounds and over different varieties of ground. The men are then exercised in forming estimates of unknown distances, advantage being taken for this purpose of the ability the men should previously have acquired, of accurately measuring a distance by pacing, to send markers out in several directions with instructions to take a certain number of steps:—the instructor will then know the distance of each—or they may be directed to take position in certain designated localities and after they have served their purpose as markers can, by prearranged signals com-

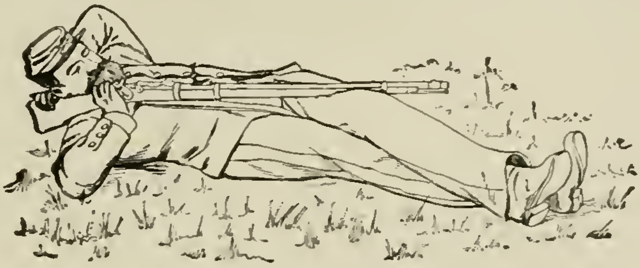


Fig. 3, Firing Lying Down—"Texas Grip."

Fig. 4. Firing Lying Down.

municate their distance to the squad. In either case the officer can listen to the estimates of the men and then inform them of their errors. It is desired that all should be able to judge the distance to within $\frac{1}{10}$, and expected that the expert will be able to reduce this error to $\frac{1}{20}$ of the true length. The exercises of the men who exhibit the greatest proficiency are advanced the limit of 600, and finally to 1000 yards, the same methods as those already indicated being followed. When the majority of the men have become proficient in these exercises the company is divided into two squads, and starting from a common point, march (preceded by several men to measure the distance by pacing) in opposite directions, halting occasionally and estimating the distance separating them. At each halt, each squad signals to the other the distance they have traversed from the origin, which is imparted by the markers only to the instructors, the true distance they are apart is then told the men after they have estimated. This method of squads instead of single men for the object, may be continued mainly for the benefit of the officers up to 1500 or 2000 yards.

Exercises in estimating distances by sound are also conducted. Squads of men of varied strength firing volleys both in the open and behind partial cover.

The firing exercises are divided into the individual range firing at known distances, and the individual and company skirmish firing at undetermined distances. The individual range firing is of two classes, the regular practice, upon which the classification depends and during which all possible precautions are always taken to insure fairness and accuracy of record, and the additional practice, which in general terms is any firing in which the conditions are such that the scores made cannot be considered in the classification. The latter is generally resorted to by men endeavoring to perfect themselves for competitive firing, and who either desire to practice at times when the required supervision cannot be given or who wish to fire cartridges in excess of the number allowed for a single range on a single day. The regular practice which may be formerly participated in at some designated hour by the entire company or conducted by smaller squads at other times, is held three times a week during the practice season, and always in the presence and under the supervision of an officer. All company officers and enlisted men are required to attend unless prevented by guard duty, sickness, or confinement under guard.

The company after arriving at the target ground break ranks and are permitted to rest at ease until their turn for practice arrives. For the firing the men are divided into pairs and fire alternately until each completes a score of five shots; either or both of the pair may, if the instructor deems it advisable, fire additional scores of five shots each,but not more than eight scores or forty shots are permitted. This limit in practice is seldom reached. The pair to succeed those firing are always designated in sufficient time to prevent any delay. The Instructor always carefully observes the men firing and after each shot corrects such faults as may have been committed.

In advancing the soldier from range to range as his proficiency increases, advantage is taken of the spirit of emulation and the man's desire to obtain a high class in marksmanship, to promote him from one distance to another as soon as he makes at the former range the score necessary for qualification in the successive classes. Thus except for the poorer shots or previously uneducated men, the firing each season is commenced at 200 yards, and the soldier advanced from 200 to 300 yards, when he makes at the former range the scores required to qualify him for the Second Class. When the soldier makes at 300 yards the scores required at that range to qualify him for the Second Class,he is,unless the Instructor considers some practice at 400 yards advisable,advanced to 500 yards and continues to practice there until at that range he makes the scores required for a Second Class man. The soldier who has followed this course will now have completed his qualification for the Second Class; he then resumes practice at 200 yards and is successively advanced to 300 and 500 yards, as he makes at each range the scores required for the First Class. He continues practice at 500 yards until he completes the qualification for the latter Class. Practice is then resumed at 200 yards,and the soldier successively advanced to 300, 500, and 600 yards, as he makes at each range the scores required for qualification as a marksman; practice is continued at the latter range until the qualification as a marksman is completed. Whenever a soldier completes his qualification at 500 yards for either the Second or First classes, and as just prescribed would, to improve his record, resume practice at 200 and 300 yards, the scores previously made at these ranges are first considered; for some or all of the scores required for qualification for the higher classes may already have been made at one or more of the shorter ranges. If all the scores required to qualify the soldier for the class immediately above the one he has just reached were, in his previous practice, made at any range, firing is omitted at that particular range when resuming practice for the higher class. In a similar manner,if some but not all of such scores were made during that same season in previous firing, the soldier when practicing for the higher class is advanced a range as soon as he makes scores which, considered in connection with his previous record, would qualify him for the higher class.

This course of progressive instruction is not necessarily pursued by the sharp-shooter of a preceding year, nor is it made incumbent upon the Commanders, but rather laid down as a guide, which it is recommended that he follow in the company instruction, while recognizing that as the weather on the day assigned for target practice may be much better adapted for firing at a range other than that which, in accordance with the foregoing plan, would have been selected for the practice of the majority of the company, as a soldier may repeatedly fail in his effort at some particular range to qualify for a higher class, and as continued practice without any advancement or change of conditions might result in his discouragement rather than improvement, and also, for the contrary reason, as the required scores at some ranges might be made under peculiarly favorable conditions of weather, and before the soldier was sufficiently instructed to derive from practice at a longer range its full benefit, the instructor, while endeavoring to follow closely the indicated method of advancement, should, in the exercise of a careful discretion, vary it as far as the exigencies of any special case appear to render a different method more advisable.

Besides the rules laid down for the guidance of the instructor, and the other regulations that it is prescribed he shall follow, a large number of pages of "Rifle and Carbine Firing" are devoted to practical suggestions and advice to the individual sodier, relating in detail to his practice at the different ranges, to the effect of variations in the cartridge, in the gun, and in the wind, light and other conditions of the atmosphere upon the flight of the bullet, and to the measures he should take to forsee and overcome the difficulties they impose. By careful study the soilier is thus enabled to acquire a mastery of all the details of target firing, which will fit him to enter with favorable prospects into competitive firings or what is of much greater importance will make him such an expert shot, that whenever the distance of an enemy can be determined with accuracy on the battle field will add greatly to the effect of his individual fire.

Following the range practice comes the individual skirmish exercises; these take place in the latter half of the practice season, and includes firing at varied and undetermined distances, comprised between the limits of 200 and 600 yards. The squads of from eight to sixteen men are formed about 600 yards (for Cavalry armed with the carbine at about 500 yards) from a line of figure targets, representing men in the act of firing standing, and at appropriate commands for maneuvering skirmishers they are advanced, at quick time, until a point a little more than 200 yards from the targets is reached, when they are withdrawn at double time, to their first position. During the advance 5 halts are made, and one shot fired at each halt. The same rule governs during the retreat.

The individual skirmish is practice held at least three different times. For the first firing the target, Fig. 7, figures of skirmishers standing (Target D); for the second firing of skirmishers kneeling (Target E); and for the third firing of skirmishers lying down (Target F). The targets for each practice are arranged in line with a distance of 5 yards between centers, and that the accuracy of fire of each soldier may be known, a target is assigned to each man. Numbers are placed against the butt, above each figure, that each soldier may be able to distinguish his proper target. A hit in any portion of the targets, whether from direct or ricochet firing, is counted and scored 1. Either of those practices are repeated as often as the Company Commander may deem advisable. These individual skirmish practices are continued until the errors most generally committed by each man become known and are eradicated; they are then followed by the company skirmish firing in which the skirmish line is formed as it would be in battle, except that the recruits of the year, unless they have advanced rapidly in their range work, do not participate. The target described further on, is so arranged as to represent a hostile line, equal in strength to that engaged, and the firing is conducted in a manner similar to that for the individual skirmish except that at each halt two shots, instead of a single shot are fired, and the results of the practice are judged by the collective score of the entire company rather than by the record of its individuals, which in fact does not become known. The Post Commander is required to exercise a personal supervision over the company skirmish firing, examining the targets, inspecting the list of men engaged, and observing that none of the different companies obtain any unauthorized advantages, or fail to avail themselves of all proper opportunities.

As except at large posts, the entire garrison can be exercised at this drill in from one to two hours, no company is permitted to make more than one advance and retreat on any one day; sufficient time is thus afforded for all the others, and the practice can then be held under similar conditions of weather, by every company.

This practice having been only introduced in the United States Army this year (1885) could not be carried out at all posts with all the completeness that its great merits deserved. In very many cases no ground was available for the firing, and the novelty of the practice and the lack of information concerning its advantages and necessities, placed obstacles that could not be overcome in the way of such efforts as were made to temporarily send companies to more favorable localities for the firing.

Probably in future seasons such measures as are common in foreign Services will be obtained in ours and companies marched for several days when necessary, bivouacking at night, and thus entailing no additional expense, from their permanent garrison to such grounds in the vicinity as may be suitable, or even to an adjacent post where the desired facilities can be more easily obtained. If this much to be desired end can be reached, the men will then not only be exercised in the most practicable and valuable portion of their musketry instruction, but incidentally afforded a practice and experience that can be obtained in no other or better manner.

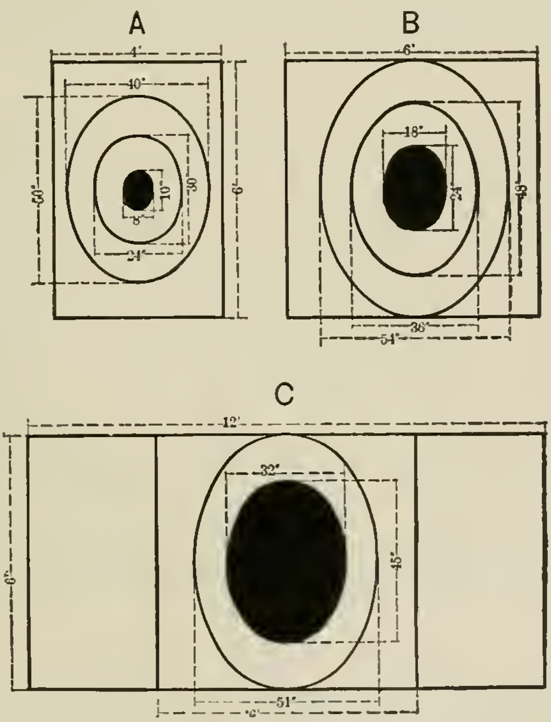


Fig. 5.

The very great importance of the company skirmish firing has been alluded to, when describing the somewhat similar exercises used in foreign armies, where especial emphasis is laid upon it, and the range firing generally considered as holding to it only the same relation that the preliminary drills do to the soldier's individual known distance target practice. This follows particularly from the marked practical feature that it possesses in the nature of the objective and the undetermined distance, also greatly from the opportunity that it affords the officer to acquire the ability to control his men, under the excitement incident to firing and to promote thereby the fire discipline of the company. There can be no doubt but that when it is carefully followed the accuracy of fire of the men upon the battle-field will be greatly promoted, and their efficiency much in advance of other troops who have not received the instruction.

In the targets both for their range and skirmish firing, the influence of the practical ideas of the Germans and Austrians, and of the desire now gradually permeating our army to educate the men for war rather than for target firing, is plainly noticed. For the range firing, three different targets are used, termed targets A, B, and C. At target A, the firing is held at 100 and 200 yards, from a standing position and at 300 yards in a kneeling or sitting position. For 500 or 600 yards target "B" is used, and for longer range up to 1000 yards target "C," the firing being held in a lying position the bull's-eye and other divisions in these targets are ellipses whose eccentricity is for all the same in any one target, but differing in the different targets, being greater for the "B" or mid-range target, than for the "A" or short-range target, and still greater in the "C" or long-range target. The dimensions of the various divisions of the targets are given in the plate: hits in the bulls-eye count five, in the next division called the "center" four, in the next division called the "inner" three, and in the remainder of the target termed the "outer" they count two. These targets are made of paper and pasted on cotton cloth which is fastened to a frame of the proper dimensions. Except when stations are but temporarily occupied, these frames, made of wood, are so arranged that they can be withdrawn after each shot, and the bullet-hole covered with a patch of the proper size. The frames are generally arranged in pairs and in such a manner that as one target is withdrawn the other appears in a position for firing. Different varieties of these target frames, revolving or sliding, either vertically or horizontally and perpendicularly to, as well as in the direction of the line of fire, are supplied, and the firing thereby greatly expedited.

In laying out ranges, the local topographical features of course have a predominating influence, a general plan. Fig. 6, is however prescribed as a guide to which all ranges conform as nearly as possible. This contemplates a continuous trench or marker's shelter in which the targets are placed at intervals of about 15 yards; this then permits any set of markers to be relieved without causing a cessation of firing on that or adjacent targets, and is further of great advantage whenever the range may be desired for exclusive competitive practice. About 20 yards in rear of the targets a traverse of earth at least 20 feet high is thrown up, disposed in steps to prevent extensive cutting by the bullets. To indicate the respective firing points for the several targets, stakes are placed at each 100 yards and on lines perpendicular to the targets; these are marked with the number of the target and the distance. On the flanks of the range, poles are placed from which streamers are flown to indicate the direction and approximately the strength of the wind. For convenient storage of the marker's implements a shed or small building is erected in the target pit and on extensive ranges, where Department competitions are held, a second and larger building is placed back of the last firing points for the necessary offices—these two buildings are connected by telephone.

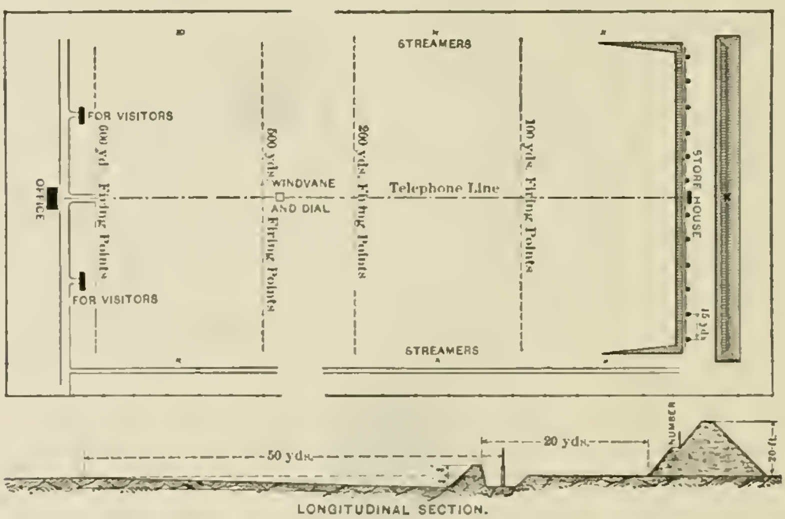


Fig. 6.

The skirmish targets, Fig. 7, are steel frames so constructed that while sufficient strength and stiffness is secured, but a slight surface is exposed to the blow of the bullet: they are covered with cotton cloth cut to the shape of the frame, and finally with black paper, cut as silhouettes. For the company skirmish firing the total number is made equal to the number of men in the firing line, the figures are placed, first a kneeling, then a standing, then a lying one, and so on throughout the entire line, the intervals between the centers of the adjacent figures being one yard. Fig. 8.

For volley and file firing the target is formed of sixteen of the standing figures in closed line. Fig. 9.

In the company skirmish firing, the targets are examined and the hits counted by commissioned officers; in the regular range practice the detail for marking in each target pit consists of two privates, preferably of the company firing, and a Sergeant or Corporal of another company. It is further required that officers be present in the pit wherever possible. Recording the values of the shots at the firing-point is also done by a Sergeant or a Corporal of some other than the company firing. In cases of posts garrisoned by a single company, where this plan consequently cannot be pursued, a new paper target is used for each practice, and the number of hits in each division counted upon the conclusion of the firing, and compared with the record at the firing point. The scores at the firing point are recorded in ink, in a book in which two pages are assigned to each soldier. This record gives the value for each shot fired, with the total score at each of the ranges considered in the classification, also summaries by which the class in which the soldier is at any time, can be determined at a glance; and the results of his individual skirmish firing. The record of the company in company skirmish firing and in volley and file practice is also entered. That the soldier may be the better able to profit by past failures or successes, he is provided with a private book in which he records not only the value, but by appropriate diagrams, Fig. 10, the exact location of each hit. This, together with his observations upon the atmospheric conditions, and the record of such changes as he may have made in his sight adjustment during the firing, form a history of the practice available for subsequent study. As has been previously indicated, the classification of the men is not postponed to the close of the season, but ed, and worn on the coat collar, and for the third year a pin of silver, which is worn on the left breast. Classification as a marksman in future years brings no further recognition. The sharp-shooter when first qualifying receives a pin of silver with a cross pendant, to which for every third year in which he attains that class a clasp or bar is added. Upon these classifications depends what is termed the individual figure of merit of the company, which is determined at any period by multiplying the number of sharpshooters in the company by 200, the number of the marksmen, 1st, 2nd, and 3rd, Class men by 100, 60, 30 and 10 respectively, giving to those who have been present, but not practiced a multiplier zero, and then dividing the sum of these products by the total number in all the classes. Where practice has been conducted in exact conformity with the requirements of the prescribed system, this figure of merit will indicate the degree of accuracy in known distance firing, or in other words in target practice that any body of men have in their best efforts succeeded in accomplishing. It might also be considered as affording, when a comparison is drawn between any two companies, grounds for a judgment as to the probable relative effect of their fire. When on the defensive, against objects whose distance they were enabled to obtain with considerable accuracy. What

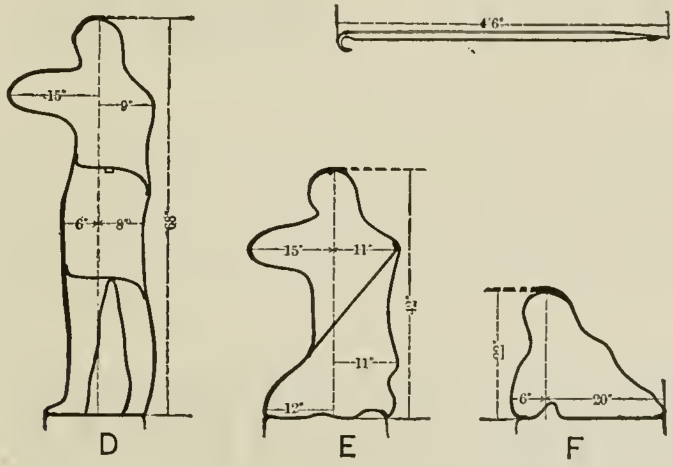


Fig 7

is at once made as soon as firing is begun, and is continually corrected as a soldier improves his record; this affords room for a soldier's ambition, and continually adds to his desire to excel, the stimulus afforded by competition. After first firing, all are in the Third Class; for advancement to the Second Class four scores (not necessarily consecutive) must have been made at each of the ranges, 200, 300 and 500 yards, which aggregate 50 for those firing with the rifle, and 50, 48 and 45 respectively for those firing with the carbine. When the totals for these selected scores at these ranges are brought up to 65 with the rifle, or to 65, 60 and 55 respectively with the carbine, the soldier is rated in the First Class. When the totals at the same ranges are still further increased to 80, and the same total made at 600 yards (80, 75, 70 and 65 respectively, for the carbine,) the soldier is called a marksman. For the highest, the Sharpshooters' Class, totals of 90 must have been made at 200, 300 and 500 yards, of 85 at 600 and 800 yards, and of 80 at 1,000 yards.

To the marksman for the first and second years of reaching that grade, small nickel buttons are award-

is termed the skirmish figure of merit is given by the percentage of possible score in the best skirmish firing of the company as a body; it directly expresses the most effective results obtained in this class of firing, where celerity of movement, promptness and accuracy in the estimate of the distance, in the selection of the particular objective, and in the accurate delivery of fire and a perfection of discipline under circumstances as nearly similar to those existing on a skirmish line as can be found in peace, all exercise a predominating and deciding influence. The final judgment of the proficiency of the company is given by the means of these two partial results and is termed the general figure of merit, it then may be considered as expressing not only the general proficiency of the company, but as further indicating for any two regiments, or any two companies, the probable relative effect of their fire under all the conditions incident to both a defensive and an offensive action, and consequently affords a good relative measure of their probable efficiency on the battle-field.

During the season reports are forwarded monthly from each company, to the Inspector of Rifle Practice in the Department in which they are stationed; these reports show the figure of merit for individual firing, and towards the close of the season for the skirmish firing also, with the names of the officers and men who have had but little practice and the reasons for such omissions. This is also accompanied by a report of the qualifying scores of such sharpshooters and marksmen as have reached those grades during the month; certificates and the prizes before mentioned are then issued for these men by the Department Inspector. At the close of the year the company makes a report of the totals of the best four scores of each man at the ranges at which he received instruction, of their classification and of the individual, the skirmish and the general figure of merit as it then appeared. From these reports a consolidated regimental report, giving summaries of these results for the regiment, and a similar consolidated report for the Department are prepared. The latter reports are forwarded to the Headquarters of the army, when the results for the year for the entire army and for its respective departments, regiments and companies is published in orders.

Supplementary to the regular course of instruction and added to further increase the interest of the men, are the several contests between selected shots which are held annually. For the first of these firings, the Commanding Officers of each regimental Non-commissioned Staff or band, and those of each troop, battery, or company, select from among all the enlisted men of their commands the most suitable marksman, due regard being paid not only to the excellence of shooting, but to the steadiness and good soldierly habits and conduct, and report the name of the man thus chosen to the Post Commander, who sends him to the place of competition on the date that may be fixed by the Department Commander.

Each Post Commander reports to Department headquarters the names of any commissioned officers (qualified marksmen) in his command who may desire to enter the competition and whom he can recommend for that purpose; further stating, whenever more than one officer is recommended, the comparative proficiency, as rifle shots, of those reported. From these reports or from such additional reports of scores actually made, as the Department Commander may require, the Department Commander selects two officers as competitors from each regiment in his command, and in addition such officers from the different staff corps as he deems proper.

The Department Commander may also select as competitors enlisted men, not exceeding five in all, from the general service detachments or from the general staff of the army.

The officers and men thus selected assemble at some convenient post early in August of each year, and after such an amount and kind of preliminary practice (not exceeding three days in duration) as the Department Commander may prescribe, compete for places on the Department team of twelve.

In this competition the firing is at fixed targets at known distances, and also as skirmishers at undetermined distances, and the composition of the team determined by the aggregate of the scores for both classes of firing.

That part of the competition taking place at known distances extends over two days (not necessarily consecutive), ten shots being fired each day by each competitor at each of the ranges 200, 300, 500, and 600 yards. The firing at 200 yards being from a standing position; at 300 yards either kneeling or sitting, in both cases at target A; and at 500 and 600 yards at target B lying down; any variety of these positions authorized by the regulations for competitive firing being permitted.

That part of the competition embracing the skirmish firing also extends over two days, not necessarily consecutive, one advance and retreat, as skirmishers, being made each day by each competitor.

For the skirmish firing, a target composed of the three skirmish figures arranged as shown on either flank of the company skirmish target, Fig. 8, is employed and each competitor allowed forty cartridges. The firing is conducted as prescribed for the individual or the company skirmish firing except that the halts are fixed at fifteen seconds each and the competitor allowed to fire at his discretion (instead of only one or two shots) during that period, hits also are scored five points when in the lying figure, four in the kneeling and three in the standing figure.

The twelve competitors who make for this four days' competition the highest aggregate scores constitute the department team, and the two competitors making the next highest total scores are added as alternates.

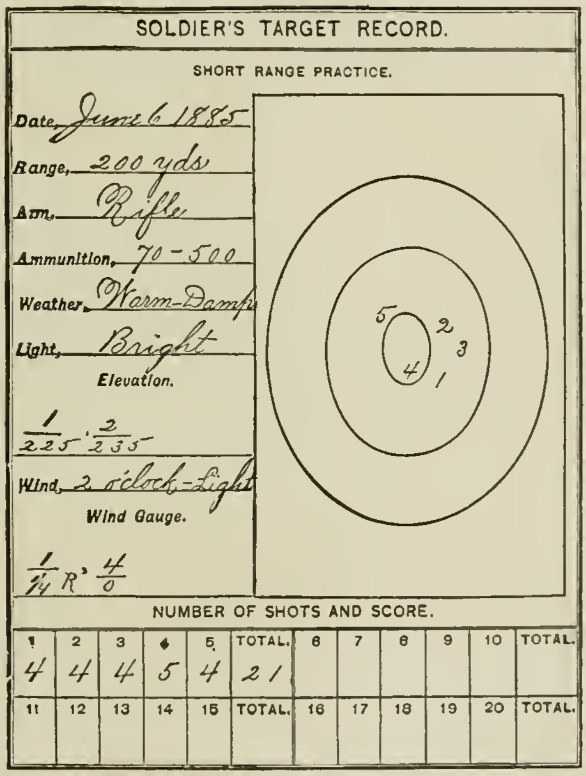
To the competitors winning the first place on the department team a suitably inscribed gold medal is awarded, and to the competitor, whether a member of the team department or not, who makes the best aggregate score for the two days competitive skirmish firing, a suitably inscribed silver medal. These medals, and such others as may be won in division or army competitions, become the property of the winners, and may be worn on all dress occasions.

Fig. 8—Company Skirmish Firing.

Fig. 9—Volley and File Firing.

In assembling the competitors, no ordinary exigency of the service, field, or other duty will be allowed to interfere with the representation of every company having a qualified marksman, and Post Commanders will forward to the place of competition the descriptive lists of enlisted men, and the qualifying scores with their dates, of *all* marksmen selected for the competition.

The Division Commander assembles the Department teams at some convenient post in his Division, to compete, in the latter part of August or early in September, for the honor of places upon the Division team of twelve. This competition, both as regards the duration of the preliminary practice and the competitive firing at known distances and as skirmishers, and the determination of the successful competitors, will be conducted in the manner prescribed for the competitive examination; the firing being *individual* by the collective members of all the teams, and not a contest of the teams as units determine their relative order of merit in the team, and for the following prizes: First prize, a gold medal, suitably inscribed; to the next two members of the team suitably inscribed gold medals, and to the next three members of the team, each a silver medal. In addition to the above prizes, a suitably inscribed gold medal will be awarded to the member of the team who makes the best aggregate score for the two days of skirmish firing which form part of the Army competition. Only marksmen qualifying as such during the current target year will be eligible for selection for the foregoing competitions. Whenever a marksmen has been three times a member of a Department team and has won any three of the authorized medals, he is announced in orders from the headquarters of the Army as belonging to a distinguished class, no longer eligible, to enter the Department competition. "Distinguished marksmen" who have not previously been on the Army team may, however, be selected once, but not a second time, as members



SOLDIER'S TARGET RECORD.

SHORT RANGE PRACTICE.

Date, June 6 1885

Range, 200 yds

Arm, Rifle

Ammunition, 70-500

Weather, Warm-Damp

Light, Bright

Elevation.

1/225, 2/235

Wind, 2 o'clock-Light

Wind Gauge.

1/¼ R, 4/0

NUMBER OF SHOTS AND SCORE.

1	2	3	4	5	TOTAL.	6	7	8	9	10	TOTAL.
4	4	4	5	4	21						
11	12	13	14	15	TOTAL.	16	17	18	19	20	TOTAL.

Fig. 10.

against each other. The alternates of the different teams will not fire in the Division competition unless required to replace members of their team who may be prevented by other duty or by sickness from competing.

To the members of the Division team thus selected the following prizes will be awarded: First prize, a gold medal suitably inscribed; to the next three, suitably inscribed gold medals; and to the remaining eight winning competitors, each an appropriate silver medal.

Every alternate year, twelve of the best shots in the entire Army will be selected in the manner that may be designated in orders, and assembled at some convenient time and post. The marksmen thus chosen constitute the Army team, and will compete (after three days' preliminary practice) in the manner prescribed for Department and Division competitions to of that team. Expressions on the part of the competitors of approbation or disappointment with reference to any scores made by themselves or others, must not be uttered loud enough to be heard at the firing points. Protests and objections must not be directly submitted to the Officer in Charge, but to one of the Range Officers. In case a competitor considers the decision of the latter unwarranted by the facts as presented, he may appeal to the Officer in Charge. Final appeals from decisions of the Officer in Charge must be made in writing and forwarded through that officer to the authority ordering the competition. These regulations and such special rules or directions as the Officer in Charge may give, must be rigidly complied with by competitors and all other persons upon the range grounds at all times and under all circumstances. See *Marksmanship* and *Rifle Practice.*

TARIERE.—A machine of war similar to the battering-ram (which it preceded), excepting that the head was pointed. It made the first opening in the wall, which was increased by the *belier*.

TARPAULIN.—A large sheet of the coarsest kind of linen or hempen cloth, saturated with tar to render it waterproof. It is used for covering loaded wagons, the hatchways of ships, and similar things, as a temporary protection from wet.

TARRED LINKS.—Tarred links are made of old rope, covered over with a composition to give light. The materials employed are *old slow-match* or *rope; cartridge-thread;* and *ends of rope*. One link requires ⅛ pound of *tow*, and 1 to 1¼ pounds of *composition*. To make the links, the old rope is well beaten with mallets; the short ends are tied together with cartridge-thread. The links are formed by coiling the soft rope around the hand, in coils of 3 inches interior and 6 inches exterior diameter, loosely tied with thread. The links are covered with composition, as described for fascines. Tarred links burn one hour in calm weather, half an hour in a high wind, and are not extinguished in the rain. Two of them are put in a rampart-grate on a bed of shavings. The grates are placed about 250 feet apart. See *Fireworks*.

TARTAN.—A pattern cloth of different colors, printed side by side and crossways, forming the well known checkered pattern. The tartan pattern admits of great variety of modifications, each clan in Scotland having its own pattern. The Highland regiments have each distinctive tartans.

TARTARES.—A word used in the French Army to distinguish officers' servants and batmen from the soldiers who serve in the ranks. *Tartare* likewise means a groom.

TASA.—In the East Indies, a kind of drum, formed of a hemisphere of copper, hollowed out and covered with goat-skin. It is hung before from the shoulders, and beat with two rattans.

TASKING.—Experience has shown that, in ordinary soils, a man with a pick can furnish employment to two men with shovels; that, not to be in each other's way, the men should be from four-and-a-half to six feet apart; and, finally, that a shovelful of earth can be pitched by a man twelve feet in a horizontal direction, or six feet in a vertical direction. To distribute the workmen, the counterscarp crest is divided off into lengths of twelve feet, and the interior crest into lengths of nine feet. These points might be marked out by pickets numbered one, two, three, etc. In each area, thus marked out a working party is arranged consisting of a pick with two shovels placed near the counterscarp, two shovels near the scarp, and one man to spread, and one to ram the earth, for two working parties. The time required to throw up a work will depend on the nature of the soil and the expertness of the laborers. From troops accustomed to the use of ditching tools, six cubic yards may be considered a fair day's work in ordinary soils, when the earth is not thrown higher than six feet; but when a relay is placed on an offset in the ditch, from four to five cubic yards may be taken as the result of a day's work for each man. Expert workmen will throw up from eight to ten cubic yards at task work. Assuming the profile of the parapet to be normal, the time for throwing up the work may be roughly calculated, as follows: The area of the section of the parapet is about one hundred and eighteen square feet. The area laid off for a working party has a length of six feet. It may be roughly estimated that the working party assigned to one of these areas is required to make an embankment containing seven hundred and eight cubic feet, or about twenty-six cubic yards. An excavation which measures twenty-three cubic yards will give earth enough to make a parapet containing twenty-six cubic yards. Calling the amount of excavation to be twenty-four cubic yards, and supposing each party to take out only four cubic yards per day, it will require six days to construct the parapet. The parapet, of the dimensions given, can be constructed by fatigue details, in one-third of this time, or less, by increasing the number of men in each working party, dividing the party into reliefs, and working continuously until the parapet is finished. When the embankment has reached the height of the banquette tread, additional working parties are organised, for the purpose of constructing the revetments, which are required to support and protect the interior slope. When no engineer soldiers can be spared to oversee the work, substitutes must be obtained. There will be found, in all of the infantry regiments of the United States service, Non-commissioned Officers who have had experience in the labors of excavating and embanking. These can be detailed to act as engineer soldiers and can fit themselves in a very short time to discharge the duties assigned to them. The method of posting the men is a matter of detail, acquired from practice; the only condition imposed is that there shall be no *crowding*. Only a limited number of men can work at the same time, and rapidity of execution can only be obtained by frequent reliefs. Rapidity of execution is facilitated by good judgment, especially in the selection of the men. Good axemen should not be used to dig; and good diggers should not be used as axemen. Proportioning the work according to the skill displayed by the men will materially shorten the time required for its execution.

TASLET.—A piece of armor formerly worn on the thigh.

TASSE.—Formerly a piece of armor for the thighs. It was an appendage to the ancient corselet, consisting of skirts of iron that covered the thighs, fastened to the cuirass with hooks.

TASSETTES.—A rounded form of the *tuilles*, composed of several distinct pieces.

TATTOO.—The beat of drum announcing the hour at which the day closes in, when all day duties cease, and night duties commence, and when soldiers must be in quarters. The hour varied, until very late, according to the season of the year. But it is changed now to 10 P.M. throughout the year. At foreign stations this hour is to be adhered to as far as is practicable, but it may be changed at the discretion of General Officers Commanding, to suit the degree of latitude in which their respective commands are situated. This rule does not apply to troops on active service in the field, and the tattoo is to be sounded at such an hour as may be ordered by the Commander of the Forces. Also written *Taptoo*.

TATTOOING.—A custom very extensively prevalent among savage nations, of marking the skin with figures of various kinds, by means of slight incisions or punctures and a coloring matter. The term is of Polynesian origin, and is said to be derived from a verb *ta*, which signifies to strike. Tattooing is almost universal in the South Sea Islands, except where Christianity and civilization have put an end to it. New Zealanders heads, exhibiting tattooing, are among the curiosities to be seen in museums; and at one time it was very common for the masters of vessels visiting New Zealand to purchase them and bring them home, although there is too much reason to believe that the price paid for them stimulated the feuds of the natives. The tattooing of the New Zealanders and other South Sea Islanders often covers the whole face, and sometimes also the chest, arms, and other parts of the body with elaborate patterns. It is performed in youth, and marks the transition from boyhood to manhood, like the assumption of the *toga virilis* among the ancient Romans. The operation is accompanied with superstitious ceremonies, and is attended with considerable pain, which, of course, is to be endured with manly indifference. An instrument of bone, toothed on the edge, is employed, which is applied to the skin, and struck with a piece of wood, having first been dipped in a thick mixture made by rubbing down charcoal with a little water. The marks which result are


TASMANIA
BASS STRAIT
BANKS STRAIT
WELLINGTON
DEVON
DORSET
RUSSELL
WESTMORELAND
CORNWALL
MONTAGU
LINCOLN
GLAMORGAN
SOMERSET
CUMBERLAND
FRANKLIN
MONTGOMERY
MONMOUTH
PEMBROKE
BUCKINGHAM
ARTHUR
KENT
LAUNCESTON
HOBART
Storm Bay
Adventure Bay
South West Cape
South East C.
C. Pillar
Tasman Hd.
British Miles
Geographical Miles
Longitude East from Greenwich

permanent, and appear black on a brown skin; although they are dark blue on the skin of a European. Tattooing is, or has been, practiced in almost all parts of the world. It seems to be one of the practices prohibited to the Jews, in Lev. xix, 28, "Ye shall not make any cuttings in your flesh for the dead, *nor print any marks upon you*," from which may be inferred its prevalence among the surrounding tribes in the days of Moses, and its connection with their superstitions. The Bedouin Arabs, the Tunguses, and other eastern tribes, and many tribes of American Indians, practice it at the present day. Among the Bedouins, it is a favorite mode of female adornment. It prevailed among the ancient Thracians, and was distinctive of high rank. The ancient Britons also practiced it, and traces of it appear to have lingered in England till after the Norman Conquest. Perhaps the practice of sailors to print anchors and other marks on their arms, may be regarded as a relic of it still subsisting.

TAU.—In Heraldry, a cross of a form somewhat resembling the Greek letter *Tau*. St. Anthony is generally represented with a cross of this description, embroidered on the left side of his garment.

TAXIARCHS.—In the Athenian Army, ten in number (every tribe having the privilege of electing one), and commanded next under the *Strategoi*. Their business was to marshal the army, give orders for their marches, and appoint what provisions each soldier should furnish himself with. They had also power to cashier any of the common soldiers, if convicted of a misdemeanor; but their jurisdiction was only over the Foot.

TAYLOR GUN.—The Taylor machine-gun has in the gun proper a horizontal range of parallel rifle barrels, five in number, of 0".43 caliber, securely united to each other and to a hollow breech, which contains the firing mechanism, etc., and supports upon its top the cartridge hopper. A hand-crank, at the right-hand side of the breech, operates a transverse shaft, common to the firing mechanism, etc., of all the barrels. Between the elevating screw and the breech a device for spreading the fire is interposed. This device consists of a hollow, laterally extended head, swiveled to the screw; a slide, working in this head and attached by ball and sockets, to the bottom of the breech; a hand lever, extending rearwardly through said slide from a fulcrum on said head; and a pair of stop-jaws within said head adjusted to any desired distance apart by means of a right and left screw-shaft operated by a hand wheel, at its left-hand end. A folding seat, upon the trail of the carriage accommodates a man in convenient position to manipulate the spreading lever by means of his left hand, while with his right he turns the firing-crank. A folding breech-sight, and a rigid front sight are attached respectively to the top of the breech and to the top of the barrel frame in line with the right-hand barrel. Other appurtenances of the gun require no particular description. The features of peculiarity in the gun, apart from details of mechanical workmanship, are comprised in the parts within and upon the breech.

The gun is designed for center-primed fixed ammunition of a standard rifle range; and is designed and adapted to be distributed indiscriminately to the infantry and machine-gun batteries. Each case or package contains twenty-five cartridges in five rows of five each, with their heads abutting against each other at a certain distance from the top of the lower part of the case. The ball ends are kept at the proper distance apart, and in proper position, by the means of crossed strips of straw-board within the case, which is of the same material. The gun is adapted to be made with any desired number of barrels without change of plan, and the parts belonging to the respective barrels may be interchangeable, so as to be substituted for each other or replaced from the manufactory with the utmost facility. Other general advantages *claimed* for the gun are: (1.) Economy, great certainty and rapidity in loading, owing to the transfer of the ammunition directly to the gun from simple paper boxes, in which the same is packed for transportation at the cartridge factory. (2.) Simplicity and compactness, with certainty in the firing and shell-ejecting mechanism. (3.) Effective support against recoil in line with the respective barrels as afforded by the operating cams. (4.) Convenience of access to the working parts of the gun without dismantling the same. (5.) Simplicity and convenience of means for manipulating the gun in action.

Several improvements and modifications have been proposed by the inventor of this gun; the special features of the gun in its present shape are: (1.) The combination of the breech-block, the series of barrels arranged in a horizontal plane, the sliding locks or plungers, and the cams or eccentrics carried by a shaft transverse to the barrels, and actuating the locks or plungers in succession. (2.) The cams constructed with concentric front and rear portions to cause a dwell of the plunger at each extremity of its stroke. (3.) The breech-frame constructed with removable longitudinal bars. (4.) A feed-plate constructed with flanged grooves or guides adapted to receive and draw the cartridges from the cases in which they are packed and convey them to a feed opening or openings of suitable character. (5.) A hopper or feeder constructed with flanges or grooves for the reception of the cartridges and divergent throats to conduct them to the breech-chamber. (6.) A feeder for machine-guns, consisting of a series of parallel bars, with spaces for the automatic arranging or assembling of the cartridges with their points in corresponding position preliminary to their introduction into the breech or charge-chamber. (7.) The blades or fingers for drawing cartridges by their flanges from cases in which they are packed. (8.) The combination of a series of cams carried by a through shaft, and a series of followers bifurcated to pass the said shaft when operated by the cams. (9.) The cams with their shoulders in combination with the lock-carriers or yokes and their shoulders acted on by the said cams. (10.) The sliding lock-carriers or yokes, each having a bifurcation to adapt it to pass the shaft, and a vertical slot for the passage of the operating cam. (11.) The combination of the operating cams, the lock-carriers (or yokes) and the sliding locks or plungers constructed, connected, and operated as shown. (12.) The feeding-hopper provided with the oscillating valves in combination with the sliding locks or followers and their top-plates for operating the said valves. (13.) The combination of the firing-pins and the removable cocking-slides. (14.) The spring guiding-jaws in combination with the firing-chambers and extractors, and the ejectors for knocking the shells out from between said jaws. (15,) The plate or blade projecting down within each hopper-throat to serve as a guide for the points of the cartridges and adjustable by means of a set-screw to suit cartridges of different lengths. (16.) The combination with the guide plates or fingers and the fixed back plate of the extension gauge-plate to serve as a guide in introducing the cartridges. See *Battery-gun*.

TEAK.—The staple timber of India and Burmah, and the most useful and durable timber known, soon seasoning and easily worked. The Malabar teak is superior to that of Burmah, in strength and durability. Good teak resembles coarse mahogany, with reddish-brown streaks, having very close and straight grains. A cubic foot of unseasoned wood weighs 55 to 60 lbs. It is extensively used in the Bombay Gun-carriage Agency.

TEAM.—Two or more horses or animals of any description harnessed together. Thus, in applying the term in artillery draught, it means the horses attached in double draught to batteries, according to the custom of the service.

TEAMING.—In the foundry, the operation of pouring the molten cast-steel from the crucible into the ingot-mold. 2. The operation of transporting earth from a fortification cutting to the embankment.

TEBET.—A kind of axe which the Turks carry at their saddle-bow during war.

TECHNICAL TROOPS.—A name given to a body of troops peculiar to Germany and Austria, consisting of men trained in technical engineer duties, but incorporated with the many different battalions of the Guards, Line, and *Landwehr*. The do not seem, during the campaign of 1870-71, to have been of much use, for, brought under fire in conjunction with their comrades, they suffered severely during the earlier actions, and afterwards the battalions to which they belonged were so weak that the technical troops were retained for the ordinary duties of infantry soldiers. Pioneers could easily be converted into an equivalent force.

TEEPE—An Indian cabin or hut. Time and space are not considered by the Indians, and wherever they pitch their teepes there is their home. In the arrangement of their villages, the teepe of the Chief is placed in the center and those of the warriors around it, according to rank. The entrances to the lodges always face the rising sun. The number in a teepe varies from six to fifteen persons and half as many dogs. Two fighting men for each teepe is a fair average. The leading events and achievements of their lives are recorded on their lodges by a rude system of hieroglyphics.

TEFTERDAR EFFENDI.—The Commissary General as commonly called among the Turks.

TELEGRAPH.—A general name for any means of conveying intelligence other than by voice or writing. The idea of speed is also implied. Alarm-fires, the semaphore and the signals used at sea, are among the earlier forms of telegraph. It has been reserved for our own day to develop into practical use the capabilities of electricity and magnetism as a means of distant communication; although in earlier times, the possibility of such a use of this natural power has been frequently suggested. The public use of the electric telegraph dates not earlier than 1846; but the idea that magnetism could be applied for distant communication is at least two centuries and a half old. Galileo, in one of his dialogues on the rival astronomical systems, written in 1862, puts in the mouth of one of his speakers, a reference to a secret art, by which, through the sympathy of the magnetic needle, it would be possible to converse across a space of two or three thousand miles. In 1753, a letter appeared in the *Scots Magazine*, bearing the initials C. M., and headed—"An Expeditious Method of Conveying Intelligence."—in which we must recognize the first perception of the uses to which telegraphy might be put. This interesting letter starts with the remark that it "is well known to all who are conversant in electric experiments, that the electric power may be propagated along a small wire fence from one place to another without being sensibly abated by the length of its progress;" and it goes on to describe an arrangement of wires corresponding in number to "the letters of the alphabet," to be fixed in glass or jeweler's cement at intervals of 20 yards, and to convey from an electric machine or rubber, a current which would lift each letter, "marked on bits of paper, or other substance that might be light enough" to rise to the electrified ball which formed the terminal of each wire. The apparatus proposed is crude and clumsy, yet we can hardly fail to recognize, in the letter of this Renfrew man, the full appreciation of what the electric telegraph might become. From a period shortly anterior to the date of the letter in the *Scots Magazine*, down to 1837, a large number of proposals, more or less ingenious are on record. The space at our command will not permit us to describe all those inventions, or to enter upon the much-vexed question as to who is entitled to the name of inventor of the electric telegraph. We must be content to furnish a description of the more important instruments in use, some statistics of the more recent history of telegraphy generally, and a notice of the progress of submarine-telegraphy. In our description of instruments, etc., we shall assume the reader to be familiar with the chief facts of galvanism and electro-magnetism. Telegraph instruments may be classed under two heads, namely, those which record the signals, and those which only give passing signals to the observer or listener. Among the former are several varieties, namely, those giving a record in arbitrary signs (*i. e.*, in the dots and dashes of the Morse alphabet); those which print in ordinary characters, such as the Hughes type-printing instrument; and lastly, a class of instruments giving a *fac-simile* of the message. The latter two classes are not much used, and the number of Hughes instruments in use in this country has somewhat decreased. The great bulk of the telegraphing of the world is done either by the Morse printer, or by the non-recording instruments; and to those we shall therefore devote the major part of our description.

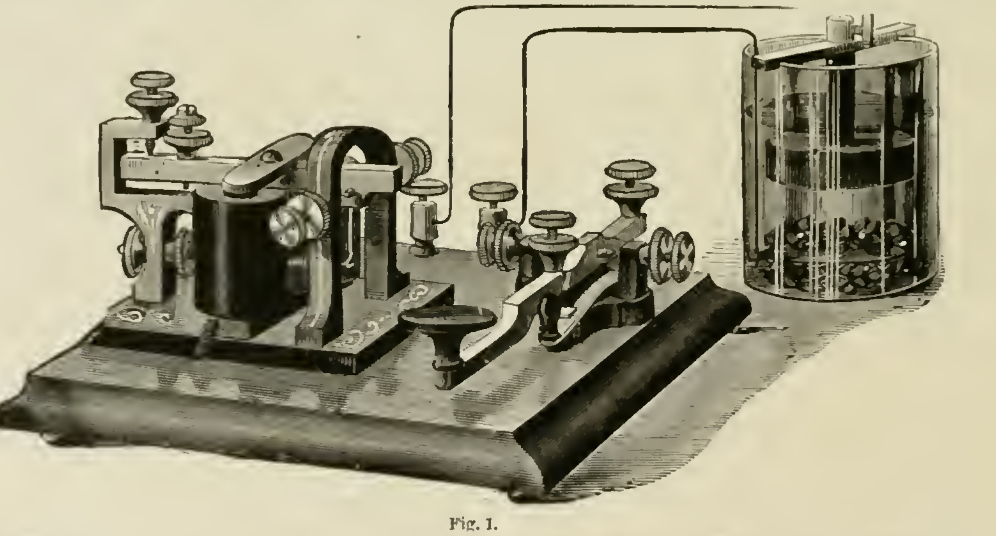


Fig. 1.

The leading principle in the Morse and other allied instruments is, that by the depression of a key or other method, an electric circuit is "closed" or completed, and a signal is transmitted along the wire to the distant station, where, on its arrival, it reproduces the signal by the action of an electro-magnet or otherwise. Electrically, the Morse apparatus, Fig 1, consists of the transmitting-key, and the electro-magnet and armature; while mechanically, it consists of a lever, with circular wheel or disk, attached to the armature, and a clock-work arrangement by which the paper tape to be printed upon is carried forward under the disk. On the current being received from the station, it traverses the coils of the electro-magnet, and the armature is drawn down by the action of the current. Screws regulate the play of the armature, and of the inking-disk, at the other end of the lever.

In the first Morse instruments the marks were made on the paper with a pointed style (the instrument being thus known as the *embosser*); but by the invention of the ink-writing arrangement of Siemens, which we are now considering, the legibility and permanence of the record were secured, besides the advantage that a very light current will serve to make the marks. The case containing the clock-work, the arrangement of wheels by which the paper tape is unwound and carried forward, and the switch, by which the running of the tape is stopped, are ingenious constructions. The passage of a current draws down the armature, and elevates the disk, causing a straight mark on the tape so long as the current flows. When it ceases, a spring draws back the armature, and the mark is discontinued. Thus the duration of the current determines the nature of the mark, a momentary passage causing a dot, a longer depression of the key a dash; and as the alphabet invented by Prof. Morse consists of dots or dashes, or a combination of the two, the above explanation discloses the whole mystery of this system of the telegraphy to those who have mastered the phenomena of electricity. Before going further, the details of the Morse alphabet, universally recognized as a masterpiece of cryptography, may be given. The signals, as given below, are arranged in the groups, and accompanied by the mnemonic phrases, adopted by the British Post-office when, in 1870, the transfer of the telegraphs to the Government rendered necessary the rapid training of thousands of telegraphists throughout the kingdom:

	Group 1.		Group 2.
.	E, Earwigs	—	T, Turnips
. .	I, infest	— —	M, make
. . .	S, summer	— — —	O, oxen
. . . .	H, houses.	— — — —	Ch, cheerful.
	Group 3.		Group 4.
. —	A, A	— .	N, No
. — —	W, wet	— . .	D, difficulty
. — — —	J, jacket's	— . . .	B, baffles
. . —	U, uncomfortable	— — .	G, great
. . . —	V, very!	— — . .	Z, zeal.
	Group 5.		Group 6.
. — .	R, Remember!	— . —	K, Kindness
. — . .	L, law	— . — .	C, conciliates
. — — .	P, preserves	— . — —	Y, youth
. . — .	F, freedom.	— . . —	X, extremely
		— — . —	Q, quickly.

The arrangement for numerals is equally ingenious. Each figure is represented by five signals, thus:

1, . — — — —	6, — . . . .
2, . . — — —	7, — — . . .
3, . . . — —	8, — — — . .
4, ... —	9, — — — — .
5, ...	0, — — — — —

These are the numerals printed long, but on busy circuits expert clerks adopt the practice of "sending short," omitting all after the first dash in 1, 2, and 3, four of the dots in 5, and all before the last dash in 7, 8, 9, and 0. It is stated that Prof. Morse founded his alphabet upon information given him by his brother, a journalist, as to the numerical relation of the letters in the English alphabet, the simplest signal (a dot) being given to E, and the next simplest (a dash) to T, those letters occuring the most frequently in our language.

For the generation of power in the electric telegraph, Daniell's batteries (see GALVANISM) are chiefly employed in this country. Various forms of the Bunsen battery are also used, especially on the Continent. The power employed varies with the length of line, the condition of the wires as regards insulation, and the nature of the instruments used. In towns, wires are carried "over-house," or by underground pipes, the wires in the latter case being insulated by means of a gutta-percha or other suitable covering. The subterranean method is being applied to extend lines, especially in Germany, and is found to answer as well as the over-head system, while it avoids many of the casualties to which the latter is liable. In pole and over-house lines, the wires are kept from each other and from contact with the earth by insulators of various kinds. White porcelain and brown stoneware are the chief materials used. The former, when of good quality, well glazed and well burned, is perhaps the most perfect of all insulating materials, and does not deteriorate with age. The fewer the poles are in number on which the wires are suspended, the better is the insulation and the less the cost, but the liability to accident is probably greater. The number of poles used varies from 16 to 30 per mile, and is governed by the number of wires carried, the configuration of the track, and other considerations. On road lines, the number of poles is generally larger than in the case of the telegraphs carried alongside railways, the greater levelness and straightness of the latter reducing the number of supports required. The wire chiefly used for inland telegraph purposes is of iron, galvanized, and of No. 8 ($\frac{1}{6}$ in.) gauge. The conductivity of a wire increases in the ratio of the square of its diameter (the resistance decreasing in the inverse ratio), and the advantage of using a thicker wire on the longer lines is thus seen. No. 4 wire is, for this reason, used on some of the longer lines.

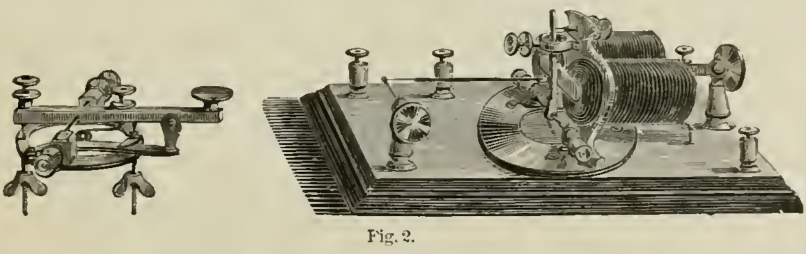


Fig. 2.

Mention has been made of the "earth." This is the technical expression used in relation to the fact discovered by Steinheil in 1838, that the earth itself serves the purpose of completing the circuit, and renders the use of a second or return wire unnecessary. The "earth" may consist of a buried plate of metal connected with the battery or line-wire, and of sufficient surface to afford the necessary diffusion. The gas or water pipes of a town form excellent "earths" care being taken that the connection is made with the pipe itself, and not with a branch, where a badly made joint might spoil the connection. Where dissimilar "earths" are in use, as for instance, a copper plate at one end, and an iron pipe at the other, a *quasi* battery is created, and vexatious currents pass along the line. Hence the "earths" on a circuit should be made alike. The earth, being regarded as a large reservoir of electricity, offers no sensible resistance to the passage of the current, in the same way as the ocean would receive or supply at any point an indefinite quantity of water.

While this quality of the earth is one of the most valuable aids to telegraphy (reducing so materially the cost of wire erection), it presents at times those embarrassing interruptions known as *earth currents.* These currents, at all times unwelcome visitors to a telegraph office, are very variable, changing rapidly at times from positive to negative, altering their direction with the hour of the day, and leaving one circuit to appear on another in a manner not explainable. The lines most liable to such disturbances are those running N. E. and S. W.; that is, connecting places separated in a straight line in those directions, and without reference to the actual direction of the wires. The easiest remedy for earth currents, when they are of sufficient strength to effect the lines, is to dispense with the earth connection, and revert to the original plan of using two wires. Thus between any places where there are two wires, both may be disconnected from the "earth," and used as a complete metallic circuit. Another remedy has been found in extending the circuit by joining to it a further wire, the terminal point of which lies beyond the direction or line in which the earth current is flowing. We must refer to the larger treatises on telegraphy for all information regarding lateral induction, the velocity of electric discharge, the tests for resistance, insulation, etc., and also for notices of some of the less prominent pieces of apparatus now found in the instrument room of the electrician.

We now proceed to notice several methods by which the transmission of signals is facilitated or accelerated. First among those may be placed the *relay*, Fig. 2. Siemen's polarized relay is now in very extensive use in this country. In the previous description of the Morse, we have assumed the instrument to be worked directly by the current sent along the line. On long circuits, however, direct working could only be accomplished by great battery power, as, owing to inevitable loss by leakage, a current loses greatly before it reaches its destination. It is found to be a much better arrangement to have the instrument worked by a "local current," derived from a local battery at the receiving station.

When two stations far apart are to be connected by telegraph, it is usual to transmit the signal to a half-way station, and thence to re-transmit it to its destination. The retransmission is not effected by manipulative skill, but by mechanical contrivance, so that, while the half-way station may read the message sent, no time is lost in the transmission. This is effected by making the intermediate instrument act as a relay in transmitting a message to the next station. The system to be fully explained, would require more detail than we can here give to it. The speed of the ordinary Morse instrument is limited to the rapidity with which the hand of the operator can move the key, so as to preserve the proper spacing between the marks at the receiving instrument. We are indebted to Sir Charles Wheatstone for an apparatus which trebles, and in some cases quadruples the carrying capacity of the wire, securing, at the same time, mechanical accuracy in the relative size of the dots, dashes, spaces, etc. To effect this, three different instruments are required: First, there is a perforator, by which holes are punched in a paper slip to correspond with the signals required. The operator strikes three disks, the central one producing a central hole, which is of no avail electrically, only carrying forward the paper; the left-hand disk producing two holes, directly opposite to each other, on the sides of this central row; and that on the right producing two holes, placed diagonally to each other. The passage of the electric current is regulated by the position of the outer holes. Those opposite each other admit of a momentary passage of the current through the "transmitter" used in sending the message—while the holes diagonally placed produce a lengthened mark, corresponding to the dash. The following diagram represents the word "and," as shown on the punched slip:

```
oo    o    o    o     oo
oooooooooooooooo
o  o       oo       ooo
```

As printed at the other end, this reads:

```
—   —   —
a    n    d
```

The third portion of this instrument is the "receiver," Fig. 3, in which the currents sent by the action of the punched slips in the transmitter are reproduced in the dots and dashes of the Morse code—the printing being, moreover, done with a mathematical accuracy which keying by hand cannot attain.

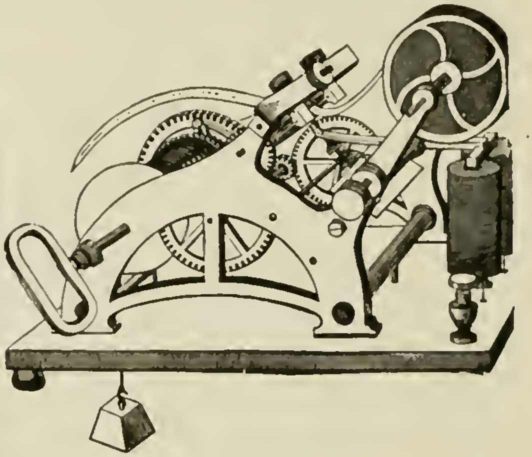


Fig. 3.

The speed of transmission depends on the length of line and state of the atmosphere; but the movement of the clock-work, both of transmitter and receiver, is capable of adjustment to any speed below 120 words per minute.

All that has been said as to the battery, the earth insulation, etc., is applicable to nearly every instrument now in use: the exception being several magneto-electric instruments, such as the Wheatstone's "ABC," in which the use of a battery is dispensed with, power being generated by two bobbins coiled upon an armature rotating continuously over the two poles of a permanent magnet. On the upper surface of this instrument is seen a circle of buttons corresponding to the letters of the alphabet, by means of which levers, arranged vertically in a circle, may be pressed down. These levers press a pitch-chain into a series of indentations on the periphery of a metal disk, the chain having sufficient slack, so that when a second lever is depressed, the first must be raised. A series of currents, corresponding to the number of letters between each lever pressed down, is sent into the line, and operating on two little bent magnets, moves forward a ratchet-wheel having a pointer on the same axis which shows the letter on a dial-card. In this way the message is spelled out letter by letter, and as the instrument gives not an arbitrary sign, but the letter itself, it is much used in private telegraphs. The non-recording instrument most used in this country (excluding private telegraphs) is the single-needle instrument of Cooke and Wheatstone. It consists of an upright galvanometer, with astatic needles, one of which moves within the coil, and the other upon the front of the dial. The needles are loaded at the lower end, to maintain them perpendicular when no current is passing. The instrument is worked by means of two keys, like those of a piano, a deflection of the needle to right or left being effected by depressing one or other of the keys. The signal is shown both on the sending and receiving instrument. The Morse alphabet is used, a deflection to the left corresponding to the dot, and one to the right representing the dash. Before the introduction of high-speed automatic instruments for the more important circuits, expert telegraphists in many cases dispensed with the reading of the printed slip, reading by the sound, which, by long practice, became a language perfectly intelligible to them. The great advantage of this was, that the use of the eye was obtained exclusively for the task of writing down the message. In Sir Charles Bright's "bell" instrument, most admirable results, in point of speed, have been attained. The bells, different in sound, are placed at the two sides of an upright instrument, so that the clerk, bending forward to write, may concentrate his attention on that duty, translating in his mind the tinkle of the hammers as they ring out their message. The bells are now worked in the Morse code—the left bell a dot, and the right bell a dash; but when first introduced, the instrument had a code of its own, based on the desire to complete each letter as much as possible on one bell. A simpler acoustic telegraph has been brought into use in America (hence called the "American sounder") and England. This instrument, Fig.4, is, shortly stated, the Morse without its wheel-work and ink printing. The use of the "sounder" has greatly increased in this country owing to its cheapness and efficiency. For a description of the type-printing and *facsimile* instrument, on which very great advances have been made in recent years, we must refer our readers to the larger treatises on the telegraph and its history.

The fact that two currents may be sent simultaneously (one from each end) has been long recognized by electricians, but the principle of the duplex was revived and patented by Stearns, an American, in 1872. At first the duplex-working was only tried on short circuits of 40 to 60 miles, but it has now become a matter of daily use on every busy circuit, long or short, both in this country and abroad. The principle of the duplex system is that the current sent on the depression of the key is divided into two parts, one half being carried through one pair of coils in a differential galvanometer to the line, and the other half through the other pair of coils to a resistance coil, and thus to earth. The resistance of the latter is made exactly equal to that of the line-wire, and the instrument of the sender being so placed that this divided current presses equally in each direction, this instrument remains unaffected, while the armature at the other end responds to the signal sent. At the same time a telegraphist at the other end is sending a current, which is divided in like manner, and leaves his own instrument unaffected while operating on the armature of the first instrument. The two currents on the line-wire assist or oppose each other in such a way as to affect the equilibrium in the differential galvanometer, but each operates only on the distant instrument. Duplex-working led to *diplex*, that is, two messages passing over a wire in the same direction at once, and to this has followed quadruplex and multiplex telegraphy. Quadruplex-working was first perfected in 1876 by Prescott, Edison, and Gerritt Smith, but the possibility of its being accomplished was suggested by Stark, of Vienna, in 1855. It was introduced into Great Britain as a practical branch in 1878, and is now used from London to Liverpool, Dublin, and other towns. An illustration of the value of these additions to the wire power is afforded by a wire from Chicago to Pittsburgh, 550 miles, which is quadruplexed, and at Pittsburgh branches off in two duplex circuits to Baltimore and Philadelphia, giving Chicago duplex communication with these two places. In the same way Middlesborough and West Hartlepool have been duplexed to London, on separate wires as far as Leeds, and quadruplex on one wire thence to London. The most original feature of the telegraph section of the Paris Exhibition of 1878 was the harmonic telegraph of Haskins and Gray, based on principles laid down by Cromwell Varley in 1870. In one application it occupies a place midway between duplex and multiplex telegraphy, namely in the "way duplex," or as it was felicitously termed by the late Mr. Orton, the "phantom circuit." A wire may be occupied by the ordinary business of a series of intermediate offices, while there may be superimposed on that a through traffic (which can be duplexed) between the terminal stations. Thus between Chicago and Dubuque, a wire provides for 17 intermediate stations, working ordinary Morse sounders, while the harmonic telegraph (the principle of whose action is vibratory currents sent and received by musical forks tuned in unison) works between the terminals. By an extension of this principle we have the multiplex telegraph, each fork taking off at the receiving end those vibrations corresponding to its own tone.

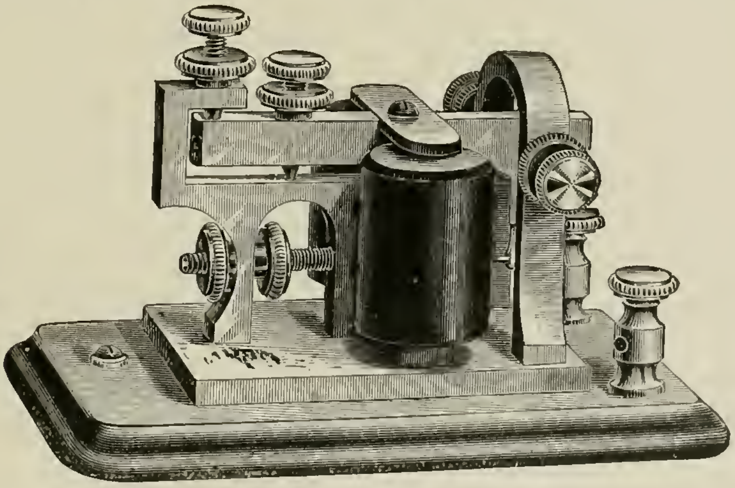


Fig. 4.

From the year 1850, when a copper wire insulated with gutta-percha, submerged between Dover and Calais, continued in use for one day, the progress of submarine telegraphy has been as remarkable as that of telegraphy on *terra firma*. The Malta-Alexandria cable was laid in 1861, and continued in use till 1872, when from repeated breakages in shallow water, its use was discarded. The core consists of a strand of seven copper wires, covered by three layers of gutta-percha; outside of this, a server of tarred yarn, and, finally, eighteen iron wires, constituting the sheathing. This was the first long cable successfully laid (its total length, in three sections, being 1331 miles); and it was also the first properly tested under the water before being laid, and carefully constructed with constant watchfulness as to its electrical and mechanical conditions. The cable was then thrown out of use because the chafing it underwent in shallow water made it too expensive in maintenance. So far as construction goes, it corresponds very nearly with Sir James Anderson's typical "successful iron-covered cable." With careful testing and supervision, and with the weight of cable, etc., duly proportioned to the strain, etc., a cable forms a permanent property of very much value. A new form of cable, with lead as the conductor, has been suggested. In 1877 the task of duplexing a submarine cable was accomplished by Muirhead on the Aden and Bombay cable of the Eastern Telegraph Company, and the "artificial line," or balance, has been since applied successfully to other cables, including the two crossing the Atlantic. In view of the enormous cost of submarine telegraphy, the attainment of a means by which the carrying capacity of a cable is nearly doubled is of vast importance. In 1877 the Marseilles-Algiers cable, belonging to the French system, was duplexed by M. Ailhaud. The *Journal Télégraphique* gave in 1877 a list of 149 cables belonging to companies, and 420 belonging to government systems, existing at that date. In point of number, Norway stood first, with 193 cables, but the total length of these is only 233 nautical miles. The total length of the 420 government cables was 4,442 nautical miles, of which Britain possessed 49, measuring 1,338 miles. The longest of these (excluding cables to the Continent) is to Guernsey 70, and to Shetland 63 miles. The company cables (of which 96 per cent. had their administration in London) measured 59,547 nautical miles, the longest cable is that from France to America, 2,585 nautical miles, and the largest organization is that of the Eastern and Eastern Extension Companies, embracing 48 cables of a total length of 21,883 nautical miles, to which, since 1876, several thousand miles have been added in new routes or duplicated cables. In 1879 Great Britain was connected with Europe by eighteen cables, and with Ireland by five cables. From Europe to America seven cables crossed the Atlantic (five from Ireland, one from France, and one from Portugal to Brazil). A cable from Nagasaki to Shanghai joins the internal system of Japan with the outer world; while by cables of 557 miles from Singapore to Batavia, and 1,082 miles from Java to Australia, the distant Colonies are brought into the telegraph system of the world. Many additional cables, including one to Natal and the Cape, are projected or in course of construction; and before long it cannot be doubted that the imagination of the poet, to "put a girdle round the earth in forty minutes," will be cast into the shade by the realities of the electric telegraph.

The following instructions, for the construction and equipment of permanent telegraph lines have been recently issued from the Office of the Chief Signal Officer, Washington, D.C.

KIND OF POLES.

The supports of a line must be poles of the most durable timber, preferably of red cedar, black locust, or heart of yellow (pitch) pine. Should these not be procurable, or only at too great cost, recourse must be had to other kinds of timber, such as chestnut, red wood, white cedar, yellow cypress, tamarack, fir, larch, spruce, white or post oak, sassafras, and others, from which good service may be expected. Pine and cottonwood poles, wired to mesquit, cedar or juniper stubs can be satisfactorily used. The poles must be the stems (butts) of live, young timber; reasonably straight; well barked; neatly trimmed; properly seasoned.

DIMENSIONS OF POLES.

The poles must be not less than twenty-two (22) feet long, not less than five (5) inches in diameter at the smaller (top) end, and not less than seven (7) inches in diameter at the larger end. It may be necessary to vary these dimensions somewhat, and, if the best varieties of timber are used, a diameter of four and one-half (4½) inches may be properly used; a length of twenty-four (24) feet is preferred to one of twenty-two (22), especially if it is probable that a second wire will be required, or if the ground (sand or light loam) in which the poles are to be set is such as to require deep setting.

NUMBER OF POLES.

The number of poles to be provided depends upon the character of the country, whether open, timbered, prairie, hilly, mountainous, etc., and upon the roads, whether crooked or straight. Not less than twenty-five (25) poles per mile must be used, but in timbered country, with crooked roads, it may be necessary to increase the number to thirty (30), or even more in special cases.

PREPARATION OF POLES.

When practicable, the poles must be cut while the sap is down, and the bark removed, and allowed to season before they are placed in the line; this increases the durability of most kinds of poles, and facilitates the transportation and erection of the same. Well seasoned poles may be preserved, but unseasoned poles are injured by charring.

PROTECTION AGAINST LIGHTNING.

Wherever there is danger from atmospheric electricity, lightning-rods must be attached to every fifth pole to facilitate atmospheric discharges and prevent the splintering of the poles. They consist of ordinary line wire, attached to one side of the poles by staples, and from end to end thereof continuously.

INSULATORS.

The common screw-glass insulator, with a well-seasoned oaken bracket, gives excellent results. The brackets are attached with one twenty-penny and one forty-penny nail. Various patent insulators have value for special uses.

WIRE.

No. 9 iron wire, drawn from charcoal rods and coated with zinc, (galvanized) is the standard for line wires. It is generally purchased in half-mile coils, with joints well soldered, and weighs about three hundred and twenty (320) pounds to the mile. For general use "Extra Best Best" No. 9 wire is preferred. For tie-wires No. 9 is used, cut into lengths of from 10 to 12 inches, and annealed.

BUILDING-TOOLS.

Axes, for felling and preparation of poles, and for clearing the way for the line. Hatchets, weighing about one and one-half (1½) pounds, and having a bit four (4) inches wide, a head or poll with which to drive spikes, and hickory handles fifteen (15) inches long. Diggers, weighing about fifteen (15) pounds, pointed at one end and a flat, cutting-point or edge at the other. Shovels, spoon, long-handled, and spades. Post-augers or post-hole diggers, for use on prairies and alluvial bottoms free from gravel. Shears, foot-plates, pikes, cant-hooks and tamping-bars, for erecting and setting the poles. Reels, for delivering the wire from coils. Pliers, files, jointing-tools, strapped-vises, soldering-pot, solder, muriate of zinc, climbers, pulleys and rope for making joints, etc.

SURVEYING.

The route of the line having been decided upon and the materials prepared or procured, a competent person must proceed to measure the distances and indicate, by stakes, the places at which poles are to be erected. When the line follows highways or other defined routes, he will necessarily be governed by the bounds of such route, and must place his stakes within those bounds, and in such a manner as to avoid, as far as possible, danger to the line from passing vehicles.

As a general rule, in open (unfenced) country, where the ground is practicable for wagons, the stakes must be run in straight lines, but, where there is a well-defined and traveled road, the line of stakes must follow the general direction of such road, and be set at such distance from it that the line (when completed) shall not be exposed to injury from passing vehicles, or in case the wire should become detached from the insulators it cannot, by any chance, hang in the road and interfere with or endanger traffic. With this in view, the stakes must be so placed that the line can be readily inspected and examined by repairmen from the road. Whenever practicable the line must be removed from the road a distance of about thirty (30) feet. *Roads should never be crossed unless imperatively necessary* to avoid bad lands or trees which are too numerous to cut away, or to make material saving by shortening the line. In rolling country stakes must be planted on the crests of hills and not on each side, as in the latter case the wire will not be raised sufficiently high above the ground to be free from danger of being broken by passing herds or vehicles.

In level country the stakes must be set seventy and two-fifths ($70\frac{2}{5}$) yards apart, or at the rate of twenty-five (25) to the mile. This distance may be increased when the configuration of the ground renders it necessary, as in crossing streams, ravines, etc. In hilly, rolling, and well timbered country, especially with crooked roads, it will be necessary to shorten the distance, even to sixty (60) yards (twenty-nine poles to the mile), or in special cases to a less distance.

At all crossings, the distance between the stakes must be shortened.

DIGGING HOLES.

The depth to which poles should be set depends upon the character of the soil in which they are placed. In rock, gravel, or stiff clays a depth of four (4) feet is sufficient, while in light loam or sand it is necessary to increase the depth to four-and-a-half ($4\frac{1}{2}$) and even five (5) feet.

A foreman (or officer) must follow the surveyor with a sufficient number of men, equipped with cutting-bars and spoon-shovels (particularly well adapted to digging in light soils), the ordinary long handled shovel, which is more easily procured, or post-hole diggers, where the soil will admit of their use. This party will dig the holes for the reception of the poles at the stakes. If there is a sod, one of his men must be equipped with an ordinary spade, with which to cut and remove the sod: indicating the size of the hole to be dug, and facilitating the work by performing a part therof for which the bars and spoons are not well adapted. *The foreman (or officer) must see, personally, that the holes are put down to the proper depth*, and are of the same size at bottom and top. He will have, of course, direction of the force, and be held responsible for good service. For poles at crossings, curves, and long spans, the holes must be dug to a depth corresponding to the strain to be brought upon them. For different lengths of poles the following rules will be observed: 22-foot poles, four (4) feet deep; 25-foot poles, four-and-a-half ($4\frac{1}{2}$) feet deep; 30-foot poles, five (5) feet deep; 35-foot poles, five-and-one-half ($5\frac{1}{2}$) feet deep; 40-foot poles, six (6) feet deep; 45-foot poles, six-and-one-half ($6\frac{1}{2}$) feet deep; 50-foot poles, seven (7) feet deep; 55-foot poles, seven (7) feet deep.

DELIVERY OF POLES.

The poles must be delivered as soon as practicable after the stakes have been set or the holes dug, with the butt of the pole by the stake or hole, and the top in the direction from which the raising party will come. No equipment is necessary for this labor, except the means used for the transportation of the poles and stout staves upon which to carry them, if it should be necessary to move them to reach the holes. For crossings and long spans the heaviest and longest poles must be selected; for angles and sharp curves, select from the strongest.

ATTACHING INSULATORS.

As soon as the poles are delivered, and before they are erected, the insulators and brackets must be distributed. A man, (or several, as may be needed,) equipped with a hatchet and supplied with nails, will attach the brackets, first cutting a seat for them upon the side of the pole, and at such a distance from its top that the insulator, when in place, shall not extend beyond the top of the pole. One twenty-penny nail at the point and one forty-penny nail at the shoulder of the brackets will be required. The insulator must then be screwed on.

LIGHTNING-RODS.

The same man (or men) who performs the labor of attaching the brackets and insulators must also attach the wire lightning-rods, and for that purpose must be supplied with the rods and staples. Lightning-rods made of ordinary line wire must be attached to every fifth pole before erecting the latter. These will be securely fastened to the pole with staples in such manner that the line wire, in case it should become detached from the insulator, cannot come in contact with the rods, (one-fourth of the distance around the pole from the insulator). The rods must extend above the top of the pole about three (3) inches, and extend under and be firmly secured to the bottom of the pole.

RAISING AND SETTING POLES.

After the brackets, insulators, and lightning-rods are in place the poles must be erected. A sufficient number of men, (the number depending upon the weight of the poles,) equipped with pikes, foot-plate, (ordinary short-handled shovel will do,) cant-hooks, shovels, and rammers, and directed by a foreman (or officer) will erect the poles, turning them so that the insulators shall occupy their proper positions.

The insulator must be placed on the same side of all the poles, and *preferably away from the road*, except at angles, crossings, or curves, where they will be placed so that the strain, when the wire is strung, will tend to press the insulator toward the pole. The foreman (or officer) must see, *personally that in every case the earth is well tamped around the pole from the bottom to top of the hole with tamping bars*, and heaped so as to shed water, and prevent pools of water forming at the base of the poles. The success of the work depends greatly upon this, and on no account will it be neglected. Poles must be set vertically, except at angles or curves, where a slight inclination will be given them, in such manner that the component of the strain in the direction of the length of the pole will tend to press it into the ground.

STRINGING THE WIRE.

To complete the line it is only necessary to string the wire. The force for this purpose consists of an officer (or foreman), a wireman and assistant, and a number of climbers, together with a wagon or other means for the transportation of the wire. The wireman is equipped with tools for connecting the coils, as file, vise and pliers, or joint-tools, and should have also a hatchet and a few insulators to replace any which have been broken in erecting the poles. A soldering-pot is necessary, if it be practicable, to solder the joints. Great care must be taken in jointing the wire. This is done by turning the end of each wire —for four or five turns—closely and as nearly at right angles as possible around the other; the ends must be cut off short and, when practicable, the joint dipped in a vessel containing melted solder. The men for tieing are equipped with climbers, climber's belts and pliers, and furnished with tie-wires. The tie-wires are short pieces of line wire, or of wire specially procured for the purpose, cut, annealed, and formed on an insulator, so that they will embrace the insulators, and the ends project parallel to each other two (2) or three (3) inches beyond the line-wire. The wagon contains a reel and one or more coils of wire. A coil of wire is placed upon the reel, the binding wires removed, the *outer end of the wire* led out and attached to the starting point. Then the wagon moves along the line as near the line of poles as possible, the wireman maintaining such a check upon the reel as will allow the wire to run out straight, and preventing too much from being drawn off. The climbers—all at the same time—ascend the poles, carrying the wire which has been extended. Upon reaching the top of the pole and so securing their positions that their hands are free, each climber places a tie-wire upon the insulator, the line-wire against the insulator above the tie-wire, and bends the ends of the tie-wire upward, so as to sustain the line-wire. The wireman then carefully strains the line-wire, either by the motion of the wagon or the labor of men, as may be advisable, until the deflection in the center of a seventy (70) yard span does not exceed one and one-half (1½) feet, (allowing less in cold weather and more in warm weather,) when the climbers, using their pliers, give each end of the tie-wire one and one-half (1½) turns about the line-wire, leaving the points of the tie-wire toward the insulator, which secures the line-wire and completes the work. In country free from timber the line-wire must be secured to the insulator on the *side toward* the pole, so that the bracket will catch the wire in case of breakage of insulator; in timbered country, on the *side away from* the pole, so that falling trees will not break line-wire, but merely tear it from the tie-wire. The officer (or foreman) must see that each man performs his duty promptly and well; will order "up" when the wire is ready and the climbers in place at the foot of the pole; "haul," when the climbers have reached the top of the pole and placed the wire in position; "bind," when the wire is sufficiently strained. Wire should not be tied to trees when it can be avoided. It may save time and labor in the first instance, but the cost and labor of keeping such a line in repair will soon exceed what would have been necessary to erect poles throughout its entire length when the line was being built. When *necessary* to tie to trees, the regular tree-insulator should be used, or the tie-wire suitably fastened, the ends being wound loosely to allow of an easy, lateral movement of the wire.

NUMBERING POLES.

Distinctly mark with paint each twenty-fifth (or mile) pole with its proper number, from the initial to the terminal point of the section, to facilitate rendering reports and to enable repairmen to report locations of repairs made and needed.

CLEARING AND TRIMMING.

In forests or groves, especially such as are dense or choked with undergrowth, axe-men must precede all others, except the surveyor, and clear the way for the work. When the line has been erected, they must follow and remove all branches or twigs which may be, or liable to be, thrown in contact with the wire; clearing back for a space of four (4) to six (6) feet, and removing all dead branches, no matter what their distance, that might be thrown down by high winds and, falling, endanger the line. When the line passes through regions where it is liable to be injured by prairie-fires, the sod should be broken and grass turned to a distance of ten (10) feet from each pole. Officers in charge of telegraph lines running through such sections should send a party along the line each year to break the sod around the poles.

RIVER CROSSINGS.

When navigable streams cross the route of line, it is usually the better plan to use cables, except where they are liable to be washed out by freshets; but if this method be, for any reason, impracticable, elevated supports must be found or constructed, and the wire suspended above danger from passing vessels. Natural supports, such as trees well rooted in safe positions, if such can be found of sufficient height, may be used: or masts erected and securely stayed with wire or wire rope guys. If the span between supports be not more than fifteen hundred (1,500) feet, the line wire can be used, care being taken to select the best and a length without joints, or with joints very carefully secured. For greater spans a steel wire (or compound wire having a steel core) is necessary, with which spans upwards of two thousand (2,000) feet can be made, provided the points of supports are high enough to allow of a proportionately deep curve to the wire. Extreme care must be given to such crossings and too great strain avoided. The supports, whether natural or artificial, must be protected by lightning rods.

CABLES.

In placing a cable across an inlet, stream, or other body of water, it must be laid, whenever practicable, directly from the reel on which it has been received from the manufacturer. The reel will be rigged on a horizontal axle, in the stern of a suitable boat, or a small vessel when the weight of the cable is too great for a boat, and payed out as steadily and regularly as possible. Especial care is necessary to prevent the formation of kinks, and to cause the cable to lie smoothly on the bottom. Both shore ends of the cable must be buried sufficiently deep in trenches to thoroughly protect them from exposure to the air and injury from vessels, wheels, etc., and must be covered with stones or rocks of sufficient weight to keep it down, and prevent the earth from being washed away. The ends must be carefully secured to the cable-pole in such a manner that the pole will serve as a buoy in case of the washing away of the pole. Lightening-arresters must be used at both extremities of a cable, and placed in the cable-boxes. These boxes must be made of well-seasoned pine plank, two (2) inches thick, firmly dovetailed together, eight (8) inches square inside, lined with woolen cloth and well painted. The door must be hung with strong hinges, and the whole box must be water-tight when closed. In connecting the line-wire with the cable, a hole large enough to admit the wire is bored through the side of the box. This hole must have considerable inclination from the inside downward to the outside, to prevent the rain from coming in. The wire must be brought down from the top of the pole, to which the box is attached, to the side of the box, and the end passed to the inside through a gutta-percha tube, and bent over to prevent it from being pulled out. The line-wire must be then connected, by a piece of insulated wire, with the binding screw on one side of the lightning-arrester, and the copper wire of the cable must be fastened to the binding screw on the other side. The horizontal plate between the points must be connected on both sides with the outside or armor wires of the cable, which will form an excellent ground. The lightning-arresters must be tested before placing them in the boxes, as the points are liable to be in contact with the plates. The door of the box must be provided with a strong lock and kept locked, except when opened for the purpose of examining the arresters after every thunder-storm and at other times by authorized persons. The cable, from the ground to the cable-box, must be encased in a wooden box to protect it from injury. For office equipment and connections, see article *Field Telegraphy*.

WIRE.

At terminal offices the iron line wire must be carried to an insulator attached to the wall of the building in which the offices is to be, and there secured. Attach to the end of the line-wire an insulated office-wire and pass it through the wall to the screw-post of the switch or that of the lightning-arrester. This wire must come from below to the passage through the wall, in order that rain-water may not follow it into the opening. At way offices, break the continuity of the line-wire; fasten the ends to separate insulators on a pole at or near the office; run the ends of the wire to insulators on the office building, and thence by insulated wires to the lightning-arrester, as in the case of the terminal office. All connections between copper and iron wire must be soldered to prevent galvanic action and consequent formation of non-conducting oxides.

GROUND WIRES.

At the termini of the lines or circuits good ground connections are necessary, and may be prepared by burying a copper plate two(2 or three(3) feet square in *moist earth*, or utilizing water pipes, to which a stout copper wire is securely soldered, and carrying the wire to the office or the battery-room. At way offices a sufficiently good ground-wire may be made by burying the ends of a copper wire, to the length

Form A.

Weekly Report of Construction Party, Military Telegraph Line.

Commanded by..

For the week ending..

This Report	Last Report	How Employed	Remarks [to embrace reasons for changes.]	Miles, Number of.	Remarks [to embrace all important items of line construction.]
Number of—					
Officers,				Stakes set.	
Sergeants,				Poles hauled on line	
Corporals,				Holes dug.	
Privates,				Poles erected.	
Civilians,				Wire strung.	
Teams,					
Horses,					
Shovels,					
Digging-bars,					
Axes,					
Hatchets,					
Pliers,					
Vises.					

Note.—All persons and property with the party, and all work done, though not mentioned in the printed form, will be carefully noted thereon.

Form B.

Roll of Non-commissioned Officers and privates employed on extra-duty as mechanics, overseers, and laborers in constructing U. S. Military Telegraph Lines, during the time specified below, by..............................

Number.	Names.	Company.	Regiment.	By whose order employed.	In what capacity employed.	Term of service. From—	Term of service. To—	Term of service. No. of days—	Rate and amount of pay. Per diem. Cents.	Rate and amount of pay. Amount. Dollars.	Rate and amount of pay. Amount. Cents.	How employed—Remarks.
......	....	......	....	....	....	...	...	...	....	......	......	....
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I certify that the above is a correct roll of Non-commissioned Officers, musicians, and privates employed on extra-duty during the time specified above: that the remarks opposite their names are correct and just: that none of the men enumerated have been paid extra-duty pay for the time specified, respectively, and have actually performed labor during all the days, including Sundays, as charged.

Examined:.................................... (Signed in Duplicate.) ____________________

Chief Signal Officer, U. S. Army. *In Charge of Construction Party* of three (3) or four (4) feet, in *moist earth* and carrying the free end to the lightning arrester.

BATTERIES.

Some adaptation of the Daniell's zinc-copper cells is preferable. The Callaud cells are extensively used. The "Eagle's" leaden cup is effective and not liable to be broken.

TOOLS.

Each office requires to be equipped with pulleys and rope, file, pliers, strapped and hand vises, climbers, axes, and hatchets and supplied with wire, insulators, and nails for purpose of repair.

REPORTS.

The officer in command of each working party must keep a careful record of the amount of line built under his direction, and on every Saturday a report must be made to the officer in charge of the U. S. Military Telegraph Lines, or to the Adjutant General of the Department in which the line is being constructed, showing the number of miles of line completed at date of the report, the number of miles of holes dug, of poles set up and of wire strung since last report, the distribution of material, and the rank, company, regiment, and occupations of every individual of the working party, together with the number and duties of civilian employes. The report must also show the distribution of wagons and teams, and the use to which everything is put that is connected with the working party. (Form A, page 413.) Generally, the work to be done by the troops will be to dig the holes, set up the poles, and distribute the wire, poles, and other material along the route of the line. Especial care is enjoined upon the officers in command of working parties to ascertain, with the utmost accuracy, the total number of miles of line built on the section under their charge. To ensure correctness in this particular, the length of line built each day must be carefully recorded at the close thereof, the weekly report made up from the record thus kept, and the latter preserved for future reference. Upon completion of the work a general report, embracing the whole section, must be made, accompanied by a map showing the general features of the country traversed by the line, giving the names of towns or settlements lying on or contiguous to the line, and a general statement as to the resources of the country as regards timber suitable for poles for maintaining the line in repair after completion.

In order that there may be no delay in the payment of extra duty pay to enlisted men engaged in constructing or repairing telegraph lines, rolls, properly filled out in accordance with Regulations on Form B, page 413, must be forwarded monthly to the Chief Signal Officer.

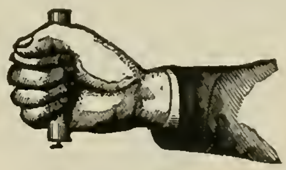
Any incidental expenses incurred in connection with the work of construction will be paid on presentation of vouchers in duplicate, signed by the officer in command of the party, or else by the party, from whom all of the purchases were made, or by whom the services were rendered. Accompanying the vouchers, a statement—both certified to and approved by the officer in command—showing the character of the purchases or services must be forwarded. Everything necessary in the way of tools, material, etc., should be on the ground. In case anything additional should be required, a request, to be telegraphed from the nearest telegraph office, should be made therefor to the officer in charge of that division of the United States Military Telegraph Line, when it will be promptly furnished, or authority given to procure what is wanted at the nearest available point. See *Field Telegraphy*, *Signals*, and *Universal Telegraphy*.

TELEMETER.—Our present artillery and small-arms, dependent for accuracy of aim upon sights graduated according to the distance of the target, demand, as a logical sequence, some method of measuring that distance. Up to the present time this want has not been satisfactorily supplied, for the reason that the telemeters hitherto proposed all depend upon more or less simplified processes of triangulation; they necessitate the measurement of a base line, or the use of stakes; they entail calculation, and they further require that the target have a fixed and easily-seen point of aim, a condition rarely existing in actual service. Finally, none of these instruments have been generally adopted. For want of a telemeter, artillery officers regulate their fire by observing the bursting of their projectiles, a method that can be successfully applied only when the forces fired at are in sight and in open *terrain*, for the slightest intervening obstacle, an inequality of surface, a hedge, bushes, a corn-field, will defeat its application. The instrument here described seems to be called for to complete the modern weapon by furnishing a means of exactly regulating the elevation. It measures the distance of the adversary by observing the interval which elapses between the smoke or flash and the report of his fire. It is a glass tube graduated along its length into divisions which represent distances. This tube, closed at both ends, is filled with liquid, through which moves a metal index formed of two discs united by a central stem. The diameter of these discs is somewhat smaller than that of the tube, so that, when the latter is vertical, the index slowly descends with a uniform movement. The glass is protected by a brass casing, having an aperture which discloses the scale and index.

To use the telemeter hold it horizontally in the hand, the index at the origin of the scale, and attentively regard the enemy's position. At the instant the smoke or flash is perceived quickly turn the wrist so as to bring the instrument into the vertical, when the index descends; upon hearing the report return it to the horizontal by the inverse movement of the wrist, and the index stops. The number on the scale corresponding to the lower disc, which serves as marker, is the distance sought. This very simple chronometric device is characterized by a uniform movement and works with extreme precision. Hence, knowing the velocity of sound and that of the index, it is easy to graduate the scale into divisions which exactly represent distances. An important attribute, which has been successfuly given the instrument, is its power of self-adjustment for temperature. To effect this the volume and density of the index and the density and dilatability of the liquid are so combined that the velocity of the index is influenced by temperature in the same proportion as is the velocity of sound, consequently the readings are always correct. A velocity 1-25000 that of sound has been adopted for the index, so that a millimetre on the scale represents twenty-five meters of distance. Each degree of the scale represents twenty-five meters, and with the eye the fifth of a division can be estimated. A great number of trials have been made of this telemeter. When proved by the vibrations of a pendulum or the beats of a watch it is absolutely true, while the exactness of its indications in measuring distances depends upon the aptness of the observer.

On the battle-field, when the action becomes general, the telemeter is useless; the noise, the excitement, the ardor of the struggle, and the nearness of the adversary render its application impossible. But its sphere is self-apparent; in every combat which precedes or accompanies at a distance the general engagement of masses, in encounters of the advanced guards, in the efforts of artillery in gaining and maintaining positions, in the attack of infantry upon batteries, in skirmishing, its importance becomes paramount and of a nature to decide the fate of the combatants. Its indications may become equally important on board men-of-war and in sea-coast batteries. During a siege, a struggle which lasts for months, when day and night the besieged reply to the besiegers shot for shot, the telemeter is of special service. A battery established at a distance and completely masked may receive the fire of every piece that can be pointed toward it from the moment it opens. Its first rounds will be uncertain, while from all parts telling replies will come. If, for safety, it opens fire at night its distance will only be the better known. This instrument not only indicates the distance but also enables us to correct the elevation for that distance, an elevation which varies from day to day with the condition of the powder and the state of the atmosphere. For this latter purpose it is only necessary to reply with percussion shell, and observe the explosion and report; if the indication be the same as for the enemy's fire the projectile has reached its object; if it vary, the proper correction must be made. Experience alone will show all the possible uses of the instrument described.

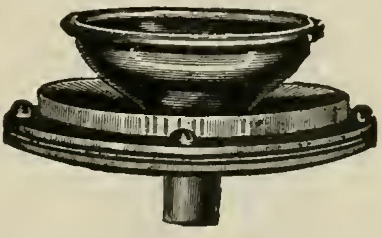
It is only necessary to mention another important application. It is well known that it is impossible to determine accurately the bursting point of shrapnel exploding in air, and, consequently, to know whether the fuse has been properly cut or otherwise regulated. In fact, herein lies one of the grave defects of this projectile. By using the telemeter and observing the explosion and report the point of bursting is exactly located. Without entering into further details, it is certain that the military telemeter is destined to play an important part in future warfare. The enlisted man can use it as well as the officer, for its employment requires only sight, hearing, and touch; it is extremley simple, practical, and very cheap. It



may be kept in damp places, even under water, without changing its readings; it may be *broken*, but it cannot be put out of order. In brief, its indications surpass by far in precision all attempts heretofore made to estimate distances in the field. See *Azemar Telemeter*, *Gautier Telemeter*, and *Range-finder*.

TELEOMETER.—A prismatic micrometric telescope, the invention of M. Porro, an officer of the Piedmontese Engineers. By a happy adaptation of prisms, as reflectors, its length is reduced from the ordinary dimensions to about the measure of the breadth of the hand, so as to be easily portable, and it is set for any eye in a moment by a small screw moved by the thumb. It may be used either as an ordinary telescope, or as a means of measuring the distance from the eye, of any object whose actual height is known. It is in this latter application that we shall now particularly consider the instrument. An apparatus is adapted to a small tube which contains the focal glass, or that glass which is applied to the eye, consisting of wires stretched across this tube at various spaces. These wires have three separate spaces, viz., *first*, including the space occupied by three wires, or in other words between the upper and lower wire; *second*, the space between the two wires, the intermediate and lower wire; and *third*, the space between two other wires, not so distant from each other as in the second case. By the subdivisions of the scale at the side, the whole, or a part only, of the object, whose total height is known, may be taken as a term of comparison in the estimation of distances. The object, or part of the object selected, must correspond exactly with one of the spaces, or in other words be intercepted by two of the wires of the teleometer. A micrometer, consisting of five wires is applied to the focal glass of the telescope. See *Range-finder* and *Stadia*.

TELEPHONE.—Hitherto the accurate determination of the time of flight of small-arm projectiles has been practically impossible at long ranges, owing to our inability to see them strike, even when firing over water. The discovery of the telephone has opened up to us a simple as well as novel means of obtaining the time desired, and has also afforded us the means of verifying the formulas by which these times were formerly deduced. In 1860 Reis of Frankfort first recognized the principle of the telephone, using a membrane which, vibrating under the action of the sound, caused pulsations of electricity to pass along the wire, and actuated the armature of an electro-magnet, which, mounted on a sounding-board, reproduced a sound corresponding in pitch and rhythm with the original. The quality of the sound was however entirely lost. There are several claimants for priority in the discovery of the principle of the articulating telephone, and the discoveries of Gray of Chicago, and Graham Bell, an Edinburgh gentleman resident in America, appear to be nearly contemporaneous, and attained by the different lines of study. The articulating telephone of Bell, which was first shown at the Philadelphia Centennial exhibition, is now of very simple construction. A small bar magnet, with a coil of wire over one end, is placed close behind a diaphragm of ferrotype, the whole being enclosed in a case furnished with a mouthpiece. Words spoken into the telephone are reproduced faithfully on a similar instrument at great distances, and by use of the microphone the most minute sounds have been distinctly heard and even magnified. Many extraordinary results have been achieved in conveying and reproducing sounds, and self-caught sounds from "induction" in the wires have produced interesting results. The Elgin tele-



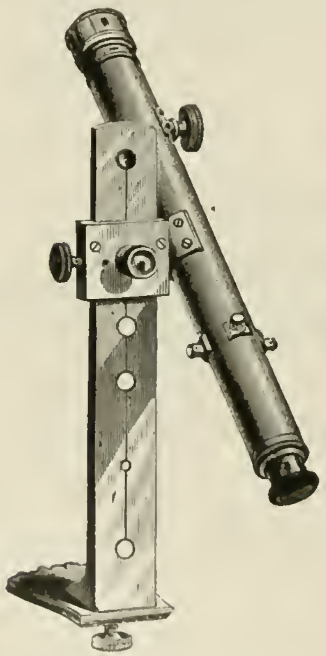
phone, shown in the drawing, is very much used at military posts, and for all short lines not over one mile in length. It may be worked without battery, the *call*, *speaking* and *hearing* being combined in the one instrument Three requirements appear to be demanded to bring the telephone into general use, namely, a simple and reliable call or *avertisseur*, an increase of the sound to render it unnecessary to hold the telephone up to the ear, and the removal of induction currents. Various methods for accomplishing each of these ends are now proposed, but the difficulties are not yet wholly overcome. A controversy exists whether the sounds in the receiving telephone are vibratory or molecular, or a combination of both.

Interesting experiments were recently made at Sandy Hook, N. J. Two telephones provided with Blake transmitters were used. One was placed within a few feet of the gun and left open to receive and transmit the sound of the discharge. The other was in the shelter-proof, which was but about thirty feet in front of the right edge of the target. A stop-watch beating fourths of a second was used in connection with it. The telephone being at the ear, the instant the sound of the discharge was received at the target, the watch was started, and on the bullet striking was stopped. A mean of a large number of observations, which rarely differed more than a quarter to a half of a second from each other, gave the time of flight. Of course there is a slight delay in starting the watch, but this is neutralized by a similar one in stopping it. The times given may, therefore, be accepted as strictly correct. It is worthy of notice that the times vary on different days, being shortened by a rear and lengthened by a head wind.

The angles of elevation for each gun at each range were taken by means of a quadrant with a stem entering the barrel. In addition the angles were computed from the triangle on the gun, the heights of front and rear sights used being known, and the distance, measured on the axis of the bore, between them. It may be stated that the angles at the higher ranges differed materially when taken on different days, head and rear winds causing much greater variations than at the short ranges, owing to the longer times the bullets were subject to their influence. Winds also affected the extreme range of the guns, especially of the service and other arms using light bullets.

TELESCOPIC SIGHT.—A telescope fitted to the sight-vanes of a compass, which can be put on and removed at will. The telescope is furnished with the usual cross-wires, etc., and attached to a movable band, which, as shown in the engraving, can be slipped over the sight of a compass, clamped at any point desired, and put in adjustment by any person who has a screw-driver and a steel adjusting-pin.

To put this attachment in place, slip the band over the south side of the compass, having (as shown in the cut) the telescope on the right hand and the front



clamp-screw on the outer surface of the sight; and place the band as low as will allow the telescope to revolve in either direction without striking the compass. This place should be marked by a line across the sight, that the band may be set at the same point in subsequent use.

To fasten the band to the sight, first bring up the clamp-screw in front with a pressure just sufficient to hold the band to its place, then tighten the screw on the left until the band is brought up against the right edge of the sight, and finally touch the front clamp-screw again, when the fastening will be complete.

To put the telescope in focus, turn the end of the eye-piece either back or forth by the thumb and fore-finger until by the spiral motion of the tube the cross wires are brought into distinct view; the object-glass is then moved in either direction by the pinion on the side of the telescope until the object is clearly seen.

The adjustments of the telescopic sight are as follows: (1) To make the telescope axis horizontal. (2) To bring the optical axis of telescope into a position at right angles to the axis. (3) To make the optical axis of telescope cut the same line as the sight-vanes of compass.

To make these adjustments—and, indeed, to do any correct work with a compass—the spindle should be well fitted, and the level-bubbles remain in the center when the instrument is revolved upon its spindle; the sights also should trace a plumb-line when the compass is level.

To make the first adjustment: The compass being in good order, first bring the levels into the center; place the band in position upon the sight, as before described; bring the telescope into focus and set the vertical cross-wire on the vertical edge of a building, distant from fifty to sixty feet, and at a point near the ground; clamp the compass to the spindle, and raise the telescope to the top of the building. If the wire strikes to the right of the edge, it shows that the right end of the telescope axis is lowest.

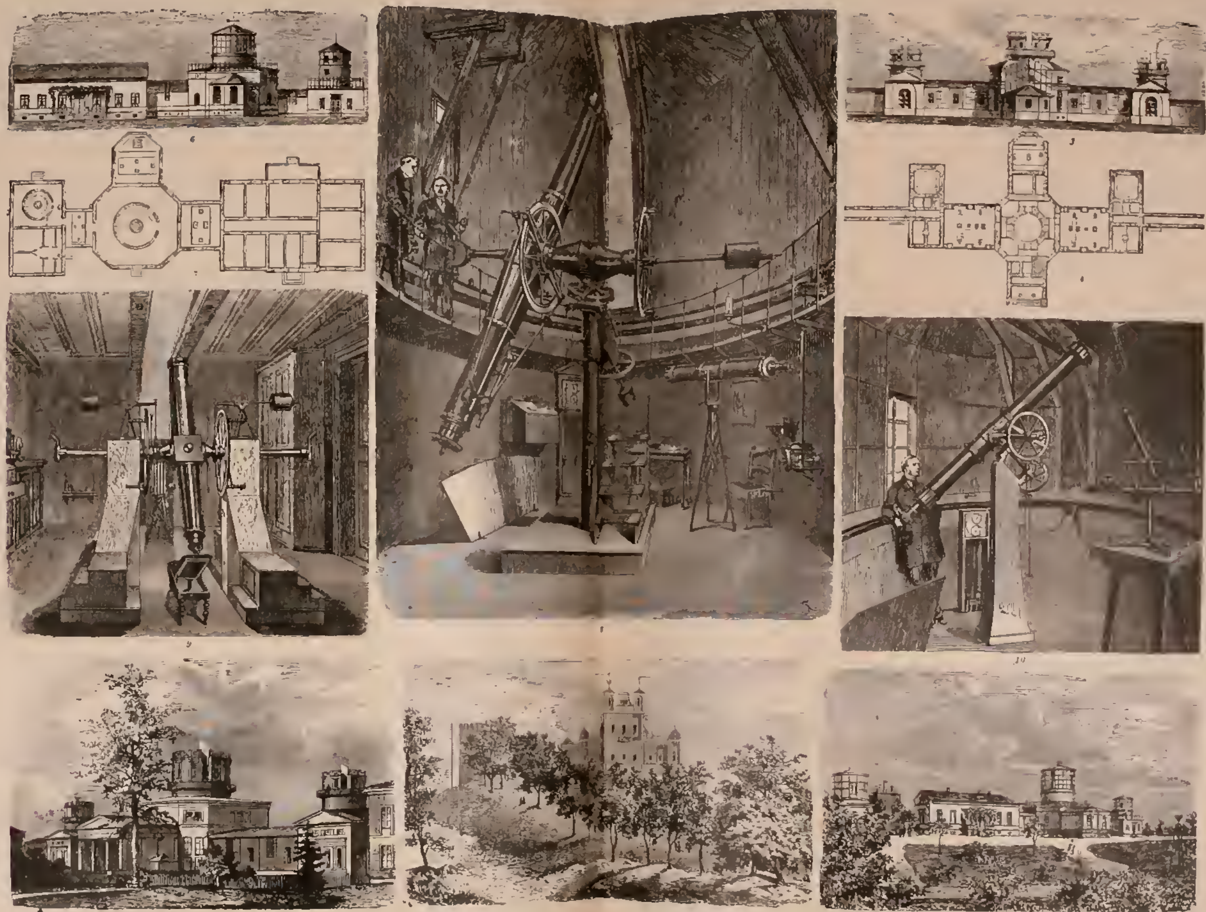
To raise it, loosen the clamp-screw on the left, and with a small screw-driver turn in the little screw on the right side of the band and under the axis until the correction is made.

If the cross-wire strikes to the left when the telescope is raised, proceed exactly the reverse in making the correction until the wire will follow the edge from one end to the other, when the adjustment will be complete. If the vertical cross-wire is not parallel to the edge, loosen the capstan-head screws, and turn the ring by the screw-heads until the correction is made; and finally tighten the screws.

To make the second adjustment—that is, to bring the optical axis into a position at right angles to the axis of the telescope so that the cross-wires will indicate two points in opposite directions in the same straight line—proceed as follows: Having the instrument level, find or place two objects, one on each side of the compass, and from three hundred to four hundred feet distant from it, which the sight-vanes will intersect; clamp to the spindle and sight through the telescope at either of the objects; if the vertical wire strikes to the right, loosen the clamp-screw in front, and with the screw-driver turn in the little screws set in the front side of the band, one on each side the telescope axis, until the vertical wire bisects the object—looking again through the vanes to see that the compass has not moved on its spindle, so that the same object is seen through both telescope and sights. If, however, the cross-wire should strike to the left of the object, proceed in a manner exactly the reverse until the error is corrected.

Then, without disturbing the compass, revolve the telescope and sight to the object in the opposite direction; if the vertical wire strikes to either side, half the error must be removed by the cross-wire screws shown on the outside of the telescope—first loosening the screw on the side towards which the wire is to be moved, and then tightening the opposite screw until one-half the error is corrected, and the remainder by the two small screws in front of the band. Having made the correction, sight again through the vanes and telescope, repeating the operation until the error is entirely removed, when the adjustment will be complete.

It should be here remarked that the adjustment just described, and which is usually termed the adjustment of the line of collimation, is fully described in the account of the various transit-instruments in this work, and may be effected with this attachment by the telescope alone, without reference to the sight-vanes—precisely as directed in the adjustments of a transit-instrument. It is always made by by the manufacturer, and need not again be disturbed except in cases of accident or a careless interference with the cross-wire screws; but in any event it can be easily effected by any surveyor in a few moments, and with very little practice.



TELESCOPES AND OBSERVATORIES. 1. Observatory at Greenwich. 2. Observatory at Pulkova. 3. Southern view of the same. 4. Horizontal section of the same. 5. Leipzig observatory. 6. Southern view of same. 7. Horizontal section of the same. 8. Interior of the great cupola of the same. 9. Meridian hall of same. 10. Interior of small cupola of same.

If the surveyor has made the second adjustment, as just described, he has already put the optical axis of the telescope in line with the sights, and so effected the final adjustment; but if not, and especially if the telescope sight is to be applied by himself to a compass to which the maker has not fitted it, then he will proceed as follows: Having the compass level, direct the sight to some clearly defined object—a post, staff or vertical bar of a window—some three or four hundred feet distant, clamp to spindle and observe the same with the telescope. If the vertical wire strikes to either side, remove the error by the two screws in front of the band, as already described in the previous adjustment, until the correction is made; and the telescope will then bisect the same object in either direction, as is indicated by the sight-vanes.

When the adjustments are complete the attachment can be put in place on the sights, removed and replaced again in a moment, and without danger of derangement in any of its parts.

The advantages of the telescope over the ordinary sight-vanes will be apparent to everyone who has ever seen them compared, or who has given the matter a moment's reflection. Much longer sights can be taken, either fore or back, and lines run up and down steep hillsides with the same facility as on level ground, and all with more accuracy, and with inexpressible relief to the eyes of the surveyor, so often severely strained by the use of the sight-vanes of the ordinary compass. Indeed, it may be said that every compass can with this simple attachment be transformed into a transit-compass at will, and thus all the advantages of the telescope brought within the reach of every surveyor at comparatively trifling cost.

The optical axis of the telescopic sight is at one side of the line of sight of the sight-vanes, but parallel to it. The difference between a sight taken with the sight-vanes, and one taken with the telescope, is, at a distance of two hundred feet, about two minutes, —so small that it may be disregarded in any survey made with the magnetic needle. If *all* lines are run with the telescopic sight, the angles measured will be accurate, as even this slight difference is entirely eliminated. See *Compass* and *Zalinski Sight*.

TELLEVAS.—A large shield formerly used, and very similar to the *pavois*.

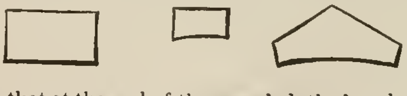
TELL OFF.—A military term, expressing the dividing and practicing a regiment or company in the several formations, preparatory to marching to the general parade for field exercise.

TEMPERATURE OF EXPLOSION.—At the moment of explosion, if T represents the temperature reckoned in degrees Centegrade from absolute zero (—274° C.), the following equation will exist with permanent gases, P V=C T, in which C is a constant, V is the volume occupied by the exploded gas, and P is the pressure in atmospheres exerted by it.

TEMPERING.—Hardened steel is too brittle and hard to work, while annealed steel on the other hand is too soft for any sort of cutting instrument or tool. Between these two extremes are various degrees of hardness which are suited to the many different uses to which steel is applied. Each of these degrees of hardness has a certain temperature to produce it, which is indicated by a certain color. The art of tempering consists in heating the hardened steel to exactly the desired temperature and color, and then cooling it. To temper any article, it is necessary to polish it all or in part that the color may be visible. The various colors which appear on the surface of hardened steel slowly heated are, yellowish white or light straw color, corresponding to a temperature of 450° F.; violet, deep blue, 580° F., and then the steel becomes red hot. The heat for tempering should be very slowly applied to prevent the steel from burning, and also because a certain time is essential to heat the mass thoroughly. In practice the more slowly the heat is applied, the tougher and stronger the steel becomes. Care must also be taken that the metal is not raised to too high a temperature, since the more intense the heat in tempering, the more the hardness is removed, and the softer the steel becomes. The heat for tempering may be applied in various ways; for large articles it is most conveniently done by the direct application of flame in some sort of furnace; while for small articles melted lead, hot sand, or a red-hot iron plate or ring is used. After the article has been raised to the desired temperature which is judged by the color, it is removed from the source of heat, and immersed in water or oil, or allowed to cool in the air; for if heated slowly it matters little how it is cooled.

Oil is used as a bath for toughening large tubes of mild cast-steel, calculated to be used as barrels for heavy built-up-guns, because of the high temperature required to convert it to the vaporous state, and its imperfect conducting quality, which causes the steel to part with its heat less rapidly. This comparatively slow rate of cooling is necessary to form a uniform degree of contraction, thus giving the steel a longer time for the rearrangement of its particles, and making the strain more uniform throughout the mass. Heavy masses or thick lumps of highly carbonized steel, whether tempered in oil or water, cannot be hardened without becoming fractured either internally or externally. A tube of mild cast-steel is lifted by a powerful crane and placed in a perpendicular position in an upright furnace, which has been previously heated with wood to a red-head. It rests on an iron shoe placed on the grate-bars to prevent the cold air from coming in contact with its extreme end. Great care is taken to heat the mass uniformly, fuel being added gradually until the whole tube is entirely surrounded with wood, thrown in at the top of the furnace. Wood is used because of its purity; it is not so liable to degrade the steel as other fuels. The amount of heat received by the steel is judged by eye and by long practice and attention. The more uniform the temperature, the straighter the block will keep, and the more even its temper. After the steel has acquired proper uniform temperatnre throughout, the travelling crane is brought over the furnace, its top removed, and the large iron tongs, pendent from the crane, fasten themselves to the steel tube; a small collar being upon its end to prevent the tongs slipping. See *Annealing*, *Oil-bath* and *Steel*.

TEMPLATE.—A mold in wood or metal, showing the outline or profile of moldings, and from which the workmen execute the molding. The drawing shows a set of templates, for verifying the shape of lock-lugs, the angle of the rear *sight-mass*, the curve between the base-line and the front of the rear sight-



mass, that at the end of the cascabel, the bevel of the breeching-hole, the opening of the cascabel, and the shape of the muzzle-swell.

If the inspection should take place at the foundry, the templates used for chipping might be verified and used for inspection. For guns of the Dahlgren pattern, a bronze model, showing the shape of the *lugs* and rear sight-mass, and the position of the vents, is furnished as a guide to the contractors. See *Inspection of Ordnance*.

TENACITY.—That property of material bodies by which their parts resist a force employed to attempt to separate them. It is the result of the attractive forces exerted by the particles of matter upon one another through those infinitesimally small spaces which are supposed to exist between them; hence it differs in different materials, and even in the same material at different degrees of temperature. The practical bearings of the tenacity of solids (especially of wood and iron) are discussed in the article Strength of Materials; and we shall therefore here only state a few of the conclusions at which Muschenbroek and other experimentalists have arrived regarding the modifications which the tenacity of metals undergoes in consequence of various processes. Forging and wire-drawing increase the tenacity of metals in longitudinal direction. Copper and iron have this property more than doubled, while gold and silver have it more than trebled by these metals being drawn into wire. Mixed metals have usually a greater tenacity than simple ones. See *Alloy*.

TENAILLE.—The tenaille is a low work placed in the re-entering formed in the enceinte ditch by the curtain and flanks of the bastioned system, being isolated by a ditch between it and these parts of the enceinte. Its chief purpose is to serve as a mask, covering the scarp walls of this re-entering from fire, as well as the outlets to the enceinte ditch, which are usually placed in the center of the curtains.

The tenaille has received various forms from engineers. In some cases it has been made with two faces or wings, making a re-entering angle opposite the center of the enceinte curtain. In others the two wings, instead of being prolonged until they meet, are connected by a short curtain parallel to that of the enceinte. In some examples it has the form of a small bastioned front. In others it consist of two flanks connected by a curtain. These flanks in some cases have been casemated for guns and mortars. The tenaille is usually revetted with masonry both in front and rear. In some cases the ends alone, towards the flanks of the enceinte, are revetted, the intermediate portions consisting of but an ordinary earthen parapet without either scarp or gorge walls. See *Outworks*.

TENAILLED SYSTEM OF FORTIFICATION.—Several engineers of professional eminence have proposed tenailled enceintes as offering defensive properties superior to the bastioned. A description of a front planned by Carnot, will give a good idea of the arrangements made in this system. The great reputation, acquired by Carnot during the French Revolution, in which he played so conspicuous a part as a soldier, statesman, and executive officer, connected with his professional education as an engineer officer, gave great weight to his views on fortification. Having noticed the exposure to ricochet fire of artillery on ramparts without bomb-proof shelters,and the feeble resistance offered by garrisons in some of the sieges of his day, he planned this and other fronts to remedy these defects. Carnot thought their was no system superior to the bastioned when used on a level site, or when the defilements of the different parts were easily made. On rugged or mountainous sites, the problems of defilement for the bastioned system are difficult,and this induced him to devise this method for such sites,as more simple, less expensive, and fulfilling all the conditions of a permanent fortification to an equal if not greater degree than the bastioned. The *plan* consists of a continuous enceinte, the re-entering angles of which are 90° and the salients not less than 60°. The interior of the place is enclosed by a wall, of sufficient height to be secure from escalade,its plan being parallel to the enceinte; it is arranged with loop-holes for musketry, these being in arched recesses of sufficient depth to screen the men using them from vertical fire. Casemated batteries for artillery are placed at the re-enterings, to flank the ditch between the wall and the earthen rampart of the enceinte. The rampart and parapet of the enceinte are detached from the scarp wall; a narrow corridor being left between the foot of the exterior slope and the back of the wall. This wall has one tier of loop-holes, and broken forward at the re-entering, has embrasures for cannon with which to flank the ditch between it and the tenaille.

It is observed that the ditches and terre-pleins of all parts of this method are peculiarly exposed to ricochet fire. It is highly probable that the detached scarp walls would soon be battered down by the heavy projectiles passing over their earthen masks. To enable the garrison to sally out in force, he arranges the counter scarps with so slight a slope, that troops can ascend it with ease. There is nothing to prevent an active enemy, on repulsing the sortie, from following the retreating troops into the works themselves.

The system has found but few advocates, and, except in particular localities, where the natural features of the site demanded it, and for small works, it has met with no practical applications. Requiring that the salient angles shall not be less than 60°, and the re-entering angles between 90° and 100°, the tenailled system is only adapted to regular polygons of a sufficient number of sides to admit of these conditions being satisfied. If the exterior sides are kept within the limits usually admitted by engineers for bastioned enceintes, the faces of the tenailles become very long, and the re-enterings very deep; thus presenting two serious defects; long lines which are very much exposed to enfilade, and a great diminution of the interior space, as compared with the bastioned enceinte. The ditches when dry can only be swept by casemated defenses in the re-entering angles; and even then but partially, unless the casemated embrasures are placed very near the level of the bottom of the ditch, in which case the enceinte would be exposed to a surprise through the embrasures; and in the contrary case, liable to a like attempt from the dead space at the re-enterings below the embrasures. In wet ditches this exposure to surprise would be much less if the ditches could not be forded. In either case the defect arising from embrasure casemates placed in a re-entering angle would be a serious objection to using the guns of each side simultaneously. When the salient angles of the tenailles are acute, the effect of the enfilading fire would not be felt alone on the face enfiladed, but on the adjacent face or front, and shot passing over would damage the adjacent tenailles. See *Fortification* and *System of Fortification*.

TENAILLE LINE.—To remedy the defects of the redan line, it has been proposed to break the curtains forward, so as to form two branches, one perpendicular to the face of each redan. This suggestion has led to the *tenaille line*, which consists of a combination of small and large redans, or simply of redans of the same size, forming salient and re-entering angles. This combination is superior to the redan line. The salients are protected by a cross-fire, and ditches of the large redans are partially flanked; moreover, it presents fewer assailable points, on a given front, than the redan line; and its retired parts afford good positions for artillery.

The faces of the large redans should not exceed 160 yards; and their salient angle should not be less than 60°. The faces of the small redans should not be greater than forty yards, and should be nearly perpenpicular to those of the large redans. These combinations will give two limits for the length of the capitals of the large redans, and for their distance apart. When the salient angles are 60°, the length of the capitals will be about 138 yards, and the distance between them 228 yards. When the salient angle of the small redan is 60°, the capitals of the large redans will be eighty yards long, and the distance between them 316 yards. In the first case there will be a greater number of assailable points on a given front, but the re-enterings will be the stronger; in the second case the reverse of this will happen. Of course the size of the redans will not be restricted to the limits here laid down. This system is defective, in presenting long faces to an enfilade fire, and in taking up a considerable depth of ground, from the salients to the re-enterings,which restricts its application to particular localities. See *Lines*.

TENAILLON.—The term tenaillon is applied to a kind of face-cover, or counterguard, of the demi-lune. It is only to be met with in some of the old fortified places of Europe, and was added to give more strength to fronts wherever the demi-lune was too small.

TEN-INCH SEA COAST MORTAR.—A cast-iron, smooth-bore mortar, without chamber, used in the United States Service. The following table shows the principal weights and dimensions of the piece:

Designation.	Lbs.	Inch.
Caliber	....	10
Weight	7300	....
Prepondsrance	00	....
Length of piece	....	47.05
Length of bore	....	32.5
Windage	....	0.13
Charge (maximum), mortar-powder.	12	....
Charge to fill shell	5	....
Charge to burst shell	2	....
Charge to blow out fuse	0.5	....
Weight of carriage	2924	....

The carriage is of wrought-iron, and is provided with an eccentric axle and truck-wheels similar to the carriage for the 13-inch mortar. The mortar is fired from a wooden platform. With heavy charges, the shell used in the 10-inch gun may be used for this mortar. The 10-inch siege-mortar shell may be used with moderate charges. See *Mortar*.

TEN-INCH SIEGE-MORTAR.—A cast-iron, smooth-bore mortar, without chamber, used in the United States siege service. The following table shows the principal weights and dimensions of the piece:—

Designation.	No.	Lbs.	Inch.
Caliber	......	......	10
Weight	......	1900	......
Preponderance	......	00	......
Length of piece	......	......	28
Length of bore	......	......	20.5
Windage	......	......	0.13
Charge (maximum) mortar-powder	......	4	......
Weight of shell (empty)	......	90	......
Charge to fill the shell (musket-powder)	......	5	......
Charge to burst the shell (musket-powder)	......	2	......
Charge to blow out fuse (musket-powder)	......	0.3	......
Weight of carriage	......	1313	......
Weight of mortar-wagon	......	3185	......
Total weight of mortar, carriage, mortar-wagon, and implements	......	6600	......
Horses to transport	8	......	......

The mortar is fired from a wooden platform. The carriage is of wrought-iron, and, being without a chassis, rests directly upon the platform.—*See Mortar* and *Siege-mortar*.

TEN-INCH SMOOTH-BORE GUN.—A cast-iron muzzle-loading gun in barbette, used in the United States Service. The following shows the principal numbers, weights, and dimensions of the piece:

Desination.	No.	Lbs.	Inch.
Caliber	......	......	10.
Length of piece	......	......	136.6
Maximum diameter	......	......	32.
Minimum diameter	......	......	16.2
Length of bore (calibers)	10.5	......	.....
Windage	......	......	0.13
Initial velocity (feet)	1275.	......	......
Charge (cannon-powder)	......	25	......
Solid shot	......	128	......
Shell (unfilled)	......	102	......
Weight of piece	......	15,000	......
Preponderance	......	......	......

Carriage, wrought-iron; front pintle, without air-cylinders or other recoil checks. The new-pattern carriage will be provided with pneumatic buffers. The top-carriage will weigh 2500 pounds, and the chassis 3500 pounds.

The piece admits of 30 degrees elevation and 6 degrees depression. Its platform is a permanent portion of the fortification. See *Ordnance*.

TENNEY.—In Heraldry orange color, one of the tinctures enumerated by heralds, but not of frequent occurrence in coat-armor. It is indicated in engravings by lines in bend sinister, crossed by other barways.

TENSILE STRENGTH.—As applied to materials is their power to resist being torn asunder by a force exerted by a breaking instrument in the direction of length. The *tensile strength* should be carefully tested in all materials used in the construction of ordnance or any permanent works. Specimens carefully prepared should be subjected to the testing-machine, to the satisfaction of all concerned. Cast-iron of good quality, such as is used in casting guns, ranges from 14,000 to 17,000 pounds on the square inch. In America, whenever the *tensile strength* of iron falls below 20,000 pounds per square inch, the quality is rejected, and the gun is considered unfit for service. The drawings show the forms of specimens to be used when testing for tensile strains. Fig. 1. represents that for *wrought-iron* and *alloys*; or like Fig. 4, and can be made with long or short reduced section. Fig. 2, represents that for *cast-iron* and *alloys*; or like Figs. 1 or 4, and can be made with long or short reduced section: and any width up to 3 inches. Fig. 3, represents that for *iron plate*; or with reduced area like Fig. 1, or plain like Fig. 4, or any width to 3 inches. Fig. 4, represents that for *metals*, in general of any length from 14 inches to 4 ft., of the following dimensions: 3 in. × ⅝ in., 1 in. square, 1½ in. round or smaller sizes. Figs. 5, 6, and 7, represent those for a *chain*, *wire rope* and *hemp rope*, respectively, of

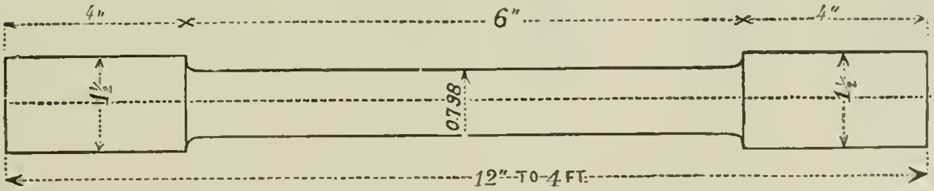


Fig. 1.

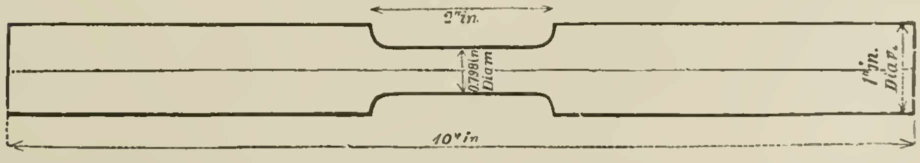


Fig 2.

any length from 18 inches to 4 feet, measuring inside of shackles or loops. The outside measurement of shackles or end loops must be 3 inches by 4 inches, or less, viz; so as to go through a hole 3 inches by 4 inches. Fig. 8, represents the form of a specimen for testing *cement* or *artificial stone*, as adopted by the New York Department of Docks and Public Works.

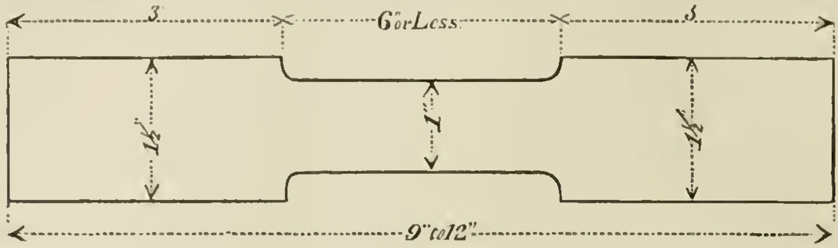


Fig. 3.

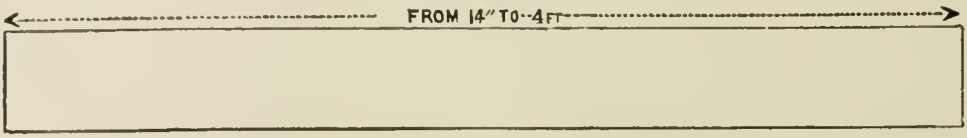


Fig 4.

After the density of a specimen has been ascertained, and before it is inserted in the holders of the testing-machine, its smallest diameter is accurately measured and recorded. This is done by sliding-calipers, an instrument provided with a vernier, which measures hundredths of an inch, and thousandths of an inch may be readily determined by a practiced eye.

Fig. 5.

Fig. 6.

Fig. 7.

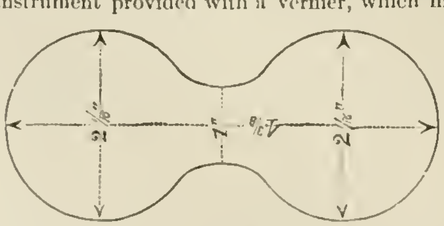


Fig. 8.

The breaking weight is divided by the area of the smallest diameter of the specimen, and the quotient gives the tenacity, or the strength per square inch. That is, let a represent the breaking weight, b the area, and x the tenacity per square inch—

$$b : 1 \text{ square inch} = a : x$$

The table, page 421, contains the area and the logarithms for all the variations of diameter likely to occur in tensile samples.

TENT.—Without speculating on the relative priority of tents and other forms of human dwellings, it is safe to assume, that among nomadic tribes, some shelter, easily framed and portable, must have been felt to be a primary necessity. The skins of animals, or the larger kinds of foliage, would form the earliest coverings, for which textile fabrics would be substituted as civilization advanced. In the book of Genesis, the patriarchs, Noah, Abraham, Lot, Isaac, Jacob, are represented as dwelling in tents, probably much the same as the modern Arab tents, which are large structures, very rude in form, covering a considerable space of ground, but being of small height. Among the Nineveh sculptures is a representation of the tent of King Sennacherib, which, like modern tents, was supported by ropes: numerous tents of the officers and common people are likewise shown. The early Greek, and afterward the Macedonian tents were small coverings of skins, under each of which two soldiers slept. Alexander the Great is said to have had a pavilion of extraordinary magnificence. Its roof, one mass of gilded embroidery, was sustained by eight pillars covered with gold. In the center, was the royal throne; and 100 beds could be made up within the temporary edifice. The Roman soldiers seem to have used two varieties of tents—one, a tent proper, of canvas or some analogous material, and constructed with two solid upright poles, and a roof-piece between them; the other, more resembling a light hut, of a wooden skeleton, covered by bark, hides, mud, straw, or any material which afforded warmth. Of these tents, the poles of the first would have been too cumbrous for carriage, and were probably cut afresh at each halting-place; the latter was evidently unsuited to removal, and was most likely only erected for winter-quarters, or a long sojourn. The Roman tent held 10 soldiers, with their *Decanus* or Corporal. In Persia, there are many tribes who pass their whole time in tents, which, naturally, they have brought to considerable perfection. They make them nearly hemispherical, with a wooden framework, and covered with felt, while worked hangings close the aperture. This felt admits of the exhibition of much taste in its decoration. The Chinese lower orders live much in tents. They are ordinarily of matting. These people are clever in their construction, and make them of great size, and with considerable comfort. Modern Military tents are all made of linen or cotton canvas, supported by one or more poles according to shape, and held extended by pegs driven

Diam.	Area.	Logs.	Diam.	Area.	Logs.	Diam.	Area.	Logs.
1.190	1.11220	.0461839	1.204	1.13853	.0563429	1.297	1.32120	.1209698
1.191	1.11407	.0469135	1.205	1.14042	.0570639	1.298	1.32324	.1216393
1.192	1.11594	.0476425	1.206	1.14231	.0577845	1.299	1.32528	.1223083
1.193	1.11782	.0483707	1.207	1.14421	.0585045	1.300	1.32732	.1229767
1.194	1.11969	.0490985	1.208	1.14610	.0592237	1.301	1.32937	.1236446
1.195	1.12157	.0498257	1.209	1.14800	.0599425	1.302	1.33141	.1243120
1.196	1.12345	.0505523	1.210	1.14990	.0606607	1.303	1.33346	.1249788
1.197	1.12533	.0512783	1.290	1.30698	.1162693	1.304	1.33550	.1256451
1.198	1.12721	.0520035	1.291	1.30901	.1169423	1.305	1.33755	.1263109
1.199	1.12909	.0527283	1.292	1.31104	.1176148	1.306	1.33960	.1269763
1.200	1.13097	.0534523	1.293	1.31307	.1182868	1.307	1.34165	.1276411
1.201	1.13286	.0541759	1.294	1.31510	.1189583	1.308	1.34370	.1283033
1.202	1.13475	.0548989	1.295	1.31713	.1196293	1.309	1.34576	.1289691
1.203	1.13664	.0556211	1.296	1.31617	.1202998	1.310	1.34782	.1296325

into the ground. British tents comprise the hospital-marquee, a large oblong tent with high side-walls; and the round tent, or bell-tent, for troops. The latter is 12 ft. 6 in. in diameter, 10 ft. 4 in. high, weighing, with all its appurtenances, 68 lbs., and giving sleeping accommodation to 16 men; the appurtenances comprise 2 mallets, 50 pins, 20 ropes, 20 loops, and 2 long ropes, for use in storms in giving additional firmness round the central pole. In modern tents, there is a low side-wall of canvas, to give greater room inside. These tents are said to be comfortable and moderately healthy, if floored with tarpaulin, vulcanized india-rubber, or other waterproof material. The great drawback is the tendency to blow over. To obviate this, and the inconvenience arising from the conical shape, Maj. Rhodes, a British officer, invented some years ago a new tent, which has found much favor both in England and other countries. He does away with the central pole, and has a circular frame, hinging in the center like the ribs of an umbrella, over which the canvas is stretched. It is claimed for this tent, that it is more roomy than the regulation-tent, in proportion to its weight, is better ventilated, and possesses far greater stability. Numerous tents and shelters of special patterns are described and illustrated under headings throughout the Encyclopedia.

The prevalence of many epidemics in all parts of the world may be regarded as the scourge of the present and the constant menace of the future, and our highest civilization finds its best exponent in the provisions made for the relief of the afflicted, and for the protection of the more fortunate. The care of the sick and wounded in the armies, either on the field of battle or elsewhere, has also enlisted the sympathies and commanded the attention of scientific and military men, and the hitherto insufficient means of alleviating the sufferings of our common humanity have made a strong appeal to the inventive genius of the age. In Europe the Society of the Red Cross has given this subject special consideration, and, on September 1st, 1885, an Exhibition was held at Antwerp, under the direction of that Society to which inventors were invited to present plans for barracks or field-hospitals, which might be utilized either in the field or in cities where epidemics may prevail. A programme was issued early in the year

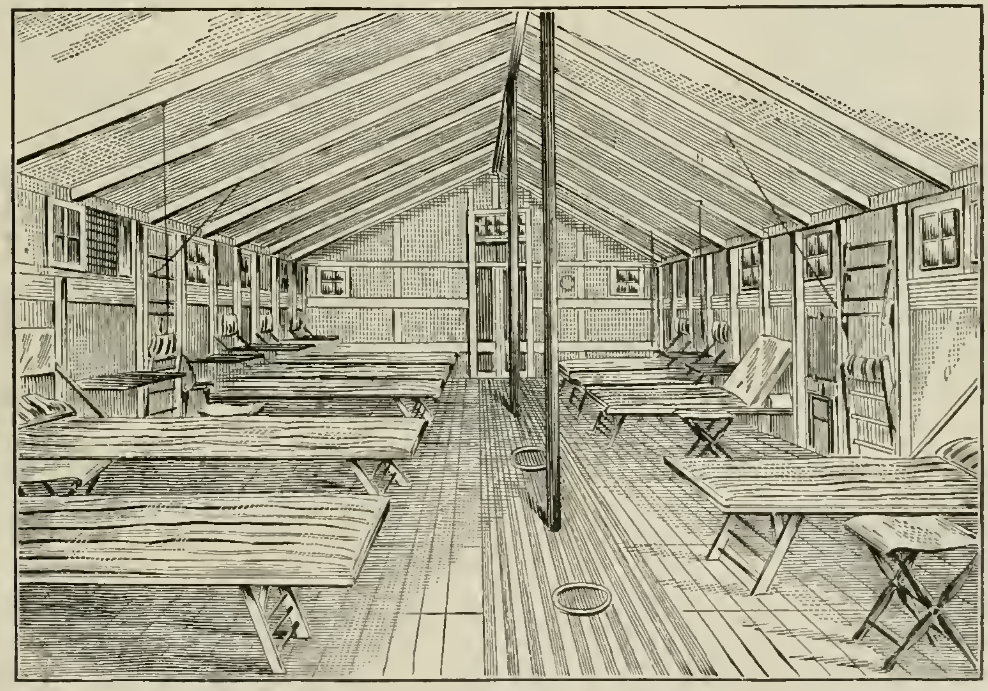


Fig. 1. Ducker Barrack—Inside view.

setting forth the points of excellence desired, and among the principal qualifications were the following: "The barrack should be capable of quick transformation either upon the theater of war, or for use in cities; it should constitute an independent whole, and be capable of being joined at will to form a part of a larger hospital. It should be constructed in all its parts in such a manner that it can be: 1st taken down easily: 2d. Transported without difficulty: 3d. and be set up again with rapidity to receive the sick and wounded. Its component parts should be firmly held together, and be able to resist the effects of violent winds. The materials employed should be impervious to rain, and as far as possible incombustible. As to dimensions it should accommodate twelve beds, and in order to facilitate its erection, it is very often necessary that the different pieces of which it is composed, should be interchangeable and require no skilled workmen to erect it or take it down. The floor not to be in direct contact with the ground and careful attention should be given to the best methods of heating, ventilating and disinfecting the structure."

solutely interchangeable, no numbering being necessary. The structure is firmly held together by an original adjustment without the use of nails or screws. Any ordinary inequality of the ground is provided for by adjustable feet on the side sections, which have a play of 8 or more inches. The heating and ventilating apparatus are the result of great care and experience, and careful attention has been given to the hygienic laws in all their vast application. At each end an annex is attached, in one of which is placed the heating apparatus, while the other may be used as a commode, if desired. Any number of these structures may be joined together at will, and with contagious diseases, when it may be desirable to destroy the hospital and to substitute a new one, such a change could be made without exposing the patient or removing him beyond the area covered by the structure. The transformation from a barrack to a field-hospital, or vice versa, can be effected in five minutes. The structure can be set up in from one hour to one hour and a half, and being placed on an ordinary wagon can be easily moved by a single horse. Every required point, as set forth in the programme

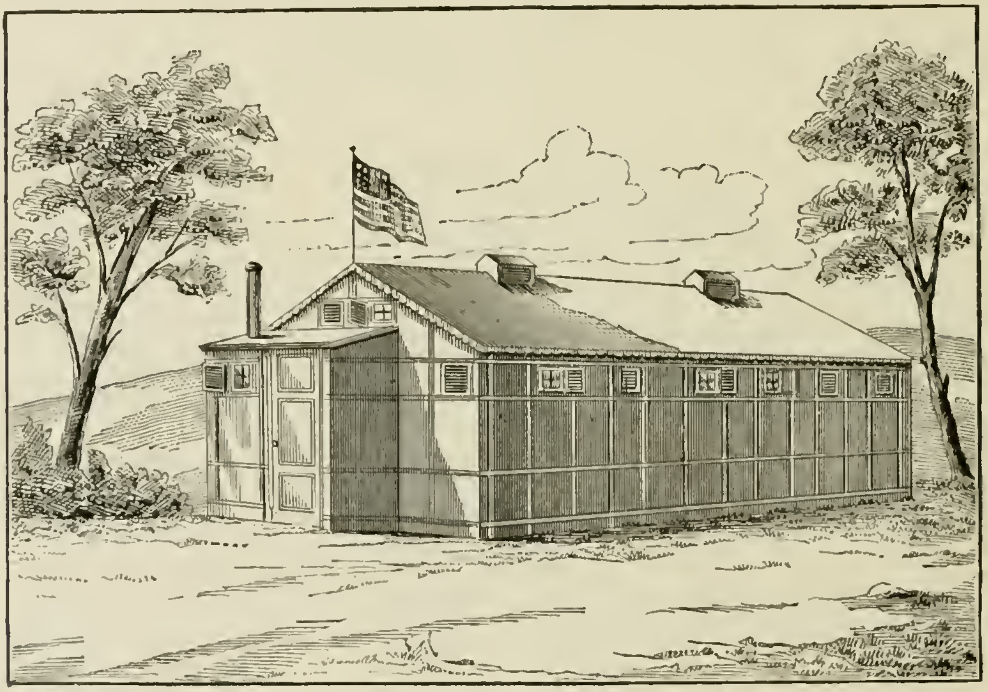
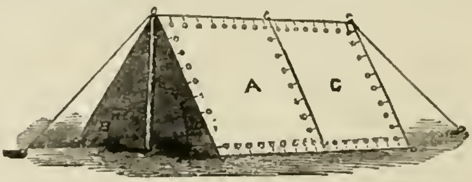


Fig. 2. Ducker Barrack—Outside view.

In accordance with the above requirements Mr. William M. Ducker, of Brooklyn, N. Y., invented and patented a barrack or field-hospital which was exhibited at Antwerp, and which received a medal offered by the Empress of Germany, and elicited the highest commendations from the many military and medical gentlemen who examined it. Figures 1 and 2 show the inside and outside views of this barrack or tent. The structure combines the qualities of simplicity, stability, lightness, cheapness, convenience, ease of transportation, facility of erecting and taking down, incombustibility, and superiority of heating and ventilation. It is 34 feet long, 17 feet wide, 6½ feet high at the side-walls, and 10½ feet high at the ridge-pole. It is constructed of wooden frames and cotton duck, and rendered practically incombustible by a fire-proof preparation. Its component parts are side sections which fold together, being permanently hinged, and which contain the beds, tables, and chairs with other accessories, end sections, floor sections, rafters, a ridge-pole, and a standard army duck roof extended over all. Each respective part is absolutely

at the Antwerp Exhibition has been fully met by the William M. Ducker, or American System, and it amply merits the high praise which it has received both in this Country and in Europe. It will doubtless supply a want which has for years been felt, and the thanks of the world, on behalf of those who suffer in war or through disease, will be extended to the ingenious inventor. See *Farrow Combination-tent.*

TENTES D'ABRI.—Small tents used in the French



Army. They are easily put up and struck. They are carried by the men in their knapsacks, two men to each tent, but they have been found to be a great incumbrance, too much weight being placed on the men's shoulders. A *tente d'abri* consists of two sheets about 5 feet 6 inches broad, 2 poles, and 7 pins, and weighs about 11 lbs. when dry; it is issued at the rate of 1 to every 3 men. The sheets, by means of button-holes, can be converted into bags, or can be joined to other sheets and thus form a larger tent, as shown in the drawing.

TENT-PINS.—Pieces of wood, which are indented at the top, and made sharp at the bottom, to keep the cords of a tent firm to the earth.

TENT-POLES.—The poles upon which a tent is supported. These are usually jointed at the center to render them easier of transportation. See *Farrow Combination-tent.*

TEREBRA.—A long and strong spear, placed on a kind of pin or axis, so that it might be worked in a groove by machinery. The work that this boring implement had to accomplish was to break up the first stone, and thus to make the commencement of a breach; and thereupon the battering-ram would be brought up to enlarge the opening by beating away the adjoining stones.

TERMINAL ANGLE.—In gunnery, the angle which a tangent to the trajectory forms with the horizontal plane at the point of descent. See *Angle.*

TERMINAL VELOCITY.—When a body falls in the atmosphere, there is a certain limit to the velocity it will acquire, and this is attained theoretically when the resistance of the air has become equal to the accelerating force of gravity; the motion of the body will then continue uniform, and is called its *terminal velocity*. Should the projectile be a solid cast-iron shot, having a diameter, d, its terminal velocity will be $178\sqrt{d}$; but if the ball be a *shell, leaden bullet,* etc., its terminal velocity will be $178\sqrt{\frac{s}{s'}d}$, in which s= weight of the shell or bullet, and s'= weight of a solid ball of the same diameter.

TERRE-PLEIN.—In fortification the flat surface of the rampart, on the front portion of which the parapet and banquette are formed, and of which the rear slopes down to the general level of the inclosure.

The word terre-plein is used to designate the surface on which the men stand in readiness to defend the parapet, and at the same time are screened from the enemy's view. The terre-plein may be the natural surface of the ground, it may be above this surface, or it may be below it, as the bottom of a trench. In ordinary field-fortifications the terre-plein is the natural surface of the ground. When the terre-plein is above the natural surface of the ground, the latter is termed the parade.

TERRITORIAL ARMY.—This term is given to an organized military force in France, or *second reserve*. It is designated a special army, having its own numeric classification, its special corps, and its independent organization. France has really, therefore, two armies, the active and territorial. The former is intended for mobile war in the field; the latter, on the contrary, is charged with the care and defense of fixed points of territory, fortresses, strategic points, coasts, and *Etappen* stations and lines. It will, as a rule, have to operate only in more or less important detachments, while the active army operates in masses. The territorial army will rarely detach bodies of troops to join the active army, and if the law has provided for this detachment, it is only mentioned as an exception. The strength of the territorial army may be said to be always less than half the active army.

At the present time, the name of each individual belonging, according to the last military law, to the territorial army has been entered on local registers, and then distributed (on paper) among the several territorial regiments. Each of the eighteen military districts into which France is divided has either 8 or 9 such regiments of infantry, with the exception of the first (Lille corps) district which has but 7. To provide for the cavalry of the territorial army (the scheme contemplating the separate formation of each arm), returns have been made of the local distribution of all horses in private hands capable of being adapted for the service. In the same manner the regiments of the territorial artillery, each assigned to one district, will be raised according to specially arranged districts, each to be capable of horsing one regiment of field-batteries. A battalion of engineers will be enrolled in each of the regular districts, taken from such men as will be specially fit for it. See *French Army.*

TERTIATE.—To examine the thickness of metal in ordnance with callipers. The term "tertiating" is derived from the process originally adopted in measuring the three principal dimensions of a gun, viz., the caliber, the length of the bore, and the thickness of the metal at the breech.

TERZEROL.—The German name for a small pistol with a wheel-lock, invented in the 16th century, also written *Tercerole.*

TESACK.—A Bohemian sword of the 15 century, 39 inches long, and composed entirely of iron. The wearer had his sword-hand protected by an iron or dear-skin gauntlet which reached to the elbow. The *Düsack* does not differ very materially from this kind of sword.

TESTIERE.—That part of the horse-armor which covered the juncture of the *chanfrien*, *neck-armor* and *jaw-plates*. The term was sometimes applied to the whole head-armor of the steed.

TESTING-MACHINES.—Machines employed at arsenals and foundries for testing the strength of materials with strains of different kinds, and for determining the lubricity of oils and other materials used to avoid friction between moving parts. The standard testing-machines of the world are made in great variety by Messrs. Riehlé Brothers, United States. The drawing shows a very complete horizontal testing-machine for ascertaining the tensile strength of bolts, wire or rope, chain and metal plates.

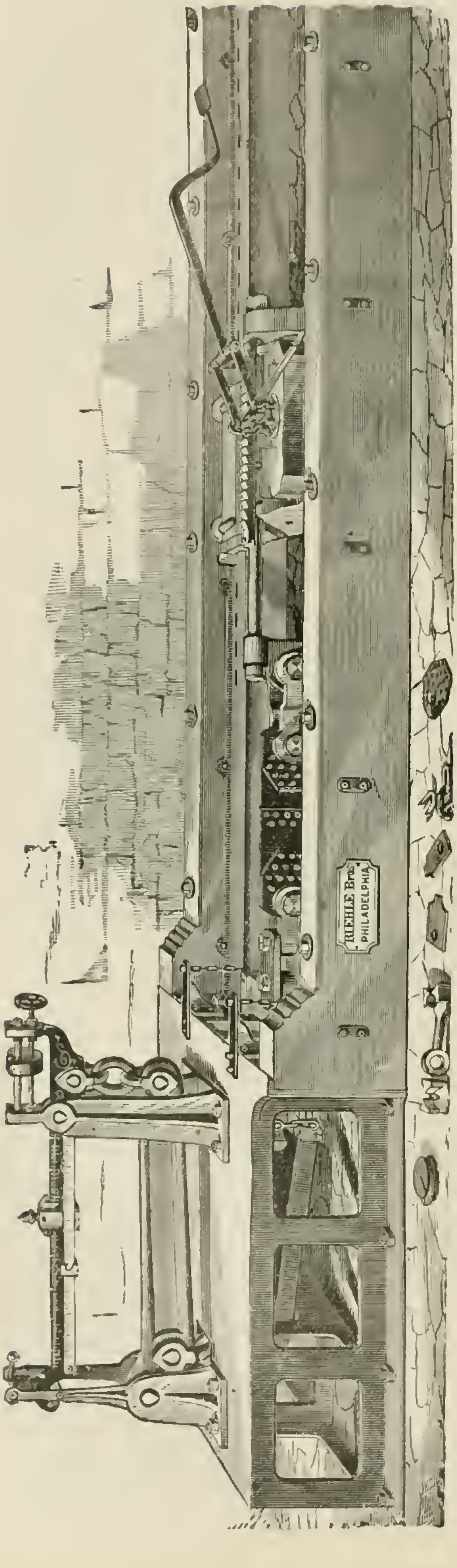
DIMENSIONS.

Extreme height	5 ft. 6 in.
Extreme length	22 ft.
Extreme width	4 ft.
Weight	10,750 lbs.

ADAPTATION.

Tensile specimens	20 in. to 100 ft.
Round "	$2\frac{1}{2}$ in. or less.
Square "	2 in. × 2 in or less.
Flat "	$3\frac{1}{2}$ in. or less × $1\frac{1}{4}$ in. or less
Transverse "	12 in. to 18 in.
Compressive specimens	20 ft. or less.
Compressive surfaces	10 in. × 12 in.
Motion of Plunger	6 inches.

The specimen (riveted metal plates) is shown in the position for testing. The advantage gained by a horizontal testing-machine over an upright one is, that while you can take in as short a specimen as in the upright machine, you can also test with the same accuracy and no more trouble, a specimen of all most any length. The cross-heads holding the tools, that secure one end of the specimen together with pump and jack, are run on wheels on a track or guide, and the track fastened on to heavy timbers can be extended almost indefinitely. The handle on the jack at the right hand side works on a ratchet, so that when the hand is raised a tooth on the other end of it takes a new hold, and when depressed forces the plunger of the jack back to its original position. The carriage, as it might be called, is stopped by means of pins dropped into the proper holes. The intermediate lever in this machine is suspended upon knife edges; and, as in the upright machine, connects the tools holding one end of the specimen with the weighing-beam, but the strain is horizontal and not perpendicular. This machine is very accurate and the parts are all delicately balanced



upon steel fulcrums before the test is made, and this equipose retained all through the process of testing, so that practically there is really no friction to allow for. This machine can be modified, with proper appliances, to test the resistance by compression of iron or stone columns, or any material in any shape, also traverse strength of girders and metal bars, etc. Its capacity is 150,000 lbs.

The machine is furnished with Riehlé's wedge-clamp, which solves by a simple device a difficulty long experienced by makers of testing-machines, that of securing a perfectly central pull or stress on the flat specimens to be tested, without the possibility of any twist or tearing from the edges or sides. The invention consists of wedge-clamps having their faces which grip the specimens, slightly raised through their centers longitudinally their entire or partial length. Wedges having curved backs, and wedges with ball-and-socket joints, are made to accommodate specimens of uneven thickness, but they will not prevent a twist or torsion of the specimen if opposite corners of same above and below are unequal in thickness or the surfaces are harder. Then, again, the teeth of wedges may wear away unevenly, and allow the specimen to slip or shift. In the Riehlé wedge-clamp the specimen is engaged immediately through the axial line, and presses continuously a little harder than at the edges. The edges are then relieved

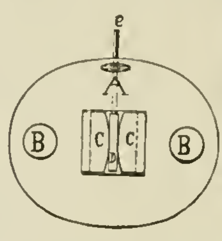


Fig. 1.

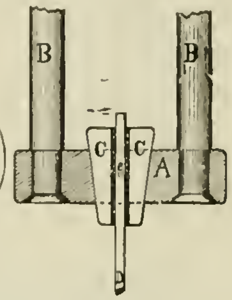


Fig 2.

under all circumstances, and a side-pull causing a tear is averted. Fig. 1 shows a plan of the wedge-clamp, with a specimen in position; Fig. 2 is a sectional view of the same.

Of course, the inclinations of the surfaces of the wedges are exaggerated in the drawings, so as to distinctly set forth their features. CC, are curved face wedges; D, is the specimen; E, is a pin that is used to guide the specimen to the center of the testing-tools. Experience has proved that *hydrostatic power* is superior to *worm gear*, as applied to testing-machines for heavy work, and in almost every instance, for several reasons; especially when hand power is used. First.—The friction is comparatively insignificant. Second. The ease and rapidity of operation. Third.—The economy of space. Fourth.—The instantaneous relief of all strain. Fifth.—The quick adjustment that can be made to long or short specimens. Sixth.—The rapid following up of the stretch of ductile material.

In the screw, with its worm gearing, etc., the friction is simply enormous, absorbing more than three-fourths of the power expended in operating it under heavy pressure. If worked by hand it is a laborious undertaking to make one test, and the time employed is in proportion to the length and character of the specimen. It necessitates the practice of testing in short sections, whilst the fairest test is conceded to be of a specimen with long reduced section, say 4 inches or 8 inches, or a piece without any reduced section. The gearing takes up a great deal of room, and a compact machine of great power cannot be made. The impression that a screw will apply a permanent fixed strain upon a specimen being tested for an indefinite length of time, is erroneous, as after the specimen has passed its limits of elasticity, or commenced to stretch, the weighing-beam of the screw-power testing-machine drops, and the stretching or the yielding of particles continues. See *Cement-tester*, *Cloth-tester*, *Emery Testing-machine*, *Leather*, *Oil-tester*, *Paper-tester*, *Rodman Testing-machine*, *Spring-tester*, *Twine-tester*, *Vertical Testing-machine* and *Wire-tester*.

TESTUDO.—In ancient warfare, a defensive arrangement of the shields, by means of which a body of men advancing against a wall for assault or mining sought to protect themselves from the darts and weapons of the defenders. The men standing in close order joined their shields above their heads, the edges overlapping, until the whole resembled the shell of a tortoise (*testudo*). The name was also applied to a machine moving on wheels, and roofed over, under which soldiers worked in undermining or otherwise destroying the walls in a siege. See *Battering-ram*.

TETE-DE-PONT.—In fortification, a work covering the communication across any river; also termed a bridge-head. Bousmard says a *tête-de-pont* ought to unite the properties of a perfect defense of the river on both sides, to cover the bridge well, with space sufficient to contain the garrison, and to furnish a free passage for a considerable body of troops. The *tête-de-pont* should also be sufficiently strong to resist an assault. See *Bridge-head*.

TETRAPHALANGARCHIA.—The grand phalanx of the Greeks. An army corps was composed, 1. Of a *tetraphalangarchia*, also termed a grand phalanx, consisting of 16,345 oplitai. An *epitagma*, of 8192 psiloi; and an epitagma of cavalry of 4,095 men. The heavy armed, or infantry of the line, bore to the light infantry and cavalry the ratio of the numbers 2, 4, and 1.

The composition of the old grand phalanx was as follows: Tetraphalangarchia = 4 *phalanxes* = 16 *chiliarchiae* = 64 *syntagmata* = 256 *tetrarchiae* = 1024 *lochoi* or files = 4096 *enomitiae* of 4 men each. It is thus seen that, in the various formations, a division of the whole could be made by the powers of 2 or 4.

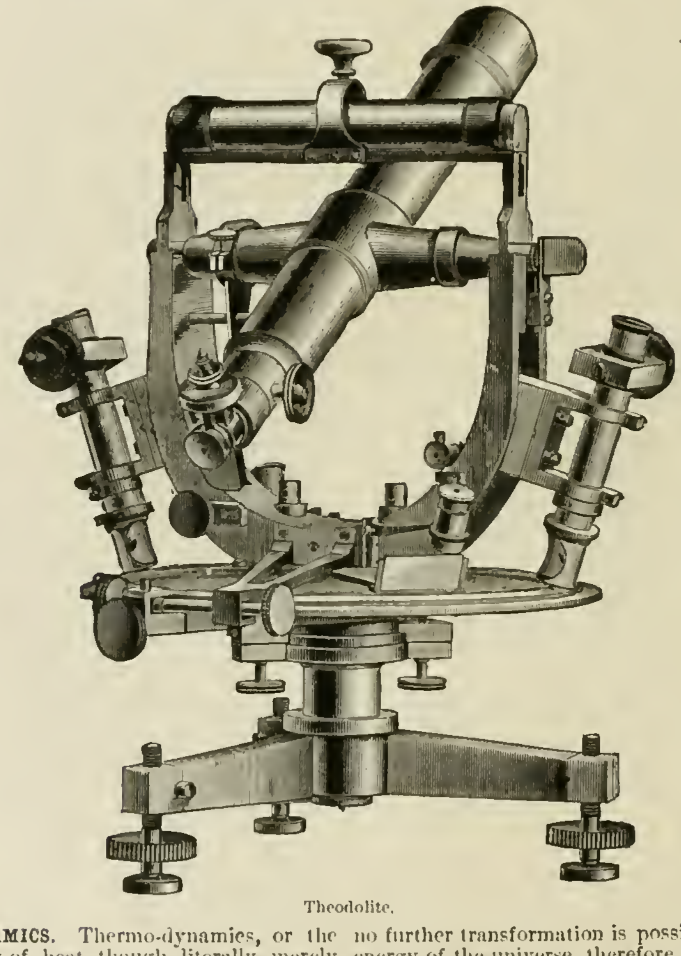
TETRARCH.—A title originally designating what is signified by its etymology, the Governor of one of four divisions of a kingdom or country; but in the usage of the later Roman Empire, given undistinguishingly to all minor rulers, especially in the East, possessing sovereign rights with their territory, but dependent on the Emperor, and in many cases removable at his pleasure. This was especially the case in Syria, where the Princes of the family of Herod are called indiscriminately by this title (Luke iii. 1) and by that of King (Matt. xiv. 9). The Tetrarch in this latter sense was in truth a Sovereign, although a Dependent Sovereign; and there are instances in which it seems to have been applied to really Independent Sovereigns of small Principalities.

TEUTONIC KNIGHTS.—One of the more celebrated of the military and religious orders to which the Crusades gave birth. The sufferings of the Christian soldiers at the siege of Acre excited the sympathy of certain merchants of Bremen and Lubeck, who rendered such important services by the erection of hospitals and otherwise, that Duke Frederick of Swabia, with the sanction of Pope Clement III. and Emperor Henry VI., enrolled them in an Order of Knighthood, as the Teutonic Knights of St. Mary of Jerusalem. Only Germans of noble birth were made admissable to the Order, the original founders having probably been ennobled before being enrolled. The members were at first all Laymen, but Priests were soon admitted as Chaplains; and there was also added about 1221 a class of half-brothers similar to the serving-brothers of the Templars and Hospitallers. The habit of the Order was a white mantle with a black cross; and the Knights took vows of poverty and chastity, which in later times were not very strictly interpreted. Their first seat was Acre. On the overthrow of the Kingdom of Jerusalem, the Grand Master removed to Venice, and from thence in 1309 to Marienburg, on the banks of the Vistula. In 1237, this Order became united with the Brethren of the Sword in Livonia. In the course of the 13th century, the Teutonic Knights were, with the sanction of the Pope, engaged in a bloody war to enforce Christianity on the heathen nations inhabiting the southern shores of the Baltic, which resulted in the acquisition by the Order of Prussia, Livonia, Courland, and other adjoining territories. Warriors from all parts of Europe in that and the following century joined their standard, including Henry IV. of England, accompanied by 300 Attendant Knights and Men-at Arms. The conquests of the Order raised it to the rank of a Sovereign Power, with a territory extending from the Oder to the Baltic, and embracing a population of between two and three millions, the Grand Master having his seat at Marienburg, in Prussia. The decline of the Order began in the 15th. century, and its fall was brought about partly by internal dissensions, and partly by the attacks of neighboring States. Sigismund of Poland wrested western Prussia from the Knights; and Albert of Brandenburg, who was chosen Grand Master in hopes of his aiding the Order against Poland, ended an unsuccessful war with Sigismund by an arrangement, according to which the territories of the Order in Eastern Prussia were formed into a Duchy, to be held by Albert and his successors. Mergentheim in Swabia then became the seat of the Grand Master, who was recognized as a spiritual Prince of the Empire. At the peace of Presburg in 1805, the Emperor of Austria obtained the rights and revenues of the Grand Master; but in 1809 the Order was abolished by Napoleon, its lands passing to the Sovereigns in whose dominions they lay. The Teutonic Order, however, still continues to preserve a titular existence in Austria

THAULACHE.—Armor and weapons of the ancient French, consisting of small shields (rondelles), and halberd or spear.

THEATER OF WAR.—A term synonymous with "Seat of War," and meaning any extent of country in which war is carried on, or where hostile armies can come into collision with one another. See *Strategy*.

THEODOLITE.—An instrument much employed in land-surveying for the measurement of angles horizontal and vertical is neither more nor less than an altitude and azimuth instrument, proportioned and constructed so as to be conveniently portable. Like all instruments in very general use, the variations in its construction are almost numberless; but its main characteristics continue unaltered in all forms. It consists essentially of two concentric circular plates of copper, brass or other material (the upper plate, or *upper horizontal*, either being smaller, and let into the lower, or *lower horizontal*, or the rim of the lower raised round the outside of the upper), moving round a common axis, which, being double, admits of one plate moving independently of the other. Upon the upper horizontal rise two supports, bearing a cross-bar, which is the axis of a *vertical circle* moving in a plane at right angles to the former. This latter circle either has a telescope fixed concentric with itself, or a semicircle is substituted for the circle, and the telescope is laid above, and parallel to its diameter. The circles, as their names denote, are employed in the measurement of horizontal and vertical angles. For these purposes the outer of the horizontal circles is graduated, and the inner carries the index-point and the verniers; the vertical circle is also graduated, and the graduations are generally read off by an index-point and vernier firmly attached to the supports. The upper horizontal is furnished with two levels placed at right angles to each other, for purposes of adjustment, and has a compass-box let into it at its center. The stand consists of a circular plate supported on three legs, and connected with the lower horizontal by a ball-and-socket joint; the horizontal adjustment of the instrument being effected by means of three or four (the latter number is the better) upright screws placed at equal distances between the plates. The telescope is so fixed as to be reversible, and the adjustments are in great part similar to those of other telescopic instruments, but are too numerous and minute to be here detailed. Both horizontal plates being made, by means of the screws and levels, truly level, the telescope is pointed at one object, and the horizontal angles read off; it is then turned to another object, and the readings-off from the graduated circle again performed; and by the difference of the readings, the angular horizontal deviation is given; and when vertical angles are required, the readings are taken from the vertical circle in a similar manner. The instrument, as represented in the drawing, is made by Fauth & Co., United States. See *Altitude and Azimuth Instrument*, and *Engineer's Transit.*



Theodolite.

THERMO-DYNAMICS. Thermo-dynamics, or the dynamical theory of heat, though literally merely the science of the relations of heat and work, is now very generally employed to denote the whole science of energy. See *Force.* We propose in this place to give a general sketch of this grand modern generalization, supplementary to what will be found in the article just referred to, but, for the sake of continuity, we must repeat a little of what was there given, though in a somewhat different form.

Energy is strictly defined as the power of doing work, and is of one or other of two kinds—*potential* or *kinetic.* A raised weight, a wound-up spring, gunpowder, and the food of animals, are instances of stores of potential energy. A missile in motion, wind, heat, and electric currents are instances of kinetic energy. Sound, light, and other forms of wave motion, are all instances of mixed potential and kinetic energy. The modern theory of energy contemplates its conservation, transformation, and dissipation. The conservation of energy is the experimental fact, that energy is, like matter, indestructible and uncreatable by any process at the command of man. The transformation of energy is the statement of the experimental fact, that any one form of energy may in general be transformed wholly or partially into any other form. This used to be known as the correlation of forces. But it is subject to the condition derived from the first fact, that the portion transformed retains its amount unchanged. It is also subject to the law of dissipation, or degradation, which is a statement of the experimental fact, that energy generally tends at every transformation to at least a partial transformation into heat; and that, once in that form, it tends to a state of uniform distribution, in which no further transformation is possible. The original energy of the universe, therefore, though still of the same amount as at creation, being in a state of ceaseless transformation, has been in great part frittered down into heat, and will at length take wholly that form.

Newton took the first great step. In a scholium to his third law of motion, he lays down in a few clear words the conservation of energy as the embodiment of the experimental results known in his day with reference to forces and visible motions. Part of this statement of Newton's was afterward reinvented under the name of conservation of vis-viva; but all that Newton really wanted to enable him to complete the conservation of energy was an experimental knowledge of the nature of heat, electricity, etc. That heat is motion of some kind, not matter, and that the laws of its communication are the same as those of the communication of visible motion, was experimentally proved at the very end of last century by Davy. Rumford had almost completed a proof a year or two before; but he had also made a very fair attempt to determine the "mechanical equivalent" of heat—i.e., the quantity of heat which is equivalent to a given amount of mechanical work. That there is such an equivalent is at once evident by looking at Davy's discovery in the light of Newton's scholium already referred to. But though the dynamical theory of heat was thus really founded in 1799, it was not generally received. The first to call attention to it was Séguin, nephew of the celebrated Montgolfier (from whom he states that he derived his views), who, in 1839, distinctly enunciated the equivalence of heat and mechanical work, and sought to prove by experiment that heat disappears, or is put out of existence, in the production of work from a steam-engine.

In 1842 Mayer published a short note, in which he enunciated the conservation of energy as a metaphysical deduction from the maxim, *Causa æquat effectum.* He made no experiments to prove this general statement, but he made a calculation of the mechanical equivalent of heat from the specific heats of air—assuming that when heat is produced by compression, its amount is the equivalent of the work spent in compressing. His result was erroneous, because his data were imperfect. But it appears that his assumption, quite unwarranted as it was, is really very nearly true for air. In 1843 Colding, led also by some metaphysical speculations, propounded the doctrine, but endeavored to base it upon actual experiments. Finally Joule, also in 1843, published an experimental determination of the mechanical equivalent of heat (770 foot pounds as the work required to heat a pound of water one degree Fahr.), which is within half per cent. of the most trustworthy results since obtained. Joule had been, since 1840 at least, making quantitative determinations of equivalence between various forms of energy; and was led to propound the general law of conservation of energy by the only legitimate process—viz., experiment, as contrasted with metaphysical assertions of what ought to be. The complete foundation of the science on a proper basis is thus due to him; though, as we have seen, portions of it were established thoroughly by Newton and by Davy.

Before we consider what are the principal features of the theory as now developed, it is necessary to refer to the admirable investigations of Fourier and Carnot, which, though in some respects defective, must be considered as real advances. Fourier's great work, *Théorie de la Chaleur*, is devoted to the laws of conduction and radiation, *i.e.*, to the dissipation of heat, and is one of the most remarkable mathematical works ever written. Carnot's work, *Sur la Puissance Motrice du Feu*, is the first in which any attempt is made to explain the production of work from heat. It is unfortunately marred by his assumption that heat is a material substance, though it is only fair to say that he expresses grave doubts as to the truth of this hypothesis. He begins his investigation by premising the following principle, sadly neglected by many subsequent writers: "If a body after having experienced a certain number of transformations, be brought identically to its primitive physical state as to density, temperature, and molecular constitution, it must contain the same quantity of heat as that which it initially possessed." Hence he concludes that when heat produces work, it is in consequence of its being *let down* from a hot body to a cold one, as from the boiler to the condenser, of a steam-engine. His investigation, though based on an eroneous hypothesis, is extremely ingenious, and forms the foundation of the modern theory. We give a sketch of it, preparatory to our account of the present state of the theory, and for this purpose we choose a somewhat hypothetical case, as simpler than the most common practical one. This the case of a piston working air-tight in a cylinder closed at the bottom.

Suppose we have two bodies, A and B, whose temperatures, S and T, are maintained uniform. A being the warmer body, and suppose we have a stand, C, which is a non-conductor of heat. Let the

sides of the cylinder and the piston be also non-conductors, but let the bottom of the cylinder be a perfect conductor; and let the cylinder contain a little water, nearly touching the piston when pushed down. Set the cylinder on A; then the water will at once acquire the temperature S, and steam at the same temperature will be formed, so that a certain pressure must be exerted to prevent the piston from rising. Let us take this condition as our starting-point for the cycle of operations. 1. Allow the piston to rise gradually; work is done by the pressure of the steam, which goes on increaing in quantity as the piston rises, so as always to be at the same temperature and pressure. And *heat is abstracted from* A, namely, the latent heat of the steam formed during the operation. 2. Place the cylinder on C, and allow the steam to raise the piston further. More work is done, more steam is formed, but the temperature sinks on account of the latent heat required for the formation of the new steam. Allow this process to go on till the temperature falls to T, the temperature of the body B. 3. Now, place the cylinder on B; there is of course no transfer of heat; because two bodies are said to have the same temperature when, if they be put in contact, neither parts with heat to the other. But if we now press down the piston, we do work upon the contents of the cylinder, steam is liquefied, and the latent heat developed is at once absorbed by B. Carry on this process *till the amount of heat given to B is exactly equal to that taken from A* in the first operation, and place the cylinder on the non-conductor C. The temperature of the contents is now T, and the amount of caloric in them is precisely the same as before the first operation. 4. Press down the piston further, till it occupies the same position as before the first operation; additional work is done on the contents of the cylinder, a further amount of steam is liquefied, and the temperature rises. Moreover, *it rises to S exactly*, by the fundamental axiom, because the volume occupied by the water and steam is the same as before the first operation, and the quantity of caloric they contain is also the same—as much having been abstracted in the third operation as was communicated in the first—while in the second and fourth operations the contents of the cylinder neither gain nor lose caloric, as they are surrounded by non-conductors. Now, during the first two operations, work was done by the steam on the piston; during the last two, work was done against the steam: on the whole, the work done by the steam exceeds that done upon it, since evidently the temperature of the contents, for any position of the piston in its ascent, was greater than for the same position in the descent, except at the initial and final positions, where it is the same. Hence the pressure also was greater at each stage in the ascent than at the corresponding stage in the descent; from which the theorem is evident. Hence, on the whole, a certain amount of work has been communicated by the motion of the piston to external bodies; and the contents of the cylinder having been exactly restored to their primitive condition, we are entitled to regard this work as due to the caloric employed in the process. This, we see, was taken from A, and wholly transferred to B. It thus appears that *caloric does work by being let down from a higher to a lower temperature*. And the reader may easily see that if we knew the laws which connect the pressure of saturated steam, and the amount of caloric it contains, with its volume and temperature, it would be possible to apply a rigorous calculation to the various processes of the cycle above explained, and to express by formula the amount of work gained on the whole in the series of operations, in terms of the temperatures (S and T) of the boiler and condenser of a steam-engine, and the whole amount of carolic which passes from one to the other.

Though the above process is exceedingly ingenious and important, it is to a considerable extent vitiated by the assumption of the materiality of heat which is made throughout. To show this, it is only necessary to consider the second operation, where *work is supposed to be done* by the contents of the cylinder expanding *without loss or gain of caloric*, a supposition which our present knowledge of the nature of heat shows to be incorrect. But it is quite easy, as seems to have been first remarked by J. Thomson in 1849, to put Carnot's statement in a form which is rigorously correct, whatever be the nature of heat. J. Thomson says: "We should not say, in the third operation, 'Compress till the same amount of heat is given out as was taken in during the first.' But we should say, 'Compress till we have let out so much heat that the further compression (during the fourth stage) to the original volume may give back the exact original temperature." It is but bare justice, however, to acknowledge that Carnot himself was by no means satisfied with the caloric hypothesis, and that he insinuates, as we have already seen, more than a mere suspicion of its correctness If we carefully examine the above cycle of operations, we easily see that they are *reversible*, *i.e.*, that the transference of the given amount of caloric back again from B to A, by performing the same operations in the opposite order, requires that we expend on the piston, on the whole, as much work as was gained during the direct operations. This most important idea is due to Carnot, and from it he deduces his test of a *perfect* engine, or one which yields from the transference of a given quantity of caloric from one body to another (each being at a given temperature) the greatest possible amount of work. And the test is simply that *the cycle of operations must be reversible*. To prove it, we need only consider that, if a heat-engine, M, could be made to give more work by transfering a given amount of caloric from A to B, than a reversible engine, N, does, we may set M and N to work in combination, M driven by the transfer of heat, and in turn driving N, which is employed to restore the heat to the source. The compound system would thus in each cycle produce an amount of work equal to the excess of that done by M over that expended on N, without on the whole any transference of heat; which is of course absurd. The application of the true theory of heat to these propositions was made in 1849, 1850, and 1851 respectively, by Rankine, Clausius, and Sir W. Thomson. Rankine employed a hypothesis as to the nature of the motion of which heat consists, from which he deduced a great many valuable results. Clausius supplied the defects of Carnot's beautiful reasoning; accommodating it to the dynamical theory by a very simple change, and evolving a great number of important consequences. But by far the simplest, though at the same time the most profound, writings on this subject, are those of Sir W. Thomson, to be found in the *Transactions of the Royal Society of Edinburgh*; and these must be consulted by any reader who desires to have a clear statement and proof of thermo-dynamical laws, not complicated by unnecessary hypotheses or formulæ, and yet perfectly general in its application.

In its new form, thermo-dynamics is based on the two following laws:

Law I. (Davy and Joule.) When equal quantities of mechanical effect are produced by any means whatever from purely thermal sources, or lost in purely thermal effects, equal quantities of heat are put out of existence, or are generated.

Law II. (Carnot and Clausius.) If an engine be such that, when it is worked backward, the physical and mechanical agencies in every part of its motions are all reversed, it produces as much mechanical effect as can be produced by any thermo-dynamic engine, with the same temperatures of source and refrigerator, from a given quantity of heat.

The proof of this second law differs from that of Carnot (already given as regards reversible engines) by being no longer based on the supposition of the materiality of heat, but on the following axiom, in some of its many possible forms: It is impossible, by means of inanimate material agency, to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects. It will be easily seen that the pair of engines (one reversible) before mentioned would, if worked in combination, form a perpetual motion; and besides, would constantly transfer the heat from a colder to a warmer body.

One of the immediate and most important deductions from these principles is—that only a fraction of the heat employed in any engine is converted into useful work (the remainder being irrecoverably lost). This fraction was shown by Thomson to be capable of expression as

$$\frac{S-T}{S}$$

where S and T are the temperatures of the source and condenser, *measured from the absolute zero* of temperature. See *Heat*. Thus, an air-engine, in which a greater range of temperature can be safely used than in a steam-engine, employs effectively a much larger portion of the heat supplied to it; and there is no doubt that air-engines would supersede steam-engines, if we could get a material capable of enduring the great heat required.

THERMOMETER.—A term which, in spite of its derivation, is usually restricted to instruments which measure temperature by the *expansion* of bodies. Like that of the telescope and microscope, and many other valuable pieces of philosophical apparatus, its early history is very obscure.

There are various claimants who seek to share at least a part in the credit of its invention; and they agree pretty well in referring it to somewhere in the beginning of the 17th century. We shall not waste space in endeavoring to settle such matters of history, but proceed at once to a description of the forms of the instrument now most commonly used; after which we shall say a few words about the actual value of their indications, and finish by a rapid sketch of a few other instruments also adapted for the measurement of temperature, but not usually known by the name of thermometer. Let us commence with the ordinary spirit-thermometer, shown in Fig. 1, where the indications are given by the expansion of a quantity of alcohol which fills entirely a glass bulb and partially a narrow tube attached to it. To construct such an instrument, a capillary tube is selected, of as uniform a bore as possible. The easiest method of testing its uniformity is to introduce a column of mercury, about an inch long, into the tube, and gradually move it along by inclining the tube, carefully measuring the length of the column in each of its successive positions. It is obvious that the column will be longer the smaller is the mean section of the portion of the tube occupied at any time by the drop of mercury. If considerable differences of length are found the tube is rejected at once. The best tubes are those which, if showing any change, taper very slowly but nearly uniformly from one extremity to the other; a defect which can easily be allowed for in the subsequent graduation of the instrument. A bulb is blown on one end of the selected tube; large, if the instrument is meant to be very delicate; small, if a common instrument is to be made, or one which will work through a great range of temperature. The bulb is heated to expand the contained air, and then the open end of the tube is plunged into alcohol, usually tinged with coloring matter, for greater visability. As the bulb cools, the atmospheric pressnre on the alcohol in the vessel forces some of it into the stem, and perhaps a little into the bulb. The tube being then inverted, a few dextrous taps suffice to shake the greater part of the alcohol into the bulb. The lamp has again applied, with caution, until the alcohol boils, and the rapidly escaping vapor drives the air almost entirely from the tube, whose open end is again plunged at once into the colored spirit. Unless the stem be nearly 40 feet in length—and thermometers have been made by Forbes of a length approaching to this for the measurement of underground temperature—the alcohol fills the whole of the ball and stem as soon as the glass has cooled. The bulb is again cautiously heated, so that, by the expansion of the spirit, such a portion may be expelled, that, when the whole is again cooled, the level of the liquid in the tube may stand near some point previously determined on with reference to the particular employment for which the instrument is destined. Finally, the lamp being again applied to the tube, near the upper surface of the liquid, that portion of the spirit is again made to boil; and while the vapor keeps the free end of the tube clear of air, that end is hermetically sealed; and the glass-blower's part of the work is done. A somewhat similar, but a more difficult process has to be gone through, if other liquids, such as ether, sulphuric acid, mercury, etc., are employed to fill the bulb; each of these liquids having its own special use in certain philosophical inquiries, as we shall presently see. It only remains that the instrument be *graduated*, so that some definite information may be given by its indications. In the older thermometers, the scale was arbitrary, so that no comparable readings could be taken by means of different instruments. In the finest modern instruments, also, the scale is usually quite arbitrary, being, in fact, engraved on the tube during the process of calibration above described. But then, by careful observation, certain difinite temperatures are measured in terms of this arbitrary scale, so that the value of a degree and the position of some definite zero-point are determined for it, and the result engraved on the tube. These numbers enable us, by an easy calculation, to reduce the observed reading of the fine instrument to its equivalent in some of the standard scales. At present, we assume, what is very nearly true for mercury at least, that equal increments of bulk correspond to equal increments of temperature. All, then, that is necessary is to fix two definite temperatures, and assign their positions on our scale. Water being one of the most common bodies in nature, and being everywhere easily obtainable in a state of great purity, is usually employed; and its *freezing* and *boiling* points are taken as the definite points. The temperature of freezing water or of melting ice is almost absolutely fixed, for pressure alters it only very slightly. It is otherwise with the boiling-point of pure water, for this is considerably raised by increase of pressure; so much so, in fact, that if the barometer be not attended to, an error of several degrees is possible. Hence we must define the particular pressure, usually 30 inches, at which the boiling-point is to be determined. The thermometer, constructed (so far) as above described is to have its bulb, and nearly the whole of the portion of the stem which contains liquid, immersed in pounded ice, from which the melted portion is freely trickling; and when the level of the spirit has become stationery, its position, the *freezing-point*, is marked on the tube. Similarly, the barometer standing at 30 inches the bulb is inclosed in the steam immediately above the surface of water freely boiling. We thus obtain the *boiling-point*. It only remains that we decide by what numbers these points shall be indicated, because (on account of the nearly uniform expansion of mercury) then the remaining divisions can be at once filled in by dividing the interval between them into equal parts, or, if necessary, allowing for a slight taper in the tube. The only scales which require mention are those of Fahrenheit, Réaumur, and Celsius. Of these, the first is commonly used in Britain, the second in Germany and the third in France; but this last, under the name of *Centigrade* scale, is almost exclusively used by scientific men of all nations. The relations of these scales will be easily understood by means of the following figure:

Fahr.	0	32	77	122	212
Reau.		0	20	40	80
Cent.		0	25	50	100

In the Fahrenheit scale, the freezing point is 32°, and the boiling-point 212°, so that the space between these is divided into 212—32, or 180, equal parts or degrees. In the others, the freezing-point is the zero, but the boiling-point is 80° and 100° respectively. It is of course perfectly easy to reduce from one of these scales to another. Thus—What is the centigrade reading for 77° Fahr. (See the dotted line in the figure)? The numbers in Fahrenheit's scale are all too great by 32, because 32°, and not 0°, stands for the freezing-point. Subtract this from 77, and we have 45. Hence the required number of centigrade degrees must bear the same ratio to the 100 from freezing to boiling in that scale that the 45 bears to the 180° between the same limits in Fahrenheit's. The requisite number is therefore $\frac{45}{180}\,100=25°$ C. In words—*To convert Fahrenheit to centigrade, subtract* 32, *and multiply by* $\frac{100}{180}$ *or* $\frac{5}{9}$. *Vice versa—To pass from centigrade to Fahrenheit, multiply by* $\frac{9}{5}$, *and add* 32. Thus the Fahrenheit value of 50 C. is $\frac{9}{5}\,50+32=122$, as in the figure. Of course the similar processes with Réaumur's scale present no difficulty. It is supposed that Fahrenheit fixed his zero at the point of greatest cold that he had observed, possibly in Iceland, more probably by means of a freezing mixture, such as snow and salt, or sal-ammoniac. It is much to be desired that the centigrade scale alone were to be employed. A mercurial thermometer ceases to be of use for temperatures only a little above the freezing point of mercury; but it has a wide range upward, as mercury does not boil till about 600° C. On the other hand, a spirit thermometer, though of little use beyond about 50° or 60° C., as alcohol boils at 70° C., is useful for any degree of cold yet produced, as alcohol has never yet been frozen. When extreme sensitiveness is required, either being considerably more expansible than alcohol, is sometimes employed; as by Thomson in detecting the effect of pressure on the freezing-point of water. Water, again, would be about the very worst substance with which a thermometer could be filled; for not to speak of its expanding in the act of freezing, and therefore necessarily bursting the instrument, if it were ever allowed to reach the freezing-point, its scale would read partly backward and partly forward; for as ice-cold water is gradually heated up to 4° C., it contracts, and begins to expand again after that limit has been passed. To make all thermometers self-recording, various schemes have been proposed,of which we shall notice only one or two. Those most commonly used indicate only *maximum* and *minimum* temperature during each 24 hours; or during the interval which has elapsed since they were last set. The usual arrangement consists of two thermometers, a mercurial and a spirit one, fixed horizontally to the same frame, with their bulbs at opposite ends of the frame. Above the mercury is a small piece of steel or ivory, and *in* the spirit a small and light float of glass or enamel. Capillary forces prevent the steel from entering the mercury, and the enamel from leaving the spirit. As the mercury expands, it pushes the steel before it, and, when it again contracts, it leaves it behind; the end nearest the mercury thus remaining at the highest or maximum indication which that thermometer has given. In the spirit-thermometer, the liquid as it expands, freely passes the enamel, and leaves it undisturbed; but it can never contract so as to leave it dry. It therefore pulls the enamel back when it contracts, and thus the extremity furthest from the bulb marks the lowest point which the spirit has reached, or the minimum temperature. To set this instrument, incline it so that the steel falls back to the surface of the mercury—the enamel at the same time comes to the surface of the spirit. The best mode of registration is undoubtedly the photographic. For this purpose, a mercurial thermometer is placed vertically before a narrow slit, in such a way that no light can pass through the slit save above the level of the mercury in the tube. A gas flame is kept burning at some distance in front of the slit, the bulb of the thermometer being protected from its radiation; and behind the slit a sheet of prepared photographic paper is exposed to the narrow line of light which passes above the mercury. This paper is fixed on a cylinder with a vertical axis, which is made to revolve uniformly by clockwork. Lines are drawn by the clockwork on the paper, giving the position of the slit at each hour of the 24, or the gas-flame is mechanically reduced or eclipsed at intervals of an hour; so that the record, when photographically developed, gives the temperature for every minute of the day and night; the portion of the paper which has been exposed to the light is blackened.

Among ordinary meteorological instruments the *wet-bulb* thermometer is deserving of notice. It is simply an ordinary thermometer, with the bulb covered with paper or cotton-wool, kept constantly moist by the capillary action of a few fibers connecting it with a small vessel of water. If the air be *saturated* with moisture, there will be no evaporation, and the wet-bulb thermometer will give the same indication as the dry-bulb. But the drier and the warmer the air is the faster does the water evaporate, and (the latent heat of evaporization being mainly taken from the moist bulb) the lower does the mercury sink in the moist-bulb instrument. The difference between the readings of the two instruments, compared with the actual temperature, as shown by the dry-bulb, thus leads to a determination of the hygrometic state of the air. So far, we have spoken of the instruments now in common use. But the *air*-thermometer was probably the oldest form; and possesses a scientific superiority over those just described. Theoretical and experimental investigations, connected with the modern dynamical theory of heat she s tnat the equal increments of heat produce almost exactly equal changes of bulk in a nearly perfect gas, such as air, if the pressure to which it is exposed be constant. Hence, temperature, as measured by an air-thermometer, gives a true indication of the quantity of energy present in the form of heat. As the comparison of an air-thermometer with a mercurial one shows that, for temperatures not greater that 300° C., or 572° Fahr., the indications of the two agree very closely,the ordinary mercurial thermometer practically possesses within these limits the same advantage. As the pressure of a gas depends on the amount or heat it contains, the *absolute zero* of temperature, or the temperature of a body wholly deprived of heat, may be determined by finding the temperature at which a perfect gas would cease to exert pressure. For ordinary temperatures, it is found that air increases in bulk by .3665, and hydrogen by .3668 of its bulk, when heated under constant pressure from 0° to 100° C. Again by Boyle's law, if the air be compressed again, at constant temperature 100° C., to the bulk it had at 0° C., its pressure is increased by .3665 of its former amount. Thus p_o being the pressure at temperature 0° C., p that at t° C., we have,when the volume is kept constant,

$$p \text{ sub } t = p_o (1 + .003665t).$$

If we assume this to hold for all temperatures, p sub t vanishes when

$$1 + .003665t = 0;$$

$$\text{or } t° = -274° \text{ C. very nearly.}$$

That is to say, at 274° C., under the freezing-point of water, a perfect gas ceases to exert pressure on its containing vessel—*i. e.*, is deprived of that thermal energy on which pressure depends. The air-thermometers in common use are affected by the pressure, as well as the temperature of the atmosphere. To avoid this inconvenience, Leslie and Rumford in the present century revived the *differential thermometer* of Sturmius. In this instrument,in one of its common forms, a bulb is blown at *each* end of the tube (which is bent into a U-form), and the liquid in the stem is used merely as an index, both balls being full of air. The length of the column of fluid is usually adjusted so that it can just fill one of the vertical arms and the horizontal portion of the tube; and the quantities of air in the two balls are so adjusted that the column will take this position *when the two balls are at the same temperature.* If the one ball be heated more than the other the liquid index will take a new position, and this is read off by a scale applied to either of the vertical arms. The graduation of this instrument may be effected by calculation, but it is usually done experimentally. Leslie made good use of it in his investigations on heat; and,with various adjuncts,such as coloring the glass of one ball while that of the other was left white; silvering or gilding one of the balls; covering one of them with moist silk or linen, etc., this instrument became in his hands a *photometer*, an *aethrioscope*, a *hygrometer*, etc. To thermometers which depend for their action on the expansion of solids, the name PYROMETER is frequently given; but that of Breguet, as delicate as a good ordinary mercurial thermometer, is not alluded to in that article. The principle of this very beautiful instrument may easily be explained thus. In bending a slip of wood, the fibers on the convex side are necessarily more extended than those toward the concave side. Conversely, if the fibers on one side of a slip of wood were to expand more than those on the other, the slip would bend. Bréguet solders together two thin strips of gold and platinum, or platinum and silver; for portability and concentration bends the compound strip into a helix, fixes its upper end, and attaches a horizontal index to the lower end. The least change of temperature in the surrounding air changes the length of one side of the compound slip more than the other, and the helix twists or untwists through an angle very nearly proportional to the change of temperature. Referring to the drawings, Fig. 2, shows Sixe's self-registering maximum and minimum thermometer. This beautiful and very ingenious instrument consists of a long cylindrical bulb, united to a tube of more than twice its length, bent round each side of it in the form of a syphon, and terminating in a smaller oval-shaped bulb. This bulb and part of the connecting tube are partly filled with pure spirit; the lower part of the syphon is filled with mercury, and the remainder of the tube and the long bulb are completely filled with spirit. A steel-index,with hair-spring, moves in the spirit, in each arm, above the mercury. The action of the instrument is as follows: As the temperature increases, the spirit in the long bulb expands, forcing the mercury to rise in the right

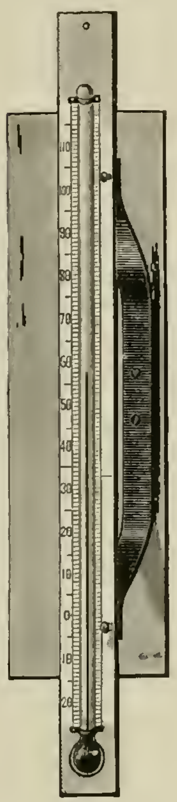


Fig. 1.

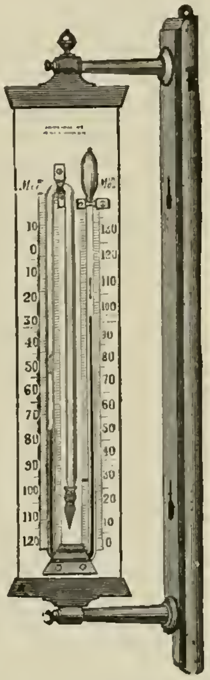


Fig. 2.

Fig. 3.

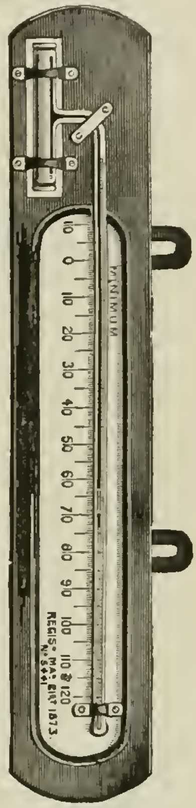


Fig. 4.

tube, where it also rises by its own expansion As it thus advances the index is driven before and left at the highest point. As the temperature decreases, the mercury recedes, driving the index point in the left-hand tube before it, and leaving it at the coldest point. The left-hand tube is, therefore, graduated from zero at the top downward, while the right-hand scale is an ascending one, ranging from zero at the bottom to 130 at the top. The instrument is set by drawing the indices down into contact with the mercury by means of a small magnet which is passed down the outside of the tubes. When compared with standard instruments, and properly made, these are admirable thermometers, and are highly recommended for general observations. Fig. 3, shows Phillip's maximum thermometer. It consists of a tube arranged in a horizontal position, and having a small portion of air introduced so as to cut off about half an inch of mercury from the end of the column. An increase of temperature pushes the detached mercury forward, where it is left on the contraction of the column of mercury, thus showing the highest point reached. The instrument is set by turning it bulb downward, when the detached mercury falls back into position by force of gravity. When well made this forms a serviceable and accurate instrument, the self-registering clinical thermometers, now so universally used, being made on this principle. Fig. 4, shows Rutherford's minimum thermometer. It consists of a glass tube arranged horizontally, and filled in the usual manner, but with alcohol instead of mercury, a black glass index moving freely *in* the fluid. The instrument is set by raising the bulb and allowing the index to float to the end of the column of alcohol. As the temperature decreases, the column recedes carrying with it the index to the lowest point, where it remains, while on an increase of temperature, the alcohol alone reascends. The end of the index farthest from the bulb shows the lowest temperatnre re-reached. Fig. 5, shows the Signal Service thermo-

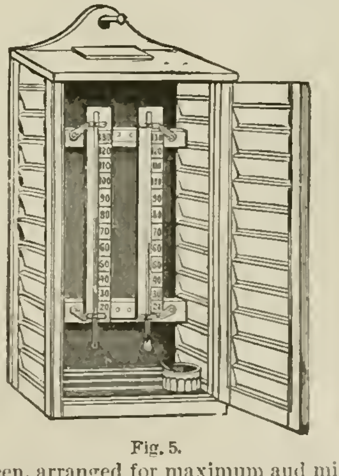


Fig. 5.

meter screen, arranged for maximum and minimum, thermometers, with lowered sides, permitting free access of air. See *Hypsometrical Thermometer*.

THIERY HOOPED GUN.—Experience shows that the rupture of guns commonly takes place following planes passing through the vent, and that the fragments are projected in the rear and laterally, following the inclination of these planes with respect to the axis of the piece.

Hoops of wrought-iron placed transversely upon the reinforce would prevent lateral explosions: but it happens sufficiently often that the rupture taking effect through many planes, cutting through the vent, the breech is found separated and projected in the rear.

In this case it should be feared that the transverse hoops, torn away with the breech, would be dispersed, and would add themselves to the number of fragments. To obviate this defect, in order that under all circumstances the fragments of the burst gun should remain together and be contained in the envelope of wrought-iron, it is evidently necessary that all the parts of this envelope should be bound together with sufficient strength to resist rupture in the longitudinal direction. In consequence, Thiéry conceived the plan of composing the wrought-iron envelope: 1st. Of a longitudinal armature extending from the platband of the breech to about 4.8 inches beyond the trunnions. 2nd. Of transverse hoops, placed side by side, from the trunnions to the platband of the breech formed by the last of them.

This envelope of wrought-iron has some analogy to the pieces of ordnance of wrought-iron constructed at the origin of artillery, and by means of which they fired the enormous bullets of which history makes mention. Those gigantic culverins were composed of longitudinal bars of wrought-iron placed in the manner of staves, and secured together by transverse hoops of wrought-iron.

THILLER.—The horse which goes between the shafts, and supports them; also, the last horse in a team. Commonly written *thill-horse.*

THIMBLE.—An iron ring attached to the end of drag-ropes, siege and field. The thimble is firmly secured in its place by a spliced eye of rope surrounding its outer circumference.

THIRTEEN-INCH SEA-COAST MORTAR.—A cast-iron smooth-bore mortar used in the United States service, and without chamber. The following are the principal weights and dimensions of the piece (eccentric axle): Weight of piece, 17,120 lbs.; preponderance, *nil;* extreme length, 51.5 in.; length of bore, 35.1 in.; windage, 0.13 in.; charge (maximum), mortar powder, 20 lbs.; weight of shell (empty), 216 lbs.; charge to fill shell, 11 lbs.; charge to blow out fuse-plug, 0.3 lbs.; weight of carriage, 4,140 lbs. The mortar is fired from a wooden platform.

The carriage is of wrought-iron, and, being without chassis, rests directly upon the platform. An axle carrying at each of its extremities a truck wheel, passes through the carriage near the front end; this axle is eccentric, and when thrown in gear the truck-wheel, rest upon the platform; only the rear part of the shoe then rests on the platform and moves with sliding friction. Two steps are placed on the front part of the carriage for convenience in loading.

The thirteen-inch mortar (center-pintle carriage) differs from the above only in the method of mounting. Both have the same carriage, but instead of the carriage resting directly on the platform, as in the first, the carriage for the center pintle is mounted on a chassis itself resting on the platform. The chassis is attached at its center to the platform by a pintle, and traverses upon iron circles in the manner usual for this class of carriages. In addition to the eccentric axle at the middle of the chassis, for throwing it in and out of gear, there is another axle, also eccentric, carrying a traverse-wheel which works between the parts of a double transom on the front end of the chassis. This wheel communicates motion to the chassis. A crane is attached to the left cheek for hoisting the shell to the muzzle. The chassis has an inclination to the rear of three degrees; it is made of wrought-iron, and weighs 5560 pounds. See *Mortar.*

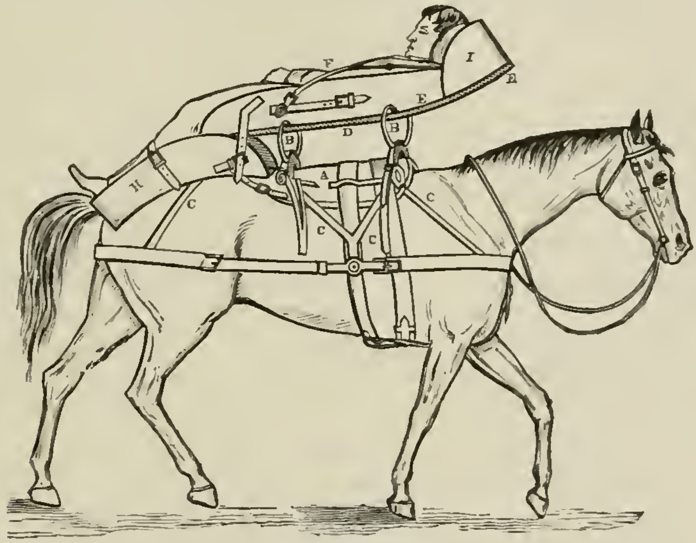
THIRTY TYRANTS AT ATHENS.—A body of Rulers invested with sovereign power after the close of the Peloponnesian war. They were all native Athenians, but members of the aristocratic party, and chosen by the Spartan Conquerors, who, knowing the animosity existing between the Democracy and Oligarchy of Athens, hoped to rule the city through the agency of the latter. Their Government was a positive "Reign of Terror," and marked by the most infamous cruelties. Even Mitford, with all his hatred of democracy, speaks of the "shamelessness of crime" as surpassing all that had previously occurred in Grecian history. It lasted only one year, when it was overthrown by the return of the Athenian Exiles under Thrasybulus.

THIRTY TYRANTS OF ROME. The collective title given to a set of military usurpers who sprung up in different parts of the Empire during the 15 years (253-68 A. D. occupied by the reigns of Valerian and Gallienus, and amid the wretched confusions of the time, endeavored to establish themselves as Independent Princes. The name is borrowed from the Thirty Tyrants at Athens, but, in reality, historians can only reckon nineteen—Cyriades, Macrianus, Balista, Odenathus, and Zenobia, *in the East;* Postumus, Lollianus, Victorinus and his mother Victoria, Marius, and Tetricus, *in the West;* Ingenuus, Regillianus, and Aureolus, in Illyricum and the countries about the Danube; Saturninus, in Pontus; Trebellianus, in Isauria; Piso, in Thessaly; Valens, in Achaia; Æmilianus, in Egypt; and Celsus, in Africa. See Niebuhr's *Lectures on Roman History*, and Gibbon's *Decline and Fall of the Roman Empire.*

THISTLE.—The Order of the Thistle, called also the Order of St. Andrew, is of no very ancient date. The earliest-known mention of the thistle as the national badge of Scotland is in the inventory of the effects of James III., who probably adopted it as an appropriate illustration of the royal motto, *In defense.* Thistles occur on the coins of James IV., Mary, James V., and James VI.; and on those of James VI. they are for the first time accompanied by the motto, *Nemo me impune lacesset.* A collar of thistles appears on the gold bonnet-pieces of James V. of 1539; and the royal ensigns, as depicted in Sir David Lindsay's armorial register of 1542, are surrounded by a collar formed entirely of gold thistles, with an oval badge attached. This collar, however, was a mere device until the institution, or, as it is generally but inaccurately called, the revival of the Order of the Thistle by James VII. (II. of England), which took place on May 29, 1687. Statutes were issued, and eight knights nominated by James; but the patent for the institution of the Order never passed the great seal. After falling entirely into abeyance during the reign of William and Mary, the Order was revived by Queen Anne, Dec. 31, 1703. See *Andrew.*

THISTLE LITTER.—During the Florida campaign, Captain H. L. Thistle, of the Louisiana Volunteers, devised a single litter horse conveyance, designed for the transport of wounded men through the narrowest defiles, or over the most encumbered and difficult ground. The drawing, copied from that filed with the application of the patentee, shows the construction and manner of using the litter. The litter, resting on the springs, B,B, is firmly attached to the saddle, A., which is kept in place on the horse's back by the gearing, C,C,C,C. The head-board, I, and foot-board, H, being adjusted, as shown in the drawing, the patient is placed on the litter and secured by the diagonal straps, F, and a strap over the legs. When not in use it may be folded, so as to occupy but little space, and may be removed from the saddle, A, which may then be used as an ordinary pack-saddle. This litter has been highly endorsed by American officers, who have produced it to meet the exigencies accompanying Indian warfare. See *Litter.*

THOMAS GUN.—1. A breech-loading small-arm, having a fixed chamber closed by a movable breech-block, which rotates about a horizontal axis at 90° to the axis of the barrel, lying below the axis of the barrel and in front, being moved from above by a thumb-piece. The piece is opened by bringing the hammer to the full-cock and drawing back the breech-block by its thumb-piece; as it descends it retracts the firing-pin by the action of a hammer-stop lever on the projecting head of the retractor, the notched body of which engages with a notch on the firing-pin, and it also presses down one end of the friction-lever, the other end of which locks the sear and keeps the hammer from falling until the breech is closed. It is closed by reversing the movement of the block. The mechanism is such that the block is



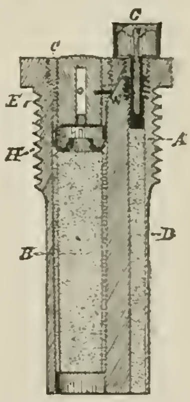
Thistle Litter.

well secured against the effect of any accidental discharge in closing, and is afterward more completely locked by the descent of the hammer beneath the breech-block when the piece is fired. Extraction and ejection are essentially the same as in the Remington rifle. 2. A variety of heavy ordnance rolled into a tube, from a plate of inch iron. There were 14 or 15 layers of plate forged into a mass over an internal cast-steel tube. Over the breech were two hoops, 13 inches long by 3 inches thick. The length of the gun was $11\frac{1}{2}$ feet; the total diameter 26 inches. It was rifled with three projecting ribs, $1\frac{1}{2}$ inches wide each, the diameters of the bore being 7 and $6\frac{1}{4}$ inches. The gun burst with a $27\frac{1}{2}$ pound charge and a 138 pound shot.

THOMAS PROJECTILE.—This projectile closely resembles the Hotchkiss. The lead is forced into the grooves by a sliding ring instead of a cap. The particulars of the rifling and projectile are as follows:—Pitch of rifling, one turn in 18 feet; number of grooves (flat, square-cornered), 7: width of grooves, 1.8 inches; depth of grooves $\frac{1}{10}$ inch; weight of shell 55 pounds; length, 10.2 inches; diameter 6.3 inches; diameter of powder-chamber, 3.2 inches; bursting charge, 1 pound $5\frac{1}{4}$ ounces; charge, 7 pounds.

THOMAS RIFLING.—This system originally resembled the Hotchkiss expansion system. But later, the rifling consisted merely in leaving three or more very narrow lands and the same number of very wide grooves in the gun. Projections were planed in the shot to correspond with the lands. At first sight this system closely resembled the *centrical* system, except that the grooves are made in the shot and the projections in the gun. But it will be observed that the centrical grooves are so rounded as to *gradually* lift the shot and hold it in the center of the bore, and that spherical shot cannot be fired from a *Thomas* gun without injuring the three narrow lands, and without some strong and cumbrous arrangement to stop the excessive windage. The lands are also in the way of loading the powder easily and rapidly.

THOMPSON COMBINATION-FUSE.—The time and percussion arrangement of this fuse are entirely independent of each other, the metal stock, A, being bored throughout its length on one side conically for the time-fuse, B, and on the other cylindrically for the percussion device. The time-fuse is ignited by a plunger, E, which forms part of, and is secured to, the screw-cap, C, by a brittle wire, W, the lower end of this plunger being slightly recessed to receive a fulminate wafer, H. The inner end of cap arrangement is turned under, forming a hollow cone. The percussion device or friction primer, G, consists of a brass tube, filled with friction composition pressed around a flat brass wire having serrated edges, the outer end of the wire being secured to a cylinder of thin brass which projects beyond the fuse-stock. The friction primer is provided with a screw-thread to secure it to the stock, and the channel, *D*, into which it is screwed, is filled with quick-burning powder. The action of the fuse is as follows:—The shock of discharge frees the plunger, which, being thrown violently back, the fulminate, *H*, is ignited on the cone, setting fire to the time-fuse. Should the projectile strike before the burning out of the time-fuse, the wire in the projecting primer, *G*, is driven through the friction composition, and the powder in the channel, *D*, is ignited, the flame from which communicates directly with the powder-charge. See *Fuse*.



THOMPSON GUN.—This breech-loading rifle consists of a cast-iron body, A, of the usual Rodman model, embracing, by light shrinkage, a steel tube, B, of uniform thickness, which extends throughout the bore, and is secured in position by a screw-thread at the breech-end. The rear end of the tube is smoothly-faced, and abuts against the breech-block. The breech-block C works in a slot in the cast-iron casing at right angles to the bore; it is circular in cross-section, and is rolled laterally to and fro into position for loading and for firing, a portion of its cylindrical surface being cut into cogs which fit into a toothed rack, laid horizontally upon the floor of the slot. Power is applied by means of a lever, which is attached to a shaft or spindle, secured to the center of the breech-block and extending outward through the breech of the gun in the direction of the axis of the bore. As the breech-block is rolled back and forth the spindle also traverses the face of the breech, a slot then being cut for this purpose large enough to allow the requisite space. A toothed disk,attached near the outer end of the spindle and working in a rack below, serves to secure steadiness of motion. The back of the breech-block is faced with a cam, which,as the breech is closed,comes in contact with a corresponding cam on the rear face of the slot, by which means the block is forced forward until its beveled front face is in close contact with the correspondingly-faced end of the tube, and the breech effectually closed. When closed, the breech-block is supported in rear throughout so much of its circumference as is not intersected by the slot in which the spindle moves. The breech-block, the spindle, and the cam upon the face of the slot are of steel.

The rifling of this gun is only provisional,it being proposed that, ultimately, it shall have twenty-one grooves and lands, each of equal width. At present every third groove only is cut, so there are but seven grooves. Width of grooves, 0.9 inches; width of lands,4.5 inches; depth of grooves,0.1 inches; twist, one turn in 70 feet. The chamber at present employed is of two diameters; that of the larger part, or powder-chamber, being equal to the diameter of the bore through the grooves; that of the smaller part, or shot-chamber, being equal to the diameter of the bore across lands, plus the depth of one groove. The length of the powder-chamber is 17.25 inches, commencing at the breech-block; the length of the shot-chamber is 14.72 inches, estimating from the powder-chamber to the rifled portion of the bore. The chamerbs are connected by the appropriate ramp; the junction of the bore and shot-chamber has an inclination of 1 in 8. There is no provision made for a gas-check or for a vent proper,as it was the intention of the inventor to use metallic cartridge-cases, center-primed, discharged by a firing-pin passing through the centers of the breech-block and spindle, and cocked and discharged by a suitable device.

The projectile at present made for this gun is the Butler breech-loading projectile, with double bearings. The front bearing consists of a light ring of soft brass applied to the forward end of the projectile, and of a diameter only 0″.05 in excess of the bore, and is not intended to aid materially in conveying rotation. The rear bearing or rotating device consists of a double-lipped ring, the outer lip of which is flared so as to exceed the diameter of the shot-chamber. The front bearing-band is secured to the projectile by an annular undercut, into which it is "crowded" cold. The sabot in the rear is attached by a screw-thread. The distance from the apex of the front band to the flare of the sabot is such that when the projectile is pushed forward in the chamber, the front and rear bearings shall meet the front and rear ramps of the chamber respectively, and thus cause the projectile to be accurately centered in the operation of loading. Weight of projectile, 600 pounds. It is also intended to experiment with projectiles having grooved copper lands,front and rear,as now used in France and Germany.

The steel tube and breech-block were manufactured by the Bochum Steel Company, Bochum,Prussia. The iron casing was cast and finished at the South Boston foundry,at which place, also, the steel tube was rifled and inserted and the breech-mechanism applied. The gun-casing was cast on the Rodman plan, and cooled from the interior by a current of cold water. Owing, however, to the bulk of the casting and the weight of metal employed—which considerably exceeded any previous demand made upon the resources of the foundry—it was necessary, in the first instance, to strengthen the furnaces, enlarge the gun-pit, provide new flasks for the moulds, and lengthen out the lathes.

The following are the principal dimensions of the gun:—

Exterior diameter of the gun at muzzle	27	inches.
Exterior diameter of the gun 25 inches from muzzle	29.2	inches.
Exterior diameter of the gun 65 inches from muzzle	31.6	inches.
Exterior diameter of the gun 105 inches from muzzle	42.6	inches.
Exterior diameter of the gun at breech	47	inches.
Exterior diameter of the gun at neck	43	inches.
Maximum diameter 41 inches from breech	56	inches.
Diameter of trunnions	15	inches.
Diameter of exterior of steel tube	15.5	inches.
Diameter of powder-chamber	12.30	inches.
Diameter of shot-chamber	12.155	inches.
Diameter of bore	12	inches.
Length of bore, including chambers	192	inches.
Thickness of breech-block in direction of bore	12.4	inches.
Length of breech-block slot across bore	33	inches.
Length of breech-block spindle	29.3	inches.
Length of trunnions	4.5	inches.
Distance between rimbases	56.1	inches.
Diameter of loading chamber through breech	12.5	inches.
Total length of gun	226.32	inches.

Pitch of rifling, one turn in 70 feet.

The carriage provided for this gun is of the general pattern of the 15-inch service-carriage,with such modifications as the dimensions of the gun require. A friction recoil-check is attached. See *Cast-iron Guns*, and *Ordnance*.

THOMPSON INDICATOR.—Not long since, the United States Government being desirous of ascertaining which of the various patterns of indicators in use was the most efficient, with a view to its adoption as the standard for naval service, Engineer-in-Chief William H. Shock, U.S.N., Chief of the Bureau of Steam Engineering of the Navy Department, issued an order directing the Commandant of the Boston Navy Yard to appoint a Board for this purpose. The Board consisted of three officers of the Engineer Corps, who made a most favorable report of the Thompson Indicator. Other indicators, though competent to register the steam action of ordinary throttling engines with considerable accuracy, even at tolerably rapid rotative speed, were found very unsatisfactory when applied to the high speed automatics, in which the changes of pressure to be recorded were very much

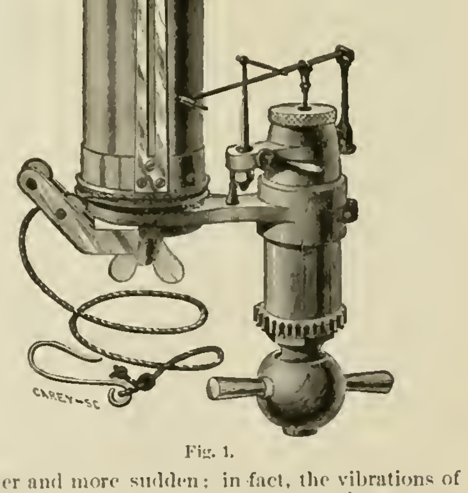


Fig. 1.

greater and more sudden; in fact, the vibrations of the pencil carrying mechanism were at times so excessive as to render the diagrams almost worthless. By means of the improvement in this instrument, the parallel movement is materially simplified, and the disturbing element, momentum of the moving parts, is reduced *fully three-fourths*. Fig. 1 shows the improved Thompson indicator, having a cord-carrying apparatus which receives the cord from the groove of the paper-barrel cylinder. Now, while this may be turned about upon its center by means of a thumb-screw shown below, there are many cases, especially in the very high speed engines, where it must be adjusted at a certain point only, in order to give the barrel a smooth motion; in other words, in practice the indicator user is sometimes brought up with the possibilities of making a proper connection by the lack of facility in this motion; but with the attachment shown in Fig. 2, the pulley is mounted on the end of a stand which slides into a socket-bearing, and this socket is grooved so that the thumb-screw will hold the grooved pulley, as shown, looking downward; the cord is taken from the groove of the paper-barrel cylinder directly through the hole. This attachment can be made by means of the thumb-screw and groove, which is not shown in the engraving, upon the stand which carries the wheel, to form any possible angle within the range of 360°—a complete circle. It is much better than that where the two wheels were used, from the fact that no matter what the angle of reflection may be or the direction that may be necesrary to take the cord from, it will always work smoothly, for the pulley face and the face of the groove on the paper cylinder are always in proper position, one with the other, to take the cord smoothly from the paper cylinder on to the bearing surface of the pulley, and thence to the motion wherever that may be arranged. It is sometimes most important in the high-speed, short-stroke engines to have the greatest possible range of adjustment in this motion; for sometimes considerable trouble is experienced upon engines, running 350 or 360 revolutions, in so arranging the cords as to use independent arcs or connections for each indicator, and at

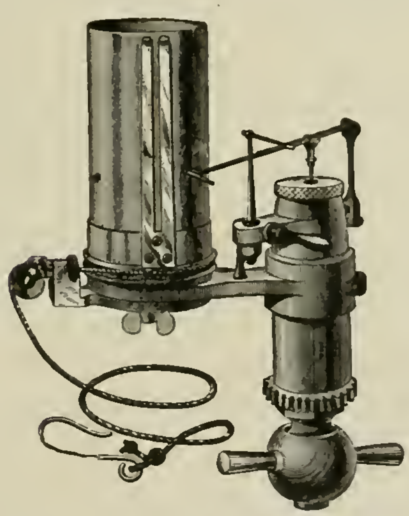


Fig. 2.

the same time make such connections with reference to right lines that no distortion of the diagram should be given. The old arrangement, shown in Fig. 1, did not give the facility which is required in a practical sense, but Fig. 2 will cover every possible or probable obstacle as well as facility of adjustment. This is especially the case where the steam-pipe is in the way, or, as in the case of high-speed electric light engines, where two different arcs can be used by sliding them along the shaft, we can, by moving the stand on the bottom of the indicator by means of a thumb-screw, adjust this to any angle, and then by a simple movement of the pulley to the right or left, over or under as the case may be, we can cover any angle that may be called for, for it will certainly be within 360° somewhere. This combination is a very happy one; mechanically there is no disadvantage, and practically it is a very great improvement. The whole thing is simple, it is put together very nicely, as all the work upon these instruments is now done; it does away with one of the most annoying things that the careful indicator user comes in contact with—the distortion of his diagram by the inability to make a fine adjustment, at a time when perhaps he

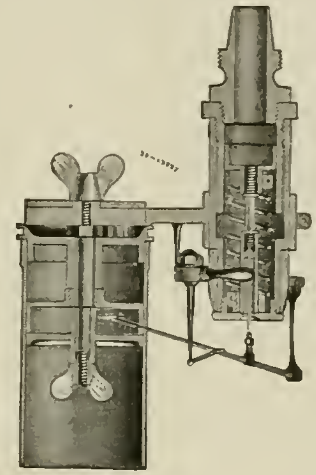
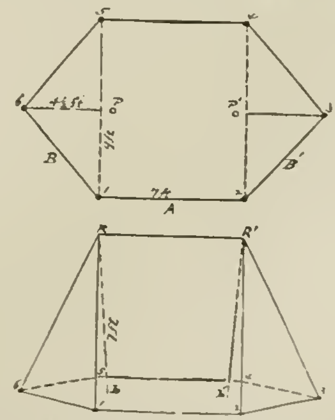


Fig.3.

is lacking a little in patience, may have burned his fingers, or be annoyed still further, or perhaps perplexed by not obtaining the fine adjustment that is necessary to avoid any possible distortion or misconstruction of the lines of his diagram. The pulley, as shown in Fig. 2, works upon a sleeve which rotates in the stand according to the requirements of the position, and which is held in its place where adjusted, by the thumb-screw which acts as a binding screw working in the groove on the sleeve, so that it is held in any position that may be chosen, and yet be free to revolve the moment the binding screw is loosened, without any possibility of interfering with the motion by means of scarring the sleeve or disturbing the particles of metal on its surface, so as to prevent its freedom of motion or its facility of adjustment. Fig. 3 gives an inside view of the indicator, and will serve to fully explain the action of the instrument. See *Indicator*.

THOMPSON TENT.—This tent invented by Gilbert Thompson, United States Army, possesses many advantages over the heavy tents at present used. With



a weight of 24 pounds of canvas (10 oz. duck), it covers over 100 square feet of ground, and is so constructed that one man may easily put it up and take it down. It affords ample accommodation for six men (within the space 1245), with end spaces (165 and 231) sufficiently large to receive a small stove and valuable boxes. It is without annoying guy-ropes, and possesses many advantages of ventilation when any of the sides *B*, *A*, or *B'* are raised and may be so pitched as to expose one of the angular faces 6 *R*, or 3 *R'* to the wind. Another great advantage over the 'A' tent is that it affords a greater *available* space, for the same weight of canvas. The ground plan and the dimensions, also a perspective view of the tent when pitched, are shown in the drawing.

THORAX.—The Roman name for the *cuirass*, modeled so as to conform to the figure of the bust of the wearer.

THOROUGH-PIN.—In a horse, the enlargement between the flexor of the foot and the extensor of the back. It is the result of any over-work, but hardly constitutes unsoundness in a horse. It should be treated as for wind gall.

THREE INCH RIFLE.—This piece used in the United States field-service is made of wrought-iron after a plan invented at the Phœnixville Iron Works, Penn. This plan consists simply in wrapping boiler plate around an iron bar so as to form a cylindrical mass of a certain diameter. The whole is placed in a furnace and brought to welding heat and then passed between rollers to unite it solidly together. The trunnions are afterwards welded, or "jumped" on, and the piece is bored and turned to the proper size and shape. The form of the piece, as shown in the drawing, is the same in general character as that of the Rodman gun. The following are its principal weights, dimensions, etc.: Weight, 820 pounds; diameter of bore, 3 inches; length of bore, 21½ diameters; number of grooves, 7; depth of grooves, 0.075 inch; twist, 11 feet; projectile, weight of, 10 pounds; powder, 1 pound. The projectiles used are shells with time and percussion-fuses, and case and canister shot. Hotchkiss, Schenkle, and Dyer projectiles are all suited to the rifling of this gun. A 3-inch Parrott rifle-gun, using Parrott projectiles, is also employed in the U. S. field service. This is a cast-iron piece reinforced with a band of wrought-iron, similarly to other guns of the Parrott system. See *Field Artillery*.

THROAT.—1. The narrowed space between the flanks of a bastion at their junction with the curtain or between the rear ends of the faces of a *redan*. 2. The narrowed entrance to the neck of a puddling furnace, where the area of flue passage is regulated.

THRONE.—The chair of Royalty, an ornamented seat raised above the level of the floor, on which it stands, often covered with a canopy, and intended for the use of a Sovereign or other Potentate. From an early period the Asiatic Monarchs are represented as enthroned; the same usage of a dignified chair set apart for the Sovereigns was adopted in Greece, where also it was customary to represent all the greater gods, as enthroned. In the Middle Ages and modern times, the throne has been in all Monarchical Countries the chair occupied by the Sovereign on state occasions. The name of throne was also given, in the early centuries of the Christian Church to the raised seat in the middle of the tribune behind the altar, where the Bishop sat surrounded by his Clergy. The throne is now a common metaphorical expression for sovereign power and dignity.

THROUGH VENT.—This vent is screwed in, but has no cone, the bottom being set up into a recess to seal the junction of the copper and iron. The Palliser converted guns have these vents.

THRUSH.—Thrush or trush, in usual form, consists in inflammation and ulceration of the sensative surfaces within the frog, giving rise to a fetid discharge, constituting unsoundness, and usually causing lameness. Want of cleanliness is the chief cause. Daily, when the horse returns to his stable, the foot should be washed out with soap and water, carefully dried, and the fissures filled with mineral tar. If amendment does not speedily ensue, a dressing of calomel should be substituted for the tar several times a week. Ragged or loose portions of the frog may be removed by the knife or scissors.

THRUST.—Hostile attack with any pointed weapon. In bayonet exercise, the thrusts are used after each parry, the object being to reach the adversary before recovering his guard; they are executed at the command *thrust*, given quickly after the command *parry*. They may also be used after the *advance*, the *retire*, the *passades*, and the *volts*. *To thrust in tierce.* Extend both arms, straightening at the same time the right leg, the bayonet at the height of the breast, barrel up, butt in advance of, and to the right of the head, guard at the height of the eyes; the right side covered. *To thrust in quarte.* The same as in *tierce*, covering the left side. *To thrust in seconde.* Same as *tierce;* barrel to the left, the butt under the right forearm, the bayonet aimed below the arms. *To thrust in prime.* Extend the left arm to its full length, straightening at the same time the right knee,, the left arm below the piece, the barrel downward; the position of the right hand the same as in the *parry in prime*. The positions are shown in Figs. 1. 2. 3, and 4. See *Bayonet Exercise*, and *Lunge*.


Fig. 1.


Fig. 2.


Fig. 3.


Fig. 4.

THUD.—The sound of a bullet on hitting the tended object.

THUG.—One of an association of robbers and murderers in India, who practiced murder not by open assault but by stealthy approaches, and from religious motives. They have been nearly exterminated by the British Government.

THUMBIKINS.—An old instrument of torture employed for compressing the thumb, largely made use of by the Inquisition in Spain, and also occasionally used in England when examination by torture was practiced there. The last instance of its application in Britain was in the case of principal Carstairs, on whom this mode of torture was inflicted for an hour and half at Holyrood by the Scottish Privy Council, with the view of obtaining from him confession of the secrets of the Argyll and Monmouth parties, but without effect in producing any disclosures. Also written *thumbscrew*.

THUMB-RING.—A ring fastened to the guard of a dagger or sword for the purpose of receiving the thumb. Double *thumb-rings* are sometimes made, in order to fix the dagger on a staff, or at the end of a lance, to resist cavalry.

THUMB-STALL.—In artillery, a stall of buckskin stuffed with hair, which a cannoneer wears on his thumb to cover the vent while the piece is being sponged and loaded.

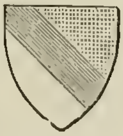
THUNDER BOLT.—In Heraldry, a bearing borrowed from classical mythology, which may be described as a twisted bar in pale inflamed at each end, surmounting two jagged darts in saltire between two wings displayed with streams of fire.

Thunderbolt.

THUNDERING LEGION.—A legion of the Roman Army; it is the subject of a well-known and miraculous legend of Marcus Aurelius's war with the Marcomanni (174 A. D.), his army, according to this narrative, being shut up in a mountainous defile, was reduced to great straits by want of water; when, a body of Christian soldiers having prayed to the God of the Christians, not only was rain sent seasonably to relieve their thirst, but this rain was turned upon the enemy in the shape of a fearful thunder-shower, under cover of which the Romans attacked and utterly routed them. The legion to which these soldiers belonged was thence, according to one of the narrators, called the Thundering Legion. This legend has been the subject of much controversy; and it is certain that the last told circumstance at least is false, as the name "thundering legion" existed long before the date of this story. There would appear, nevertheless, to have been some foundation for the story, however it may have been embellished by the pious zeal of the Christians. The scene is represented on the column of Antoninus. The event is recorded by the pagan historian Dion Cassius, who attributes it to Egyptian sorcerers; and by Capitolinus and Themistius, the latter of whom ascribes it to the prayers of Aurelius himself. It is appealed to by the nearly contemporary Tertullian, in his *Apology*, and is circumstantially related by Eusebius, by Jerome, and Orosius. It may not improbably be conjectured, supposing the substantial truth of the narrative, that the fact of one of the legions being called by the name "Thundering" may have led to the localising of the story, and that it may have, in consequence, been ascribed to this particular legion, which was supposed to have received its name from the circumstance. See *Legion*.

TIERCE.—1. In Heraldry, a term of blazon used to indicate that the field is divided by lines into three equal parts. A shield may be tierce in pale, in fess, in bend, in bend-sinister, or in pall; all which, with other arrangements in tierce, are common in French heraldry. Tierce in pale, in English heraldry, is an occasional mode of marshaling three coats in one escutcheon under special circumstances.

In Pale.



In Bend.

In Pall.

2. A thrust in fencing delivered at the outside of the body over the arm. See *Fencing*.

TIER-SHOT.—Grape-shot are so called when in regular tiers and divided by disks. See *Grape-shot*.

TIESING MAGAZINE-GUN.—This gun belongs to that system in which a fixed chamber is closed by a bolt sliding in line with the axis of the barrel and operated by a lever from below. The breech-bolt is a single piece, to which links are hinged at either side. These links are in turn connected by a knuckle-joint, with others, hinged to the receiver. These links support the bolt when closed, as in firing. The axes of the pivots about which the links rotate, are in line with the axis of the bore. The construction is such that no strain comes on the pivots. The upper rear ends of the forward links lock in the receiver, giving additional support to the bolt. A groove on the inner surface of each rear link receives the end of a pin in the breech-bolt lever; motion of the lever is consequently accompanied by a corresponding motion of the links and, through them, of the bolt. The hammer is cocked by the end of the firing-pin when the lever is thrown open.

The piece is fired by a center-lock of the usual pattern. The magazine, which is in the tip-stock, is loaded through a gate in the side cover of the receiver. The carrier is pivoted at the rear of the receiver. The upper end of the breech-bolt lever is slotted. This slot receives the rear portion of the carrier. When the lever is thrown open the bottom of the slot strikes an arm, rotating the carrier about its hinge, bringing its front opposite the mouth of the magazine. The reverse motion of the lever raises the carrier until its upper surface is parallel to the axis of the bore. No wiping-rod is provided with this gun, and there is no magazine cut-off. As a magazine-gun, 3 motions are necessary to operate it, viz: opened, closed, fired. As a single-loader, 4 motions are necessary, viz: opened, loaded, closed, fired. The gun carries 9 cartridges in the magazine and 1 in the chamber. See *Magazine-gun*.

TIGE MUSKETS.—Rifle-muskets are wholly indebted to the elongated projectile for their efficiency and celebrity. Elongated shot possess, when their axes are coincident with the path they describe, the properties of being less resisted by the air, having longer ranges and greater penetrating power than spherical projectiles of the same diameter. To obviate the difficulty and loss of time in loading ordinary rifles, by forcing the ball into the barrel by repeated blows of the ramrod or a mallet, on account of which that arm had been little used, M. Delvigne proposed that the bullet should have sufficient windage to enter freely into the barrel, in order that, when stopped by the contraction of the chamber with which this arm was furnished, it might be forced to expand and enter into the grooves, on receiving a few smart blows; thus the piece being fired, the bullet would come out a forced, or rifle ball, without having been forced in. But this ingenious contrivance was not found to answer. The edge of the chamber on which the ball lodged, not being opposite to the direction of the blow, did not form a sufficient support upon which to flatten the ball when struck by the ramrod, and thus cause the bullet to expand; whilst portions of the charge of powder previously poured in, having lodged on the contraction, cushioned and still further impeded the expansion of the shot; and as, obviously, no patch could be used, the grooves were liable to get foul, and to become leaded, to an extent which could not be effectually obviated. To remedy this defect, Colonel Thouvenin proposed in 1828 to suppress the chamber, and substitute a cylindrical tige or pillar of steel, screwed into the breech in the center of the barrel, so that the bullet, when stopped by, and resting upon the flat end of the pillar, directly opposite to the side struck, might more easily be flattened and forced to enter the grooves. But here another defect appeared. The pillar occupying a large portion of the center of the barrel, and the charge being placed in the annular space which surrounds it, the main force of the powder, instead of taking effect in the axis of the piece, and on the center of the projectile, acted only on the spherical portion of the bullet which lies over this annular chamber, and thus the ball, receiving obliquely the impulse of the charge, was propelled with diminished force. The next improvement, which was proposed by M. Delvigne, was to make the bottom of the projectile a flat surface; the body cylindrical, and to terminate it in front with a conical point, thus diminishing the resistance of the air comparatively with that experienced by a solid of the same diameter having a hemispherical end. The form of the projectile was, therefore, an approximation to that of Newton's solid of least resistance. In 1841 a patent was obtained by Captain Tamisier for his method of giving steadiness to the flight of cylindro-conical shot, by cutting three sharp grooves each .28 inches deep, on the cylindrical part of the shot, by which the resistance of the air behind the center of gravity of the projectile being increased, the axis of rotation was kept more steadily in the direction of the trajectory; the grooves being to this projectile what the feathers are to the arrow, and the stick to the rocket. But the tige musket having been found inconvenient in cleaning, the pillar liable to be broken, and, after firing some rounds, the operation of ramming down so fatiguing to the men as to make them unsteady in taking aim, M. Minié, previously distinguished as a zealous and able advocate for restoring the rifle to the service in an improved form, proposed to suppress the tige, and substitute for it an iron cup, put into the wider end of a conical hollow, made in the shot; this cup being forced further in by the explosion of the charge, causes the hollow cylindrical portion of the shot to expand and fix itself in the grooves, so that the shot becomes forced at the moment of discharge. A slip of cartridge-paper is wound twice round the cylindrical part of the projectile, so that, as the latter does not become forced or rifled till the charge is fired, it fits so tightly to the barrel as to be free from any motion which would be caused by the carriage of the rifle on a march, or by its being handled before the shot is fired. But unless the cup be driven, by the first action of the explosion of the charge, so far into the conical space in which it is placed, as to cause the lead to enter into the grooves of the rifle before the shot moves, there will be no rotation—the paper wrapped round the shot not sufficing for this purpose. In the experiments of 1850 it was found that the hollow part of the Minié cylindro-conical shot was very frequently separated entirely from the conical part by the force with which the cup was driven into the hollow part of the shot, and sometimes remained so firmly fixed in the barrel that it could not be extracted; but in the more recent trials with shot made by compression and with better lead, no such failure occurred.

TILT.—A thrust, or fight with rapiers; also an old military game. Tilters usually wore *tilting-helmets* of large size, which were placed over the ordinary helmets.

TILTED STEEL.—This variety of steel is simply blistered steel very moderately heated and subjected to the action of a tilt-hammer, by which means its density and tenacity are increased. See *Blistered Steel* and *Steel*.

TIMARIOT.—A Turkish cavalry soldier who has a certain allowance made him, for which amount he is not only obliged to arm, clothe, and accouter himself, but he must likewise provide a certain number of militiamen. The allowance is called *Timar*. This revenue grows out of lands which originally belonged to Christian clergy and nobility, and which the Sultan seized when they conquered the countries they inhabited.

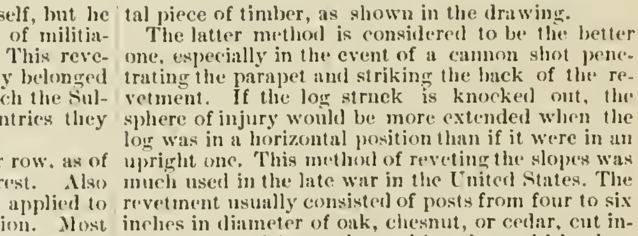
TIMBER.—1. In Heraldry, any rank or row, as of ermine, in a nobleman's coat; also a crest. Also often written *Timbre*. 2. A general term applied to all wood used for purposes of construction. Most of these have been described under their respective names; but the following tabular statement will show the value of some of the leading sorts of Colonial timber which are now beginning to be imported:

Name.	Colony whence Imported.	Breaking Strain of Specimens two in. sq. by twelve in. long.	Specific Gravity.
		lbs.	
Iron-wood...	Jamaica	14,991.2	
Greenheart.	B. Guiana	12,215.6	1.089
Hickory......	N. S. Wales	7,795.4	
Mora..........	B. Guiana	9,700.2	0.922
Water-gum..	N. S. Wales	7,760.1	
Blue-gum....	N. S. Wales	7,167.1	0.843
Bully-tree....	Jamaica	6,724.0	
Purple-heart	B. Guiana	6,393.3	
Locust-tree..	B. Guiana	6,062.7	
Stringy-bark	N. S. Wales	5,795.9	
Cedar.........	Jamaica	3,196.7	
Yacca.........	Jamaica	2,204.6	

The usual rule for measuring round timber is to multiply the length by the square of one-fourth the mean girth, or $\frac{L C^2}{16}$; L being the length of the log, and C half the sum of the circumferences of the two ends.

TIMBER HITCH—One of the knots used in moving or lifting ordnance, bridging, etc. It is made by passing the end of the rope round a spar or piece of timber, leading round the standing part, and passing several turns round itself, then hauling taut. It has this advantage, that, as long as the strain is maintained, it never gives way. It is a good fastening for hauling a carriage out of a difficulty.

TIMBER REVETMENT.—Fascines, gabions, and hurdles are used for revetments when timber is scarce or when there are better uses to which the timber may be applied. Timber is a suitable material, both on account of its comparative durability, and for the ease with which it can be worked into the shapes required. Its scarcity, and its usefulness for other purposes, are the reasons for not employing it more freely for revetments. When abundant, it will be used in preference to any of the other materials for the revetment of interior slopes and scarps. There are two general methods employed in making timber revetments. One method is to place the logs in a horizontal position, piling them in rows one above the other with the proper inclination, and fastening them in place, by pinning the layers together, and by anchoring ties. The other method is to cut the sticks into short lengths and to place them in contact with each other in an upright position, then cap the posts in a very substantial manner, by a horizontal piece of timber, as shown in the drawing.



The latter method is considered to be the better one, especially in the event of a cannon shot penetrating the parapet and striking the back of the revetment. If the log struck is knocked out, the sphere of injury would be more extended when the log was in a horizontal position than if it were in an upright one. This method of reveting the slopes was much used in the late war in the United States. The revetment usually consisted of posts from four to six inches in diameter of oak, chesnut, or cedar, cut into lengths of 5½ feet and set with a slope of $\frac{4}{1}$ in close contact in a trench, at the foot of the breast height, two feet in depth. These were sawed off sixteen inches below the crest and shaped to receive a horizontal capping piece of six-inch timber, hewed or sawed, to a half-round, as shown in the sketch. The lower ends of the posts rested upon a two-inch plank placed in the bottom of the trench. The capping piece was "anchored" in place, by ties notched into logs buried in the parapet. The slope of $\frac{4}{1}$ is steeper than that assumed for the ordinary profile. See *Retrenchment.*

TIMBREL.—A small musical instrument, of the drum species, in use in ancient times, which was carried in the hand, and was apparently not unlike the modern tambourine, with or without bells.

TIME EXPIRED MEN.—Non-commissioned Officers and men, in the English service, whose time of service is expired. On their return from foreign service, they are sent to the Regimental Depot to be discharged.

TIME OF FLIGHT.—In gunnery, the time a projectile takes in describing *any portion* of the trajectory, reckoned from the moment of discharge, or the whole range.

TIME-FUSE.—This fuse is composed of a case of paper, wood, or metal, enclosing a column of burning composition, which is set on fire by the discharge of the piece, and which, after burning a certain time, communicates with the bursting-charge. Its successful operation depends on the certainty of ignition, the uniformity of burning, and the facility with which its flame communicates with the bursting-charge.

The ingredients of all time-fuse compositions are the same as for gunpowder, but the proportions are varied to suit the required rate of burning. Pure, mealed powder gives the quickest composition, and the others are derived from it by the addition of niter of sulphur in certain quantities. The rate of burning of a column of fuse composition depends on the purity and thorough incorporation of the materials, and on its density. These qualities are best secured by procuring the materials from the powder-mills ready mixed and granulated like powder, in which form it is not more liable to deteriorate than powder, and can be preserved for a long time without the possibility of alteration. The compositions used have the appearance of ordinary unglazed cannon powder, but the proportions of the ingredients differ from those composing cannon-powder. By combining these compositions in different proportions and adding small quantities of mealed powder, driving a few fuses and burning them for trial, the several compositions for driving the various fuses are found.

The safety-plugs are made of the softest led wire. This wire is cut into short lengths, and put through moulds to bring them to the proper diameter. They are then put into the plug-making machine, which cuts and forms the lead wire into the proper shape and length for safety-plugs. Before the composition is driven into the case, the safety-plug is inserted with its cavity end in the smaller end of the paper case, and the solid portion of it projecting below the tapering end of the case. A steel punch with a conical shaped end, being introduced into the case and entering the cavity of the safety-plug, is struck a smart blow with a mallet, which forces the soft led out, pressing it hard against the sides of the paper case. The jar of concussion consequent upon the explosion of the charge in the bore is so great as to detach the plug from the case, so that from the moment the shell leaves the gun the communication is open between the burning composition in the fuse and the bursting-charge in the shell, and as soon as the composition is consumed the shell will explode. The paper case is secured in a steel mould or socket, which is made to adjust so closely to the exterior of the case as to sustain it and also protect the safety-plug against the pressure applied in condensing the composition. Two or more of these moulds are placed around the edge of the circular plate carried upon the lower part of the frame, and revolving so as to bring the moulds in turn to the shaft.

The *safety-cap* is a circular leaden patch with a lip attached, cut out of soft sheet-lead that is about .06 of an inch thick. It is punched out with a cutter of the proper shape and dimensions. This patch, with a thin piece of parchment of the same shape and size under it, is put on over the top of the water-cap and driven down into the recess in the head of the fuse-stock with a punch made for the purpose, having the length of the fuse in raised letters on the end, so as to leave this mark on the leaden patch.

For special firing time-fuses may be shortened, by unscrewing the water-cap and backing the paper-case out from the lower end with a drift and mallet; cutting off from the lower end the proportional part required and inserting the upper part in the stock; forcing it down with a few gentle blows with the drift and screwing in the water-cap. It is preferable, however, when circumstances will admit, to take up such distance as will correspond with the time of flight of one of the regulation lengths. In shortening the fuses there is danger of disturbing the column of composition.

For rifle-projectiles, where the flame of the charge is entirely cut off from the fuse, the time-fuses are fitted with a detonating arrangement at the top. This consists of a small hollow cylinder of metal, termed the *igniter*, containing a small quantity of detonating composition, and having a firehole communicating with the fuse-composition. A plunger is suspended in the detonator by means of a wire, and when the gun is fired the suspending-wire is broken, and the plunger coming in contact with the detonating composition explodes it, thus firing the fuse-composition.

The question of a good fuse for all conditions of service is still to be determined. For ordinary firing with smooth-bore projectiles, the service time-fuse, as made for many years past, continues to give good results, but the greatly increased range and time of flight at present obtainable with heavy guns render it desirable to adopt a principle of shell-explosion independent of the time of flight and of the preservation in good order of a long column of composition. See *Bormann-fuse*, *Fuse*, *Mortar-fuse*, and *Sea-coast-fuse.*

TIME SIGNALS.—Signals established in many important cities of England and the United States for the purpose of transmitting standard time by the telegraph. The first use of the system was in 1852, by Mr. C. V. Walker, the English Royal Astronomer. There are now in the United States observatories which perform this service, in Washington, Allegheny, Albany, Cincinnati, Chicago, Cambridge and New Haven. The method now employed is known as the Jones System. In it the clock which furnishes the standard is placed in the same electric current with those to be controlled. In the clock to be regulated is a helix, which alternately encircles two magnets attached to the pendulum, which are alternately attracted and repelled by the helix. In New York and Boston the time of exact noon is indicated by dropping a ball from the flag poles of conspicuous buildings by means of an electric current.

TIME THRUST. In fencing, a thrust given upon any opening which may occur by an inaccurate or wide motion of the adversary, when changing his guard, etc. This accurate and critical throwing in of a cut or thrust upon an opening that may occur is usually called *timing.*

TIN.—A white metal approaching silver in luster. It is found in great abundance in Cornwall and in parts of Europe, in Chili and Mexico, in the peninsula of Malacca, and in the Island of Banca. It is very malleable; it fuses at 442° Fahr., and contracts slightly on consolidation. Its density varies from 7.29 to 7.6, the lightest being the purest metal. It is used as an alloy with copper in forming gun-metal.

TINCTURE. In Heraldry, one of the metals, colors, or furs used in armory. See *Heraldry.*

TIN CUPS.—Cups used with heavy breech-loading guns, which serve, in conjunction with the vent piece, to seal more effectually the powder chamber, and to prevent the escape of gas, which is very destructive to the angular face of the vent piece. The cup is placed between the end of the cartridge and vent-piece. A small hole in it serves both for the passage of the vent fire, and also for the cup being placed in position. There are two sizes of tin cups, the low and high-gauge. Low-gauge cups are only required for guns with iron breech bushes. The cup should be drawn out to the rear by means of a hook.

TINDAL.—An attendant on the army in India.

TINDER.—An inflammable material, usually made of half-burned linen. It was formerly one of the chief means of procuring fire before the introduction of chemical matches. The tinder was made to catch the sparks caused by striking a piece of steel with a flint; and the ignited tinder enabled the operator to light a match dipped in sulphur. This intermediate step was necessary in consequence of the impossibility of making the tinder flame. Partially decayed wood, especially that of willows and other similar trees, also affords tinder; and certain fungi furnish the German tinder, or amadou.

TINKER.—A small mortar, formerly used on the end of a staff, now superseded by the Coehorn.

TIRAILLEURS.—An independent body of marksmen, formerly in the French Army, when few regiments were armed with rifled arms. They were used sometimes in front of the army to annoy the enemy, sometimes in the rear to check his pursuit. The term *tirailleur* is now applied to all troops acting as skirmishers. It appeares that *tirailleurs* were first employed in the American Army.

TIRE.—A band or hoop of iron used to bind the felloes of wheels, to secure them from wearing and breaking. The tire should embrace the *soles* of the felloes uniformly and with a powerful grasp, so that its fiber shall be in a state of tension, compressing proportionately the felloes and spokes. This is secured by shrinking on the tire, after first expanding it by heat; and thus securing an unbroken chain of pressures round the wheel converging to its axis.

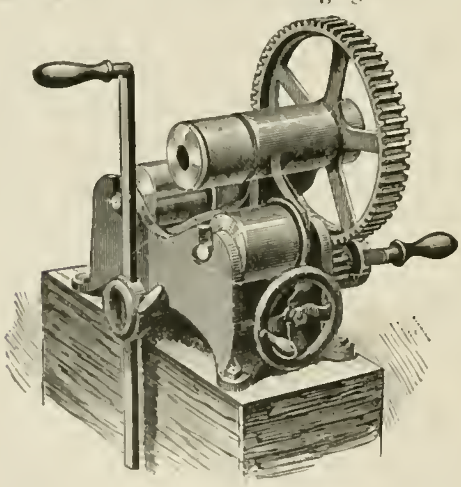


Fig. 1.

The tire should fulfill the following uses: 1. By means of its uniform normal pressure, induced by the tension of its fibers, to protect the spokes against injury from *side thrusts*; to secure this, the cross section of the tire must be so great in area as to preclude any sensible extension of its length when exposed to the tensile strains due to *side thrusts*. 2. To protect the felloe from splits and indentations by stones and other hard substances over which the wheel passes; to distribute the pressures evenly upon the sole of the felloe, and to protect it from being worn down by abrasion. The tire should be neither so broad as to cause excessive grinding action, nor so narrow as to sink deeply into ordinary yielding ground. Fig. 1 represents the tire-bending machine used in arsenals for light and medium work. This machine will bend accurately and easily tires from the lightest to $\frac{5}{8}$ in. thick. The circle to be made is fixed by means of a right and left hand screw, operated by the hand wheel acting equally upon the two lower rollers. The rollers are three inches wide. The upper roller is faced with steel and milled to insure the regular feeding through of the work. It is strongly geared, and two cranks may be used if desired. Weight 140 lbs. Fig. 2 represents the common form of tire shrinker. The tire lies in a properly shaped former, and force being applied to the handle with the left hand, the right hand remains at liberty to use the hammer in keeping the work true and straight—the only safe way of getting a perfect result at a single heat. The cams which grip the work are set by means of levers at the will of the workman, and are

Fig. 2.

instantly withdrawn from the finished tire in the same way. All slipping at starting, and all jamming and sticking after finishing, are thus avoided. In the English Army there are two kinds of tires, viz. the *ring-tire* and the *streak-tire*. The former, which is simply a band of iron fastened on without any break, has been universally used, for years past, in the artillery service in India. In the home service, until very lately, the streak-tire, which is fastened upon the wheel in pieces, and not in one continued ring, was the usual pattern; but the ring-tire is now adopted for all wheels not exceeding 3 inches in breadth. The breadth of field-carriage tires is 3 inches, $\frac{3}{4}$ inch thick; that of siege-carriages, 6 inches, and $\frac{1}{2}$ inch thick. See *Wheel*.

T IRON.—A kind of angle-iron having a flat flange and a web like the T, by which it is called. T-iron is now extensively used for gun-carriages and other ordnance constructions.

TOCSIN.—An alarm drum, formerly used in armies as a signal for charging, on the approach of an enemy.

TODTENORGEL.—An *organ-gun*. One of the earliest of these machines was made at the beginning of the 15th century. It was loaded from the muzzle, and was composed of small wrought-iron cannon rudely mounted on what looked like the trunk of a tree, and moved on two round disks of wood for the wheels.

TOE CALK.—A prong or barb on the toe of a horse's shoe, to prevent slipping on frozen ground.

TOGA.—The principal outer garment of the Romans, and originally, perhaps the only one. Subsequently, an under-garment, the *tunic*, was added. It was probably of Etruscan origin, and yet it came to be considered the distinctive badge of the Roman citizen, whence the Roman people are called *togati*, or *gens togata*; and consequently, when the Cisalpine

Gauls received the rights of citizenship, their country was spoken of as *Gallia togata*, in opposition to transalpine Gaul, or *Gallia braccata* (breeched). At first it was apparently semicircular in shape—so, at least, say Dionysius, Quintilian, and others—but afterward, when it came to be an elaborate and complicated dress, it must have been a smaller segment than a semicircle. The mode of wearing the toga is difficult to describe, and required considerable art to make the folds fall gracefully. The toga was made of woolen cloth, and except in the case of mourners, was of a white color. Accused persons sought to excite sympathy by going about in a soiled (*sordida*) and unsightly toga; while those who were seeking office were wont to dress themselves out in garments which had been made artificially bright by the help of chalk, hence their name of *candidat* (shining ones), candidates. The *toga prætexta* had a broad purple border, and was born by childern, and most though not all of the Magistrates. The *toga picta*, so called from being ornamented with embroidery was worn by Generals when enjoying their "Triumphs." Under the Emperors, the toga, as an article of common wear, fell into disuse, the Greek *pallium* and other garments being used instead; but it continued to be used by officials on solemn or festive occasions.

TOGGEL.—A belaying-pin. Also a small piece of wood fastened to the end of a string or lanyard serving as a hold to grip by. Commonly written *toggle*.

TOISE.—In the ancient French system of measures, the unit of linear dimension. It was divided into 6 feet, each foot (*pied*) into 12 inches, and each inch (*pouce*) into 12 lines (*lignes* or *points*). It is equivalent to 1.94903659 French meters, or to 6.3946 English feet. The *toise* is of frequent use in Fortification and Military Surveying.

TOLEDO.—An esteemed Spanish sword, so called from the place of manufacture.

TOLENON.—An ancient machine of war, having a long lever moving on a pivot, suspended from an upright higher than the rampart, having at one end a box to contain 20 men, who, by drawing down the other end, might be raised high enough to fire into the loop-holes, or even to get upon the wall. Also written *tolleno*.

TOMAHAWK.—A light war-hatchet of the North American Indians. The early ones were rudely made of stone, ingeniously fastened to their handles by animal sinews, or cords of skins. European traders supplied hatchets of steel, the heads of which were made hollow, for a tobacco-pipe; the handle of ash, with the pith removed, being the stem. These hatchets are used in the chase and in battle, not only in close combat, but by being thrown with wonderful skill, so as always to strike the object aimed at with the edge of the instrument. The handles are curiously ornamented. In the figurative language of the Indians, to make peace, is to bury the tomahawk; to make war, is to dig it up.

TOMAN.—In the East Indies, a term signifying 10,000 men.

TOMBAC.—Red brass—an alloy composed of 93 parts of copper and 7 of zinc. The Werndl cartridge case is made of this material.

TOMMY ATKINS.—A familiar term given by soldiers to their pocket ledger or small account book. The origin of this name arose from every document, paper, etc., being headed for convenience sake, "I, Tommy Atkins," etc.

TOMPION.—1. A plug fitted to the bore of a gun, at the muzzle to protect it from injury by the weather. 2. The iron bottom of a charge of grape-shot.

TOM-TOM.—The form of *kettle-drum* used by the Chinese, Hindoos, and Cingalese. The bowl is of sonorous bronze, and the head is of parchment. It is usually beaten by the hand, and resembles the *darabooka* of Ancient and Modern Egypt, which is in use under allied names throughout the Arabic tribes. The *tom-tom* is, however, placed on the ground, while the *darabooka* has a handle by which it is grasped by the *left* hand, being played by the *right* hand. The *darabooka* is thus a connecting link between the *drum* proper and the *tambourine*. It is perhaps more generally called *tam-tam*. The *tom-tom* is the original kettle-drum, and in some shape is found among most nations, savage and comparatively civilized.

TONGS.—To pick up any shot which may fall upon the ground, iron tongs, joined to wooden handles, are used. They consist of two arms joined by a pivot, each arm at its lower end being fastened to a semi-circular piece, which clasp firmly under the shot when the handles are closed.

TONGUE.—That part of the blade of a sword on which the grip, shell, and pummel are fixed. The bayonet is figuratively called a triangular tongue, from its shape.

TONNAGE.—The amount of space that stores take up on board ship, which is calculated either by the weight or by cubic measure, a ton consisting generally of 40 cubic feet; but metals and very heavy articles are estimated by actual weight, without reference to bulk. The following is the mode of taking the tonnage of a gun-carriage, which is equally applicable to any other article. The movable parts such as the wheels, shafts, etc., are taken off, and the body of the carriage laid upon the ground, right side up, or otherwise, as may be most convenient. The length of the longest part is then measured, as a guide for the least length of space which the carriage can occupy, and the width of the widest part for the least width. These dimensions give the size of the rectangular base, upon which the body and the other portions are packed as closely as may be convenient. When packed the greatest height in feet, multiplied by the length and breadth of the base in feet, gives the number of cubic feet occupied by the carriage, and the product divided by 40 gives the tonnage.

TONNELON.—An ancient drawbridge, used nearly in the same manner and for similar purposes as the *harpe* and *exostre*.

TOOKSWORDS.—In India, the Vizier's body of Cavalry.

TOPEKHANA.—In India, the place where guns are kept; an arsenal.

TOPEYS.—Turkish artillerymen or gunners. Also written Topgis.

TOPGI-BACHI.—The Master-General of the Turkish artillery.

TOPIKHANNAH.—In India, a house for keeping guns; an arsenal or armory.

TOPOGRAPHICAL DEPARTMENT.—A Department of the English War Office under the Director of Surveyors, who is an Officer of the Royal Engineers. It comprises the Ordnance Survey, which includes the various National Surveys and the Topographical Depot, the collection of maps, plans, descriptive books, and journals of Staff Officers from all parts of the globe. The Officers of the Topographical Depot keep themselves informed, up to the latest date, on all matters pertaining to their Department, so that, on an army taking the field, the General may at once be put in possession of all information about the country to be invaded or occupied.

TOPOGRAPHICAL ENGINEERS.—The duties of this Corps consist in surveys for the defense of the frontiers, and of positions for fortifications, in reconnaissances of the country through which an army has to pass, or in which it has to operate; in the examination of all routes of communication by land or by water, both for supplies and military movements; in the construction of military roads and of permanent bridges connected with them; and the charge of the construction of all civil works, authorized by Acts of Congress, not specially assigned by law to some other branch of the Service. The United States Corps of Topographical Engineers was merged into the Corps of Engineers in 1863.

TOPOGRAPHICAL RECONNAISSANCE. This very important sudy is not confined to all Military Colleges and the Staff, but also practiced by officers of every branch of the service, so as to enable them to perform in an efficient manner the duties of flanking parties, of detachments, and of outposts.

A topographical reconnaissance will consist of a sketch of the ground, accompanied by a written report. Want of time and the presence of the enemy, may prevent an officer from doing more than making a rapid examination of the country or object he is ordered to reconnoiter. In this case a written report without a sketch may prove of great value. Certain qualifications are necessary to be possessed by officers sent on reconnoitering duties, such as a facility in sketching, in judging distances correctly by the eye, by their own pace, and that of their horses. A knowledge of the language of the country reconnoitered, of fortifications, as well as the habit of observing ground with reference to military operations, are most useful.

In reconnoitering, the following general notes and observations should be made:

Roads.—These should be examined and described mile by mile, and a report made upon them as to their width, their fitness for cavalry, infantry, and artillery; whether they are likely to become impassable in bad weather; whether easily repairable, and whether materials for mending them exist near at hand, and of what kind: their contraction, such as fords, bridges, and defiles; width, material, and strength of the bridges; the means of defending the passage over them. The names of the towns, villages, and single houses along the road; the cross- and by-roads, and the distance to the towns, villages, and private houses they lead to.

Rivers and streams.—Their sources and their general direction; their breadth, depth, nature of their bottoms, banks, and beds; whether navigable, and by what description of vessels; the quality of their water, and the variations to which they are subject at certain seasons; the number of fords, their quality, capacity, and possibility of improvement; the nature of the ground within cannon-shot of each bank. The bridges; the material used in their construction; their length and breadth; whether accessible to artillery and capable of sustaining its weight; the best method of destroying, and what material at hand to repair them if destroyed; the best position for defending them and works to defend them. The ferries; their length and nature, and landing place on each side; the number and nature of boats used; the number of men and horses that can be transported at each trip.

Canals.—Their course and breadth; the nature of the traffic carried on by them; the number of boats and their capacity; the number of locks, and how they can be destroyed or repaired.

Fords.—When and where passable; nature of their bottoms, whether sand, clay, rock, or gravel; notice landmarks, depths, fluctuations. Describe the roads and approaches to the fords; best position for defending them, and what works to be constructed to cover them; how they can be improved, and how to be obstructed.

Marshes, lakes and ponds.—Their situation and extent, boundaries, navigation, landing-places. The method and means of crossing them; how fed by water; if dry at certain seasons; their general character.

Inundations.—Their cause, and means of traversing them; or, if impassable, what are the shortest routes round them.

Mountains and hills.—What parts of the country are mountainous, hilly, or undulating; whether the hills are steep or broken by rocks, or if their ascent is is gradual. Their roads, passes, and paths; whether practicable to artillery, cavalry, or infantry. The best way of defending them; the works that will be required to improve them; the supplies to be obtained. The nature of the valleys and ravines; their breadth, and whether easy or difficult of passage.

Defiles.—Note their length and their nature; how they can be occupied and defended in case of retreat. Whether they can be attacked or turned.

Forests and woods.—What roads pass through them; their extent and their capacity for troops; whether they are an advantage or hindrance to attack or defense. The kind of trees composing them; whether adapted for abatis, entanglement, or for telegraphic purposes; if far apart, permitting cavalry to penetrate, or thick and difficult to traverse. Single trees should be noted, or other conspicuous objects to give direction to columns.

Towns and villages.—Their size; whether fortified or open, the number of houses and inhabitants; what supplies can be obtained. The description of houses and the number of troops which can be accommodated; what stabling or other cover for horses; the best means to place them in a state of defense if attacked; whether healthy or unhealthy at particular seasons and the cause; the supply of water; the number of carriages, horses, mules, and draught oxen; of bakeries, butchers' shops, mills, and forges.

Detached houses.—How they are built; of what materials their roofs; if well supplied with forage and provisions; their defensible capacities; whether easily burnt.

Railways.—Their direction, length, and gauge; their construction as regards the country through which they pass; tunnels, cuts, and viaducts; their breadth and length and depth. Whether they consist of double or single lines; description of rails used, and how secured. The number, size, and situation of stations; the means they afford in transporting troops and material; the quantity of rolling stock they possess (locomotives, carriages, trucks, etc.), their adaptation to transport, and the best means of destroying them.

Positions should be reconnoitered with a view to their military occupation, and, in doing so, the number and description of troops necessary to occupy them, as well as their distribution, according to the features presented by the positions, should be taken into account. No rigid rules can be laid down upon this point; but the depth of the position, the obstacles, such as rivers, morasses, etc., whether in rear, front, or flanks, the means of strengthening them, the key or keys, and lines of communication should be considered.

These principles apply equally to the selection of sites for encamping grounds; the supply of water and means of transport should be noted; the space required, the best position for headquarters and outposts, as well as its sanitary condition.

In reconnoitering a fortified post or village, all obstacles that may impede the march of the attacking force should be observed and reported upon.

Fences.—Their use as defenses, and how they may be levelled.

Slopes.—Whether all arms can move up and down them; whether cavalry, after ascending, will be in a condition to charge.

Districts.—It should be observed what parts are mountainous, hilly or flat; nature of hills, direction of chief ridges; extent of their valleys and ravines; whether the country is barren or cultivated; by what cattle and in what numbers it is grazed; what parts are open, and what parts are enclosed; the nature of enclosures and of the soil; what parts are suitable for cavalry, infantry, and artillery; care should also be taken to observe the geology, botany, and climate.

The general features of the district should be considered with reference to their bearing upon any plan of campaign which may be denoted in the instructions as being under consideration. The best positions to be occupied with a view to the operations of the campaign should be pointed out and described, and a sketch of them should be annexed to the report. The lines of operation, either covered or impeded by them, as well as any positions favorable to the enemy, should be noticed.

Reconnaissances can be made daily from outposts by Officers commanding pickets. These, with a few men, can creep up to commanding points near the enemy's position for the purpose of seeing what he is about. An easy mode of finding out whether a village is occupied by the enemy or not, is by sending a party of horsemen at full gallop through the main street. If occupied, the enemy will fire, and, if not, the party will pass unmolested, and thus the information be obtained.

Balloons afford effective means of learning the whereabouts and doings of an enemy.

Before disembarking troops on the enemy's shore, in order to select a good spot for that purpose, a reconnaissance should be made by the naval and military officers. See *Strategy*.

TOPOGRAPHY.—Among the first necessities of a Military Commander is a thorough knowledge of the physical conformation, the obstacles, and the resources of the country in which he has to operate. It frequently happens that the field of warfare is one of which no careful survey is procurable. It devolves, then, on the Officers of the Staff to make their Chief acquainted with all the particulars he requires; hence, topographical drawing is made a principal ingredient in the course of study at all Military Colleges. These surveys in England devolve on the Quartermaster General's Department. An Officer of this service is expected to traverse a country with rapidity, to measure distances by eye or intuition, to note them roughly down as he rides, to obtain a rough knowledge of hills and valleys, of roads and ravines, rivers and the means of crossing them. He must at the same time make himself acquainted with the means of sustenance produced by the country, with the feelings of the people—whether friendly or hostile—with the transport which can be drawn from the villager, with the position and strength of fortified places, and, in short, with every particular which can be of service to the Commandant. His reconnaissance finished, not without fatigue and danger, he is expected to sit down and produce an eye-map, or a full report of all he has seen and heard. See *Topographical Reconnaissance*.

TORCE.—In Heraldry, a garland of twisted silk, by which the crest is joined to the helmet. A crest is always understood to be placed on a torce, unless where it is expressly stated to issue out of a coronet or chapeau. Also written *Torse*.

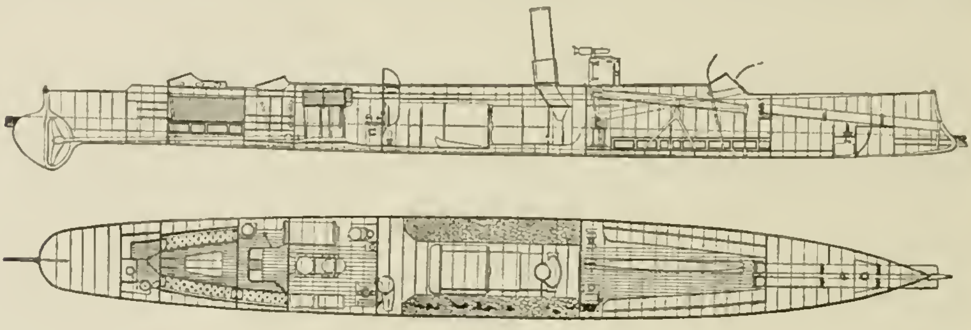
TORCHES.—Torches are made of a number of strands of twine slightly twisted, or old rope, covered with a composition to give light. The following materials are required in the manufacture:—*Hemp-twine*, slightly twisted; about 0.08 inch diameter; *cartridge-thread; mutton-tallow; yellow wax; rosin; glue; quicklime.* To prepare torches, melt in a pot, 1 part of tallow, 2 of yellow wax, and 8 of rosin, stirring it with spatulas. The twine is formed in hanks of about 40 threads, 3 feet long, cut at one end, and tied with twine, forming a handle at the other. The hanks are immersed for 10 minutes in the composition, and then drawn through a mould of a proper size. They are suspended by the handle in a shady place to harden; 24 hours after, they are painted over with a warm solution of a half pound of quicklime and ¾ of an ounce of glue to a quart of water.

With old rope, boil the rope, well beaten and untwisted, in a solution of equal parts of niter and water; when dry, cut it in pieces 4 feet long; tie three or four of these pieces around a piece of pine wood, 2 inches in diameter and 4 feet long; cover the whole with a mixture of equal parts of sulphur and mealed powder, moistened with brandy; fill the intervals between the cords with a paste of 3 parts of sulphur and 1 of quicklime. When it is dry, cover the whole torch with the following composition: *Pitch*, 3parts; *Venice turpentine*, 3 parts; *turpentine*, ½ part. See *Fireworks*.

TORMENTUM.—A war engine of the Middle Ages, to shoot large stones, balls, or, pieces of rock. Authors of the 15th and 16th centuries have drawn a large number of these machines, but so varied in their construction as to appear productions of fancy rather than copies from any real objects. The term is sometimes applied to a pistol, a gun, or a piece of ordnance; but the *tormentum* is nothing more than the catapult.

TORPEDO BOATS.—The problem of constructing small vessels of high speed, and arming them with an efficient equipment for offensive torpedo operations, has long since passed the experimental stage, and Naval Officers now have at their disposal vessels of small size capable of outstripping and in favorable circumstances of destroying the fastest and most powerful fighting ships of the day. The great services rendered in the American civil war with ordinary steam launches and very inefficient torpedoes showed the immense value of this system of warfare, and maritime nations were not slow to appreciate the importance of the more recent advances in mechanical science, which ultimately gave them the Thornycroft torpedo boat and the Whitehead torpedo. As a consequence, all the great European Powers are now more or less fully supplied with torpedo boats, varying in efficiency from the simple Norwegian torpedo boat of ten years ago with its towing torpedo, to the Italian and Danish first-class boats of to-day with their Whitehead torpedoes and Nordenfelt or Hotchkiss machine-guns. The towing and spar torpedoes, owing to the improvement in machine-guns, are now rarely fitted except as an alternative armament, as only under the most favorable conditions would it be possible to approach sufficiently near to a vessel to use them under the terrible hail of missiles which could be kept up by her machine-guns. The result is that at present nearly all the torpedo boats under construction are to be armed with the Whitehead torpedo, and nearly all of them are to have in addition machine-guns to enable them to fight other boats, and to distract the attention of the guns' crews of any ship they may have to attack. As a consequence of the conditions under which torpedo boats are intended to be used, all the various types have gradually been resolved into two distinct groups, viz. those attached to and carried by large vessels, and those sufficiently large to act independently, and to a certain extent to keep the sea. These two groups have been named by the English Admiralty the second and first class groups, respectively. The second-class boats are intended to be used as auxiliaries to the ships to which they may be attached, and the first-class for harbor and coast defense. The second-class boat is fitted with davits and discharging frames, so arranged that when the davits are inboard the frames with the torpedoes in them may be carefully housed on deck, and when the davits are brought forward, the frames, by means of a system of parallel motion, are not only lowered over the side, but are kept close to it, so as not to effect injuriously the stability of the boat. When in the firing position, the discharging frame is parallel to the center line of the boat and 2 feet below the surface of the water, with the forward end slightly inclined downward, so as to facilitate the egress of the torpedo. In this system no external impulse is given to the torpedo, which is set in motion by the action of its own engine, the pulling of a lanyard liberating the torpedo and then starting its engine. There are a good many objections to the frame-and-davit discharging gear, such, for example, as the great resistance offered by the frames and torpedoes when in the discharging position, and the necessity of reducing the speed of the boat to about three knots before firing. Hence, in 1880, the Admiralty considered the possibility of carrying the torpedoes in troughs on the forward part of the deck, all ready for discharging, and ejecting them by means of an impulse gear similar to the compressed air apparatus in use in the Navy, but using steam instead of compressed air.

The armament of the first-class type of boat is very different from that of the second-class boats, and consists of three 14-inch torpedoes, two being carried in transporting carriages on the sides of the vessel, and one in the torpedo gun, as it has been called, on the forward deck. This gun, it will be observed, is, like other guns, not only capable of being elevated and depressed, but also of being trained so that the torpedo may be discharged ahead on either side. There is no necessity, therefore, for the boat attacking bows on, as in the case of the second-class boats, neither is it necessary to stop her immediately before or after discharging her torpedo, as she may run past an enemy and discharge the torpedo while running at full speed. The torpedo gun is loaded by running the transporting carriages along to the rear of the gun, and opening the door which carries the air-impulse tubes; the torpedo is then pushed into its place, the door closed, and the gun is again ready for firing. In the earlier examples of this gun the torpedo was



ejected by means of compressed air in a telescopic impulse tube, but I have been told that the more recent arrangement is to eject it by means of a cartridge containing a slow-burning powder. On comparing this armament with that of the second-class boats, it will be observed that where these boats carry two torpedoes into action, all ready for being ejected, the English first-class boat only carries one. It is true that the two torpedoes in reserve can readily be put into the gun, but the boat must retire while this is being done, or the men engaged in the operation will be very much exposed. A more serious objection, in my opinion, is the exposed position of the reserve torpedoes. A Nordenfelt bullet striking one of them in the machinery compartment would at least render the torpedo useless, while if a Hotchkiss shell were to explode in the air-chamber, the chamber would be blown to pieces, and serious damage might be inflicted on the boat. Authorities differ as to the effect of a shell exploding among the gun-cotton of the charge. Foreign officers maintain that it would explode the gun-cotton, while our own officers consider, from experiments they have made, that it would simply cause a harmless ignition. These differences of opinion may possibly be the result of differences in the composition of the gun-cotton or in the charge of the shell. The dimensions of most of the Admiralty first-class boats are: Length over all, 87 feet; beam, 10 feet 10 inches; draught of water, 5 feet 2 inches; with a displacement of 32.4 tons. That illustrated by the model, however, is fitted with a ram bow, and is 90 feet 6 inches in length over all. The engines are compound surface condensing, similar to those in the second-class boats, with cylinders $12\frac{3}{4}$ inches and $20\frac{3}{4}$ inches in diameter by 12 inches stroke, and give out 469 indicated horse-power at a speed of 443 revolutions per minute, the speed of the boat at the time being $21\frac{3}{4}$ knots per hour.

One of the largest boats yet built for the Danish Government, is represented in the drawing. She is 110 feet long by 12 feet beam, draws 6 feet 3 inches of water, and has a displacement of $52\frac{1}{2}$ tons. Her general arrangement is somewhat similar to that of the Italian boats, the principal differences being in the torpedo room, which is larger and has the conning tower at the after end, and in the cabins, the after of which is set apart for the executive officers and is entered from the deck, while the forward one is reserved for the engineer and is entered from the engine room. The engines are compound surface-condensing, and have an auxiliary engine for driving the pumps. The cylinders of these engines are $14\frac{1}{2}$ inches and $24\frac{1}{4}$ inches in diameter, by 14 inches stroke, which, at a speed of 400 revolutions per minute, gave 750 indicated horse-power, the speed of the boat being $20\frac{3}{4}$ knots. On the three hours' trial the speed was found to be 19.91, or pratically 20 knots per hour. The boiler of this boat is similar to those in the English and Italian first-class boats, but is larger, having 1,014 square feet area of heating surface and 27.4 square feet of grate surface. The armament consists of four 15-inch Whitehead torpedoes 19 feet in length carrying a charge of 80 pounds of gun-cotton, and capable of going a distance of 1,000 yards at a speed of 18 or 19 knots. Instead of having a large number of torpedo boats round the coast, the Danish Government propose to carry this boat, and others of her class which they propose to build, from point to point of the coast, on their railways. Thus an enemy, although he might know the number of torpedo boats the Danes had, would never know where to expect one or more to turn up. We believe we are right in saying that the Danish torpedo boat is larger than any other vessel of its class afloat, but she will not occupy this proud position much longer, as the English are now building a somewhat larger boat for the Russian Government. This vessel will be 113 feet long by 12 feet 6 inches beam, with a displacement of $58\frac{1}{2}$ tons. Her contract speed is the same as that of the Danish boat, but she will do it under much more adverse conditions, as the Russian authorities have insisted on carrying an unusually heavy load on the trial, so that there may be no doubt of her keeping up her trial speed on service.

In this connection a brief notice of some of the boats employed by the Germans in their torpedo-warfare will be interesting. The *Ziethen* is an unarmored German iron-built vessel, 226 feet long, 28 feet broad, 18 feet 6 inches deep, and has a load-draught of 11 feet 8 inches. This handsome vessel was built and completed by the Thames Iron Works, Blackwall, London, for the torpedo-service of the German Imperial Government, and she is intended to carry out a series of experiments at sea with the Whitehead or fish torpedo. She has twinscrews and two pairs of non-compound engines, by Messrs. John Penn & Son, designed to indicate 2,500 horse-power. There are six cylindrical boilers, each containing two furnaces, set in the vessel back to back, occupying the whole width and about 30 feet fore and aft of the vessel, besides the fire-rooms one of which is forward and the other aft, next to the engines. The maximum speed is 16 knots per hour at sea, and as the vessel is not to be used as a cruiser, economy of fuel was not a consideration of the design. The *Ziethen* is built with two tubes, not much unlike screw-propeller-shaft tubes, placed in a line with the keel, one forward and the other aft, having valves at either end. They are 6 feet below the water-line; the after tube projects just over and beyond the rudder, the outlet of the forward tube is about 16 feet back in the forebody of the vessel and a triangular portion of the hull is made to hinge in the stem and lift into a water-tight well, so that there is no projection to interfere with the speed of the vessel. From these tubes the torpedoes are to be expelled by means of compressed air forced in by pumps worked by a steam-engine. A small pipe connects the tube with a Kingston valve in the bilge of the ship. The torpedo used in this vessel is represented to be an improvement over the weapon for which the patent was purchased by the British Government. It is cigar-shaped, is about 17 feet 6 inches long, by 15 inches in diameter at the center, and the pressure of air contained in its chamber, when launched from the tube, is stated to be 1,000 pounds per square inch. To use the torpedo it is first charged with air to the desired pressure by means of an air-compressing pump, and then set to the depth and distance intended to be run, after which the fore end containing the explosive charge is secured, and the percussion arrangement properly adjusted. The torpedo being then ready for action it is pushed into the launching-tube, the valve behind is closed, and the water from the Kingston valve admitted into the tube. A pump in the engine-room supplies air to a reservoir under a high pressure, and when it is wished to discharge the torpedo, the exit-valve of the tube being open, communication is opened between the reservoir and an apparatus in the rear end of the launching-tube, which forces the torpedo out with great velocity, at the same instant tripping its air-valve, which sets in motion the engine that works the screw-propeller by the self-contained power accumulated in the air-chamber. The speed at which the torpedo leaves the ship is represented to be 18 miles per hour, and that it will maintain this speed for a short distance with a given immersion, after which the speed, consequent upon lessened pressure in the air-chamber as the engine works it off, will gradually diminish until the distance of about 2,500 feet from the starting point is reached, when it will have run its course. The slower the velocity at which it is started the greater the distance it will run, depending on the capacity of the air-chamber and the pressure of air contained therein. The line of horizontal travel is preserved by regulating-mechanism with which the weapon is provided. The principal features of construction of the Whitehead-Luppis fish-torpedo are unknown to the public, for its mechanism has been successfully kept a secret since its first introduction to notice. Each of the several European governments which purchased the secret appointed a small number of officers to be put in possession of a complete set of drawings furnished with the weapons, and they are bound on honor not to reveal their workings. Many attempts have been made to describe the invention, but none of them were of any value until Lieut. F. M. Barber, U. S. N., entered the field and wrote his exceedingly clear and comprehensive paper, delivered as a lecture at Newport, R. I., November 20, 1874. This paper not only gives a clear understanding of the supposed construction in all its essential features, but also points out to ingenious mechanical minds ideas for producing similar projectile torpedoes.

It may not be out of place here to say what is known to Naval Officers, but not to the public, viz., that, as before represented, it is cigar-shaped, or more properly approaching in form a spindle of revolution. It is made of thin metal, either iron or steel; the fore end, containing the explosive material, is made separately and secured to the main body when desired. The air-reservoir next adjoining the fore end constitutes about one-half of the torpedo-vessel, and its strength must be very great to withstand the pressure. Aft of this reservoir is a set of three-cylinder engines actuated by air received through a pipe from the reservoir. The screw-propeller operated by the engines is connected by a shaft passing through a tube. There is a rudder or external mechanism capable of regulating the depth under water at which the torpedo shall advance, and also of keeping it straight or sending it on any curve that may be desired, taking into account currents and eddies. It has been announced that the torpedo can be set to run a straight course under water of from 600 to 6,000 feet, according to its speed from 18 knots per hour to 9 knots; that at a starting speed of 5 knots a range of 12,000 feet may be reached, and that the charge is sure of exploding on striking its object; that it can be arranged so as to half-cock or full-cock its trigger when approaching the object at which it is directed, and to rise near the water-line, or sink to the keel of the enemy's ship, as may be desired. If it misses its aim, a safety-pin is released, and the torpedo goes harmlessly away, to be recovered at any future time. The weak point of the instrument is that, being propelled by an air-engine, the speed naturally decreases with the decreased pressure in the air-chamber, and although a very high rate of speed is insured throughout the journey, the velocity is the least at the termination of the course, when speed for the purpose of breaking through guards or netting around a ship is most desired.

England, France, Germany, Austria, and Italy have purchased the right to use this torpedo, and Spain and Russia will probably soon follow in securing the secret. The first-named governments have paid, it is reported, about $73,300 for the privilege of its use, with examples and drawings. The improvement and development of the instrument and system of working it is an object of continued study and experiment by the English, at the royal arsenal, Woolwich, and in the river Medway, by the Italians at Venice; by the French at the mouth of the Charente; by Austria at Fiume, where the inventor has his factory; and by the Germans in the North Sea. The German government intends to determine, by careful experiment at sea, whether it can be delivered with certainty from a ship more or less in motion riding on waves, against another vessel similarly circumstanced, and perhaps moving under sails; in fact under all conditions likely to happen in war. For this purpose, together with the cost of the *Ziethen*, the patent-fees and torpedoes, about $350,000 additional have been appropriated, and it is intended to expend $150,000 additional when the experiments justify it.

The first torpedo-boat constructed by the English for ejecting the Whitehead fish-torpedo through a launching-tube was the *Vesuvius*, an iron vessel of 241 tons, built in 1874. This vessel has one tube in the fore end, and she has been used in Portchester Lake, near Portsmouth, as a school of instruction in the use of the Whitehead torpedo for both executive and engineer officers. The naval authorities of England, Germany, and other European countries take advantage of the mechanical knowledge of their naval engineers, and employ then in their torpedo-service as well as in all naval-machinery work.

Several other vessels for torpedo-services exclusively, have been projected by the British Admiralty, besides which it has been determined to apply the apparatus for working the Whitehead torpedo to all vessels, both armored and unarmored, fitted out for service. The first ship to which the necessary machinery for working it has been adapted was the powerful coast-defense vessel *Glatton*. In this vessel, recently fitted for the purpose, the tube is on the broadside below the armor, and a similar arrangement will probably be made in other vessels fitted for sea.

The most successful automatic or self-propelling torpedo tested in the United States is the one invented by Mr. John L. Lay, late an engineer officer United States Navy. A specimen of this torpedo was shown at the Centennial Exihition. It was made of boiler-iron: was shaped like a spindle, 28 feet 3 inches in length, and was divided into four compartments. The front end, technically called the nose, contains the explosive material, viz, about 300 pounds of powder and 75 pounds of dynamite. The motive power, which consists of carbonic-acid gas generated in the usual way, is conducted from the generating apparatus, through iron tubes, to the engine, which is in the fourth section, and which operates the screw-propeller. The initial pressure is about forty atmospheres. The third, or middle, section contains a roll of two or more miles of insulated wire which is paid out from the torpedo itself, and serves to keep up electrical conection with the firing stations The torpedo is submerged to about four-fifths of its volume. Its maximum speed claimed is 10½ knots, but it seems from the Newport experiment that 7 knots only were attained. The instrument is entirely under the control of the electrician, who, by means of a series of contacts, opens or closes the communicating valves, and thus increases or diminishes the speed, and stops or starts the torpedo as required. It may be fired either by contact or by closing the electric circuit. Its position is always kept in view by a rod projecting from its surface.

The German torpedo boat *Uhlan* was built in Germany by the Stettin Engine Company, and was launched early in the summer of 1876. The German papers announced the leading features of the boat, and, as they are peculiar and unusual, we copy the description:

This vessel will receive a torpedo charged with dynamite, to be carried on a 10-foot ram, lying deeply under the water-line; which torpedo is to explode on contact with the hostile ship. To protect the torpedo-boat from the results of the discharge of its own torpedo, the vessel is built with two complete fore parts, sliding one within the other, and having a considerable extent of intermediate space between them. This space is filled with a tough and elastic material, (cork and marine glue,) and thus if even the bows were carried off, there would be a second line of resistance. The object of the filling is to act like a buffer, deadening the blow and protecting the stem.

Another striking feature is the great power of the engines. The *Uhlan* carries an engine of 1,000 indicated horse-power. The steam is supplied by Belleville's tubular generator. The vessel, in fact, is all engine, only a very small space being left for coal and crew. The great power of the engines is necessitated by two circumstances. In the first place, the steamer has to be propelled at a high speed, and it has a very great draught, so as to offer but little scope to projectiles. In the next place, the greatest facility of steering or maneuvering had to be attained: hence the proportion of width to length, 25 to 70 feet. In order to save the crew at the worst, a raft has been constructed, which is filled with the above mixture of cork and marine glue, and placed near the helm. When the *Uhlan* enters into action the dynamite cartridge is to be fixed by divers at the point of the ram. The rudder is then to be fixed; and the crew are to open a wide port on the ship's side, and with their raft jumped into the water. The steamer is then allowed to rush forward and burst its cartridge on the enemy's armor. The crew, however, are to hold on to the torpede-boat by a line while they are awaiting the result of the explosion; and in case their boat is not hurt they are to board it again, in order, if necessary, to repeat the maneuver. The price of this torpedo boat is about 200,000 thalers.

Spar-torpedo launches for marine warfare are now being generally adopted into the service of all foreign navies. They may be divided into two classes, viz, those intended for river service and those designed for ocean purposes; both classes are built of either iron or steel. The first are usually about 45 feet long and 7 feet 5 inches broad, with a draught of water of about 3 feet 6 inches, and have 2 feet free-board. The frames are made of 1-inch angle iron with ¾-inch reverse irons, the plates being ¼ inch thick at the keel and $\frac{3}{16}$ inch at the gunwale. There is a steel turtle-back shield ¼ inch thick forward, to afford protection to the men and steering-wheel, and to throw off the water which might come on board from the explosion of the torpedo. The engine and boiler hatches are also provided with steel sliding covers. For boats of this size the engines are in one pair and operate a single screw; they are vertical, direct-acting, and non-condensing, with a maximum indicated power of about sixty horses. The diameter of each cylinder is 7 inches, and the stroke 7½ inches. The boiler is of the locomotive type, made of the best Lowmoor iron, and capable of being worked to 140 pounds pressure per square inch, and the maximum speed of the boat is from 13 to 14 knots per hour. The boats intended for ocean-work are designed to be navigated in any weather short of a storm, and are made on the same principle but with larger scantling, greater draught of water, and more height of free-board.

During 1875 a torpedo-boat for ocean purposes was built by Messrs. Yarrow and Hedley, on the Thames, for the Navy of Holland. It is 66 feet long, 10 broad, and 5½ feet deep, and is driven by a pair of inverted, inches direct-acting engines, of 11 inches diameter of cylinders and 14 stroke of pistons. The boiler is of the locomotive type, with a total heating-surface of 450 square feet, and a working pressure 140 pounds per square inch: the estimated maximum horse-power is 200. This firm has now in course of construction one of their fast torpedo-steamers for the Russian service in the Black Sea. It is 85 feet in length, and the guaranteed speed on the measured mile is 20 knots per hour. In the boats provided with non-condensing engines there is a chamber to which the exhaust-steam is conducted, and in which the condensation is effected against a portion of the skin of the boat, the plates there being increased in thickness; the object being simply to condense the steam in order to avoid the noise, and not to obtain a vacuum. One of the primary conditions required for these boats is high speed; the more quickly one can dart out from the shelter of a bank or ambush, and approach her adversary, the more likely is she to escape observation. Another condition is that the machinery shall be noiseless. This condition is now obtained by means of the exhaust-chamber referred to. The English Government have not as yet done much in the direction of special torpedo-launches, but ordinary launches and cutters have been fitted for this service. The method of fitting these boats hitherto used has been to cover the forepart of the boat with a canopy of canvas, to work the torpedo-spar on outriggers placed on either side of the boat, and to rig it out and in by means of a rope worked from the stern-sheets, another rope being attached to the heel of the spar to ease it out and rig it in again. They have also adopted the electric method of firing at will and not by contact. The system of torpedoes employed and the method of working the spars are so well known, that remarks thereon would be superfluous. It may be mentioned however, that in the Dutch boat referred to there is an auxiliary steam-engine to facilitate the working of the spars. The *Oberon* is an iron vessel, of 649 tons B. M., which has for several years past been used for carrying into effect a series of extensive and costly experiments, by exploding torpedoes near to and against her bottom, the chief object in view being to ascertain the effect of torpedo explosions on the double bottoms of armored ships, under different forms of construction and various conditions of attack. For this purpose the vessel has had an outer bottom built to the inner skin, which is intended to represent, as nearly as possible, the bottom of the broadside-armored ship *Hercules*, and to be of about the same strength. The *Oberon* has an original ½-inch plate bottom, single-riveted, with support afforded by angle-iron transverse frames 21 inches apart. These frames consist of two pieces of angle-iron riveted together. The second or outer bottom, ¾-inch thick is fixed at a distance of 3 feet 6 inches from the inner one at the keel, and 2 feet 3 inches above the water-line. This bottom has every alternate plate with both its edges double-riveted outside those of the adjacent plates. Along the center of each of these alternate or outside plates, which are those that first come in contact with any external object, runs a longitudinal frame attached also to the inner bottom. Transverse frames run around at intervals of 4 feet, and are riveted to both bottoms by means of an angle-iron. Thus the space between the two bottoms of the ship is divided up by the longitudinal and transverse frames into spaces something like cubes or boxes, the top and bottom of such boxes being furnished by the inner and outer bottoms of the ship, and the four sides by the frames crossing one another. To lessen the weight of the metal, circular holes are cut in the middle of these box-sides in most cases. Every fourth transverse frame, however, is thoroughly closed and made a water-tight bulkhead. It will be seen, therefore, that this is an exceedingly strong bottom. The several experiments made with this vessel have been published in detail. We here reproduce one from *Engineering*, for the benefit of those interested in this special branch of naval warfare:

"The *Oberon* torpedo-hulk was placed in No. 10 dock at Portsmouth, on Wednesday afternoon, and the water having been let out, on Thursday morning it was possible for the first time to observe clearly the injuries she sustained from the torpedo experiments of Monday. The ship is divided into seven water-tight compartments, of which the two in the immediate neighborhood of the discharges were destroyed and filled with water. The bulkheads of four of the others remained intact, but permitted the water to leak through, but not beyond the capacities of the ordinary ship's pumps to keep down. The center compartment amidships remained perfectly dry; and as this was the largest in the vessel, it sufficed, with the artificial flotation which was afforded by upward of 300 casks which were packed away in the fore and aft compartments, to float the *Oberon* at high-tide, and enable her to be taken in tow with little difficulty. In consequence of the buoyancy thus imparted to her, she settled with great deliberation, and it was the general impression at the time that she had not been severely hit, and least of all by the Harvey torpedo, which had been suspended from the starboard bow. This impression was effectually dispelled by the melancholy spectacle which presented itself on Thursday morning when the ship was fully exposed in dock. Notwithstanding the lightness with which she lay in the water—she drew only 11 feet, and consequently bore only a distant comparison with an iron-clad with its machinery and weights on board—every charge seems to have told with terrible effect, any one of the holes being sufficient of itself to have sunk the best iron-clads, in spite of the Makaroff mat or any other leak-stopping devices that could have been applied. The Harvey torpedo, which contained 66 pounds of gunpowder, has split and bulged in an area of plating of the outer bottom about 16 feet square, extending downward through two longitudinals to the garboard plates, and laterally to the water-tight frame on each side of No. 4, utterly destroying the intermediate brackets.

The injury here is very clearly defined, the longitudinals and the frames having apparently acted as knives, so cleanly have the plates forced in upon them been cut through in the direction of the fiber of the iron. Had the longitudinal girders been placed closer together, the resistance would have been greater, and the damage to the inner bottom would at least have been less. The bracket-frames, which are only kept in position by angle-irons, seem to have been snapped and doubled up with alarming ease by the force of the concussion. The inner bottom has been extensively damaged and bulged in, but not so much as might have been supposed from the appearance of the outer skin, the straightness of the bows having allowed much of the explosion to spend itself vertically. As might have been expected, the greatest damage is exhibited under the bilge on each side of No. 30½ frame, against which two charges, respectively of 33 pounds of slab gun-cotton and 33 pounds of granulated gun-cotton, were fired. Here frightful wounds were visible—wounds which are plainly past redemption. The holes are about 18 feet square each, and extend from the third stake below the armor-shelf well-nigh to the keel-plating. The greatest force appears to have been exerted on the starboard side by the granulated preparation. The iron skin has been torn from the rivets, the girders and bracket-frames shot away, and the upper plating wrenched completely off from their supports and blown away. The port side of the same frame presents a similarly ruinous aspect. The only difference is—and practically it is one without a distinction—that the plates, instead of being broken off, are lacerated in all directions and forced upon the inner bottom, which here as also on the opposite side is torn and forced inward. With the exception that the taffrail is blown away and the galley dismantled, the explosive forces seem to have been confined for the most part within well-defined limits. The wounds left by the previous experiments have not been re-opened, and though the ship must have been lifted fore and aft, the fissures amidships do not appear to have extended. It is probable that, after a careful survey has been made, the *Oberon* will be filled with coal and submitted to a series of shell experiments. She can be of no further use for torpedo purposes."

Is is impossible not to be struck by the suggestiveness of the above mentioned experiments with reference to the future not only of naval warfare, but, in a still more impressive degree, of naval architecture. The terrible injury which the *Oberon* has sustained proves beyond all caviling that no iron-clad can withstand the bursting of a torpedo in contact; a torpedo would prove destructive almost wherever it struck; a ship could hardly be saved by a turn of the helm. A projectile from the 81-ton gun would probably not prove utterly destructive, unless it hit at right angles with the keel; but a torpedo, so long as it hits, no matter where, would dislocate the integrity of the ship within an area large enough to prove fatal. The larger the vessel the more likely it is to fall a prey to the torpedo or the water-rocket. Its size would render it more susceptible to attack, and its slower speed would make it more difficult to get out of the way of an active enemy. Smaller ships, therefore, would seem a necessity of the time, leaving details of construction for further consideration. The question of stopping leaks from the outside, which was raised in the case of the *Vanguard*, again suggests itself here. It would appear that this was the most hopeful way of dealing with a leak of this character, where there is so much bent plate, which, while it is very difficult to repair, affords support to the sail or other material let down over it from the outside. Some experiments as to the possibility of closing such leaks would be very valuable. Contact charges and the action of the movable torpedo lead naturally to the contemplation of the probable effect of the Whitehead fish-torpedo. On every ground this has become a grave question for the British, especially since it has been found that it can be dispatched from the deck of armor-clad or other ships. As long as a special and subordinate class of vessels was devoted entirely to this species of attack, and had to carry tubes below the water-line, it was argued that approach would be excessively difficult; but when the heaviest armor-clads can, without sacrificing anything, avail themselves of this additional weapon, the question wears a different aspect.

The Paris correspondent of the London Times has sent to that paper the following notes on some recent interesting torpedo experiments with one of Messrs. Thornycroft's spar torpedo-boats: This was the first occasion of testing, in French water, whether a torpedo could be launched against a ship in full sail. Accordingly, Admiral Jaurez, who commands the squadron, ordered a disabled ship, the Bayonnaise, during a rather rough sea, to be towed out by a steamer belonging to the Navy. A Second Lieutenant, M. Lemoiune, was sent for, and informed that he had been selected to make the experiment of launching the Thornycroft against the Bayonnaise while both were in full sail. He accepted the mission without hesitation, picked out two enginemen and a pilot, and went down with them into the interior of the Thornycroft, of which only a small part was above water, this visible portion being painted of a grayish color so as to be easily confused with the sea. The torpedo was placed so as to project from the bow of the vessel, at the extremity of which were two lateen-sail yards about three meters in length. The towing-steamer then took up its position in front of the squadron, and the Thornycroft also assumed the position assigned for it, an interval of three or four marine miles separating the torpedo and the Bayonnaise. A signal being given both were set in motion, the steamer advancing in a straight line and the Thornycroft obliquely, so as to take the Bayonnaise in flank. The steam-tug went at 14 knots an hour, going at full speed in order to escape the Thornycroft. The latter went 19 knots an hour, a rate not attained by any vessel in the squadron. The chase lasted about an hour, the squadron keeping in the rear, so as to witness the operations. At the end of that time the distance between the Thornycroft and the Bayonnaise had sensibly diminished, and at a given moment the former, in order to come up with the latter at the requisite distance, had to slacken speed to eight knots an hour. The whole squadron watched this last phase of the struggle with breathless interest, and the people often asked themselves whether the shock of the torpedo would not infallibly destroy the little vessel which bore it. It was feared that the lives of Second Lieutenant Lemoiune and his two companions were absolutely sacrificed. However, the two vessels got visibly nearer. All at once the Thornycroft put on a last spurt, and struck the Bayonnaise with all its force on the starboard-bow. The sea was terribly agitated, a deafening report was heard, and the Bayonnaise, with a rent as big as a house, sank with a wonderful rapidity. As for the Thornycroft, rebounding by the shock about 15 meters off, even before the explosion occured, it went round and round for a few moments, and then rather quietly resumed the original direction taken by the squadron. No trace remained of the Bayonnaise; it was literally swallowed up by the sea. Unanimous plaudits greeted the courageous sailors as they joined the Admiral's squadron to report on the mission they had accomplished. The experiment was repeated two days later, under the same conditions, with another disabled ship, and with the same success; and, in the opinion of competent men, this is one of the most decisive torpedo experiments which have yet been made. The little torpedo boat, with its lateen-sail yards, resembles a small, gray lizard, and she is scarcely discernible in the water. It is evident that a single boat of this kind would be unable to approach an enemy's ship unless at dusk, or when it would be impossible to distinguish it at a distance, for had such an attack been attempted in broad daylight, the Thornycroft would manifestly have been knocked to pieces by the guns of the threatened ship before it could have carried out its project. On the other hand, it would be quite impossible for one or even several ships to defend themselves against a simultaneous attack, say by twenty or by twenty five Thornycrofts; and as these cost only the fiftieth part of the expense of a man-of-war, this experiment presents a formidable problem to State Navies. What is certain is that those who witnessed the affair were greatly impressed by it, and are persuaded that it is the starting-point of an inevitable transformation in naval tactics. See *Torpedoes*.

TORPEDO CATCHER.—The construction of torpedo catchers was as much a necessity in naval warfare after the development of the torpedo system of small, quick-steaming torpedo craft as armored protection for battle ships became in consequence of the growth of the gun. The catchers, or police of the sea, do not differ, except in bulk and speed, from the active and dangerous little enemies which they are intended to capture or destroy, and in this respect the Admiralty would appear to have applied the old detective principle of setting a thief to catch a thief. The first of the new craft yet afloat was tried in Stokes Bay, near Portsmouth, not long since, with remarkable results, not only as regards speed but also as regards maneuvering power. This latter quality of the torpedo catcher was even more noteworthy than the former, and has been secured by the application of a principle which though successfully tried in steam pinnaces, launches and in the various subnarine mines constructed by the Royal Engineers, had not previously been adapted to first-class torpedo vessels. During the past four years we have noticed the gradual development of the invention of Mr. John Samuel White, of East Cowes, which is now popularly known in the Service as his "turn-about" system. Boats built according to this plan have their deadwood removed in order to obtain facility in turning, and are fitted with an inner and outer rudder, simultaneously actuated, either of which would suffice to steer the vessel in the event of the other being lost or disabled. The present experimental torpedo boat was undertaken by Mr. White for the purpose of demonstrating the applicability of his invention to larger vessels, and with a view to her acceptance by the Admiralty on her fulfilling all the conditions guaranteed. She is considerably larger than any of the existing torpedo craft in her Majesty's Navy, being 150 feet long, 17 feet 6 inches broad, and 9 feet 6 inches deep. Her displacement is about 125 tons. Her lines resemble those of similar vessels now in use, but she is fitted with a turtle deck and a spur ram. Like the others, she is built of thin steel, and has a conning tower amidships, from whence she will be steered in action. Messrs. G. E. Belliss, of Birmingham, the makers of all the machinery of Mr. White's boats, joined with him in the undertaking, supplying compound engines of the three-cylinder type, the high pressure cylinder being 20 inches and the two low pressure cylinders 24 inches in diameter, the whole being substantially supported on light steel columns. The stroke is 18 inches. Great care has been taken in the design to keep the weights as low as possible, having due regard to efficiency. There are two air pumps driven from the low pressure cross-heads, while the feed pumps are driven direct from the crank shaft. Steam is supplied by two locomotive boilers, with the feeds so arranged as to insure an equal supply of water to each boiler, and as the result of the trial the possibility of successfully employing two boilers with forced draught without difficulty, either as regards the feed or priming, was clearly demonstrated. A great feature in the design is the division of the boiler room by a longitudinal water-tight bulkhead, the connections being arranged so that either boiler can be worked independently in case of accident. The vessel is also steered by steam. The trial was conducted by Mr. White and Mr. Morcom. The weather was somewhat boisterous, but notwithstanding the state of the sea the vessel was remarkably steady, and also free from vibration when going at her maximum speed. The total weight on board was 25 tons, 15 tons representing coal and

10 tons (furnished by iron ballast) her armament of Whiteheads and rapid-firing guns. Provision, however, has been made for carrying 35 tons of coal in the bunkers, while the space forward and aft for the accommodation of officers and crew and stores is unusually large. Six runs on the measured mile were first made for the purpose of ascertaining the speed under the special conditions of load, which resulted in the realization of a mean speed of 20.70 knots, the mean boiler pressure being 126 pounds, the revolutions 319 per minute, and the indicated horse power 1.387. The highest speed in the direction of the wind was 22.43 knots, and the following times which it took to complete the miles will show the regularity with which the speed was maintained: With the wind, 2;43, 2:40$\frac{1}{2}$ and 2;40$\frac{1}{3}$ (repeated); against the wind, 3;09, 3;07, and 3;05. The average indicated horse power per square foot of grate was 23, which was maintained with a mean air pressure in the stoke holes of 2$\frac{1}{3}$ inches, which was considered a very high result. The vessel was afterward tested in the usual manner for maneuvering power. At full speed, with the helm hard over 30°, the starboard circle was completed in 1:17, (238 revolutions of the engines), and the port circle in 1:12 (270 revolutions.) At half speed the starboard circle was completed in 1:14 (237 revolutions), and the port circle in 1:15 (246 revolutions). The diameter of the circles was about a length and a half of the boat, or 225 feet. The craft was finally run for three hours' continuous full-power steaming to test the endurance of the mechanism. No mishaps occurred, and the speed and revolutions were maintained throughout. See *Torpedoes*.

TORPEDOES.—These weapons depend for their utility more upon their deterring than upon their actual destructive power. Men who will march bravely up through a blaze of musketry will walk timidly over ground in which they suspect the hidden mine. Torpedoes may be simply shells charged with powder and slightly buried under the ground; or they may be wooden boxes, kegs, or any other vessel capable of

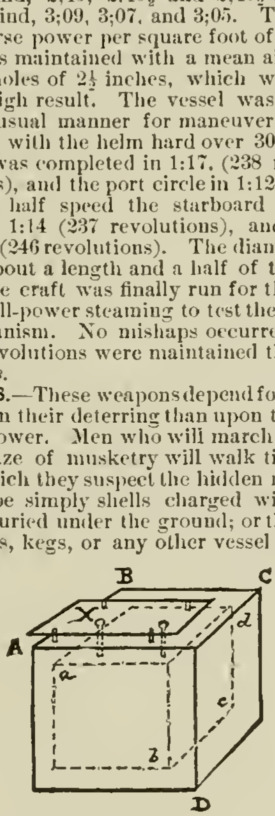


Fig. 1.

holding and keeping dry a charge of powder. Shells produce their effect from their fragments, and likewise, if large, from the blast of the explosion. Charges otherwise inclosed produce an effect only by the blast; consequently the greater the quantity of powder the greater will be the effect. The chief difficulty in planting torpedoes is in the arrangement for igniting them at the proper moment. This may be done by electricity, as for submarine mines, or by a self-acting device whereby the charge is exploded by the tread of an enemy passing over it. The device employed by the Russians at Sebastopol is perhaps the best of many that have been tested. The case consisted of a cubical wooden box (*a b c d*), shown in Fig. 1, large enough to contain a charge of 10 to 20 pounds of powder. This box was contained in another box (A B C D), leaving a space between of about 2 inches, which was filled with pitch, rendering the powder in the inner box secure from moisture. The top of the exterior box was placed 6 or 8 inches below the surface of the ground, and on it rested a board about the size of the top; this board stood on four legs of hoop-iron about 4 inches high. The top of this board was near the surface of the earth, and covered slightly so as not to be perceived. On any slight pressure upon the board, such as a man treading upon it, the hoop-iron supports yielded and the board came in contact with a glass tube (X) containing sulphuric acid; the tube breaking liberated the acid, which came in contact with a priming of potassa chlorate and loaf-sugar within the box, causing instant combustion, and, as a consequence, explosion of the powder. The glass tube is placed within another of lead, tin, or other metal which bends readily, yet is strong enough to afford a certain degree of protection to it. The metal tube conducts the acid to the interior after the glass is broken. Instead of the interior box, a shell filled with powder may be used. Other devices for exploding the charge are frequently employed. They are constructed upon the principle of a plunger striking upon fulminating composition, but these are difficult to construct so that moisture will not enter and destroy either the fulminate or charge. When torpedoes are planted, the position of each one should be so marked as to be known to friend, but not to the enemy. They should not be planted in front of any work from which sorties are to be made. They are useful along all beaches to prevent the enemy from landing.

The torpedo is the development of an idea which dates back to the invention of gunpowder—the petard on land, the powder ship at sea: but Bushnell, of Connecticut, appears to have invented at once, during our war of the Revolution, the two factors of success—a sunken boat and an explosive torpedo. His was exploded by clock-work, and is of the first, or *applied* kind, the true torpedo; though he afterward experimented, and as fruitlessly as usual, with the second kind, the *drifting* torpedo, or infernal machine. The third variety, the *sunken*, is the submarine mine. The drifting torpedo is usually sunk by a line from a log or keg, and explodes when driven up against an obstacle by the tide or current. During the Turkish war of 1877-78 a floating can with surrounding arms was in use, as also a shuttle-shaped torpedo with a surrounding ring. All are evidently precarious in their action, and dangerous to all, whether friends or foes, who may chance to encounter them. If their use cannot be discontinued by national agreement, it seems only fair that any caught setting them should be subjected to martial law forthwith, ranking by right with spies, marauders, and private corps. There has yet been no fair trial by an invading fleet armed with the latest appliances of the efficiency of the third, or submarine mine. The Turks with divers and the electric light, cut loose and raised the Russian torpedoes; nor is it necessary for this to capture the firing-stations. The English, working on the fact that the explosion under water of the equivalent of 300 lbs. of powder will explode all mines within a radius of 100 yards, invented a steam launch, directed by wires, which could be sent ahead, could drop two torpedoes, retire, and finally explode them, without other handling than the battery-wires. It has not yet been tried, and probably, in a sea-way, never will be. Nothing is so effective as the torpedo run out by a spar and exploded by a battery. Ours of the late war were percussive. The torpedo boat invented by Admiral Porter, and constructed before the Turkish war, is an almost submerged steam launch, made of iron, with a double skin, carrying four persons—a spar-man, who commands and manages the torpedo, the battery-man, a steers-man, and an engineer. The idea was borrowed by the English about 1878, but almost all these boats are too large for the purpose. They carry a spar from the bow, and sometimes one on either side. The torpedo is launched, by dropping the spar, so as to strike the enemy at about ten feet below water; and a bowsprit, often with a spring buffer, prevents the launch approaching nearer than 20 feet at the least, the limit of safety for the equivalent of 150 lbs. of powder. The Whitehead and its American prototype, the Harvey, and other towed torpedoes, and boom or spar torpedoes from a vessel itself, are all either uncertain in effect or impotent when in action and in a sea-way, from the very necessities of the case. Defense against torpedoes lies in booms of logs, with nets, and if possible, battery attachments, to show where the attack is made, and guns ready trained on certain points. Against torpedo-boats Hobart Pacha was the first to use a cordon of logs, made fast by lines to his yard-arms, and boomed out from the hull. Nets, and now wire-netting, have been substituted, with a line of spars all round to keep them at proper distance. The electric light should be used, with patrol boats, and a sufficient number of guns should be kept in readiness, so as to be quickly trained on any point. Gatling guns in the tops will pierce any common launch, made as they are of boiler iron; and the English rocket battery might be found useful. Better than anything is the new Hotchkiss revolving-cannon, and it is a question whether two patrol-boats, armed with this and a spar torpedo, will not prove a sufficient protection against the only thing that has yet proved an entire success, an open launch, manned by a resolute crew.

Torpedoes or submarine mines should be carefully moored and laid on the bottom in several lines, the mines of the second line being opposite to the

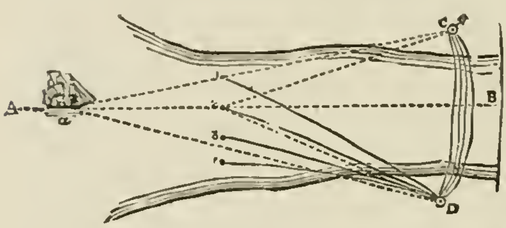


Fig. 2

intervals of the first, so that it is difficult for a hostile ship to pass up a defended channel without coming within reach of one or more of them. As a ship approaches, her course is carefully watched so as to fire a mine at the right moment. In order to explain how this is done, let us take the case of the channel AB, Fig. 2. Two or more lines of mines are laid down across its mouth. For the sake of clearness we show only a few of those of the first line in the diagram. At C and D two stations are selected, commanding a view of the defended waters. At C is the voltaic battery, and the wires from the mines connect them with D, while a second series of wires, each corresponding with one of the first series, connects D and C. There are thus two breaks in the circuit of every mine, one at C, where a number of 'firing-keys' are arranged so as to place at will the battery in connection with any of the wires; the second break is at D, where similar firing-keys connect at will each wire of one series with the corresponding wire of the other. A ship is seen approaching on the course AB. When she is at *a*, the observer at C notices that her bearing is the same as that of mine No. 1. He therefore closes the break in the first circuit by means of the firing-key, but no current passes, for the observer at D sees her well to the left of the bearing of mine No. 1, and therefore leaves his break open. Not until she is actually over No. 2 will both observers at the same moment see that her bearing corresponds to that of No. 2, and closing both breaks in the circuit, fire the mine. By means of a telescope combined with the firing-key, these bearings can be taken with great accuracy. In some cases the ship herself is made to close the circuit in striking a rather complicated apparatus called a circuit-closer, which floats above each of the mines arranged on this system. These weapons were first used by the Russians in the Baltic in 1854; but in the American war of secession of 1861-65 they were extensively and often successfully employed. The damage effected by a torpedo exploding beneath a ship is very great, but the failures are very frequent by the explosion happening at a wrong moment. In the Franco-German war of 1870-71, the French fleet was effectually scared from the Prussian ports by the dread of torpedoes. Torpedos were much employed in the Russo-Turkish war of 1877.

At the present time, the Sims torpedo is the subject of experiment with a view to its adoption by the United States. Experiments thus far have given most satisfactory results. This torpedo is a cylindrical hull of copper, 1-16 of an inch thick. The ends are conical and capped with steel. It is 28 feet long and 21 inches in diameter, and is made in four parts or sections, which are put together by means of lock joints. This copper hull is supported at a distance of about five feet under the water by a comparatively indestructible float, which is also made of copper, and is filled with packed cotton as a means of buoyancy. This float may be riddled with shot and yet it will stay on the surface and support the submerged torpedo. The float and torpedo below it are connected together by steel stanchions. On top of the float are two rods, or guides, surmounted by balls. These indicate to the operator where the torpedo is. They are hinged to the float and are kept upright by springs. When the torpedo dives under or cuts through an obstruction, the springs allow the guide balls to lay in a socket, and to stand upright again when the obstruction is passed. The whole apparatus is provided with a steel propeller and rudder.

The torpedo may force its way through cables or similar obstructions by means of a sharp, strong blade which forms the prow, and which is set at an angle of 60 degrees, like the ram of an ironclad. This angle gives the knife great power in cutting, especially as the structure moves with great speed. Not only does this formidable prow serve this purpose, but when it strikes a spar or any other floating barrier the slant makes the whole vessel dive under, and its buoyancy enables it to rise on the other side as it continues on its course towards the object of its attack. The torpedo is extremely simple in its construction; the gross weight is about four thousand pounds, but, when taken apart, no single section weighs more than eight hundred pounds. Copper and brass are used almost exclusively, and this does away with the faults which steel torpedoes presented to the English Admiralty.

The great feature of the torpedo which marks it out from all others is the fact that it is propelled, steered and exploded by electricity. All other moving torpedoes contain in themselves the means of motion. As the space is small the power is soon exhausted. Then the torpedo-boat is useless for further maneuvering, although, so long as the power lasts, it can be steered from the shore by an attached cable. In the Sims torpedo, however, the power is generated by a dynamo-electric machine on shore, and a continuous current of power can be kept up as long as is desired. The dynamo machine may be kept in the heart of the city if necessary, and the electricity conveyed to the shore by an underground wire, or the dynamo may be in a fort or on board of a war vessel. In fact all men-of-war carry dynamo machines now.

In the bow of the submerged torpedo is placed a charge of 400 pounds of best grade dynamite, which occupies the whole front section. The second section is an air-tight chamber. In the third section is coiled two miles of cable, weighing 700 pounds to the mile. It is played out as the torpedo flashes through the water, and thus the propeller is not compelled to do the work of dragging a cable along the bed of the ocean or harbor. One end of the cable is connected with the propelling and steering apparatus in the fourth section of the hull, while the other end of the cable is connected on shore with the dynamo that furnishes tbe power, as well as with the key-board of the operator. Inside of this cable are two wires—one for steering and the other for propelling. In the last section of the torpedo are two powerful magnets, which hold the rudder in the center when the hull is going on a stright course. When it is desirable to change the course the operator moves a small lever on the key-board and the current passes into one magnet or the other and the rudder is pulled about in the proper direction.

A rate of more than eleven miles an hour has been attained in repeated Government tests,and the officers who have been experimenting for years with the torpedo say that it will be easy to get a still higher rate of speed with the same apparatus.

That the torpedoes cannot be destroyed by artillery fire from an enemy's ship has been thoroughly proved. The floats have been anchored in front of a fort and kept under a concentrated fire for hours, and still, riddled as they were, they floated and were ready for immediate service. Of course no shot could hit the submerged torpedo, as the solid water would cause missiles to ricochet. While conducting the secret experiments at Willett's Point, Gen. Abbott tested the float under fire and in his official report said:—

"The float was anchored down in front of a 32-pounder howitzer. It was first fired five times at a range of 370 yards and then eight times at a range of 186 yards with double-shotted canister charges, each containing ninety-six balls. Five large holes were made by this firing, and the float was then towed about a mile by a steam launch at the rate of five miles an hour. On its return it had only lost 150 pounds of its 800 pounds buoyancy and was perfectly serviceable for use in an attack."

Referring to the inability to obstruct to the progress of the torpedo, the same Engineer said: "The mast of a schooner fifty-six feet long was anchored by two 500-pound anchors, one at each end. The torpedo was driven against this obstruction twice at the rate of nine miles an hour, and the shock did no damage, but in both cases the torpedo dived under the log and continued its course uninjured. I regard these tests as sufficient to prove that the torpedo is quite safe against any artillery fire which it would encounter in actual service, and that no temporary protection in the shape of spars or logs moored around a vessel would be of any value against an attack. Probably a deep iron netting might check its course, but the explosion of its charge would be sure to open a route for a second torpedo following in the wake of the first. The charge when exploded would disrupt a modern double cellular iron warship at a range of thirty-one feet."

One of the principal features in favor of the Sims torpedo is the steering power. During the tests at Willett's Point it was made to describe a circle both ways and take a different course entirely, which showed how easily the boat could strike any desired object. On the 16th of last June, Gen. Abbott had a 57-foot spar anchored near Willett's Point. The torpedo was started from a quarter of a mile away. It struck the spar squarely in the middle, as was desired and then dived under it. It was started out again, and the next time it struck the spar within a foot and a half of the same spot, after which it passed under the obstruction and continued on its course. The balls on the top of the float are designed to tell where the boat is to the operator who is running it. By keeping his eye on the balls he can always tell where the torpedo is and direct it accordingly. As soon as the boat has reached the side of the vessel the discharge is made by pressing a key on the board. All of the electricity which had been used to propel it, by a neat adjustment of relays passes into the explosive gelatine and first discharges a small cartridge of fulminate of mercury, which in turn discharges the dynamite and produces the effect. If it is desired, the explosion can be caused by contact with the enemy's ship. In steering the torpedo the operator does not need to be exposed to any danger. He may be down in a well one hundred feet deep, and an officer can shout "Right." "Left," "Stop her." "Explode," and so on. In the experiments at Willet's Point sometimes the operator never raises his eyes from the key-board.

Valuable improvements have been recently perfected which add largely to the value of the Lay torpedo. This torpedo is now submerged several feet which makes it invulnerable to shot or shell and enables it to strike a vessel below its armor. The superincumbent water also renders the force of the explosion many times more destructive than when exploded near the surface. The speed has been increased by imparting chemical heat to the motive power (carbonic acid gas), which gives it all the elasticity of steam without emitting any fumes or any smoke visible to the eye. A uniform rate of speed for the entire run is now attained in any kind of temperatrue at the rate of 18 miles per hour. This torpedo can now be operated at a distance of 2 miles, carrying in its magazine 200 pounds of dynamite, which may be exploded at any time through the insulated wire or by impact. It can be used with the same accuracy at night as by day, and as a small battery carried in one hand, is the only thing really needed outside of the torpedo for its practical use, it can be run from any point on shore or from an open boat in mid-ocean. The perfect control of its course and direction, the rapidity of its flight, the enormous charge of explosive, makes the Lay torpedo one of the most destructive weapons of modern warfare.

We will close this article with a description of the Berdan torpedo. In the Berdan system two torpedoes are used in place of the one in other systems. This system is of two-fold application: either (*a*), the first torpedo, which is explosive, strikes the net and blows it to pieces, and the second torpedo, also explosive, connected with the first by a line and following it at a distance of some thirty or forty feet, enters through the rent which has thus been made in the net by the first, and so reaches the ship; or (*b*), the first torpedo, which is non-explosive, merely strikes the netting, stops, and serves as a fulcrum for the second—the real and explosive—torpedo to work upon.

The second of these schemes is the one on which stress is laid. It lacks several objections to which the first is open.

In the first scheme each torpedo—the front and the rear one—resembles its fellow, each is explosive, the one is used to break up the netting, the other, proceeding through a clear passage, to break up the ship. The front torpedo is steered from the torpedo boat, and the rear one is guided by being connected with the first. Each has its own motive-power, but that of the first is somewhat greater than that of the second.

The second scheme is, however, the one which claims interest.

The first torpedo here resembles the second one except that it is not explosive, is steered by rudder-lines from the torpedo-boat, or from the shore, and that there are some peculiar contrivances in the second which cause it to makes its dive under the net when the first torpedo becomes fouled in it.

We will suppose the ship to be attacked sighted. The torpedoes are fired at it. Each proceeds with its own motive power, the second being regulated to need a slight assistance from the first, afforded by means of a thin rope or wire cord. When the netting is reached the first torpedo will stop; the cord between the first and second torpedos, formerly taut at once slackens and lets fall a species of rudder ledge or trap underneath the centre of the second torpedo. This projecting ledge being caught by the water as the second torpedo advances, it is sufficient to drag the torpedo down into the water, where it will progress at an angle of 15 degrees to the surface. In this manner it will dive under the ship's netting.

Having gone the length of the tow-line the torpedo will be brought sharp up to the surface again; the surface in this case being the ship's bottom, not protected, as its sides are, by iron plates. Striking here the explosion follows. When the ship is not protected by nets, the only change made in the system is by using a shorter towing line. To speak more precisely, the rear torpedo does not float on the surface as it follows the first, but is balanced to sink a few feet below water, and so to escape destruction from the ship's shot. The entire length of the torpedo is 31 feet; its width at midship section is 21 inches; its depth 31 inches; its displacement 2,800 pounds. The explosive substance is gun-cotton or dynamite to the amount of 100 kilogrammes. This explosive is fired by a new apparatus, by a small copper pin being cut off when the impact takes place against the ship. A very slight shock is enough to effect this, far slighter than that required in the hitherto invented machines. Upon this pin being cut it liberates a bolt which shoots against the cap of an ordinary rifle-cartridge, and the explosion follows. The motive power of the torpedo, a very important point, is more or less new. This power is gained by the combustion of 3 rows of 4 one-hundred-pound rocket tubes filled with rocket powder; and this powder is compressed with a mixture of clay which secures regular burning and the time required for the torpedo to run a distance of one English mile at the rate of twenty-four miles an hour. The pressure of gas given off will be about 2,000 lbs. to the square inch; but, if required, it may be increased safely up to 5,000 lbs. The gas generated by combustion of the rocket powder rushes through a nozzle and acts upon several compartments of a turbine which revolves the torpedo's screw, thereby increasing the power about 1,200 per cent. above that of the old system of reaction, that is of the gas acting directly upon the water.

The torpedo can, again, be steered from the torpedo-boat with accuracy throughout its entire course. The steering apparatus is new, and a result of General Berdan's investigations in cable-laying thirty years ago. It consists *inter alia*, of two grooved wheels with a mile of fine plaited linen cord passing over dynamometers. Pressure is put on by friction breaks worked by two levers. In this manner the torpedo can be steered from leaving the torpedo-boat to being fouled in the net. The second torpedo, as we have said, has no special steering apparatus; its direction is determined by that of the first.

The steering is greatly facilitated by the fact that the steering lines and the drag of the second torpedo keep the stern of the first always directed towards the steersmen. As the first torpedo also runs just below the water line, a disc 3 or 4 feet above the water is used to steer by in the daytime and a lamp reflecting only to the rear is used at night. Against torpedo boats or wooden ships the first torpedo only is used.

To conclude, the four great points of novelty in the invention, are 1, its steering apparatus; 2, its motive-power; 3, these torpedoes can be launched from shore from boat davits on any ship, or from a railway truck, from the torpedo boats built expressly for this purpose; in fact, they can be launched from any part of the coast or from any ship without any special preparations or arrangements for that purpose; 4, the use of a pair of torpedoes acting together instead of a single one. The last point is in fact the characterizing one of the invention.

A joint Commission was recently appointed by Sweden, Norway and Denmark, for the purpose of determining the amount of the charge necessary to be employed in a surface-torpedo exploding a few inches below the surface of the water. The report of this Commission shows that the formula obtained calls for large amounts of dynamite or gun-cotton to produce the effect required. "For 5-inch armor this equation calls for 82 lb. of dynamite No. 1; for 6-inch armor, 119 lb.; for 8-inch armor, 211 lb.; for 10-inch armor, 330 lb.: and for 24 inches, the belt plating of the *Inflexible*, 1,900 lb." The charge of the Berdan torpedo is 221 lbs. (100 kil.) See *Lay Torpedo, Locomotive Torpedoes, Torpedo Boats*, and *Submarine Mines*.

TORQUED.—In Heraldry, twisted or bent. Said of a dolphin haurient, which forms a figure like the letter S.

TORQUES.—A species of gold ornament, meant to be worn round the neck, which was much in use in ancient times, both among Asiatic and north European nations. It consisted of a spirally twisted bar of gold, bent round nearly into a circle, with the ends free, and terminating in hooks, or sometimes in serpents. These ornaments seem to have formed an important part of the wealth of those who wore them, and of the plunder obtained by the Roman Conquerors from a Celtic or Oriental Army. A monument erected to a Roman soldier not unfrequently specified the number of torques that had been conferred on him. Numerous examples of the torques have been dug up in Great Britain and Ireland, as well as in France, and are to be found in archaeological collections. Both in Europe and in Asia, the torques resembled one form of bracelet on a larger scale.

TORSIONAL STRAIN.—In torsional strains the main lever of the testing-machine is inoperative. The recorded breaking weight then is only two hundred times greater than the actual weights on the platforms, which is equal to one-tenth of the usual reading in other tests. But as the torsion lever is 30 inches long from its axis to the point where the center of the chain acts upon it, the weight as above ascertained, is multiplied by 30, and the product represents the strain exerted at a point 1 inch from the axis of the strained bar. In practice, it is found more convenient to read off the weights for torsion in the same manner as in other tests, and to multiply that reading by three.

Although one end of the bar is firmly fixed it will yield a little by its compression on the keys, and therefore its angular deflection is determined by the difference between the reading on the arcs. The deflections of the bar is noted at each addition of a certain number of pounds of pressure; and at each addition of, say, 500 or 1,000 pounds, the bar is released from strain and the permanent set ascertained. The greatest angle of deflection and the breaking weight are also recorded. The torsional strength is—

$$S = \frac{W\, r}{d^3},$$

in which W = breaking weight; r = radius of torsion lever; d = diameter of specimen. See *Rodman Testing-machine*.

TORTU D'HOMMES.—A particular formation which was formerly adopted by the besieged when they made a sortie.

TORY.—A political designation taken, it is stated, from savage Irish tribes, and originally applied to the followers of the Duke of York, afterward James II. Johnson defined the Tory as "One who adheres to the ancient Constitution of the State and the Apostolical Hierarchy of the Church of England." The present "Conservative" party of England is the historical successor of the Tories. In this Country during the Revolution the adherents of the Crown were called Tories. A curious local use of the word was that of the common people in some parts of the South during the Civil War, applying it to irregular troops or "Bushwhackers" claiming to be federals.

TOSHACH.—The name which was given among Celtic nations to the military leader of a clan or tribe, whose functions were in early times always separated from those of the supreme judicial officer. When the office of Toshach, originally elective, became hereditary, according to the principle of divided authority characteristic of Celtic communities, it remained permanently in the eldest cadet of the clan.

TOTEM.—The ruder races of men are found divided into tribes, each of which is usually named after some animal, vegetable, or thing which is an object of veneration or worship to the tribe. This animal, vegetable, or thing is the *totem* or *god* of the tribe. From the tribe being commonly named after its totem, the word is also frequently employed to signify merely the tribal name. Numerous tribes with totem exist in America, in Australia, the South Pacific Islands, and in Central Asia; and there are some reasons for thinking that such tribes were once numerous even in Europe among races belonging to what is called the Indo-European division of the human family.

Among the red Indians of America the following are totems of tribes existing or known to have existed: the wolf, bear, beaver, turtle, deer, snipe, heron, hawk, crane, duck, loon, turkey, musk-rat, sable, pike, cat-fish, sturgeon, carp, buffalo, elk, reindeer, eagle, hare, rabbit, and snake; the reed-grass, sand, water, rock, and tobacco-plant. Among the tribes of native Australians the totems are similarly, for the most part, selected from the fauna of the country. The totems of the Kirghiz tribes of central Asia are all of them animals, to which (in explanation of their reverence for them) the tribes trace back their descent.

It has been suggested that the explanation of the crests and emblems of the now disrupted tribes and clans of our own Country, and of Europe generally, is to be found in the supposition that the creature or thing on the crest was originally the totem of the clan or tribe. On this supposition the wide-spread clan Chattan or Cattan, for instance, which is represented in the Scotch Highlands, and can be traced in France, Germany, and Egypt, would fall to be recognized as the *cat* tribe, the cat having once been its *totem*, as it is still its crest or emblem. It has also been thrown out that many of the mythical traditions of ancient Greece admit of a reasonable meaning, if we suppose that there were anciently in Greece tribes with *totems*—bull, boar, and lion tribes; snake, ant, and dragon tribes.

TOUCH.—A military term, signifying that a man in the ranks is feeling the elbow of the man next to him.

TOUCH-BOX.—A box containing lighted tinder, formerly carried by soldiers, who used match-locks, to kindle the match.

TOUCH-HOLE.—The vent of a cannon or other species of firearms, by which fire is communicated to the powder of the charge.

TOUCH-WOOD.—The wood of willows and some other trees softened by decay. It is used as tinder for obtaining fire, from the readiness with which a spark ignites it.

TOUR—Anything done successively or by regular order; as, a *tour of duty*. All tours in the United States Army, as far as practicable, are regulated by roster. See *Roster*.

TOURBILLON.—In pyrotechny, a paper case filled with composition, with the holes for the escape of the gas so disposed as to cause the case to rise vertically in the air at the same time that it revolves horizontally around its middle point. It has light wings attached to it to direct its motion. See *Fireworks*.

TOURNAMENT.—A military sport of the Middle Ages, in which combatants engaged one another with the object of exhibiting their courage, prowess, and skill in the use of arms. The invention of the tournament has been ascribed to Geoffroy de Preuilly, ancestor of the Counts of Anjou, who lived in the 10th Century. France was its earliest *locale*, whence it spread first to Germany and England, and afterward to the South of Europe. A tournament was usually held on the invitation of some Prince, who sent a King-of-Arms or Herald through his own Dominions and to Foreign Courts signifying his intention of holding a tournament, and a clashing of swords in presence of ladies and damsels. The intending combatants hung up their armorial shields on the trees, tents, and pavilions around the arena for inspection, to show that they were worthy candidates for the great honor of contending in the lists in respect of noble birth, military prowess, and unspotted character. The combat took place on horseback, or at least was always begun on horseback, though the combatants who had been dismounted frequently continued it on foot. The usual arms were blunted lances or swords; but the ordinary arms of warfare, called arms *à l'outrance* were sometimes used by Cavaliers who were ambitious of special distinction. Tournaments were the subject of minute regulations, which in some degree diminished their danger. The prize was bestowed by the lady of the tournament on the Knight to whom it had been adjudged, he reverently approaching her, and saluting her and her two attendants. The period when tournaments were most in vogue comprised the 12th, 13th, and 14th centuries; and the place where the most celebrated English tournaments were held was the Tilt-yard, near St. James's, Smithfield, London. The church at first discountenanced tournaments, some of its decrees prohibiting persons engaging in them under pain of excommunication, and denying Christian burial to a combatant who lost his life in one. The church seems, however, to have looked with more favor on these combats after the middle of the 13th century. During the 15th and 16th centuries, tournaments continued to be held, but the alteration in the social life and warfare of Europe had changed their character, and they are rather to be regarded as State Pageants than as real combats. The death of Henry II. of France, in 1559, consequent on the loss of his eye at a tournament, led to their general abandonment, both in France and elsewhere, and there have been few attempts to revive them even as mere spectacles. A magnificent entertainment, consisting of a representation of the old tournament, was given at Eglinton Castle in 1839, by the late Earl of Eglinton: Lady Seymour was the Queen of Beauty, and many of the visitors enacted the part of ancient Knights; among them Prince Louis Bonaparte, afterward Napoleon III.—According to Ducange, the difference between a tournament and a Joust is that the latter is a single combat, while in the former a troop of combatants encounter each other on either side. But this distinction has not been always observed.

TOURNIQUET.—In surgery, a bandage which can be tightened or compressed to any extent. It is chiefly used to stop hemorrhage in cases of amputation, and is invaluable on the field of battle. In cases of emergency and in the absence of a surgical tourniquet, a silk or cotton handkerchief twisted tight by means of a stick passed through the slack, is a good substitute; a bullet or round stone being placed over the artery. See *Surgery*.

TOURS-MODELES.—These towers were recommended by Napoleon as reduits for coast batteries, and are very similar to the Martellos.

TOWER BASTIONS.—In fortification, bastions constructed of masonry, at the angles of the interior polygon of some works. They have usually vaults or casemates under their *terre-pleins*, to contain artillery, stores, etc.

TOWER FORTS.—The favor with which the views of Montalembert have been received in Germany has led to the adoption of his circular casemated towers, both as isolated forts, and combined in a system of detached works for covering a space to their rear for an intrenched camp, as at Lintz. These towers, in their interior arrangements, are the same as the defensive barrack already described; with the exception of those differences in the details of the construction which the difference in their plans would call for. They have several tiers of covered fire for artillery and musketry, and an open battery on top, the parapet of which is either of earth, or of masonry, according to the dimensions of the tower. In the towers of Lintz they are surrounded by a ditch, and the whole of the masonry which would be exposed to the besieger's batteries is covered by a glacis, leaving only the guns on top to have direct views on these batteries; the second tier firing under an elevation over the crest of the glacis mask. The ditch towards the interior is crossed by a temporary fixed and a draw bridge leading to the second story of the tower. The guns of the top battery are placed on a revolving platform, their carriages being of a peculiar construction to admit of the axis of the guns remaining parallel, so as not to have their shot diverge from the object to be reached, and, at the same time, to occupy as little space laterally as will just suffice for the service of the guns. An earthen parapet covers the guns on the side exposed to the besieger's fire, and one of masonry towards the interior. These towers, with the exception of the open battery, have the defects of divergent fires common to all works with a circular plan; and the open battery is liable to be rendered useless, or be ruined by a well-aimed shot or two, or a heavy shell falling on its platform. The tower without earthen masks can only be used with advantage in positions where it will not be exposed to being breached from a distance; and is a very good auxiliary in sea-coast defense, for points where the object is solely to prevent an enemy's vessels from making use of a safe anchorage on the coast. See *Fortification*.

TOWER OF LONDON.—In the early days of English history, a powerful fortress, on the left bank of the Thames, subsequently a state prison of mournful associations, and now a repository for small-arms and the jewels of the Crown.

TOWER OF WAR.—An ancient engine of war. The towers were supported on wheels: the lower story was devoted to the battering-ram, all the others were filled with archers and light-armed soldiers generally. The towers being brought up close to the wall, put the besiegers on a more equal footing with the besieged, in that they could discharge their missiles from the same height, and even, by means of a drawbridge, engage in hand to hand encounters on the top of the wall. It was a great effort with the besieged to destroy these engines by fire; to guard against which the tower was usually covered with raw hides or metal scales, hence the name of *testudo* (tortoise), which, eventually, the whole engine acquired.

TOW-HOOK.—An implement made of round iron, with a hook at one end, and a small hammer welded at the other. It is used for unpacking the ammunition-chests of field-carriages, the hammer being used for making any repairs on the strapped shot and shell and fixed ammunition, which may be found necessary, or for any other purpose.

TOWN-ADJUTANT.— Both the Town-Adjutant and Town-Major are officers on the Staff of a garrison. They are often veteran officers, too much worn for field-service. The pay depends on the magnitude of the trust. The Town-Major ranks as a Captain, the Adjutant as a Lieutenant. The duties of these officers consist in maintaining discipline, and looking after the finding of the batteries, etc. See *Town-Major*.

TOWN-MAJOR.—An officer who regulates all the duties of a garrison, such as the detail and supervision of garrison guards, the disposal of prisoners in the garrison guard-room, the roster of officers for garrison duties, the superintendence of military police escorts (a regiment is usually told off weekly for this duty), parole and countersign, hours for retreat, and preparation and issue of garrison orders.

TOY FUSE. The ordinary blasting-fuse is known in this country under the name of the *safety fuse* and Toy's fuse; in England, as Bickford's fuse. It consists essentially of a column of fine-grained gun-powder inclosed in flax, hemp, or cotton, and made up with different coverings, according to the use to which it is applied. When intended for immediate use in wet ground or under water, it is covered with varnished tape or gutta-percha. The fuses are somewhat uncertain in their rate of burning, but average about one yard in a minute. The ordinary varieties must be kept in a cool, dry place, and preserved from contact with oil.

TRABAND.—A trusty brave soldier in the Swiss infantry, whose particular duty was to guard the Colors and the Captain who led them. He was armed with a sword and a halbert, the blade of which was well sharpened.

TRABUE MAGAZINE GUN.– The receiver of this gun is bored through longitudinally for the breech-bolt, in line with the barrel, and also below the barrel, in line with the magazine, which is in the tip-stock. It is also cut away at the side, forming at rear a shoulder for locking the bolt, and at the same time an opening for inserting the cartridges into the chamber or magazine, and also for ejecting the empty shells.

The bolt is composed of three principal parts, viz: the body or locking-tube; the cocking-piece or hammer, into which the firing-pin is screwed; and the bolt-head, which carries the extractor. An arm of the latter is pivoted in a slot in the bolt-head; a small spiral spring bearing on the arm above the pivot causes the hook of the extractor to descend after it has passed over the head of the cartridge. The fron part of the firing-pin passes through the spiral spring and through the extractor arm, On the rear of the locking-tube is a small projection, which enters a corresponding notch in the front face of the hammer. When the bolt is unlocked, the projection, riding out of the notch, cams the hammer to the rear, withdrawing the point of the firing-pin within the face of the bolt.

The magazine is loaded through the receiver. The cartridges descend an inclined arm, on the inner side of the guard, when a finger on the under side of the bolt-head, forces them into the magazine. They are prevented from escaping from the latter by a spring-top, which is pivoted to the left side of the receiver and operated by a push-button. The lower end of the stop springs through an opening in the side of the receiver just in front of the mouth of the magazine. When the piece is to be used as a magazine gun, the push-button of the magazine-stop is pushed to the front, the first cartridge under the pressure of the magazine-spring backs up the inclined arm of the guard until its head is checked by a notch in the receiver. If the bolt then be closed, the finger of its head runs under the cartridge and raises its front, when the bolt forces the cartridge into the chamber.

When the piece is to be used as a single loader—which can only be done when the magazine is empty—the cartridge-follower runs out from the magazine and forms a floor, so to speak, to the receiver, so that the cartridge, on being inserted into the receiver, is in line with the barrel. The closing of the bolt then forces it into the chamber. This gun carries six cartridges in the magazine and one in the chamber.—See *Magazine-gun*.

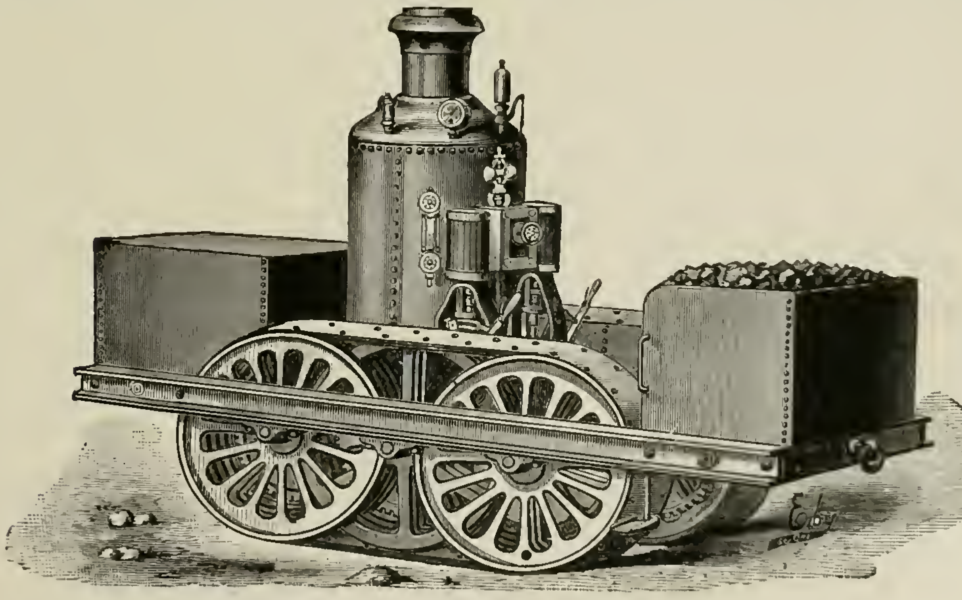
TRACES.—The straps, chains or ropes by which a carriage is drawn by horses. The minimum tension of the trace is obtained when its direction is perpendicular to the mean direction of the resistance conveyed by the pipe-box to the axle-tree arm, the prolongation of the trace intersecting the line of resistance at their point of contact. In the field-artillery the inclination of the traces is about 6½°. The horses can exert greater power, and that power will be more advantageously applied, by giving the traces some slope upwards from the carriage. See *Harness*.

TRACING.—After having determined upon the dimensions of the profile, and having selected the trace, the first step in building the work is to mark its outline upon the ground. This operation is called tracing. The operation of tracing consists in marking the sub-crest and other necessary lines upon the ground, so that they can be distinctly seen, and can be used to determine all other lines and points of the work. The tracing of a field work may be made by means of a drawing which represents the work to be constructed; or it may be made directly upon the ground without the use of a drawing. When a drawing is used, it is usual to take two points upon this drawing, which can be easily located upon the ground, and join these points by a straight line. This line is then taken to represent a base line which can be used in laying out the work. From the different angular and important points of the plan, perpendicular lines are drawn to this base line. The distances to the base line, and the distances intercepted upon it, are measured and noted upon the drawing. Going to the site, the two assumed points are located upon the ground, and a straight line is drawn through them. This line is the base, and is marked upon the ground either by a cord, or by a furrow in the ground made with a pick. The distances are then measured off on the base line, and the points marked where the perpendiculars are to be constructed. These perpendiculars are then constructed by some of the simple methods used for this purpose, and the distances to the angular points laid off on these. These points, thus determined, are then marked by stout pickets driven into the ground. The angular points are then joined by straight lines, and these lines are then marked upon the ground by a cord stretched between the adjacent points, or by a furrow made in the ground. The marking of these lines completes the tracing of the sub-crest. If there is no drawing, but the work is to be laid out directly upon the ground chosen, it is usual for the engineer to first select the salient points of the work, and mark them by stout pickets driven into the ground. He may then determine the re-entrants by inspection, or by some rule. Which method he will use will depend upon the kind of tracing to be made. The angular points, all determined, are then connected by straight lines, marked as in the previous case. See *Field-fortification* and *Profiling*.

TRACING IMPLEMENTS.—The pickets and cord used in making out the details of field-works. The *tracing-pickets* are 18 inches long and one inch in diameter. For ordinary use they are tied up in bundles with their bark on· but for setting out night-work the bark should be stripped off to make them more readily seen. The ordinary pickets used for fascines are from 2′ to 4′ long, and from $1\frac{1}{4}''$ to $1\frac{3}{4}''$ thick; those for setting out or tracing the works are 18″ long and 1″ diameter. The *tracing-tape* or cord is a strong white tape or cord usually 150 feet long, and divided off into spaces of 6 feet, a piece of tape 6 inches in length being sewed to each point of division. At each end of the tracing-tape a short piece of cord is attached to tie the tape to two tracing-pickets. The tracing-tape, for convenience, is rolled up into a ball.

TRACK OF ARTILLERY CARRIAGES.—The breadth contained between the two wheels of a carraige, measuring from the outer rim of each wheel. The track of the field-artillery carriage wheels is 5 feet 2 inches from outside to outside of the tire.

TRACTION ENGINE.—So little experience has been gained in the employment of road locomotives for hauling heavy guns, siege-trains, and transport wagons in time of actual war, that no reliable data exists for forming a practical opinion upon this subject. It has, however, for some time been the opinion of some of our most experienced engineers and artillery officers that steam-power may be advantageously employed as an important auxiliary to an army on the march. An engine can develop at least the power of 10 horses. It costs nothing when not in use. It can work night and day without fatigue or requiring rest, consequently its power is always at hand, and can be used at any moment and to the fullest extent. A road locomotive can be used as a fixed engine to use wood or pump water. It can be employed for transporting guns or other war material, and is specially useful in the neighborhood of a fortress, as the traction engine with its train would form a much more rapid means of communication with detached railway stations than ordinary carts or wagons drawn by horses or bullocks. The Prussians at Metz constructed a line 20 kilometers long, in order to skirt the fortress of the city, but it was not required as the garrison capitulated before its completion. In addition to the above uses, the engine can be so constructed that flanged railway wheels may be substituted for the ordinary sized wheels used on common roads, and it will then serve as a light railway locomotive in case the enemy may have destroyed or secured the rolling-stock on the existing railways. A traction engine for military purposes should be made as light as possible, and constructed almost entirely of wrought-iron, or steel, in order to diminish the chances of breakage. Its weight should not exceed 5 tons, with about 12 cwts. on the driving wheels so that it may be able to pass over pontoons as at present constructed, and also over temporary wooden bridges hastily made to repair the masonry or iron



blown up by the enemy. It should be furnished with a powerful windlass suitably arranged.

The drawing represents the Nixon traction engine, recently patented in the United States. The frame is constructed of four parallel I steel sills with cross beams at ends, and diagonal braces throughout, except at base of boiler, giving stiffness to frame, and supporting at ends the coal tender and water tank, thereby giving equal distribution of weight and balance on the tracks. The parallel sills are 24 inches apart from centers, to which are attached on the under side of sills, by adjustable boxes, three axles on each side. On these axles are firmly keyed three driving wheels of 2 and 3 inch faces, with a space of 2¼ inches apart on axles. On the front and rear axles are four wheels; the first and fourth, or outer wheels are 3-inch face, and are flanged with flanges on outside of wheels to prevent track from slipping off in turning. The center axles have three wheels of 2-inch face. The gangs of wheels intermesh or overlap each other; the tiers of center gangs work close to the hubs of front and rear gangs. Revolving over with these gangs of wheels are two tracks of rubber or other suitable elastic material composed of an inner layer, outside of which are transverse wood or metallic bars, secured through layer and plates by rivets or bolts, to retain the track in shape transversely. The gangs of wheels are driven forward or backward, or the one track forward and the other backward in turning, by spur gears secured to inside of wheels; front and rear gangs are connected by idle gears on center axles. The center axles are driven in the same direction by spur gears on axles, of the same diameter as those on front and rear axles. Positive driving motion is given by long pinion to all six axles from reversing yacht engines, one on each side of upright boiler for each track. The approximate width of each rubber track is eighteen inches; thickness, four and one-half inches; height of wheels, four and one-half feet; length of track in contact with the earth, sixty inches; hence $60 \times 18 \times 2 = 2,160$ inches of earth contact or traction, over which is distributed the weight of engine and that part of track not in contact with the earth. This engine's tracks have no loss of power by suction or adherence to the ground if the ground is wet, therefore no loss of power by carrying its tracks forward. The tracks cannot be broken by passing over an obstruction, as the rubber will give to the wheels until the wheels rotate over, and then instantly return to place. There will be no sticking on an obstruction for each gang of wheels are drivers, and will propel, if only one is in contact. The adherence of the tracks to the periphery of the one-half of the front and rear gangs and the bottom and top of the center gangs of wheels insures no slipping of wheels on the tracks, when worked to its fullest power on steep inclines. The rubber tracks supporting the engine will act as cushions to take all jar from the whole machine on uneven, stony ground or street crossings in towns. This should save a machine and wear one-third longer before repairs are needed. The tracks are to be built of rubber, which is durable and will not chip by flint or stone; their durability has been fully tested as auxiliary ties or covering for tires, to obtain traction in England where the iron tires were soon damaged by the flint. See *Steam-sapper.*

TRAIL.—1. In a field-carriage, that part of the carriage which rests on the ground when unlimbered, and which is hooked on to the pintail of the limber when limbered up. The beam of the earlier gun-carriage is made of one block, or of two pieces of timber tabled together; under either circumstances it is termed a *block-trail* carriage. Since the introduction of iron carriages the block-trail carriage has been abandoned, and the bracket-carriage is now the service pattern. The trail of a siege bracket-carriage is formed by the extremities of the cheeks which rest on the ground.

2. The difficult art of trailing or tracking is of great importance in Indian warfare. While it is impossible for most white men to acquire this faculty, the constant exercise of the *bump of locality* through successive generations and the thorough investigation of every "sign," have rendered all Savages sure guides over boundless prairies and through pathless forests. A "trail" is made up of various signs or evidences that something has been present. All marks left on the ground, rocks, grass, trees, or brush—the form, size, stride and directions of footprints and the firmness of impression, should be carefully noted. It should be made an invariable rule, when halting or camping, to make a reconnaissance of the ground in the neighborhood, with a view to ascertaining if any living thing is near or has lately passed. The footprints of animals, their gait and direction, whether slowly walking (as in the act of feeding) or running (as when frightened), are all very significant signs. Much valuable information may be gained by carefully observing signs; but to follow a trail successfully, one must not only possess a thorough understanding of all signs, but also a knowledge of the character and habits of the thing trailed, the general features of the country round about, and the powers of the eye and ear must be cultivated to a great degree of acuteness. The Indian well knows that the trail is his principal weakness, and he is never at a loss to resort to some ruse to complicate it, such as traveling over rocks, along the channels of streams, etc. He seldom thinks of danger ahead, but always keeps a proper rear-guard in position, and strongly fortifies his camp toward the rear. When closely pursued, a party of Indians will scatter and travel singly or in small detachments; and usually when the pursuers follow a single detachment, it will travel over the roughest and almost impracticable country, and make a detour of many miles. When the trail is leading toward some pass, *saddle* or low ridge, or well-defined landmark and suddenly becomes indistinct, it is generally safe not to expend time in hunting it; but to push rapidly on to the pass, etc., where the trail will in all probability be found again. Before scattering, a point for concentrating is generally agreed upon.

When traveling over an unknown country, the Indian is guided by his nomadic instinct and the information received from those who have visited the section before. This fund of knowledge is very great. It is related that an Indian scout became quite noted for the accuracy with which he could designate suitable camps and the various physical features of the country, relying *entirely* upon the information received from his father, who hunted in the same locality years before. Traveling Indians usually set up mounds of stones to indicate the route and various other items of information, to those who may follow. In a timbered country, where the trail is frequently covered with snow, the stones are placed in the forks and branches of the trees; or, the trees are *blazed* so that the notches face the traveler and at least two of them may be in sight at once. The Indian seldom refers to the sun, moon or stars for his direction when traveling; but places his confidence in something nearer at hand, which he believes to remain in the same place and which he thoroughly comprehends. The trailer should not allow anything deviating from the common order of things to escape a rigid investigation. A close scrutiny will generally reveal both the plan and purpose of every active living creature. While keenly alike to all sounds, he should be able to unmistakably recognize the most ordinary, such as the croaking of frogs, the barking of coyotes, the hooting of owls, the cry of panthers or wolverines, the screaming of hawks and eagles, the creaking of limbs, etc. When trailing Indians, it is often important to know the especial customs of the various tribes. With this knowledge, the examination of the deserted camps, halting and resting places will invariably reveal the identity of the tribe once there; the fashion of fire making, the style, cut and finish of the moccasin, the form of lodge, etc., are all unmistakable evidences. This information is very useful when hostile and friendly Indians occupy the same country, and it is necessary to be able to distinguish between their trails.

Various circumstances connected with the trail will afford important information. Indians, when walking, point the toes inward, whether in moccasins or other gear. Many white men, in the Indian country, wear moccasins, but they leave a track with the toes turned outward. The various patterns of boots and shoes leave their distinctive tracks, and the particular way in which a boot or shoe has been pegged or repaired will enable an astute trailer to follow its print among hundreds of others. A careful notice of the form and depth of the impressions will generally indicate whether the person carried a burden or not; whether traveling at will or in haste; whether sober or intoxicated. The age of the track may be determined in various ways. If rain has fallen, it may be seen whether the tracks were made before, during or after it, by carefully noticing the grass, etc., trodden down, and observing whether or not sand or anything adheres to it. The morning or evening dew upon the trail will also furnish a test of time. The position of the grass, the sand, dust, etc., drifted from or upon the track will serve to determine its age relative to the blowing of the wind, or its sudden change of direction. Should there be several tracks, and the time when one was made be known, the ages of the others may be determined by noticing where they cross and observing which overlies the others. When the trail becomes lost in an unfavorable locality, it is best not to consume time in hunting it, but to proceed in the probable direction until a favorable ground is found, and then hunt it. In a grassy locality, or in plains of coarse sand or shingle, the trail is seldom visible at short distance, but may be noticed by looking out well ahead. In a rocky country, or where the ground is very hard, when it is desirable to ascertain the track of a prowling enemy or animal, the Indians usually sprinkle sand (if obtainable) over the trails in suitable places. This is an old trick, for it is said in the Apocrypha that the prophet Daniel did this when he wished to ascertain who it was that nightly consumed the meat which was placed before the idol of Bel.

Frequently, when the ground is very hard or rocky, a close examination will reveal sign, in the shape of stones or pebbles turned so as to lie with that side up, which has formerly rested on the ground. In such places, flakes of foam, fragments dropped from the animal's mouth, or minute blood specks (when trailing the wounded) are great helps. A bare-footed person, when passing over hard rocks, will leave a sign, in the shape of fine dust caked by perspiration. If there be marks of lodge-poles upon an Indian trail, they may be regarded as a peaceful indication, and showing that the Indians passed with their families, lodge-material and effects; if there be no such traces on the trail, it is an equally good sign that a *war* or *hunting* party passed, as they always leave such impedimenta in a place of safety. It might be desirable to ascertain whether or not some members of an escaping party of Indians are women: this may be frequently determined by following the trail until a place is found where they have stopped to rest and smoke. The men sit cross-legged, and when sitting down cross their feet (locked closely together) and slowly lower their bodies to the sitting posture. The women sit with both feet and lower legs turned under, either to the right or left.

It is often very difficult to rapidly follow horse or pony tracks over rocks or any very hard ground. When they pass over grass without treading it down, the trail is shown by the grass assuming a different shade of color from that about it. The appearance of horse or pony tracks is very different at a *walk*, *trot* and *gallop*. The Indian pony is seldom or never shod, and the distance between his tracks (walking) is about 2 feet and 10 inches. The track may be readily distinguished from that of the American horse (larger and generally shod), or that of the mule (about the same size, but narrower and more angular). When the pony trots, the tracks are from 6½ to 7½ feet apart, the impressions less distinct and more irregular. In the gallop, they are from 8 to 9 feet apart, and unless the ground is very hard, there are no distinct impressions, but a mere disturbance of the earth.

A careful study of the impression left on the ground will serve to determine the pace at which the animal was moving. A walking or feeding horse should leave a well marked track, and a sudden scattering of earth, sand or gravel would indicate fright and an increased pace. A knowledge of the movements of the pony, will frequently give valuable information regarding the rider—whether he is moving leisurely and is subject to surprise, or whether he has discovered his pursuers and is moving rapidly on in order to avoid a conflict. To determine whether the horses have riders or are running loose, follow the trail until ordure is found: when scattered along the trail, it is a sure sign that the animal was ridden and not permitted to stop. An equally good test, is to follow the "trail" into a woods and observe whether or not it lies under any branches of the trees too low to permit the easy passage of a mounted man beneath them. An Indian rider always mounts and dismounts from the right side, and by noticing the places where the mounts and dismounts are made, it may be ascertained whether the rider is an Indian or a white man. The moisture where the earth is removed and the droppings along the trail are good indications of the age of the tracks. Where water has been crossed, the ground will, for some distance beyond, be wet, and show where drops of water have fallen from the animal's body or legs or where it has been splashed while in the act of crossing. Tracks on snow may be followed with great rapidity, but it is frequently difficult to distinguish between those left by different animals. The mode of shoeing, any defects in the hoofs or shoes, and whether shod all around, on the fore feet only, or not at all, should be carefully noted, as such items are sure to furnish valuable information at some time or another. Much may be learned of the Indian's condition by carefully observing the nature of his trail and camping places. Should abandoned property or comparatively valueless articles be left along the trail, and should there be indications of disorder generally, it is evident that he has experienced demoralization.

TRAIL ARMS.—A position in the Manual of Arms executed as follows: The Instructor commands—

1. *Trail*, 2. Arms.

Same as the first motion of *order arms*. (Two.) Incline the muzzle slightly to the front, the butt to the rear; drop the left hand by the side.

1. Carry, 2. Arms. At the command *carry*, bring the piece to a vertical position with the right hand, the little finger in rear of the barrel; at the command *arms*, execute what has been prescribed for the *carry*, from the position of *order arms*. See *Carry Arms* and *Order Arms*.

TRAIL BRIDGE.—Ferrying is usually performed by means of boats. But when boats cannot be had, or when there are not enough of them, the ferrying may be done by using rafts, or some other buoyant arrangement. The boats and rafts may be propelled by oars, they may be drawn across by ropes, or they may be made to move by the action of the current. The simple rope ferry is frequently seen in use over streams of moderate width and with a sluggish current. A rope is stretched from bank to bank, and men, standing on the raft or in the boat, seize the rope by their hands and pull the boat along. When the boats are made to cross by the action of the current, the method is known either as the trail bridge, or as the flying bridge. In the trail bridge, a rope is stretched across the stream, and drawn very tight, to keep it above the water. The boat is attached to this rope by a pulley, and is made by means of its rudder, to have its side make an angle of about fifty-five degrees (55°) with the direction of the current. The force of the current acting upon the side of the boat may be divided into two components, one parallel to the rope, and the other perpendicular to it. The latter component is balanced by the connection of the boat with the rope; the other component drives the boat across, the pulley allowing motion in that direction. This method requires a velocity in the current of not less than three feet a second, and a width of stream not greater than one hundred and fifty yards.

The flying bridge is employed when the width of the stream is too great for the use of the trail bridge. The principle of the flying bridge is the same as that of the trail bridge. The difference is in the details employed.

In this bridge, instead of stretching a rope across the stream, a cable is used, one end being fastened to the boat, or raft, and the other end anchored in the stream. This cable is supported at intermediate points by small boats, casks, or other means, to keep the cable above the surface of the water for the necessary distance.

All these methods of crossing a river are frequently used, and possess peculiar merits. But when large bodies of troops with their transportation are to be crossed, they do not offer all the advantages of the bridge. See *Bridges*, and *Flying Bridge.*

TRAIL-EYE.—An attachment at the end of the trail for limbering up. See *Lunette* and *Traveling-carriage.*

TRAIL HANDLE.—A traversing handle attached to the trail of the new field-guns. It is made of iron, T-shaped, and fixed to the trail in such a manner that it can be laid flat on it, when not required, without being unshipped. This handle has been in use with the late Indian artillery batteries for many years past.

TRAIL-HANDSPIKE.—A handspike for field-carriages, 53 inches in length, and usually made of hickory or young oak. See *Handspike.*

TRAIL-PLATE.—The ironwork attached to the end of the trail which includes the trail-eye. This eye or loop is fixed in the new carriages, and forms a part of the trail-plate. Swivel loops were formerly used in the Madras carriages, and they are said to have had this advantage, that, if the gun-carriage upset, it did not entail the fall of the limber.

TRAIN.—1. A line of powder, laid to lead fire to a charge, or to a quantity intended for execution. When several charges are to be fired at the same moment, it is necessary so to proportion the trains to explode them, that, starting from the same point, the distances in time from that point to the charges may be all equal. The following cases show the manner of obtaining this result. For two charges place a trough on the shortest line from the one to the other, mark the centre of it, and let the principal trough join it in that point. For three charges connect, as above, the two which are nearest. Let a trough lead from the middle point of this to the third charge; bisect the whole length of trough between this third charge and either of the others: then let the principal trough be joined to this last point. For four charges first connect them two and two, then join the central points and proceed as above. The elbows of a trough impede the communication of the fire, for which an allowance must be made when proportioning the trains, each elbow being valued at 3 in.: thus if on one side of the point where the principal trough connects is one elbow more than on the other, the principal trough should be placed 3 in. nearer to the charge on that side, which is done by placing it 1½ in. from the central point towards that side. Square elbows impede somewhat more than oblique ones. Experience has shown that two trains may be placed within 18 in. of one another if covered with earth, and exploded separately without interference.

2. The carriages and animals laden with provisions or warlike stores, required for an army in the field.

The train is usually divided into four sections. If money or powder form a part of the train, it should occupy the center of the second section, as this point is usually best protected. The provisions and other munitions will be distributed equally among the other sections; so that, should any one be cut off by the enemy, a portion of each kind may be saved in the remainder. As it takes some time to set the whole column in motion, the horses are harnessed and hitched to successively, by sections. The second section will not commence to harness until the first is ready to move off, and so on in succession. The time for this operation will be ascertained by the officer in charge of the convoy; so that each section may be notified of the proper moment to prepare for the march. This should be done in order not to fatigue the horses unnecessarily, by keeping them standing in harness. The train marches in single or double files, according to the state of the roads. The files should not be doubled unless the road is wide enough for three files; and also when the train can march in this order at least an hour; otherwise there will be too great inconvenience and loss of time in changing the order of march. To pass from single to double file, the hindmost wagons of the first and third sections will lead off to the side of the road; and so on each in succession to the one at the head. The leading wagons of the second and fourth sections move briskly on in their new line of direction, followed by those in their rear, until they come up with the leading wagons of the other two sections. An interval of four paces should be preserved between the files. To change from double to single file, the first section quickens its pace, and when its last wagon has passed the leading wagon of the second section, this and the rest of the section follow in the new line. The greatest attention should be paid to preserve regularity and good order in the march. For this purpose, small detachments of infantry, taken from the center division of the escort, should march at intervals on the flanks of the train. When the number of men will admit of it, each wagon should be under the guard of a soldier, or at least of one man to three wagons. If neither of these arrangements can be made, each section may be placed under the charge of four or five horsemen, who will keep in constant motion along the line, to see that all goes on well. If, for any purpose, a wagon is obliged to halt, it must fall out of the line, and not be allowed to enter it until the rear wagon of its section has passed. The line should be kept well closed up; the leading wagons slackening their pace, to allow the others to come up, if retarded by any intervening obstacle.

When from any cause the train is forced to halt for some time, as for the repair of a bridge, the passage of a defile, etc., the wagons should be parked either in lines of sections, or as many in line as the character of the ground will admit of. An interval of about twenty paces may be left between each line. If there is any apprehension of an attack under these circumstances, the lines may close to within fifteen paces; the openings on the flanks being covered by wagons placed across them. When the train halts to park for the night, a strong position should be chosen, offering only one side, if practicable, to an attack. The park may be formed by lines of sections or in squares, as may be deemed most advisable. The faces of the park should be flanked by some pieces of artillery, and the angles be covered by any temporary obstacle, as a chevaux-de-frise, a slight abatis, etc. The different portions of the escort will take position around the park, to cover it from the enemy's approach; those divisions, which march with the convoy, being posted behind the wagons, and the obstacles which cover them. The usual dispositions of out-posts and patrols will be made, to guard against a surprise. It is not safe to park in villages, nor even to pass through them on a march, when any powder is in the convoy.

When the park is formed as a temporary intrenchment, to cover the escort against an attack, an open portion of ground should be selected, which offers no covers for the enemy to approach within musket-range. The wagons may be placed in one line, or in two if their number is sufficient to inclose the necessary ground for the troops, etc., so as to form a square, rectangular, or circular figure, as the locality may require. When the inclosure is formed of a single line of wagons, they are placed wheel to wheel, with an outlet of three or four feet between every six wagons: a wagon being placed, six paces to the rear of the line, behind each outlet to close it. If the inclosure is a double line, the wagons are placed end to end; and wheel to wheel, outlets, as in the preceding case, being left between every four wagons, and closed as before. The poles of four-wheel carriages, are placed outwards; the shafts of the two-wheel inwards; the horses picketed opposite their wagons. The wagons that contain ammunition, or valuables are placed within the inclosure, at the point regarded as least exposed. If the convoy is surprised on a march, and have not time to park in square, the files should be rapidly doubled if moving in single file, the heads of the horses be turned towards the center of the road, so as nearly to touch each other, and the wagons be brought as closely together as practicable. See *Convoy* and *Field-service*.

TRAIN-BANDS.—A force of militia, not differing essentially from that force, substituted by James I. for the old English fyrd, or national militia. The train-bands of London were chiefly composed of apprentices; and their unruly doings formed the subject for many facetious plays and tales. In the civil wars, the train-bands sided with the Parliament; and Charles II. restored the militia on its old local footing.

TRAINER.—In the United States, a militiaman, when called out on *training-day* for drill, exercise, or discipline.

TRAIN-TACKLE.—A purchase by which a gun-carriage is secured to a ring-bolt in the platform or deck, to prevent running out while loading.

TRAITOR—One who violates his allegiance and betrays his country; one guilty of treason; one who, in breach of trust, delivers his country to its enemy, or any fort or place intrusted to its defense, or who surrenders an army or body of troops to the enemy, unless when vanquished: or one who takes arms and levies war against his country: or one who aids an army in conquering his country. See *War-traitor*.

TRAJAN'S WALL.—A line of fortifications stretching across the Dobrudscha from Czernavoda, where the Danube bends northward, to a point of the Black Sea coast near Kustendji. It consists of a double, and in some places a triple, line of ramparts of earth, from 8¾ to 11 feet in height on the average (though occasionally it attains an altitude of 19½ feet, bounded along its north side by a valley, which, being generally marshy, and abounding in small lakes and pools, serves admirably the purpose of a fosse. This valley was long erroneously supposed to have been at one time the channel by which the Danube emptied itself; and a scheme for utilizing it by the construction of a canal to provide a more commodious water-communication with the Black Sea, in lieu of the long and troublesome navigation by the Sulina mouth, has been frequently mooted, and is undoubtedly quite practicable; but the cost of the undertaking has hitherto been a bar to its execution. During the war of 1854 Trajan's wall became an important line of defense on the invasion of the Dobrudscha by the Russians, and the invaders were twice defeated in their attempts to pass it—at Kostelli (April 10) and Czernavoda (April 20 to 22).

TRAJECTORY.—A body projected in space in a direction inclined to that of gravitation is acted upon by two forces, *the force of projection*, which, if acting alone, would carry the body onward forever in the same direction and at the same rate; and *the force of gravity*, which tends to draw the body downward toward the earth. The force of projection acts only at the commencement of the body's motion: the force of gravity, on the contrary, continues to act effectively during the whole time of the body's motion, drawing it further and further from its original direction, and causing it to describe a curved path, which, if the body moved in a vacuum, would be accurately a parabola. This is readily seen by considering Fig. 1, in which A represents the point from which the body is projected (suppose the embrasure of fort): AB the direction of projection (horizontal in this instance); A1 the distance which would be passed over by the projectile in one unit of time if gravity did not act; 1—2, the distance which would

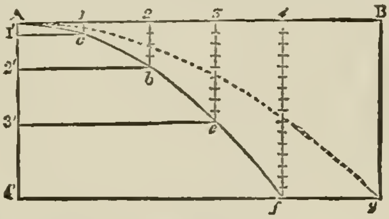


Fig. 1.

similarly be described in second unit of time; 2—3, 3—4, etc., the distances corresponding to the third, fourth, etc., units of time—all these distances being necessarily equal, from the impulsive nature of the force of projection; A1′, again, represents the distance which the projectile would fall under the action of gravity alone in the first unit of time; 1′—2′ the distance due to gravity in the second unit of time; 2′—3′ the distance due to the third unit, etc., the distance A1′, A2′, A3′, etc., being in the proportion of 1, 4, 9, etc. (see *Falling Bodies*); hence, by the well-known principle of the parallelogram of forces we find at once, by completing the series of parallelograms, that at the end of the first unit of time the body is at *c*, at the end of the second at *b*, at the end of the third at *e*, etc. Now as the lines, 1′*c*, 2′*b*, 3′*e*, etc., increase as the numbers 1, 2, 3, etc., and the lines A1′, A2′, A3′, etc., as the numbers 1^2, 2^2, 3^2, it follows that the curve A*cbe* is a parabola. As, by the second law of motion, each force produces its full effect undisturbed by the other, it follows that the projectile reaches *f* in the same time as it would, without being projected, have taken to fall

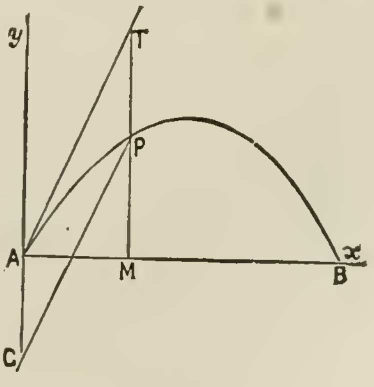


Fig. 2.

to 4′. A greater velocity of projection would make it take a wider flight; but at the end of four seconds, it must still be at some point in the same horizontal line—at *g*, for example.

In order to determine exactly the motion of a projectile, and to find its range, greatest altitude, and time of flight, it will be necessary to examine its nature more technically—for which some slight knowledge of algebra and trigonometry is requisite. Let the body in this instance be projected obliquely to the direction of gravity, from the point A (Fig 2) in the direction AT, and let the velocity of projection v be sufficient, if gravity were not to act, to carry it to T in t units of time, and let the force of gravity, if allowed to act upon it at rest, carry it to G in the same time; then, as before, the body, under the action of both forces, will be found at P (which is found by completing a parallelogram of which AT and AG are the sides) at the end of t units of time, having fallen through a distance equal to TP (not at once, but in a constant succession of minute deflections, as indicated in Fig. 1) in that time. Let t represent the time of flight, v the velocity due to projection, g the accelerating force of gravity, and let A be the angle of elevation TAB; then AT $= vt$, TP $= \frac{1}{2}gt^2$, TM $= vt$ sin.A; and consequently PM (or y) $= vt$ sin.A $- \frac{1}{2}gt^2$ (1.): and AM (or x) $= vt$ cos.A.

Now, if we find from the last two equations the values of t, and equate these values, we obtain by an easy algebraic process, the equation $y = x \tan. A - \frac{gx^2}{2v^2 \cos.^2 A}$: and if the height through which the body must fall to acquire a velocity equal to the velocity of projection be called h, then $v^2 = 2g.h$, $h = \frac{v^2}{2g}$, $4h = \frac{2v^2}{g}$, and $\frac{1}{4h} = \frac{g}{2v^2}$, substituting which in the equation, we obtain $y = x \tan. A - \frac{x^2}{4h. \cos.^2 A}$ (2), as the equation to the path of a projectile, where x is the horizontal distance, and y the corresponding height above the level of the point of projection. Suppose, now, that we wish to find the *time of flight* on the horizontal plane, it is evident that at the end of its flight the projectile will be at B, and y will be equal to zero: hence, putting $y = 0$ in equation 1., we obtain $t = \frac{2v \sin. A}{g}$. The *range* or distance AB is similarly found by putting $y = 0$ in equation 2., when x is found to be equal to $4h$ sin. A cos. A, or $2h$ sin. 2 A. The *greatest altitude* is evidently the point which the projectile has attained at the end of half the time of flight, or after it has traversed half its horizontal range, hence, by putting $x = 2h$ sin. A cos. A in equation 2., or $t = \frac{v \sin. A}{g}$ in equation 1., we obtain $y = h \sin.^2 A$. A slight examination of the expression for the range will show that it is greatest when the body is projected upwards at an angle of 45° to the horizon, and that a body projected at a greater angle than 45° has the same range as one projected at an angle correspondingly less. These results, however, do not correspond to the actual circumstances of the case, except when the projectile possesses considerable density and its motion is slow, for in all other cases, the resistance of the air, which increases in a rapid ratio with the velocity of the projectile, causes it to deviate very considerably from a parabolic orbit, especially during the latter portion of its course. The problem of the motion of a projectile thus complicated becomes of considerable difficulty; partly because our knowledge of the law of resistance of the air is imperfect (it was supposed by Newton to be proportioned to the square of the velocity), and partly because the law varies with every minute change in the form, size, and density of the body projected, so that, under these circumstances, the beautiful and simple theory sketched above is practically useless. The chief illustrations of the theory of projectiles are the motion of missiles thrown by the hand, or arrows impelled from a bow, in both of which cases the resistance of the air is comparatively ineffective, the velocity being small; in the far more important case of ball-practice, whether with firearms or heavy ordnance, its effects are so powerful as to render the laws of gunnery mere deductions from experience. The laws of the motion of projectiles, also the parabolic curves of falling liquids, may be beautifully illustrated and demonstrated with apparatus employed for the purpose. See *Didion's Formulas*, *Equations of Motion of Projectiles*, *Projectiles*, and *Resistance of the Air*.

TRAMRAIL.—The employment of the differential pulley in combination with an overhead rail and a trolley, as shown in the engravings gives rise to a most useful and economical machine in the foundry and arsenal. The track employed for this purpose consists of light I-beams, which can be easily curved and for which special forms of hangers, fish-plates, bolts, etc., have been designed, and which are also provided, where necessary, with switches and turntables. The trolley is arranged to run freely on the lower flange of the tracks, and is provided with four wheels or rollers, two on each side. The axles of of these wheels are inclined at such an angle that the bearing of the wheels coincides with the angle of the flange of the I-beam so that the wheels roll easily on the latter without wear or undue friction.

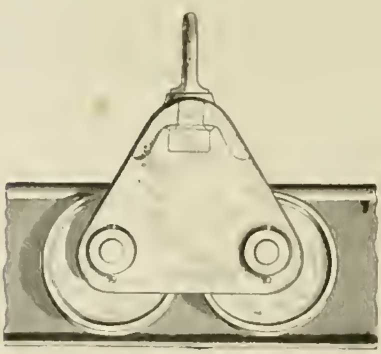


Fig. 1.

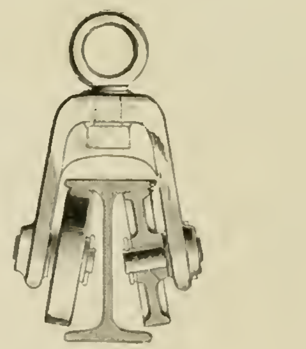
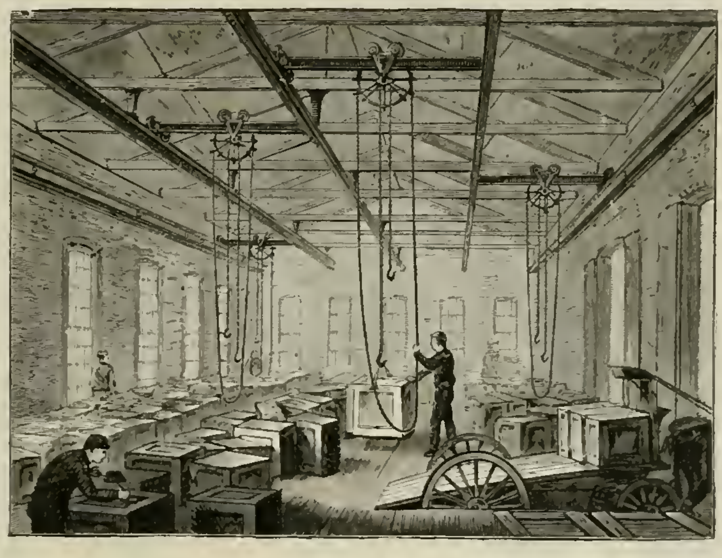


Fig. 2.

Fig. 1 is a side elevation and Fig. 2 is and end view of an overhead tramrail and trolley, showing clearly the arrangement of the several parts. The construction of the fish-plates, hangers, etc., is such that they avoid all interference with the passage of the trolley, and thus permit the track to be extended to any desired length, while by means of switches and turntables it can be carried to any desired points within a building or yard, and be made to cover the entire area of a warehouse or works. In short lengths, tracks of this kind are particularly useful over large lathes, planers and other machine-tools to assist the workmen in handling heavy pieces of ordnance. They are built of capacities for handling loads of all sizes.

The usual capacities are from 500 to 2,000 pounds, but they have been built of sizes to handle loads up to 10 tons. They are applicable to a wide range of uses, the precise construction and arrangement varying greatly according to the work to be done.

The following engraving represents another application of the system of overhead tramrails or transfer tracks consisting of two parallel rails, supported from above, with a light bridge or traveler running upon them, and this in turn provided with a trolley, so that the bridge can move longitudinally upon the rails, and the trolley be moved transversely on the bridge. By means of the compound motion thus obtained the entire space included between the two overhead tracks can be reached. The drawing shows this system as applied to a warehouse or packing room, and represents four pairs of overhead tracks, each carrying an independent bridge, so that the entire floor of the warehouse is covered by the apparatus. Special designs of hangers, bridges, trucks and trolleys have been devised in the development of this system of handling heavy weights, the details of which need not be here described. The system has already been extensively adopted with most satisfactory results. See *Differential Pulley-block* and *Trolleys*.

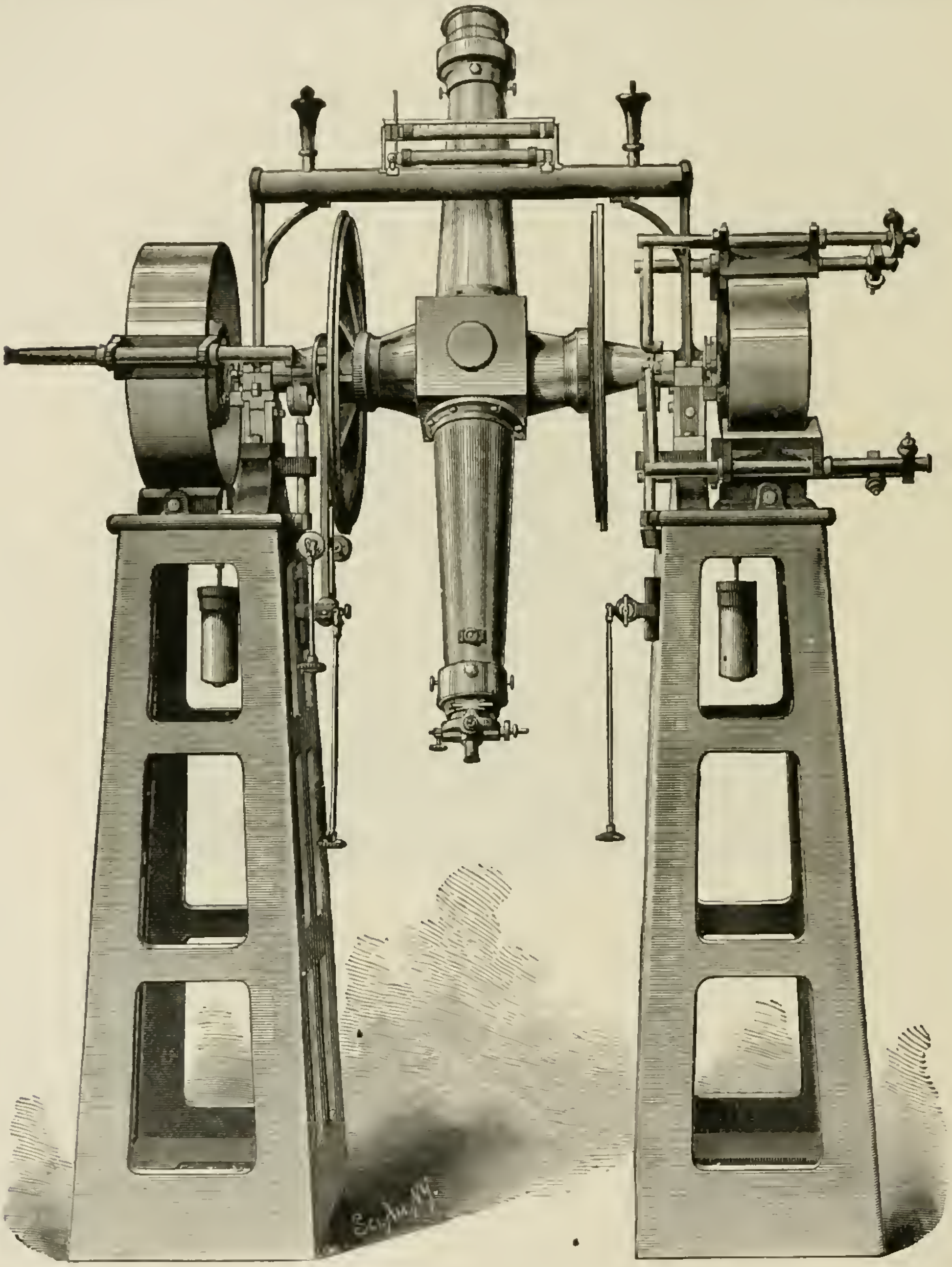


TRANSFER.—The permission granted officers and soldiers to exchange from one regiment or arm of the Service to another. The term is also applied to a soldier taken out of one company troop, or battery, and placed in another. In the United States Service, the transfer of officers from one regiment or corps to another is made only by the War Department, on the mutual application of the parties desiring the exchange. An officer is not transferred from one regiment or corps to another with prejudice to the rank of any officer of the regiment or corps to which he is transferred. Officers below the grade of Field-officers, transferred from one regiment or corps to another, on their mutual application, are renominated for reappointment with rank as of the date of the commission of the junior officer previous to the transfer, and upon confirmation by the Senate are recommissioned accordingly. These new commissions determine their rank in their regiments and corps, as well as in the Army. The same principle governs in exchanges of Field-officers from one corps or arm of Service to another. Field-officers of the same arm of Service may, on their mutual application, be transferred from one regiment to another without change of rank or commission, excepting in regiments that have in their organization more than one Field-officer of the same grade. If the result of the transfers would not affect the positions or precedence of other Field-officers of the same grades in their own regiments, the exchanges may be made in General Orders without alteration of rank or commission. The transfer or exchange of company officers in a regiment is not made without previous approval by the General of the Army. Temporary assignments of officers to do duty with other companies than their own are not prohibited. Non-commissioned Officers or soldiers are not transferred from one regiment to another without the authority of the Commanding General. The Colonel of a regiment may, upon the application of the Captains, transfer a Non-commissioned Officer or soldier from one company to another of his regiment,—with the consent of the Department Commander in the case of a change of post. See *Exchanges*.

TRANSFLUENT.—In Heraldry, passing or flowing through a bridge. Said of water.

TRANSFUGE.—One who abandons his party in time of war, and goes over to the enemy; a turncoat or deserter.

TRANSIT INSTRUMENT.—One of the most important of astronomical instruments, consisting of telescope fixed to a horizontal axis, so as to revolve in the plane of the meridian, and is employed, as its name denotes, in the observation of the meridian transits of the heavenly bodies. The axis, which is the most important part of the instrument, and thus demands the utmost care in its construction, consists of a hollow sphere or cube, to opposite sides of which are tightly fastened the bases of two cones in whose apices the pivots are screwed; the sphere or cube is pierced for the admission of the telescope, which is firmly soldered at right angles to the axis. One of the pivots is hollowd so that a stream of light can be directed from a lantern half way along the interior of the axis, and through an aperture in the side, into the telescope tube, where, being received by an annular mirror, set at 45° to the axis and telescope tube, it is directed to the eye-piece, and brilliantly illumines the field of view, while the annular form of the mirror prevents every interference with the passage of rays from the object under observation to the eye. The pivots must be very carefully turned to a perfectly cylindrical form, and fitted into the instrument, so that their axes are accurately in line. One extremity of the axis carries one and sometimes two small graduated circles, each supplied with index, clamping-screws, and vernier; these circles are capable of indicating angular measures to within 1′ or 2′. The pivots rest on massive blocks of stone or other stable material which is little affected by change of temperature, stability being the great mechanical essential of the instrument. This condition satisfied, there are three adjustments necessary before a transit can be observed; the axis must be horizontal; the line of collimation must be at right angles to the axis of motion; and the latter must be placed so as to point accurately East and West. On the perfection of the first two of these adjustments depends whether the telescope sweeps over a great circle of the sphere, and the third is necessary to insure that this great circle shall be the meridian of the place of observation. These adjustments can never be made quite perfect, and the usual mode is to investigate the amount of error in each, and allow for it in the apparent result. To note accurately the instant of time by the astronomical clock when the object (e. g., a star) is seen to pass the center of the field of view, is the essential part of a transit observation. The most effective method is to register the beats of the clock by an apparatus, which, at the end of each oscillation of the pendulum, marks a dot upon a uniformly moving slip of paper. This is effected by the agency of electricity, and is one of its most valuable contributions to astronomical science. At a certain point in each oscillation of the pendulum, it becomes a part of a complete galvanic circuit, the contact being immediately broken by its progression in its oscillation; and it is at these points



that the galvanic agency causes the dot to be made. The instant of any transit's occurrence is similarly noted by the observer, who, by a tap on a break-circuit key, fastened to the side of the transit instrument, causes the graver to make an extra dot; and the distance of this dot from the previous seconds one, compared with the distance between two seconds dots, gives the time very accurately, almost to $\frac{1}{100}$ of a second. Various ingenious modes of registering have been proposed, all founded on the above principles. It is from the times of transit of the several heavenly bodies thus accurately observed, that their right ascensions are determined.

The transit instrument was invented by Römer about 1690, and first described in 1700. One was erected in Greenwich observatory by Halley in 1721; but it was little used till 1742. The present instrument in that observatory is by Troughton, and was erected in 1816. The drawing shows the instrument as made by Fauth and Co., United States. The telescope has about 8 feet focal length and 6 inches aperture. The circles are three feet in diameter, and one is divided into five-minute spaces, which are read off by means of 4 micrometer-microscopes to single seconds. The microscope-holder is in the form of a pulley concentric with the circles, allowing the ready shifting of the microscopes to any part of the graduation. The other circle serves as a finder, and is provided with a coarse graduation. Clamp and tangents are by means of rods and handles. Illumination is regulated by means of a milled head near eye-end. The pivots are about two inches in diameter, made of hardened steel or phosphor-bronze. The level, of best quality, is read by means of a mirror. A right ascension and declination micrometer with a parallactic eye-piece motion is provided. The piers are of iron, are coated with asbestos, and usually covered with mahogany. When Messrs. Fauth and Co., in 1877, made the Princeton Meridian Circle, they guaranteed the graduation would be within one second. A critical examination by Prof. C. A. Young shows the graduation to be much better than that. Since then they have improved their dividing-engine to such an extent that they guarantee the graduation to be within one quarter second. See *Engineer's Transit*, and *Equatorial*.

TRANSMISSION OF POWER FOR MILITARY PURPOSES.—While the interest attaching to this subject is unquestionable, we are nevertheless very doubtful whether a successful result can be attained in one particular application, namely the establishment of large undertakings for distributing hydraulic power to a number of factories, either existing or contemplated, similar to the undertakings at Shaffhausen, Fribourg, and Bellegrade. At the first of these places, in spite of favorable circumstances, rapid extension of working, and good management, the profit has been very small on the capital outlay. The manufactories at the two places, being much less favorably situated, have failed after a short and profitable existence. Their failure has shown very clearly that their founders labored under a strange delusion in supposing that cheap motive power was in itself sufficient to create industries in localities where their essential elements were wanting.

1. TRANSMISSION OF POWER BY WIRE ROPES.

The introduction of iron-wire ropes for transmitting power to a distance has arisen from the necessity of replacing leather or India rubber by some material less expensive, less effected by atmospheric influences, less extensible, and especially possessing a much higher tensile strength. The large amount of the power which must exist to make special machinery advantageous for transmitting it to a distance does not constitute one of the reasons for the change of material, inasmuch as belts of leather and India rubber are capable of transmitting very considerable power. In reality they owe this capability to a special property which they possess, and which releases them completely from the theoretical laws to which attention has just been directed in the case of ropes. If the belt is wide, a partial vacuum is produced between the belt and the rim of the pulley, by the aid of an adequate velocity, which causes the atmospheric pressure to press the belt close against the pulley. An adhesion is thereby produced which is totally independent of friction, and enables the tensions to be considerably reduced. Accordingly the tension T of the driving span, instead of attaining the value 2 P, need only equal P. A greater reduction of the friction on the bearings is therby effected, and there is a greater power of transmission with the same section. Thus, whilst formerly in large factories the belts served only to transmit the power from the main driving shafts to the different machines, they are beginning to be employed to drive the main shafts themselves from the prime mover. The Americans were the first to adopt this course. This extended use of belts is regulated by certain pactical rules which it may perhaps be useful to point out. It is advisable to make the belts travel at a high speed, 4,000, 5,000, and even 6,000 feet per minute, which leads to the adoption of large diameters for the pulleys. As flexibility is essential, it is preferable not to double the leather, but to rest satisfied with the greatest single thickness, amounting to 5-16 or 3-8 inch, and to resort to large widths. As the adhesion does not depend on the friction, the roughness of the surfaces in contact is more injurious than useful; and accordingly, contrary to the old practice, the hair or grain side of the leather being the smoothest, is turned to the pulley. Since the even motion of the pulleys is a very important condition, it is advisable to employ, as far as possible, light and perfectly balanced pulleys, and supports with a wide base and movable bearings. It is for this reason that American pulleys are sold by the piece and not by weight. The widths which the Americans give to belts put up on this principle are such that the circumferential strain $P = \frac{\text{Power transmitted}}{\text{Speed of rope}}$, is 50 to 67 pounds per inch of width, which represents a strain of 156 to 185 pounds per square inch of section. There was a leather belt at the Philadelphia Exhibition of 1876 which had a width of 5 feet; but generally they barely exceed $3\frac{1}{4}$ or 4 feet; while for greater widths several belts are employed, placed side by side. The Williams & Orton Manufacturing Company, Sterling, Illinois, lead in America, in the manufacure of iron-wire ropes for power transmission. These ropes are composed of a certain number of strands, each having a core of hemp, which are rolled round a central core, also of hemp. They are wound on in the opposite direction to that of the wires in each strand. The pulleys or sheaves, Fig. 1, are of large

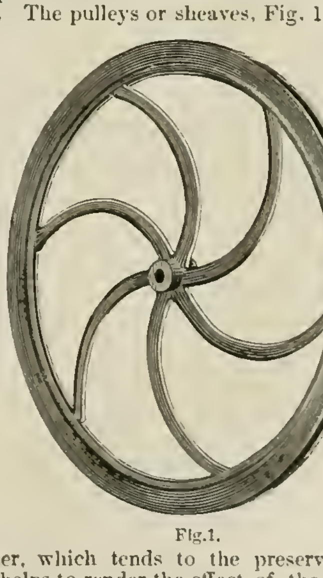


Fig.1.

diameter, which tends to the preservation of the ropes, helps to render the effect of the stiffness insignificant, and diminishes the effect of the friction of the bearings. If the distance is considerable, the transmissions are divided into several relays, with a separate rope for each. The relays are separated by stations. Each station is provided with a horizontal shaft upon which a double-grooved pulley is fixed, which is the driven pulley as regards the relay terminating there, and the driving pulley in reference to the succeeding relay. The stations are usually arranged on masonry pillars, Fig. 2, somewhat raised according to the configuration of the ground, for it is necessary that the rope should be in no danger of touching the ground. Sometimes the power has to be partially distributed in its course; under these circumstances the shafts at the stations are made use of for the purpose. Frequently also it is necessary to

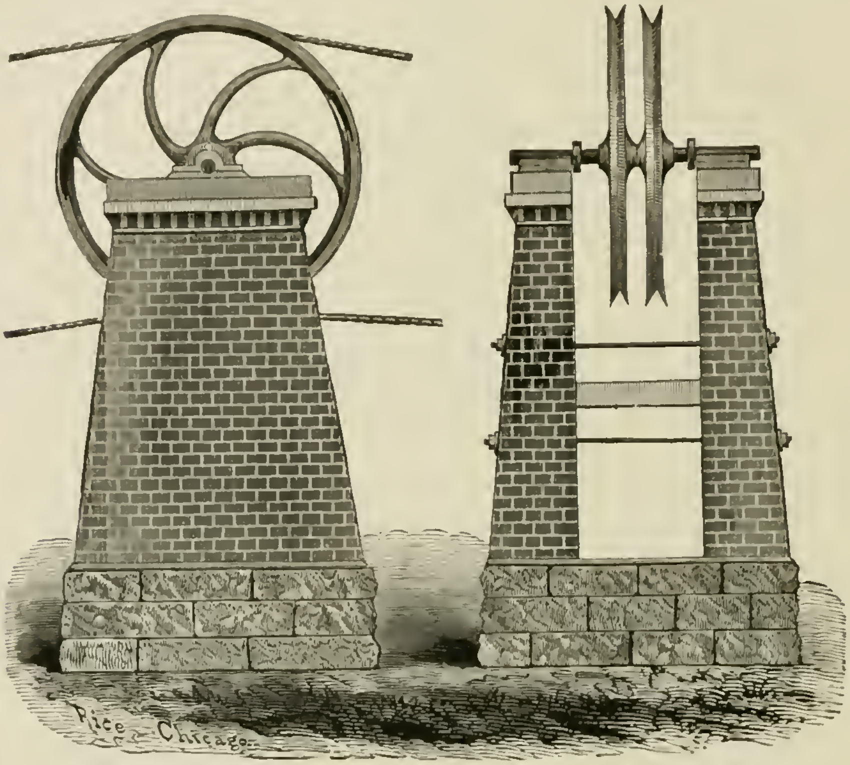


Fig. 2.

place intermediate pulleys along a relay, which differ from the end pulleys of the relay in serving merely to support the rope. Occasionally a relay has been made 650 feet long, but usually 420 to 500 feet is the limit. The weight of the most ordinary sizes of pulleys employed, including their shafts, are on an average as follows:

Diameter.			Weight.			
			Single-groove pulley.		Double-groove pulley.	
Meters	*Feet*	*In.*	*Kilogrammes*	*Pounds.*	*Kilogrammes*	*Pounds.*
5.50	18	0	2,775	6,232	3,750	8,267
4.50	14	9	2,350	5,180	1,170	6,988
3.75	12	4	1,100	2,425	1,850	4,078
2.13	7	0	362	798	528	1,164

The pulleys have grooves of the shape of a V, rounded off at the bottom, and having there a swallow-tailed notch in which the lagging is fixed. Experience proves that the best lagging is made of pieces of leather, cut from the hide in the form of the notch, and placed in it end upwards.

This lagging generally holds out on an average of about three years. It wears out most rapidly on the intermediate pulleys; it has been observed that the rotation of these pulleys is more rapid than the motion of the rope, which occasions slipping. The iron wires of which the rope is made have to bear two distinct molecular strains. The first designated by *s*, is the tension resulting from the maximum tension T in all round, the pulley is once more placed on the lathe, so as to turn down the bottom of the groove to necessary to transmit the motion, and its value in pounds per square inch is accordingly—

$$s = \frac{T}{\frac{\pi}{4} d^2 i},$$

d being the diameter of the wires, and *i* their number. The second strain results from the flexure produced by the winding upon the pulley, and may be expressed with sufficient accuracy by

$$z = E \frac{d}{2R}$$

R being the radius of the pulley, and E the modulus of elasticity of iron, say 20,000 kilograms per square millimeter, or 28,445,000 pounds per square inch. It is clearly necessary that the sum of these strains, $s+z$, should not exceed a certain limit, which is fixed at 18 kilogrammes per square milimeter (25,600 pounds or say 11 tons, per square inch). In most of the ropes with which the author is acquainted the values allowed are approximately $s=10$ kilograms (14,220 pounds per square inch) and $z=8$ kilograms (11,380 pounds per square inch). The speed of the ropes may, without any inconvenience, attain, and even exceed, 20 meters per second (4,000 feet per minute, or 25 miles per hour). To preserve the ropes from oxidation and improve their adhesion, they are coated with a heated mixture of grease and rosin. A special machine enables the ropes to be subjected to a preliminary squeezing to increase their length; by this means the subsequent elongation from wear and tear is diminished, and the number of shortenings which become necessary is reduced. It is difficult to lay down any general rule as to the duration of the ropes, for this depends upon the conditions under which they work. In practice it must not be assumed that a rope in constant use will last more than a year.

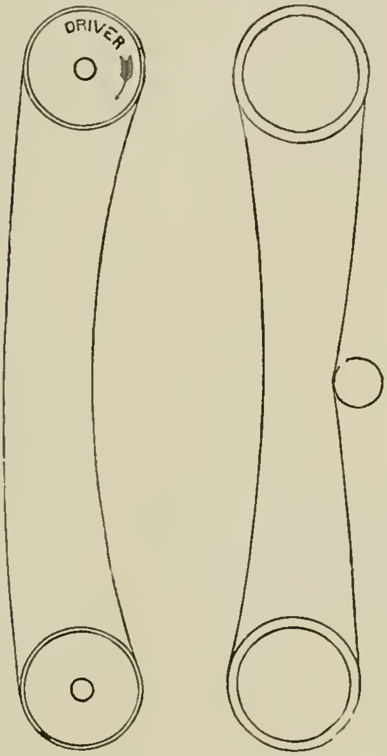


Fig. 3. Fig. 4

The curve in which the rope hangs is a catenary, Fig. 3; and it is upon the form of the particular catenary in which it hangs, whether more or less deep, as well as upon its lineal weight, that the tension to which it is subjected depends. By fixing the weight of the rope and its length, the form which its two spans assume in common, when at rest, is determined, and consequently their common tension, which latter must be such as to produce in running the two unequal tensions, T and t, necessary for the transmission of the power. Moreover, the tension in either span is not the same throughout its whole length; it is a minimum at the lowest point of the curve, and goes on increasing towards the two extremities. The calculation of the tension at the lowest point is very complicated if based upon the true form of the catenary; but by substituting a parabola for the catenary, which is allowable in almost all cases, the calculation becomes very simple. If the two pulleys are on the same level, the lowest point is midway between them, and the tension at this point is

$$S_0 = \frac{pl^2}{8h}$$

p being the lineal weight of the rope, l its horizontal projection, which is approximately equal to the distance between the centers of the pulleys, and h the deflection in the middle. The catenary possesses the remarkable mechanical property that the difference between the tensions at any two points is equal to the weight of a length of rope corresponding to the difference in level between the two points. The tensions, therefore, at two ends will be

$$S_1 = S_0 + ph = \frac{pl^2}{8h} + ph$$

By substituting for S_1 in the above equation, the required values of T and t, and solving it with relation to h, the deflections h_1 and h_2 of the driving and trailling spans will be obtained. The deflection h_0, common to the two spans at rest, will be given by the equation

$$h_0 = \sqrt{\tfrac{1}{2} h_1^2 + \tfrac{1}{2} h_2^2}$$

If, as before, w represents the sectional area of the iron portion of the rope, s the unit strain which the maximum tension T produces on it, we have

$$ws = T\frac{pl^2}{8h_1} + ph_1$$

Taking the sectional area w of the rope in square inches and its weight p in pounds per foot run, the ratio $\frac{w}{p}$ differs little from a mean value of 0.24 (104 in French measures); the safe limit of working-tension usually assigned for iron-wire ropes is $s = 14,$-220 pounds per square inch (French measures $s = 10$ kilograms per square millimeter). Hence,

$$\frac{w}{p}s = 0.24 \times 14{,}220 = 3410$$

and we have the approximate equation

$$\frac{l^2}{8h_1} + h_1 = 3410 \text{ (French measures 1040)}$$

which is useful as giving a relation between the length l and deflection h_1, for the driving span of a rope. In the case of leather,

$$\frac{w}{p} = 2.53 \text{ approximately (French measures 1,100)}$$

and as it is impossible to give s a higher value than about 355 pounds per square inch (0.25 kilogram), the relation obtained would be

$$\frac{l^2}{8h_1} + h_1 \quad 900 \text{ (French measures 275)}$$

which with equal deflections would give much shorter spans. If the working tension s were reduced to the American limit of 185 pounds per square inch (0.13 kilogram) for leather belts, the above figure 900 would be reduced to 470 (French measures 143), which would further shorten the span nearly one-half. It is therefore owing to the great strength which iron-wire ropes possess in proportion to their weight that they admit of long spans, with a smaller number of supports, Fig. 4, and consequently smaller loss of power by friction. They may therefore be expected to yield high efficiency. As a matter of fact, the experiments of M. Ziegler on the transmission of power at Oberursel give for the mean efficiency of a single relay $\frac{Q}{P} = 96.2$ per cent. The efficiency of transmission by relays, including m intermediate stations, is appoximately obtained by raising the efficiency of a single relay to the power of $\frac{m+2}{2}$. It often happens that the two pulleys of a single relay are at different levels, in which case neither span of the rope has the same tension at its two extremities; the tension at the upper end of each exceeds that at the lower by the quantity p H, H being the difference in level between the two extremities, or, which is approximately the same, between the centers of the two pulleys. It is evidently the tension of the driving span at its lower end which must be regulated so as to obtain the proper driving tension T for the transmission: so that there is a certain excess of tension at the upper pulley. When power has to be transmitted to the top of a very steep incline, the establishment of a relay station exactly at the top of the incline is generally avoided; intermediate pulleys are put there in preference, one for each span, the relay itself being prolonged for a certain distance on the level. This is the course which has been adopted for the transmission of power from the two turbines at Bellegarde, where a height of about 115 feet has to be surmounted. Fig. 5 shows the manner of changing the direction of the line of transmission by the use of bevel-wheels.

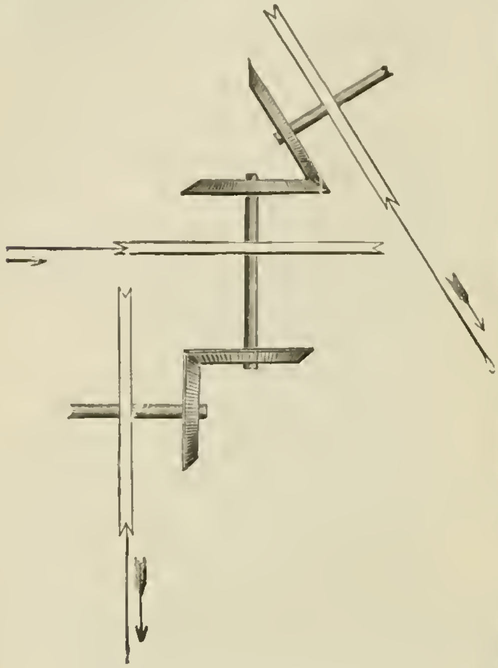


Fig. 5.

II.—TRANSMISSION BY COMPRESSED AIR.

Hitherto the method of transmission by compressed air has only been used for boring the headings of mines and the long tunnels. In these cases, as is well known, the work to be done consists in a rapid boring of holes for the purpose of blasting the rock with powder or dynamite. As this kind of work requires a high pressure of air, and almost entirely precludes the employment of expansion, the utilization of the motive force is necessarily defective: but in consequence of the peculiar convenience which compressed air offers for the work, and particularly the improved ventilation which it affords, the advantage of its employment is undoubted, and leaves in the background the question of efficiency. If, however, this method were resorted to for driving through rock soft enough to be excavated directly by the mining tool, it is possible that expansion might be used in the machine working the tool. In the case of the transmissron of power for general industrial purposes the question of efficiency is usually of great importance. The ultimate efficiency of transmission is the product of three partial efficiencies: (1) that of the air-compressing machine; (2) that of the pipes by which the compressed air is conveyed; and (3) that of the machine which the compressed air works. The efficiency of the prime mover and that of the tools worked by the compressed-air machine should not be brought into this estimate.

The air-compressing machines, generally called compressors, are piston pumps, having self-acting inlet and outlet miter valves, controlled by springs and worked by the air pressure itself. The essential condition to be fulfilled by an air-compressor is that the temperature of the air during compression should as far as possible, be kept constant; the reason, as is well known, being as follows: Let P be the power expended in compressing a given initial volume of atmospheric air into a given final volume whilst fulfilling this condition. If the air were compressed in a cylinder impermeable to heat, the heat resulting from compression would remain in it, and would raise its temperature and pressure, thus involving the expenditure of a power, P_1, greater than P for its compression. But after the compression had been effected the temperature of the compressed air would rapidly fall to the surrounding temperature, and would only represent a store of power, P_2, less than P; thus the powers $P_1 - P$ and $P - P_2$, making together $P_1 - P_2$, would be lost. Even if the metal barrel of the compressing pump is not absolutely impermeable to heat, it is impossible to avoid not merely important losses of power, but also an amount of heating that is very injurious both to the working and to the durability of the machine. It is only by the help of water that the rise of temperature can successfully be kept down within moderate limits. The Seraing or water-piston compressor was first tried with this object. The great defect of this apparatus is the loss of power resulting from the altering movement imparted to a large body of water. This loss is approximately proportional to the volume displaced by the piston raised to the power $\frac{5}{3}$, and to its speed raised to the power $\frac{4}{3}$. To reduce this loss it would be necessary to divide the required production of compressed air amongst a great number of compressors, and to make them work slowly, by giving them large dimensions. This renders the first cost of erection, and the space required, comparatively large. The speed of the compressor working on this system at Mont Cenis was limited to 8 or 10 revolutions per minute, and that of the smaller compressors, which have been used for headings in mines has been generally limited to 15 or 18 revolutions. It was next attempted to employ the water for cooling in a manner which, whilst efficacious, should not entail the above loss of power, and should admit of a higher speed of working. The object was accomplished by two methods, which can be used separately or together. One consists in making the water circulate through a casing surrounding the pump barrel, and through cavities formed inside the piston and piston-rod. The other method, which is still more efficacious, consists in ejecting a very fine spray into the pump barrel, whereby the water is brought into direct contact with the air to be cooled. Both these methods, suggested by M. Colladon, have been applied, under his instructions, to the St. Gothard compressors, and have furnished excellent results. These machines have perfectly answered their purpose, and have worked at a speed of 60 to 80 revolutions per minute, producing only a limited rise in temperature. Compressed air, in passing along the pipe, assumed to be horizontal, which conveys it from the place of production to the place where it is to be used, as for instance to the rock drill,—see Fig. 6, experiences by friction a diminution of pressure, which represents a reduction in the mechanical power stored up, and consequently a loss of efficiency. The loss of pressure in question can only be calculated conveniently on the hypothesis that it is very small, and the general formula employed for the purpose is—

$$\frac{p_1 - p}{\triangle} = \frac{4\,L}{D} f(u)$$

where D is the diameter of the pipe, assumed to be uniform, L the length of the pipe, p_1 the pressure at the entrance, p the pressure at the farther end, u the velocity at which the compressed air travels, $\triangle$ its specific weight, and $f(u)$ the friction per unite of length. In proportion as the air loses pressure its speed increases, whilst it specific weight diminishes; but the variations in pressure are assumed to be so small that u and $\triangle$ may be considered constant. As regards the quantity $f(u)$, or the friction per unit of length, the natural law which governs it is not known and it can only be expressed by some empirical formula, which, whilst according sufficiently nearly with the facts, is suited for calculation. For this purpose the binomial formula $au + bu^2$, or the simple fermola $b_1\ u^2$ is generally adopted; a, b, and b_1 being coefficients deduced from experiment. The values, however, which are to be given to these coefficients are not constant, for they vary with the diameter of the pipe; and in particular contrary to formerly received ideas, they vary according to its internal surface. The uncertainty in this respect is so great that it is not worth while with a view to accuracy, to relinquish the great convenience which the simple formula $b_1\ u^2$ offers. It would be better from this point of view to endeavor as has been suggested, to render this formula more exact by the substitution of a fractional power in the place of the square, rather than go through the long calculations necessitated by the use of the binomial $au+bu^2$. Accordingly, making use of the formula $b_1\ u^2$, the above equation becomes—

$$\frac{p_1-p}{\triangle}=\frac{4\ L}{D}b_1\ u^2:$$

or, introducing the discharge per second, Q, which is the usual figure supplied, and which is connected with the velocity by the relation—

$$Q=\frac{\pi D^2 u}{4}$$

we have—

$$\frac{p_1-p}{\triangle}=\frac{64}{\pi^2}\ \frac{b_1}{D^5}LQ^2$$

Generally the pressure p_1 at the entrance is known, and the pressure p has to be found; it is then from p_1 that the values of Q and $\triangle$ are calculated. In experiments where p_1 and p are measured directly, in order to arrive at the value of the coefficient b_1. Q and $\triangle$ would be calculated for the mean pressure $\frac{1}{2}(p_1+p)$.

The values given to the coefficient b_1, vary considerably, because, as stated above, it varies with the diameter, and also with the nature of the material of the pipe. It is generally admitted that it is independent of the pressure, and it is probable that within certain limits of pressure this hypothesis is in accordance with the truth. D'Aubuisson gives for this, in his "Traite d'Hydraulique," a rather complicated formula, containing a constant deduced from experiment, whose value, according to a calculation made by the same author, corresponds approximately to $b_1 = 0.0003$. This constant was only determined by taking the mean of experiments made with tin tubes of 0.0235 meter ($\frac{15}{16}$ inch), 0.05 meter (2 inches), and 0.10 meter (4 inches) diameter; and it was erroneously assumed that it was correct for all diameters and all materials. M. Arson, Engineer to the Paris Gas Company, published in 1867, in the "Mémoires de la Société des Ingénieurs Civils de France," the results of some experiments on the loss of pressure in gas when passing through pipes. He employed cast-iron pipes of the ordinary kind. He has represented the results of his experiments by the binomial formula $au + bu^2$, and gives values for the coefficients a and b, which diminishes with an increase in diameter, but would indicate greater losses of pressure than D'Aubuisson's formula.

It only remains to refer to the motors supplied by the compressed air. This subject is still in its infancy from a practical point of view. In proportion as the air becomes hot by compression, so it cools by

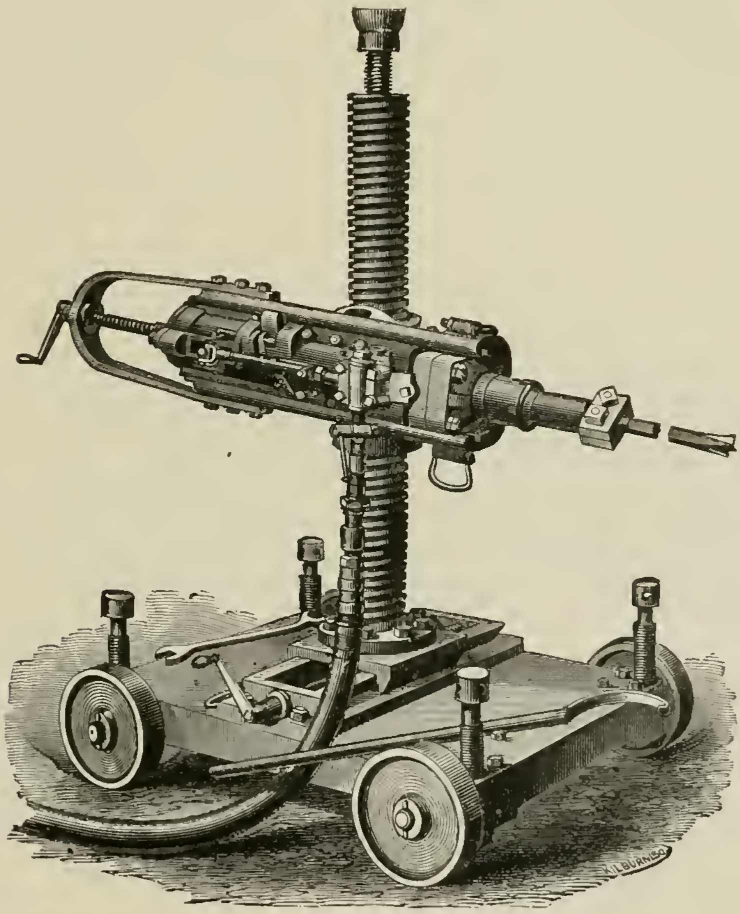


Fig. 6.

expansion, if the vessel containing it is impermeable to heat. Under these conditions it gives out in expanding a power appreciably less than if it retained its original temperature; besides which the fall of temperature may impede the working of the machine, by freezing the vapor of water contained in the air. If it is desired to utilize to the utmost the force stored up in the compressed air, it is necessary to endeavor to supply heat to the air during expansion, so as to keep its temperature constant. It would be possible to attain this object by the same means which prevent heating in compression, namely, by the circulation and injection of water. It would perhaps be necessary to employ a rather larger quantity of water for injection, as the water, instead of acting by virtue both of its heat of vaporization and of its specific heat, can in this case act only by virtue of the latter. These methods might be employed without difficulty for air machines of some size. It would be more difficult to apply them to small household machines, in which simplicity is an essential element; and we must rest satisfied with imperfect methods, such as proximity to a stove, or the immersion of the cylinder in a tank of water. Consequently, loss of power by cooling and by incomplete expansion cannot be avoided. The only way to diminish the relative amount of this loss is to employ compressed air at a pressure not exceeding 3 or 4 atmospheres.

The only real practical advance made in this matter is in Mékarski's compressed-air engine for tramways. In this engine the air is made to pass through a small boiler, containing water at a temperature of about 120° Cent. (248° Fahr.), before entering the cylinder of the engine. It must be observed that in order to reduce the size of the reservoirs, which are carried on the locomotive, the air inside them must be very highly compressed; and that in going from the reservoir into the cylinder it passes through a reducing valve, or expander, which keeps the pressure of admission at a definite figure; so that the locomotive can continue working so long as the supply of air contained in the reservoir has not come down to this limiting pressure. The air does not pass the expander until after it has gone through the boiler already mentioned. Therefore, if the temperature which it assumes in the boiler is 100° Cent. (212° Fahr.), and if the limiting pressure is 5 atmospheres, the gas which enters the cylinder will be a mixture of air and water vapor at 100° Cent.; and of its total pressure the vapor of water will contribute 1 atmosphere and the air 4 atmospheres. Thus this contrivance, by a small expenditure of fuel, enables the air to act expansively without injurious cooling, and even reduces the consumption of compressed air to an extent which compensates for part of the loss of power arising from the preliminary expansion which the air experiences before its admission into the cylinder. It is clear that this same contrivance, or what amounts to the same thing, a direct injection of steam, at a sufficient pressure, for the purpose of maintaining the expanding air at a constant temperature, might be tried in a stationery engine worked by compressed air with some chance of success. Whatever method is adopted, it would be advantageous that the losses of pressure in the pipes connecting the compressors with the motors should be reduced as much as possible, for in this case that loss would represent a loss of efficiency. If, on the other hand, owing to defective means of reheating, it is necessary to remain satisfied with a small amount of expansion, the loss of pressure in the pipe is unimportant, and has only the effect of transferring the limited expansion to a point a little lower on the scale of pressures.

III. TRANSMISSION BY PRESSURE-WATER.

As transmission of power by compressed air has been specially applied to the driving of tunnels, so transmission by pressure-water has been specially resorted to for lifting heavy loads, or for work of a similar nature, such as the operations connected with the manufacture of Bessemer steel, or of cast-iron pipes. The transmission of power by water may occur in another form. The motive force to be transmitted may be employed for working pumps which raise the water, not to a fictitious height in an accumulator, but to a real height in a reservoir, with a channel from this reservoir to distribute the water so raised amongst several motors arranged for utilizing the pressure. We are not aware that these works have been carried out for this purpose. In many towns, however, a part of the water from the public mains serves to supply small motors: consequently, if the water, instead of being brought by a natural fall, has been previously lifted artificially, it might be said that a transmission of power is here grafted on to the ordinary distribution of water. Unless a positive or negative force of gravity is introduced into the problem, independently of the force to be transmitted, is must be assumed that the motors supplied with the pressure-water are at the same level as the forcing-pumps: or more correctly that the exhaust from those motors is at the same level as the surface of the water from which the pumps draw their supply. In this case the general efficiency of transmission is the product of three partial efficiencies, which correspond exactly to those mentioned with regard to compressed air. The height of lift contained in the numerator of the fraction which expresses the efficiency of the pumps, is not to be taken as the difference in level between the surface of the water in the reservoir and the surface of the water whence the pumps draw their supply; but as this difference in level, *plus* the loss of pressure in the suction pipe, which is usually very short, and *plus* the loss in the channel up to the reservoir, which may be very long. A similar loss of initial pressure affects the efficiency of the discharge channel from the reservoir. Such a reservoir, if of sufficient capacity, may become an important store of power; while the compressed-air reservoir can only be so to a very limited extent. Omitting the subject of the pumps, and passing on at once to the water mains, we may first point out that the distinction between the ascending and the descending mains of the system is of no importance, for two reason; Firstly, that nothing prevents the motors from being supplied direct from the first alone; and secondly, that the one is not always distinct from the other. In fact, the reservoir may be connected by a single branch pipe with the system which extends from the pumps to the motors; it may even be placed at the extreme end of this system beyond the motors, provided always that the supply pipe is taken into it at the bottom. The same formula may be adopted for the loss of initial pressure in water pipes, as for compressed-air pipes, viz:

$$\frac{p_1 - p}{\delta} = \frac{64}{n^2}\frac{b_1}{D^5} L Q^2 \pm h.$$

h being the difference of level between the two ends of the portion of pipe of length L, and the sign + or — being used according as the pipe rises or falls. The specific weight δ is constant, and the quotients $\frac{p_1}{\delta}$ and $\frac{p}{\delta}$ represent the heights z_1 and z to which the water could rise above the pipe, in vertical tubes branching from it, at the beginning and end of the length L.

The values assigned to the coefficient b_1 in France are those determined by D'Arcy. For new cast-iron pipes he gives—

$$b_1 = 0.0002535 + \frac{1}{D} 0.00000647,$$

and recommends that this value should be doubled, to allow for the rust and incrustation which more or less form inside the pipes during use. The determination of this coefficient was made from experiments, in which the pressure did not exceed 4 atmospheres; within these limits the value of the coefficient, as is generally admitted, is independent of the pressure. The experiments made by M. Barret, on the pressure pipe of the accumulator at the Marseilles docks, seem to indicate that the loss of pressure would be greater for high pressures, everything else being equal. Of machines worked by water-pressure, we will refer only to two, which appear in every respect the most practical and advantageous. One is the piston machine of M. Albert Schmid, Engineer at Zurich. The cylinder is oscillating, and the distribution is effected without an eccentric, by the relative motion of two cylindrical surfaces fitted one against the other, and having the axis of oscillation for a common axis. The convex surface, which is movable and forms part of the cylinder, serves as a port-face, and has two ports in it communicating with the ends of the cylinder. The concave surface, which is fixed and plays the part of a slide-valve, contains three openings, the two outer ones serving to admit the pressure-water, and the middle one to discharge the water after it has exerted its pressure. The piston has no packing. It has grooves turned in its circumference, which produce a sort of water packing, maintained by adhesion. A small air-chamber is connected with the inlet pipe, and serves to deaden the shocks. This engine is often made with two cylinders, having their cranks at right angles. The other engine, which is much less used, is a turbine on Girard's system, with a horizontal axis and partial admission, exactly resembling in miniature those employed in raising water at the water-works of St. Maur, near Paris. The water is introduced by means of a distributor, which is fitted inside the turbine casing, and occupies a certain portion of its circumference. This turbine has a lower efficiency than Schmid's machine, and is less suitable for high pressures; but it possesses this advantage over it, that by regulating the amount of opening of the distributor, and consequently the quantity of water admitted, the power can be altered without altering the velocity of rotation. As it admits of high speeds, it could be usefully employed direct, without the interposition of spur-wheels or belts, for driving magneto-electric machines employed for the production of light, for electrotyping, etc. Fig. 7 shows the best possible arrangement for a large turbine with a horizontal axis, all bevel-gears and steps being avoided. The table, page 469, gives the efficiencies, as measured in 1871 by Professor Fliegner, of a Girard turbine, constructed by Messrs. Escher Wyss & Co., of Zurich, and of a Schmid machine.

It will be observed that these experiments relate to low pressures, it would be desirable to extend them to higher pressures.

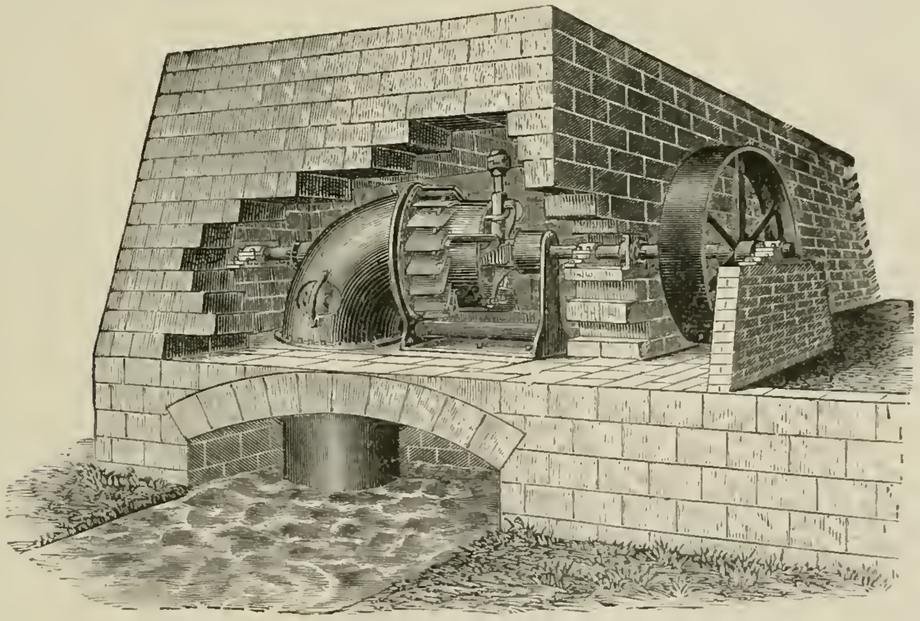


Fig. 7.

IV.—TRANSMISSION BY ELECTRICITY.

However high the efficiency of an electric motor may be, in relation to the chemical work of the electric battery which feeds it, force generated by an electric battery is too expensive on account of the nature of the materials consumed, for a machine of this kind ever to be employed for industrial purposes. If however the electric current, instead of being developed by chemical work in a battery, is produced by ordinary mechanical power in a magneto-electric or dynamo-electric machine, the case is different; and the double transformation, first of the mechanical power, into an electric current, and then of that current into mechanical power, furnishes a means for effecting the conveyance of the power to a distance. When an electric current, with an intensity i is produced, either by chemical or mechanical work, in a circuit having a total resistance R, a quantity of heat is developed in the circuit; and this heat is the exact equivalent of the power expended, so long as the current is not made use of for doing any external work. The expression for this quantity of heat, per unit of time, is $A i^2 R$: A being the thermal equivalent of the unit of power corresponding to the units of current and resistance in which i and R are respectively expressed.

The product $i^2 R$ is a certain quantity of power, which is called *power transformed into electricity*. When mechanical power is employed for producing a current by means of a magneto-electric or dynamo-electric machine—or, to use a better expression, by means of a *mechanical generator of electricity* it is necessary in reality to expend a greater quantity of power than $i^2 R$, in order to make up for losses which result either from ordinary friction or from certain electro-magnetic reactions which occur. The ratio of the quantity $i^2 R$ to the power W actually expended per unit of time is called the efficiency of the generator. Designating it by K, we have—

$$W = \frac{i^2 R}{K}.$$

It is very important to ascertain the value of this efficiency, considering that it necessarily enters as a factor into the evaluation of all the effects to be produced by means of the generator in question. Mechanical generators of electricity are certainly capable of being improved in several respects, especially as regards their adaptation to certain definite classes of work. But there remains hardly any margin for further progress as regards efficiency. Power transformed into electricity in a generator may be expressed by $i\omega MC$, ω being the angular velocity of rotation, M the magnetism of one of the intervening poles, either inducing or induced, and C a constant specially belonging to each apparatus and independent of the units adopted. This constant could not be determined except by an integration practically impossible and the product M C must be considered indivisible Even in a magneto-electric machine (with permanent inducing magnets), and much more in a dynamo-electric machine (inducing by means of electro-magnets excited by the very current produced), the product M C is a function of the intensity. From the identity of the expressions i^2R and $i\omega$ M C we obtain the relation—

$$MC = \frac{iR}{\omega},$$

which indicates the course to be pursued to determine experimentally the law connecting the variations of M C with those of i. Some experiments made about 1876 by M. Hagenbach on a Gramme dynamo-electric machine appear to indicate that the magnetism M C does not increase indefinitely with the intensity, but that there is some maximum value for this quantity. If, instead of working a generator by an external motive force, a current is passed through its circuit in a certain given direction, the movable part of the machine will begin to turn in the opposite direction to that in which it would have current in the given direction. In virtue of this been necessary to turn it in order to obtain from it a motion, the electro-magnetic forces which are generated may be used to overcome a resisting force. The machine will then work as a motor or receiver.

Casting a restrospective glance at the four methods of transmission of power which have been examined, it would appear that transmission by ropes forms a class by itself, whilst the three other methods combine into a natural group, because they possess a character in common of the greatest importance. It may be said that all three involve a temporary transformation of the mechanical power to be utilized into potential energy. Also, in each of these methods the efficiency of transmission is the product of three corresponding factors or partial efficiencies, namely: 1st, the efficiency of the instrument which converts the actual energy of the prime mover into the potential energy; 2d, the efficiency of the instrument which reconverts this potential energy into actual energy, that is into motion, and deliverd it up in this shape for the final motors which perform useful work; 3d, the efficiency of the intermediate agency which serves for the conveyance of potential energy from the first instrument to the second. This third factor has just been given for transmission by electricity. It is to a certain extent the correlative of the efficiency of the pipe, in the case of compressed air, or of pressure-water. It is as useful in the case of the electric transmission, as of any other method, to be able, in designing a system, to estimate beforehand what results it will be capable of furnishing; and for this purpose it is necessary to calculate exactly the factors which compose the efficiency. In order to obtain this desirable knowledge, the three following points should form the aim of experimentalists: 1st. The determination of the efficiency K of the principal kinds of magneto-electric, or dynamo-electric, machines working as generators. 2d. The determination of the efficiency K, of the same machines working as motors. 3d. The determination of the law according to which the magnetism of the cores of these machines varies with the intensity of the current. Transmission by electricty is still in its infancy; it has only been applied on a small scale and experimentally. Of the three other systems, transmission by means of ropes is the only one that has been employed for general industrial purposes; whilst compressed air and water under pressure have been applied only to special purposes, and their use has been due much more to their special suitability for these purposes, than to any considerations relative to loss of power. Thus the useful effect of the compressed air used in driving the tunnels through the Alps, assuming its determination to be possible, was undoubtedly very low; nevertheless, in the present state of our appliances, this is the only process by which such operations can be accomplished. It is believed that transmission by ropes furnishes the highest proportion of useful effect; but that, as regards a wide distribution of the transmitted power, the other two methods, by air and water, might merit the preference.

Escher Wyss and Co.'s Girard Turbine.

Effective head of water.		Revolutions per minute.	Efficiency.
Meters.	Feet.	Revolutions.	Per cent.
…	…	…	…
…	…	…	…
…	…	…	…
…	…	…	…
20.7	67.9	628	68.5
20.7	67.9	847	47.4
…	…	…	…
24.1	79.0	645	68.5
27.6	90.5	612	65.7
27.6	90.5	756	68.0
31.0	101.7	935	56.9
31.0	101.7	1,130	35.1

Schmid Motor.

Effective head of water.		Revolutions per minute.	Efficiency.
Meters.	Feet.	Revolutions.	Per cent.
8.3	27.2	226	37.4.
11.4	37.4	182	67.4
14.5	47.6	255	53.4
17.9	58.7	157	86.2
20.7	67.9	166	89.6
20.7	67.9	225	74.6
24.1	79.0	238	76.7
24.1	79.0	389	64.0
27.6	90.5	207	83.9
…	…	…	…
…	…	…	…
…	…	…	…

TRANSOM.—In artillery, a stout piece of timber or beam connecting two corresponding parts of a carriage. All wooden siege-carriages, formed of two brackets, are connected together by three transoms, but the length of the transoms, which regulates the width of the carriage, varies according to the nature of the gun.

TRANSPORTATION REQUESTS.—The officers of the Quartermaster's Department issue to each Company over whose road or line transportation is required for troops and officers of the United States, and individuals entitled to transportation at Government expense, a *Request* of the form provided by the Quartermaster General, setting forth the number of days for which the Requests will be good; the date when and place where issued; the name of the Company or party required to furnish the transportation; the name of the person to be transported, or in charge of the party to be transported, and the number of persons and pounds of extra baggage, if any, accompanying him; the company and regiment to which the person named belongs; the points from and to which, and the general route or initial letters of the roads over which transportation is required, and the points of original departure and ultimate destination. They also state on the back of the Request by what authority it is issued, by giving the number, date, and place of issue of the order requiring transportation to be furnished, and the nature of the journey or purpose for which it is to be performed, as follows: "Changing stations," "Joining recruiting service," "Conducting recruits to regiment (or station)," "Returning to station from conducting recruits to regiment (or station)," "Returning to regiment (or station) from recruiting service," "Assigned recruits *en route* to regiment (or station)." "Deserter," "Returning from furlough, proper officer notified," "On detached service" (the nature of the service to be stated), "*En route* to Soldiers' Home," "Discharged soldier *en route* home (or *en route* to a Paymaster), indorsed on final statement," "Insane soldier with escort to Insane Asylum," "Guard and prisoners," "Guard and Indian prisoners," "*En route* to (or returning from) Court-Martial," "*En route* to (or returning from) Civil Court—under orders without summons," "Released convict," "Journey to procure an artificial limb—cost to be refunded from appropriation for artificial limbs," "Superintendent of National Cemetery," "Clerk (or Agent) of the Quartermaster's Department," etc.; and if the Request is issued by virtue of any contract, that fact is stated and the contract designated.

The following form is used in the United States army:—

I. No......... Not transferable, and good only for..days from date.

Quartermasters Department, U. S. A. Request for Transportation. Not valid until countersigned by the issuing officer.

....18......

The...
Will please transport...
....pounds extra baggage.
Co...Regiment......................................
From...to..
Via..
En route from......................................to..

....
Quartermaster General,
Brt. Maj. Gen., U. S. Army.

Signature of issuing officer,
....
Quartermaster, U. S. A.

Remarks:..
....

The holder of this Request or the officer in charge of troops is required to fill the receipt below before signing, stating the exact number of men transported, and the places from and to which transportation has been furnished. The receipt should be filled up in ink if practicable, and if the person receipting cannot write his name, there should be a witness to his mark. Names and places should be written in full, and if the transportation is furnished by other than Passenger train, or Passenger car, the fact should be stated.

...., 18...........

I certify, on honor, that the..
has furnished transportation for...
....pounds extra baggage,
From...to..
in compliance with the above Request

Sign here.

....

Transportation is not purchased over a road or line of roads in whole or in part indebted to the United States, or which are land-grant roads subject to deduction from full rates, or to which payment for the transportation is forbidden by law, or which are required by law to transport troops of the United States free of cost, charge, or expense to the Government; nor over any of the Pacific roads to which United States bonds were issued in aid of their construction; nor over any road with which a contract has been made for the transportation at less than the regular through or local rates, except at contract or reduced prices. This is not to prohibit purchasing tickets over land-grant roads or over the roads with which a contract has been made, when the cost to the Government is not greater than the rates to which it would be entitled under the contract or after the deduction for land grant. In case of purchase of tickets under these circumstances, full explanation should be made on the face of the voucher.

TRANSPORT CARTS.—Carts used for the conveyance of stores of all natures both of food and ammunition, and for the carriage of the sick. When an army takes the field, the Control Department has the selection and provision of carts for the carriage of the stores, tents, etc. In the selection of all carriages, that which travels the easiest and lightest is to be preferred.

TRANSPORTS.—Government vessels or trains for the conveyance of troops. Without a powerful system of transport an army is helpless. To cross a sea a large fleet of vessels properly fitted for the men and horses is requisite. When the English Army of about 30,000 men crossed in 1854 from Varna to the Crimea, it took 600 vessels to carry them without any reserves of stores or food. Not less important to the army moving by land is the transport. On entering battle infantry and cavalry usually carry three days' rations with them and 60 rounds of ammunition. The moment these become exhausted they become dependent on the Transport Department for their replenishment. The first reserves are immediately in rear. To bring up supplies from these, and to keep these reserves themselves supplied, is the duty of the Military Train as regards food, and of the Field-train in respect to ammunition. Between the grand depot and the base the operation is generally intrusted to the wagons and beasts of the country, driven by natives, of course under proper military control. The amount of transport required by an army seems almost fabulous. The lowest computation must put one animal to four fighting-men. In addition to the transport of food and ammunition the wounded and sick have to be carried, both from the field to the hospitals and during a march. In the British and American Armies the direction of the transport rests with the Quartermaster General; in the French Army it is under the *Intendant*, who is over all the Administrative Departments.

When the transport is by rail, the most suitable car for carrying horses separately in warm weather is the *slat stock-car*, built of slats and open all around, but tight in roof. Another kind, known as the "*combination car*," is made with five doors on each side and one at each end, which may be closed tight for stores, or with iron grates whenever carrying horses. These are suitable for either warm or cold weather. Both kinds are usually 27 feet 4 inches long, 7 feet 9 inches wide, and 6 feet 8 inches high, inside measurement. Each car will carry fourteen artillery or sixteen common horses or mules. The horses all face towards the same side of the car, and are hitched by their halters to the framework. If the journey is to be continued beyond eighteen or twenty hours, the horses will require to be watered and fed. Nose bags are generally used for the grain. If the drivers are attentive, they, by taking advantage of all the short halts made by the train, can feed grain and hay quite easily by hand. Half rations will be sufficient under any circumstances. Before placing the horses on the cars, they should be thoroughly groomed and cooled: they should have nothing more on them than their halters. When the journey is to continue for several days, (but never beyond four without unloading) the horses should stand lengthwise of the car, facing each other, and hitched to two bars placed for the purpose across the car. The bars have space between them sufficient for feeding purposes and for a man to remain in charge. When thus arranged only about one-half as many can be carried in each car as in the other case. By loading in this way, close *box-cars* may, even in hot weather, be used, the doors being left open for ventilation.

Artillery-carriages and transportation-wagons are carried on *platform-cars*. These are generally 28 feet long by 8 feet wide. When properly loaded each will carry two field-guns and two caissons complete. To load them the carriages are unlimbered and the spare wheels removed from the caissons; the rear train of a caisson, its stock to the rear, is run to the front end of the car and its stock rested on the floor; another rear train is run forward in like manner until its wheels strike or overlap those of the first, when its stock is rested on the floor. A limber is then placed on the car with its pole to the front, resting on the rear train; the second limber is backed on and its pole held up until a gun, trail foremost, is run under it: the trail of the gun is rested on the floor and the pole of the limber on the gun-carriage. The other gun is run on in the same mann r, and its trail rested on the floor under the first gun; a limber is next run on and its pole rested on the last gun; the remaining limber is run on with its pole under the preceding limber. All of the carriages are pushed together as closely as possible and firmly lashed. Where the carriages are liable to chafe each other, they are bound with gunny-sacking or other stuff.

Siege-guns can be carried in a similar manner. Two siege-guns with their carriages and limbers complete can be carried on one car, and in addition, boxes of ammunition or stores may be piled between and underneath the carriages. One *flat-car* will carry two army transportation-wagons standing, besides a large quantity of other material. If the wagons are *knocked down*, the same car will carry four. Twenty-four thousand pounds is considered a safe load for one car on a good track. Baggage, harness, forage, etc., are usually carried in *box-cars*. The average size passenger car will seat sixty men, but a small car will seat only fifty. The men must be provided with cooked rations for the whole trip. Each car must be liberally supplied with drinking water, lights at night, and all other conveniences, to make it unnecessary for the men to leave them during stoppages of the train. The officer in command of troops on a train must act in harmony with the railroad officials, and must not interfere in any manner whatever with the *running* of the train. The experience gained during the War of the Rebellion shows that to supply an army of 100,000 men in the field by means of a single line of rails, the proportion of rolling-stock should be—engines 0.25 and the freight cars 6.0 to every mile of road. This does not provide for the conveyance of troops. In calculating the amount of rolling stock available for use, a deduction of 50 per cent. for locomotives and 30 per cent. for all other carriages must be made for those usually undergoing repairs. From the foregoing data, a small calculation will give the amount of railroad transportation required for any given number of troops, artillery, or material, and the capacity of a road for performing the work.

In the United States Service there are no vessels fitted up especially for transportation of troops, horses, or artillery material. Even during the four years of the War of the Rebellion no attempt was made toward it further than temporary arrangements for some particular voyage. The voyages were short, lasting generally only two or three days, never exceeding eight. Embarking and disembarking were usually accomplished with wharf facilities. In only three or four instances were the movements of an expeditionary character, requiring these operations to be performed on an open beach or in front of the enemy. As desirable and advantageous as it would have been to have had desirable transports properly fitted up, the absolute necessity for it was never felt, and consequently they were never adopted. Guns, caissons, ammunition, and other material of this character are carried in the same manner as ordinary merchandise. When once within reach of the ship's tackle, the officers and crew of the vessel will know how to stow and take care of them to the best advantage. When practicable, it is not only the most expeditious, but altogether the best way to leave the carriages mounted. The length of the voyage and the character and capacity of the vessel will determine whether or not this should be done, and in what part of the ship stored. Other considerations, such as facilities for embarking and disembarking, will likewise go to determine these questions. The horses are more difficult to provide for, and it is with reference to their accommodation and safety that vessels for the transportation of artillery should be selected.

When the voyage is to extend beyond six or seven days at sea, the vessel should have room between decks where stalls can be fitted up. But if the voyage is of a shorter duration, stalls are not absolutely necessary. In this case the vessel best adapted is a long low steamer, with a clear upper deck for the accommodation of the horses. The guns, carriages, harness, and baggage are all stowed between decks, where likewise the men find ample room. In many steamers a large gangway on each side leads to the main deck, through which the carriages can be run by hand. In vessels not so provided they have to be lowered by means of tackle down the main hatch,—a slow and laborious process.

Horses, in all cases, should stand athwart-ship: in this position they better accommodate themselves to the rolling motion of the vessel. When on the upper deck they should face inward; this, for the reason that the spray will not then strike them in their faces, and, besides, when facing each other in this manner they will suffer less from fright and nervous excitement. A vessel, of not less than 25 feet beam will accommodate two rows of horses, leaving a space between the rows, and between the croups of the animals and the sides of the ship, ample for the proper care of the horses. These spaces are, furthermore, necessary as gangways for working the vessel. The average artillery horse occupies a deck space of 8 feet by 2 feet 4 inches. It results, therefore, that the whole length of the deck in feet divided by the last dimension will give the number that may be accommodated in each row. As they stand better when close together, side by side, no allowance need be made for space between them.

All stalls, hitching-bars, or whatever other arrangement for securing horses, must be strong beyond any possibility of giving way. The living force exerted by a row of horses as they swing with the motion of a ship in a heavy sea-way, is very great, and it is better to have no securing arrangements whatever than to have those that, by giving way, will wound and injure the animals in the wreck. If the transport is to be used in very inclement weather, the spar deck, over the horses, should be covered. Canvas stretched over a secure frame is better than boards, as the latter, in a severe storm, might be carried away, and its wreck would cause disaster among the horses.

For the first few days on ship board food is to be given rather sparingly, and bran is to form a large portion of it; but after the horse becomes accustomed to his new situation and his appetite increases, he is to be more liberally fed. A bran mash, or oats and bran mixed, is to be given to him every other day. The spare stalls admit of the horses being shifted, rubbed down, their feet washed, and the stalls cleaned out every day when the weather permits. Hand-rubbing the legs is of the greatest consequence to the comfort and well-being of the horse, and is to be practiced, if possible, every day, or whenever the horses change stalls.

Horses are to be slung in smooth weather, and allowed to stand on their legs in rough and stormy weather. In smooth weather they will rest their legs and feet by throwing their whole weight into the slings. To sling a horse in rough weather, whereby he is taken off his feet, would only have the effect of knocking him about with the roll of the ship. Horses standing, accommodate themselves to the motion of the vessel. They are not to be placed in the horse-hammock until they have been at sea for a week, as some would only be made uneasy by the attempt to do so.

When the horses are between decks, too much attention cannot be paid to the constant trimming of the wind-sails, so as to insure plenty of fresh air. The wind-sails should be well forward, and extend down to within two or three feet of the deck. When a horse between decks becomes ill, and the weather is at all fine, he should be removed to the upper deck, where the fresh air and change will probably soon bring him right again. Besides the ordinary grooming utensils for stable service, there should be a plentiful supply of stable brooms, hoes, and shovels for cleaning out the stalls, and baskets or other light vessels for removing the manure. The ship must be well lighted and the guards attentive; sea-sick men must not be intrusted with this important duty. Disinfectants, such as chloride of lime and of zinc, copperas, powdered gypsum, etc., should be freely used, and upon embarking the artillery Commander will see that they are supplied. The feed-troughs and nostrils of the horses are washed every morning and evening with diluted vinegar. Water is allowed at the rate of six gallons a day per horse and one gallon per man. During the voyage the Commanding Officer will make it his especial study to act in harmony with the master of the vessel. There must of necessity be divided authority and responsibility. Order and neatness among the men and cleanliness with the horses are to be looked after by the Commander of the troops. In attending to these duties, due care will be observed not to interfere needlessly with the duties of the crew nor with the belongings of the ship. See *Disembarkation* and *Embarkation*.

TRANSVERSE STRENGTH. For determining the transverse strength of metals a specimen bar is taken, 2 or 3 feet long, and about 2 inches square. It is prepared for the test with a slight dressing with the file or grindstone on one of its faces near each end, in order that the bar may bear more evenly against the supports when under the strain. The middle of the bar—the part where the fracture occurs—is dressed in like manner on each of its four faces, in order that its breadth and depth in this part may be accurately measured.

The breaking force is applied on the under side of the bar, in the middle, and forces it upwards against the supports at the ends. The deflection is measured by inserting a graduated, tapered metallic scale between the upper surface of the bed-frame and the under side of the bar-holder, directly beneath the forcing-line of the latter, against the center of the bar. The space enlarges as the bar bends, and the graduated wedge measures minutely the deflection of the bar at any stage of its progress. A record is kept of the "deflection" and *set*, which shows the quantity of deflection and permanent set under a given pressure, which is designed to be near to, but somewhat less than, the minimum breaking weight. Also of the "last deflection," which gives the amount of deflection under the pressure of the breaking weight.

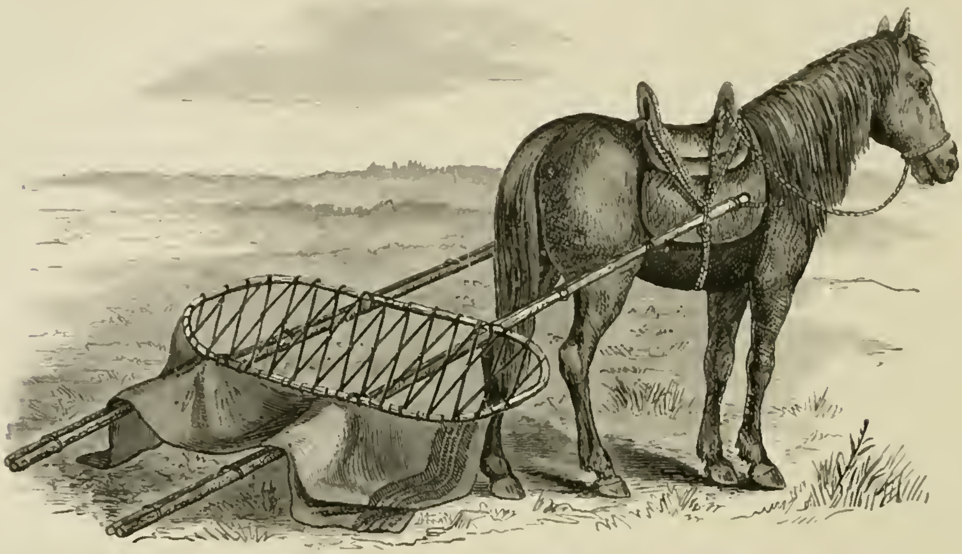
The *unit of strength* represents the weight in pounds required to break a bar 1 inch square rigidly supported at one end; the weight being applied at a distance of 1 inch from the point of support. For square bars it is determined by the formula—

$$\frac{l\,W}{4\,bd^2} = S$$

the unit of strength, in which l = the length between the supports. W = the breaking weight, b = the breadth of the bar, d = the depth of the bar. The breadth and depth are accurately measured near the fracture; and, as the dimensions are irregular, it is proper to measure in three places for each; one measure to be taken in the middle of the bar, and the other two near the corners. The mean of the three measures to be taken as the true dimension. If the bar is defective, the results cannot, of course, be relied on. See *Rodman Testing-machine*.

TRAVEE.—An Indian horse-litter. The ordinary teepe poles, with which the Indians pitch their tents when in villages, are generally used in constructing the travée. The Dakota and Mountain Sioux, who use mountain-pine or ash poles, select straight, well-proportioned saplings of those woods, trim them down to the proper size and taper, and then lay them aside to season. Dr J. W. Williams, United States Army, has furnished the details of one of these *travée*, as shown in the drawing.

The poles are about 30 feet long and the oval couch rim (made of ash) is bent into the desired shape while the wood is green. A network of raw-hide is afterward lashed to the rim and completes the bed. The bed $3\frac{1}{2}$ to 4 feet in its transverse, and $2\frac{1}{2}$ to 3 feet in its conjugate diameter. When a *travée* is to be rigged, two or three teepe poles, according to size and strength, are selected for each shaft and lashed together, butts to butts, with raw-hide. The system is then lashed to the pack-saddle with the same material, the small ends of the poles trailing on the ground. The Indians sometimes use a breast-strap as an additional stay. The bed, with the longer diameter laid transversely, is next secured to the shafts, one foot in rear of the horse, about six inches of each end of the bed being allowed to overlap the shafts. A blanket, piece of canvas, or buffalo robe lashed to the lower half of the oval rim of the bed completes the outfit. When a patient is to be carried, he is laid transversely on the bed, partly reclining on the side, with knees slightly drawn up, and head and shoulders bent forward and secured to the bed by drawing the blanket up over him and lashing it to the upper part of the rim. Such an arrangement is well adapted for transporting wounded over a rough country, and is very economical in its requirements. In case of an Indian war, when villages are attacked and captured, there never will be any difficulty of obtaining material for building the *travé*; under different circumstances they will have to be prepared beforehand. The Indians use the *travée* for carrying all sorts of baggage, and with them it seem to be no impediment to rapid marching. Early references to



this drag or litter use the word *travail* (plural travaux), a term possibly applied, by metonymy, to a labor-saving appliance. It seems more probable, however, that the early French voyagers and missioners who visited the Western wilderness gave the name of *travée*, with the reference to the poles held apart by *traverses*. *Travée*, according to Littrè, denotes two side-posts connected by cross-pieces. The various corruptions of the term, *travor*, *travoir*, *travois*, *traveau*, *travaise*, etc., are probably Indian *patois*. See *Litter*.

TRAVELING ALLOWANCE.—An allowance of money granted to officers and military subordinates traveling on duty and under proper orders. The allowance is given to defray the necessary expenses of the journey. In the United States Service, officers are allowed a mileage; and a soldier discharged from the service, except by way of punishment for any offense, or on his own application, or for disability prior to three month's service, is allowed pay and rations, or an equivalent in money, for such term of time as shall be sufficient for him to travel from the place of his discharge to the place of his residence, computing at the rate of twenty miles to a day. Whenever an officer is ordered from one station to another, or for the performance of any duty, not being with troops, he proceeds by the shortest usually traveled route without unnecessary delay; nor does he for any cause whatever, except that of sudden illness, apply for leave of absence or permission to delay from the time he receives the order until he arrives at his place of destination.

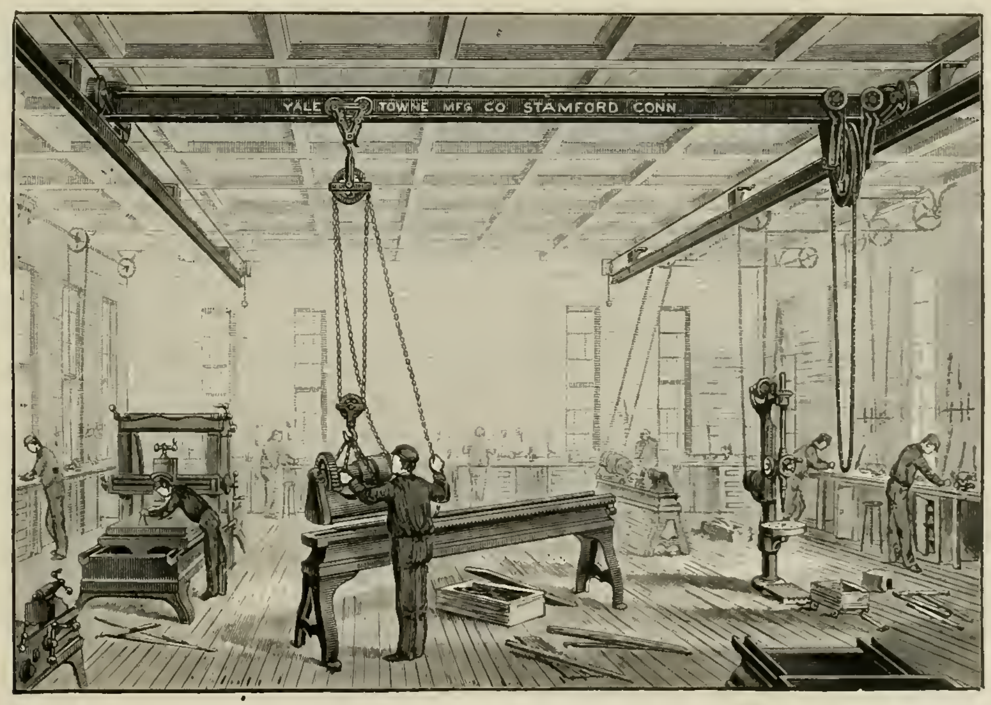
Whenever an officer under orders appears to have made unusual or unnecessary delay on the route, immediately on his arrival at the post the commanding officer calls upon him to report the cause thereof. Should such report be unsatisfactory, the officer is placed in arrest, and charges against him for his unauthorized absence are immediately submitted to the Department Commander. If the delinquent officer be superior in rank to the Commander of the post, the report will be made by the officer himself to his Department Commander. See *Mileage*.

TRAVELING CARRIAGE.—Any traveling gun-carriage should satisfy the following conditions:—Adaptability of form to load; stability; strength; ease and convenience of draught; durability; facility of repair; suitability for shipment; economy in manufacture. The position of the gun when firing is equally suitable for traveling. The length of the trail furnishes a convenient means of carrying the sponges and traversing-handspikes; and the spaces left between brackets and wheels allow room for axle-tree-boxes capable of holding small stores and a few rounds of case, which must be handy to the gun in the event of surprise at close quarters. In field-carriages the weight at the trail handles must not be more than can be readily lifted by two men in limbering up. To insure stability in traveling, it is necessary that the vertical through the common center of gravity of gun and *body* shall fall within the triangle of support when limbered up, and so far in front of the axle-tree that it shall not be liable to fall behind it up the steepest practicable inclines. The center of gravity of the body should be so placed with reference to the axle-tree of the gun-carriage that it should revolve through an angle of at least 20° about it before unstable equilibrium is attained. This proviso does not conflict with the conditions of equilibrium in firing. The position of the trunnion-holes is regulated by the required position of the center of gravity to ensure stability, and this position throws rather more weight on the point of the trail than is desirable for convenience in laying. When the carriage is limbered up, the center of gravity of the limber body and *all it* sustains should be slightly in front of the axle-tree, so as to exert a small constant pressure on the back of the shaft-horse. The strains in traveling in many points resemble those when the gun is fired, though generally less in degree. The wheels must be dished to resist side thrusts. The trail-eye must be made sufficiently massive in the neck to withstand the bending moments produced by the blows of the trail on the limber hook and side strains in locking. Its connection with the point of the trail must be long enough to allow an ample supply of rivets for security under these blows. The pressures and jolts of the trail cause bending moments on the hook at its junction with the axle-tree bed proportional to the horizontal distance of the bottom of the hook from the bed. In the gun-carriage the width of the trail at the locking plate is only about 9 inches, and this trifling width gives the wheel a very good turning power before it meets the trail, the actual *angle of lock* being with the present 5′ track more than 50°, the limber wheels being kept as high as those of the carriage. This is a valuable requisite for combining ease with convenience of draught. A high front-wheel enables the carriage to move at speed over rough and broken ground without the risk of a collision with obstacles in the route. With a 5′ front-wheel the lowest part of the bodies of carriage and limber is the friction plate of the trail, which clears the ground by a space of more than 18 inches. The minimum length of the trail, fixed by the conditions of stability in firing, should not be exceeded, as any additional length increases the weight of the carriage and the difficulty of turning. It is important that when the carriage is completely equipped and limbered up, the weight conveyed through the shafts upon the back of the shaft-horse shall not be excessive. The adjustment of this weight can be regulated by the distances at which the limber-hook and the center of gravity of the load are placed from the transverse vertical plane of the axle. When the carriage is unlimbered, the weight on the back will be increased *directly* as the weight removed from the limber-hook and the distance of that weight from the plane of the axle; and inversely as the distance of the shaft-tug from the same plane. See *Gun-carriage.*

TRAVELING-CRANE.—A light traveling-crane, for operation by hand, in which the hoisting mechanism consists of a Weston differential pulley-block suspended from the trolley, is shown in the engraving. The bridge is arranged to travel lengthwise upon the longitudinal tracks, and the trolley to move transversely upon the bridge, so that the entire rectangular space between the tracks is covered by the crane. If desired, several trolleys and blocks can be fitted to the same crane. This style of crane is built of any desired capacity from one ton upward, and of any desired span. The mechanism attached to the right hand end of the bridge consists substantially of the bridge-traveling apparatus. It is operated by a single endless hand rope or chain, reaching from the machine downward toward the floor, by pulling one side of which the bridge is propelled in one direction upon its tracks, while by pulling the opposite side the bridge is propelled in the opposite direction.

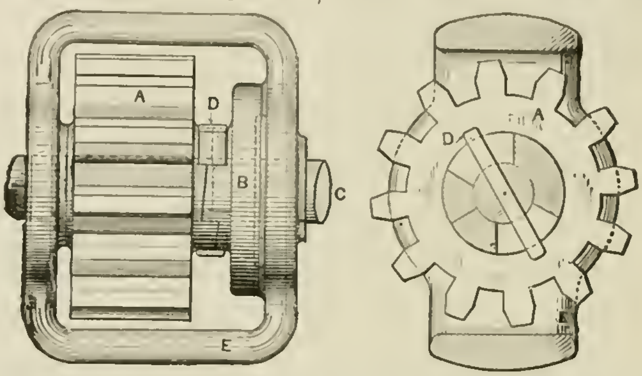
None of the mechanism projects more than a few inches above the top of the bridge, so that the latter may be placed close to the ceiling or roof-timbers of the room, thus affording the greatest possible height of hoist. The longitudinal motions of the bridge are effected by pulling the hand-rope as above explained, and the transverse motion of the trolley on the bridge by pushing or pulling the suspended load. This crane is especially adapted to light foundry work, to the erection of light machinery, to the setting of work in lathes, planers, etc., and for use over very heavy machines, such as steam-engines, rolling-mills, etc., for the removal and handling of parts during repairs.

Frequently, the crane is provided with two independent trolleys, each having a differential pulley-block suspended from it. Thus arranged, it is particularly convenient for lifting bulky loads, or for handling heavy guns or machinery which requires to be removed for repairs or inspection. Each trolley is provided with independent mechanism for causing it to travel upon the bridge, and is controlled by means of a single endless hand-chain depending from the trolley, as shown in the engraving. This construction is desirable wherever the head-room admits of it. Where absolutely necessary, however, the mechanism can be so arranged as to occupy but little more space above the bridge than in the crane shown above. When desirable, the crane may be arranged for operation by hand from the floor below, the operating mechanism being contained entirely within a trolley-crab, placed on the top of the bridge and moving transversely upon it. This location of the trolley is to be preferred wherever the head-room within the building admits of it. Two or more trolleys may be placed upon the same bridge. The bridge is arranged to travel lengthwise upon the longitudinal tracks, and the trolley to move transversely upon the bridge, so that the entire rectangular space between the tracks is covered by the crane. This design of crane is built of any desired capacity up to 10 tons, and of any span.



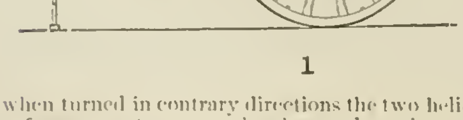
The squaring of the bridge, and its motion upon the longitudinal tracks, and also the motion of the trolley upon the bridge, are all effected by the Weston system of fixed cables. The crab or housing containing the mechanism travels upon rails on top of the bridge, and is located entirely above the latter, so that the breaking of any of its parts will merely allow them to rest upon the bridge without permitting the load to fall more than a few inches. This disposition of parts is always desirable if the over-head space is sufficient to admit of it, and should be adopted wherever the circumstances of the case make it feasible.

The several operations are effected by four endless hand chains or ropes depending from the crab. Those at the opposite sides of the crab give motion to the bridge and to the trolley. Those at the ends of the crab effect hoisting and lowering, one of them passing over a small wheel for quick speeds, and the other over a larger one slow speeds, a third speed being obtained by using both simultaneously. The hoisting gear consists of cut steel worms, engaging with cut worm wheels, with provision for thorough lubrication. The main hoisting chain is endless, and passes over pocketed chain wheels by which it is driven, the arrangement of parts being such as to distribute the wear equally throughout the entire length of this chain.



A safety-device, consisting of automatic friction ratchets in combination with the worm shafts, is employed, so that the load is always self-sustained in any position and cannot run down. No one form of safety-ratchet is applicable, without modification, to all the varying requirements of the crane. The drawing shows a form in which the ratchet is frictional and no toothed ratchet-wheel is required. The pinion, A, and the frictional ratchet or collar, B, are both loose upon their shaft, C. The adjacent hubs of these two parts have formed upon them a helix, so that when turned in contrary directions the two helical surfaces mount upon each other, and produce a longitudinal pressure which locks the several parts into frictional engagement with the sides of the housing, E, and so prevents the backward rotation of the pinion under the pressure of the load. In this case the parts occupy the relative positions shown in the sectional view, the cross-pin which is attached to the shaft standing midway between the two shoulders on the opposite helices. If the shaft be rotated in a direction to cause hoisting, the cross-key, D, moves forward until it picks up both the pinion, A, and collar, B, by pressing against the slotted openings in their hubs, and thus presses them into a position where the longitudinal pressure of the helices is relaxed and the parts rotate freely with the shaft. If this action be discontinued while the load is suspended the pinion, A, will rotate backward through a small arc carrying with it the key, D, and shaft, C, while the collar, B, remains stationary, and in this way the helical hubs restore the end pressure and the parts are again locked fast. If the shaft then be rotated backward, the key, D, will first pick up the collar, B, by pressing against the slot in its hub and move it forward into coincidence with the corresponding slot in the hub of the wheel, A, when, the end pressure being relaxed, the parts will again rotate freely so long as the shaft is turned backward, but upon the discontinuance of this motion the pressure of the load will again move the wheel, A, backward until the end pressure is restored. The exterior frictional face of the collar, B, is of larger diameter than that which abuts against the hub of the pinion, A, and the frictional resistance against the frame, thus acting at a greater radius, is sufficient to resist the strain of the load and hold the pinion stationary. See *Cranes*, *Hand Traveling-crane* and *Power Traveling-crane*.

TRAVELING FORGES.—The traveling-forge is a complete blacksmith's establishment, which accompanies a battery for the purpose of making repairs and shoeing horses. In the United States Service, it consists of a body, upon which is constructed the bellows-house, etc., and the limber, which supports the stock in transportation. The body is composed of two rails, the stock, and the axle-tree. The bellows-house is divided into the bellows-room and the iron-room. Attached to the back of the house is the coal-box, and in front of it is the fire-place. From the upper and front part of the bellows an air pipe proceeds in a downward direction to the air-box, which is placed behind the fireplace. The vise is permanently attached to the stock, and the anvil, when in use, is supported on a stone or a log of wood, and when transported is carried on the hearth of the fire-place. The remaining tools are carried in the limber-chest. When in working order the point of the stock is supported by a prop. The following is the nomenclature of the traveling-forge: *Lunette* (1); *prop* (2); *vice* (3); *stock* (4); *wheel-guard plates* (5);



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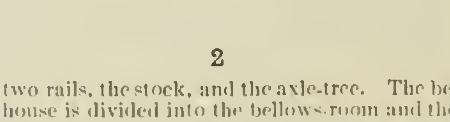

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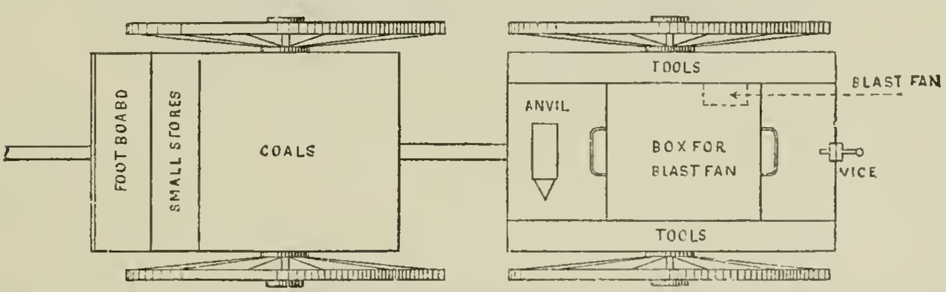
stock-stirrup (6); *fire-place* (7); *back of fire-place* (8); *air-back* (9); *wind-pipe* (10); *bellows* (11); *ribs* (12); *hinges* (13); *hook* (14); *fulcrum* (15); *hook* and *staple* (16); *roof of bellows-house* (17); *bows* (18); *studs* (19); *girders* (20); *end-boards* (21); *bottom boards* (22); *side-rail* (23); *lock-chain hook* (24); *coal-box* (25); *lid*, or *roof* (26); *handles* (27); *hinges* (28); *turnbuckle* and *hasp* (29).

To put the bellows in place, remove the coal-box from the back of the bellows-house; take out the two stay-plates at the lower ends of the rabbets in the brades; put the projecting ends of the upper bellows' arms in the rabbets, and slide them up until the ends of the lower arm come into their places; put on the stay-plates, and fasten them down with the thumb-nuts; screw the brass elbow-pipe into its place, through the hole in the sheet-iron front of the bellows-house; put in the copper pipe, and screw up the collar which connects it with the elbow-pipe.

There are two forges, one for the service battery, designated by the letter "A;" and one for the general reserve, designated by the letter "B." The forges of the general reserve differ much from those of the service battery only in their equipment; they are designed for more extensive repairs than can be made in the battery. A new pattern of field-forge has been proposed by Colonel Laidley, United States Ordnance Corps, which gives much satisfaction.

The construction of the Swedish field-forge is both novel and peculiar. It makes an important departure from the long-established ideas on this subject, and, though not such as can be recommended in its details, the marked feature which makes it stand out in strong contrast with the forges used by other nations—the substitution of the rotary fan for the leathern bellows—is one deserving of consideration and imitation The economy of space and weight in the forge, a matter of much importance, is considerable, and this too is gained without sacrificing efficiency. The fire-pan is made of thick wrought-iron, and is provided with two strong hooks for supporting it from the end of the forge-box. It has also a copper pipe attached for conducting the blast from the fan to the fire-pan. The rotary fan is arranged in a portable box, which contains the necessary countershaft and pulley for increasing the speed and the means of adjusting the tightness of the belt. There is a small sliding window on the side to supply the air, and an orifice on the top, covered with a movable cap, for attaching the blast-pipe. The tools and iron are carried in boxes which may be readily removed. The anvil, block, and fire-pan are carried loose. The supply of coal is carried in a chest on the limber., with an additional box for small tools. The wheels for forge and limber are very low, being only 3 feet 6 inches in height, and quite light.



The English forge consists of a rectangular frame iron, which fold under the frame when it is packed of angle iron, supported upon four legs also of angle for the march. The fire-pan is supported over one end of the frame on collar-bolts, and has a back of plate-iron, hinged so as to fold down on the fire-pan when not in use. At the other end of the frame, and hinged to it, is a rocking-staff frame to support the bellows, which rests in slots in the sides of the frame. The rocking-staff pivots on a tee-swivel on the top of its frame. The forge-frame has four handles for convenience of handling. The water-trough is of sheet-iron, with flat hooks on the side to hang it to the fire-pan. The nail-anvil is secured by a nut to the frame of the wagon at the rear end on the near side. The vise when in use is fixed to the end of the splinter-bar. The forge-frame, bellows, anvil and block, water-trough, etc., are carried on the march in an artillery wagon, the frame secured by two screws to the bottom of the wagon.

	Pounds.
Weight of bellows......	77
Weight of forge, frame, etc.........................	304½

See *Cavalry Forge*.

TRAVELING-KITCHEN.—Marshal Saxe, it is believed, first suggested the good idea of cooking while marching, so as to economize the strength of soldiers; have their food well cooked in all weather, and avoid the numerous diseases caused by bad cooking, and want of rest. Colonel Cavalli of the Sardinian artillery, has with the same laudable motive embraced a kitchen-cart in the improvements suggested by him to replace the wagons now in use; and an attempt is here made to elaborate the same idea of a travelling kitchen, designed for baking, making soup, and other cooking, while on a march. The cart is 12½ feet long, mounted on two 6-feet wheels, and covered with a very light canvas roof with leather-cloth curtains. A large range or stove forms the body of the vehicle; its grate is below the floor, its doors opening on a level with it. A *Papin digester* is inclosed above the grate, in a flue whence the heat may pass around the double-oven in the rear, or straight up chimney, as regulated by dampers. At the side of the digester, over the grate, is a range, suited to various cooking vessels. The top of the oven forms a table nearly 5 feet square, at which three cooks may work, standing upon the rear platform. A foot-board passes from this platform to the front platform, where the driver and a cook may stand. Stores may be placed in the lockers at the side of the range, and under the rear foot board. The chimney may be turned down, above the roof, to pass under trees, ect., and may be of any height to secure a good draft. By bending the axle like that of an omnibus, the vehicle may be hung without danger of top-heaviness. Cooking vessels, more bulky than heavy, may be suspended from the roof, over the range, when not in use. The digester may have a capacity of 100 gallons, and an oven, of 60 to 75 cubic feet, would be quite adequate to the cooking for 250 men; or the dimensions of the cart may be smaller, and each company of 100 men might have its own traveling-kitchen, which would also furnish oven and cooking utensils for camp.

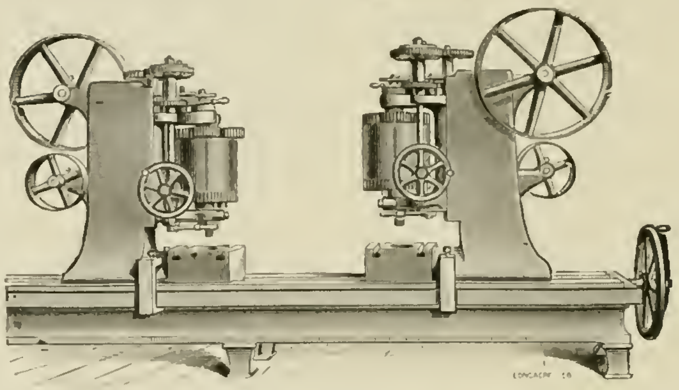
TRAVELING TRUNNION BEDS.—Contrivances for the purpose of distributing the load more equally over the gun-carriage. On the upper surface of the cheeks, near the rear ends, are placed two projecting bolts which, with the curve of the cheeks, form resting places for the trunnions, when the piece, is in position for transportation. They are called *traveling trunnion-beds*. When the piece is in this position its breech rests upon the bolster, which is a curved block of wood, bolted to the upper side of the stock.

On each side of the trail, and perpendicular to it, a strong maneuvering bolt is placed to serve as places to apply the handspikes in maneuvering the carriage.

TRAVERSE.- In gunnery a term used when directing a piece of ordnance either to the right or left of the position it is in. In field pieces, mounted on carriages, traversing takes place from the trail. With mortars, it is performed by hand-spikes in rear and front of the bed, and with siege guns by the application of handspikes to different parts of the carriage. The Armstrong gun has an adjusting wheel screw which enables the pointer to traverse the gun with his own hand and with the greatest accuracy.

TRAVERSE CIRCLES.—In gunnery, circular plates of iron, fastened to a bed of solid masonry, on which the traverse wheels, which support the chassis, roll.

TRAVERSE-DRILL.- A drill for boring slots, and in which the drill-stock has a traverse motion for adjustment. The drawing shows a double transverse drill, specially adapted for drilling pin-holes at both ends of links, rails and check metals (in the construction of sea-coast and other large carriages) at the

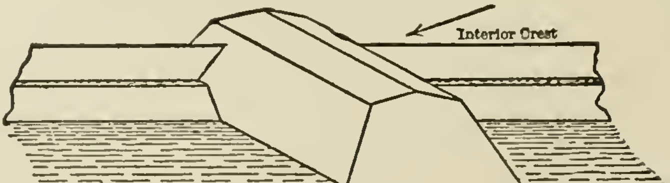


same time, so as to secure perfect uniformity in the distance between them. For this purpose the boring machines are right and left-hand, sliding on a solid bed, and adjustable to or from each other, to suit the required length of links. The boring machines are so placed as to permit the links to be put in place from one side, and, when done, passed out on the other side of the machine. The driving is effected by horizontal belts passing over guide-pulleys, and around a drum on the spindles. The cutters used in this machine are kept cool by water fed to them through the center of the spindle. In the link boring machine the two heads are united by bars of wrought iron and can slide freely on the cast-iron bed. The expansion of the wrought-iron bars being the same as the expansion of the link being bored, insures uniformity in the length of the finished work. See *Drilling-machine*.

TRAVERSES.—Mounds of earth, above the height of a man, placed at frequent intervals on a rampart to stop shot which may enfilade the face of such rampart. A fire of this nature, in the absence of traverses, would dismount the guns, and prove altogether ruinous. The traverses also give means of disputing the progress of the assailant who has gained a footing on the wall, for each traverse becomes a defensible parapet, only to be taken by storm.

The construction of the traverse is usually very simple—the main object being to interpose a mass of earth upon a line of fire, in the shortest time possible. This is done by piling sand-bags, filled with earth upon the spot to be occupied by the traverse, and raising there a mass thick enough and high enough to serve the end required. Gabions filled with earth are frequently used for the same purpose. The top of a traverse is usually made ridge-shaped, so as to carry away the rain water which falls upon it. The sides of the traverse are sloped, the inclination of the slopes being the same, or different, according to the degree of exposure of the traverse to the enemy's fire.

The traverse shown in the drawing is an example of a traverse built to shelter the men on the banquette from a slant or enfilading fire, coming in the direction shown by the arrow. Its top is made ridge-shaped. The side towards the enemy has the natural slope of the earth; the opposite side is made steeper and should be revetted. The thickness of the traverse depnds upon its exposure to the enemy's fire. If a fire can be brought directly upon it, it should have the same thickness as that given to the parapet. Its height and length depend upon the amount of banquette and terreplein which are to be defiladed by it. Instead of being ridge-shaped, the traverses are, in many cases, made with a cross section similar to that of the parapet. See *Gabionade*, *Splinter-proof Traverse*, and *Wing Traverses*.



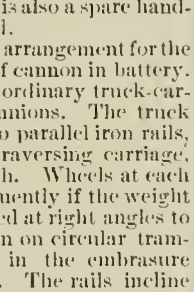
TRAVERSING GEAR.—An automatic traversing apparatus, in Machine-guns, by which a limited angular movement in a horizontal plane may be given. It is designed as follows: To the opposite side of the transverse shaft on which the crank is fitted, is keyed a sleeve, having cut on its exterior a right and left hand screw, on which works the tapered end of a forked piece. This is dropped into a socket, in the outer end of a brass casting, against which the upper end of the elevating-screw presses. A crutch passes through the upper socket, then through a brass-ring fitted with a clamp, and finally through the lower socket of the casting, by which means it is permitted to turn as it passes along a worm, in either direction. On the outer end of the sleeve is keyed a nut or ring, capable of adjustment at every half-turn of the worm. This is effected by a pin on the ring, and corresponding holes midway between the intersection of the threads of the worm, thus regulating the range of motion of the breech of the gun. This ring serves to close one end, and thus make the screw endless, and also to turn the crutch into the return groove; the inner end of the sleeve being arranged so as to accomplish the same object. As the firing-crank, is turned, the barrels, carrier, lock-cylinder, and worm are revolved. The latter, working on a crutch, gives the piece a continuous lateral traverse which may be enlarged or contracted as desired, by means of a nut; thus spreading the fire over a wide range, or contracting it. The crutch may be thrown out of gear, and the gun fired without swinging. Elevating or depressing the gun does not interfere with the lateral traverse, as the elevating-screw presses against the bottom of the casting to which the crutch is attached, and thus both run up or down alike. See *Gatling Gun.*

TRAVERSING HANDSPIKE.—For traversing the gun,in field carriages, this handspike is inserted into the handspike-ring at the end of the trail,when in action; but when the gun is limbered up,it is strapped on the surface of the trail. There is also a spare handspike carried underneath the trail.

TRAVERSING PLATFORM.—An arrangement for the more rapid and easy movement of cannon in battery. The gun is either mounted on an ordinary truck-carriage, or on rollers under its trunnions. The truck or rollers work in and out on two parallel iron rails, which rails are mounted on the traversing carriage, and are 16 feet or more in length. Wheels at each end of this platform,or more frequently if the weight of the gun be very great,are placed at right angles to the direction of the rails, and run on circular tramways, which have their center in the embrasure through which the gun is fired. The rails incline upward toward the rear,to moderate the gun's recoil. The advantages are,that the leverage for turning the gun is increased by the platform's length, while the circular rails diminish the resistance; that the gun is easily run out for firing on the upper rails; that by its own recoil it runs itself in again for loading; and that a much smaller embrasure is required to give a good compass to the muzzle.

TREAD.—In fortification, the upper and flat surface on which the soldier stands whilst firing over the parapet; usually called the *Banquette-tread.*

TREADWELL COMBINATION FUSE.—This fuse is a modification of the Splingard fuse,and consists of the following parts:—A metal fuse-plug, *E*; a paper case, *A*,into which the fuse composition,*B*,is driven around a mandrel, a leaden corrugated cylinder, *C*, being left as a lining of the fuse composition after the mandrel is withdrawn; a tube, *D*, closed at the front end, is now made by pouring fluid plaster of Paris, or this with asbestos mixed. The theory of the fuse is that the fuse composition when it is burning down leaves the plaster of Paris tube unsupported, and at impact the closed end is broken off, giving the flame of the fuse access to the bursting charge of the projectile. See *Fuse.*



TREADWELL HOOPED GUN.—This cannon consists of a body (in which the caliber is formed), the walls of which are of one piece, surrounded by rings, hoops or tubes, in one or more layers, placed upon the body under great strain, and by which the body is compressed and the natural equilibrium of the molecules or particles of which it is composed disturbed by their being brought nearer together: this is accomplished by making the hoops smaller than the part which they are to surround, and then expanding them by heat, and then suffering them to shrink or contract after having been put in their places. The hoops are secured to the body of the gun, and the several layers of hoops to each other by screw-threads, when they shrink to there places as described.

TREASON.—In the United States, treason may be either against an individual State or against the United States. In the former case it is an offense at common law. By the Constitution treason against the United States consists in levying war against them, or in adhering to, or giving aid and comfort to their enemies. It is further provided that no person shall be convicted of treason unless on the testimony of two witnesses to the overt act or upon confession in Open Court. The penalty is death. A conspiracy to commit treason does not constitute the crime, unless followed by overt acts. In the meaning of the term "enemies" of the United States, pirates or robbers actually invading our territory are included. See *High Treason.*

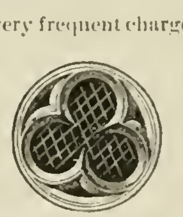
TREATY.—Any agreement of friendship, alliance commerce, or navigation, entered into between two or more independent States. Treaties have been divided by publicists into *personal* and *real*, the difference being that the former relate exclusively to the persons of the contracting parties—for example, treaties guaranteeing the throne to a particular Sovereign and his family—and the latter are treaties for national objects, independent of the Rulers of the State. While personal treaties expire with the death of the Sovereign, or the extinction of his family, real treaties bind the contracting parties independently of any change in the sovereignty of the States. The Constitution of each particular State must be looked to, to determine in whom the power of negotiating and contracting treaties with foreign powers resides. In Monarchies, whether absolute or constitutional, it is usually vested in the Sovereign. By the Constitution of Great Britain, the exercise of this power is subject to parliamentary censure; Ministers who advise the conclusion of any treaty which shall afterward be judged derogatory to the honor, or disadvantageous to the welfare of the nation, being liable to impeachment, a proceeding of which English history affords numerous instances; as the impeachment of De la Pole, Earl of Suffolk, in 1451, for making a Convention of Peace without the assent of the Privy Council; of Wolsey, in 1529, by the House of Lords, for making treaties without the King's knowledge; and of the Earl of Orford by the Commons, in 1701, for advising treaties for dividing the dominions of Spain. In Republics, the Chief Magistrate, Senate, or Executive Council is intrusted with the exercise of this sovereign power. The Constitution of the United States of America vests it in the President, with the advice and consent of the Senate. No special form of words is necessary for the validity of a treaty: but modern usage requires that an agreement which has originally been verbal, should as soon as possible be committed to writing. There are certain compacts between nations which are included in the exercise of a general implied power confided to certain public agents as incidental to their official position. Such are the acts of Generals or Admirals limiting hostilities by truces, capitulations, or cartels for the exchange of prisoners, which do not require the ratification of the supreme authority, unless there be a reservation making that necessary. In other cases, however, a Public Minister or other Diplomatic Agent is not entitled to conclude or sign a treaty with the foreign power to which he is accredited, without a full power independent of his general letter of credence. Even in the case of a treaty concluded with full powers, it is often considered expedient to have a special ratification by the sovereign, or other proper authority of the state contracting. A treaty is considered to be extinguished when one of the contracting powers loses its existence as an Independent State, when the internal Constitution or either State is changed so as to make it inapplicable: and in case of war between the contracting parties, unless the stipulations of the treaty have been expressly with a view to the rupture. As there is often a difficulty in distinguishing stipulations perpetual in their nature from those that are extinguished by war, it is common to insert clauses in treaties of peace reviving and confirming the treaties formerly subsisting between the contracting parties. A *treaty of guaranty* is an engagement by which one State promises to aid another when it is disturbed, or threatened to be disturbed, in the peaceable enjoyment of its rights by a third power. *Treaties of alliance* may be offensive or defensive: in the former, the ally engages generally to co-operate in hostilities against a specified power, or against any power with which the other may be at war; in the latter, the engagements of the ally extend only to a war of aggression commenced against the other contracting party. The execution of a treaty is occasionally secured by hostages; as at the Peace of Aix la-Chapelle, in 1748, when several Peers were sent to Paris as hostages for the restoration of Cape Breton by Great Britain to France.

TREBUCHET.—A modification of the battering-ram, used in the Middle Aages. It was designed for throwing stones and making a breach. In its simple form it was put in motion by means of a rope pulled by four men. Subsequently the *trebuchet* was made double. These shot stones by the backward and forward motion of the beam, one end of which was always loaded while the other returned. The *trebuchet with a sling* was constructed in much the same manner as the simple trebuchet, with this difference, that, at a given moment, a hook fastened to the long end of the beam let fly one of the ropes, and to the stone was shot forth from the tangent of the circle described. Also written *trebucket*.

TREFLE.—A term used in mining, from the similarity of the figure to trefoil. The simple trefle has only two lodgments; the double trefle, four; and the triple one, six.

TREFOIL.—In Heraldry, a very frequent charge, representing the clover-leaf, and is always depicted as *slipped, i. e.*, furnished with a stalk.

Trefoil in Heraldry.



Trefoil in Architecture.

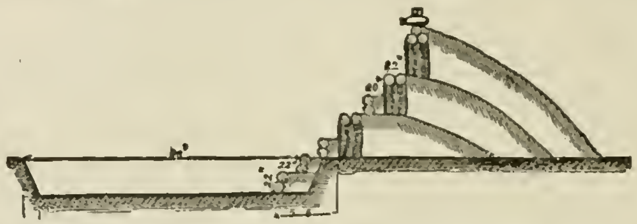
TREFOIL-BUCKLER.—A shield or buckler in the form of a tree-lobed leaf which was sometimes worn by the Greek soldiers in ancient times.

TRELLISED ARMOR.—Armor of the Middle Ages, made both of quilted linen and skin, strengthened with straps of thick leather, placed trellis-wise. Each square is armed with a riveted nail-head.

TRENCH-CART. The trench-cart is a common hand-cart, employed principally in the transportation of ammunition in siege-trenches. In the Crimea, trained pack-mules were employed in transporting ammunition and other supplies, from the depots to all parts of the trenches.

TRENCH CAVALIER.—This work consists of a parapet raised on a mound of earth for the purpose of obtaining a plunging fire on the covered-way of the besieged work. The mound should in all cases be of such height that the cavalier will have a command of 4 feet 3 inches over the crest of the covered-way.

There are two modes of constructing the cavalier, depending on the nature of the soil. When the excavated earth is of such a nature that it can be easily made to stand at any slope, a profile shown in the drawing is preferred, as requiring less time and materials. After having laid out the position of the cavalier by the full sap, the sappers widen the trench 6 feet, and make a step at the bottom of the trench 22 inches in height, and 5 feet 6 inches within the gabion of the parapet; this step serves as the platform on which the sappers mount to level the earth of the parapet even with the fascines on top of the first gabion, for the purpose of raising a second tier of gabions, which is placed 22 inches beyond the



first. The second tier is filled with earth, and crowned with two fascines, and the mound is raised to a level with the fascines, by widening the trench to the rear. The earth is now leveled even with the top of the fascines, and a third tier of gabions is placed just on the outside of the second; it is filled with earth, crowned with three fascines, and the mound is raised to a level with the upper fascine. This top tier forms the parapet of the work. Loop-holes are made by arranging sand-bags on top of the parapet, for the purpose of covering the heads of men whilst in the act of firing. As the successive tiers of gabions are placed, steps, revetted with fascines, are made to lead to the top; these steps have a rise and tread of 22 inches; the top one serves as a banquette.

When the soil excavated is loose, a cavalier made in the manner just described would not be sufficiently firm. The following construction will in this case be used. After having traced out the cavalier as before by the full sap, a row of gabions is placed in the bottom of the trench, along the foot of the interior slope; this row is filled with earth, and crowned with two fascines, and earth is filled in between it and the interior slope of the trench and brought to a level with the berm. A third tier of gabions is placed on this platform alongside of the row forming the parapet of the trench; this tier is, in like manner, filled with earth and crowned with two fascines. The second tier of the cavalier is commenced, by placing a fourth row of gabions over the joint of the two in the first tier; this is filled with earth, crowned with two fascines, and the mound is raised on the exterior to a level with this fourth gabion. A fifth row is next placed alongside of the two in the first tier, filled with earth and crowned with two fascines. A sixth is then placed alongside of the fourth, in the second tier, and arranged like the preceding. Finally, the parapet is formed on this second tier, by placing a gabion above the joint between those of the second tier. The steps are made to ascend to the top, by throwing up a mound of earth, on the interior, against the gabionade, and forming the surface into steps revetted with fascines, as in the last case. In conducting the operations in both these cases, it will be seen that the top of the mound of earth in rear of gabions should be preserved on a level of at least a gabion and a half in height below the top of each successive tier of gabions when filled with earth, in order to give the workmen an ample cover from the enemy's fire. See *Cavalier*.

TRENCHES.—In offensive works and batteries, it is necessary on many occasions to throw up a parapet, from earth excavated in rear of the parapet; such an excavation is termed a *trench*. The usual depth of trenches is 3 feet. Should the nature of the ground be such as not to yield sufficient earth for the parapet, a small ditch must be made in front. In a siege, the approaches made by the besiegers are termed trenches, which are opened at varying distances from the place, depending upon circumstances. See *Siege*.

TRENCH-SHELTER.—A trench hastily thrown up to give cover to troops on a field of battle. It is always 1 foot 3 inches deep, and the parapet is from $1\frac{1}{4}$ to $1\frac{1}{2}$ feet high. A trench 2 feet broad can be made in from 10 to 20 minutes; one 4 feet wide in from 20 to 40 minutes; and one 7 feet broad in from 30 to 60 minutes, There are also small trenches in rear for the supernumeraries.

TREND.—In fortification, the general line of direction of the side of a work or a line of works.

TRENSE.—A Germanic bit made of iron. It was of the Merovingian epoch, and was used on war-horses.

TREPIED.—An ancient name for a ballista when supported on three legs.

TRESSURE.—In Heraldry, a subordinary, generally said to be half the breadth of the orle, and usually borne double, and flowered and counter-flowered with fleurs-de-lis. It forms part of the royal insignia of Scotland, which are: or, a lion rampart gules, armed and langued azure, within a double tressure flory counterflory of the second. The origin of the tressure in the arms of Scotland has been traced by the older heralds to the 9th c., when they relate that it was granted by Charlemagne to King Achaius of Scotland, in token of an ancient alliance between France and Scotland, and with the view of indicating that the French lilies would in time coming be a defense to the Scottish lion. Chalmers insinuates that these two monarchs were probably not aware of each other's existence; and, in point of fact the double tressure is not known to have been borne earlier than the time of Alexander III., on whose seal it appears. The tressure is, however, held in great honor in Scottish Heraldy, and Lyon King-of-Arms has not been permitted to grant it to any subject without a royal warrant; as a mark of especial favor, it, has, however, occasionally been accorded by the Sovereign to the representatives of important families directly descended by a maternal ancestor from royalty, or who had deserved well of their King and Country.

TRESTLE BRIDGE.—A bridge supported on trestles. This kind of bridge is very useful in establishing communications across shallow rivers with sound and hard beds, and not subject to sudden floods; it can be readily constructed with any kind of timber, easily placed in shallow water; it is not, however, suitable for deep muddy rivers. Trestle bridges are of three kinds, the length of the legs depending on the depth of the water. They are described as follows:—

Two-legged trestle.—Formed of two transoms, two legs, and two diagonals lashed together: it is used for streams 6 feet deep and running with a velocity of 5 feet per second, or in deeper streams if the velocity is less, and is suitable for any kind of hard bottoms. *Four-legged trestle.*—Made of one transom, four legs, and four diagonals lashed together. Used in still waters where a greater length of leg than 12 feet is not required, or in running streams where the water is not more than 3 feet deep, or the velocity greater than 3 feet per second. Another kind of four-legged trestle bridge can be made in the same manner, put together with nails, and is useful for bridges intended to stand for some time, as rope lashings soon rot under water. *Tripod trestle.*—Made of one transom, six legs (three on each side, and placed in a triangle lashed at the apex, and fixed together at the basis by ledgers), four cross-bearers to support the transom, and four stakes to support the bearers, the whole lashed together. This kind of bridge is particularly useful for military purposes; it may be used in water 6 feet deep, with a velocity of 5 feet per second, and in all streams with muddy bottoms.

TREWS.—The name given to the pantaloons worn by the soldiers of certain Highland regiments. They are made of various tartan cloths. The regiments which wear the kilt do not wear the trews.

TRIA JUNCTA IN UNO.—The motto of the Knights of the Military Order of the Bath, signifying "Faith, Hope and Charity."

TRIAL.—All trials before Courts-Martial, like those in Civil Courts, are conducted publicly; and in order that this publicity may in no case be attended with tumult or indecorum of any kind, the Court is authorized, by the Rules and Articles of War, to punish at its discretion, all riotous and disorderly proceedings or menacing words, signs, or gestures, used in its presence. The day and place of meeting of a General Court-Martial having been published in orders, the officers appointed as members, the parties and witnesses, must attend accordingly. The Judge Advocate, at the opening, calls over the names of the members, who arrange themselves on the right or left of the president according to rank. The members of the Court having taken their seats and disposed of any preliminary matter, the prisoner, prosecutor, and witnesses are called into Court. The prisoner is attended by a guard, or by an officer, as his rank or the nature of the charge may dictate; but during the trial, should be unfettered and free from any bonds or shackles, unless there be danger of escape or rescue. Accommodation is usually afforded, at detached tables, for the prosecutor and prisoner; also for any friend or legal adviser of the prisoner or prosecutor, whose assistance has been desired during the trial; but the prisoner only can address the Court, it being an admitted maxim, that counsel are not to interfere in the proceedings or to offer the slightest remark, much less to plead or argue. The Judge Advocate, by direction of the President, first reads, in an audible voice, the order for holding the Court. He then calls over the names of the members, commencing with the President, who is always the highest in rank. He then demands of the prisoner, whether he has any exception or cause of challenge against any of the members present, and if he has, he is required to state his cause of challenge, confining his challenge to one Member at a time; after hearing the prisoner's objection, the President must order the Court to be cleared, when the members will deliberate on and determine the relevancy or validity of the objection; the member challenged retiring during the discussion. Sufficient causes for challenge are: the expression of an opinion relative to the subject to be investigated; having been a member of a Court of Inquiry which gave an opinion; or of another General Court-Martial, in which the circumstances were directly investigated: or of another General Court-Martial in which the circumstances were investigated incidentally and an opinion formed thereon; prejudice, malice, or the like. The privilege of challenge is not confined to the prisoner; for there may be sources of prejudice in favor of the prisoner as well as against him, and urgent motives that may sway to acquit, as well as condemn. When the prisoner and prosecutor decline to challenge any of the members, or where the causes of challenge have been disallowed, the Judge Advocate proceeds to administer to the Members of the Court, the oath prescribed by law which is in the following words: "You, A. B., do swear, that you will well and truly try and determine, according to evidence, the matter now before you, between the United States of America and the prisoner to be tried; and that you will duly administer justice according to the provisions of "an act establishing rules and articles for the government of the armies of the United States", without partiality, favor or affection; and if any doubt shall arise, not explained by said articles, according to your understanding and the custom of war in like cases; and you do further swear, that you will not divulge the sentence of the Court, until it shall be published by the proper authority: neither will you disclose or discover the vote or opinion of any particular Member of the Court-Martial, unless required to give evidence thereof, as a witness, by a Court of Justice in due course of law. So help you God." The oath is taken by each Member holding up his right hand and repeating the words after the Judge-Advocate. After the oath has been administered to all the Members, the President administers to the Judge-Advocate, the particular oath of secrecy to be observed by him, and which is as follows: "You, A. B., do swear that you will not disclose or discover the vote or opinion of any particular Member of the Court-Martial, unless required to give evidence thereof as a witness, by a Court of Justice in due course of law, nor divulge the sentence of the Court to any but the proper authority, until it shall be duly disclosed by the same. So help you God." The oath taken by the President and Members contains a twofold obligation to secrecy: 1st, That they will not divulge the sentence of the Court, until it shall be published by proper authority: and, 2d, That they shall not disclose or discover the vote or opinion of any particular Member of the Court-Martial, unless required to give evidence thereof by a Court of Justice, in a due course of law. Both these obligations have their foundation in reason and good policy. No sentence of a General Court-Martial is complete or final, until it has been duly approved. Until that period it is, strictly speaking, no more than an opinion, which is subject to alteration or revisal. In this interval, the communication of that opinion could answer no ends of justice, but might, in many cases, tend to frustrate them. The obligation to perpetual secrecy, with regard to the votes or opinions of the particular Members of the Court, is likewise founded on the wisest policy. The officers who compose a military tribunal are, in a great degree, dependent for their preferment on the President. They are even, in some measure, under the influence of their Commander-in-Chief—considerations which might impair justice. This danger is, therefore, best obviated by the confidence and security which every Member possesses, that his particular opinion is never to be divulged. Another reason is, that the individual Members of the Court may not be exposed to the resentment of parties and their connections, which can hardly fail to be excited by those sentences, which Courts-Martial are obliged to award. It may be necessary for officers, in the course of their duty, daily, to associate and frequently to be sent on the same command or service, with a person against whom they have given an unfavorable vote or opinion on a Court-Martial. The publicity of these votes or opinions would create the most dangerous animosities, equally fatal to the peace and security of individuals, and prejudicial to the public service. The oath which is taken by the Judge Advocate, contains the same obligation to secrecy, except so far as it relates to the person who has the approving or disapproving of the sentence of the Court. It is not inconsistent with his oath or duty, for the Judge Advocate to communicate to the proper authority, his views of the proceeding of the Court. The Judge Advocate is, however, bound by oath, as well as the Members of the Court, to maintain the strictest secrecy with regard to the votes or opinions of individuals for the reasons above stated. The oath taken by the Members of the Court commences with these words: "You, A. B., do swear that you will well and truly try and determine, according to evidence, the matter now before you, between the United States of America and the prisoner to be tried." The expression "prisoner," in the singular number, seems to imply that the swearing, and consequently the trial, should in each case be separate. That course should therefore be pursued. Application to delay the assembling of the Court, from the absence or indisposition of the witnesses, the illness of the parties, or other cause, should be made, when practicable, to the authority convening the Court; but application to put off or suspend the trial may be urged with a Court-Martial, subsequent to the swearing of the Members. It may be supported by affidavit, and the Court, in allowing it to prevail, must be satisfied, if the cause be absence of a witness, that the testimony proposed to be offered is material, and that the applicant cannot have substantial justice without it. The points, therefore, which each witness is intended to prove, must be set forth in the application, and it must also be shown that the absence of the witness is not attributable to any neglect of the applicants.

A precise period of delay must be applied for, and it must be made to appear that there is reasonable expectation of procuring the attendance of the witness by the stated time; or, if the absence of a witness be attributed to his illness, a surgeon, by oral testimony, or by affidavit, must state the inability of the witness to the Court, the nature of his disease, and the time which will probably elapse before the witness may be able to give his testimony. The Court must obviously be adjourned at any period of its proceedings, prior to the final close of the prosecution and defense, on satisfactory proof, by a Medical Officer, that the prisoner is in such a state, that actual danger to his health would arise from his attendance in Court; and where the prisoner is so ill as to render it probable that his inability to attend the Court will be of such continuance as to operate to the inconvenience of the service, either by the detention of the Members of the Court from their regiments, or from other cause, the Court may be dissolved by the authority which convened it. Though the prisoner may have been arraigned, and the trial proceeded with, the prisoner, on recovery, would be amendable to trial by another Court. The illness of the prosecutor would, in few cases, justify the suspension of the trial, excepting, perhaps, for a very limited period; all prosecutions before Courts-Martial being considered as the suit of the United States, or an individual State, as the case may be. The Court being regularly constituted, and every preliminary form gone through, the Judge-Advocate, as prosecutor for the United States, desires the prisoner to listen to the charge or charges brought against him, which he reads with an audible voice, and then the prisoner is asked, whether he is guilty or not guilty of the matter of accusation. The charge being sufficient, or not objected to, the prisoner must plead either: 1st, Guilty; or 2d, Specially to the jurisdiction, or in bar; or 3d, The general plea of *not guilty*, which is the usual course where the prisoner makes a defense. If from obstinacy and design the prisoner stand mute, or answer foreign to the purpose, the Court may proceed to trial and judgment, as if the prisoner had regularly pleaded *not guilty;* but if the prisoner plead *guilty*, the Court will proceed to determine what punishment shall be awarded, and to pronounce sentence thereon. Preparatory to this, in all cases where the punishment of the offense charged is discretionary, and especially where the discretion includes a wide range and great variety of punishment, and the specifications do not show all the circumstances attending the offense, the Court should receive and report, in its proceedings, any evidence the Judge Advocate may offer, for the purpose of illustrating the actual character of the offense, notwithstanding the party accused may have pleaded guilty; such evidence being necessary to an enlightened exercise of the discretion of the Court, in measuring the punishment, as well as for the approving authority. If there be any exception to this rule, it is where the specification is so full and precise as to disclose all the circumstances of mitigation or aggravation which accompany the offense. When that is the case, or when the punishment is fixed, and no discretion is allowed, explanatory testimony cannot be needed. Special pleas are either to the jurisdiction of the Court, or in bar of the charge. If any officer or soldier be arraigned by a Court not legally constituted, either as to the authority by which it is assembled, or as to the number and rank of its members, or other similar causes, a prisoner may except to the jurisdiction of the Court-Martial. Special pleas in bar go to the merits of the case, and set forth a reason why, even admitting the charge to be true, it should be dismissed, and the prisoner discharged. A former acquittal or conviction of the same offense would obviously be a valid bar, except in case of appeal from a Regimental to a General Court-Martial. Though the facts in issue should be charged to have happened more than two years prior to the date of the order for the assembling of the Court-Martial, yet it is not the province of the Court, unless objection be made, to inquire into the cause of the impediment in the outset. It would be to presume the illegality of the Court, whereas the Court should assume that manifest impediment to earlier trial did exist, and leave the facts to be developed by witnesses in the ordinary course. A pardon may be pleaded in bar. If full, it at once destroys the end and purpose of charge, by remitting that punishment which the prosecution seeks to inflict; if conditional, the performance of the condition must be known; thus, a soldier arraigned for desertion, must plead a general pardon, and prove that he surrendered himself within the stipulated period. No officer or soldier, being acquitted or convicted of an offense, is liable to be tried a second time for the same. But this provision applies solely to trials for the same incidental act and crime, and to such persons as have, in the first instance, been legally tried. If any irregularity take place on the trial rendering it illegal and void, the prisoner must be discharged, and be regarded as standing in the same situation as before the commencement of these illegal proceedings. The same charge may, therefore, be again preferred against the prisoner who cannot plead the previous illegal trial in bar.

A prisoner cannot plead at the bar that he has not been furnished with a copy of the charges, or that the copy furnished him differed from that on which he has been arraigned. It is customary and proper to furnish him with a correct copy; but the omission shall not make void, though it may postpone the trial. If the special plea in bar be such that, if true, the charge should be dismissed and the prisoner discharged, the Judge-Advocate should be called on to answer it. If he does not admit it to be true, the prisoner must produce evidence to the points alleged therein; and if, on deliberation, the plea be found true, the facts being recorded, the Court will adjourn and the President submit the proceedings to the officer by whose order the Court was convened, with a view to the immediate discharge of the prisoner. The ordinary plea is *not guilty*, in which case the trial proceeds. The Judge-Advocate cautions all witnesses on the trial to withdraw, and to return to Court, only on being called. He then proceeds to the examination of witnesses, and to the reading and proof of any written evidence he may have to bring forward. After a prisoner has been arraigned on specific charges, it is irregular for a Court-Martial to admit any additional charge against him, even though he may not have entered on his defense. The trial on the charges first preferred, must be regularly concluded, when, if necessary, the prisoner may be tried on any further accusation brought against him. On the trial of cases not capital, before Courts-Martial, the deposition of witnesses not in Line or Staff of the army, may be taken before some Justice of the Peace, and read in evidence, provided, the prosecutor and person accused are present at the same, or are duly notified thereof. The examination of witnesses is invariably in the presence of the Court; because, the countenance, looks and gestures of a witness add to or take away from, the weight of his testimony. It is usually by interrogation, sometimes by narration; in either case the Judge-Advocate records the evidence, as nearly as possible, in the express words of the witness. All evidence, whatever, should be recorded on the proceedings, in the order in which it is received by the Court. A question to a witness is registered before enunciation; when once entered, it cannot be expunged, except by the consent of the parties before the Court; if not permitted to be put to the witness, it still appears on the proceedings accompanied by the decision of the Court. The examination in chief of each particular witness being ended, the cross-examination usually follows, though it is optional with the prisoner to defer it to the final close of the examination in chief. The re-examination by the prosecutor, on such new points as the prisoner may have made, succeeds the cross-examination, and finally, the Court puts such questions as in its judgment may tend to elicit the truth.

It is customary when deemed necessary by the Court, or desired by a witness, to read over to him, immediately before he leaves the Court, the record of his evidence, which he is desired to correct if erroneous, and, with this view, any remark or explanation is entered upon the proceedings. No erasure or obliteration, is, however, admitted, as it is essentially necessary that the authority which has to review the sentence, should have the most ample means of judging, not only of any discrepancy in the statements of a witness, but of any incident which may be made the subject of remark, by either party in addressing the Court.

Although a list of witnesses summoned by the Judge-Advocate, is furnished to the court on assembling, it is not held imperative on the prosecutor to examine such witness; if he should not do so, however, the prisoner has a right to call any of them. Should the prisoner, having closed his cross-examination, think proper subsequently to recall a prosecutor's witness in his defense, the examination is held to be in chief, and the witness is subject to cross-examination by the prosecutor. Although either party may have concluded his case, or the regular examination of a witness, yet should a material question have been omitted, it is usually submitted by the party to the President, for the consideration of the Court, which generally permits it to be put. The prisoner being placed on his defense, may proceed at once to the examination of witnesses; firstly, to meet the charge, and secondly, to speak as to character, reserving his address to the Court, until the conclusion of such examinatian. The prisoner having finished the examination in chief of each witness, the prosecution cross-examines; the prisoner re-examines, to the extent allowed to the prosecutor, that is, on such new points as the cross-examination may have touched on, and the Court puts any questions deemed necessary. The prisoner, having finally closed his examination of witnesses, and selecting this period to address the Court, offers such statement or argument as he may deem conducive to weaken the force of the prosecution, by placing his conduct in the most favorable light, accounting for or palliating facts, confuting or removing any imputation as to motives; answering the arguments of the prosecutor, contrasting, comparing and commenting on, any contradictory evidence; summing up the evidence on both sides, where the result promises to favor the defense, and, finally, presenting his deductions therefrom.

The utmost liberty consistent with the interest of parties not before the Court and with the respect due to the Court itself, should, at all times, be allowed a prisoner. As he has an undoubted right to impeach, by evidence, the character of the witnesses brought against him, so he is justified in contrasting and remarking on their testimony, and on the motives by which they, or the prosecutor, may have been influenced. All coarse and insulting language is, however, to be avoided, nor ought invective to be indulged in, as the most pointed defense may be couched in the most decorous language. The Court will prevent the prisoner from adverting to parties not before the Court, or only alluded to in evidence, further than may be actually necessary to his own exculpation. It may sometimes happen that the party accused may find it absolutely necessary, in defense of himself, to throw blame and even criminality on others, who are no parties to the trial; nor can a prisoner be refused that liberty, which is essential to his own justification. It is sufficient for the party aggrieved, that the law can furnish ample redress against all calumnious or unjust accusations. The Court is bound to hear whatever address, in his defence, the accused may think fit to offer, not being in itself contemptuous or disrespectful.

It is competent to a Court, if it think proper, to caution the prisoner, as he proceeds, that, in its opinion, such a line of defense as he may be pursuing would probably not weigh with the Court, nor operate in his favor; but, to decide against hearing him state arguments, which, notwithstanding such caution, he may persist in putting forward, as grounds of justification or extenuation (such arguments not being illegal in themselves,) is going beyond what any Court would be warranted in doing. It occasionally happens, that, on presenting to the Court a written address, the prisoner is unequal to the task of reading it, from indisposition or nervous excitement; on such occasions the Judge Advocate is sometimes requested by the President to read it; but, as the impression which might be anticipated to be made by it, may, in the judgment of the prisoner, be affected more or less by the manner of its delivery, Courts-Martial generally feel disposed to concede to the accused the indulgence of permitting it to be read by any friend named by him, particularly if that friend be a military man, or if the Judge Advocate be the actual prosecutor. Courts-Martial are particularly guarded in adhering to the custom of resisting every attempt on the part of counsel to address them. A lawyer is not recognized by a Courts-Martial, though his presence is tolerated, as a friend of the prisoner to assist him by advice in preparing questions for witnesses, in taking notes, and shaping his defense.

The prisoner having closed his defense, the prosecutor is entitled to reply, when witnesses have been examined on the defense, or where new facts are opened in the address. Thus, though no evidence may be brought forward by the prisoner, yet should he advert to any case, and by drawing a parallel, attempt to draw his justification from it, the prosecutor will be permitted to observe on the case so cited. When the Court allows the prosecutor to reply, it generally grants him a reasonable time to prepare it; and upon his reading it, the trial ceases.

Should the prisoner have examined witnesses to points not touched on in the prosecution, or should he have entered on an examination impeaching the credibility of the prosecutor's evidence, the prosecutor is allowed to examine witnesses to the new matter; the Court being careful to confine him within the limits of this rule, which tends to the re-establishing the character of his witnesses, to impeaching those of the defense, and to rebutting the new matter brought forward by the prisoner, supported by evidence. He cannot be allowed to examine on any points, which, in their nature, he might have foreseen previously to the defense of the prisoner. The prosecutor will not be permitted to bring forward evidence to rebut or counteract the effect of matter elicited by his own cross-examination; but is strictly confined to new matter introduced by the prisoner, and supported by his examination in chief. A defense, resting on motives, or qualifying the imputation attaching to facts, generally lets in evidence in reply; as, in such cases, the prisoner usually adverts, by evidence, to matter which it would have been impossible for the prosecutor to anticipate. The admissibity of evidence, in reply, may generally be determined by the answer to the questions: Could the prosecutor have foreseen this? Is it evidently new matter? Is the object of further inquiry to re-establish the character of witnesses impeached by evidence (not by declamation) in the course of the defense, or is it to impeach the character of the prisoner's witnesses? Cross-examination of such new witnesses, to the extent limited by the examination in chief, that is, confined to such points or matter as the prosecutor shall have examined on, is allowed on the part of the prisoner. See *Court-Martial.*

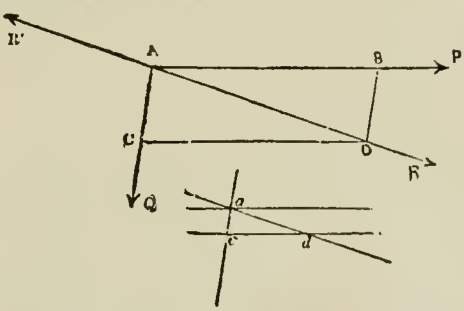
TRIAL BY BATTLE.—In ancient law, the giving of gage or pledge for trying a cause by single combat, formerly allowed in military, criminal, and civil cases. In writs of right, where the trial was by champions, the tenant produced his champion, who, by throwing down his glove as a gage or pledge, thus waged or stipulated battle with the champion of the defendant, who, by taking up the glove, accepted the challenge. See *Wager of Battle.*

TRIANGLE.—An instrument used for laying off angles, and with a straight edge for drawing parallel lines. They are made of hard wood, rubber, or metal, and are either solid or with open center; the angles are usually 30, 60, and 90 degrees, or 45, 45, and 90 degrees; the length of the sides vary from 5 to 12 inches. The wooden triangles are lighter, less expensive, and less liable to soil the paper than the metal, but cannot be made so accurately; the wood triangles are also apt to warp and become incorrect by wear in using. The advantage of the open over the solid triangles is, when of wood that they are less liable to warp, and if of metal they are lighter; besides these reasons, they do not conceal so much of the drawing, and in using them the draughtsman can see better how to draw his lines. To see if the right angle of a triangle is correct, draw a straight line, and bring the edge of one of the sides exactly on it, having the right angle about the middle of it; then draw a line along the other side, from the right angle; now, it is to be supposed there is a right angle

on each side of the last line drawn; to prove it, take up the triangle and place it in the same position it occupied before, but on the opposite side of the last line; now, if the angle of the triangle is not 90 degrees, when one side corresponds with its line the other will not. To prove the angle of 30, see if it is one-third of 90, and the angle of 60 should be double of the 30 angle. The edges of the triangle can be tested in the same manner as the edges of a straight edge. The simplest way to test the right angle of a triange is by the right angle of the T square, one edge of the triangle being held against the blade and the two right angles brought together; the other side of the triangle should fit evenly on the head of the T square; the other plan is the most correct, as there may be an error in the angle of the T square. The triangle is one of the most useful articles in a draughtman's set of instruments.

TRIANGLE GIN.—There are two patterns of this style of gin; the 16 feet, and the 18 feet. The latter are for general service: the former are applicable only to mounting guns on traveling, or standing carriages, platform, wagons, etc., and two of them are required with all guns heavier than 56 cwt. See *Gin.*

TRIANGLE OF FORCES.—The name given to a proposition in mechanics which is merely a formal modification of the *parallelogram of forces*, and, as generally stated, is its converse. The parallelogram of forces enunciates that, if two forces, P and Q, represented in direction and magnitude by AB and AC —inclined at an angle to each other, act on a point A, their resultant, R, is represented in direction and magnitude by the diagonal, AD, of the parallelogram formed on the two lines AB and AC. Now, as the resultant, R, is equivalent to the combined action of P and Q, it would exactly counterbalance them if acting in the opposite direction AR′, but would still be fully represented by the diagonal line AD, taken as from D to A. Also, instead of AB, CD may be taken to represent P. Hence as the sides of the triangle ACD completely represents the three forces, we have the proposition, that if three forces in the same plane be in equilibrium on a particle; and if in that plane any three mutually intersecting lines be drawn parallel to the directions of the forces, the lengths of the sides of the triangle thus formed will be proportional to the magnitudes of the forces. Its proof rests upon the previously ascertained fact that R′, P, and Q, three equilibrating forces at A, are proportional to AD, CD, AC, and on the geometrical theorem that a triangle who sides are respectively parallel to those of another triangle, has its sides proportional to those of the latter; and consequently the ratio and relative direction of the forces R, P, and Q are fully represented by *ad*, *cd*, and *ac*, the sides of the triangle *acd*.



Again, as the sides of a triangle are to one another as the sines of the opposite angles, so also are the forces which the sides represent. Hence
P:Q:R′::CD :AC: AD::sin. CAD: sin. :ADC: sin. ACD (and substituting the sines of the supplementary angles)
:: sin. QAR′ : sin. PAR′ : sin. PAQ;
that is, each force is proportional to the sine of the angle between the directions of the other two.

TRIANGLES.—A wooden instrument used at one time in the army, to which soldiers were tied when sentenced to receive corporal punishment. It consisted of three poles fastened together at the top, and which permitted of the legs being stretched out in the shape of a triangle. In each leg there was a spike which kept it firm on the ground; an iron bar, breast high, was fastened across one side of the triangle.

TRIANGULATION.—The operation of dividing any portion of the earth's surface into triangles of as large a size as possible, which may be called primary, and which must be afterward subdivided into triangles of a smaller size, forming a great network of secondary or subsidiary triangles, which serve as a means of working down from great to less, and finally completing, by a system of scientific checks, an accurate map or delineation of the region covered by such triangles, forming the geodesical process called a trigonometrical survey. See *Ordnance Survey*. The same operation is used in the measurement of an arc of the meridian, for the purpose of ascertaining the length of a degree of latitude or longitude on any part of the earth's surface; but in this case, only primary triangles are necessary, as no topographical detail is required, and the positions of the apexes of the triangles are astronomically fixed in the most careful manner, which is not always done in the triangles of a trigometrical survey. In carrying out a system of triangulation, much judgment and an accurate local knowledge of a country are necessary; and it very often happens that a more extensive range of angles can be obtained from a comparatively low station than from the tops of the highest mountains. The angles of each triangle should be as near equal as possible, and, unless local circumstances render it unavoidable, very acute or obtuse angles should not be used. The sides of the primary triangles should be as long as can be conveniently observed, but in practice they vary from 80 miles or more to 4 miles or even less. The angles are generally determined by a large theodolite, of as simple and strong a construction as possible, which is fixed on the most elevated points of mountain ranges, etc. When the apexes of the triangles are very distant, heliostats, or mirrors reflecting the sun's rays, are often used, and in dark or cloudy weather the Drummond light has been employed. The primary triangles being fixed on the spherical surface of the earth, certain formulæ, according to the rules of spherical trigonometry, must be applied to reduce them to the simple calculations for ascertaining, from certain well known data, all the sides and angles of the plain triangles. The whole of those calculations are always dependent on the accurate measurement of a base or fundamental line. The instruments invented by Captain Drummond, R.E., with which he be measured the base-line of the Irish Survey at Lough Foyle, and which were afterward employed by Sir T. Maclear in verifying Lacaille's base-line on the Plains of Malmesbury, in the Cape triangulation, appear to have been as nearly perfect as possible. At the end of a large triangulation, a second or testing base-line is always measured at a distance from the original one; if the measured length of this agrees with that ascertained by calculation, it may be considered a proof of the accuracy of the work in general. In the survey of Great Britain by Mudge and Colby, bases of verification were measured for at least every 200 miles except in Scotland, where only one was measured near Aberdeen. The triangles of the English Survey have been extended to and connected with those of France, Russia, etc., as far East as Siberia, and South to Algeria; and it is not at all improbable that the triangles of the Russian Survey will eventually be connected at one side with those of the great survey of India, which already has the apexes of many of its triangles on the summits of the Thibetan Himalaya, and to the eastward across Behring's Strait, with those of British America and the United States.

TRIARII.—In the Roman legions, Triarii consisted of veteran soldiers, who formed the third line in the order of battle. See *Hastati*.

TRIBUNE.—In Roman antiquity, an officer or magistrate chosen by the people, to protect them from the oppression of the patricians or nobles, and to defend their liberties against any attempts that might be made upon them by the Senate and Consuls. The Tribunes were at first two, but their number was increased ultimately to ten. There were also Military Tribunes, Officers of the Army, of whom there were from four to six in each legion.

TRIBUTE.—An annual or stated sum of money or other valuable things, paid by one Prince or Nation to another, either as an acknowledgement of submission, or as the price of peace and protection, or by virtue of some treaty, as the Romans made their conquered countries pay tribute.

TRICK.—A term used in Heraldry to denote a mode of representing arms by sketching them in outline and appending letters to express the tinctures, and sometimes numerals to indicate the repetition of charges.

TRICOLOR.—Literally no more than a flag in three colors, which is the case of almost every national ensign: but the applied sense limits it to flags having three colors in equal masses. The principal European tricolor ensigns are: France—blue, white, red, divided vertically. German Empire—black, white, red, divided horizontally. Italy—green, white, red, divided vertically. Belgium—black, yellow, red, divided vertically. Holland—red, white, blue, divided horizontally. The tricolor took its rise at the commencement of the French Revolution as the badge of the National Guard. The red and blue were selected as the arms of Paris, and the white was added, as the color of the army, to show the intimate union which should subsist between the people and the armed force.

TRIDENT.—1. In Roman antiquity, a three-pronged spear much used in the contests of gladiators by the Retiarius. 2. In classic mythology the trident is used as the symbol of Neptune's sovereignty over the sea. It consisted of a staff, armed at one end with three short prongs, with double barbs at the points, resembling the *fuscina* used by the Italians in catching large fish, particularly the sword-fish, from which we may perhaps infer that Neptune was originally the god of the fishermen. It was customary among the Grecian states to place the figures of their patron deities, or their appropriate symbols, on coins; hence we frequently meet with the trident on ancient coins, such as those of Saguntum, etc.; likewise on the Sicilian coins of Hiero, etc.

TRIGGER.—A steel-catch, which being pulled disengages the cock of a gun-lock, and causes the hammer to strike the nipple in percussion-muskets, and the firing-pin in breech-loaders. The pull of the trigger should not be too great, a three-pound pull being the minimum. It should be pressed by a steadily increasing pressure of the finger in the direction of the axis of the barrel, without communicating motion to the rifle, the breath being held until the hammer falls. If the trigger is too hard and is pulled convulsively, the muzzle will be turned to the right. There should be a quick and decided connection between the mind and finger. Few men can pull off the trigger of the average service rifle with the first joint of a single finger. It is well for each soldier to fire his own and the same gun on all occasions, in order to become acquainted with its defects of construction, and learn how to make allowances for consequent deviations from the theoretical trajectory. See *Hair-trigger*.

TRIGGER-TESTER.—A contrivance to test the triggers of rifles. According to the Regulations of the National Rifle Association all *military* rifles must sustain upon the trigger, full cocked, the minimum weight of 6 pounds, and all *other* rifles 3 pounds. The tester is usually made by attaching to an iron rod, bent to an angle or hook at the upper end (to hang on the trigger), as much lead as will, with rod and all, weigh 6 or 3 pounds.

TRIGONOMETRICAL SURVEY.—Trigonometrical surveying is that higher branch of measurement of the earth's surface in which the use of angular instruments, such as the theodolite, altitude, and azimuth instrument or sextant, is indispensible in forming the network of triangles, on the accuracy of which the correctness of the survey depends. In the article TRIANGULATION, the necessary operations have been briefly adverted to, and in ORDNANCE SURVEY will be found a sketch of the history of the principal modern trigonometrical surveys executed, or now being made.

In the *Aide Mémoire of Military Sciences*, conducted by officers of the Corps of Royal Engineers, a very full and complete article will be found on this subject; and the Government Blue Books, from time to time issued on the surveys both of England and India afford much valuable information on the internal economy and arrangements necessary for carrying on such vast works.

When it is necessary to fix the astronomical position of the stations, of course, the transit zenith sector and other instruments used in the observatory, must be transferred to situations very often difficult of access, exposed to strong winds, etc., which adds much to the difficulty of getting correct observations. Meteorological and magnetic observations are often taken simultaneously with the astronomical; and, indeed, are now considered as nearly indispensable in modern operations. See *Surveying* and *Triangulation*.

TRIGONOMETRY.—The measurement of triangles. This definition, though expressing correctly enough the scope of trigonometry in its early stages, is now wholly inapplicable, as trigonometry, like geometry, has far exceeded its primitive limits; and though the original name is, for convenience, retained, the science may be more properly defined as the "consideration of alternating or periodic magnitude." Trigonometry, within the limits of its earlier definition, is geometrical; its advance beyond these limits is due to the introduction of purely algebraic methods. The quantities with which geometrical trigonometry has to deal are certain lines definitely placed with respect to an angle, and consequently varying with it. These lines, generally denominated *trigonometrical functions* of the angle, are the sine, cosine, tangent, cotangent, secant, and cosecant, and are represented in the ac-

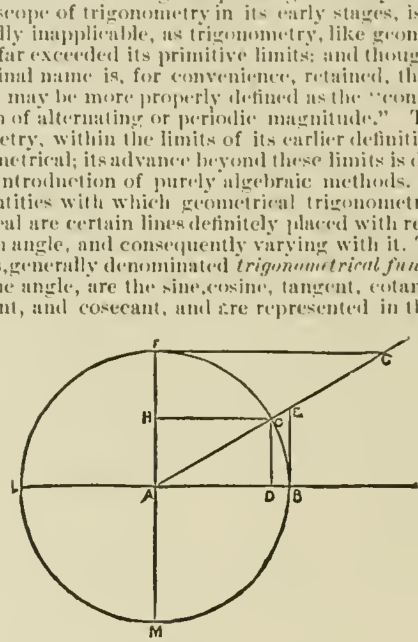


Fig. 1.

companying figure. The angle BAC is placed at the center of a circle, called the circle of reference; its *sine*, CD, is the perpendicular let fall from the extremity of one radius upon the other; the *cosine*, DA, is that part of the radius between the foot of the sine and the center; the *tangent*, BE, is drawn at right angles to one radius to meet the other produced; the *secant*, AE, is the radius produced to meet the extremity of the tangent; the *cotangent*, FG, is drawn from the extremity of a radius at right angles to one of the former, to meet the other produced; and the *cosecant*, AG, is the radius produced to meet the extremity of the cotangent. Other functions, as the *versed sine*, DB, which is the distance from B to the foot of the sine, and its counterpart, the *coversed sine*, FH, have been occasionally introduced and defined, but they are of no practical use. EAF, the angle which must be added to BAC to make up a right angle, is called the *complement* of BAC; and CAL, the defect of BAC from two right angles, is called its *supplement*; and by inspection of the figure we can see at once that the sine of BAC, CD, is equal to AH, the cosine of its complement; that the cosine of BAC, AD, is equal to CH, the sine of its complement; and that generally any function of an angle is the co-function of its complement, and *vice versa*; also, that CD, the sine of CAB, is also the sine of its supplement; AD, the cosine of CAB, is the cosine of its supplement; and that generally the function of an angle is the function of its supplement. If a right angle be added to BAC, then we have the triangles ADC, ABE, shifted so as to be situated in the same relative position to AF as they are now to AB, and each line is consequently at right angles to its former position, hence the sign of BAC is the cosine of (90°+BAC), and similarly of the others. By an extension of this process of investigation we arrive at the general conclusions that *if an angle be added to or taken from one or an odd number of right angles, the function of the original is the co-function of the one so derived;* and that *if an angle be added to or taken from an even number of right angles, the functions of the original angle are* *the functions of the derived one.* But since a function of an angle is the same function of its supplement, a knowledge of the function would enable us to determine to which of the two angles it belonged, unless we possessed some knowledge of more than the mere magnitude of the function. This desideratum is supplied in the following manner: B is taken as the zero-point of reckoning, the radius BA, which is thus supposed to be fixed, is one of the bounding lines of every angle, the other side being supposed to move in the direction BFL, as the angle increases. Let the radius AC be supposed to sweep round the circle in a left-hand direction (viz., toward F), then, as it approaches F, the sine CD increases, till, on reaching F, the sine coincides with the radius; passing F, and moving toward L, the sine diminishes, till, on reaching L, it becomes zero. Continuing its progress round the circle, the angle BAC becomes *re-entrant* (viz., greater than two right angles); and its size again increases, becoming equal to the radius at M, and diminishing at the fourth quadrant till it becomes zero at B. While the angle increased from B to L, the sine was drawn *downward;* for the other half of the revolution, it was drawn *upward;* hence, in the first and second quadrants, the sine is said to be *positive*, and in the third and fourth *negative*, the position of a function in the first quadrant being adopted as the standard. The following table shows the variation (increase or decrease, and between what limits, as well as the sign affecting it) of each of the functions as the angle increases:

the above relations, tan. $= \frac{BC}{AB}$, sec. $= \frac{AC}{AB}$, cot. $= \frac{AB}{BC}$, and cosec. $= \frac{AC}{BC}$; and in algebraic trigonometry these latter are the definitions of the trigonometrical functions. The only angular functions which

A Fig. 2. B

geometry enables us to determine with accuracy are those belonging to the angles of an equilateral triangle, an isosceles right-angled triangle, and an isosceles triangle which has each of the angles at its base double of the third angle (*i.e.*, base angles each 72°, vertical angle, 36°); and from these, by means of a proposition (demonstrated in all text books on the subject) which determines the functions of the angle (A+B) from a knowledge of the functions of A and of those of B; and also, as a corollary to the preceding, the functions of 2A, 4A, 8A, etc., and inversely of $\frac{1}{2}$A, $\frac{1}{4}$A, etc., from a knowledge of those of the angle A, have been obtained and tabulated the

Angle.	Sine.	Cosine.	Tangent.	Secant.	Cotangent.	Cosecant.
0° to 90°	inc. 0 — R,+	dec. R — 0, +	inc. 0 — ∞,+	inc. R — ∞,+	dec. ∞ — 0, +	dec. ∞ — R,+
90° " 180°	dec. R — 0,—	inc. 0 — R,—	dec. ∞ — 0, —	dec. ∞ — R,—	inc. 0 — ∞,—	inc. R — ∞,+
180° " 270°	inc. 0 — R,—	dec. R — 0, —	inc. 0 — ∞,+	inc. R — ∞,—	dec. ∞ — 0,+	dec. ∞ — R,
270° " 360°	dec. R — 0,—	inc. 0 — R,+	dec. ∞ — 0, —	dec. ∞ — R,+	inc. 0 — ∞,—	inc. R — ∞,—

We here observe that all the functions increase and decrease alternately as the angle of which they are the functions passes from one quadrant to another; also that the sine and cosecant are affected by the same signs, as also are the cosine and secant, and tangent and cotangent.

Again, from Fig. 1, we obtain, from the properties of right-angled and of similar triangles, the following relations between the functions; Sin.^{2}+cos.^{2}= R^2, tan.^{2}+R^2=sec.^{2}, cot.^{2}+R^2=cosec^2, tan. : R :: sin. : cos., sec. : R :: R : cos., cot. : R :: cos. : sin., cosec. : R :: R : sin., and cot. : R :: R : tan. From these eight relations we can easily obtain any one function in terms of any other, both as regards its magnitude and sign.

The reason why the circle and its radius are employed in the definition of the functions is that we may obtain some invariable standard by which to estimate them, for while, as the angle increases from 0° to 360°, its functions are in a state of constant change, their standard of reference, the radius, remains the same. For greater simplification the radius is taken as unity, and the relations become sin.^{2} +cos.^{2}=1, tan.^{2}+1=sec.^{2}, cot.^{2}+1=cosec^2, and (by the reduction from the proportional to the divisional form of the other five relations) tan.$=\frac{\text{sin.}}{\text{cos.}}$, sec.$=\frac{1}{\text{cos.}}$, cot. $=\frac{\text{cos.}}{\text{sin.}}$ cosec. $=\frac{1}{\text{sin.}}$, tan.$=\frac{1}{\text{cot.}}$; the various functions being expressed in terms of the assumed unit. Thus, in the right-angled triangle ABC (Fig. 2), if AC be radius, BC = sin., and AB = cos., of the angle A; but if the radius be assumed as unity, sin. A $= \frac{BC}{AC}$, cos. A $= \frac{AB}{AC}$, and similarly from

functions of all angles from 1′ to 45°, the functions of angles from 45° to 360° being, as is evident from the above remarks respecting complementary and supplementary angles, merely repetitions of these.

The relations between the angles and sides of a triangle are three in number, and are obtained from simple geometric considerations; they are—(1) AB : AC : : sin. C : sin. B; (2) cos. B$=\frac{AB^2+BC^2-AC^2}{2AB \cdot BC}$; (3) AB + AC : AB—AC : : tan. $\frac{1}{2}$(B + C ; tan. $\frac{1}{2}$(B—C). From these relations in conjunction with the fact that the three angles of a triangle collectively amount to 180°, it is possible, having given any three (one being always a side) of the six elements (three sides and three angles) of a triangle, to determine the other three. It is this that constitutes trigonometry in its primitive and elementary form. If the triangles be right-angled, only the first relations and the property of the sides of a right-angled triangle, are necessary for the complete solution. Further information on this subject will be found in any text-book. Algebraic trigonometry is one of the most important branches of analysis, but it is too extensive and varied to be even sketched here; suffice it to say, that in it the trigonometrical functions are not considered as geometrical magnitudes, but as numerical quantities having certain relations to each other, and that the circle as well as the angular functions are treated as multiples or sub-multiples of the radius. Many important results, such as the approximate estimation of the circumference of a circle, the completion of the solution of cubic equations, etc., have been obtained by its means; and a thorough knowledge of its modes and results is absolutely necessary to an acquaintance with higher mathematics. Spherical trigonometry is plane trigonometry applied to spherical triangles.

TRINCANO SYSTEM OF FORTIFICATION.—In this system the bastions are large and retrenched at the gorge; the flanks are triple; the outer is casemated and separated from the bastion, the inner forms a cavalier and is preceded in the capital by a reduit with covered way. The enciente is covered by counter guards and ravelins, the latter having a circular battery at their salient to fire on the approaches. The salient places of arms have the form of bastions. The traverses of the covered-way consist of sap-rollers supported by trucks, and may be rolled into the ditches before abandoning the outwork. The palisades are fixed to a ground sill, and thus can be lowered or raised at pleasure.

TRINGLE. A riband or a piece of wood nailed on the sides of a traversing-platform, to prevent the trucks from running off in the recoil.

TRIPARTED.—In Heraldry, parted in three pieces; having three parts or pieces: as a cross *triparted.*

TRIPPING. In Heraldry, having the right fore-foot lifted, the others remaining on the ground, as if he were trotting:—said of an animal, as a hart, buck, and the like, represented in an escutcheon. Also often written *Trippant.*

TRIPPLE ALLIANCE.—The name by which two different treaties are known in all history; viz., 1. A treaty concluded in 1668 at the Hague between England, Holland, and also Sweden, having for its object the protection of the Spanish Netherlands, and the checking of the Conquests of Louis XIV. 2. An alliance concluded in 1717 between Britain, France, and Holland against Spain, which concluded among its stipulations that the Pretender should quit France, and that the Treaty of Utrecht should be carried into effect as regards the demolition of Dunkirk. The Protestant succession was guaranteed by this treaty in England, and that of the Duke of Orleans at France.

TRIUMPH.—The name given in ancient Rome to the public honor bestowed on a General who had been successful in war. It consisted in a solemn procession along the *Via Sacra* up to the Capitol, where sacrifice was offered to Jupiter. The victor sat in a chariot drawn by four horses—his captives marching before, his troops following behind. Certain conditions had to be fulfilled before a triumph could be enjoyed, and it was the business of the Senate to see that these were enforced. Under the Empire Generals serving abroad were considered to be the Emperor's Lieutenants, and, therefore, however successful in their wars, they had no claim to a Triumph. They received instead *triumphal decorations* and other rewards.

The appearance that Rome presented on the occasion of a Triumph, especially in later times, was joyous in the extreme. All work was suspended; the temples were thrown open, and decorated with flowers; the populace were clad in holiday attire, and crowded the steps of all the public buildings in the *Via Sacra*, and the forum, or mounted the scaffoldings erected for the purpose of viewing the procession; banquets were spread before every door. As for the *Imperator* himself, after having pronounced a eulogy on the bravery of his soldiers, he ascended the triumphal car, entered the city by the *porta triumphalis*, where he was met by the Senate, and now the procession began. First marched the Senate, headed by the Magistrates; next came a body of Trumpeters; then a train of carriages and frames laden with the spoils of the vanquished; then a body of Flute-players, followed by the oxen doomed to be sacrificed, and the sacrificing Priests, etc.; then the distinguished Captives with bands of inferior prisoners in chains; after whom walked the Lictors of the Imperator, having the fasces wreathed with laurel. Next came the hero of the day—the Imperator—in a circular chariot, attired in an embroidered robe (*toga picta* and flowered tunic (*tunica palmata*), bearing in his hand a laurel bough, in his left a scepter, and having his brows garlanded with Delphic laurel. He was accompanied by his children and his intimate friends. His grown-up sons, the Legates, Tribunes, and Equites, rode behind; and the rear was brought up by the rest of the soldiery, singing or jesting at their pleasure, for it was a day of carnival and license. When the procession had reached the Capitoline some of the captive chiefs were taken aside and put to death; the oxen were then sacrificed, and the laurel wreath placed in the lap of Jupiter. In the evening the Imperator was publicly feasted, and it was even customary to provide him a site for a house at the public expense.

The *Ovation*, or lesser Triumph, differed from the greater chiefly in these respects: that the Imperator entered the city on foot, clad in the simple *toga praetexta* of a Magistrate; that he bore no scepter, was not preceded by the Senate and a flourish of trumpets, nor followed by his victorious troops, but only by the Equites and the Populace, and that the ceremonies were concluded by the sacrifice of a sheep instead of a bull, whence, doubtless the name *Ovation* (from *ovis*, a sheep). The Ovation, it is scarcely necessary to add, was granted when the success, though considerable, did not fulfill the conditions specified for a Triumph.

TRIUMPHAL ARCH.—In military history, a stately monument or erection, generally of a semicircular form, adorned with sculpture, inscriptions, etc., in honor of those heroes who have deserved a triumph.

TRIUMPHAL COLUMN.—A column erected among the ancients in honor of a hero, and decorated with various kinds of crowns, corresponding to the number of his achievements in battle. Each crown had its particular name, as *vallaris*, which was filled with *spikes*, in memory of his having faced a palisade; *muralis*, adorned with little turrets or battlements, for having mounted an assault; *obsidionalis*, or *graminalis*, of grass, for having raised a siege; and *triumphalis*, of laurel, for a grand triumph. See *Triumph.*

TRIUMVIRATE.—The name given in Roman history to the private league entered into between Pompey, Crassus and Cæsar—the three most powerful men of their time; the object of which was to carry out their own schemes of aggrandizement, in spite of the opposition of the Senate. This compact was not a triumvirate, in the proper sense of the term; it had no legally constituted existence; and it was, in fact, only a very treasonable conspiracy of three men against the legitimate authority of the State. The term is less incorrectly applied to the division of Government between Octavian (Augustus) Mark Antony, and Lepidus in the civil wars that followed the murder of Cæsar—an arrangement sanctioned, and, therefore, legalized by the Senate. The former is usually called the *first*, the latter the *second* triumvirate.

TROJAE LUDUS.—Among the Romans, a species of mock fight, similar to the tournaments of the Middle Ages, performed by young Noblemen on horseback, who were furnished with arms suitable to their age.

TROLLEYS.—The trolley of a crane is that movable carriage from which the load is immediately suspended and by which longitudinal motion of the load upon the jib, or the bridge, of the crane is effected. The term truck is usually restricted to the wheeled carriage used to support each end of the bridge of a traveling-crane, or the corresponding part of rectilinear cranes of all kinds. Rectilinear cranes require usually at least one trolley, and one or more trucks. Rotary cranes one trolley only.

The whole load of a crane is hung primarily upon the trolley, and where trucks are used, is transferred in full to them, together with the weight of the crane itself. It is desirable, therefore, that these parts should not only possess ample strength to resist the strains they may be subjected to, but also that they be so arranged that any yielding or breakage of their parts will not allow the load to fall to the ground, but only permit it to descend until the supporting beam rests on the rails upon which the trolley or truck is to travel. For this reason the

Triumphs, etc. 1. Burial of Alexander the Great. 2. Epaminondas's phalanx advancing in echelon order. 3. Emperor Aurelian's triumphal procession.

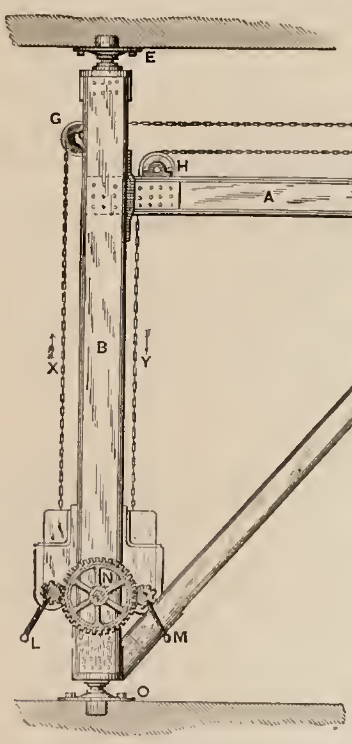
construction should be such that the ends of the bridge; in traveling and similar cranes, overlap the longitudinal tracks, and the axles or housings of the trolley, in cranes of all kinds, overlap the rails upon which it runs. It is desirable that the vertical distance between these overlapping parts and the rails be as small as possible, so that, in event of any break occurring, the distance through which these parts pass before being arrested is so small that no serious shock can ensue. With careful designing this distance can be reduced to merely the necessary clearance of these portions, which need not exceed more than one inch or less.

A natural preference exists for wrought-iron rather than cast-iron as the material from which to construct the moving parts of a crane; and, unquestionably, it is always best to use wrought-iron for parts that are to be exposed to tension under heavy loads. Cast-iron, however, is the better material for those parts that are subject to compression, and by skillful designing it is usually possible so to arrange the parts of trolleys and trucks as to use cast-iron wherever a stiffness or resistance to compression is required, while still employing wrought-iron for the parts under tension. In this way the greatest economy is attained, and not unfrequently a better result secured than by the use of either material alone.

The wheels, both of trolleys and trucks, should be true cylindrically, should be double-flanged, and, by preference should have chilled treads. If wheels of small diameter are used, in order to economize height, they should be provided with anti-friction bushings, to counteract the increased resistance to traction caused by their small diameter. The wheel-base, or distance from center to center of the adjacent wheels, should be as large as possible, in order to avoid cramping between the rails, and to facilitate the easy motion of the carriage upon its track. In large traveling-cranes it is desirable that the axles of the truck-wheels be supported in spherical bearings, so that the wheels may adjust themselves to any yielding of the track which may result from the passage of heavy loads, and thus all unnecessary straining of the parts of the truck be well avoided.

In jib, traveling and other cranes provided with trolleys, some mechanism is necessary to effect the longitudinal motion of the latter. This may be accomplished by a rack and pinion, or by endless chain or rope attached to the trolley and operated by a driving-wheel at one end, with a suitable guide sheave for returning it at the opposite end. All devices of this kind are entirely distinct from the hoisting gear of the crane and are operated independently. Under some conditions a separate mechanism for this purpose is desirable, but usually this is not the case. We illustrate below the system adopted in most of the Weston cranes which, as will be seen, effects the motion of the trolley by means of the devices employed for hoisting and lowering, and thus obviates the need of any separate mechanism.

The drawing represents a jib-crane with combined hoisting and traversing gear. Referring to the figure, A, B and C, are respectively the jib, mast and brace of the crane. D is the running block, J the trolley carrying the sheaves which form the upper block, F, G and H, guide sheaves by which the two parts of the chain are directed to the two housings attached to each side of the mast near its base, and



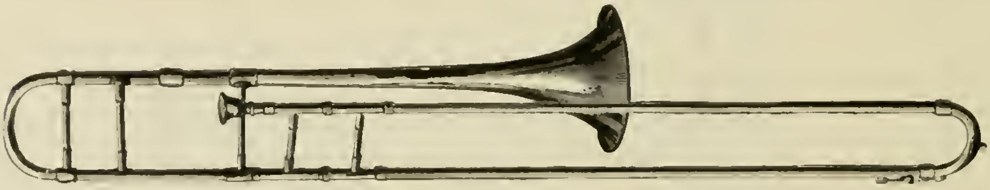
containing the operating mechanism. Each of these latter is a complete and independent hoisting machine, operated respectively by cranks and handles, L and M, the shafts of which extend through the housings, so that cranks may be applied upon either or both ends of the shaft. The chain, X, passes from the left hand housing over the guide sheave, G, then around the guide sheave, F, and so to the trolley, J, where it passes over another sheave and extends downward to the block, D. In a like manner, the other part, Y, of the chain passes from its housing over the sheave, H, directly to the trolley, and so down to the block. By turning the crank, M, so as to haul in the part, Y, of the chain, the load will be raised, and, in like manner, by turning the crank, L, so as to haul in the part, X, of the chain, the load will also be raised. By simultaneously turning both cranks so as to haul in both parts of the chain, the load will be raised at double speed. By rotating either or both of the cranks in the opposite direction, the opposite motions will be effected, and the load will be lowered at single or double speed. By slipping both pinions on their shafts so that they engage with the large spur wheel, N, between them, motion of one pinion will be communicated to the other at an equal speed, *but in a contrary direction*, the result of which will be to cause the part, Y, for example, to be hauled in and the part, X, to be paid out (as indicated by the arrows on the drawing) at exactly equal speed. The consequence of this will be to cause the trolley, J, to be pulled toward the mast by the part, Y, of the chain, while at the same time the part, X, of the chain will be released or paid out at the same speed, and thus oppose no resistance to the inward motion of the trolley. During this time the parts of the chain lying below the trolley, and between it and the block, D, are not disturbed, so that the load remains suspended upon them, and no unnecessary friction or wear of the chain is caused by needless rendering of the chains over the sheaves in the trolley and block. It will thus be seen that, when it is desired to move the trolley in either direction, the two parts of the chain which lead from the trolley back to the operating mechanism, are utilized to effect its motion, thus dispensing with the need of any separate mechanism for this purpose, while at the same time the rest of the chain remains stationary and is not subject to wear.

In traveling-cranes the same result is obtained, save that, in some cases, the horizontal parts of the chain pass directly from the trolley to the operating mechanism without being deflected by guide sheaves, although in most cases it is found best to place the mechanism beneath the bridge, in which case the action is identical with that above explained, except that the operating mechanism is close to the guide sheaves, G and H, instead of at some distance below them, as in the case of a jib crane. In power cranes, of whatever type, this arrangement is equally applicable, the only difference being that the several motions are effected by power, transmitted through suitable clutches, instead of by manual effort applied to the cranks or hand chains.

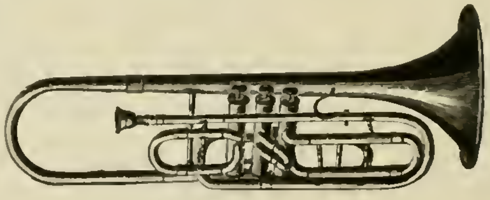
A prominent and a most valuable feature of this construction consists in the even distribution of wear over all parts of the chain. Referring to the drawing it may be explained that the two parts, X and Y, of the chain, after passing through the housings at the foot of the mast, enter a suitable box or receptacle, and are there united, so that the chain is endless, although for clearness of description its two parts or sides are distinguished in the foregoing description by the letters, X and Y. It is found in practice that, in using cranes thus constructed, the operator frequently changes from one crank to the other, so that when hoisting the part, Y, for example, will be hauled in, while, whenever it is desired to lower or to cause travel of the trolley, the part, X, may be paid out, and in this way the whole length of the chain is gradually passed through the operating mechanism and each of its links subjected to equal wear. No special attention need be given to the attainment of this end, as the varying requirements of use secure its attainment without any attention on the part of the operator, and all parts of the chain are ultimately subjected to practically equal wear. Where the chain is wound upon a drum, on the contrary, certain parts of the chain will necessarily receive most of the wear, and will become weakened and unsafe while the rest of the chain may be perhaps almost unimpaired. This equal distribution of wear over the entire length of the chains, which is accomplished by the Weston system of construction, thus gives great durability to the chains, and proportionately increases their safety. It may be noted also that, as the parts of the chain between the trolley and the block are not disturbed during the motion of the trolley, a much smoother and quieter action occurs than when these parts of the chain are compelled to render over the sheaves, as is the case with the ordinary construction. This feature is of particular value in foundry work, and is valuable in all cases as tending to diminish the wear upon the chain, and thus prolong its life. See *Cranes*, *Jib-crane*, and *Tramrail*.

TROMBLON.—A firearm which was formerly fired from a rest, and from which several balls and slugs were discharged. An ancient wall-piece.

TROMBONE.—1. A large deep-toned brass instrument, of the trumpet species, but consisting of two separate parts so constructed that the two ends of one fit into those of the other, and consequently, by sliding the one part in or out, the tube through which the air passes may be shortened or lengthened,



and the pitch changed at pleasure. Three kinds of trombone are in general use, in bands, differing in pitch: the *alto trombone*, represented in the following drawing, with a compass of more than two octaves and a half and written on the C clef, third line; the *tenor trombone*, written on the C clef, fourth line;



and the *bass trombone*, the lowest of all in its range of notes. It is written on the F clef, and is an octave lower than the alto, and a fifth lower than the tenor. There is also a *double-bass trombone*, which is but rarely used. The trombone, if judiciously employed, is a very effective instrument in the band the tone is grander and more powerful than that of the trumpet.

2. An early species of blunderbuss for boat-service, taking its name from its unseemly trumpet mouth.

TROOP.—In cavalry, the unit of formation, forming the command of a Captain, consisting usually of 60 troopers, and corresponding to a company of infantry. The officers of a British troop are the Captain and two Lieutenants. Two troops form a squadron. The trooper's pay is 1s. 5d. a day.

TROOP CORPORAL-MAJOR.—The chief Non-Commissioned Officer of a troop in the British Household Cavalry.

TROOPER.—A term applied either to the horse of a cavalry-man or to the cavalry-man himself; any private or soldier in a body of cavalry.

TROOPING THE COLORS.—A ceremony performed in the British Service, at the public mounting of garrison guards. The origin of the ceremony does not appear to be clearly known. It is surmised that it comes from the Germans, and is symbolic of their ceremonious reception by a force on taking the field, and that the marching of them along the face of the parade is to remind every individual soldier of the duty he owes to his colors, and to demand from him the tacit pledge to fulfil that patriotic duty. Another explanation is given that the ceremony is significant of the formal housing of the colors after having been in the field: and Gorse, on "Military Antiquities," is cited to the following effect:—

"The Captain leading them (his troops with the colors) out of the field, and coming near to the place intended to lodge his colors, converts the ranks of musketeers of both divisions to the right and left outwards and joins them; and being so fixed, the body of pikes stand in the rear and the ensign at the head of them, the Captain before the colors with the drum, and Sergeants guarding the colors on each side, and the Lieutenant behind the standard-bearer; and all being advanced shall troop up with the colors folded on his lodgings or quarters; and as he approacheth thereto, he shall, with a bow to his Captain, carry in his colors; then the word shall be given to all the musketeers to make ready; that being done they shall all present, and upon the beat of the drum or other word of command, give one entire volley."

In this may be traced the rudimentary idea of the present elaborate ceremony of trooping.

TROOPS.—The militia sytsem of the United States arose from that jealousy of standing armies which has always characterized the Anglo-Saxon peoples. After the Revolutionary War, Congress determined to limit the regular army to the actual requirements of immediate necessity, and supplement it by a State Militia. The President is Commander-in-Chief of the Militia of the several States, when called into the actual service of the United States. He has the power to call on these forces, by orders to any officers of the Militia he may address, in case of invasion or rebellion against the authority of the United States. The Militia may be required to serve for a period not exceeding nine months. The troops receive during this time the pay and rations of soldiers of the Regular Army, and the officers rank next after officers of the same grade in the regular service. The majority of the State Constitutions require the passage of laws for the organization and equipment of their Militia. The Governer is the Commander-in-Chief, and subject to his orders are the necessary officers, chosen by various methods in the different States. It was customary for many years to have annual drill days for all the State troops, who were compelled to attend under penalty, but the laws providing for them have been repealed or fallen into disuse. Voluntary organizations are now formed, which select their own uniforms and the branch of the service they desire to be attached to. The actual Militia of the United States consists of these volunteer troops and all other able-bodied male citizens of the age of 18 and under 45, with the exceptions provided by the National and State laws, all of whom are subject to be summoned to perform Military duty according to the laws of Congress or of their respective States.

The State Militia was often called out during the Revolution, and the "Whisky Insurrection" of 1794 was put down by the Militia of Pennsylvania, New Jersey, Maryland, and Virginia. During the War of 1812 disputes arose between the National and State authorities regarding the right of the President to determine whether the emergency had arisen which authorized his calling them out, the right to place them under officers of the President's appointment, and the right to march them beyond the limits of the State. The Court decided in favor of the President, and his right to decide whether the Militia shall be summoned, and his right to place them under the command of a federal officer ranking their own officers is no longer disputed. During the Civil War, the first call of the President for 75,000 men was principally filled by the Militia, and the total number of volunteers, drafted men, and Militia troops during the whole war was 2,690,401. There were 1,000,516 men in the field at the proclamation of peace, and of these soldiers about 978,000 were volunteers or drafted men. See *Militia*.

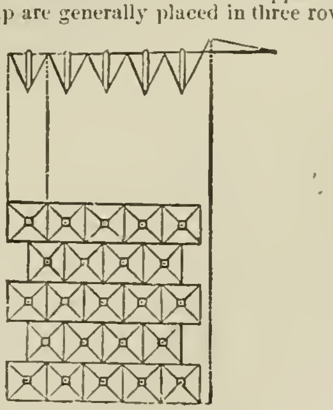
TROOP-SERGEANT MAJOR.—The Chief Sergeant of a troop in the British Service.

TROOP-SHIP. A merchant ship "taken up," as it is called, for the conveyance of soldiers by sea.

TROPHY.—A memorial of victory erected on the spot where the enemy had turned to flight. Among the Greeks (with the exception of the Macedonians, who erected no trophies), one or two shields and helmets of the routed enemy, placed upon the trunk of a tree served as the sign and memorial of victory. After a sea-fight, the trophy consisted of the beaks and stern ornaments of the captured vessels, set up on the nearest coast. It was considered wrong to destroy such a trophy, and equally wrong to repair it, when it had fallen down through time, for animosity ought not to be perpetual. In early times, the Romans never erected trophies on the field, but decorated the buildings at Rome with the spoils of the vanquished. Of this practice, we have a familiar instance in the *rostra* or beaks set up in the forum. In later times, pillars and triumphal arches were employed to commemorate victories. Besides these, in modern times, the humiliation of an enemy is rendered lasting by such devices as the bridge of Jena, of Waterloo, and by the distribution of captured cannon. Morally considered, this practice is no improvement upon the simple and perishable trophies of the ancient Greeks.

TROPHY-MONEY.—Certainmoney formerlyr aised in the several counties of the kingdom of Great Britain, towards providing harness and maintaining the Militia.

TROUS-DE-LOUP.—Military pits in the form of an inverted truncated cone or quadrilateral pyramid: their diameter at top is six feet, and width at bottom eighteen inches. A stake is, in some cases, planted firmly in the bottom, its top being sharpened, and the point a few inches below the upper circle. Trous-de-loup are generally placed in three rows, in



quincunx order, a few yards in front of the ditch. They are readily laid out by means of an equilateral triangle, formed of cords, the sides of the triangle being eighteen feet: the angular points mark the centers of the pits. The earth taken from them, is spread ever the ground between them, and is formed into hillocks to render the passage between as difficult as possible. If brushwood or light hurdles can be procured, the pits may be made narrower, and covered with the hurdles, over which a layer of earth is spread. Trous-de-loup are sometimes placed in the ditch; in this case their upper circles touch. Small holes of an inverted pyramidal shape with stakes, may be used for trous-de-loup. These obstacles are principally serviceable against cavalry, and when only two or three feet deep may be usefully employed in rendering impassable shallow, wet ditches, inundations, and fords; and, like abattis, they may be advantageously placed on the salients of works, on the weak points of lines, or in their intervals. They may thus compel the enemy to attack the strongest parts. The ardor of infantry may be much checked by unexpected obstacles within point-blank musket shot of the place attacked. See *Accessory Means of Defense* and *Pits*.

TROUS-DE-RAT. Literally, rat-holes, or rat-catches: figuratively, any very disadvantageous positions into which troops are rashly driven.

TROUS-DE-TENAILLE.—A name given to the passages at the extremities of the tenaille.

TROUSERS.—A part of the uniform. In the United States Army, they are prescribed as follows:—*For General Officers, Officers of the General Staff, and Staff Corps.*—Dark blue cloth, plain, without stripe, welt, or cord. *For all Regimental Officers of Cavalry, Artillery, and Infantry.* Light blue cloth, same shade of color as prescribed for enlisted men, with stripe one and one-half inches wide, welted at the edges; color, that of facings of their respective arms, except Infantry, which will be dark blue.

For Storekeepers.—Dark blue cloth, without stripe, welt, or cord.

For Chaplains.—Plain black, with black cord on the outer seam.

Whenever, in extreme southern latitudes, white pants are worn by enlisted men, all officers must in like manner wear them.

For Enlisted Men of all Arms, of the Signal Service, and of the Ordnance Department.—Sky-blue mixture; waistband three and a half inches wide, to button with two buttons, in front; pockets in front, opening at top. Sergeants to wear a stripe one inch wide, color of facings; and Corporals to wear a stripe one-half inch wide, color of facings, except Infantry, which will be dark blue.

For Engineers.—According to pattern in Quartermaster General's Office.

For Ordnance Sergeants.—Crimson stripe, one inch and one-quarter wide.

For Hospital Stewards.—Emerald green stripe, one inch and one-quarter wide.

For Commissary Sergeants.—Cadet gray stripe, one inch and one-quarter wide.

Trousers for all mounted men are reinforced. In extreme southern latitudes, in summer, Commanding Officers are authorized to sanction the use, on duty, of white pants, to be bought, out of the pay of the soldier, of the local merchant or trader. Whenever white pants are worn by enlisted men, the officers are required to wear them also.

TROWEL-BAYONET.—A bayonet so called from its shape, and intended to serve as both a bayonet and an intrenching-tool. It is the invention of Colonel Rice, of the United Stated Army, and is used in the United States Army with much satisfaction. See *Rice Trowel-bayonet.*

TRUCE.—An agreement between belligerent parties to suspend hostilities for a specified time, the war still continuing. Truces are of several kinds: *general*, extending to all the Territories and Dominions of both parties: and *special* or *particular*, restrained to particular places, as by sea and not by land. They are also *absolute*, *indeterminate*, or *limited* and *determined* as to certain things, for example, to bury the dead.

During a truce, it is dishonorable to occupy more advanced ground, or to resort to any act which would confer advantage. A truce requires ordinarily to be confirmed by the Commander-in-Chief to become binding. It is lawful to break it before the prescribed period, on notice previously agreed on being given to the opposite party. This is called denouncing a truce. See *Armistice*, and *Flag of Truce.*

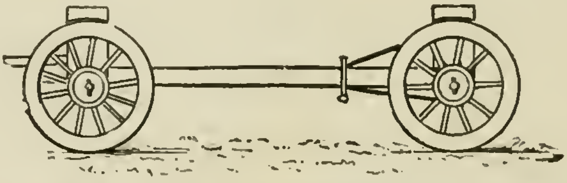
TRUCE OF GOD.—A suspension of arms, which occasionally took place in the Middle Ages, putting a stop to private hostilities, at or within certain periods. See *God's Truce.*

TRUCK-CARRIAGE.—An inferior kind of platform wagon. It is used for carrying ordnance and heavy boxes for short distances; for taking guns through the passages or sally-ports in which there are no short turnings. There are three sizes of truck carriages, large, medium, and small. Guns are mounted on them and lashed in the same manner as on sledges. This carriage goes under another name in ordnance nomenclature. See *Truck-wagon.*

TRUCK-HANDSPIKE.—An implement for use with casemate carriages in running them from battery. It is made of wrought-iron, is round and tapered to fit the mortises in the periphery of the gun-carriage trucks.

TRUCKS.—Small iron wheels attached to garrison standing carriages; wooden or copper ones to ship carriages. The latter are made of one piece of wood, from 12 to 19 inches in diameter, and their thickness is always equal to the caliber of the gun.

TRUCK-WAGON.—A powerfully-constructed four-wheel wagon, intended for the transportation of iron gun-carriages, sea-coast mortars and their carriages, and other similar heavy weights. The wheels have a diameter of 42 inches; the axles are of iron and the bolsters of heavy pieces of timber, having their upper surfaces flush with the tops of the wheels. Heavy plates of iron cover the tops of the bolsters and project slightly over the wheels. The ends of these plates are turned up, forming a projection about two inches high, to prevent the body transported from slipping off sideways. The width between these projections is just sufficient to admit the chassis of the 15-inch gun. The wagon is capable of being coupled long or short, to suit the length of the object to be transported. The pole, like that of an ordinary road-wagon, is furnished with double trees for attaching horses. When a 13-inch mortar *without* its bed is to be carried, two stout skids, about 12 feet long and 12 by 12 inches thick, are placed on the wagon. The skids are notched to fit the bolsters, to prevent them from sliding to the front or rear, and a shallow recess is cut in them to form a seat for the mortar. The mortar is placed on the skids with its axis parallel to the axis of the wagon; it is hoisted into this position by means of the gun-lift or the gin.



TRUMELIERES.—Hollow plates of metal to be buckled over the mail, and adjusted to the outer surfaces of the legs and thighs, for their protection.

TRUMP TRUMPET.—A wind instrument, made of brass or silver, and used in the cavalry and mounted artillery. Some trumpets have lengthening pieces by which the key is changed. In its usual form it consists of a tube, less in diameter than the horn, doubled up in the form of a parabola, and sounded by a mouth-piece. Music for the trumpet is written in the key of C, the key to which the instrument is to be adapted being pointed out by the composer.

The pitch is an octave higher, than that of the horn. Trumpets in the key of C, D, and E flat, are most used; but there are also trumpets in A, B flat, E, F, and G. To enable the trumpet to give a complete series of semitones, finger-keys and sliding tubes have been introduced by some makers, rather to the detriment of the freshness and fullness of tone of the instrument. Trumpets with pistons and cylinders give all the intervals of the chromatic scale. Valved trumpets have a movable valve similar to that of a trombone.

TRUMPETER.—A soldier in a cavalry regiment, whose duty it is to re-pronounce or pass on the orders of the Commanding Officer; for which purpose certain recognized simple tunes have arbitrary meanings attached to them.

TRUMPET-MAJOR.—The Non-commissioned Officer in charge of the trumpeters of a regiment of cavalry.

TRUMPET-SIGNALS.—The *assembly of trumpeters* is the signal for the formation of trumpeters, and is the first signal for *reveille*, *assembly of guard details*, and *tattoo*, which it precedes by such interval as may be prescribed by the Commanding Officer; it is also the first signal for *review*, and other forms of ceremony. In large camps or garrisons, marches are played in the streets or in front of the quarters between the *assembly of trumpeters* and the *reveille* and the *tattoo*. The morning-gun is fired at the first note of the *reveille*, or, if marches be played before the *reveille*, it is fired at the commencement of the first march. The *assembly* is the signal for forming in ranks, and calling the roll; it is usually sounded five minutes after the termination of *reveille*, *drill-call*, and *tattoo*. It is also sounded after the signals for such other duties as require company roll-call. When marches are played before the *reveille* and the *tattoo*, the *assembly* may be sounded immediately after the *reveille* and the *tattoo*. The *assembly of trumpeters* and the *assembly* both precede the *retreat*, the interval between them being prescribed by the Commanding Officer: the interval between the *assembly* and *retreat* being only that required for formation and roll-call, except when there is a dress parade. The evening gun is fired at the last note of the *retreat*. *Adjutant's call* is the signal for companies and guards to assemble on the regimental or garrison parade-ground. *The general* is the signal for packing up effects, striking tents, and loading wagons, preparatory to marching. *To arms* is the signal for men to turn out under arms, with the least practicable delay, on their company parades. *Assembly*, *reveille*, *retreat*, *tattoo*, *adjutant's call*, *to the color*, the *flourishes*, and the *marches*, are sounded by all the trumpeters united: the other camp or garrison calls, as a general rule, are sounded by the trumpeter of the guard or orderly trumpeter.

When a command is given by the trumpet, the chiefs of subdivision give their proper commands orally. In the evolutions of large bodies of troops the subordinate Commanders cause their trumpeters to repeat the signals of the chief trumpeter, who accompanies the Commanding Officer. The memorizing of these signals will be facilitated by observing that all movements to the right are on the ascending chord, that the corresponding movements to the left are corresponding signals on the descending chord; and that the changes of gait are all upon the same note.

TRUNCHEON.—A club or cudgel; also, a staff of command. The *truncheon* was for several ages the sign of office. Generals were presented with the truncheon as the sign of investiture with command; and all those officers who belonged to the suite of the General, and were not attached to regiments, carried a truncheon, or staff, whence the name of officers of the *Staff*.

TRUNDLE-SHOT.—A bar of iron, 12 or 18 inches long, sharpened at both ends, and having a ball of lead near each end; it upsets during its flight.

TRUNNION-CHAINS.—Trunnion-chains are three in number, for light or heavy weights. They are made of a patent looped-link chain. A pair is required to carry a gun. One is passed under each trunnion and hooked on the head of the screw of the sling-cart.

No. 1, composed of one chain, 59 inches long, the ends joined by a ring; weight 27 pounds. No. 2, composed of two chains, each 59 inches long, the ends joined by a ring; weight, 53 pounds. No. 3, composed of two chains, each 47 inches long, the ends joined by a ring having three branches; two for the ends of the chains composing the pair, and the third for the hook of the screw; weight, 61 pounds. Thickness of the iron composing the link, .5 inches. Length of iron for the connecting ring, 23 inches for No. 1; 24 inches for Nos. 2 and 3. Size of iron for connecting ring, 1.375 inches, round.

TRUNNION GAUGE.—An iron ring of the proper diameter of the trunnions, employed in the inspection of cannons. Its outer edge coincides with the diameter of the rim-bases. To verify the position and alignments of the trunnions of a gun, it is first necessary to ascertain, by means of the Trunnion-gauge and of the calipers, their cylindrical form and their diameters, which should be the same, or allowance must be made for half the difference in measuring their axial distances from the base-line, by the *trunnion-rule*, which should next be done. These distances should be equal, or their axes do not coincide, an error not tolerated. The lengths of the trunnions are measured with a foot-rule, and the diameter of the rim-bases by that of the exterior rim of the Trunnion-gauge. See *Inspection of Ordnance*.

TRUNNION-HOOP.—The hoop of a *built-up gun*, upon which the trunnions are built. Many large guns are cast without trunnions, and the trunnions are afterwards built upon them.

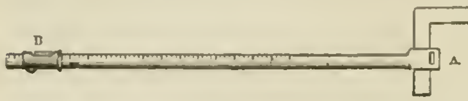
TRUNNION-LATHE.—A machine-tool for turning off the trunnions of ordnance or oscillating steam cylinders. The machine employs a shaft, carrying a revolving cutter, which is susceptible of feed-motion to and from the axis of the shaft upon which it revolves. The shaft is arranged to slide up to and from the article to be planed, and is operated by a revolving former at its rear end, working upon a shaft at right angles to the one carrying the tool, which also has a sliding motion to bring the different parts of the former to act upon the tool-carrying shaft.

TRUNNION-LOOP.—A piece of rope about 18 inches long, having its two ends firmly spliced together, forming thus a ring, which is placed over the trunnion, serving as a means of applying a hand spike to slue the piece in different directions.

TRUNNION-PLATE.—In gunnery, a plate in the carriage of a gun, mortar, or howitzer, which covers the upper part of the cheek and goes under the trunnion.

TRUNNION-RING.—A solid wrought-iron forging which is turned, bored and shrunk on the gun: the fibre of the metal is in the contrary direction to that of the *breech-piece*.

TRUNNION RULE.—An instrument employed in the inspection of cannon, for measuring the distance of the trunnions from the base-ring or line. It consists of an iron rod with a head at one end, through which passes one branch of a small square, A. The center of the rod is marked on the end, and the square is set so that the inner edge of the branch which is parallel to the rod is at a distance equal to the semi-diameter of the trunnion from the center. It is secured in this position by screws and clamps. The upper side of the rod is graduated to inches and tenths. A slide, B, with a slot through it, to show the graduation beneath, traverses upon it, and is kept from turning by a guide on the lower side. There is a vernier on the slide, graduated to hundredths of an inch; a thumb-screw serves to secure the slide at any point on the rod. That end of the slide from which the graduation of the rod commences has both of its sides drawn out, to form knife-edges; the knife-edges and the end of the slide are in the same plane. When the square at the end is placed on the trunnions, the end of the rod will touch its side at the point of its greatest diameter. The rod being held parallel to the axis of the bore, with the side of the head pressing the rim-base the knife-edge will be in proper position to fall into the base-line when moved to find it. If the alignment of the trunnions be correct, it will serve as a means of determining the correctness of the *line of sight*, which be-

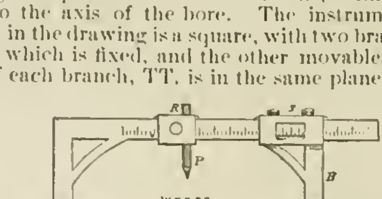


fore the gun is removed from the lathe, should be traced on the sight-masses and the swell of the muzzle, and should be at right angles to the base-line, to the axis of the trunnions, and to the connecting-piece of the trunnion-square, when its branches rest against their rear, with the plates across their upper surfaces. The inspector should further satisfy himself of the correct tracing of the line of sight on the gun, by examining the lathe and the manner of tracing it in the plane of the axis of the bore, at right angles to the axis of the trunnions, as by it are placed the sights and vent, and in their absence it serves as a line of metal sight. See *Inspection of Ordnance*.

TRUNNIONS.—The *trunnions*, in gunnery, are the two solid cylindrical arms projecting from the side of the cannon for the purpose of supporting it on its carriage. They are placed at or near the center of gravity, on opposite sides of the piece, with their axes in the same line, at right angles to the axis of the piece, and in the same plane with that axis.

TRUNNION SIGHTS.—Sights placed on the trunnions of rifled guns for laying them. There are two kinds used with the present ordnance, viz., *drop-sights* and *screwed-in sights*. The drop-sight consist of a gun-metal socket, collar, and pillar, and a steel leaf. The screwed-in sight is made of steel, and is screwed into the sides of the trunnion pieces, with the exception of those for the 40-pr. (new pattern) and 9-pr. guns, the trunnion sights of which are made of gun-metal. See *Sight*.

TRUNNION-SQUARE.—A steel or iron instrument employed in the inspection of ordnance for ascertaining the position of the trunnions, with reference to the axis of the bore. The instrument, as shown in the drawing is a square, with two branches, one of which is fixed, and the other movable. The foot of each branch, TT, is in the same plane and is



parallel to the upper edge of the main piece which connects them. The latter is graduated to inches and tenths. The movable branch, B, slides on the main piece, and may be secured to it by two thumb-screws, S. It is provided with a vernier-scale graduated to hundredths of an inch. Between the branches there is a slide, R, also provided with a vernier, graduated as before, with a thumb-screw to secure it firmly; in its center there is a sliding point, P, moving vertically, with a thumb-screw to fasten it. Above the foot of each branch there is a slit to receive the shank of a plate, H, on the end of which a thread is cut; the lower edge of the plate forms a right angle with the branch, and the plate is fastened to the branch by a nut, at a point from the end equal to the semi-diameter of the trunnion which is marked on each branch; the graduated steel wedge, W, is used to mearure the radiation of the trunnions from the feet of the square. When the feet of the branches, or the lower edge of the plates, rest upon the trunnions, the upper edge of the main piece is parallel to their axis, if their alignment is correct. When in the latter position, the edges of the feet will lie close against the sides of the trunnions. The trunnion-square is placed upon the trunnions in the plane of their axis. The feet of its branches should coincide with the surfaces of both trunnions, throughout their length, above and in rear, and their inner edges with the faces of the rimbases. Then, with *beam-compass*, describe on the upper surface of the gun the distance of the axis of the trunnions from the base-line, and push the sliding-point of the square down, till at that distance it touches the surface of the gun, and screw it fast. Turn the gun over again scribe on it the same distance from the base-line. The square, being again applied will determine whether the trunnions are above or below the axis of the bore, which will coincide with that of the gun, if accurately bored, and turned on the same centers and bearings. If the branches rest upon the trunnions before the point of the slider touches the gun at the scribe, their axis is below, but if the point touch first, above the axis of the bore by half the space between. The graduated wedge, being placed under the vertical sliding-point, will determine the amount. If both touch at once, both axes are in the same plane. No gun should be received, whose axis of the trunnions is above the axis of the bore. See *Beam-compass*, and *Inspection of Ordnance*.

TUBAGE. By tubage the cast-iron screw-seat is replaced by a strong and hard screw-thread in steel, and by theory the strain on the cast-iron, on a greater diameter of the weaker metal, increases its resistances to rupture by the *breech strain* at the initial point of the screw in the cast-iron, where rupture is liable to occur and "déculassement" ensue. By not confining the length of the tubage to a mere fillet of steel, but by extending it along the bore some distance, we undoubtedly further relieve the strain on the cast-iron at the screw seat by the hold the tube takes on the cast-iron body in front of the breech, resulting from the friction arising from the transmitted tangential strain in firing. This friction evidently tends to prevent a rearward action of the tube, and acts counter to the strain on the breech, and hence considerably relieves the cast-iron at that point.

The object of the introduction of steel tubes in the French naval cast-iron guns was, primarily, to give increased strength—especially, as above stated longitudinally and incidentally to give a surface of bore more perfect in its capacity for resisting erosion and utterings from the deteriorations arising from the contact of the powder gases. The increase in longitudinal strength was a *sine qua non* as exhibited by the failures of the fretted model of 1864, and this point alone demanded the introduction of tubes. The introduction of thin tubes merely to protect the bores had been repeatedly tried, but they added but little stength, although the wear of the bore appears to have been retarded. The present short steel tube has been the result of the essays in the tubage of guns; and the general dimensions of this part of the system of the model of 1870, with reference to the body and other parts, are shown in Fig. 1.

The appliances for the heating of the cast-iron bodies for the reception of steel tubes are marked by great simplicity. A cylindrical furnace, sufficiently large in its exterior diameter for the gun or guns to be heated, is extemporized on the foundry floor, and of a sufficient height to receive fully that portion of the gun necessary to be heated up sufficiently to give the necessary expansion to the cast-iron for the easy and free insertion of the tube. It is placed over a pit, and the projection portion of the chase is thus provided for when the gun is lowered into the furnace. The general features of the furnace, as shown in the section, Fig. 2, are a brick exterior wall, dry built, and provided with proper interstices as the successive layers are added in the course of its erection. A thin iron cylinder constitutes the interior walls, and the intermediate space is filled with wood fuel to furnish the necessary heat. Tie-bolts, radial and lengthways of the extemporized furnace, are supplied to give the necessary strength and solidity to the system. The gun, of course breech up, is inserted into the furnace by the crane or cranes of the foundry, and after the insertion of the tube is sent to be finished by the subsequent operations of frettage, provision of breech-block seat, truing up of bore, rifling, etc., and its final completion for service. The naval calibers are 14cm, 16cm, 19cm, 24cm, 27cm, 32cm, 34cm, 37cm, and 42cm. The three last have only recently been added; and the four 42cm guns recently constructed at Ruelle, are the first of this model. These guns, with one exception, are all steel, and are built up of thick steel tubes, tempered in oil, and with two tiers of fretties of puddled

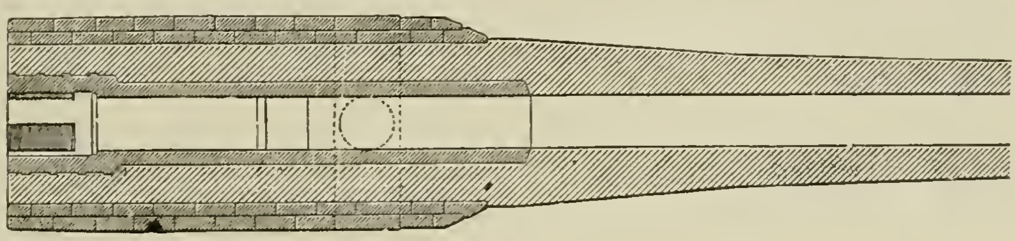


Fig. 1.

steel shrunk on. The tubes are the product of Le Creusot, and are all cast from Siemens furnaces, and forged under the large hammers of those Works. Only three of these, however, have a full steel construction; the fourth differing from the others in having a cast-iron body instead of a steel one. This latter is intended purely for ballistic purposes, and to be used as soon as completed at the polygon of Gavre. The weight of the steel gun is 75 tons; the weight of the experimental gun, however, is 100 tons: the French engineers giving 25 *additional* tons weight for the *same caliber and power* when cast iron enters as a component in the system as a substitute for the steel bodies.

The details of these guns (42cm) are as follows:

Length of the bore in calibers	22
Weight in tons..	75.4
Weight of bursting shell............pounds...	1,726
Weight of the charge.....................do......	617.3
Initial velocity..................................feet...	1,738
Living force in foot-tons..........................	36,628
Living force per ton of metal.....................	485.8
Living force per pound of powder............	59.3
Living force per inch of circumference......	70.8

The more marked features of this system are the amplitude of power contemplated, rivaling, as it does, the best efforts of the Armstrong steel construction; a weight of charge one-half the weight of projectile being designed, and a calculated muzzle velocity of 1,962 feet being expected to be attained. The weights of the different lengths for the same caliber varying from 43.3 to 51.6; and the muzzle energy secured is, say, about 20,000 foot-tons, or about 400 foot-tons, roughly, per ton of metal. The shortening of the guns is found necessary to adapt them for vessels not admitting of the 28½ calibers standard for length.

It will be observed that the chambering has only an increase of about 0.44 inch above the bore, a marked difference between it and the English chamber and those proposed in the United States. It is, however, to be noted that the importance of using chambers has not escaped the attention of the French naval authorities, as the introduction of larger chambers in guns of the model of 1870 is one of the features of the work now being executed at Ruelle, recent experiments at Gavre having shown the feasibility of their application to the model in question. About 10 per centum in capacity of chamber is added to the original 12.59-inch model of 1870 gun: and the resulting muzzle velocity, using the normal shot with an increase in the weight of powder by 62 pounds, has been increased 40 feet. It is understood that besides the 32cm guns being altered, that the lower natures of model 1870 down to 14cm will be chambered to further increase their power. The power, however, attained by these guns is far inferior, caliber for caliber, to that attained by their more formidable rivals built up of steel, now being prepared for introduction into the French marine.

The following references regarding the power of these guns may be of some interest. From tables believed to be as complete, generally, as can be obtained, it will be seen that, including the Dard model and the latest 34cm guns now in process of construction, the ratio of weights of powder to projectiles is one to two, and one to three where steel alone is used: one to five in the model of 1870, steel tubed and fretted; and one to six for the model of 1864, which latter are no longer standard. In our service, unchambered 8-inch have a ratio of one to five, as in the French model of 1870. Our experiments leave as yet in dispute the propriety of using a ratio of 1 to 3¼, as contemplated in the chambered breech-loading 8-inch recently tested at Sandy Hook. The maximum velocity contemplated for constructions, all steel model of 1876, is 1,625 feet; with the model of 1870, 1,404 feet, and with model of 1864, say 1,100 feet. These velocities are those appertaining to the caliber of 27cm. As above stated, however, 1,962

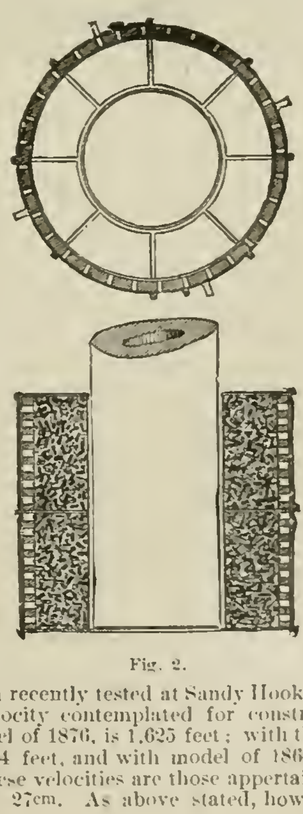


Fig. 2.

feet is calculated for the more recent construction of (1880 and 1881) caliber 34cm gun. Referring to the 27cm gun, it may be stated that the weight of the projectile is the same for all models cited (1864 to 1881); the charges, however, differing from ⅛ up to ⅙ of the weight of the projectile.

The calculated pressures for the models of 1875 and 1876, are respectively, per square inch, about 35,500 pounds for the former, and 41,000 pounds for the latter. The difference in these pressures, which it is believed occur in service, although sensibly different, show that the cast-iron fretted construction of 1864 were—by the powders adopted for their service - less severely strained than the constructions of 1870 and 1876. No more glaring evidence of the inadequacy of cast-iron when compared with the combination of this metal with steel tubes and frettes, or with steel constructions simple and pure, can be exhibited than shown by the above figures. That modern constructions within the present resources of metallurgy can attain at least double the energy per ton of metal (leaving out the question of endurance), when compared with the cast-iron constructions of the past (although fretted with steel), leaves no reasonable room for argument on the advisability of the further use of cast-iron alone and simple, and shows that its employment at all in gun constructions is only warranted by the fact that a safe construction, but of comparatively low power, will probably be the result of its combination with tubes and frettes of steel, and that hence merely an economical construction as compared with the use of steel will be secured.

It must not be forgotten, however, that not only about equal weight, united by locking together, the whole strengthened by two rows of shrunk-on frettes, superimposed over the body. The fermeture placed in the rear section of the body has no connection with the interior tube. This construction generally gives all the advantages to be derived from the use of the strongest and most suitable metal for ordnance; is built up in accordance with the theories of construction for tangential strength, as far as they can practically, and with due regard to economy be applied: and by the separation of the inner tube from the body, disconnecting the end strain from the tangential at this point, introduces a feature constituting a true and important departure from the ordinary mode of construction now in vogue. The *failure*, however, *to lock* the tube to the body to prevent the forward thrust of the former, arising from the friction of the moving projectile, and the gases on the shoulder of the chamber—save by the friction between the tube and body, is a *radical* defect, and *experience* has developed it and led to a modified form of construction, shown in Fig. 3.

It consists of a hollow cylinder screwed into the casing, and with sufficient length to afford a rest for the fermeture, and to afford a means of being locked to the interior tube. This, of course, will prevent the tendency of the tube to move to the front; and it was this cause, it appears from recent French authorities, that led to the modifications just noted. They say, alluding to the original model of 1875:

Ce mode de tubage n'a pas donné de bons résultats, ainsi que la remarque en a été déjà faite dans le 1er chapitre à propos des canons modèle 1875 ; la fixité du tube *n'est pas* suffisamment assurée.

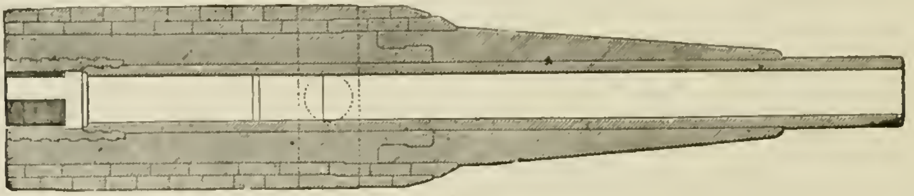


Fig 3.

lower power is a drawback, but that although the steel constructions cost per pound about 2.9 times that of the cast-iron tubed and hooped gun, yet the endurance of the former is estimated at about three times that of the latter. The latter fact amply compensates for the excess of prices, especially in those guns which may be called upon for continuous long-continued firings, as in the cases of the defense of seaports—particularly large harbors exposed to continued and renewed attacks—and ship armaments, where the great lightness, power, and strength of steel ordnance become matters of vital importance. In cases, however, of secondary lines of defense, such as those positions where inferior power will suffice, and where less continuous demands upon the resources of the protecting batteries will be made, and where the guns will not be called upon to cope at short ranges with blockading squadrons, the inferior and cheaper constructions can be utilized; and for such should, in consequence, have preference. In many of these cases the guns will never be used, and will have probably become obsolete before any demands upon them, beyond practice, will be made.

The original model of 1875 a very perfect construction in steel is designed, generally, after its prototype of 1870, to which it is a natural sequence growing out of the experiences of ten years of test and of manufacture of the latter, aided by the developments and advancements resulting from the rapid strides in France and England in the production of steel. Its salient features as above stated, are a steel, oil-tempered tube *(held simply by shrinkage)*, placed in a steel body consisting of two parts of

In this modification, the junction of the inner tube and body takes place practically at a point equivalent to the bottom of bore in muzzle-loading guns, and as the phenomena in the act of firing in a breech-loading or muzzle-loading gun—the breech-loading gun using a French fermeture—are essentially the same, it is believed that all the disadvantages arising from having to contend with the union of the *two* strains at the bottom of the bore still attain in this construction. The absolute separation, however, of the longitudinal and tangential strains by designs in construction which shall contemplate entirely different parts of the system to separately withstand these stresses, is now one of the most prominent ideas which is engaging the attention of the ordnance constructors of the day. The first inventor to believe that an advantage might be gained by the complete separation in a gun construction, *united in all its parts*, of the tangential and longitudinal strains at the breech was Captain Emile Schultz, of the French artillery, who, as far back as 1875, shows, in one of his illustrations of a wire gun, a design giving a practical application of this idea.

Referring to the experience in the French Service, which showed the absolute necessity of the introduction of some means for the prevention of *décullassement* in the fretted cast-iron guns of model of 1864, we see that reinforcement with interior steel tubes was the remedy resorted to, to remove the evil. A separation of the two strains appears to be a more radical treatment, and it is even probable that a cast-iron fretted or wired gun, *without an interior tube*—the longitudinal stress being borne *outside* of the body of the gun—might be tried as promising a fair solution of the problem for guns of a secondary order of power, if not too cumbersome and heavy in construction. See *Schultz Wire-gun*.

TUBE.—A primer for ordnance. A small cylinder placed in the vent of a gun, and containing a rapidly burning composition, whose ignition fires the powder of the charge. See *Friction-primer*.

TUBE-POUCH.—The artilleryman's leather pouch for carrying friction-primers. It has two loops, by which it is fastened to the belt. The *priming-wire* and *Gunner's gimlet* are carried with it.

TUBERATED.—In Heraldry, a term signifying knotted or swelled out.

TUBE-WELL.—An American contrivance, introduced into England about 1867, having for its object the obtaining of a small supply of water in a very short space of time by the application of a limited amount of manual power. The apparatus comprises three parts—a tube or well, a rammer or monkey, and a pump. The tube consists of an iron pipe about 1¼ inches diameter, made in pieces of convenient length, which can be screwed together end to end. The pipe terminates at the lower end with a solid tempered steel point, and is perforated for about 16 inches from the end with small lateral apertures. The pipe is driven a short way into the ground, just sufficient to keep it upright without falling, and is temporarily kept in that position by hand. A strong iron clamp is fixed to the tube by clamping-screws at a short distance above the ground; and another clamp is similarly fixed higher up. Two pulleys are supported by the upper clamp. The rammer or monkey, consists of a 56 pound iron weight, which slides up and down the tube, encircling it like a ring or belt. The rammer, being raised by two men, is allowed to fall with its full weight on the lower clamp; thus giving a series of blows which drive the tube into the ground. When the lower clamp becomes level with the surface of the ground it is raised up the tube; as is likewise the other clamp, which supports the two pulleys. Successive lengths of tube and successive shiftings of the clamps afford the means of enabling the perforated end of the tube to reach soil whence water can be obtained. When the symptoms appear of water having been reached a small suction-pump is applied, and the water pumped. It is only when water is expected to be reached at a moderate distance below the surface that this apparatus is available, as it is not powerful enough for great depths, nor is the bore of the tube sufficient for a large influx of water; but the required conditions being found to exist, the apparatus saves a large amount of ordinary boring. As the water is pumped up, the loose sand and gravel disappear from the point of the tube, allowing the formation of a small pool or well: while small pebbles which collect around the perforations act as a sort of filter. The tube can be extracted from the ground by forcing the rammer upward against the upper clamp. During the trial of this apparatus in the cricket-ground at Old Trafford, Manchester, the tube was sunk to a depth of 10 feet in 22 minutes, and water had been reached in even less than that time. Such a form of well, it is considered, will be free from the liability of received dirty surface-water: and no accident is possible from foul air or from the falling in of the sides. A well 15 feet deep was sunk in one hour in the Botanical Gardens at Mancherter, and excellent water reached. Another was sunk in the grounds of St. Cloud in half an hour, and pumped up water at the rate of 20 liters (18 quarts) per minute. The inventor accompanied the American Federal Army, and enabled the troops frequently to obtain water by the aid of these pumps. On one occasion, to try the capabilities of the tube, he sank one to a depth of 150 feet, at Ithaca, in New York State. Tube-wells were sent out with the British military force to Abyssinia. See *Well-boring*.

TUILLE.—A plate or small shield which covers the front of the thigh. It being secured by straps and buckles, allows free movement of the limb.

TUCK.—An early name for a long and very narrow sword.

TUKTA-REWAN.—A conveyance for the wounded, used in some parts of the East Indies.—It very much resembles some of the palanquins of the 16th century, and is so shaped as to permit the patient to rest either in a semi-recumbent or prone position. See *Two-horse Litter*.

TULLUB.—An Indian term signifying a demand, but it is commonly used amongst the natives of India when speaking of their monthly pay.

TULWAR.—In the East Indies, a term signifying a sword.

TUMBLER.—The piece in the interior of a gun-lock by which the main-spring acts on the hammer, causing it to fall and explode the cap. It is connected with the main-spring by a *swivel*, which transmits the full pressure of the spring to the swivel arm. The tumbler has a partial revolution on pivots (the *arbor* being one), the extreme limits of its motion being from full cock to the striking of the hammer on the cap. The hammer is carried on the square of the tumbler; this is the outwardly projecting end of the arbor. See *Lock*.

TUMBLER-PUNCH.—A small two-bladed punch used for pushing the arbor of the tumbler, the band-springs, etc., from their seats, in taking a gun apart.

TUMBRIL.—A covered army cart on two wheels, for the carriage of ammunition, tools, etc., belonging to the artillery. The name obtained a melancholy celebrity from being applied to the carts which served to carry the unfortunate victims of the French Revolution to the guillotine.

TUMELIERES.—Plates of armor, which superseded the lower part of the mailed hose in the 12th and 13th centuries.

TUNIC.—A close-fitting coat, having short sleeves, worn in ancient times by the Romans. This sort of clothing was prevalent among the French after their return from the Crusades to the Holy Land. They adopted it from the Saracens, and seemed ambitious of appearing in a garb which bore testimony to their feats of valor. These tunics, which were converted into a sort of uniform, obtained the name of *saladines* among the French, in compliment to the Emperor Saladin.

TUNNELING.—In giving any brief and intelligent sketch of the history of tunneling, dating from the earliest records relating to this class of work up to the present time, it will be necessary, not only to make brief mention of the work done, but also of the various methods employed. This leads to a concise description of appliances of various kinds, beginning with the first recorded work and following up for some centuries, during which time there was little change in the methods, or in tools used. With the invention of gunpowder the entire system was revolutionized, and work was undertaken which before had been impracticable on account of cost and time. After the discovery of gunpowder, it became possible to break the rock more cheaply and expeditiously; but until 1630 this new agent was employed only in warfare. During that year it was first employed in Germany in mining by drilling holes by hand and breaking the rock with the explosive compound. While Schwartz is credited with the invention of powder, the Chinese are said to have been acquainted with the compound A. D. 80. This system was followed until a quite recent date. In 1847, Sobrero discovered nitro-glycerine, and in 1849, J. J. Couch, an American, invented the first machine-rock drill. With the advent of these new appliances, the former system was revolutionized and perfected so that works of great magnitude could be undertaken with a certainty of speedy completion at a comparatively low cost. The history of tunneling is therefore properly divided into three periods. The first period covering the time from the time of Rameses II. to the date of the invention of gunpowder, during which time, work was done by the use of hand-tools, wedges and fire-setting. The second period extends from the date of the invention of gunpowder, 1320, to 1861, when machine-rock drills (Sommeiller's) were first employed for practical work in the Mt. Cenis Tunnel. The third period extends from 1861 to the present time, during which time the machine-rock drill and high explosives have come into general use.

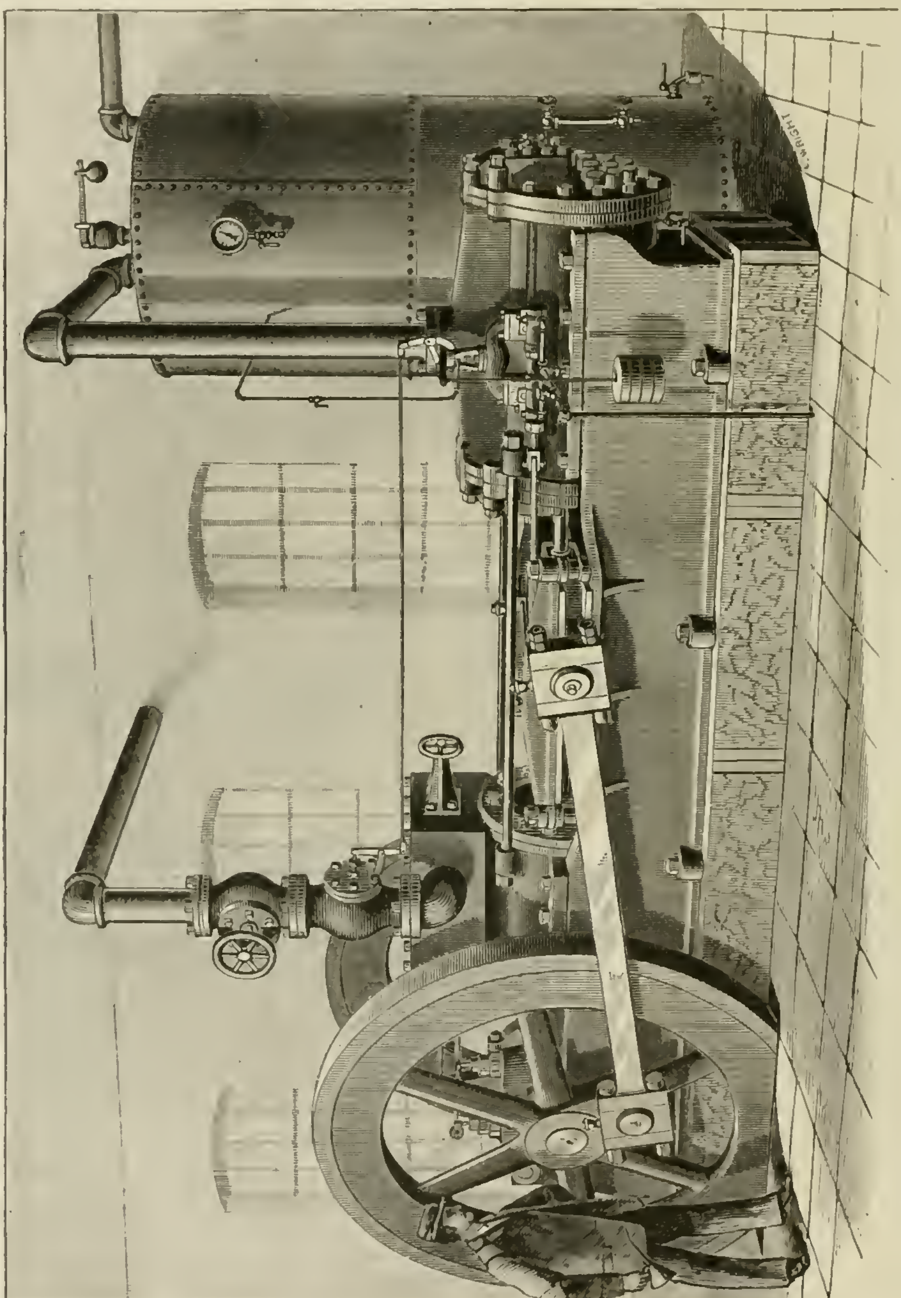


Fig. 1—Ingersoll Single "Straight Line" Air Compressor.

The recorded history of tunneling dates back to the reign of Rameses II. when rock was excavated by means of a few hand-tools, wedges and "fire-setting," which consisted in heating the rock and quickly cooling it with water, a means occasionally employed at the present day for cracking boulders.

The fire-setting system is at present to some extent employed in Japan, though it is being rapidly superseded by hand-drilling with explosive compound. It is supposed that the Ancients were to some extent acquainted with the use of the diamond for boring and cutting rock. If true, M. Lischot, centuries later revived one of the lost arts which to-day we see perfected in the diamond pointed rock boring-machine. It must be admitted that the Egyptians were the pioneers in rock excavation, as it is evidenced by the numerous subterranean tombs, grottoes and caverns, yet in existence. A more fitting tablet than the everlasting rock on which to re-

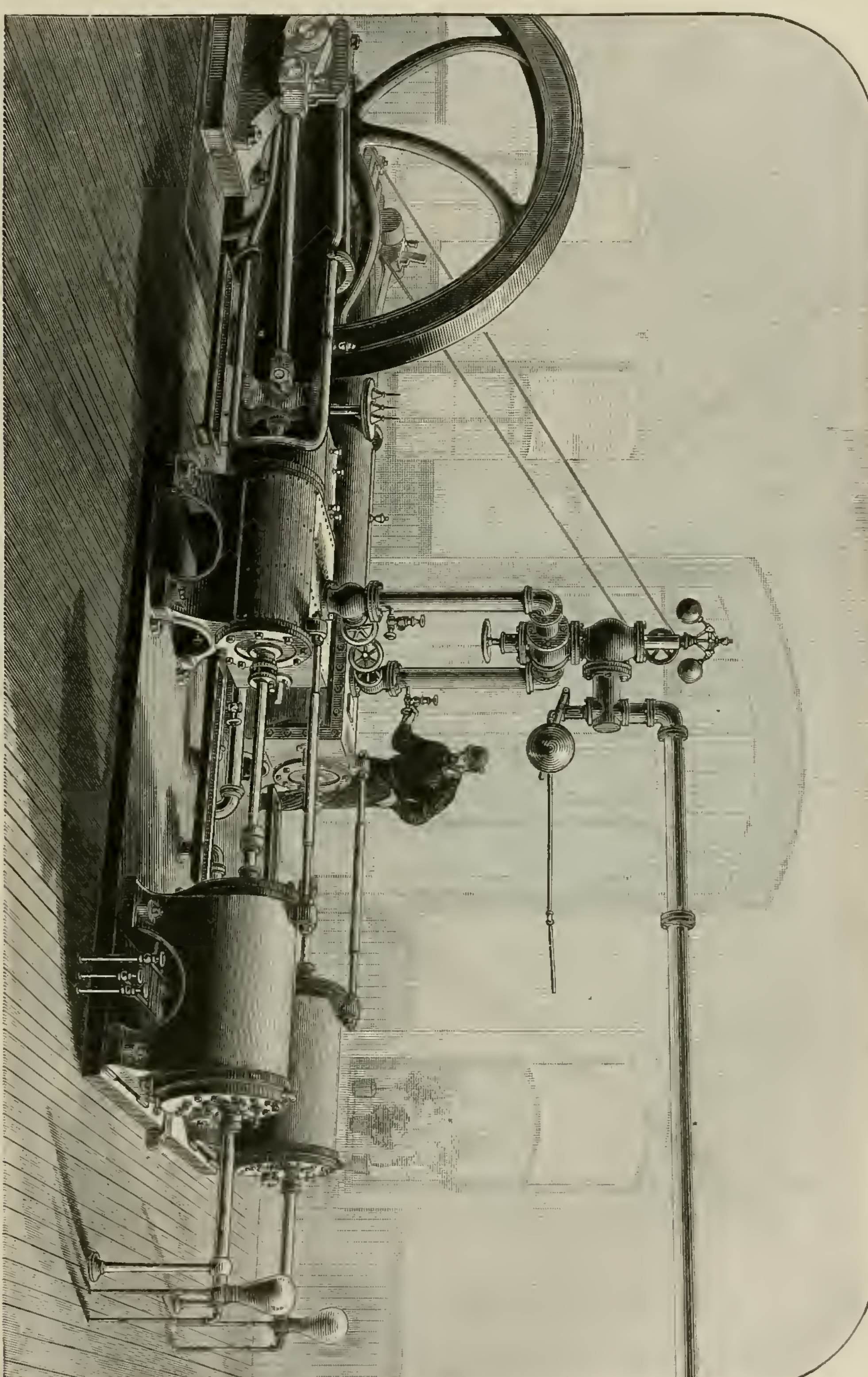


Fig. 2.—Rand Duplex Air Compressor. Class A.

cord the history of their Herculean task could not have been selected.

The first cave (semi-tunnel) known to have been excavated is the Nigope, cut about 260 B. C. The records of similar work in Egypt, Asia and Europe from this date forward are quite numerous. In America similar work was done by the Aztecs and Peruvians; most if not all of these excavations were used as temples or sepulchers. The exception to this general rule is a tunnel run under the Euphrates at Babylon for communication. Simeramis began the great work of tunneling the mountains of Baghistan about this time. During the Sixth Century a tunnel 4,248 feet long was constructed in the Island of Samos. The Etruscans undoubtedly gave the Romans their first lessons in tunneling; but it is among the records of the Romans where we first find tunneling carried on an extensive scale, and in a manner well worthy of the study of modern engineers. The stupendous works constructed by the ancient Romans, many of which are still in existence and in a good state of preservation, bear evidence of their skill and thorough knowledge of such work. Their tunnels for conveying water, for drainage and passage were constructed not only through rock, but through earth, and the masonry was built with such skill and perfection, that in many cases it yet remains in a good state of preservation. The Romans did not confine such work to Rome and its immediate vicinity, but carried it on in all countries which they subjugated. In the year 359 B. C. the Romans constructed a tunnel 6,000 feet long, 7 feet high and 5 feet wide, to tap Lake Albanus. This was worked through some fifty shafts and was completed in one year. After the fall of the Roman Empire, tunnel work was almost entirely suspended until after the Dark Ages. During 1450 Anne of Lusignan revived tunnel construction on a large scale by beginning a tunnel in the Alps between Nice and Genoa. The English were the pioneers in soft ground tunneling.

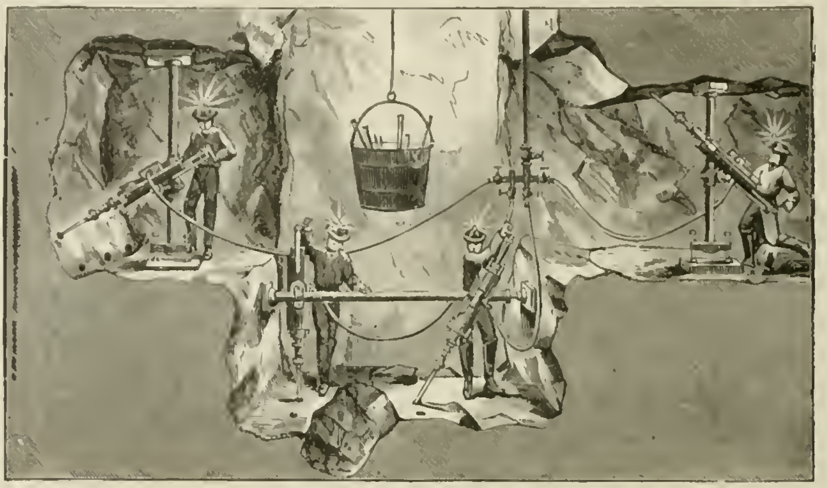


Fig. 3.—Rock Drills used in Railroad Work.

The first wide modern tunnel (515 feet long, 22 feet wide, 37 feet high) for transportation was constructed by Riquet in 1679-81. The second modern tunnel (Harecastle No. 1) on the Grand Trunk Canal, England, 8840 feet long, 9 feet wide, 12 feet high, was begun in 1766 and completed in 1777. This tunnel initiated work of such nature on a large scale in England, and in 1856, 45 tunnels aggregating in length 219,827 feet had been driven in England alone. The first railroad tunnel in which locomotives were used, was constructed in 1826-30, on the Liverpool and Manchester Railway. The first tunnel in the United States was constructed near Auburn, Pa., on the line of canal built by the Schuylkill Navigation Company. It was 450 feet long, 20 feet wide, 18 feet high, cut through red shale. This work was begun in 1818, and completed in 1821. No serious obstacles were met in its construction.

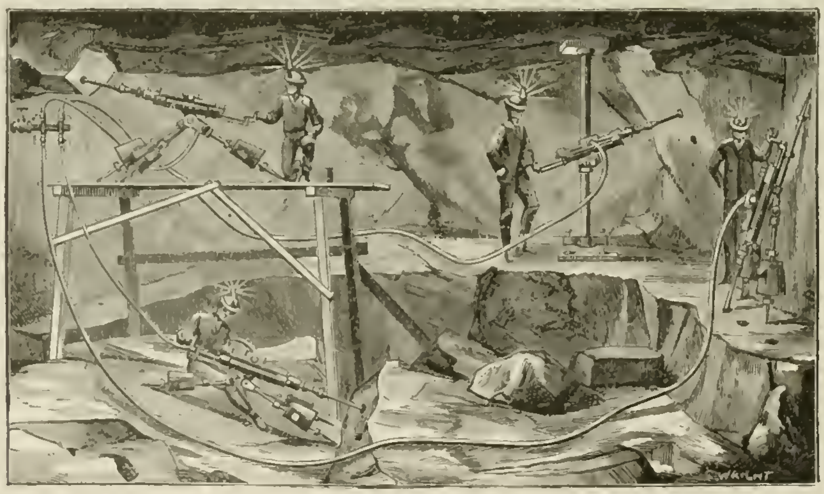


Fig. 4—Stoping and Pit Mining.

The "Hacklebernie" Tunnel, near Mauch Chunk, Pa., was the first large mining tunnel constructed in the United States. It was 790 feet long, 16 feet wide, 8 feet high, cut through hard conglomerate. Cost of excavation $7.16 per cubic yard. The first *railroad tunnel* in the United States was constructed in 1831-33, on the Allegheny Portage Railway, Pa. In 1850 there had been built in the United States 52 tunnels. 1850 marks the beginning of the grandest achievements in tunnel construction, made possible by the introduction of machine rock drills and high explosives.

In March 29th, 1840, J. J. Couch patented the first machine rock drill. On May 9th, 1849, J. W. Fowle filed a caveat for an improved rock drill and in 1850 he took out his patent for his improved drill. Fowle's invention was really the precursor of the rock drill as we now know it. To Couch belongs the honor of designing the first percussion drill as distinguished from a rotary borer, and to Fowle we owe the direct action principle. January 1861, the *first practical* machine drill (Sommeiller's) was put in operation in the Mont Cenis Tunnel. In 1847 Sobrero discovered nitro-glycerine. In 1863 Nobel first applied nitro-glycerine to blasting. In 1866 nitro-glycerine was successfully applied in Hoosac Tunnel. In 1866 Burleigh machine rock drill was successfully used in the Hoosac Tunnel. In 1867 Nobel invented dynamite. In 1867 the Wood drill was invented. In 1868 the Dubois-Francois rock drill was invented. Between the years 1871 and 1874 the Ingersoll, Rand, McKean, Ferroux and Darlington drills were invented.

From a careful study of the foregoing dates and data, it will be seen how quickly inventive skill provided new agents to meet requirements and how quickly it was rewarded with success. In 1882, rackarock was invented. This powder is stronger than dynamite No. 1. It can be transported and stored without danger. Its inventor is an American, Mr. S. R. Divine, of the Rendrock Powder Co. It has proved its value in several tunnels and in many mines, among the important tunnels may be mentioned the Haverstraw, Vosburgh, Factoryville, and at Flood Rock. See article *Submarine-blasting*.

Previous to the introduction of machine drills and high explosives, all tunneling was necessarily done with black powder and hand-drilling, and this practice is still followed to some extent. The American system of tunneling is to drive a top heading about seven feet high, full width. When the machine-drilling is employed the "cut" or wedge is generally taken from the center of the heading. The following data shows the rate of progress made by hand-drilling and black powder in tunnels driven through various rock formations.

Albany and West Stockbridge Railroad Tunnel: material, limestone and slate; driven 1841; average monthly progress in heading, 53 feet; bottom, 50 feet 9 inches. Welling Tunnel, Baltimore and Ohio Railway; driven in 1851, material, sandstone and slate; average monthly progress, 104 feet. Stump House Tunnel; Blue Ridge Railway; driven, 1855; material, mica, schist and gneiss. Monthly progress, 25 feet. Bergen Tunnel; Delaware, Lackawanna and Western Railway; driven in 1874; double track; material, dolerite. Monthly progress 22 feet. Average monthly progress in 18 tunnels driven in the United States, through hard, solid rock by hand-drilling, with black powder; 36 feet in heading, 49 feet on bottom. The average in Europe based on reports of European engineers, 36 feet to 45 feet. The Rothschönberger Stollen in Saxony is an illustration of progress made by hand-drilling, with black powder. This adit was begun in 1844 and completed in 1877. It was 13,901 meters long; average monthly progress covering a period of seventeen years, from 1847–64, 26 feet 6 inches. Cost per running meter about $51. Comparing this with the Sutro Tunnel, where machine drills and high explosives were used, it will be found that the monthly progress in the latter exceeded the yearly progress in the former. In the Sutro Tunnel, made 20,489 feet long, 10 feet high and 12 feet wide, during 1876, an average monthly progress of 306 feet was made; 360 feet being the greatest single month's progress; six (5-inch) Ingersoll drills and dynamite being used. Work on the Hoosac Tunnel, Massachusetts, was begun in 1854, but the old methods were employed (excepting some experimental work) until 1868, when machine-drilling and dynamite were introduced. Therefore, Europeans led off in the first practical application of the machine drill, first discovered in America, for in 1861 machine drills were introduced in the Mont Cenis Tunnel.

The third period in tunneling history was fairly inaugurated during 1863-64, when Nobel invented and applied nitro-glycerine to practical work. From this date forward the advances made in tunneling and tunneling appliances have been so rapid as to excite wonder. An idea of what has been accomplished can be formed by comparing progress and cost at Hoosac Tunnel, with same items relating to tunnels driven from 1883 to 1885. Data will be found in the following pages. In this connection it will be interesting to consider briefly some of the more modern tunneling appliances, and give a list of the principal tunnels, machinery used and results obtained.

The use of machine drills in subterranean excavations, made compressed air a necessity, as it can be compressed at any convenient location on the surface and then be conveyed through pipes to any desired

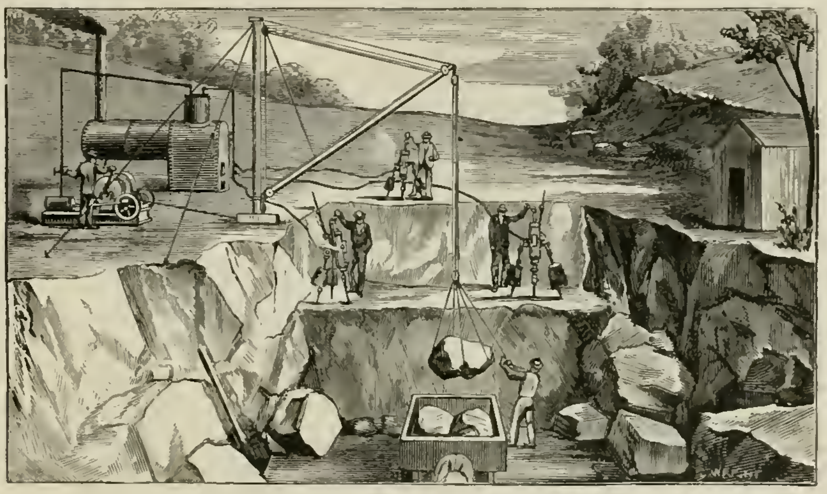


Fig. 5.—Drifting and Sinking with the Rock Drill.

distance without material loss of power, besides assisting ventilation; while steam would condense and uncomfortably heat the workings. The practical adaptation of compressed air was contemporaneous with the introduction of machine rock drills in the Mont Cenis Tunnel in 1861. The early history of air compressing appliances is made up of attempts, more or less successful, to construct an engine economical in the use of power and at the same time give a high effective in volume of compressed air delivered. The "Burleigh" was perhaps the first practical air compressing engine in use. It was introduced at the Hoosac Tunnel and has since had a large sale in the West Coast Mining Section of the U. S. In this compressor the heat developed by compression is to a certain extent neutralized by injecting cold water into the air-cylinder. Later the duplex or double compressor came into favor and is to-day the favorite in mines and permanent or large works. This class of compressors use generally a water jacket around the air-cylinder and thus partially absorb the heat of compression. The Delameter, Norwalk, and National compressors are types of this class.

The Ingersoll "Straight Line" Compressor is shown in Fig. 1. The frame, rectangular in form, straight and solid, is made in one casting, the vertical, parallel sides of which are stiffened by transverse ribs. The steam and air-cylinders are in line, and with two heavy fly-wheels, accurately balanced and turned, are supported on one continuous frame, making it impossible for any part to get out of line. Between the cylinders is a heavy cast-steel cross-head with *swivel-block*, into which piston rods are fitted and held by a king-bolt and adjusting clamp. This arrangement permits the cross-head to adjust itself to any irregularity in the length of connecting rods, caused by uneven wear in the crank-pin boxes, thus preventing a breaking strain from being brought to bear on the piston rods or cross-head. The fly-wheels overhang the frame on each side, and into these are fitted heavy steel crank pins of large diameter, set exactly opposite each other. Connection to the cross-

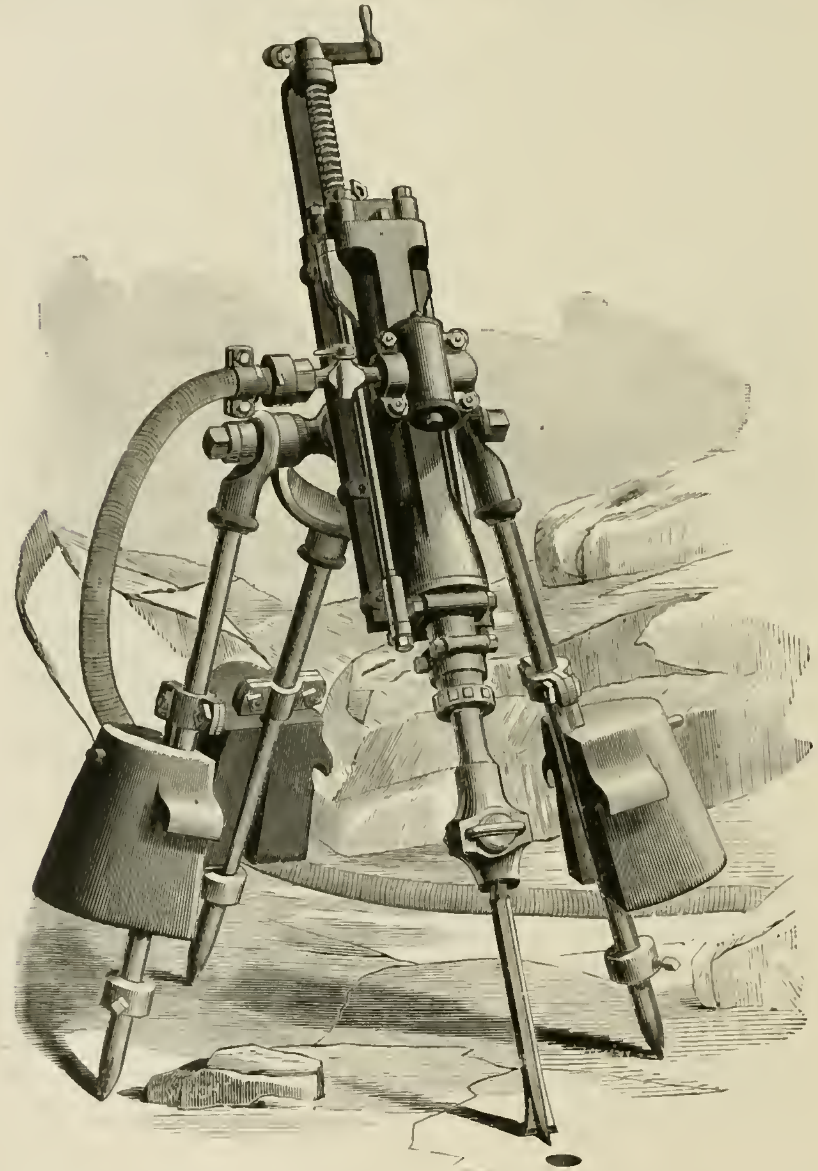


Fig. 6—Ingersoll Drill mounted on Tripod for Surface Work, Stoping, etc.

head is made by strong forged oblong rods. The main and cut-off valves are moved by rocker arms, located at the rear end of the frame, back of the main shaft. The valve rods are fitted with adjusting nuts. The main valve is the ordinary D pattern, on the back of which an adjustable cut-off valve works. With steam pressure at, say, 60 pounds, cutting off at one-half stroke, a working air pressure of 70 to 75 pounds is easily maintained. The journal-boxes are adjusted by means of a half wedge, circular on one side, and operated by means of screw-bolts passing longitudinally through the cap-bolts. The journal and crank-pin boxes, slides, induction and eduction valves are made of phosphor-bronze. The eduction valves are cylindrical and have their entire circumference for a wearing surface and guide, leaving a clear passage for the air, and obviating the constant trouble found with valves moving upon, and guided by, a small central stem. These valves work in cages screwed into the cylinder heads from the outside, and project beyond the cages sufficiently to admit springs between a rim on the valves and the face of cages. Cylindrical balanced eduction valves are used, and move in cages similar to the eduction valves, and are held in place by caps bolted to the outside of cylinder heads, through which adjusting screws pass, bearing against the valve cap.

Ample area is provided for ingress and egress of air. Every valve can be removed from the outside without ever detaching the cylinder head. Sectional composition packing rings, set out by heavy elliptic springs, are used in both pistons. Cooling is effected by a double plunger pump worked from the cross-head, *spraying* water into the cylinder, thus maintaining the air at nearly its *normal temperature, lubricating* the cylinder and *packing* the *clearance spaces*, and *forcing* the *volume of compressed air out of the cylinder. This system prevents in a great measure the trouble from freezing.* An *automatic speed* and *pressure regulator* is located on the air-cylinder and connected to the receiver by a small pipe. The regulating device consists of a double-headed piston properly enclosed, the bottom head fitting into and closing a cored passage opening into each end of the cylinder. The piston is actuated by air pressure acting against the upper piston head. Passing well over the top of the piston is a weighted lever. To the weight rod is attached a toe, above which is the stem of a stop-valve, located in the pipe supplying water to the pump. Over the lever is a bell-crank, to the upper arm of which is attached a rod connected on the other end to a second bell-crank attached to a regulating valve in the steam pipe. The upper arm of crank stands in front of the projecting stem of the steam regulating valve, which is arranged so that steam cannot be entirely shut off. If desired to carry, say, 60 lbs., pressure, the regulating lever weights are set at that point, and the safety valve on the receiver, say, two pounds higher. The position of each part is as described, while the full compliment of drills, etc., is running; but the moment a less volume of air is required, the air pressure in the receiver at once rises, and acts through the pipe upon the under side of the upper head of the regulating piston, raising the lever and through the bell-cranks and rods, shutting off steam and slowing down the speed of the compressor to produce the reduced volume of air required. If all the drills are stopped, the bottom head of regulator piston will be lifted sufficiently to open the passage before described; then the inlet and discharge valves close and cease to act, and the air from the cylinder escapes from the front to the back of the piston through the passage. The engine is taking just enough steam to turn it over and overcome its friction, there being no resistance against the air-piston. When the lever raises, the toe on the weight rod comes in contact with the movable stem of the stop-valve and stops the flow of water to the pumps. If the engine is stopped on its center, a valve is opened, letting the air pressure against the air-piston, thus throwing it off without the use of a bar. The water should be from one to eight feet below the level of spray pump.

The Rand duplex compressor, shown in Fig. 2, employs a very perfect system of cooling the air. Injecting water into the air-cylinder will cut and wear the cylinder, as no water is perfectly free from grit; besides the air cannot afterwards be perfectly well dried, and causes trouble by freezing in the exhaust ports of the machines which use it. The Rand system avoids this by circulating cold water around the cylinder through the heads and piston-rod and piston.

Mechanical appliances (drop drills) are mentioned in 1721. In 1840 rotary borers were used in Styria, but none of their experiments hit upon the plan of the present percussion machine rock drill. Attempts were made to construct a "full area" machine, *i. e.*, to cut out the full area of tunnel. Such machines were tried in Mont Cenis and Hoosac Tunnels, resulting in failure. The Beaumont circular-cutter is of this class and works quite successfully in chalk and such soft material, but it is not applicable to harder ground. Europeans vaguely claim the credit of originating the percussion machine rock drill; but to an American, J. J. Couch, unquestionably belongs the honor of first inventing such a machine, patented March 27, 1849. In his machine the drill-steel passed through the piston, being alternately caught and released and projected against the rock. The mounting was a primitive carriage. Couch and others improved on his first drill, embodying these improvements in machines which were tried in Hoosac Tunnel without success. Other machines were from time to time tested in this Tunnel. Among them Fowle's, whose patents were eventually purchased by Charles Burleigh, and out of which grew the Burleigh rock drill, which was finally adopted, November, 1866, for the Hoosac Tunnel, where it was used to the completion of that work. This was the first successful application of the machine rock drill in America. The Sommeiller machine was introduced in the Mont Cenis Tunnel in 1861. The work done by these two machines is stated among the data on these tunnels given further on, and is of interest for purpose of comparison with hand-labor and work done by the perfected drills of to-day.

Hoosac Tunnel.

This tunnel, 24,416 feet long, 24 feet wide, 20 feet high, driven through mica, schists, gneiss, conglomerate and granitic gneiss, was begun in 1854, and had been excavated but 4,250 feet when the State of Massachusetts assumed control and resumed work in October, 1863. Tunnel completed in 1876. Best average monthly progress during 1871, was 24 feet by 7 feet, heading, 145 feet. Greatest single month's progress, 167 feet. Best month's progress by hand-labor, 40 feet. Cubic yards rock removed about 361,500. Total cost of tunnel, $10,000,000. Cost per cubic yard, about $27.

The Sommeiller drill commenced its work in the Hoosac Tunnel, in Jan. 1861; seventy-five 3-ft. holes were drilled in the face of a bottom heading, 9 feet 6 inches wide, 8 feet 6 inches high, which was afterward enlarged to full tunnel section. 1,046,403 cubic yards of rock were removed. A progress three times greater than by hand-labor was attained, but owing to the crude and imperfect machines and inexperienced operators, the cost was two and a half times greater. In 1885 similar work is done with perfected machinery and experienced men, 33 per cent. cheaper and 75 per cent. faster than by hand-labor. The average daily progress by hand-labor was 18 inches. Using machine drills $4\frac{1}{10}$ feet. The cost per running foot, $356. Total cost of tunnel, $15,000,000. Cost per cubic yard, about $15. Total length, 40,137 feet. Cost per inch, machine drilling, 4 cents. Cost hand-drilling, $9\frac{1}{4}$ cents per inch. Machinery used, Burleigh drills mounted on tunnel-carriages. Air was furnished by a battery of Burleigh compressors.

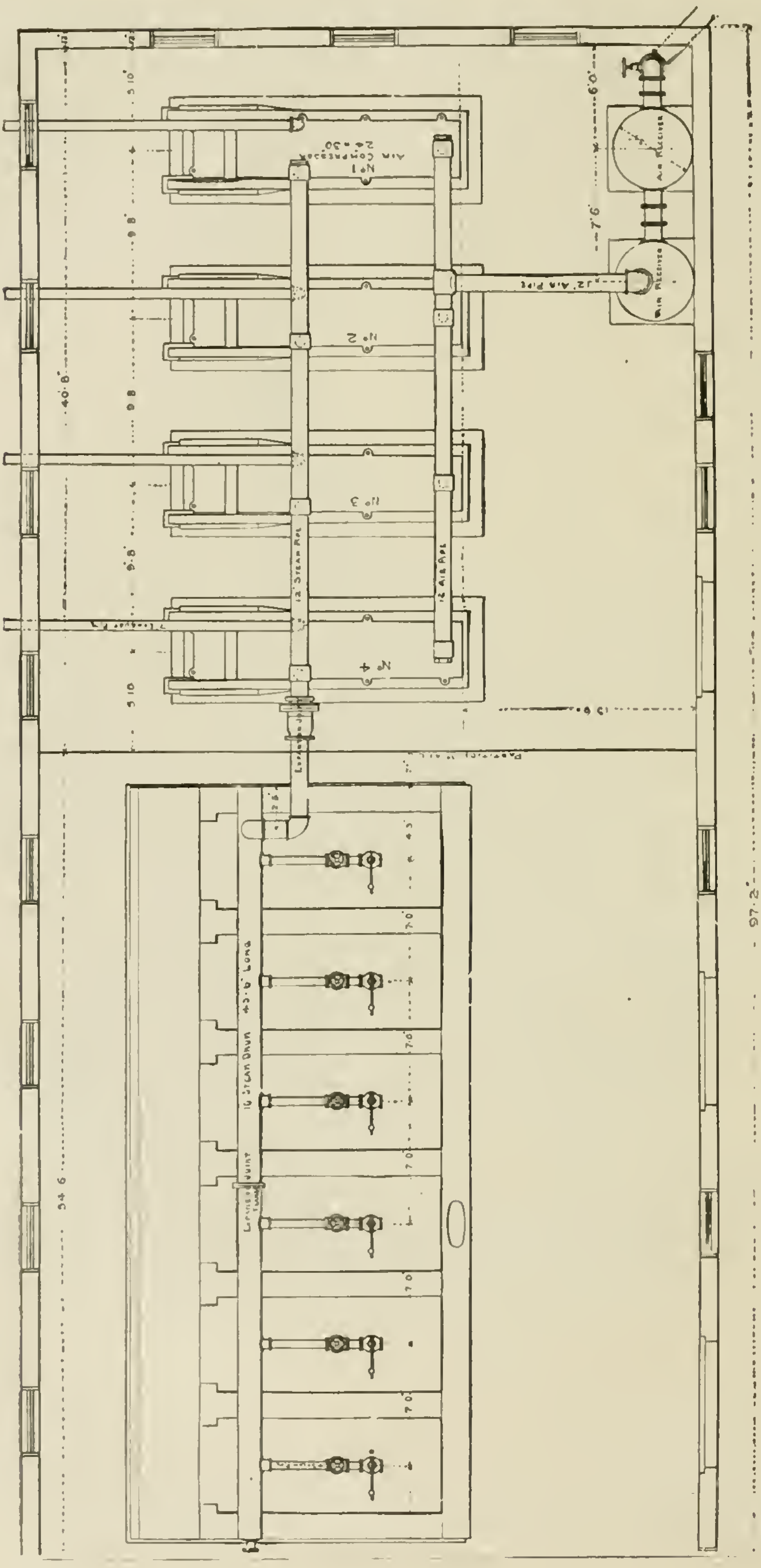
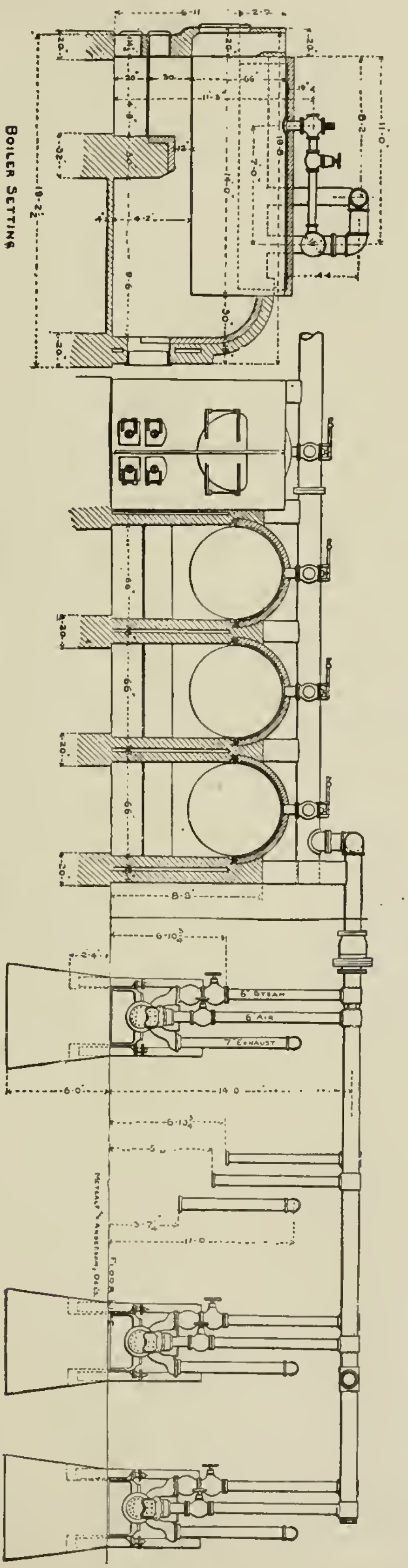


Fig. 7.—Air Compressor Plant at Washington, D. C., Aqueduct Tunnel. Ground Plan.



Washington, D. C., Aqueduct Tunnel Plant.—Side Elevation.

Nesquehoning Tunnel.

This very remarkable tunnel, 3800 feet long, 16 feet wide, 19 feet high, built through coal, sandstone and conglomerate, was begun in March, 1870, and finished in September, 1871. Drilling was done principally by machine drills, the Burleigh being employed; the blasting with black powder. Average monthly progress, 105 feet. Material excavated, 44,852 cubic yards. Cost per cubic yard, $6.86. Length of holes drilled per cubic yard, 5¼ feet. Powder consumed per cubic yard, 3½ lbs. Drill-steel consumed, ¼ lbs. Oil and lighting, 11 cents. Cost per foot, machine-drilling, including every expense for plant, repairs, steel, running, etc., 14$\frac{1}{10}$ cents. Cost of hand-drilling, about 57⅖ cents. Cost of machine-drilling per cubic yard, 75⅕ cents. Cost of hand-drilling per cubic yard, about $2.96⅖. Experience here proved that a greater length of hole and more powder was required per cubic yard by hand-drilling than by machine-drilling. This was the last tunnel of importance in the United States driven with black powder.

Sutro Tunnel.

This mining tunnel is about 40,489 feet long, 12 feet wide, 10 feet high, and runs through syenite, porphyry, etc. Preliminary work was begun October, 1869, but active work was commenced December, 1871, at which date 2600 feet had been driven. Tunnel was completed September, 1878; dynamite was introduced during 1870; machine drills, mounted (6 on a carriage) were used in 1874. The center cut and squaring up system was followed. Depth of cut 7 feet; 6 inches; distances between collar of cut holes 4 to 5 feet; 97 inches of 2½-inch diameter holes drilled per cubic yard of rock. In 1874 Burleigh drills were introduced and used until 1876, when, after a thorough practical test of the Ingersoll drill 16 of them (5-inch) cylinder) were substituted to do the work previously done with 22 Burleigh machines. Following is the record of one hour's drilling during regular work, (not during a test) with these two machine drills of equal size, in a medium hard porphyry, diameter of holes 2½ inches.

Burleigh averaged 6.10′.	Ingersoll 9.93′.
Burleigh maximum, 11,10′.	Ingersoll 18.70′.
Burleigh maximum, 3.34′.	Ingersoll 3.50′.

Highest single month's progress	360′
Highest average monthly progress for one year	310′
Highest average monthly progress for one year hand-drilling,	105′
Highest cost per lineal foot for driving heading, not including timbering,	$31.33
Highest cost compressed air per lineal foot,	$17.20
Lowest cost per lineal foot of heading,	$17.90
Lowest cost compressed air per lineal foot, heading,	$7.63

Mr. Sutro states that a tunnel 8′×10′ or larger can be driven 33 per cent cheaper and the progress tripled by machine as compared with hand-drilling.

The air was furnishrd by the Burleigh, combined with Belgian and German compressors.

Musconetcong Tunnel.

This tunnel on the Lehigh Valley, Railroad, N. J., was commenced in 1872. It has a length of 4961 ft., is 21 feet high, and 26 feet wide. It traverses 700 feet soft ground, 460 feet limestone, the balance syenite harder and tougher than elsewhere encountered in the Eastern States. It is worked on the center cut system, with top heading and bench. As this system has since been followed in all American tunnels it is unnecessary to specify the system in connection with tunnels hereinafter mentioned. The details of work on this tunnel are fully described in Drinker's work on tunneling, and only general data will be given. On account of a heavy earth cut on the West End, a slope 267 feet was sunk to grade. In November, 1872, grade was reached and top headings 8′×26′

were started east and west by hand-labor. The Ingersoll drill was introduced early in February 1873. Some 300' from the bottom of slope the heading ran into decomposed rock through which water forced itself in such quantity as to entirely fill the tunnel and raised 180 feet in the slope, undermining the props and destroying the slope, making the sinking of a shaft necessary. Headings were driven in both directions from the shaft, to tap and drain the water from the former workings. Almost insurmountable difficulties were encountered on account of the water until May, 1874, when all the workings were finally drained and regular work fairly started. Two carriages, one on either side of the center, carried six 5" Ingersoll drills. The center cut was made by drilling 12 (10-ft.) holes, 9' between collars. These with 24 side or squaring up holes, made the total of 36 holes, aggregating 408 feet, drilled for ten lineal feet advance. 25 lbs., No. 1 and 245 lbs., No. 2 Giant powder were used in these holes. Six feet of

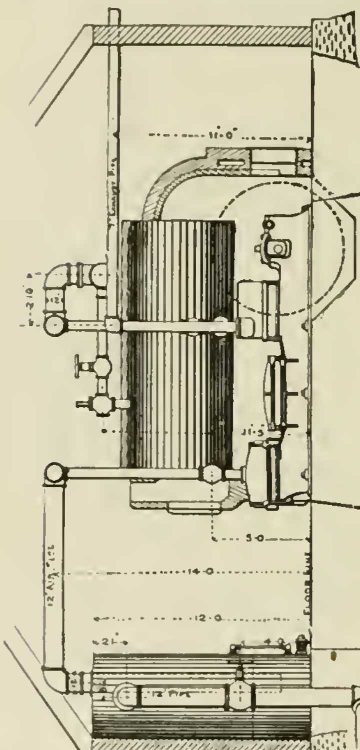


Fig. 9.—Washington, D. C., Aqueduct Tunnel Plant—End Elevation.

holes were drilled per cubic yard and 4⅝-pounds of Giant powder used. The bench was taken up by drilling top and lifting holes. For each 9 lineal feet advance on bench, 10 holes aggregating 112 feet were drilled and blasted by 107 lbs., of No. 2 dynamite, equaling about 1½ lbs dynamite and nearly 1$\frac{7}{10}$ feet of holes per cubic yard of rock. Average consumption of dynamite per cubic yard (heading and bench) 1.71 lbs. Best month's progress, hand-drilling, 50 feet. Best month's progress by machine-drilling 130 feet. Best monthly average for one year 116 feet. Machinery used 26. (5") Ingersoll drills. 4 Burleigh and 4 Rand and Waring compressors, supplied with steam by nine boilers of 400 H. P., supplied the air. Air was conducted 3,000 feet through 6-inch iron pipe with a loss in pressure of about 2½ lbs., per square inch.

The introduction of the Ingersoll drill in this tunnel, antedated its adoption in Sutro, therefore this was the first important tunnel in which the Ingersoll drill was used. This drill, represented in Fig. 6, is run either by steam or by compressed air, as circumstances require. It is so arranged that it can be shifted from one style of mounting to another at will. Drills of the same size and pattern are duplicates of each other, and *parts are interchangeable.* The valve permits a *variable* stroke of from 1 to 7 inches. Both *cylinder heads in the drill are protected on the inside by elastic cushions*, which receive the blow of the piston when the bit suddenly cuts into an open seam or hole, and allows the piston to make full stroke with safety. The valve which admits the steam or compressed air into the cylinder to move the piston is *itself moved* back and forth *by the steam or air used in the drills.* A perfect valve is *the essential point* in any rock drill, and to this simple steam thrown valve, is due the great efficiency and durability of the "Eclipse" drill. In most drills, termed "tappet drills," the valve is moved by a blow from a piece of steel or tappet, which is struck by the piston twice every stroke. It is evident that so many small pieces of metal striking together from three to five hundred times a minute, must wear and break rapidly. This is the weak point in the tappet drill which cannot be overcome. In this drill *the valve permits a variable stroke* of from one to seven inches; tappet drills require full stroke in order to trip the valve, unless aided by auxiliary valves or other complicated and delicate arrangements. The bits are forged on the ends of steel bars of different lengths, and are usually in the form of an ×, the diameter on each additional length decreasing slightly to conform to the wear on the shoulders of the preceding bit. On the opposite end a head is turned or forged to fit into the drill-chuck. In very loose, seamy rock a Z-shaped bits is sometimes used to advantage. With simple smith's tools any blacksmith can dress and in a short time, make the bits. *Much depends upon their being properly dressed and tempered*, and their form and manner of cutting secures a greater saving as compared with hand-drilling where both ends are worn away rapidly.

Mont Cenis Tunnel.

This most remarkable feat of Engineering connects the railways of France and Italy, and is on the direct railway route from Paris to Turin. The length of this tunnel is 7 miles 4¾ furlongs. It is 434 feet higher at Bardonnèche, on the Italian side, than at Modane on the French side. On this account, it is on a gradient of 1 in 45⅓ from Modane to the middle, and thence it falls 1 in 2,000 to Bardonnèche, this latter fall being sufficient to run off the water. The dimensions at Modane are 25 feet 3½ inches wide at base, 26 feet 2¾ inches at widest part, and 24 feet 7 inches, high, the arch being nearly semi-circular. At Bardonnèche it is 11¾ inches higher. It is all lined with stone masonry, except at the Bardonnèche end, where the arch is of brick. The work was begun in 1857, and was at first done in the usual way by hand; but in 1861 the perforating machines above described were introduced on the Italian side, and two years later on the French side. On June 30, 1863, the tunnel had been driven 5,800 yards, and the rate of advancement was 9½ feet per day. All the efforts of the engineers to accelerate the work were for several years unavailing; and in October, 1866, just one-half the distance, or 6,680 yards, had been pierced, showing the same constant rate of 9½ feet per day. At this rate, the tunnel would not have been completed till 1872. Owing however, to improved modes of working, and to a favorable change in the nature of the rock, the rate of advancement became greater toward the end and the two parties met on December 25, 1870. The tunnel was formally opened in September, 1871. A premium was to be paid by the French Government to the Italian Government, who did the work, for each year by which a term of 25 years, counting from 1862, was reduced. The French Government were also to pay £1,287,000 for the construction of one-half the tunnel when completed.

This great work, which appeared almost imprac-

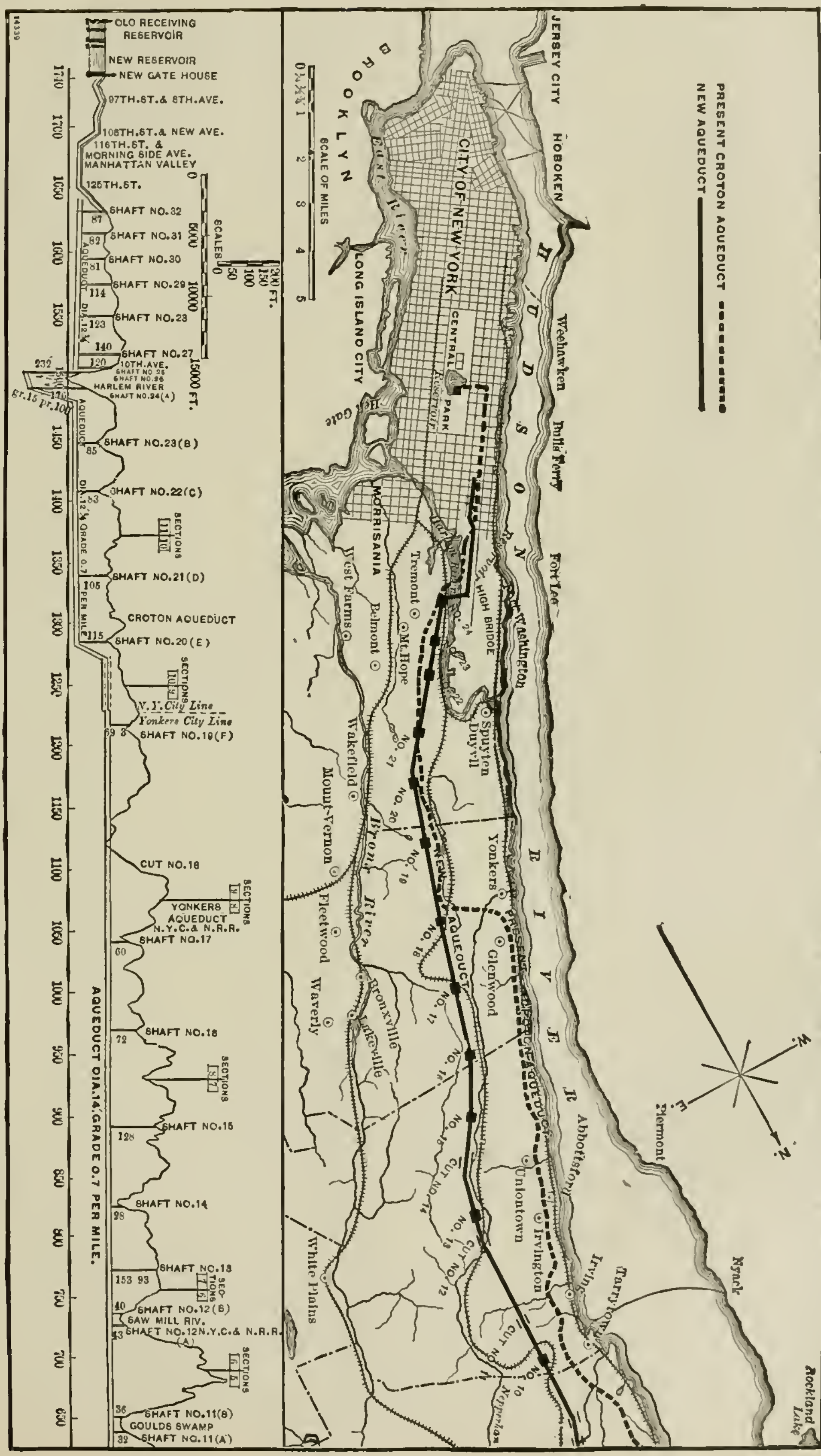


Fig. 10.—Map and Profile of the New Aqueduct, for increasing the Water Supply of New York City.

ticable to ordinary methods of tunneling by manual labor, was rendered practicable by machinery introduced by the engineers, Messrs. Sommeiller, Grandis, and Grattoni. The great difficulty lay in the fact that, from the great height of the mountain, shafts were impracticable, and progress could only be made from each end. The ventilation also presented serious difficulties. M. Sommeiller perfected a small machine, weighing six cwt., which bored a hole 1¼ inches diameter, and 3 feet deep in twenty minutes; the time taken by two miners working by the ordinary method being two hours. Eleven of these machines were placed on a movable support, and were capable of working at almost any angle. Three or four large holes were bored in the center of the heading, and round these other holes of the ordinary size, in all 80 holes. The large holes were not fired, but were for the purpose of weakening the rock. The others were then fired in succession and in detachments, beginning with those nearest the center, and working outward. The machines were worked by compressed air acting, like high-pressure steam, on a piston in a cylinder; this air being compressed outside the tunnel by water-power acting on the hydraulic-ram principle, and also by an air-pump; it was used at a pressure of five atmospheres above the atmospheric pressure, and was conveyed to the workings by a pipe 7⅝ inches diameter. After it had expended itself in working the borers, it escaped into the tunnel, and so ventilated the workings. The advanced heading was the only place where these machines were used; the enlargement of the tunnel to the full size, the building, etc., were all performed by manual labor. In view of the great importance of the Mont Cenis route, and the uncertainty of the time of completion of the tunnel, a locomotive railway was constructed in the meantime over the top of the pass. The rails were laid on the existing road, and ascended the hill in zigzag lines. The steepest gradient was 1 in 12, and on this gradient and down to 1 in 20, a third rail was laid in the center of the way, raised about 9 inches above the other rails. The engines were provided with two pairs of horizontal wheels, which being made to press against the center rail, provided the adhesion necessary for ascending and descending these steep inclines.

Saint Gothard Tunnel.

This tunnel piercing the Alps between Goeschenen and Airolo is 48,952 ft. long and passes through granitic gneiss, mica, schist and hornblende schist. The tunnel was let by contract to Louis Favre in August 1872, and work commenced on both ends in Sept. April 1880 the heading was holed. 2,000 H. P. of water was utilized for driving the turbine-wheels, to which direct acting air compressors (Collsdon system) were attached. The compressors were 30 in number, one half 16½ inches diameter 25½ in. stroke; the balance 17 in. by 18 in. These were set in groups of 3, run by one turbine, delivering air at 105 lbs. pressure. The main pipe-line was 8 inches diameter, diminishing to 4 inches at the face. Tests were made with the Sommeiller and Dubois-Francois machine drills, but finally the Ferroux and McKeon drills were adopted. The drills were mounted on carriages of 6 to 8 drill capacity. The Belgian system of work was adopted, *i. e.* driving a top heading about 8ft. by 10 ft. then enlarging at both sides and excavating down to grade. This system permits of increasing the points of attack in a large tunnel where speed, regardless of cost, is the desideratum. 13 to 18 holes, 3ft. 7 inches deep, were drilled in the face by machines working from three to five hours, according to the nature of rock. Three to four hours were required for charging, blasting and clearing away. If everything worked smoothly four sets of holes were drilled in 24 hours, giving an advance of 13 lineal feet. A single machine drilled 3 ft. 3 in. per hour. Most of the work was contracted to gangs by the running meter. Premiums above the contract price were also paid. The headings in gneiss were contracted per running meter (7.2 square yards) at 230 francs. Upper side enlargement per running meter 4.7 sqr. yards at 340 francs. Bottom enlargement per cubic meter at 30 francs. Total cost per lineal meter of complete tunnel, including everything 450 francs. The plan of subletting the work to the gangs each month, worked very successfully, as the amount of wages the workmen received depended upon their individual exertions. The men were required to complete a certain task within a certain time, but if the task was finished in say one half the fixed time, they not only received full pay and had the balance of the time to themselves, but also shared in the premium earned, if the rate of advance was in excess of the fixed rate. Mr. Sweet, Contractor for the West Point Tunnel (noted further on), found a system of premiums of great benefit. Experience shows that a successful premium system must be paid to the gangs, not to the individual workmen.

Hallet's Point.

Work at Hallet's Point (Hell Gate), N.Y., was commenced in August, 1869. A shaft 105 feet deep, 95 feet diameter was sunk through micaceous gneiss at a cost of $5.75 per cubic yard. 10 diverging tunnels were driven from the bottom of the shaft, ranging in length from 51 feet to 126 feet. These were connected by cross cuts at regular intervals. Preliminary work and idleness, owing to lack of money appropriation, consumed the time till 1874, when active operations were begun and continued till September 1876, when the work was blown up. The total length of tunnels and cross cuts driven was 7425 feet, equaling 47,461 cubic yards, excavated at an average cost of $7.44 per cubic yard, including explosives for final blast. Average cost per cubic yard for dredging, $5.52. Total average cost per cubic yard for removing the reef, $12.96. 6(5-inch) Burleigh drills mounted on single drill-carriages with a post jacking against the roof, drove an average of 235 lineal feet of tunnel per month for 12 months. Average drilling per 8 hour shift, 30 feet of holes. Average cost per foot of hole drilled, 36½ cents. Cost per foot hand-drilling, 95 cents. Dynamite exploded per cubic yard, 0.975 lbs. Total amount of explosives used in the final blast, 49,915 lbs. General John Newton, Chief of Engineers U. S. Army, deserves great credit for the conception, carrying on, and successful completion of this work in an unexplored field of engineering. It was the first attempt at exploding large quantities of dynamite by simultaneous firing, and resulted in perfect success. For a description of the unparalleled feat of tunneling and blasting at Flood Rock, near Hallet's Point, see *Submarine-blasting*.

During the construction of the tunnel under Forty-second street from Third avenue to the East River in New York City, an invention was made by the Manufacturing Superintendent of the Rand Drill Co., that has changed the whole system of tunnel working in the United States. Previous to this, tunnel work had been carried on by drills mounted upon heavy carriages, except in mines where a few small drills had been used mounted directly upon the side of a column having a jack-screw in one end, by means of which the column was kept in a vertical position. This required the removal of the whole column several times in drilling the heading of even a small tunnel. There was much difficulty in adjusting the drill after a change of the steel, and in keeping the jack-screw from getting loose from the continual jar. The new device of resting a column upon a foot having a jack-screw at each end, so arranged that a vertical plane passes through the axes of both screws and column, provided the necessary breadth of base to give stability to the column and permit the mounting of a swinging-arm upon the column on which to place the drill. This in turn permitted the drill being used upon all sides of the column for drilling hori-

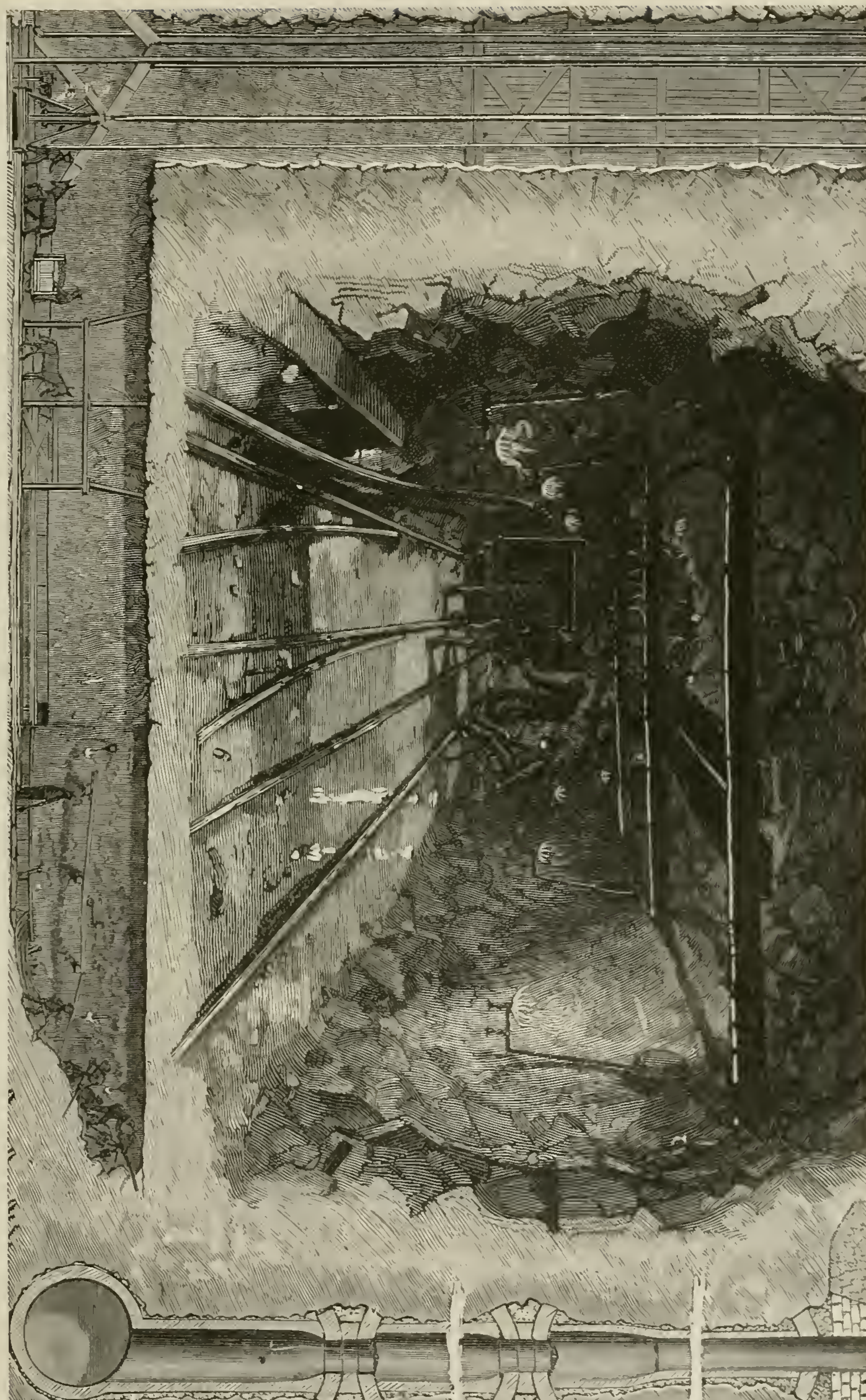


Fig. 11.—Work at the New Croton Aqueduct Tunnel. North Heading at Shaft No. 11.

zontal or vertical holes in the tunnel. Bars passed through the top of the jack-screws and one side of the column prevented them from turning. Before the use of this invention the débris of broken rock in the faces of a tunnel had to be removed after a blast to admit of a track being laid on which to bring the carriage up to the face; but by its use, now, large or small drills are set at work immediately after a blast by carrying the drill and column separately over the débris. This column was soon after adopted at Hell Gate and the famous Calumet and Hecla copper mine in Michigan, where miles of tunnel have been driven with it. The first very large railroad tunnel driven by its use was at Haverstraw, N. Y., prior to the West Point tunnel, in which it was also introduced. Then followed its use in the double-track tunnel through the very hard trap rock at Weehawken.

Another invention of a very great importance at about the same period, has had a marked effect in increasing the utility of the rock drill. At this time the chuck (which holds the steel) most generally in use has been made by clamping pieces projecting through the sides of the piston-rod, near its end. The new chuck has an enlarged end on the piston-rod; a key projects through a slot in the rod on to the shank of the drill-steel and is held in place by a U bolt; thus sufficient elasticity is obtained to absorb the shock of the blow and prevent the enormous breakage consequent upon the use of the old style of chuck. It is safe to say that if the rights of the inventors and owners of the patent were respected, and no substitute found, hardly a drill of any other kind would be used, especially in all hard rock. A third important improvement introduced at a later date, and now in common use, is a rotating-device, by means of which the piston is caused to rotate and so keep the steel turning around. The object of this improvement was to make the rotating-bar stronger, and to avoid the inconvenience then existing when a removal of the bar was necessary. The Rand and Ingersoll drills have substantially the same rotating devices—solid chucks and columns—the difference being in the steam distributing valves, and the blow struck, in the lower head and cushioning devices. At the present time the Ingersoll drill uses a split lower head and the Rand a solid head. The Rand drill cushions or takes up a blow struck at the head by rubber buffers outside the machine; the blow being transmitted by rods in tension; the Ingersoll drill cushions on the inside: both have patents for their method of cushioning and for their valves.

West Point Tunnel.

The West Point Tunnel, on the West Shore Railway, was commenced in 1880 and completed in 1883. It pierces the granitic rock, forming the point on which the Military Academy is located. The line runs directly under the parade ground, coming out on the north, directly opposite Target Hill. The south portal enters the cliff below and east of the road leading from the dock up to the plateau. Columns were used in this tunnel to support the drills. The drills rest on a swinging-arm attached to the post, commanding a large area of face without moving the post. With this method each machine, being independent, can be kept constantly at work, and the full area of tunnel is left clear for removing the débris. The work was started with Rand machinery, consisting of fifteen $\frac{3}{4}$ and $\frac{5}{8}$-inch drills and one Duplex $16\frac{1}{2}$ inch by 32-inch compressor, located at the north portal; the air being carried overground to the south face, through 3 inch wrought-iron pipe. The center cut-top (full area) heading and bench system was employed, the bench being kept about 30 feet behind the heading, at which distance it was found that the heading rock was blown clear over the bench, into the bottom of the tunnel with the bench rock. Then the large pieces were lifted into the rock cars by means of a pneumatic hoist and crane and carried to the dump without having to be broken up. This apparatus consisted of a double 8×10 inch cylinder link-motion engine mounted on a low car, to which a wrought-iron mast was attached; on the upper end of that was a cylinder in which worked the plunger that was forced and held against the roof by air-pressure. Attached to the mast was a swinging-boom of a length equal to one half the width of the tunnel. This apparatus stood on a track between the two rock car tracks. This crane is of great advantage in large tunnels in which the rock breaks large. 20 to 23 holes, 8 to 11 feet deep, were drilled in the heading, and 6 to 8 feet lifting and vertical holes in the bench. Nitro-glycerine was tested and found to be more expensive than dynamite. Close data on the work was kept by the Contractor, which, for certain reasons, he does not choose to make public. This is to be re-

Fig. 12.—New Croton Aqueduct. Pocantico Cut.

gretted, as full details of the work would be of special interest to many readers of this Encyclopedia who spent their early days at this historic spot.

Arlberg Tunnel.

This tunnel in the Province of Tyrol, Austria, is 33,650 feet long, 21 feet high, 23 feet wide, and running through micaceous shales, quartz, gneiss and mica. Work commenced June, 1880; headings met November, 1883. It was driven at both ends simultaneously, worked by bottom headers, up-raisers, top headers and enlargements in sections, varying from 20 to 28 feet in length according to the nature of the ground. The bottom heading 9 feet wide, 8 feet 21 inches high was driven on grade with a subdrain below. This heading was kept in advance of all other work, and every 100 feet an upraise was made to the roof of the top heading where faces were driven both ways, making it possible to almost indefinitely increase the number of working faces in the top headings. 3 to 4 upraises were worked simultaneously. The top heading was 6 feet 6 inches wide by 8 feet 2 inches high. It followed the face of the bottom heading at a distance of 320 feet and was driven entirely by hand-labor, as the great number of faces made it possible to keep pace with the bottom heading driven by machine drills. Everything was made subservient to the bottom heading as upon its rapid advance depended the progress of the entire work. The enlargement and arching was done on the English system. From June to November, 1880, hand-drilling was employed.

Total length of bottom heading driven in that time	677.	feet.
Average progress per 24 hours,	4.7	"
Total length of top heading in same time,	623.	"
Average per 24 hours,	4.25	"

In the East End the Ferroux and Seguin percussion drills run by compressed air were introduced, while in the West End, the Brandt hydraulic rotary machine drill run by water-power under high pressure, forced into the headings by pumps operated by turbines.

The Brandt drill differs from all purcussion or rotary machines in that a constant high hydraulic pressure-presses the cylindrical steel drill-bit against the rock with sufficient force to crush the latter. The crushing strength of hardened steel is greater than that of the hardest rock, therefore the point of the bit must penetrate the rock when sufficient pressure is applied. In order that the points shall exert pressure on new surfaces they are slowly rotated, thus crushing and breaking, but not pulverizing the rock. High pressure and slow rotary motion form the principles of the Brandt-drill. The rotary motion is effected by two hydraulic-engines, $2\frac{7}{16}$ inches in diameter, $2\frac{1}{4}$ inches stroke, and making 120 revolutions per minute. Diameter of drill-cylinder $5\frac{1}{2}$ inches, consuming 4,680 gallons of water per minute. The effective pressure upon the cylinder with a water-pressure of 1,465 lbs. per square inch, equals 26,850 pounds, making proper deductions for losses. Weight of machine, 550 pounds. Weight of hydraulic column, on which drills are mounted, 660 pounds. These weights are too great for quick handling and the constant flow of water causes discomfort and inconvenience to the machine men. Where a high pressure can be obtained from a natural head of water this machine has proved advantageous, effective and economical in repairs and power required. The West heading was driven with 2 to 4 Brandt drills at the average progress of 11.30 feet per 24 hours, for 227 days. This rate of progress was later increased to 17.25 and 20.7 feet, per 24 hours. The East heading driven with 6 percussion drills averaged an advance of 13.49 feet per 24 hours for 401 days. The rate of progress was lately increased to 18 and 20.3 feet per 24 hours. The feet of holes drilled in a given time by the percussion and hydraulic machines were the same, though the rock in the East heading was much harder than in the West, making necessary the drilling of more feet of holes and the use of more dynamite per cubic yard. The average progress per 24 hours in the East heading, machine-drilling, from

November, 1880, to August, 1883.	15.82	feet.
The same in West Heading,	13.32	"
Daily average both headings,	29.14	"

The work was contracted for at the following prices: *i. e.*, the price for one running meter in the first kilometer from each month is taken as the basis. For each following kilometer a certain price is added to the price of the preceding kilometer.

Bottom heading, first kilometer...	$22.90	per lineal ft.
Addition for each following kil...	1.53	" " "
Top heading, first kil................	15.25	" " "
Additional for each following kil..	0.76	" " "
Enlargement from $61.10 to.......	259.18	" " "

Sub-drain 2.62 ft. deep 1.97, 2.62, and 3.28 ft. wide, per running foot, $2.44, $3.10, and $3.65 respectively.

Cost per running foot of heading as follows:

Proportionate cost of plant........................	$10.30
Machine-drilling and ventilation................	9.62
Blasting, timbering, and removing debris...	12.90
Total cost per running foot..................	$32.82
Cost per running foot of completed tunnel.......................................	201.00
Total cost of completed tunne.....	$5,024,865.00
Total excavation in cubic yards...	1,027,320.00

Factoryville Tunnel.

This tunnel on the Delaware, Lackawanna and Western Railroad is 200 feet long, 16 feet wide, 21 feet high, and runs through a hard grey and red sandstone. Work was carried on simultaneously from both ends. Machinery used, 6 (3-in.) Ingersoll drills, two in each heading and one on each bench. Drills supplied with air by one 16 in. × 24 in. Ingersoll "Straight Line" air compressor, air pressure 70 to 80 pounds to the square inch. Tunnel driven on the American system; *i. e.*, center cut with heading and bench. Heading 16 feet wide, 7 feet high. The breast holes were drilled 10 feet in depth. The average feet of holes drilled by each machine per 22 hours, 100 feet. Tunnel began December 26th, 1882, completed May 26th, 1883. Average monthly progress of tunnel 440 feet. The highest monthly progress was made in April, 1883, during which month the north heading was driven 262 feet, the south heading 241 feet, or a total of 503 feet. The explosive used, in this tunnel, was rackarock, manufactured by the Rendrock Powder Company, New York.

Vosburgh Tunnel.

This tunnel on the Lehigh Valley Railroad, was started in June, 1883. Total length of tunnel 3,865 feet through grey and red sandstone. Dimensions 21 ft. × 27 ft. driven on the American system with center cut, bench, and heading. (The latter 8 ft. × 20 ft., being driven through regardless of the bench). Headings began June 19th, 1883, completed July, 1884. Machinery used on East end, 4 (3-in.) and 1 (8-in.) Ingersoll drills operated by the 16 in. × 24 in. "Straight Line" Ingersoll compressor. On the West end, power was supplied by a duplex 10 in. × 16 in. Rand compressor running 4 (3-in.) and 1 (8-in.) Rand drils. Explosives used, rackarock and dynamite. The work was started by hand-drilling.

Moshannin Tunnel.

This tunnel on the South Western Railway is 1,240 feet long, 16 feet wide, 21 feet high, and runs through hard sandstone. It was driven by the American system with center cut, heading, and bench. Tunnel driven from both ends simultaneously. Machinery employed 6 (3-in.) and 1 (8-in.) Ingersoll drills, two

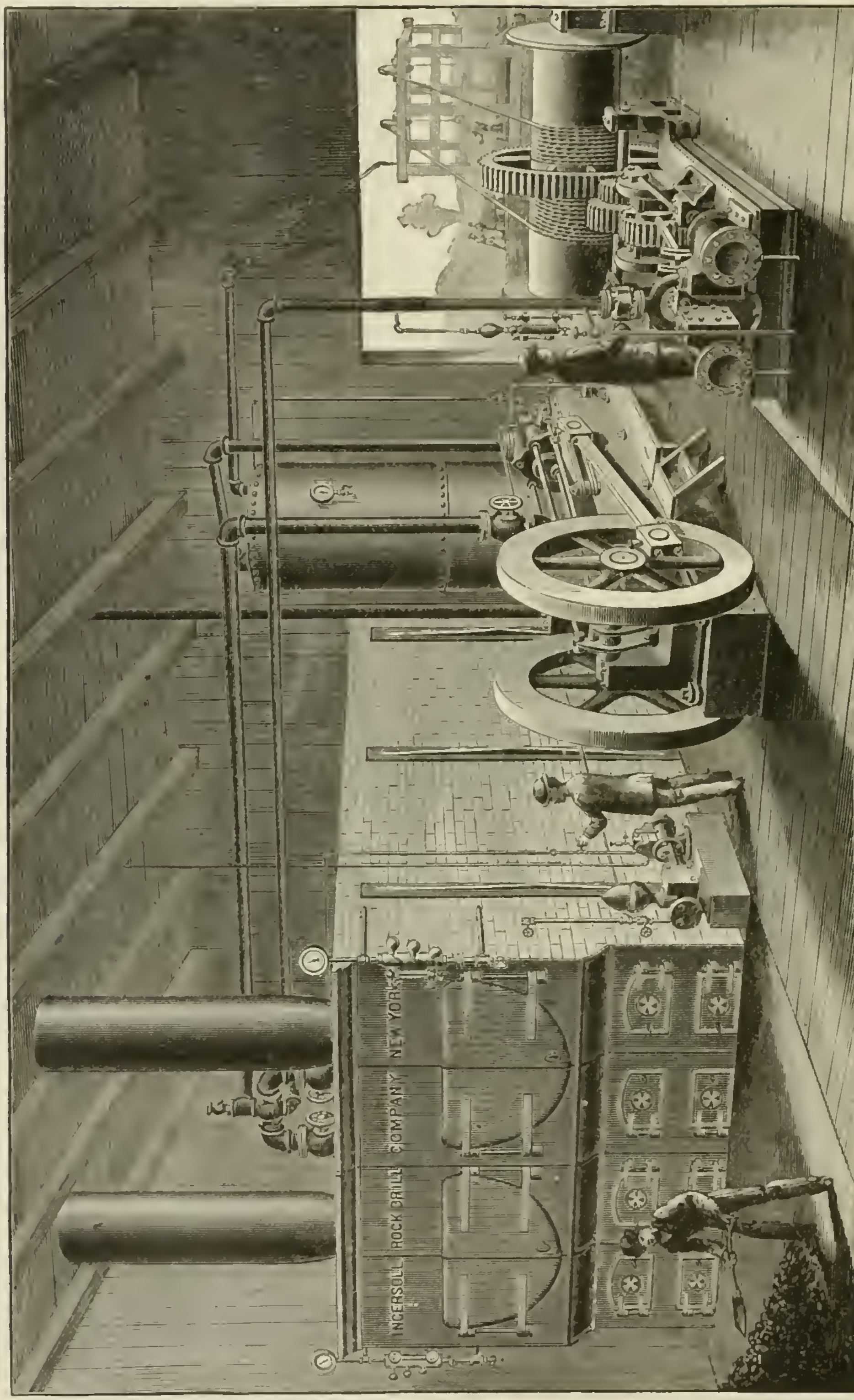


Fig. 13.—Plant Employed at Croton Aqueduct.

on columns in each heading and one on a tripod in each bench. These were supplied with air by one 16-inch × 24-inch "Straight Line" Ingersoll compressor. During the month of October, 1883, the two headings, 7 feet × 16 feet, were driven a total distance of 499 lineal feet. During this time fifty (11-hour) shifts were worked. The best week's driving was a total of 119 lineal feet. The tunnel proper was started August 1st, 1883, and finished November 1st, 1883. Monthly average in both headings 413 feet 4 inches. 18 to 21 (9-ft.) holes were drilled in the heading and 3 to 4 (8-ft.) holes in the bench. These holes were loaded with about 175 lbs. of high explosive, which broke about 90 cubic yards of rock, equal to about 2 lbs. explosives per yard of rock, costing,say 25 cents pe lb. Cost of all repairs on the six drills. $1\frac{7}{10}$ cents per cubic yard. The conditions of work, rock, machinery,etc..in this tunnel and the Factoryville tunnel were almost identical and the results obtained were practically the same.

The Washington Aqueduct Tunnel And Its Plant.

The water situation in Washington is a somewhat peculiar one. The source of supply is unlimited and the existing mains could bring to the city twice the quantity at present consumed; but the loss of head due to such a forcing process would almost entirely deprive the residents of the higher levels of a water supply; and of late years the growth of the city has been very largely upon the high-lying ground. It is to remedy this defect that the present works are being constructed. The scheme originated with Captain Robert L. Hoxie, United States Engineer Corps, who completed the plans and inaugurated actual work in December, 1883, under the direction of Major G. J. Lydecker, U. S. Corps of Engineers. A change of station soon placed Captain Symons in charge. Under his direction the work has progressed systematically and satisfactorily. The tunnel runs north-east and south-west, beginning near Howard University(where the new reservoir is being built)and opening into the old distributing reservoir north of Georgetown. The new reservoir will be supplied from the present distributing reservoir, beyond Georgetown, and a 48-inch main will lead the water from the new reservoir into the city distribution. The ground lying between the two basins is elevated and undulating to a degree that makes a tunnel necessary. This tunnel will be about $20,715\frac{8}{10}$ feet long, 11 feet wide and $7\frac{1}{2}$ feet high. It will be driven through hard gneissoid and granitic rock for the entire distance, and from the geological formation little trouble is expected from the water.

Four working shafts are located upon the line. Compressed air has been adopted by the Contractors, Messrs. Beckwith & Quackenbush, as the motive power, not only for drills to be used, but also for all hoisting, pumping and ventilating purposes. The contract requires four drills in a heading, and twenty-eight drills in all. (In practice but 2 to 3 drills are used.)

Under these circumstances it can readily be seen that the power required to run this combined plant was necessarily great, and formed a serious item in the preliminary work. The Ingersoll machinery having been selected by the Contractors, the first point to be settled was whether each shaft should be fitted with a separate plant, or a central station provided to supply the whole four miles of work. This subject was carefully considered by Mr. Pierce, of the Ingersoll Company, and the Contractors and their Consulting Engineer; the hauling of some five hundred tons of coal per month over the steep roads of the region covered. and the amount of skilled labor required by a divided plant was found to outweigh in cost the necessary pipe line of a central plant, and the latter was adopted as the most economical. See accompanying plan, Fig. 7.

The supply of fuel being a guiding consideration, the central plant was located near the mouth of Rock Creek, and directly upon the Chesapeake and Ohio Canal, where coal could be delivered at a minimum cost. A substantial building was here erected to cover the compressing plant about to be described. The power is furnished by six return tubular boilers, each boiler 66 inches in diameter and 14 feet long. These boilers being arranged in one battery, as shown on the plan, have running over the rear ends a steam-drum 16 inches in diameter and 44 feet long, supported upon the brick dividing walls. A 4-inch steam pipe, starting from a nozzle in front of each boiler, each provided with a throttle valve, etc., leads the steam from the boilers into the common steam-drum. This arrangement makes it possible to easily cut off any one or more of the boilers at will.

During the compressing process, the air is kept cool by a spray of water injected into the air-cylinder by a small pump worked from the cross-head, and is discharged in this condition into the air receiver. Two of these receivers are used. The air from the compressors is received by a 12-inch pipe which enters at the top of receiver No. 1, and descends inside to within a short distance of the bottom of the tank ; as there is about two feet of water in each tank, the air is discharged beneath the surface, and must rise through this water before it can pass over, through another 12-inch pipe, to receiver No. 2; it there again discharges under water as before, and, finally, from the top of the second receiver passes into the general supply main.

This rather paradoxical method of passing compressed air through water, for drying it, experience teaches, is the most practical way of depriving it of the vapor that would otherwise give trouble by freezing in the exhaust ports of the machines using it. It is the system in use with the best European compressors, but the Ingersoll Co. is the first, we believe to successfully apply it in this Country. The builders of the "Straight Line" compressors claim that a working air-pressure of 80 lbs per square inch can be maintained by a steam-pressure of 60 lbs., cutting off at $\frac{5}{8}$ stroke, or with an average steam pressure of 46 lbs.

To convey this compressed air to the working faces of the tunnel, a pipe-line, 5 miles long over ground, is required ; and by the time the tunnel is completed, 10 miles of pipe will be in use. This will be the greatest distance compressed air has ever been carried in this Country. The air leaves the second receiver at the Central Station by a 12-inch cast-iron pipe, and passes into a boiler-iron equalizing tank 4 feet long and 20 inches in diameter, about one mile distant. From this tank two 10-inch pipes branch out, one to supply shafts B and A, the other towards shafts C and D. Near shaft B, a 6-inch pipe leads the air to A ; and in like manner another 6-inch pipe passes from the neighborhood of C to D shaft, but experience shows that the liability of a leakage is greater than with wrought-iron pipe, and the latter is recommended. Consult Figs. 7, 8 and 9.

All the overground pipe is cast-iron, bell-jointed and leaded ; the pipe follows, as near as possible the street lines, and is buried beyond the risk of interference or damage. The estimated loss from friction is only 2 per cent., owing to the generous section of the pipe used. In the shafts and the tunnel, 6-inch and 4-inch wrought-iron pipe will be employed. The plant to be operated by this compressed air is as follows : Four Lidgerwood hoisting-engines, double-geared, reversible link-motion, having clutch and safety-brakes ; these engines will handle balanced cages. For the present there will be three Knowles pumps, each with cylinders 10 × 6 × 12 inches, and two pumps with 8 × 6 × 12 inch cylinders. The drill plant will consist of 28 Ingersoll "Eclipse" rock drills, $3\frac{5}{8}$-inch cylinders, of the improved tunnel pattern, with variable stroke, worked on columns. The daily contract progress to be made is 49 lineal feet of completed tunnel. Contract price per cubic yard $8.00

South Penn. Railway Tunnel.

This line was projected to run from Harrisburgh to Pittsburgh through the Allegheny Mountains, as a competitor of the Pennsylvania Railroad. The line selected necessitated the driving of 7 tunnels, enumerated later, aggregating 35,581 feet in length, all of which were 31 feet high and from 27 feet to 30 feet wide, through a material which for the first 500 feet was soft sandstone, changing after that distance into excessively hard sandstone of a very fine grit,which in drilling gave considerable trouble on account of its rapidly wearing down the gauge of the drill-bits. All of these tunnels were driven on the American system of center cut, heading, and bench, with column drills on the headings; the heading rock being wheeled in barrows on to a portable platform and dumped into cars below. The platform spanned the muck pile from the bench. The contract price for tunnel excavation ranged from $3.25 to $4.00 per cubic yard. During a few months the tunnels were driven single track, size 16 feet × 21 feet. This increased the cost per cubic yard about one-third as compared with full double track size. All the tunnels were driven from each end simultaneously. The following shows the rate of progress from Nov. 1st, 1884, to Sept, 12th, 1885, in both faces:—Blue Mountain, 2,089 lineal feet; average monthly progress, 209.86 feet:—Kittantiny, 2,533 lineal ft; average monthly progress, 243.55 ft; Tuscarrora, 2,436 lineal feet; average monthly progress, 234.23 feet; Allegheny, 2,361 lineal feet; average monthly progress, 227.02 ft. Sliding Hill used Rand plant on the East end and Ingersoll on the West. The best week's progress in heading was 74 lineal feet.

Excepting at the East end of Sidling Hill tunnel all of these tunnels were equipped with Ingersoll machinery, consisting of three return tubular boilers, the "Straight Line" compressors from 16-inch × 24-inch to 20-inch × 30-inch cylinders, and 3½-inch and 3¼-inch "Eclipse" drills. At the Kittatiny and Allegheny tunnels one 20-inch × 30-inch compressor furnished air at 66 lbs. pressure for 10 to 11 (3½-inch) drills working in both faces. The air was carried about 5,000 feet through 3-inch pipe, with a loss in pressure of 1½ lbs. The other tunnels were furnished with a plant located near each portal. In the softer material first encountered 3 (¼-inch) machines were sufficiently powerful, but in the hard rock the 3½-inch proved one-third more effective. The same fact has been demonstrated in the New York Aqueduct Tunnel. Therefore it would appear that the 3½-inch machine is best for all tunnel work of magnitude in tunnels 7 feet by 10 feet, or larger. In the headings, 7 feet by 27 feet, 4 machines were used on columns with adjustable arms. Two machines mounted on tripods brought up the bench, generally worked in two lifts. Electric lights were used in Sidling and Rays Hill with satisfactory results. Naptha lamps were also extensively used, and found to be much better than candles or oil lamps.

The New Croton Aqueduct.

For many years the present Croton Aqueduct—the line of which from Croton Dam to the Central Park Reservoir is indicated in part by the heavy dotted line in the accompanying map Fig. 10, has been forced to carry a quantity of water much greater than its builders designed it for, and as a natural consequence it has been so weakened that nothing but the skill and incessant watchfulness exercised by those in charge have prevented it from long ago yielding to the burden thrust upon it. The necessity for quickly providing greater carrying capacity is, therefore, apparent.

It is estimated that, even in years of the greatest drought, the Croton watershed, from whence almost all of the present supply is obtained, can be relied upon to furnish 250,000,000 gallons daily, or 100 gallons per head per day for 2,500,000 people. The building of Quaker Bridge Dam would increase the available area of watershed to 361.82 square miles, and the reservoir thus formed would have a capacity of 32,200,000,000 gallons—water sufficient to cover 9,400 acres, 10 feet deep. The dam will be built of solid masonry, will be 178 feet high above the bed of the river, and since the foundation will have to extend to bedrock—100 feet—the total height for the distance of about 400 feet in the lowest part of the valley will be about 300 feet; the width of the dam at the base will be about 200 feet, and the extreme length 1,300 feet.

The aqueduct now being built has the maximum flowing capacity of 320,000,000 gallons per day from Croton Dam to a point near the New York city boundary line, where it is designed to construct a large distributing reservoir to supply the annexed district; a part of the supply being there diverted, the remaining portion of the aqueduct has a flowing capacity of 250,000,000 gallons per day. The northern portion is 13.6 feet high and 13.6 feet wide; the semicircular arch has a radius of 6.8 feet, the concave sides are on a radius of 20.92 feet, and the invert has a radius of 18.5 feet. Where necessary, the rock walls are evened with concrete, and a masonry lining built 12 inches thick at the sides and arch, and 6 inches thick at the invert; but where the character of the rock justifies it, no masonry is needed. The other part of the aqueduct, about 6½ miles in length, will be circular in section, 12 feet in diameter, and lined with masonry 12 inches thick. Owing to the insufficient elevation of the land, this section will be depressed about 100 feet below the other, as indicated on the profile. The Harlem River is to be crossed by an inverted siphon, the depth below the river being about 200 feet. All the masonry will be of a hand-made, hard burned brick, laid in cement-mortar, one part cement to two parts clean sharp sand.

From Croton Dam to Harlem River the aqueduct is 28¼ miles long, and to Central Park Reservoir 33¼ miles; the length of open cuts—varying from 0 to 40 or 50 feet between the arch and ground surface—north of the Harlem is but about 3,000 feet; all the rest of the line is through solid rock. The method of building the aqueduct is by sinking shafts about one mile and a quarter apart, and working both ways from each. There are 24 shafts north of the Harlem and 8 south of it, varying in depth from 28 to 350 feet. Fig. 11 is an enlarged view of a longitudinal section through shaft No. 10, showing the heading, the timbering in the shaft, etc. Fig. 12 is a view of open cut, No. 8. The shaft is 17½ feet by 8 feet in the clear, with the longer dimension parallel with the axis of the tunnel. In the shaft run two cages, operated by a double-drum Dickson hoisting-engine, on one of which the loaded car is brought to the surface, while on the other an empty car is lowered into the tunnel. Steam for hoisting, pumping, and compressing air is furnished by two 90-horse power Ingersoll return tubular boilers. The Ingersoll "Straight Line" air-compressors and "Eclipse" drills are here used. The air-compressors at shaft 10 have 18×30 inch cylinders, supplying air at 80 pounds pressure per square inch, the air being first discharged into a condensing air receiver, where it is freed from all moisture, and then conducted down the shaft and into the headings through 3 and 3½-inch pipe. Each heading is driven by four 3½-inch drills, mounted two on one column, to which they are attached by means of swinging-arms which can be moved up and down or around the column; thus with two columns and four machines, the entire face is commanded at one setting of the columns. From 19 to 20 holes, 5 to 6 feet deep, are drilled for the center cut and squaring up. Two drills, mounted on tripod, drill from three to five holes 8 feet deep in the bench, some being vertical and others flat or lifting. The holes are then charged with No. 1 Giant powder in the cut and No. 3 in the side and bench, and exploded by electricity.

The foremen are required to have a round of holes drilled and blasted once each shift of ten hours, it being left to their judgement to decide the depth of cut they shall undertake to drill square up, and blast in that time. By this method about 10 lineal feet of tunnel is completed every twenty four hours in each face through very hard gneiss and granite. This is a higher rate of progress than is attainable by the deep-cut system, which does not permit of each shaft finishing its own work. Extending down the shaft is a rough looking square wooden box, which branches at the bottom, one part extending along the tunnel to one heading, and the other part to the other heading. At the bottom of the vertical portion, exhaust steam is admitted from the Cameron pump. This with the assistance of ¼-inch jets through which compressed air is taken from the main air-pipe and discharged into the box at intervals along the tunnel produces a strong current along the branches and up the shaft. The smoke resulting from each blast is thus drawn into the boxes and delivered at the top of the shaft. Where the aqueduct is under pressure special provisions is made in the manholes for guarding against the upward pressure, and drain-pipes are provided for emptying the shaft and air-pipes for the escape of air during the refilling of the tunnel. Fig. 12, is a view of the work as it now appears at the Pocantico cut—the most extensive on the line, as it has a length of about 1,800 feet. The aqueduct here is similar in section to one in rock. It has a clear height of 13.53 feet and an extreme width of 13.6 feet. The arch is 12 inches thick at the crown, 16 inches thick at the center of the sides, and 20 inches thick at the spring lines. The concave sides are 8 inches thick and are secured by walls, as shown in the cut. The invert is 12 inches thick, and rests upon a concrete foundation. In Fig. 13, we have a drawing of the Croton Aqueduct plant.

Sections 2,3,4, and 5 are equipped with the Ingersoll "Eclipse" machine rock drills (3½-inch cylinder), Ingersoll Single "Straight Line" air compressors and return tubular boilers, the Dickson hoisting-engine, and the Cameron steam-pumps. The balance of the work employs miscellaneous appliances consisting of Delamater, Rand compressors, return tubular boilers of various kinds, Dickson, Ridgerwood and Otis hoisting-engines. Sections 1, 6, 7, 8, 9, A, and B use the Rand machinery, Root blowers and exhaust fans, and the Korting ejectors are used for ventilating in portions of the work; the ejector works well when connected with tight pipe of the proper size. Electric lighting is used to a great extent, with very satisfactory results. The Ball Dynamo and lamp has the preference. Special Naphtha lamps are also quite extensively used, and furnish a clear bright light, free from smoke.

In the history of tunneling this work is the one of greatest magnitude. It is carried on under the direction of a Special Commissioner appointed by the State Legislature for the purpose. The work is done by contract awarded at a public letting as follows:

Section 1, Gate House, Smith & Brown Contract	$442,000
Sections 2, 3, 4 and 5, Brown, Howard & Co. Contract	$5,297,155
Sections 6, 7, 8, 9, A & B, O'Brien & Clark Contract	$6,598,387

The itemized contract prices are as follows:

Tunnel excavation in 14-foot diameter cross section, horse-shoe shape, per cubic yard	$6.54
Tunnel excavation in 12-foot diameter, circular shape, per cubic yard	$7 and $7.50
Brick lining masonry, per cubic yard	$10 and $11

The Engineer Corps is composed of the following-named gentlemen: Mr. Benj. S. Church, Chief Engineer; Mr. A. Fteley, Deputy Chief Engineer; Mr. H. S. Craven, Constructing Engineer: Messrs. Chas. S. Gowen, J. B. McIntyre, J. W. Wolbrecht, Alfred Craven, E. S. Gould, F. W. Watkins, and E. Wegman, Jr., Division Engineers. Mr. F. S. Cook is in charge of the Draughting Bureau.

TURBINE.—A form of water-wheel, much used in military establishments, and more especially in powder works. It was invented by Fourneyron in 1823, and in the original form the discharge is outward, the water in the central chamber being directed upon the buckets by curved chutes. At the Ohktenskoi Mills, situated on the Ohkta River, about six miles from St. Petersburg, we find a most useful and satisfactory application of turbines. The river furnishes the greater part of the power required for running the mills, but their number has been from time to time increased until the capacity of the stream has been exceeded, and now horses and steam have to be employed in addition to the water-power. The grounds vary considerably in level, and the communication between the different mills is principally by means of wheelbarrows, very little by boat, and none by railway-trucks. The motive power furnished by the river is well applied. Just below the dam two large iron tubes 200 yards long and 4 feet in diameter, resting upon iron rollers raised on brick piers 6 feet above the surface of the ground, conduct each a stream of water to a series of eight water-wheels placed between a double row of wheel-mills, so that each water-wheel communicates motion to two mills. Some of these water-wheels are overshot, of 12 horse-power, and made of wood; but those most recently put in are of iron and of a peculiar construction. The water enters through a vertical pipe into the interior of the wheel to within about 2 feet of the bottom, and is then discharged from the curved surfaces which form the exterior. It is said to have a co-efficient of .8. The rollers under the iron pipe are for the purpose of enabling it to accommodate itself readily to the changes in its length caused by the expan-

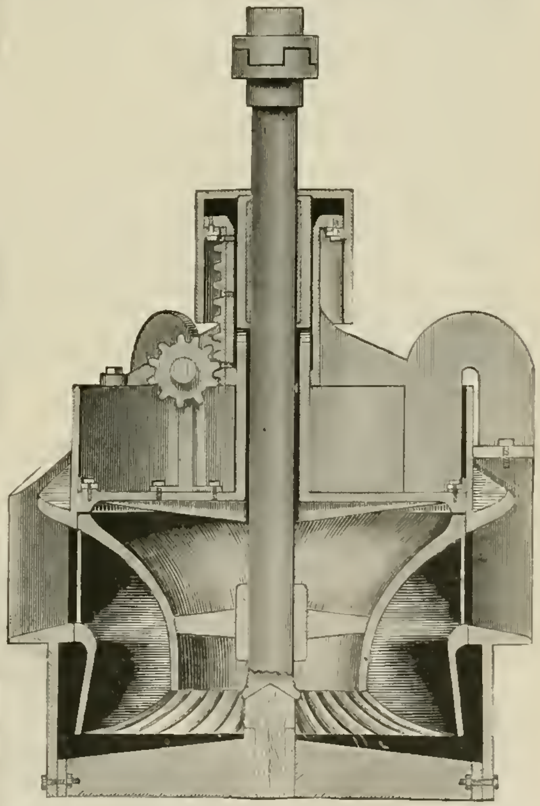


Fig. 1.

sion and contraction due to the variations of temperature to which it is exposed: and this is considerable, between three and four inches. Power for the line of mills is furnished by three turbines. The head of water is 12 feet, and the three wheels, furnishing an aggregate of 1,000 horse-power, can be run separately, or all may be made to act in conjunction on the same shaft. This power is transmitted to the different buildings by means of wire rope running over large pulleys of bronze, the most distant building to which the power is communicated being about one mile from the source.

Numerous turbine water-wheels have been invented and tested from time to time. We will notice the Risdon turbine, in detail, as it is generally conceded to be superior to all others. The table given below shows the comparative percentage of 18 turbines. Fig. 1. represents a section of the wheel and case cut vertically through the center.

The forms of the inner wall of the wheel and curved upper part shows how easy is the change of direction from nearly horizontal on admission to nearly vertical at discharge. The drawing also shows the crown-plate supported by the inverted U-shaped pieces, or goose-necks, as they are commonly called, from the top of some of the fixed guides. These U-shaped pieces are a very important feature: they are all cast fast on the crown-plate in a manner to make them very firm and rigid, and by use of them may be formed a slot or space for the gate to rise up into, and thus may be located the crown-plate just above the wheel and within the cylinder-gate, thus guiding the gate immediately at the wheel, and preventing the gate from bearing against the wheel. Locating the crown-plate inside of the gate, and low down, enables us to attach a ring of leather, or other flexible material, on the plate to bear against the inside of the gate; the pressure of the water keeps this ring always tight against the gate, effectually stopping all leak without friction, being durable, simple, and easy of access if it ever needs renewal. From the center of the crown-plate arises a long hub, inside of which, at the upper end, is formed the bearing for the shaft. The outside of this tub is turned off, and has fitted to it a spider or set of arms. The outer ends of the spider-arms are attached to the top of the cylinder-gate, and through this spider, by means of the rack and pinion, motion is communicated to the gate; the long hub on the crown-plate serving as a guide for the spider to move upon. The gate-stand is fastened to the crown-plate, and makes a very simple, strong, and effective gate arrangement. On the upper end of the spider is a flat disc, fitting within a small cylinder, and moving within the cylinder whenever the gate is moved; this cylinder is open at the bottom, and closed at its upper end, and is fastened securely on the top of the long central hub. This moving disc has a packing-ring on its under side similar to the one on the top of the crown-plate, to prevent leak. From the upper side of this disc all pressure is removed by the passages—shown by heavy dark lines—allowing the water to escape down the central hub. This then forms a very convenient arrangement to counterbalance the weight of the gate when the size of the disc is properly proportioned; for all pressure being removed from the upper side of the disc, and the pressure of the head-water being on the under side, it follows that any amount of upward pressure required can be obtained by varying the size

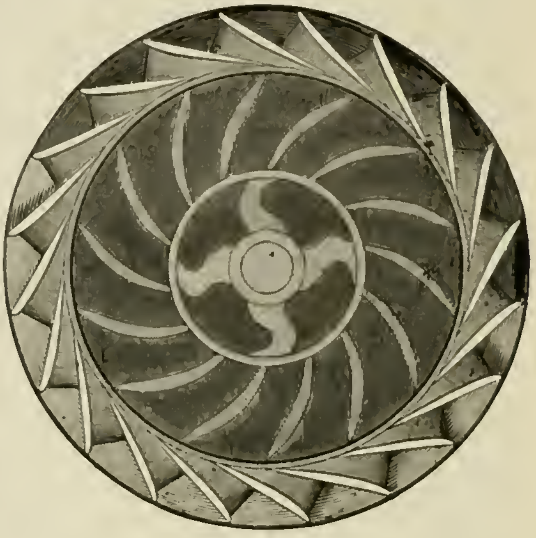


Fig. 2.

of the moving disc. This makes a convenient, simple, and effectual mode of balancing the gate, and allows it to be operated very easily, and with so uniform a resistance that it is very easily controlled by a governor. This is a matter of more importance than many imagine. Where a regular speed is required, and a gate moves harder in one direction than another, a governor is apt to move it too far when moving in the direction that it moves the easier, and then makes too great a change in the speed: or, to use a common expression, "the governor runs by," and thus keeps the speed constantly irregular by attempt-

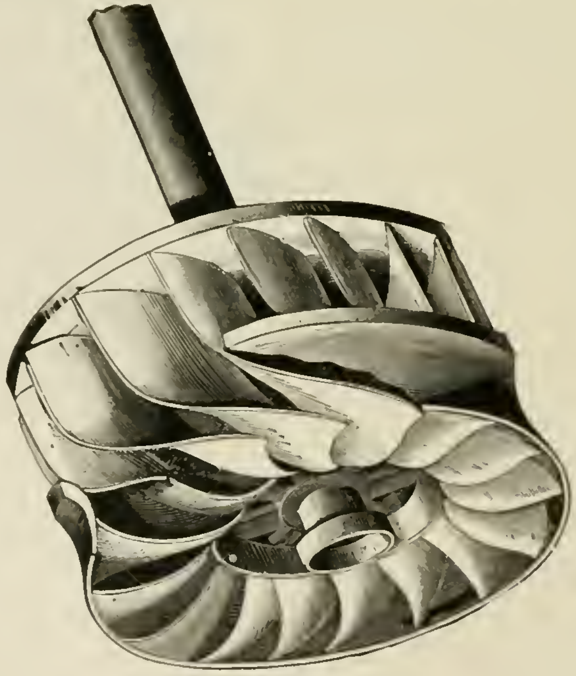


Fig. 3.

ing to correct this inequality. Fig. 1, also shows the position of the gate when fully raised, representing the lower edge of the gate coinciding with the upper part of the water-course through the wheel, showing the projections that are between the guides on the outside of the gate.

The under side of these gate-projections are very important in properly conducting the water to the wheel, a thing which a cylinder-gate without them does not do. It will be observed that the stationary guides make a gradually converging passage on two sides, for the water to approach the wheel through; while the lower guide-rim inclines upwards as it approaches the wheel, making the third side of the water-passage; and the under side of the gate-projections, inclining downwards as they approach the wheel, make the fourth side of the water-passage, thus completing it of a form that has been demonstrated to offer the least resistance to the passage of water through it, as experiments on different forms of gates have fully proved. It is of as much importance to have properly formed water-passages for the water to approach the wheel through as it is to have a properly shaped one for it to traverse through the wheel; in either case, all the force expended in overcoming friction, or shocks from abrupt changes of the direction of velocity, is that much power wasted to be troubled by obstructions, and moving easily, with equal facility either way. The draft-tube at the bottom of the wheel can be of any length required, and supports the wheel in the usual manner by a bridge-tree containing a wood foot.

Fig. 2, represents the wheel proper, with a portion of the lower band removed to show the form of the band and bucket. This wheel is cast in one piece, and, from the form of it, is very strong and not liable to break from obstructions entering it. The band serves the double purpose of strengthing the wheel, and of making the proper form for the passage of the water through the lower part of the wheel, confining it on all sides. The whole construction of the wheel tends to receive the water without shock or resistance. It avoids the downward pressure due to the head by receiving it underneath the curved inclined top, and yet obtains the pressure of the head-water upon the lower part of the bucket, with less friction and consequent loss of effect than most other turbines. Fig. 3, shows the angle of introducing the water into the wheel by the position of the guides on the outside of the wheel. It also shows the form of the upper part of the bucket at the place where the water first enters the wheel. This form has been demonstrated to offer less resistance to the entrance of the water to the wheel than any other, and is the re-

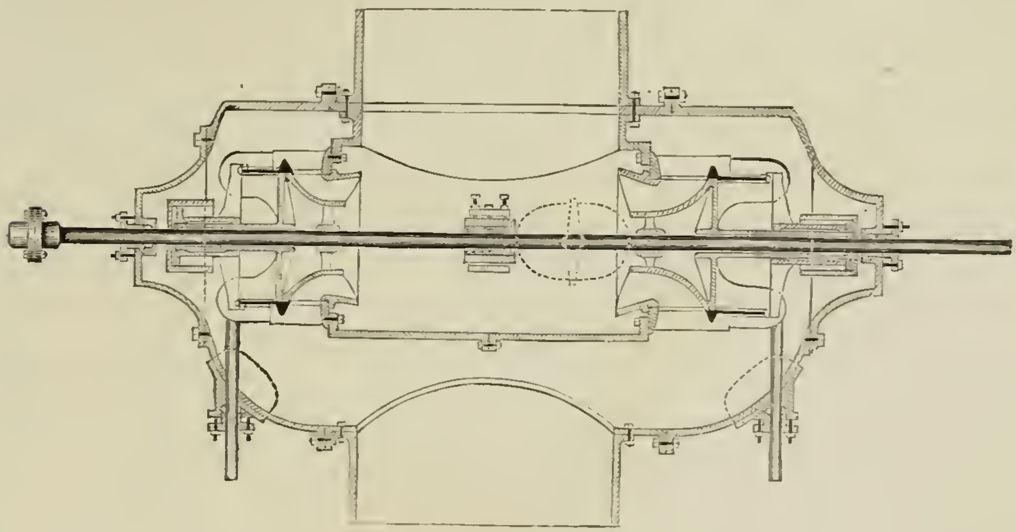


Fig 4.

that can never be restored. Three sides of the water-passage through the guides to the wheel are stationary and unvarying, and as the fourth side is of itself a proper form, and moves vertically to admit the quantity of water desired, it follows that at all stages of the gate we have the form of water-passage that occasions the least possible loss of effect. The lower guide-rim projects inside of the guides towards the wheel, and is bored out to fit the wheel freely. The upper side of this guide-rim inside of the guides is turned off true, and the lower side of the gate, directly above this part of the guide-rim, is also turned off true; when the gate is shut, these two parts come together and make a tight joint. The joint at the upper end of the gate is made as tight as is practicable by turning off the outer edge of the crown-plate to fit the inner surface of the gate, which is bored out; but, in addition to this, can be made perfectly tight by the addition of the flexible ring before described. This form of gate makes a tight gate when closed, and, as it is opened, allows no water to escape except below the gates and into the wheel, where it is intended to go, and into which it is always introduced through a properly formed regular passage. It is also a strong, durable gate, not liable sult of a careful calculation of the velocities of the water and wheel at different points, so that the curve represented by the bucket is a resultant of the different velocities, and is therefore correct in theory, and experiments have proven it also correct in application. The table, page 518, shows the percentage at different stages of gate obtained by various turbines tested at the Centennial Exhibition in 1876.

To adapt the turbines to horizontal shafts, and have them work satisfactorily, has occupied the attention of engineers for many years. It is not thought that mounting in this manner is calculated to give more power, out of the same consumption of water, than would be obtained by mounting them on a vertical shaft in the usual manner, but in many situations decided advantages are afforded. Fig. 4, shows a vertical section of a pair of turbines on a horizontal shaft, discharging into one draft-tube. One wheel is the standard and the other of enlarged capacity. When water is plenty, or a large amount of power is required, both wheels will be used at their full capacity. When less power is required, or there is a scarcity of water, the larger of the two may be used. The minimum of power and water would require the use of the smaller wheel. Any other division of the pow-

MAKER'S NAME. OR NAME THE WHEEL IS KNOWN BY.	Per cent. at full gate or discharge.	Per cent. at about 9-10 of full discharge.	Per cent. at about 7-8 of full discharge.	Per cent. at about 3-4 of full discharge.	Per cent. at about 5-8 of full discharge.	Per cent. at about 1-2 of full discharge.	Per cent. at about 4-10 of full discharge.
Risdon Wheel	87.66		86.33	82.52		75.35	
National Wheel	83.79			70.79			
Geylein Wheel (single)	83.52						
Thomas Tait	82.13			70.40	66.35		55.00
Goldie & McCullough	81.21		71.01	55.90			
Rodney & Hunt Mach. Co.	78.70	71.66		68.60	51.03		
Tyler Wheel	79.59		81.24	79.92	67.23	69.59	
Geylein's (duplex)	77.57				74.74		
Knowlton & Dolan	77.43	74.25			62.75		
E. T. Cope & Son	76.94		69.92				
Barber & Harris	76.16	73.33			70.87	71.71	
York Manufacturing Co.	75.70		67.08	67.57	62.06		
W. F. Mosser & Co	75.15	74.89	71.90	70.52		66.04	
A. N. Wolf	74.89			74.15	65.00	61.82	
O. J. Bollinger	70.46	68.78	65.33		60.29	55.52	
American Turbine	68.59		69.29				60.14
Chase Turbine Co	68.38	67.79		57.52			
J. T. Noye & Son	65.68	65.59		61.80			

er or the water than this would be well met by the wheel at part-gate. These wheels, under test, give such a high duty at part-gate, that, when they are arranged in the manner proposed, they certainly give the highest possible duty out of the water at all stages. In no other way would it be possible to obtain so high a co-efficient of useful effect, under such great variety of conditions of work and water, as in the way described here, by the turbine. See *Hydraulic Power* and *Water-wheels*.

TURCOS.—Native infantry of Algeria, in the pay of the French Government, and who were partly officered by Frenchmen.

TURKISH ARMY. By a law passed in 1869, the military service is compulsory for all Mussulmen of the Empire, and is carried out either by recruiting or by ballot. By subsequent Regulations issued in 1871, but not carried fully into effect, the length of service is of twenty years' duration, viz.: 4 in the Active Army (*Nizam*); 2 in the First Reserve (*Idatyal*); 6 in the Second Reserve (*Redif*), and 8 in the *Landsturm* or Sedentary Troops (*Hiyade*). Turkey has a population of 33 millions of inhabitants (without counting Roumania and Servia), 18 millions of which are Mussulmen. Of these, about 3 millions are nomad tribes not amenable to the conscription; another million is to be deducted for the citizens of Constantinople and other cities who manage to evade it. The remaining 15 millions are composed of Non-Mussulmen—Christians, Jews, etc. —who are not liable to serve in the army by paying a contribution, known as the *bédel*, amounting to about 1s. 2d. per head of population. It leaves, thus, about 12 millions to bear the whole burden of the conscription. The Turkish forces are divided into the Regular Army, Irregular and Auxiliary Troops. By late law the military forces are put down at 700,000 men, the Active Army furnishing 150,000, the First Reserve 70,000, the Second Reserve and the *Landsturm* 420,000, but, owing to the defective manner of calling out the annual contingent, nearly three-eights are wanting to the present Regular Army. The *Regular Army* is divided into 7 corps, comprising 7 regiments of the Guards, 36 regiments of Infantry of the Line, 2 regiments of Bosnians, 1 regiment from the Greek Frontier, another from the Servian Frontier, 3 regiments of riflemen and 2 battalions of Herzegovinians. Each regiment is composed of 4 battalions of 8 companies each. The cavalry is divided into 7 regiments of the Guards, 17 regiments of the Line, besides 1 mounted on camels and 2 independent squadrons. The infantry is for the greater part armed with Snider and Henry-Martini rifles; the cavalry with revolvers and Winchester carbines. The artillery consists of 6 regiments of field-artillery of 12 batteries each (3 horse and 9 field-batteries), and 1 regiment of reserve artillery of 3 batteries. Each battery has 6 guns, giving a total of 450 guns. There are besides 4 regiments of fortress-artillery and 2 regiments of engineers. The guns of the horse-artillery are 4-pdrs.; those of the field-batteries 6-pdrs., all Krupp breech-loaders. The mountain guns are Whitworths. The *Irregular Troops* are composed of 16 regiments of *Gendarmerie*, *Bashi-bazoucks* of volunteers (*Spahis*, *Bedouins*), giving a total of nearly 87,000 men. The *Auxiliary Troops* form the contingents supplied Albania, Bosnia, Egypt, Tunis, and Tripoli. The total military forces of Turkey exclusive of the *Landsturm* and the Guards, were estimated as follows at the end 1875:—

	War footing.	Peace footing.
Infantry	117,360	100,800
Cavalry	22,416	17,280
Field-artillery	7,800	7,800
Fortress-artillery	5,200	5,200
Engineers	1,600	1,600
Detached corps	16,000	16,000
Active army	170,376	148,680
First reserve	105,600	
Second reserve	24,000	
Irregulars	87,000	
Auxiliaries	75,000	
	461,976 men.	

The Commander-in Chief is the Sultan, and his Deputy the Grand vizier. All the branches of military administration are concentrated in the War Office under a General Military Council. Consult the tables on pages 519, 520, and 521.

TURK'S HEAD BRUSH.—A brush made use of in cleaning the bores of guns.

TURMA.—A troop of thirty-two Roman cavalry. There were ten *turmæ* in every legion, and three *decuriæ* in every *turma*. In both the legionary and allied cavalry the turma were formed in 8 files and 4 ranks. An interval the same as its front, was left between each turma. Of the two officers commanding a turma, one was placed on the right, the other on the left of the front rank. In some instances the cavalry was placed as a reserve, in rear of the triarii, and charged when necessary, through the intervals of the manipuli.

TURN BUCKLE.—A form of fastening used for securing the free ends of the implement-chains in a gun-carriage and the cover of the usual ammunition-chest.

TURNING.—1. In tactics, *turning* is a maneuver by which an enemy or position is turned. To execute a turning on the drill ground, being in march,


TURKEY
IN ASIA.
SCALE OF MILES
Railroads
BLACK SEA
TURKEY IN EUROPE
CONSTANTINOPLE
Sea of Marmora
ASIA MINOR
RUSSIA
PERSIA
MEDITERRANEAN
SEA
EGYPT
Cairo
Alexandria
Port Said
Suez
ARABIA PETRÆA
EL HEDJAZ
DAMASCUS
Beyrout
SYRIAN DESERT
Bagdad
PERSIAN GULF
CANDIA OR CRETE
Rhodes
Smyrna

Tabular Statement of the Regular or Nizam Force of the Turkish Army when placed on a War Footing by calling out of the Ichtayat or 1st Reserve Troops.

No. of Corps.	Head-quarters of Corps d'Armée.	Infantry.				Cavalry.			Artillery. Field.						Artillery. Garrison.			Engineers.	
		Battalions.	Men.	Horses.	Mn. Guns.	Squadrons.	Men.	Horses.	Batteries.	Men.	Horses.	Mules.	Guns.	Cos.	Men.	Guns.	Cos.	Men.	
1st	Const'tinople	28	23,828	693	14	37	6,037	6,535	39	6,911	7,548	293	234	144	21,600	500	40	7,480	
2nd	Shumla.	24	20,424	594	12	24	3,860	4,176	14	2,436	2,627	119	84	20	3,000	1,253	2	374	
3rd	Monastir.....	41	34,354	985	16	24	3,860	4,176	17	2,769	2,702	281	102	21	3,150	731	1	187	
4th	Erzeroum....	24	20,424	594	12	24	3,860	4,176	14	2,436	2,627	119	84	24	3,672	574	1	187	
5th	Damascus ...	24	20,424	594	12	24	3,860	4,176	14	2,436	2,627	119	84	3	450	149	1	187	
6th	Bagdad.	20	17,020	495	10	12	1,930	2,088	14	2,436	2,627	119	84	2	300	—	1	187	
7th	Yemmen	20	17,020	495	10	—	—	—	6	911	999	79	36	5	750	204	1	187	
	Total....	181	152,494	4,450	86	145	23,407	25,327	118	20,335	21,757	1,129	708	219	32,922	3,411	47	8,789	

the Instructor commands: 1. *Left* (or *right*) *turn*, 2. MARCH. The first command is given when the squad is three yards from the turning-point. At the command *march*, pronounced the instant the rank is to turn, the man on the left, who becomes the guide, faces to the left in marching, and moves forward in the new direction, without changing the cadence or length of the step. The other men advance the shoulder opposite the guide, take the double time, and advance in the new direction, till they come successively upon the alignment, when they retake the quick time, and dress toward the guide. In turning in double time, the men on the side opposite the guide must increase the gait in order to come into line.

2. An operation applied to all ordnance and usually performed when the piece is being bored, cutting instruments being applied to the exterior of the gun, which is turned down to the proper size. See *Lathe* and *Planing-machine*.

TURNING MOVEMENT.—That movement of an army, or of part of an army, for the purpose of turning or out-flanking one or both wings of the enemy. Since the introduction of arms of precision,this kind of maneuver has been frequently used,as it is impossible, without great slaughter, for an army to approach certain positions under the powerful fire of the new breech-loading rifles and ordnance. Generals prefer to hazard the loss of their communications to the certain losses of the assault. Turning movements,being performed beyond the range of artillery are necessarily very extensive, and their general use is not so much to attack the enemysflank as to draw him from a position impregnable in front, by threatening his weak side or his rear.

TURN-PIKE.—A beam filled with spikes. An old name for a *cheval-de-frise*. This constitutes a simple accessory means of defense.

TURN-TABLE.—A circular plate of metal carrying rails of the same gauge and on the same level as the adjoining rails. The plate is movable on a central pivot, supported underneath, at different intervals, and near the circumference, by small wheels. It is placed at the crossing of one or more lines of rail and on the engine or carriage being placed upon it, the plate is moved round in the direction required. Turn-tables of a modified form are used in the service of heavy guns, such as the 10-inch, 11-inch,and 12-inch guns, and perform the part of rotatory platforms. See *Mechanical Maneuvers*.

TURRET.—A revolving tower for offensive purposes, on land or water. As originally designed, the tower consisted of a cylindrical iron structure, having several tiers of casemates and one barbette platform, all revolving together around a central tower which forms the axis, the motor being a steam-engine. At the summit of the central tower is the look-out,which is capable of independent revolution,when desired, and has a telescope mounted to sweep the horizon, and with altitude adjustments. Electric apparatus fires the guns. The turret, in American vessels,is pivoted on the keel or other firm base; in English specimens it revolves on rollers under the periphery. By means of simple mechanism, it can be made either by a steam-engine or by hand, to revolve with considerabte speed, thus giving the gun a range in every direction. Turret ships were first proposed in America, by Mr. Theodore R. Timby,of New York, and were patented in England by Captain Cowper Phipps Coles of the Royal Navy, who, after much discussion with the Admiralty,was allowed to adapt the Royal Sovereign,a wooden vessel which had been built for a three-decker,to his designs. The plan was tried under disadvantages, as the ship had not originally been destined for such heavy work. Notwithstanding, the Royal Sovereign, as a turret-ship, was declared by competent officers to be at that time the most powerful vessel in the British Navy. Almost simultaneously in the United States, similar vessels, called "monitors," sprang into existence, the principal point of difference between them and the British build being that their hulls are almost entirely submerged, the turrets being wholly above the upper deck; while, in the latter, the hulls rise higher from the water, and the turrets are sunk below the deck, except in so far as is absolutely necessary for discharging the ordnance. The British model gives the advantage of higher free-board,and consequent greater safety in heavy seas. Captain Coles lost his life in the greatest naval catastrophe of modern times, the capsizing of his great turret hip, the Captain, with about six hundred souls on board, in a heavy storm in the Bay of Biscay, in September, 1870. This vessel was built after his complete design; but naval architects attribute her loss to a low free-board, coupled with heavy masting. It has for several years been in dispute whether to trust to turret-vessels or to ships with their battery in broadside. Under the administrations of Lords Palmerston and Russell, the Admiralty built broadside vessels. Lord Derby's government signalized their accession to power in 1866 by immediately ordering four iron turret-ships of immense power and 4,000 tons each. Among the advantages claimed for turret-ships are—that much heavier ordnance can be carried centrically than at broadside, with equal dislocating pressure on the keel; that in a sea the platform from which aim is to be taken is steadier at the center; that the mark offered to the enemy is smaller; and that the gunners are safer, as the turret can be turned with its port-hole away from the enemy during loading. The Devastation, with her 35-ton guns, has been exceeded in power by the Inflexible, whose armor-plating, amidships, is two feet thick, and which is furnished

Tabular Statement of Reserve Troops of the Turkish Army, the Battalions, Regiments, and Batteries of which are fully Officered and Equipped.

No. of Corps.	Head-quarters of Corps d'Armée.	1st Ban Redif. No. of Battalions.	1st Ban Redif. Infantry.	1st Ban Redif. Cavalry.	1st Ban Redif. Artillery.	1st Ban Redif. Total.	2nd Ban Redif. No. of Battalions.	2nd Ban Redif. Infantry.	2nd Ban Redif. Cavalry.	2nd Ban Redif. Artillery.	2nd Ban Redif. Total.	Mustahfiz. No. of Battalions.	Mustahfiz. Infantry.	Mustahfiz. Cavalry.	Mustahfiz. Artillery.	Mustahfiz. Total.
1st	Constantinople	28	22,400	377	753	23,530	28	22,400	1,229	1,216	24,845	28	22,400	3,511	8,274	34,185
2nd	Shumla	24	19,200	1,061	1,353	21,614	24	19,200	1,401	3,874	24,475	24	19,200	3,366	7,797	30,363
3rd	Monastir	32	25,600	1,947	2,524	30,071	32	25,600	889	1,638	28,127	21	19,200	1,964	4,681	25,745
4th	Erzeroum	21	19,200	314	984	20,498	24	19,600	1,387	1,736	22,723	24	19,200	1,023	1,565	21,788
5th	Damascus	24	19,200	966	2,045	23,211	24	19,600	690	753	21,013	21	19,200	330	370	19,900
6th	Bagdad	5	4,000	2,000	2,060	8,060	—	—	1,410	2,509	3,919	—	—	1,350	1,603	2,953
7th	Yemen	—	—	—	—	—	—	—	—	—	—	—	—			—
..	Black Sea Coast	12	9,600	—	—	9,600	12	9,600	—	—	9,600	12	9,600			9,600
	Total	149	119,200	6,665	9,719	136,584	144	116,000	7,006	11,726	131,732	136	108,800	11,714	21,290	144,734

Annual Scale of Pay Received by the Officers of the Turkish Army.

GRADE.	£	s.	d.	
Marshal Commanding First Corps	5,637	12	6	Commissioned Officers.
" " other Corps	5,421	2	6	
Lieutenant General of all arms ...	1,302	3	4	
Major General " ...	725	2	6	
Colonel " ...	391	7	6	
Lieutenant Colonel " ...	269	1	8	
Chief of Battalion or Squadron ...	197	14	2	
Major on the Staff	133	19	2	
Regimental Paymaster	131	10	0	
Adjutant Major of Right Wing or Squadron	110	8	4	
Regimental Secretary	97	19	6	
Adjutant Major of Left Wing ...	92	9	2	
Battalion Secretary	91	11	8	
" Paymaster	65	18	4	
" Assistant Secretary ...	65	18	4	
CAVALRY.				
First Captain	73	15	10	Subordinate Officers.
Second Captain	62	0	10	
First Lieutenant	55	13	4	
Second Lieutenant	51	4	2	
Sub-Lieutenant of First Class ...	48	10	0	
" " Second Class ...	44	16	8	
ARTILLERY.				
Captain	70	11	8	
First Lieutenant	53	19	6	
Second Lieutenant	49	7	6	
Third Lieutenant	47	10	10	
INFANTRY.				
Captain	70	11	8	
Lieutenant	53	19	6	
Sub-Lieutenant	49	7	6	

with two turrets, each containing two 81-ton guns. Mr. Rendel, upon whose principle the guns are mounted, uses hydraulic power, which enables the loading and firing to be very easily conducted by two men.

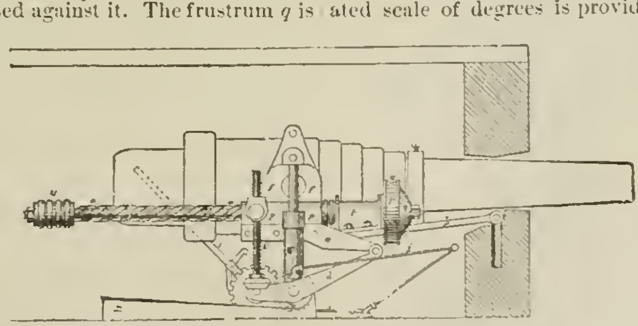
TURRET CARRIAGE.—Owing to the very confined limits within which guns must be worked in turrets generally, it is necessary that carriages intended to be used in them should fulfill two essential conditions: 1st, of checking the recoil of the gun within a very short space, so that the chassis need not be long; and, 2d, of allowing the gun to be fired through a wide field of fire with a very small embrasure or port-hole. To satisfy this last condition it is necessary that means should be provided to raise and lower the gun quickly, making it turn around an axis in the embrasure; to fill the first condition different means have been used. The carriage adopted for use in Germany in turrets is the invention of Mr. Wagenknecht, a manufacturer of Dantzic, and is known as the Minimalschaetèn-Laffete; that is, the minimum embrasure carriage. The chase of the gun rests on a strong swing-bed, *b*, of forged iron, which has a joint at the head, and a strong bolt fixed in the sole of the embrasure. When the gun is raised or lowered the trunnions slide on the swing-bed, which turns around the point *c*. The cheeks, *f*, of the carriage of cast-iron project out at top, and rest on the head of the piston of the hydraulic press, *g*. Below they are fastened to arms *e*, which are hinged to a lower arm, *d*, made fast to the body of the press. The pipes *i i* communicate from the steam-engine to the press, which is operated by a pump not shown in the drawing in order not to complicate it too much. That the gun may be maneuvered without being obliged to make use of the steam-engine, the carriage has a second apparatus for raising the gun, composed of a steel screw, which is turned by means of a ratchet and lever. The cheeks of the carriage carrying the gun can be raised or lowered either by the hydraulic press or the screws *k*.

The top carriage is mounted on two truck-wheels *m*, which have their axles in the lower arm *d*, and roll on the chassis-rails *n*, inclined upward to the rear. The cheeks and arms are connected together by bolts and axles just mentioned. The apparatus for checking the recoil is arranged symmetrically on the right and left of the piece. A strong steel screw, *o*, with a square thread and long pitch, passes through

Monthly Scale of Pay of Non-Commissioned Officers and Men of the Turkish Army.

ARTILLERY.	£	s.	d.
Sergeant-Major of Battalion	0	13	9
Battery Sergeant-Major	0	10	6
" Quartermaster Sergeant ...	0	8	9
Corporal	0	7	8
Gunner of Horse Artillery	0	6	5
" Field or Garrison Artillery	0	5	9
Corporal of Drivers	0	8	4
Farrier Sergeant	0	13	6
Saddler Sergeant	0	12	2
Magazine Sergeant	0	15	3
Sergeant of Water-carriers	0	10	6
Water-carrier	0	7	6
Trumpet-Major	0	13	8
Trumpeter	0	7	6
CAVALRY.			
Regimental Sergeant-Major	0	12	3
Quartermaster Sergeant	0	9	1
Troop Sergeant-Major	0	8	4
Corporal	0	7	6
Private	0	6	4
Farrier Sergeant	0	13	6
Saddler Sergeant	0	12	2
Corporal of Water-carriers	0	8	4
Water-carrier	0	7	6
Regimental Trumpet-Major	0	13	6
Squadron Trumpet-Major	0	8	4
Trumpeter	0	7	6
INFANTRY.			
Battalion Sergeant-Major	0	13	8
Quartermaster-Sergeant	0	10	6
Sergeant	0	9	0
Corporal	0	7	6
Private	0	5	9
Water-carrier	0	5	9
Bugle-Major of Regiment	0	13	6
Battalion Bugle-Major	0	10	6
Bugler	0	8	2
Drummer or Fifer	0	5	9

a female screw, *p*, which forms a part of the carriage. The front end of the screw *o* is terminated by a cylindrical shaft which carries the friction-brake. It is composed of the frustrum of an iron cone, *q*, fitting into a conical drum, *r*, also of iron, the periphery of which is encompassed by a friction-band, *s*, of steel, which is pressed against it. The frustrum *q* is



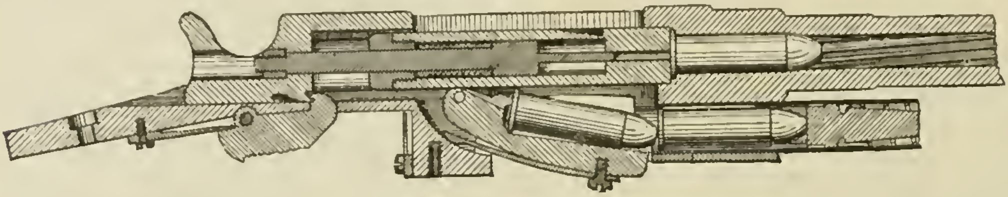
securely fastened to the end of the screw. The drum *r* can turn on the strong hollow cylinder *t*, through which the cylindrical part of the screw passes, and is bolted to the swing-bed *b*. To make the adherence of the friction-cones more perfect, wedges of lignum vitæ are placed between their surfaces. The frictiont band *s* of steel does not make an entire circle, but one end is fastened to the swing-bed, and the other to a metallic connection joining the two friction-bands together. A screw tightens the bands more or less, and thus very readily regulates the friction-brake.

In firing, the break opperates in the following manner: The gun recoils, taking along with it the whole hoisting arrangement. In the first instant the screw moves slightly to the rear, which causes the two friction-cones to press firmly against each other; but this motion to the rear is stopped almost immediately by the cylinder *t*, which is bolted to the swing-bed *b*. The screw pulled to the rear by the recoil of the gun causes the screw *o* and the frustum *q* to turn and communicate its motion to the drum *r*; but this is checked by the action of the friction-band, which must be regulated ascording to circumstances. The gun and carriage are brought to a state of rest when the work of the friction thus produced and that of the ascent of the gun and carriage up the inclined chassis-rail *n* are equal to one-half the living force of the recoil.

The piece then runs back into battery, of itself; but as this motion to the front may under certain circumstances cause violent shocks, a brake similar to that just described, but proportionately smaller, is attached to the screw just in the rear of the cylinder *t*. The friction-cones are placed in a contrary direction to those first mentioned. A buffer, *u*, composed of several strong disks of India rubber, and fastened to the rear end of the screw *o*, serves to stop the gun, breaking the shock gradually in case the friction of the brake has not been well regulated. The banded 10.23-inch gun weighs 48,500 pounds, and the turret-carriage 19,849 pounds. A snatch-block for facilitating the insertion of the projectile and charge in the gun is fastened to the breech. The weight of the projectile is 485 pounds, and of the charge 159 pounds. Each turret is armed with two guns, placed alongside and exactly parallel to each other. They are placed in position in the turret by being hoisted over the sides before the roof is put on, which is removable at pleasure. The machines used to put them in place are moved by the steam-engine. The port-holes are circular at the middle of the walls, and open outward in every direction. Both on the inside and outside they are elliptical in shape.

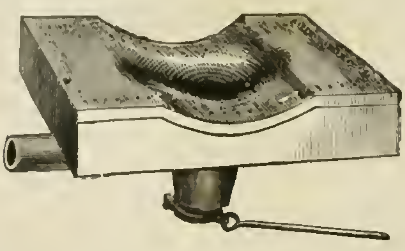
For pointing the guns the entire turret is moved by means of a steam-engine. On its roof a front and rear sight are so adjusted as to determine a line of sight exactly parallel to the axis of the gun. An opening made in the roof between the two pieces allows the gunner to direct this line of sight on the target by making signals previously agreed upon to the engineer to turn the turret as may be required. The elevation is given by means of the elevating apparatus already described; but as the rolling of the ship does not permit the use of the spirit-level, a graduated scale of degrees is provided at the side of the gun. Before firing, it is evidently necessary to wait for the precise moment when the platform of the pieces is horizontal; this instant is indicated to the gunner by the passage of a plumb-bob over a certain mark. Pointing the gun from the top of the roof is attended with certain difficulties, so it has been proposed to bore a small hole through the walls of the turret between the two guns, thus forming a kind of observation-tube with micrometer lines in it, and determining a line of sight parallel to the axis of the guns. The operation of pointing will be in this way more accurate and less dangerous. Guns as large as 10.23 inches have been mounted on this kind of carriage, and the trials to which they have been subjected have given favorable results. See *Sea-coast and Garrison Carriages.*

TURWURTH GUN.—A repeating-carbine recently introduced into the Austrian service. Like the Swiss Vetterlin rifle, its chief peculiarity is the attachment of a cartridge magazine to a sliding breech-bolt system similar to that of the French Chassepôt rifle. The drawing represents a section through the axis of the breech system. The arm can be fired eight times without reloading, viz. one cartridge in the chamber, one in the carrier-block, and six in the magazine. The operation of opening and closing the breech transfers one cartridge from the carrier-block to the chamber of the barrel and one cartridge from the magazine to the carrier-block. The eight cartridges can be inserted in the magazine in 12 seconds and can be discharged in 16 seconds. The arm without the bayonet weighs 8.1 pounds, and its length is 40.5 inches; with bayonet it weighs 8.95 pounds, and its length is 60 inches. See *Small-arms.*



TUTENAG.—An alloy of 2 parts of copper, 3 of nickel, and 6½ of zinc. It is a very hard, fusible alloy, not easily rolled, and is best adapted to casting. It sometimes contains a small proportion of iron.

TUYERE—TWEER.—The aperture in the side of a blast-furnace to admit the nozzle of the blast-pipe; also the nozzle itself. The drawing shows the Roots tuyere and fire bed, which is extensively used in American foundries. This tuyere possesses all desirable features. The peculiar method by which the blast is introduced into the fire produces the most perfect combustion and intense heat, and at the same time it concentrates and utilizes the heat. It is not a tuyere in the ordinary acceptation of the word, answering simply the purpose of introducing the blast into the forge, but it is a complete firebed, shaped in the most perfect form, which numerous experiments have demonstrated to be best adapted



to meet all requirements of the case, and put into permanent and unalterable shape, thus securing a fire of the best possible form, that requires no dressing to keep it in order. It presents no thin edges to the action of the fire. The walls are of such thickness and shape, and at such a distance from the focus of heat, and are kept so cool by the blast, and the circulation of air, that its durability is very great. Being cast in one piece, it has no part that can get out of order. Having no joints, except where the blast enters the tuyere, there is no waste of the blast by leakage. The method of introducing the blast is such, that the cinders never reach the air-openings, or stick to any part of the tuyere. Thus a heat is never lost by a choking up, or time consumed in cleaning. The arrangements being such as to secure the most perfect combustion of the fuel, and concentration of the heat, and the coal being confined in fixed limits, so as to make the smallest possible amount do the work, it heats faster, and does much work with little coal. As the tuyere is complete in itself, it can be taken out and put in place without disturbing other parts of the forge and requires no mortar, earth, or brick work to give shape to the fire. The tuyere is provided with a valve at the bottom, which serves the triple purpose of an outlet for ashes that may work through the air-openings, and of preventing an accumulation of gas, and also of keeping the fire going out when not in use. All these purposes are accomplished by opening the valve, which is done by simply drawing a rod attached to it. The fire can thus be kept for hours ready for use when wanted. Often written *twyer.* See *Cupola Furnace.*

TWENTY-FOUR-POUNDER HOWITZER.—A cast-iron, smooth-bored, and muzzle-loading howitzer, with a chamber, used in the United States Service. The following table shows the principal weights and dimensions of the piece:—

Designation.	No.	Lbs.	Inch.
Caliber	....	....	5.8
Weight	....	1475	....
Preponderance	....	70	....
Length of piece	....	....	69
Length of chamber	....	....	4.75
Diameter of chamber	....	....	4.62
Windage	....	....	0.14
Charge (cannon-powder)	....	2	....
Shell (empty)	....	16	....
Weight of canister	....	20.5	....
Carriage (the top and chassis), wooden; without recoil checks	....	....	....

The piece is mounted on a flank-casemate carriage, and has the following ranges in yards:—

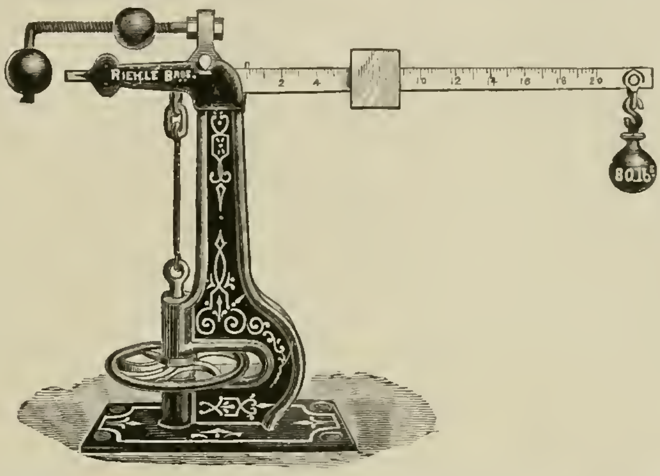
Elevation.	Shell.	Case Shot.	Time.	Charge 2 Lbs.
0° 0′	295	....	....	Canister is used for
1° 0′	516	....	....	sweeping the ditch
2° 0′	....	600	2′	in front of the cur-
3° 30′	....	880	3′	tain; for this the
5° 0′	1322	....	....	piece should be de-
5° 30′	....	1050	4′	pressed 1 to 2 deg.

The piece admits of 7 degrees elevation and 9 degrees depression. The platform is a permanent part of the work. See *Howitzer*, and *Ordnance.*

TWINE-TESTER.—A machine for ascertaining the strength of twines and stout cords. The drawing shows a contrivance of this class with a capacity of 100 pounds and the following:

DIMENSIONS.		ADAPTATION.	
Extreme height	36 in.	Tensile specimens	20 in.
Extreme length	24 in.	Motion of screw	4 in.
Extreme width	4¼ in.	....	....
Weight	25 lbs.	....	....

The twine being secured in position, the screw shown near the base is operated with one hand, while the other moves the poise forward, keeping thereby the beam in perfect equipose. When the specimen breaks, the poise on the beam will indicate the actual strength of the same. This machine is quite ornamental, and intended to set upon a table or desk. It is constructed entirely of iron and brass. It is also suitable for testing fine wire, and is of constant use in the laboratory. See *Testing-machine.*



TWIST.—The term generally used by gun-makers, to express the inclination of a groove at any point, and is measured by the length of a cylinder corresponding to a single revolution of the spiral: this, however, does not convey a correct idea of the inclination of a groove. A correct measure of the inclination of a rifle groove at any point, is the tangent of the angle which it makes with the axis of the bore; and this is always equal to the circumference of the bore divided by the length of a single revolution of the spiral, measured in the direction of the axis.

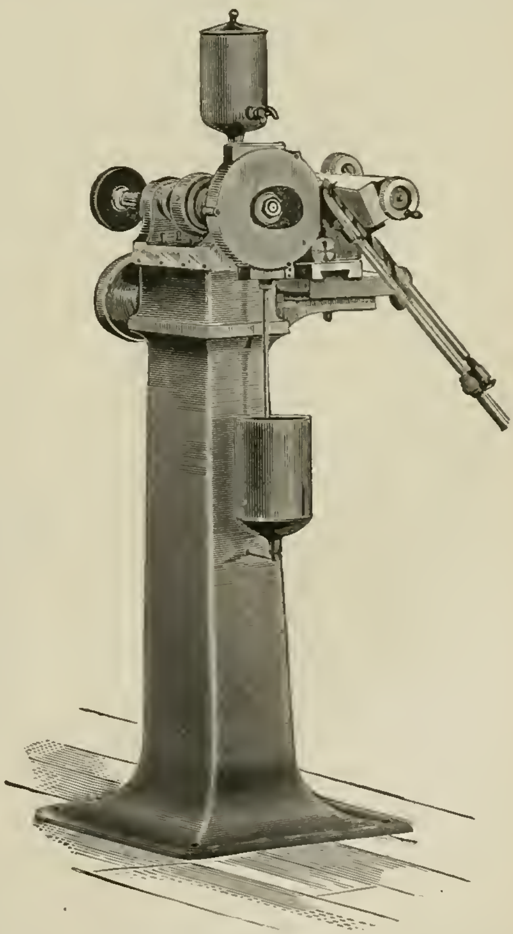
With *uniform* twist, this is estimated by the distance (generally expressed in calibers) in which the spiral makes *one turn*; with the *increasing* twist, it is estimated at any point by the distance in which the spiral would make *one turn* had the angle of spiral remained uniform, and the same as at the given point. Suppose a the angle of spiral at any point in the bore: also suppose the twist of rifling at the same point to be one turn in n calibers. Then,

$$\tan a = \frac{\pi}{n};$$

which expresses the relation between the angle of spiral and the twist of the rifling at any point in the bore. See *Grooves*, *Increasing Twist*, and *Uniform Twist.*

TWIST-BARRELS.—*Twist* is the term applied to *coiled barrels.* The iron or steel is made into a ribbon several yards long, about half an inch wide, and thicker at the breech than at the muzzle-end. It is heated to redness, wound on a mandrel, then removed and heated to the welding-point, and slipped over a rod with a shoulder at the lower end. The rod is then dropped vertically several times on a block of metal, which welds the spiral edges together. This is called *jumping.* The welding is completed by hammering. See *Gun-barrel.*

TWIST-DRILLS.—About a quarter of a century ago both Sir Joseph Whitworth and the late Mr. Greenwood of Leeds made some twist-drills; but it is to be presumed that a large amount of success was not achieved with them, and for some reason the system was not persevered with. After that period the Manhattan Fire-arms Company in America produced some beautifully-finished twist-drills. Though the workmanship in these was of a superior description, the drills would not endure hardship. It was found that the two lips were too keen in their cutting angles, and that they were too apt to drag themselves into the metal they were cutting, and finally to dig in and jam fast, and twist themselves into fragments. Mr. Morse then took the matter up, and by diminishing by about 50 per cent. the keenness of the cutting-lips of twist-drills and using an increasing twist, made a great success of them. If however the angle of twist is made to increase toward the lips, it will of course decrease toward the shank. The shorter the drill is worn, the more obtuse the cutting angle



Twist-drill Grinder.

becomes, and the less freedom will it cut with: supposing of course that, when the drill was new, the angle was the most efficient. Suppose this decrease of twist were carried still further by lengthening the drill, a cutting angle of 90° would eventually be arrived at. The old common style of drill usually has such a cutting edge; which is so obtuse as not to cut the metal sweetly, but on the contrary to have more of a tearing action, and thus to put so much torsional strain on the drill that fracture is certain to take place, even if what the writer would now consider a moderate feed was put on by the drilling-machine. It is therefore obviously advantageous to adopt from the first the best cutting angle for all twist-drills, and to preserve this same angle through the whole length of the twisted part, so that, however short the drill may be worn, it always presents the same angle, and that the most efficient which can be obtained. This cutting angle is easy to fix, and becomes an unalterable standard which will give the best attainable results. This has been adopted at the Gresley Works, Manchester, and of course applies to both lips.

A common drill may "run," as it is usually termed, and produce a hole which is anything but straight. This means that the point of the drill will run away from the denser part of the metal it is cutting, and penetrate into the opposite side which is soft and spongy. This is especially the case in castings; where, for instance, a boss may be quite sound on the one side, while the other side, being next to a heavy mass of metal, may be drawn away by the contraction of the mass in cooling, so as to be very soft and porous. In such cases it is perfectly impossible to prevent a common drill from running into the soft side. This sort of imperfect hole is most trying to the fitter or erector; and if it has to be tapped, to receive a screw-bolt or stud, is most destructive to steel taps. The taps are very liable to be broken, and an immense loss of time may also take place in attempting to tap the hole square with the planed face. A twist-drill, on the other hand, from its construction, is bound to penetrate truly, and to produce holes which are as perfect as it is possible to make them. The next important step in twist-drills has been to fix a standard shape and angle of clearance for both lips, which should also give the best attainable result. This angle might be tampered with if the re-grinding were done by hand, and too much or too little clearance might easily be imparted to the drill from want of sufficient knowledge on the part of the workman. If too little clearance, or in some cases none at all, is given to the drill, the cutting lips then cannot reach the metal, consequently they cannot cut. The self-acting feed of the drilling-machine keeps crowding on the feed until either the machine or the drill gives way. Usually it will be the latter.

Much ingenuity has been expended on machines for grinding of the two lips with mechanical accuracy. The one which has been the most successful in the United States has three motions, ingeniously combined with each other. So many motions, however, entail complication; and this, added to a system of holding the drill which was not sufficiently reliable, failed to produce the extreme accuracy it is requisite to impart to the two angles. The grinding line too is found to be more or less a source of weakness. It is therefore advisable to dispense with it if possible; and where a good twist-drill grinding machine is used, the grinding line is seldom or never looked at, and in that case is useless. If it is still desirable to have grinding lines (as in some cases where hand-grinding has to be relied upon), they should be made as faint as possible, and not cut deeply into the thin central part of the drill, so as to weaken it. The drawing represents the Pratt and Whitney twist-drill grinder, used in most arsenals and shops for sharpening drills $\frac{1}{4}$ to $1\frac{1}{2}$ inches diameter of varied length, and to finish them with clearance suitable for cutting metals of different densities and natures. A right and left hand screw chuck accurately centers and holds the drill by simply turning a hand wheel. An emery wheel, 7 inches diameter, 1 inch face, is carried on one end of the spindle, and is enclosed in a cast-iron casing, except for a little space to allow contact with the drill. It may be used either wet or dry. On the other end of the spindle is carried a wheel shaped to the inner curve of the drill lip for reducing the point. For this important operation the drill is held by hand. Weight of machine, 375 pounds. Speed of countershaft, 6 by $2\frac{1}{4}$ inch tight and loose pulleys, 550 revolutions per minute.

TWO HANDED SWORD.—A distinctive weapon of the German *lansquenets*, or mercenary foot-soldiers, who played so distinguished a part in the French religious wars. This enormous weapon, with its very straight expanding blade of portentious size, double edged and sharp at the point, with its long hilt and massive cross-guard, and with the threatening spikes at the base of the blade, presents a very alarming appearance. The blade of this sword frequently affected a wavy or flaming outline.

TWO-HORSE LITTER.—A litter figured by Inspector General R. B. Marcy, United States Army, and well adapted for the exigencies of frontier life. It is constructed by taking two poles about twenty feet in length, uniting them by two sticks three feet long lashed across the center at six feet apart, and stretching a piece of stout canvas, a blanket, or hide between them to form the bed. Two steady horses or mules are then selected, placed between the poles in the front and rear of the litter (smaller animal in front), and the ends of the poles made fast to the sides of the animals either by attachment to the stirrups

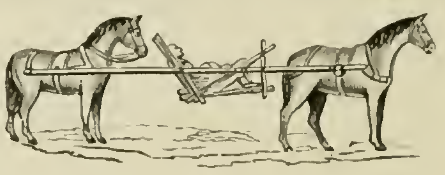


Fig. 1.

or to the ends of the straps secured over their backs. The patient may then be placed upon the litter; and is ready for the march. The elasticity of the long poles gives an easy motion to the conveyance and makes this method of locomotion much more comfortable than might be expected. To turn the litter the animals should work in *opposite* directions, the front one to the right, and the rear one to the left, or vice versa. To go down hill, hold back on the rear animal, and to go up hill whip up the rear animal; always start the rear animal first. Ordinarily a

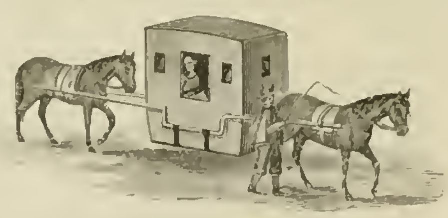


Fig. 2.

man should ride or lead each animal, and it will be very easy for such a litter to keep up with a cavalry column on the march.

This is a very ancient form of litter, often employed prior to the introduction of coaches, in the 16th century, for conveying people of consequence, or for the carriage of sick persons. Such a palanquin or two-horse litter, is figured in Charles Knight's *Old England*, compiled from several pictures in Braun's Civitates Orbis Terrarum, 1584, and is copied in Fig. 1. In Fig. 2 there is a suggestion of an arrangement that might under favorable circumstances be made available for the carriage of a wounded man, suspended either in a semi-recumbent or prone position. See *Litter*.

TYLER GABION.—A single sheet of galvanized iron, about 0·45 inch thick, 75½ inches long, 36 inches wide, with four eyelet holes, weight 26 lbs., requires no pickets. The sheet is rolled into a cylinder for use; the ends secured by strong wire ties. The noise which is made by the gabion when carried empty is a drawback from its general advantages. The sheets may be used for roofing and other purposes. Two men can make one of these gabions in ten minutes.

TYLER INSURRECTION.—A poll-tax of three groats, imposed in 1381, during Richard II's minority, to defray the expenses of the war with France, roused the spirit of resistance among the common people. An insult offered by one of the tax-gatherers to a blacksmith's daughter in Essex, led to the first open outbreak. The populace rose everywhere, and under the conduct of two peasants, named Wat Tyler and Jack Straw, they mustered in great force at Blackheath, committing violence on all who came into their hands. They had an interview with the King, who, finding resistance vain, promised acquiescence with their demands, which included a general pardon, freedom of commerce, and the abolition of villeinage. Meantime, a party of Insurgents had broken into the Tower, and murdered the Primate and Chancellor, and the Treasurer. The King, encountering Tyler at the head of the rioters in Smithfield, invited him to a Conference, when he conducted himself with an insolence that led Walworth, the Mayor, to dispatch him with a dagger. The King immediately, with great presence of mind, offered himself to head the populace, and leading them to the fields at Islington, where a body of troops had been collected for his Majesty's protection, ordered the rioters to disperse. The revolt however, was not extinguished without considerable bloodshed.

TYMPANUM.—A drum used by the ancients. It consisted of a thin piece of leather or skin stretched upon a circle of wood or iron, and beat with the hand. Hence the origin of our present drum.

TYRANT.—A name given in modern times to an arbitrary and oppressive Ruler, but originally applied, not necessarily to one that exercised power badly, but merely to one that had obtained it illegally, and therefore equivalent to our word *usurper*. The ancient Greek "Republics," it must be remembered, were generally aristocratic and even oligarchic in their constitution. When the "Governing Families" among the Athenian and Syracusan nobles, for example, quarreled with each other, it was natural, if they could not otherwise agree, that the boldest and most reckless of the set should seek for success by allying himself with the masses of the people, should figure as their champion, promise to redress their wrongs or increase their comforts, and when a fitting occasion presented itself, should, by a clever if somewhat violent stratagem—*coup d'état*, it is now called—deliver them from the domination of his order by himself grasping possession of absolute power, and ruling without any other restraint than the necessity of retaining his popularity imposed—even this limitation being frequently absent when a body-guard of foreign mercenaries rendered it superflous. If the political adventurer who thus rose on the ruins of the Constitution happened to be a man of sense, and wisdom, and generosity, his "tyranny" might prove a blessing to a State torn by the animosities of selfish Oligarchs and be the theme of praise in after-ages, as was the case with the "Tyrannies" of Peisistratos, Gelon, Hiero II., and many others; but if he was insolent, rapacious and cruel, then he sought to reduce the citizens to a worse than Egyptian bondage, and his name became infamous to all time. Such has been the fate of most of the "Thirty Tyrants of Athens," more particuarly of the blood-thirsty Critias, or Alexander of Pheræ, of Dionysius the Younger, etc. It was the method of exercising authority pursued by these and other usurpers that latterly, even in ancient times, gave the word tyrant that evil significance it has ever since uninterruptedly retained.

TZAGARA.—An ancient form of crossbow. A law was passed at the Lateran Council, held in 1139, forbidding the employment of this weapon amongst Christian nations, and restricting its use for the purpose of slaying infidels and miscreants.

U

UBIQUE.—The motto of the Royal Artillery and Royal Engineer regiments.

UCHATIUS GUN.—A bronze-steel gun cast by placing in the center of the cast-iron mould a cylinder of copper, which, by absorbing part of the heat of the molten metal, causes rapid chilling of the central portion. Both the interior and exterior portions are thus formed of the same quality of metal. In five minutes the entire mass solidifies. It was, however, found that a deep recess was formed in the top of the casting. General Uchatius met this difficulty by the addition of a sand mould, so as to form a dead-head, in which the metal remained in the molten state for a comparatively long time, and so filled up any recess. In a gun whose bore is about 3¼ inches, the bronze is compressed by the introduction in succession of six steel mandrels, which are forced home by hydraulic pressure. The mandrel is formed at the end in a truncated cone, so as to force the metal outwards and enlarge the bore, giving a caliber of 3¼ inches. The axis of the trunnions is in the same horizontal plane as that of the piece, and the trunnion-arms themselves are hollowed out conically on the face. The piece is vented vertically a little in front of the breech-block slot. The latter is cut laterally near the breech and through the piece. The gun is sighted at the right side with a small screw-sight, screwed into a patch on the gun in front of the trunnions, and a target-sight at the breech-end of the piece. A copper bush is screwed into the breech-end of the powder-chamber, for the reception of a copper Broadwell ring. The breech-block is also of bronze-steel, and is rectangular. Along the upper and under surfaces run a projection and deep groove, ensuring, together with the ribs, a perfect fit when the block is home. To the left of the breech-block is attached the arrangement for moving it.

The projectiles are of four kinds—common shell, shrapnel, carcase, and case. Rotation is given by means of four copper rings pressed into undercut rings around the projectile. The common shell is of the double wall description, which has for its object to give as many splinters as possible of a size sufficient to kill a man. The shrapnel has the powder charge at the bottom, separated from the bullets by a thick diaphragm and ignited through a tube passing down the center of the shell from the fuse-hole. The carcase is cast with very thick single walls, and its original head has three firewalls covered with pitch plaster. The case consists of a zinc cylinder filled with bullets composed of lead and antimony, between which moulten sulphur is run. Percussion and time-fuses are used.

The heavy gun throws a common shell of 16.1 lb., and at 2,000 yards it has 40 feet more velocity than the 15.4 lb. shell of the Krupp gun. The light guns are, however, inferior to the Krupp guns of the same caliber. Krupp guns also cost three or four times as much. The Austrians are highly satisfied with these guns, which are considered quite equal, and probably a little superior, to the German Krupp steel guns of latest pattern. See *Bronze Guns* and *Ordnance*.

UHLANS. Light cavalry of Asiatic origin, introduced into the north of Europe along with the Colonies of Tartars who established themselves in Poland and Lithuania. They were mounted on light, active Tartar horses, and armed with saber, lance, and latterly with pistols. Their lance was from 5½ to 6½ feet in length, and, like that of the modern "Lancers," was attached to a stout leather thong or cord, which was fastened to the left shoulder and passed around behind the back, so as to allow the lance to be couched under the right arm. Immediately below its point was attached a strip of gaudy-colored cloth, the fluttering of which was designed to frighten the enemies' horses. The early dress was similar to that of the Turks, and the regiments, or *polks*, were distinguished from each other by the red, green, yellow, or blue color of their uniforms. The Austrians and Prussians were the first to borrow this species of cavalry from the Poles. In 1734 an attempt was made by Marshal Saxe to introduce the Uhlans into France, and a "polk" of 1000 men was formed; but it was disbanded at its author's death. The Prussian Uhlans won great renown in the Franco-German war of 1870-71 by their bravery and marvelous activity. The Prussians applied the term, however, rather loosely, including all their light cavalry under the designation. In the British army, the place of the Uhlans is occupied by the hussars. Also written *Ulans*.

UKASE.—A term applied in Russia to all the orders or edicts, legislative or adminstrative, emanating from the Government. The ukases either proceed directly from the Emperor, and are then called *imenny ukas*, or are published as decisions of the Directing Senate. Both have the force of laws till they are annulled by subsequent decisions. Many ukases are issued in the course of one reign; and as an immense chaos of ukases had accumulated since 1649 (the date of the last codification of laws), the Czar Nicholas ordered (1827) that a collation of them should be made. The result was a collection of laws in 48 volumes, which has been supplemented year by year by volumes of new ukases, and which, after the elimination of such ukases as are unimportant or of temporary authority, constitutes the present legal code (*svod*) of the Russian Empire. The *prikases* are imperial "Orders for the Day," or military orders given during the campaign. Also written *Ukas*.

ULSTER BADGE. On the institution of the Order of Baronets in England by James I., a sinister hand, erect, open, and couped at the wrist gules, the armorial ensign of the Province of Ulster, was made their distinguishing badge, in respect of the order having been intended for the encouragement of plantations in the Province of Ulster. This badge is sometimes born in a canton, sometimes on an escutcheon, the latter placed either in the fess point or in the middle chief point, so as to interfere as little as possible with the charges of the shield.

ULSTER KING-OF-ARMS. The King-of-Arms, or Chief Heraldic Officer of Ireland. A King-of-Arms called Ireland existed in the time of Richard II., but the office seems to have fallen into abeyance in the following century. Ulster was created to supply his place by letters-patent of Edward VI., in 1552. Ulster holds his appointment from the Crown, and acts under the immediate direction of the Lord-Lieutenant of Ireland. His office is in the record tower of Dublin Castle; and the Professional Staff under him consists of two Heralds, four Pursuivants, one Registrar, and one Clerk of Records. The records of Ulster's office comprise pedigrees of the nobility and gentry of Ireland, certificates of their deaths and funerals, and grants of arms. The official arms of Ulster King-of-Arms are: Argent, St. George's cross gules, on a chief of the last a lion passant gardant between a harp and a porteullis or.

ULTIMATUM. In diplomacy, the final conditions or terms offered by one government for the settlement of its disputes with another; the most favorable terms which a negotiator is prepared to offer, whose rejection will generally be considered to put an end to negotiation.

UMBON.—The pointed boss or prominent part in the center of a shield or buckler. Often written *Umbo*.

UMBRIERE.—The visor of a helmet; a projection like the peak of a cap, to which a face-guard was sometimes attached, which moved freely upon the helmet, and could be raised like a beaver.

UNATTACHED LIST.—In the British Army, officers not attached to regiments. In India, when the services of soldiers in the ranks are transferred from regimental to staff employ, their names are placed on a separate list (the unattached list), which removes them altogether from their regiments. If, for any reason, a soldier is sent back to his regiment, he resumes the rank he originally held in it, unless he has been reduced to the ranks by sentence of a Court-Martial. All men attached to the Ordnance or Commissariat Departments in that Country are placed on the unattached list.

UNCAP.—The act of taking off the cap of a fuse. In Boxer's fuse, the cap is made of tinfoil, covered in most of the muzzle-loading fuses by a copper stripe covering the priming, while the breech-loading fuses are protected by cardboard and copper disks covering the escape holes. Underneath the cap is a small disk of cardboard, to which a piece of tape is attached; this tape is allowed, when the cap is put on, to hang outside the fuse, having a knot at the end. When the fuse is required to be used, the tape is taken hold of, and with a slight jerk the cap is freed from it.

UNCONDITIONAL SURRENDER. Surrendering at discretion; not limited by terms or stipulations; hence the expression, *unconditional surrender*.

UNCOVER.—When troops deploy, the different leading companies or divisions, etc., successively uncover those in their rear, by marching out from the right or left of the column.

UNDER.—In subjection to; a prefix used with certain words, which renders them self-explanatory.

For instance, in military affairs, *under arms* means that a regiment or body of troops is assembled fully armed and accoutered on parade.

Under cover.—Protected from the fire of the enemy by natural or artificial means, or, indeed, in any position out of danger.

Under fire.—To be in action, and exposed to the enemy's fire.

UNDER CANVAS.—An expression meaning, in a military sense, to be lying in tents.

UNDER METAL.—The position of a gun when the muzzle is depressed below the line of a level axis.

UNDERMINE.—To dig beneath a wall or any such support, with the view to its fall. This can be aided by gunpowder or some other combustible.

UNDISCIPLINED.—As applied to troops, not perfect in exercise or maneuvers.

UNDRESS.—In the military service, the authorized habitual dress of officers and soldiers when not in full uniform.

UNDRESS GUARD MOUNTING.—In bad weather, at night, or after long marches, *undress* guard-mounting replaces the *dress* guard-mounting. It is conducted on the same principles as dress guard-mounting, except that the trumpeters or field-music sound off, standing on the right of the guard, and that the division into platoons and the march in review are dispensed with. The music at the discretion of the Commanding Officer, may be dispensed with. See *Guard-mounting*.

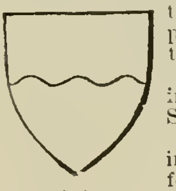
UNDRESS PARADE.—In all bad weather, undress parade takes the place of *dress parade*. The companies fall in without arms on their respective parade-ground: the First Sergeant, having reported the result of the roll-call, places himself on the right of the front rank; the Captain, or officer superintending the roll-call, dresses the company to the right: then places himself two yards in front of its center, faces to the rear, commands: 1. *Parade*, 2. REST, resumes his front and comes to parade rest. When all the officers are required to be present, they take post as prescribed in the School of the Company. If a Non-commisioned Officer is in charge of a company, he stands on the right of the front rank. The band, without instruments falls in on its own parade-ground. The Adjutant assigns the trumpeters, or field-music, a position, and, when all the companies have come to *parade rest*, he commands: SOUND OFF, at which the retreat is sounded, the Adjutant standing at *parade rest*. The retreat being sounded, the officer in charge of each company faces about, calls the company to attention, and directs the First Sergeant to dismiss it. When orders are to be published at undress parade, the companies close in, and are dressed by the officers in command of them, on a company previously designated. The band takes post on the right of the line, the trumpeters or field-music in its rear. The line being formed, the Adjutant in front of the center and facing the line commands:

1 *Parade*, 2. REST, 3. SOUND OFF.

At the second command, the trumpeters or field-music remaining in place sound the *retreat*. The Adjutant then calls the battalion to attention, publishes his orders, and commands:

Dismiss your Companies.

All the officers retire, and the First Sergeants march their companies to their respective parade-grounds, and then dismiss them. See *Dress Parade*.



Undy.

UNDY.—A term in Heraldry having the same signification as *wavy*. See *Heraldry*.

UNFIX BAYONET.—A command in the Manual of Arms executed as follows: the Instructor commands: 1. *Unfix*, 2. BAYONET.

Carry the piece to the left side as in *fix bayonet*, and place the forefinger of the right hand against the clasp of the bayonet. (Two.) Unclasp the bayonet; grasp it by the shank, wrest it from the barrel, and place it in the scabbard, the right hand falling by the side. The *carry arms* is executed the same as from *fix bayonet*.

Bayonets are *fixed* and *unfixed* from the *order arms*, by the same commands as from the *carry*, the piece being shifted from the right to the left side. To return to the carry, or order, the Instructor commands: 1. *Carry*, 2. ARMS; or, 1. *Order*, 2. ARMS. See *Manual of Arms, Fig.* 8.

UNGULED.—In Heraldry, the term applied to the tincture of the hoofs of an animal; *e. g.*, azure, a stag trippant or, attired and unguled gules, the arms of the family of Strachan in Scotland.

UNICORN.—1. The unicorn is perhaps best known as a heraldric charge or supporter. Two unicorns were borne as supporters of the Scotish Royal Arms for about a century before the union of the Crowns: and the sinister supporter of the insignia of the United Kingdom is a unicorn argent, armed, crined, and unguled, or gorged with a coronet composed of crosses patée and fleurs-de-lis, with a chain affixed, passing between the forelegs, and reflexed over the back, of the last. 2. The old name for the howitzer, as improved from the licorn, borrowed from the Turks during the last century by the Russians, and from the latter by Europe generally.

Unicorn.

UNIFORM.—In its military sense, uniform means the particular dress and equipment assigned by proper authority to each grade of the officers and men. The clothing consists of a prevailing color, variously ornamented and "faced" according to the rank and corps. Although other regiments wear other colors, scarlet may be said to be the prevailing uniform of the British Army; blue of the French: and white of the Austrian. Blue is likewise the color of the American uniform. It is surprising how late the introduction of compulsory uniforms took place in England. We find soldiers serving with corps and yet dressed after the dictates of their own fancy well into the Seventeenth Century, while in the navy, uniforms were not fixed with certainty until the beginning of the reign of King George III. The uniform is either *full dress* or *undress*. The following articles of uniform and equipment are prescribed in the Regulations of most armies: Blouse, buttons, chevrons, cravat or stock, dress coat, epaulettes, fatigue hat, forage cap, gloves, helmet, overcoat, plume, sash, shoulder-knots, shoulder-straps, spurs, sword, sword-belt, sword-knot and *trousers*.

UNIFORM SWORD.—An officer's sword of the regulation pattern prescribed for the Army or Navy.

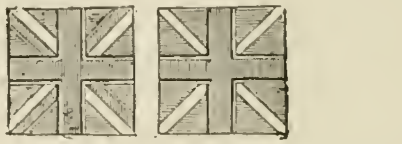
UNIFORM TWIST.—The form of a rifle groove is determined by the angle which the tangent at any point makes with the corresponding element of the bore. If the angles be equal at all points, the groove is said to be *uniform*. If they increase from the breech to the muzzle, the grooves are called *increasing*, if the reverse, *decreasing* grooves. Let ABC be a right-angled triangle, in which BC = circumference of the bore of a gun. AB = length of the bore. Now suppose the triangle ABC to be wrapped around the surface of the bore, so that B and C meet, AC will be the *helix*, or curve of the groove. Here the groove makes a complete turn in the length of the bore; but in ordinary rifle-guns the *twist* is more gradual, making less than one turn in the bore. In the case before us, AB equals the length of rifling due to one turn, that is, the distance traveled by the projectile while it is turning on its axis. AC is the total length of spiral and θ the angle of twist, or angle of the rifling. Let n = number of calibers in which the projectile makes one turn.

$$\tan \theta = \frac{BC}{AB} = \frac{\pi \times \text{caliber}}{\text{number of calibers} \times \text{caliber}} = \frac{\pi}{\text{number of calibers}} = \frac{\pi}{n}$$

In the uniform twist, the effort of rotation may be diffused over a very long centring bearing, extending along the whole cylindrical body of the projectile, which is an advantage of great importance, and when the projectile is free to escape, its motion will be much more uniform than if it received, as it were, a severe wrench on leaving the muzzle, while it is not believed that the life of the gun is materially affected by differences of powder-pressure within the possible limits which can obtain, between guns rifled with the same final angle of twist, on the uniform and the increasing systems. See *Grooves*, *Rifling*, and *Twist*.

UNION.—A term frequently applied to the National Colors. When there is a blue field with white stripes, quartered in the angle of the American Colors, that is, of the colors composed of the red and white stripes, that *blue field* is called the *Union*; and a small color of blue with white stars is called a *Union-jack*.

UNION-JACK—The National Banner of the united kingdom of Great Britain and Ireland, formed out of the combination of the crosses of St. George (argent, a cross gules), of St. Andrew (azure, a saltire argent), and of St. Patrick (argent, a saltire gules), these three crosses being the National Banners of England, Scotland, and Ireland respectively. The first Union-Jack, which was introduced by a Royal Proclamation in 1606, three years after the union of the Scottish with the English Crown, combined only the crosses of St. George and St. Andrew, and may be blazoned, azure, a saltire argent surmounted by a cross gules edged of the second. This combination was by Royal Proclamation of the date July 28, 1707, constituted the National Flag of Great Britain. On the union with Ireland, a new Union Ensign was devised, in which the cross of St. Patrick was introduced, with its four limbs edged with white on one side. This awkard specimen of Heraldry forms the



second and now existing Union Ensign. Generally speaking, it is displayed as a National Ensign on flags only; but the reverse of the bronze coins of the realm contains a not very accurate representation of it on the shield of the seated figure of Britannia. The inaccuracy consists in the crosses of St. Andrew and St. Patrick being made to assume the appearance of a single saltire with a narrow border of equal width on each side. See *Flags*.

UNIT.—In all tactical combinations, experience has shown that for each arm there is a certain numerical force, which lends itself best to the essential conditions demanded in all troops;—which are strength, activity, and the faculty of moving in any direction. This force, termed the unit, varies in the different arms. In all cases, it should not be so great but that all the men of which it is composed may be overlooked by, and be known to, the officer in command of it; and also when drawn up in its order of battle, be within reach of his voice. These last conditions place a practical limit to the tactical unit; owing to the extent to which the human voice can be distinctly heard; the space taken up by each combatant; and the form and dimensions of the figure covered on the ground by the unit in its order of battle. The *battalion* is the unit of the arm of infantry; the *squadron* that of the arm of cavalry; and the *battery* of six guns that of the arm of artillery. For each of these units, particular subdivisions have been adopted; and their command intrusted to officers of suitable grade, both to overlook and to lead them in the various combinations to which the unit may be subjected. For the details on all these points, as they do not come within the scope of this work, reference may be had to the systems of elementary tactics adopted in our service. The order of battle of the unit is usually based upon the nature of the weapon used, and the space required for handling it freely. See *Tactics*.

UNITED STATES ARMY.—The military forces of the United States consists, at the present time, of the *Regular Army* of the United States, and the *Militia* of the different States. The Regular Army of the United States consists of twenty-five regiments of Infantry, ten regiments of Cavalry, five regiments of Artillery and one battalion of Engineer soldiers; the total number of enlisted men not to exceed 25,000. it is also provided with a Corps of Adjutant Generals; of Inspector Generals; of Quartermasters; of Subsistence; of Engineers; and of Ordnance; a Medical corps; a corps of Paymasters; a Chief Signal Officer; a Bureau of Military Justice; a number of Chaplains; a force of Indian scouts; the officers on the Retired List: and the Professors and the Cadets of the United States Military Academy. In command of these there are ten General Officers, viz.: one Lieutenant General, three Major Generals and six Brigadier Generals, with the proviso that the office of Lieutenant General shall cease when a vacancy occurs in that office.

The Constitution of the United States has given the power to Congress to provide for calling "forth the Militia to execute the laws of the Union, suppress insurrections, and repel invasions." Congress, by legislation, has given the President the authority to call forth the Militia under certain exigencies as has been frequently done. When called into actual service of the United States, the Militia receive pay from the Government and are subject to the Rules and Articles of War. The Militia is therefore a part and parcel of the Army of the United States, although in common use the term is limited to mean the Regular Army alone. There is another class of troops not belonging to the Regular Army, nor to the Militia, which have been raised by Congress and employed by the Government. These troops are known as "*volunteers*," and must not be confounded with the Militia formed into volunteer companies. When a sudden emergency demands, these Volunteers are employed by authority of Congress, which gives the President the power to call for volunteers, limiting the number to be employed, and defining the proportions of the arms of service which they are to represent. As a rule the number of volunteers are proportioned among the States according to their population, and complete organizations of companies, battalions and regiments, are formed in each State and officered by the Governor of the State.

These organizations, when received into the actual service of the United States, are arranged into brigades and divisions by the United States officers and are commanded by General Officers who with their Staff-officers, receive their appointments from the United States. This makes an essential difference between them and the Militia. And although these organizations assume the names of the States in which they volunteered for service, they are truly United States and not State troops, nor Militia. They are troops raised by Congress, and although the company and regimental officers have been usually appointed by the Governors of States, it is a permission granted, and not a right yielded by Congress, to allow the officers to be appointed in that manner. Hence, when employed by the Government, they form a part of the Army of the United States, and in organization, rights, etc., have the same privileges as the organizations of the Regular Army.

The Army of the United States may then be said to be composed of the *Regular Army*, whose Commissioned Officers hold commissions for an *indefinite* period, and whose Non-commissioned Officers and privates *enlist* or engage to serve the United States for a definite period; *Volunteers*, whose commissioned Officers, Non-commissioned Officers and privates have volunteered to serve the United States for a definite period; *Paid Militia*, whose Officers, Non-commissioned officers and privates are enrolled according to law and are subject to military duty for a definite period. It will be observed that both the Regular Army and the Volunteers serve the United States voluntarily, and that the Militia, when the emergency comes, have no option in the matter, but if liable to duty, must serve in the Army when called forth.

During the War of the Revolution the Army included regular troops furnished by the several States, according to quota allotment, and Militia. The official returns made to the War Office show that there were under continental pay during the war the number of men contributed by the different States, as shown in the table, page 529.

On June, 12, 1776, Congress passed a resolution organizing the War Office; or, as it was then termed, the Board of War and Ordnance, and which consisted of 5 members. In the following year this was reorganized, a Board of War being provided for, to consist of three persons not Members of Congress. Afterward a Medical Inspection and Pay Department were added; and in 1781 the office of Secretary at War was created and his powers and duty defined. Gradually the entire official direction of the War Establishment was placed in the hands of this official,

	1775.	1776.	1777.	1778.	1779.	1780.	1781.	1782.	1783.
New Hampshire	2,824	3,019	2,283	1,283	1,004	1,777	700	744	733
Massachusetts	16,444	17,372	10,591	8,937	6,287	7,889	5,298	4,423	4,370
Rhode Island	1,193	1,900	548	3,056	1,263	915	464	481	372
Connecticut	4,507	12,127	4,563	4,010	3,544	3,687	3,921	1,732	1,740
New York	2,075	5,744	2,832	2,194	2,256	2,847	1,178	1,198	1,169
Pennsylvania	400	10,395	7,464	3,684	3,476	3,337	1,346	1,265	1,598
Virginia	3,180	6,181	7,013	5,230	3,973	2,886	4,119	1,204	629
North Carolina	2,000	1,134	1,281	287	3,920	....	....	1,105	697
South Carolina	4,000	2,069	1,650	1,650	....	....	....	....	139
Georgia	1,000	351	1,423	678	87	....	....	....	145
New Jersey	....	9,086	1,408	1,586	1,276	1,267	823	660	676
Delaware	....	754	299	349	317	566	69	164	235
Maryland	....	3,329	3,565	3,307	2,849	2,065	2,107	1,280	974
	37,623	63,061	44,920						

subject to the orders of the President, *ex-officio* Commander-in-Chief; this latter provision occuring after the adoption of the Constitution in 1789; when also the style and title of the Secretary were changed from Secretary at War to Secretary of War, which it has remained ever since. In 1812 the Quartermaster General's Department, Purchasing Department, and Ordnance Department were organized. After the close of the War of the Revolution, and when Washington had laid down his command, the Continental Army was soon disbanded. In 1798, when war with France was actually begun upon the sea, a new Army was hastily organized to repel the anticipated invasion of the United States of a French force. General Washington was placed in command and preparations for a long and doubtful struggle were carried into effect. But the Army was not called into action, negotiations with Napoleon I. reconciling the differences between the two countries, and the men were presently again disbanded. The Acts and 3 regiments and 5 battalions of Infantry; in 1794 an Act was also passed to establish various arsenals and military stores: and again another to organize a corps of Artillerists and Engineers: and to this was added in 1798 a second regiment of Artillerists and Engineers. The Act of May 28, 1798, in view of the prospective war with France, authorized the President to raise a provisional army of 10,000 rank and file, to be organized into corps of Artillery, Cavalry, and Infantry, and authorized also the appointment of a Lieutenant General, "to command the Armies of the United States."—General Washington being so appointed; and a supplementary Act (July 16, 1798) still further increased the authorization to the President by the number of 12 regiments of Infantry, with the necessary Commanding Officers and Staff, Line Officers, etc. The Act of March 3, 1799, abolished the title and office of Lieutenant General, and directed that the Commander of the Army of the United States should be commissioned by the title of the

Table showing the Number of Men and Casualties in the Regular and Volunteer Forces during the War with Mexico—1846 *to* 1848.

State.	Strength.	Killed.	Died of Wounds.	Wounded
Regular Army, including Marines	42,545	536	408	2,102
Alabama Volunteers	3,026	....	....	....
Arkansas "	1,323	19	2	32
California "	571	....	....	....
Florida "	370	....	....	....
Georgia "	2,132	6	....	8
Illinois "	6,123	86	12	160
Indiana "	4 585	47	....	92
Iowa "	253	....	....	....
Kentucky "	4,842	78	4	105
Louisiana "	7,947	13	2	8
Maryland and District of Columbia Volunteers	1,355	8	3	21
Massachusetts Volunteers	1,057	....	....	....
Michigan "	1,103	....	....	....
Mississippi "	2,423	54	1	108
Missouri "	7,016	20	3	46
New Jersey "	425	....	....	....
New York "	2,396	24	19	156
North Carolina "	935	....	....	....
Ohio "	5,536	18	....	39
Pennsylvania "	2,503	1	14	162
South Carolina "	1,077	30	26	216
Tennessee "	5,865	43	6	12
Texas "	8,018	42	4	29
Virginia "	1,320	....	....	1
Wisconsin "	146	....	....	....
Mormons "	585	....	....	....
Re-mustered "	844	4	1	3

of the Congress of the Confederation concerning the organization of the Army were, up to this time, as follows: The Act of September 29, 1789, by which "A corps of 700 rank and file (to be stationed on the frontier) to be organized, together with two companies of Artillery, raised by resolve of October 20, 1786:" and the Act of April 30, 1790, in lieu of the preceding Act, to regulate and establish one battalion of Artillery, and one regiment of Infantry, in all, 1216 men. In 1791, an Act was passed (March 3), organizing one additional regiment of Infantry; in 1792 to these were added one squadron of Light Dragoons, "General of the Armies of the United States." The opening of the war of 1812 with England brought about an increase of the Army by Congress, and directed that it should include 25 regiments of Infantry, with the necessary officers; and 20 regiments of Infantry in addition if needed, with 3 regiments of Riflemen. The Act of February 8, 1815, organizes the Ordnance Department; and that of March 3, 1815, fixed the Peace Establishment at not exceeding 10,000 men. In 1821 a still greater reduction was made; and when the Florida war broke out in 1834, the Army comprised the Staff, one regiment of Dragoons

4 regiments of Artillery, and 7 of Infantry, commanded by a Major General and two Brigadiers.

During the Rebellion the number of men enrolled and equipped in the Northern Armies was 2,690,401, including re-enlistments. They were organized into the Army of the Potomac, Army of the Tennessee, Army of the Cumberland, and Army of the Ohio; the last three being finally united into the Military Division of the Mississippi. These Armies were raised under proclamation by the President—each State furnishing its quota, according to population; by voluntary enlistment; and by enforced draft. Regimental organizations, when formed, were mustered into the Service of the United States, when they fell under the direction of the War Department, and were assigned to Brigades, Divisions, Corps, and Armies, as required. All General and General Staff Officers received their Commissions from the President; Line Officers being appointed before mustering into the U. S. Service. Towards the close of the war the difficulty of obtaining the volunteers so increased that large bounties were offered, in some cases amounting to as much as $1,500 dollars for one man. At the close of the war the Volunteer Army which was mustered out numbered about 1,100,000 men. The Regular Army was increased during the progress of the war from 18,000 to 50,000; since the war it has been reduced to 25 000.

About October, 15, 1879, the Army of the United States comprised 26,389 officers and enlisted men, divided as follows:

	OFFICERS.	ENLISTED MEN.
10 Cavalry Regiments	430	7,206
5 Artillery Regiments	278	2,387
25 Infantry Regiments	851	10,973
Engineer Battalion, Recruiting Parties, Ordnance Department, Hospital Service, Indian Scouts, West Point, and General Service	568	3,696
	2,127	24,262

The military arrangement of the Country for the distribution of the Army is as follows

1. Military Division of the Missouri, Headquarters Chicago; comprehends the Departments of the Missouri, Dakota, Texas, and Platte. In this Division there are 8 regiments of Cavalry and 18 of Infantry.

2. Military Division of the Pacific, Headquarters, San Francisco; includes the Departments of California; the Columbia; Arizona. It has 1 regiment of Artillery, 2 of Cavalry, and 4 of Infantry.

3. Military Division of the Atlantic, Headquarters New York; includes Department of the East; Department of the South. The Department of West Point is abolished. The Division includes 4 regiments of Artillery and 3 of Infantry. Under existing laws the maximum strength of the Army is 2,153 Commissioned Officers, and 25,000 enlisted men. See *Army*.

UNITED STATES INFANTRY AND CAVALRY SCHOOL.—This School, situated at Fort Leavenworth, Kansas, on the Missouri River, three miles from the city of Leavenworth, was established in December, 1881, the course of instruction being for two years. The objects of the School are: 1st, To supply the need of a course of military instruction to those officers of the Army who are not graduates of the United States Military Academy. 2d, To furnish graduates a course of instruction in the higher branches of the profession. The School is to consist habitually of not less than three Field-officers of Cavalry or Infantry, four companies of Infantry, four troops of Cavalry, and one light battery of Artillery. The officers for instruction, usually between forty and fifty, are: one officer from each regiment of Cavalry and Infantry nominated by Regimental Commanders, also Lieutenants belonging to companies which compose the garrison. All are placed on the same footing as regards military duties, practical and theoretical instruction. All are attached in turn to companies of Infantry and Cavalry, and the light battery, for the purpose of thoroughly acquainting each officer with the drill, as well as the ordinary routine duties of the different arms of service. Officers purchase their own text books, but other expenses are defrayed out of the post fund. The Senior Officer present for duty commands the School, the next five in rank constituting the Staff. The subjects for the School report in September of each odd year, are then examined and divided into two Classes. Such as show a fair degree of proficiency in English Grammar, Descriptive and Physical Geography, Arithmetic, Algebra, Plane Geography, General and U. S. History, and Composition are assigned in the First Class, all others to the Second. The subjects pursued by the First Class are:—Military, International, Constitutional and Municipal Law; Law of Evidence and Analysis of Civil Government; Elements of the Art of War and the Minor Operations of War, Field-fortifications, and Hamley's Operations of War; Tactics, Infantry, Cavalry, and Artillery; Instruction in the treatment and management of the horse; Business in the Adjutant-General's and Supply Department of the Army; Physical Geography; Trigonometry; Land and Higher Surveying with use of instruments; Drawing, Topographical and Mechanical, including map-making, reconnaissance sketching, use of simple instruments such as pocket and prismatic-compass, pocket-sextant etc., drawing plans and elevations of buildings; also Photography, Signaling and Telegraphy. The studies pursued by the Second Class are:—Geography, Grammar, Arithmetic, Algebra, Geometry, General and U. S. History; Military and International Law; Tactics, Infantry, Cavalry, and Artillery; Elements of the Art of War and Minor Operations of War; Field-fortifications; Hamley's Operations of War; Land Surveying, with use of instruments; Drawing, Topographical and Mechanical; Route-sketching, etc.; Regulations governing, and

STATISTICS OF THE UNITED STATES ARMY, 1789-1879.

Strength of Army.			Strength of Army.		
179	1 Reg't Infantry, 8 Bat. Art'y	840	1847	Mexican War......	17,812
1792	Indian border Wars.........	5,120	1884	" "	30,890
1794	Peace Establishment.........	3,629	1849-1855 ...	Peace Establishment........	10,320
1801	" "	5,144	1856-1861 ...	" " "	12,931
1807.	" "	3,278	1862	Civil War........................	39,273
1810	" "	7,154	1863-1866...	" "	43,332
1812	War with Great Britain......	11,831	1867	Peace Establishment	54,641
1815	" " " "	9,813	1868-1869 ...	" " "	52,922
1827-1821...	Peace Establishment.........	9,980	1870	" " "	37,313
1822 1832...	" "	6,184	1871	" " "	35,353
1833 1837...	" "	7,198	1872-1874...	" " "	32,264
1838-1842...	Florida War..................	12,539	1875-1879...	" " "	27,489
1843-1846...	Peace Establishment..	8,613			

methods of conducting business in the departments of Administration and Supply Departments of the Army, signalling and telegraphy. Each Class is divided into two Sections, membership being determined originally by the preliminary examination above referred to. Transfers between Sections and Classes are subsequently made at the regular examinations, which are semi-annual, as the results of these examinations seem to warrant. Proficiency is determined by a system of daily marks on a scale of 0. to 3.0 supplemented by semi-annual examinations. The practical course of instruction is so conducted by the means of daily drills, that upon completion of the course each student will have acted in the capacity of recruit in Cavalry and Artillery as well as Commander of a company and battalion (both Infantry and Cavalry) and as Chief of section and platoon in the light battery. Practical instruction is also given in the use of machine-guns and the Hotchkiss revolving-cannon. Proficiency in drill as well as promptness and punctuality in attendance upon the various duties imposed, and soldierly conduct in general, enter as large factors in determining the place of each student in the final general merit roll. Special mention is made at the final examination of each officer who is considered deserving of it, a report of which is forwarded to the Adjutant General. The Instructors are taken from among officers belonging to companies composing the garrison as well as a few who are specially detailed by the War Department. See *Artillery School.*

UNITED STATES MILITARY ACADEMY.—West Point, the site of the United States Military Academy and an important fortress during the Revolutionary War, is situated in Orange County, New York, on the west shore of the Hudson and about 52 miles from New York City. The Institution was founded by Act of Congress approved March 16, 1802. The experience of the country in the war of the Revolution convinced Washington and other statesmen of the need of such an Institution, and the Act above referred to was the result of much thought and discussion. The special object of the Academy is to fit young men for appointment as officers of the Army. It combines in one school all the purposes usually aimed at in the several schools of engineering and other military branches in foreign countries. Its graduates, upon receiving diplomas, are recommended for, and usually appointed into, the corps, or arm of service in the Army for which their qualifications fit them. It has no endowment, but is maintained by annual appropriations. Its buildings, valued at $2,500,000, stand upon a plateau of 160 acres, flanked by mountains at the west and north, and elevated 180 feet above the river. Chemical and Ordnance Laboratories, and the apparatus recently procured for the Department of Natural and Experimental Philosophy, are complete. The Library contains about 28,000 volumes, and over 2,500 pamphlets.

Each Congressional District and Territory—also, the District of Columbia—is entitled to have one Cadet at the Academy. Ten are also appointed *at large*. The appointments (excepting those *at large*) are made by the Secretary of War at the request of the Representative or Delegate, in Congress from the District or Territory; and the person appointed must be an actual resident of the District or Territory from which the appointment is made. The appointments *at large* are specially conferred by the President of the United States. Applications can, at any time, be made by letter to the Secretary of War, to have the name of the applicant placed upon the register that it may be furnished to the proper Representative, or Delegate, when a vacancy occurs. The application must exhibit the full name, exact age, and permanent abode of the applicant, with the number of the Congressional District in which his residence is situated. Appointments are required by law to be made one year in advance of the date of admission, except in cases where, by reason of death or other cause, a vacancy occurs which cannot be provided for by such appointment in advance. These vacancies are filled in time for the next annual examination. Should the Representative, or Delegate in Congress have reason to doubt the success of his nominee in passing the entering examination, he can nominate a legally qualified *alternate*. The alternate may be examined with the regular nominee in June and admitted in the event of his success and the latter's failure to pass the prescribed preliminary examinations, or may by permission delay reporting for examination, until the 25th of August following. Like the nominee, the alternate should be designated as nearly one year in advance of date of admission as practicable.

The age for the admission of Cadets to the Academy is between seventeen and twenty-two years. Candidates must be unmarried, at least five feet in height, free from any infectious or immoral disorder, and generally, from any deformity, disease, or infirmity which may render them unfit for military service. They must be well versed in reading, in writing, including orthography, and in arithmetic, and have a fair knowledge of the elements of English grammar, of descriptive geography, particularly of our own country, and of the history of the United States.

Each Cadet, soon after his *admission*, shall take the oath of office prescribed by Act of Congress of July 2, 1862, and *before receiving his warrant* shall, in the presence of the Superintendent, or some officer deputed by him, subscribe to an engagement in the following form:

I, —— ——, of the State of —— ——, aged —— years —— month , having been selected for appointment as a Cadet in the Military Academy of the United States, do hereby engage, with the consent of my (parent or guardian), in the event of my receiving such appointment, that I will serve in the army of the United States for eight years, unless soon-discharged by competent authority. And I, —— ——, *do solemnly swear* that I will support the Constitution of the United States and bear true allegiance to the National Government; that I will maintain and defend the sovereignty of the United States paramount to any and all allegiance, sovereignity, or fealty I may owe to any State, county, or country whatsoever; and that I will at all times obey the legal orders of my superior officers, and the rules and articles governing the armies of the United States.

Sworn and subscribed to, at , this —— day of ——, eighteen hundred and ——, before

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Every candidate is, soon after his arrival at West Point, subjected to a rigid physical examination by an experienced Medical Board, and if there is found to exist in him any of the following causes of disqualification to such a degree as would immediately or at no very distant period impair his efficiency, he is rejected:

1.—Feeble constitution and muscular tenuity; unsound health from whatever cause; indications of former disease; glandular swellings, or other symptoms of scrofula. 2.—Chronic cutaneous affections, especially of the scalp. 3.—Severe injuries of the bones of the head; convulsions. 4.—Impaired vision, from whatever cause; inflammatory affections of the eyelids; immobility or irregularity of the iris; fistula lachrymalis, etc., etc. 5.—Deafness; copious discharge from the ears. 6.—Loss of many teeth, or the teeth generally unsound. 7.—Impediment of speech. 8.—Want of due capacity of the chest, and any other indication of a liability to pulmonic disease. 9.—Impaired or inadequate efficiency of one or both of the superior extremities on account of fracture, especially of the clavicle, contraction of a joint, extenuation, deformity, etc., etc. 10.—An unusual excurvature or incurvature of the spine. 11.—Hernia. 12.—A varicose state of the veins of the scrotum or the spermatic cord (when large), sarcocele, hydrocele, hemorrhoids, fistulas. 13.—Impaired or inadequate efficiency of one or both of the inferior extremities on account of varicose veins, fractures, malformation (flat feet, etc.), lameness, contraction, unequal length, bunions, overlying or supernumerary toes, etc. etc. 14.—Ulcers or unsound cicatrices of ulcers likely to break out afresh.

The newly appointed Cadets are then examined by the Academic Board, and those not properly qualified are rejected.

In *Reading*, candidates must be able to read understandingly, and with proper accent and emphasis. In *Writing and Orthography*, they must be able to write, from dictation, sentences from standard pieces of English literature, both prose and poetry, sufficient in number to test their qualifications both in hand-writing and orthography.

In *Arithmetic* they must be able: 1st. To explain, accurately and clearly, its objects and the manner of writing and reading numbers entire fractional—compound or denominate. 2d. To perform with facility and accuracy the various operations of addition subtraction multiplication and division of whole numbers, abstract and compound or denominate, giving the rule for each operation, *with its reasons*, and also for the different methods of proving the accuracy of the work. 3d. To explain the meaning of reduction—its different kinds—its application to denominate numbers in reducing them from a higher to a lower denomination and the reverse, and to equivalent decimals; to give the rule for each case, *with its reasons*, and to apply readily these rules to practical examples of each kind. 4th. To explain the nature of prime numbers, and factors of a number—of a common divisor of two or more numbers, particularly of their *greatest common divisor*—with its use, and to give the rule, *with its reasons*, for obtaining it; also the meaning of a common multiple of several numbers, particularly of their *least common multiple* and its use, and to give the rule, *with its reasons*, for obtaining it, and to apply each of these rules to examples. 5th. To explain the nature of fractions, common or vulgar, and decimal—to define the various kinds of fractions, with the distinguishing properties of each—to give to all the rules for their reduction; particularly from mixed to improper and the reverse—from compound or complex to simple—to their lowest terms—to a common denominator—from common to decimal and the reverse; for their addition—subtraction—multiplication and division, *with the reason* for each change of rule, and to apply each rule to examples. 6th. To define the terms, ratio and proportion—to give the properties of proportion and the rules and *their reasons*, for stating and solving questions in both simple and compound proportion, or single and double rule of three, and to apply these rules to examples. 7th. The candidates must not only know the principles and rules referred to above, but they are required to possess such a thorough understanding of all the fundamental operations of arithmetic as will enable them to combine the various principles in the solution of any complex problem which can be solved by the methods of arithmetic. In other words, they must possess such a complete knowledge of arithmetic as will enable them to take up at once the higher branches of mathematics without further study of arithmetic. 8th. It is to be understood that the examinations in these branches may be either written or oral, or partly written and partly oral—that the definitions and rules must be given fully and accurately, and that the work of all examples, whether upon the blackboard, slate, or paper, must be written plainly and in full, and in such a manner as to show clearly the mode of solution.

In *English Grammar*, candidates must exhibit a familiarity with all the parts of speech and the rules in relation thereto; must be able to parse any ordinary sentence given to them, and, generally, must understand those portions of the subject usually taught and comprehended under the heads of Orthography, Etymology, Syntax and Prosody.

The examination will be either written or oral, or partly written and partly oral. The questions will usually be arranged in three divisions. The first division will contain questions somewhat like these: "*Name all the different kinds of Verbs, and give examples of each.*" "*What is a Pronoun?*" "*Write a short sentence using a personal, a relative, and an interrogative Pronoun, and then specify each.*" The second division will contain one or more sentences to be parsed, *e. g.*: "*Many would gladly exchange their honors for that more quiet and humble station with which thou art now dissatisfied.*" Such a sentence must be parsed *fully*, giving the part of speech, and kind, case, voice, mood, tense, number, person, degree of comparison, etc., as the case may be, of each word and its relation to the other words, thus: "*Many*:" adjective [or indefinite adjective pronoun], positive degree, third person, plural number, nominative case, agrees with *persons* understood [or subject of *would exchange*]. "*Exchange*:" verb, regular, transitive, active, potential mood, past tense, third person, plural number, agrees with *persons* understood [or *many*] for its subject. The third division will contain a large number of incorrect sentences to be corrected; thus: "*To these precepts are subjoined a copious selection of rule.*" "*Which of the two is the eldest?*" Among these, correct sentences will sometimes be introduced to more thoroughly test the knowledge of the candidate. Since the school-grammars used in different parts of the country vary among themselves in their treatment of certain words, an answer indorsed by any grammar of good repute will be accepted. Thus, in parsing the word "*many*," it may be called an indefinite adjective pronoun or an adjective agreeing with *persons* understood.

Candidates will be required to pass a satisfactory examination, written or oral, or both, in *Descriptive Geography*, particularly of our own country. To give a candidate a clear idea of what is required, the following synopsis is added as a type of the character and extent of the examination: 1st. Definitions of all the natural divisions of the earth's surface, such as zones, those relating to latitude and longitude, etc., are to be clearly and concisely given. 2d. The Eastern and Western Hemispheres. Their grand divisions, what large bodies of water partly or wholly surround them? Their oceans and their locations; the mountains, their locations, directions, and extent; the capes, from what parts do they project and into what waters? The peninsulas, their locations, and by what waters are they embraced? The parts connected by an isthmus, its name and location; the islands, their locations and surrounding waters; The seas, gulfs, and bays, the coasts they indent, and to what other waters are they subordinate? The straits, the lands they separate, and the waters they connect; the rivers, their sources, directions of flow, and the waters in which they empty; The lakes, their location and extent; 3d. The sub-divisions of the grand divisions; their names, locations, boundaries, and capitals; general questions of the same character as indicated in the second section, made applicable to each of the countries of each of the grand divisions. 4th. The United States. The knowledge under this head cannot be too full or specific. The candidates should be thoroughly informed as to its general features, location, configuration, and boundaries (both with respect to neighboring countries, and latitude and longitude); its adjacent oceans, seas, bays, gulfs, sounds, straits, and islands; its mountain ranges, their location and extent; the sources, directions, and terminations of the important rivers and their principal tributaries, the lakes, and, in short, every geographical feature of the country as indicated above. The location and termination of important railroad lines and other means of communication from one part of the country to another should not be omitted. The States and Territories should be accurately located with respect to each other by their boundaries, and as to their order on the Atlantic coast, on the Gulf of Mexico on the Pacific coast, on the Northern frontier, on the Mexican frontier, and on the Mississippi, Missouri, and Ohio Rivers. The boundary and other rivers of each State as well as all other prominent geographical features should be known. The names and locations of their capitals, and other important cities and towns are likewise to be known. In short, knowledge should be so complete that a clear mental picture of the whole or any part of the United States should be clearly impressed on the mind of the candidate.

The candidate should make himself familiar with so much of the *History of the United States* as is contained in the ordinary school histories. The examination may be written or oral, or partly written and partly oral, and will usually consist of a series of questions similar to the following: 1st.—Name the earliest European settlements within the present limits of the United States—when, where, and by whom made? When did the settlements made by other nations than the English, come under the Dominion of Great Britain, and of the United States? 2d.—What was the difference between the Royal, the Chartered, and the Proprietary colonies? How many colonies were there originally in Massachusetts and Connecticut? when were they united? How many in Pennsylvania? when were they separated? 3d.—In what wars were the colonies engaged before the Revolution? What were the principal events and results of those of King William, Queen Anne, King George, and the French and Indian? 4th.—What were the remote and the immediate causes of the American Revolution? Explain the Navigation Act, the Stamp Act, Writs of Assistance. When did the War of the Revolution properly begin? when, where, and how did it end? Give the particulars of Arnold's treason. Who were the most prominent generals in this war? Name the most important battles and their results. 5th.—The Constitution of the United States—why and when was it formed? when was it adopted? 6th.—Give the names of the Presidents of the United States in their order. Give the leading events of the administration of each one.

It is suggested to all candidates for admission into the Military Academy that, before leaving their place of residence for West Point, they should cause themselves to be thoroughly examined by a competent physician, and by a teacher or instructor in good standing. By such an examination any *serious* physical disqualification or deficiency in mental preparation would be revealed, and the candidate probably spared the expense and trouble of a useless journey and the mortification of rejection. It should be understood that the informal examination herein recommended is solely for the convenience and benefit of the candidate himself, and can in no manner affect the decision of the Academic and Medical Examining Boards at West Point.

Candidates are ordered to report in person to the Superintendent between the 1st and 20th of June, and with as little delay as practicable are subjected to the physical and mental examinations. Those who successfully pass both examinations are admitted as Cadets, subject to the result of the examination in the following January, and enter on their duties at once, without going to their homes. Those who successfully pass the January examination are required to sign articles binding themselves to serve the United States eight years from the time of their admission into the Academy, unless sooner discharged.

The academic duties and exercises commence on the first of September and continue until about the last of June. Examinations of the several classes are held in January and June, and at the former, such of the new Cadets as are found proficient in studies and have been correct in conduct are given the particular standing in their class to which their merits entitle them. After either examination, Cadets found deficient in conduct or studies are discharged from the Academy, unless for special reasons in each case the Academic Board should otherwise recommend. Similar examinations are held every January and June during the four years comprising the course of studies. These examinations are very thorough, and require from the Cadet a close and persevering attention to study, without evasion or slighting of any part of the course, as no relaxations of any kind can be made by the examiners. During the months of July and August the Cadets live in camp, engaged only in military duties and exercises and receiving practical military instruction. Except in extreme cases, Cadets are allowed but one leave of absence during the four years' course; and as a rule the leave is granted at the end of the first two years' course of study.

The Cadets are arranged in four distinct classes, corresponding with the four years of study. The Cadets employed on the first year's course constitute the Fourth Class; those on the second year's course the Third Class; those on the third year's course the Second Class; and those on the fourth year's course the First Class. The academic year commences on the 1st of July, on or before which day the result of the examination held in the preceding month is announced, and at no other time will a Cadet be advanced or transferred from one class to another, unless prevented by sickness, or authorized absence, from attending at the aforesaid examination; in which case special examination will be granted him; but in no case will a Cadet be advanced from one class to another without having passed a satisfactory examination by the Academic Board.

The following is the course of study at the United States Military Academy, the books marked thus *, being for reference:

FIRST YEAR.—FOURTH CLASS.

Department.	Text books and books of reference
Mathematics.	Davies' Elements of Algebra. Davies' Legendre's Geometry. Church's Plane and Spherical Trigonometry. Davies' Surveying. Church's Analytical Geometry.
Modern Languages.	Keetel's Analytical and Practical French Grammar. Agnel's Tabular System. Keetel's Analytical French Reader. *Spiers and Surenne's Dictionary. Whitney's Essentials of English Grammar. Hart's Manual of Rhetoric and Composition. Abbott and Seeley's English Lessons for English People. Abbott's How to Write Clearly. *Webster's Dictionary.
History, Geography and Ethics.	Lectures in Ethics and in Universal History.
Tactics of Artillery and Infantry.	Practical Instruction in the Schools of the Soldier, Company and Battalion. Practical Instruction in Artillery.
Use of Small Arms.	Instructions in Fencing and Bayonet Exercise. Farrow's Military Gymnastics.

SECOND YEAR—THIRD CLASS.

DEPARTMENT.	TEXT BOOKS AND BOOKS OF REFERENCE.
Mathematics.	Church's Analytical Geometry. Church's Descriptive Geometry, with its application to Spherical Projections. Church's Calculus. Church's Shades, Shadows and Perspective. Chauvenet's Treatise on the Method of Least Squares.
Modern Languages.	Keetels' Analytical and Practical French Grammar. Agnel's Tabular System. Borel's Grammaire Française. Bôtcher's College Series of French Plays. Rowan's Morceaux Choisis des Auteurs Modernes. *Spier's and Surenne's Dictionary.
Drawing.	Topography and plotting of Surveys with led pencil, pen and ink, and colors; construction of the various Problems in Descriptive Geometry, Shades and Shadows, and Linear Perspective and Isometric Projections; Practical Surveying in the field.
Tactics of Artillery, Infantry and Cavalry.	Practical Instruction in the Schools of the Soldier, Company and Battalion. Practical Instruction in Artillery and Cavalry.

THIRD YEAR—SECOND CLASS.

DEPARTMENT.	TEXT BOOKS AND BOOKS OF REFERENCE.
Natural and Experimental Philosophy.	Bartlett's Mechanics. Bartlett's Astronomy. Michie's Elements of Wave-Motion relating to sound and light.
Chemistry, Mineralogy and Geology.	Fowne's Chemistry. Thompson's Elementary Lessons in Electricity and Magnetism. Dana's Mineralogy. Le Conte's Elements of Geology.
Drawing.	Free Hand Drawing and Landscape in black and white. Constructive and Architectural Drawing in ink and colors.
Tactics of Artillery, Infantry and Cavalry.	United States Army Artillery Tactics. Tidball's Manual of Heavy Artillery Service, U. S. Army. United States Army Cavalry Tactics Upton's United States Army Infantry Tactics. Practical Instruction in the Schools of the Soldier, Company and Battallion. Practical Instruction in Artillery and Cavalry.
Practical Military Engineering.	Myer's Manual of Signals. Practical and Theoretical Instruction in Military Signaling.

FOURTH YEAR.—FIRST CLASS.

DEPARTMENT.	TEXT BOOKS AND BOOKS OF REFERENCE.
Civil and Military Engineering and Science of War.	Wheeler's Civil Engineering. Mahan's Stereotomy. Wheeler's Field Fortifications. Wheeler's Mahan's Elementary Course of Permanent Fortifications. Wheeler's Military Engineering. (Parts II. and III.) Wheeler's Elements of the Art and Science of War.
Modern Languages.	Vingut's Guide to Spanish and English. Morale's Progressive Reader. Ollendorff's Oral Method applied to the Spanish, by Velasquez and Simonne. *Seoane's Neuman and Baretti's Dictionary.
Law.	Woolsey's International Law. Cooley's General Principles of Constitutional Law in the United States. General Orders No. 100, A. G. O., 1863. Ives' Treatise on Military Law.
History, Geography and Ethics.	Swinton's Outlines of the World's History.
Practical Military Engineering.	Practical Instruction in the construction of Ponton and of Spar Bridges; in the preparation of Siege Materials; and in laying out field and siege works. Practical Instruction in Astronomy, in Surveying, in Military Reconnaissances, in Field Telegraphy and Night Signaling. *Ernst's Manual of Practical Military Engineering. Myer's Manual of Signals.
Tactics of Artillery, Infantry and Cavalry.	Practical Instruction in the Schools of the Soldier, Company and Battalion. Practical Instruction in Artillery and Cavalry.
Ordnance and Gunnery.	Benton's Ordnance and Gunnery. Practical Pyrotechnics. Practical Ballistics.

The pay of a Cadet is $540 per year, to commence with his admission into the Academy, and is sufficient with proper economy, for his support. No Cadet is permitted to receive money, or any other supplies, from his parents, or from any person whomsoever, without the sanction of the Superintendent.

Each Cadet must keep himself supplied with the following mentioned articles, viz: One gray cloth coatee; one gray cloth riding-jacket; one regulation great-coat; two pairs of gray cloth pantaloons, for winter; six pairs of drilling pantaloons, for summer, one fatigue-jacket, for the encampment; one black dress-cap; one forage-cap; one black stock; two pairs of ankle-boots; six pairs of white gloves; two sets of white belts; *seven shirts; twelve collars; *six pairs winter socks; *six pairs summer socks; *four pairs summer drawers, *three pairs winter drawers; *six pocket handkerchiefs; *six towels; one clothes-bag made of ticking; *one clothes-brush; *one hair-brush; *one tooth-brush; *one comb; one mattress; one pillow; two pillow-cases; *two pairs sheets; one pair blankets; one quilted bed-cover; one chair; one tumbler; one trunk; one account book; and will unite with his room-mate in purchasing for their common use, one looking-glass, one wash-stand, two wash-basins, two pails, and one broom, and shall be required to have one table, of the pattern that may be prescribed by the Superintendent. The articles marked thus* candidates are required to bring with them; the others are to be had at West Point at regulated prices; and it is better for a candidate to take with him as little clothing of any description as is possible (excepting what is marked), and no more money than will defray his traveling expenses; but for the parent or guardian to send to "The Treasurer of the Military Academy" a sum sufficient for his necessary expenses until he is admitted, and for his clothes, etc., thereafter.

The expenses of the candidate for board, washing, lights, etc., prior to admission, will be about $5 per week, and immediately after being admitted to the Institution he must be provided with an outfit of uniform, etc., the cost of which will be about $90. If, upon arrival, he has the necessary sum to his credit on the books of the Treasurer, he will start with many advatages in a pecuniary point of view, over those whose means are more limited, and who must, if they arrive, as many do, totally unprovided in this way, go in debt on the credit of their pay—a burden from which it requires many months to free themselves; while, if any accident compel them to leave the Academy, they must of necessity be in a destitute condition.

When a Cadet shall receive a regular degree from the Academic Board, after going through the classes, he is considered as among the candidates for a commission in the Engineers Ordnance, Artillery, Infantry, or Cavalry, according to the duties he may be judged competent to perform.

A sound body and constitution, suitable preparation, good natural capacity, an aptitude for study, industrious habits, perseverance, an obedient and orderly disposition, and a correct moral deportment are such essential qualifications that candidates, knowingly deficient in any of these respects, should not, as many do, subject themselves and their friends to the chances of future mortification and disappointment by accepting appointments at the Academy and entering upon a career which they cannot successfully pursue.

The following schedule shows the employment of time at the United States Military Academy:

Class.	From reveille to 6.30 P.M.	From 6.30 A.M. to 8 A.M.	From 8 A.M. to 11 A.M.	From 11 A.M. to 1 P.M.	From 1 P.M. to 2 P.M.	From 2 P.M. to 4 P.M.	From 4 P.M. to sunset.	From sunset to "evening call to quarters."	From evening "call to quarters" to 9 P.M.	half-past 9 P.M. to 10 P.M.
FIRST.	Roll-call immediately after reveille—Police of quarters—Cleaning arms, accouterments, etc.—Inspection of rooms 25 minutes after reveille roll-call.	Breakfast at 6.30—Guard-mounting at half-past 7—Recreation—Class parade at 7.	Recitation in Civil and Military Engineeri'g; also Science of War, etc., — or drawing in all these branches of study —Study.	Recitation in Ordnance and Gunnery—Cavalry Exercises—Study.	Dinner at 1—Recreation—Class parade at 2.	Recitation in Law — Ordnance and Gunnery — Mineralogy and Geology—Study.	Military exercises—Recreation—Military signals and telegraphy—Parade at sunset.	Supper after parade—Recreation—Evening call to quarters.	Study.	Tattoo at half-past 9—Signal to extinguish lights and inspection of rooms at 10.
SECOND.			Recitation in Natural and Experimental Philosophy—Study.	Recitation in Ceemical Physics and Chemistry—Cavalry Exercises—Study.		Drawing—Landscape with Lead-pencil and Landscape with colors — Recitations in Tactics—Study.			Study.	
THIRD.			Recitation in Mathematics—Study.	Recitation in French—Spanish—Study.		Drawing—Topography with lead-pencil, pen and ink and colors—Figures with pen and ink — Study — Cavalry Exercise.			Study.	
FOURTH.			Recitation in Mathematics—Study.	Use of the Sword, etc.—Study.		Recitations in French Study.			Study.	

For instruction in Infantry Tactics and in military police and dicipline, the Cadets are organized into a battalion of four companies, under the Commandant of Cadets, each company being commanded by an officer of the Army. The Officers and Non-commissioned Officers are selected from those Cadets who have been most studious, soldier-like in the performance of their duties, and most exemplary in their general deportment. In general, the Officers are taken from the First-Class; the Sergeants from the Second Class; and the Corporals from the Third Class. See *Royal Military Academy*.

UNIVERSAL TELEGRAPH.—This common means of signaling consists of an upright post of moderate height, of two movable arms fixed on the same pivot near the top of it, and of a mark called an indicator on one side of it, merely to distinguish the low numbers 1, 2, 3, from the high numbers, 7, 6, 5. One lantern called the central light, is fixed to the same pivot upon which the arms move. Two other lanterns are attached to the extremities of the arms. A fourth lantern, used as an indicator, is fixed on the same horizontal level with the central light at a distance from it equal to twice the length of the arm, and in the same plane nearly in which the arms revolve. Hence the whole apparatus consists of two fixed and of two movable lights—four in all. The number of telegraphic signs, combinations, or changes which this telegraph is capable of exhibiting is shown in the accompanying table. The number is amply sufficient for telegraphic communication whether by alphabet or by reference to a telegraphic dictionary of words and sentences. The indicator, both by day and night, is merely a mark and nothing more, and the central light by night and the post by day are also merely guides to the eye. The signs of the telegraph are in reality, therefore, only composed of combinations of two movable bodies by day and two lights by night. It has been ascertained by experiment that the arms for day signals should be about 1 foot in length per mile in order to be distinguished by a common portable telescope. By the above rule, a telegraphic arm of six feet in length may suffice for stations six miles apart, but it is better to add a little to these dimensions. The width of the arm need not exceed $\frac{2}{13}$ of its length. The indicator should be of the same width, but only $\frac{1}{2}$ of the arm in length. The height of the post should be such that movable objects near it should not obscure the indicator or arms when the telegraph is erected in the field. The telegraphs hitherto constructed on this principle are of two sizes: one having arms of $5\frac{1}{4}$ feet in length, with the lantern pivots placed $6\frac{1}{2}$ feet from the center of motion; the other having arms $2\frac{1}{2}$ feet in length only, with the lantern pivots 3 feet 2 inches from the center of motion. The latter are perfectly portable, as the whole apparatus does not weigh more than 34 lbs. In clear weather these small telegraphs make signals distinctly visible at a distance of three miles. In cases of emergency, where the portable telegraph is not with an army, it has been ascertained by experiment that the most expeditious and satisfactory arrangement will always be to copy the regular construction as closely as circumstances will permit. A post, with two planks for the arms fixed externally on each side of the post, each worked merely by a couple of strings without pulleys, will constitute a day telegraph, and the addition of lanterns will convert the same simple apparatus into a night telegraph. In both cases the arms must be counterposed by wood or iron, and also by weights in some rude manner, which must not impair the clearness of the telegraphic signs. See *Telegraph*.

TABLE OF THE SIGNS OR COMBINATIONS.

Positions.	*Appearance.*	*Positions.*	*Appearance.*
1	* * * *	25	* * * *
2	* * * *	26	* * * *
3	* * * *	27	* * * *
4	* * * *	31	* * * *
5	* * * *	35	* * * *
6	* * * *	36	* * * *
7	* * * *	37	* * * *
12	* * * *	45	* * * *
13	* * * *	46	* * * *
14	* * * *	47	* * * *
15	* * * *	56	* * * *
16	* * * *	57	* * * *
17	* * * *	67	* * * *
23	* * * *	STOP.	* * *
24	* * * *	FINISH.	* *

UNLIMBER.—To disconnect the limber from the gun or carriage. It is performed with light field carriages by two of the gunners, sometimes assisted by a third, taking hold of the trail handles and lifting the trail off the pintail hook.

UNSADDLE.—A command in the School of the Soldier Mounted, directing the removal of the saddle from the back of the horse. The command is executed as follows: Unbuckle and remove the surcingle, throw over the left stirrup, unbuckle the girth, step to the right side, passing by the head, throw over the girth and the right stirrup, and return to the left side, passing by the head; seize the pommel with the left hand, the cantle with the right; remove the saddle and place it on the ground in front of the horse, pommel to the front; take off the blanket, double it, and lay it on the saddle, folded edge to the front. In the stable, hang the saddle on its peg as soon as taken off the horse. See *Saddle*.

UNSLING CARBINE.—A command given to troops armed with the carbine, executed as follows: The Instructor commands:—1. *Unsling*, 2. CARBINE. Grasp the carbine at the small of the stock with the right hand, bring it to the front, and take the position of the first motion of *sling carbine*; free the swivel from the ring, and carry it to the rear with the right hand; grasp the carbine with the right hand at the small of the stock. (Two.) Resume the carry with the right hand. (Three.) Drop the left hand by the side. See *Manual of Arms*, and *Sling Carbine*.

UNSPIKE. To unspike a gun, try to drive the spike into the bore with a punch; if there be a shot wedged in the bore, expel it by powder inserted through the vent. When it is impossible to drive down the spike, if the bore be unobstructed, insert a charge of one-third the weight of the projectile, and ram down junk wads with a handspike, first placing on the bottom of the bore a strip of wood with a groove on the lower side containing a strand of quick-match, by which the charge is ignited; this plan will not answer when the spike is screwed or rivited into the vent. In a bronze gun, remove some of the metal at the upper orifice of the vent, and pour sulphuric acid into the cavity before firing. Should the preceding methods fail, after several trials, drill out the spike, or drill a new vent, if the gun be iron; if it be bronze, unscrew the vent-piece. See *Disabling Cannon*.

UNTERER.—One of the three parts of which the enciente is formed, in the German System of Fortification.

UPBRAIDING.—The Articles of war declare that any officer or soldier who upbraids another officer or soldier for refusing a challenge shall himself be punished as a challenger; and all officers and soldiers are hereby discharged from any disgrace or opinion of disadvantage which might arise from their having refused to accept challenges, as they will only have acted in obedience to the law, and have done their duty as good soldiers, who subject themselves to discipline.

UPDEGRAFF RIFLE. A breech-loading small-arm having a fixed chamber closed by a movable breech-block, which rotates about a horizontal axis at 90° to the axis of the barrel, lying below the axis of the barrel and in front—being moved from above by a thumb-piece. By bringing the hammer to the full-cock, a link connecting its under surface with that of the breech-block throws the latter down into the position of loading. The hammer when released moves forward to the half-cock notch, and changes its point of bearing on the block to the other side of the center of motion, by engaging with a second link like that above mentioned. As the breech-block opens, the firing-pin is withdrawn. The piece is closed by again bringing the hammer to the full-cock, the action of the link being reversed from the change of its bearing on the block. This can also be done by hand in the usual way. The piece is locked by the descent of the hammer beneath the block when the piece is fired. Extraction is accomplished by a disk pivoted on a hub formed on the side of the breech-block, and provided with the necessary radial arms. This disk is recessed for the head of the firing-pin retractor. Ejection is secured by accelerating the movement of the extractor, by a quick blow which it receives from the nearest link, at its release in the act of opening the piece.

USE.—In the foundry, a slab of iron welded to the side of a bar near the end, to be drawn down by the hammer in prolongation of the length of the bar. One mode of building up heavy shafts.

USHER OF THE BLACK ROD.—One of the officers of the Order of the Garter, coeval with the institution of the Order, and originally called "Hostiarius capellæ regis infra castrum de Windsor." The rod from which his title is derived is of ebony, mounted with gold 3½ feet in length, having at the top a lion sejant, holding before him in his forepaws a gold shield charged with the royal cipher in gold surrounded with the Garter. He has a mantle like that of Garter King of Arms, and his badge is a gold knot surrounded with the Garter, and ensigned with the Royal Crown. It is the practice to unite this office with that of the King's First Gentleman Usher daily waiter at Court, who is one of the chief officers of the House of Lords. In this capacity it is one of the functions of the Gentleman Usher of the black rod, or of his Deputy, who is known as the Yeoman-usher of the black rod, to desire the attendance of the Commons in the House of Lords when the royal assent is to be given to bills by the Sovereign or Lords Commissioners; also to execute orders of commitment for breach of privilege and contempt, and to assist at the introduction of Peers, and other ceremonies of the Upper House.

USHER OF THE GREEN ROD.—One of the officers of the Order of the Thistle, whose duties consist in attending on the Sovereign and Knights when assembled in chapter, and at other solemnities of the Order. The rod from which the title is taken is of green enamel, three feet in length, ornamented with gold, having on the top a unicorn of silver, holding before him an escutcheon charged with the cross of St. Andrew.

UTENSILS. — Utensils for camp and garrison are styled Camp and Garrison Equipage, and are furnished by the Quartermaster's Department. The Regulations allow: a General Officer, three tents in the field, one axe and one hatchet; a Field or Staff Officer above the rank of Captain, two tents in the field, one axe and one hatchet; other Staff Officers or Captains, one tent in the field, one axe and one hatchet; Subalterns of a company, to every two, one tent in the field, one axe and one hatchet; to every 15 foot and 13 mounted men, one tent in the field, two spades, two axes, two pickaxes, two hatchets, two camp kettles, and five mess pans. Bed sacks are provided for troops in garrison, and iron pots may be furnished to them instead of camp kettles. Requisitions are sent to the Quartermaster General for the authorized flags, colors, standards, guidons, drums, fifes, bugles and trumpets. The prescribed cooking utensils are evidently not adapted to field-service. The soldier is made too dependent on a baggage-train. Some tools deemed necessary for service in the French Army are also omitted in the enumeration of camp equipage at present furnished to the United States troops.

V

VAERFVADE.—The standing army of Sweden, recruited by voluntary enlistment. They receive pay and serve from three to six years. They form the Foot and Horse Guards, the Artillery and Engineers.

VAIR.—In Heraldry, tinctures are either of metal, color strictly so called, or fur. The *furs* were originally but two, *ermine* and *vair*. The former is represented by black spots resembling those of the fur of the animal called the ermine, on a white ground. *Vair*, said to have been taken from the fur of a squirrel, bluish-gray on the back and white on the belly, is expressed by blue and white shields, or bells in horizontal rows, the bases of the white resting on the bases of the blue. If the vair is of any other colors than white and blue, they must be specified. Various modifications of these furs were afterwards introduced, among others *ermines*, or ermine with the field sable and the spots argent; *erminites*, with a red hair on each side of the black spot; *pean*, with the field sable, and the spots or; *counter-vair*, or vair with the bells of one tincture placed base to base; and *potent counter-potent*, vair with crutch-shaped figures instead of bells. See *Heraldry*.

VAIVODE.—An old Sclavonian word which signifies Prince or General. This title was formerly given to the Sovereign Princes of Wallachia, Moldavia, and Transylvania.

VALENCIENNES.—A pyrotechnic composition, composed of 50 parts of nitre, 28 of sulphur, 18 of antimony, and 6 of rosin. It is commonly used as an incendiary composition, in charging shells for the purpose of increasing their destructive property, by setting fire to buildings, shipping, etc.

VALETUDINARIUM.—An infirmary or hospital for the sick. Among the Romans, the *valetudinarium*, or hospital, was only established in war time, when their armies marched beyond the boundaries of the Republic.

VALISE.—A cylindrical portmanteau of leather, 18 inches long, placed on the saddle of each off-horse of an artillery-carriage, and used for carrying the smaller articles of the driver's personal equipment. The valise is carried on a *valise-saddle*, which may be employed as a riding-saddle in case of any necessity.

VALLARY CROWN. A crown bestowed by the ancient Romans as an honorary reward on the soldier who first surmounted the outworks, and broke into the enemy's camp. It is in form a circle of gold with palisades attached, as shown in the figure. The crown vallary occasionally occurs as a heraldic bearing.

Vallary Crown.

VALLUM. Among the Romans, the parapet which fortified their encampments. It consisted of two parts, the *agger* and the *sudes*; the agger was the earth thrown up from the vallum, and the sudes were a sort of wooden stakes to secure and strengthen it. *Vallus* was the name of the stake which served as a palisade in the Roman intrenchment. Every soldier carried one of these *valli*, and on some occasions three or four of them securely bound together much like a fagot.

VALOR. Strength of mind in regard to danger: a generous quality, which, far from assuming brutality and violence, withholds the fury of the soldier, protects helpless women, innocent infants, and hoary age. Nothing which is incapable of resistance can ever be the object whereon true valor would exercise its prowess. Courage is that grandeur of soul which prompts us to sacrifice all personal advantages, and even the preservation of our beings, to a love of doing our duty. The exercise of this determined courage in the profession of arms is called *valor*. It is composed of bravery, reason, and force: by bravery, we understand that lively ardor which fires us for the combat; reason points out to us the method of conducting it with justice and prudence; and force is necessary for the execution. It is bravery which animates the heart, reason springs from the soul, and force depends upon the body. Without bravery, we fear obstacles, danger, and death; without reason, courage would have no legitimate view; and without force, it would be useless: these three qualities should concur to form true military valor. In our own Army, repeated acts of valor have been recorded, with which the reader of military history is doubtless acquainted: and such is the appreciation of bravery by both Sovereign and Country in England that the beautiful decoration of the Victoria Cross has been specially instituted as a reward for distinguished valor.

VAMBRACE.—That part of ancient armor known as the brassard; it thoroughly protected the arm below the elbow.

VAMBRACED.—In Heraldry, a term applied to an arm clothed in armor, as in the subjoined crest: a dexter arm embowed vambraced proper, the gauntlet holding a sword below the hilt in bent sinister, point downwards, argent, both the hilt and pommel or.

Vambraced.

VAMPLATE.—A round piece of iron on a tilting-spear, used to protect the hand.

VAN. The front of an army; the first line, often called the *vanguard*. The troops marching in the front of an army. See *Advanced-guard*.

VANCHOATE GUN.—A breech-loading rifle having a fixed chamber closed by a movable breech-block, which slides in the line of the barrel by direct action. It is opened by first cocking the piece, then raising the handle of the breech-bolt to a vertical position, and then withdrawing the bolt until it is arrested by striking against the upper end of the recoil screw. In raising the handle, the beveled surface of the head of the firing pin bears against the tip of the recoil-screw, and thus positively retracts the firing-pin. In withdrawing the bolt, it rides over the hammer and presses it back to the full-cock. The piece is closed by reversing the motion of the bolt. The tip of the recoil-screw prevents the firing-pin from moving forward until the breech is fully closed. It is locked by the base of the bolt-handle falling into a mortise in the side of the receiver. The piece is fired by a centre-lock of the usual pattern. Extraction is accomplished by a spring-hook upon the side of the bolt. Ejection is caused by a sliding ejector playing into a groove in the bottom of the bolt, and, in the act of withdrawing the bolt, struck forcibly against the tip of the recoil-screw. This throws the shell around the hook of the extractor by which it is held, and expels it completely from the gun. It is impossible to move the bolt, in this arm, unless the hammer is at full-cock.

VAN-FOSS.—In fortification, a ditch dug without the counterscarp, and running all along the glacis usually full of water.

VANGUARD.—That part of an army which marches in front. See *Advanced-guard*.

VANT BRAS.—An old name for the armor for the arm.

VARNISH. A solution of rosin, or of a gum rosin, in a liquid, which, when spread thinly over a solid surface, evaporates and leaves the solid in the form of a brilliant, transparent film. The principal substances used in varnishes are named in the following table:

Solvents.	Solids.	Colors.
Oil of nuts..........	Amber...........	Gamboge, annatto.
Oil of linseed....... Oil of turpentine...	Anime Copal	Dragon's blood a deep, reddish-brown.
Oil of rosemary....	Lac...............	Aloes, cochineal
Alcohol ether.......	Sandarac Mastic ...	Saffron, indigo.
Wood naphtha, or pyroligneous ether.	Dammer Common Rosin.	Turmeric.....

The rosins, or as the varnish maker calls them, gums, may be used either singly or combined, and the same remark applies to the solvents. One of the most desirable qualities in a varnish is durability a quality, which depends greatly on the comparative insolubility of the resin employed, its hardness, toughness, and permanence of color. The following is a good varnish for polished iron-work, tools, etc.: spirit of turpentine, 4 lbs., dammer, 1 lb. It is made as follows: Put the spirit of turpentine into a large bottle, pound the dammer very fine, and pour it gradually into the bottle, keeping the composition at intervals well stirred. When all the dammer is well mixed, place the bottle in the sun for 3 or 4 hours and when thoroughly amalgamated, the composition is fit for use. Apply lightly: the varnish quickly dries, and is almost imperceptible. *To keep rust from iron*: Pure grease, 6 lbs., rosin, 2 lbs. Pound the rosin fine, boil the grease, and after skimming it from any impurities, mix the rosin well with it, then cool the mixture, and apply it to your iron-work. See *Lacquer*.

VARYING ELASTICITY.—If the inner hoop of a "built-up" gun is very elastic, and the next less elastic, and so on throughout the series, the outer hoops being the least elastic, and the degree of elasticity being exactly proportioned to the degree of elongation by internal pressure, all the hoops will be equally strained by the powder, and none of their strength wasted. It is found difficult to obtain materials having the respective ranges of elasticity necessary to perfectly carry out this system. For this reason the outer tube or tubes are sometimes put under an initial tension equal to the working load, in order that the work done may be equal for all. This severe and permanent strain on the outer tube, of course, tends to relax it; but if the inner tube can stretch very much without injury, and the outer tube can only stretch a little, the permanent strain upon all parts of the gun, in order that it may be uniformely strained under fire, will be slight, and the tendency to relaxation limited.

Care must be taken to have sufficient longitudinal strength. The theoretical resistance of a cylinder under internal pressure to cross-fracture is from times as great as its resistance to splitting longitudinally, if the tenacity of the metal is the same in all directions. To obtain strength in this direction, some circumferential strength may be sacrificed by making one part the length of the entire gun, and of adequate thickness. It is probably better that this single large piece should be inside, and this is the general practice. Hoops of considerable length are desirable to add to the frictional surface, thus giving longitudinal strength to the gun. But length or continuity is chiefly desirable to transfer the strain upon one point to a large resisting area. An obvious disadvantage of a large number of hoops is that the transverse strength of the gun is much reduced. A hooped gun must always possess the defect of want of continuity of substance. However perfect the workmanship at first, in large guns the jar of repeated firing would soon shake them loose. The great defect in the Armstrong guns was developed in the shaking loose and fracturing of some of the hoops under the tremendous vibration due to firing large charges.

Both the means, that have been considered, of increasing the resistance of a gun to *mere pressure*, are perfected only in proportion to the number of separate tubes or layers employed; but on the other hand, increasing the number of parts lessens the resistance of the body to the effect of *sudden strain*. When a gun is fired, the shock is propagated from layer to layer in a wave; if the layers are already detached tubes, the outer one has no help from the rest in resisting the vibration,and the only way to modify the effect of the wave of force upon the outer layer is to give that layer great mass and thence inertia. Merely thickening the walls of a gun beyond a certain point adds very little to its resistance to internal pressure. A homogeneous gun, in a state of initial repose, however thick it may be, cannot sustain permanently a pressure per square inch greater than the tensile strength of a square inch of the metal of which it is composed. The reason is that the inner layers of metal are more stretched and strained by an internal pressure than the outer layers, in the inverse ratio of the squares of their radii. Therefore, the layers must be placed under such initial strain, or must possess such varying elasticity that all parts of the gun will be equally worked at the instant of firing. Both these conditions are perfectly carried out in proportion to the number of separate layers or tubes thus treated; but the wave of force (in distinction from statical pressure),and the effects of unequal vibration, *distress* a gun in proportion to the number of its parts, so that the building-up principal cannot be carried far without depriving the gun of the necessary mass and continuity of substance.

The system of hoops with initial tension, although theoretically perfect and an acknowledged improvement in the construction of ordnance, involves certain practical difficulties. When several thicknesses of hoops are used, it is difficult to maintain the proper longitudinal strength, and it has been found that a gun composed of two or three tubes, although not so strong to resist statical pressure as one composed of five or six tubes, would resist a greater number of heavy charges of gunpowder and prove a more trusty weapon. With the present materials, it would be almost impossible to insure uniformly a degree of elasticity in the different layers, exactly proportional to their respective elongations under fire. The Initial Tension system, slightly modified, may be brought to the aid of the system of Varying Elasticity. If the internal tube of a gun cannot stretch to the extent required without injury, placing the external tube in slight tension will remedy the defect; then the inner tube will have a greater range of safe elongation, and the outer tube will take a greater share of the strain. See *Built-up Guns*, *Cannon*, *Initial Tension* and *Ordnance*.

VARVELED.—In Heraldry, when the leather thongs which tie on the bells to the legs of hawks are borne flotant with rings at the end, the bearing is termed *jessed*, *belled*, and *varveled*.

VAUBAN SYSTEM OF FORTIFICATION.—Among the most noted methods of the bastioned system that have exercised a controlling influence upon the profession, are those of Vauban and Cormontaigne. Both of these engineers had a large experience in the construction, and in the attack and defesne of fortified places. The results of their labors are still looked upon as safe guides to the military engineer. Vauban has left examples of three different methods in the places planned by him. The fortress of New Brisac is fortified after his third method; Those of Landau and Belfort after his second; but the greater part of the places fortified by him are planned according to his first or earliest method. Vauban adopted no arbitrary or invariable combination of parts in his methods. His great excellence as an engineer is shown in the skill with which he adapted the fortifications he planned to the defensive requirements of the sites; selecting long, medium, or short exterior sides, and varying the lengths and directions of the faces and flanks so as to procure the best command over the exterior ground,and to withdraw these parts from the enfilading fire of the assailant. In his works, however,he has generally taken 360 yards as the greatest limit of the exterior side; the perpendicular of the front $\frac{1}{8}$ when the polygon is a square; $\frac{1}{7}$ for the pentagon; and $\frac{1}{6}$ for all higher polygons. With these starting-points he procured diminished angles which gave more than 60° to the sailent angles of the bastions in all cases, and flanks of suitable length both to flank the main ditch and to encounter with advantage the counter batteries which could be erected against them. Vauban followed no invariable rule in regulating the dimensions of the enceinte ditch; its most usual width at the salients of the bastions where the counterscarp is an arc of a circle,is about 36 yards; the rest of the counterscarp is tangent to this arc,and directed upon the opposite shoulder angles. All the outworks of this system are commanded by the enceinte; the outworks most advanced being also commanded by those in rear. In many of the places constructed before Vauban's time there was a *fausse-braie*, enveloping the enceinte and connected with it. This work was suppressed by Vauban, who was the first, to use the tenaille in its place. The tenaille is separated from the curtain by a ditch 10 yards wide, and from the flanks by ditches of 6 yards.

The form of the tenaille as used by Vauban was variable. In some cases he made it with a curtain and two small flanks parallel to those of the enceinte; in others it consisted simply of two wings placed on the prolongations of the faces; and finally, he gave it a small curtain and two wings, which is the form at present most generally adopted. The relief of the tenaille is so arranged as not to mask the fire of the flanks on the ditch of the enceinte along the faces; for this purpose Vauban places its interior crest on a level with the site or a little below it. Vauban increased the dimensions of the demi-lune, which had been used previous to his time. The plan and dimensions of the demi-lune vary also in Vauban's works. Its magistral is generally laid out by taking a point on bastion face at 10 yards from the shoulder angle, and drawing a line from this point to the perpendicular of the front, so as to make the face of the demi-lune equal to ⅔ of the exterior side. To strengthen the demi-lune, and secure for the troops entrusted with its defense a safe retreat when it is carried, Vauban placed in it a small redoubt. This work, in some instances, was only a simple *loop-holed wall* with a ditch in front; sometimes it was made of earth, and after the commencement of the siege. The covered-way envelopes the entire counterscarp. The general width of the covered-way is 12 yards. To set out the re-entering place-of-arms, two points are taken at 20 yards from the re-entering angle, made by the interior crests of the covered-ways of the demi-lune and bastion, and upon these crests, and from these points as centers with radii of 24 yards, arcs are described; the point of their intersection being joined with the centers gives the crests of the re-entering place-of-arms. The parapet of the covered-way is terminated in a glacis, the foot of which is from 40 to 50 yards from the interior crests. To close the places-of-arms, and enable the troops to defend the covered-way foot by foot, traverses of earth formed into parapets are placed at the places-of-arms. Defiles or passages of four feet are left between the traverses and the crest of the covered-way, for the circulation of the troops. The covered-way is palisaded to prevent surprise. In Vauban's front, ramps are made to ascend from the plane of site to the terre-plein. A postern is made under the curtain to communicate from the interior with the ditch; another postern is made under the tenaille to lead to the demi-lune. A *double caponnière*, which is a passage covered on each side by a parapet terminated in a glacis towards the ditch, covers the communication through the ditch to the gorge of the demi-lune. Single caponnières are placed in the ditch of the demi-lune, and cover the troops from the enemy's fire through its ditch. Stairs are placed at the gorges of the tenaille and demi-lune, and along the counterscarp at the places-of-arms, to ascend from the ditch to the terre-pleins of those works. To communicate with the exterior, narrow openings are made in the faces of the re-entering place-of-arms, to lead from the terre-plein to the glacis; they are termed *sortie-passages* or *sally-ports*; and are closed by barriers.

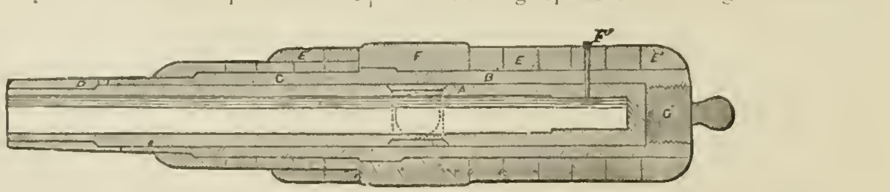
In the *trace* adopted by Vauban for the enceinte, it may be observed that the length and positions of the lines of the front, resulting from it, are in good defensive relations both for cannon and small-arms. 1. The foot of the scarp, throughout the length of the curtain and the bastions, is thoroughly swept by the fire of the flanks. 2. The length of the flank is sufficient to contain at least as many cannon as the assailant can place to counter-batter the flank from the glacis crest opposite; and the flank can also bring an efficient fire of small-arms to bear on this battery of the assailant. 3. The bastions are capacious, and would admit of efficient interior intrenchments being thrown up in them, although Vauban does not indicate this auxiliary in his first method. 4. The tenaille was devised mainly to mask the scarp wall of the curtain and flanks, whilst its relief was so regulated as not to intercept the fire of the flanks on the enceinte ditch before the bastion faces. The tenaille, however, only partially subserves its object, as it does not cover the entire scarp of the enceinte curtain and flanks; and what is a more serious defect, it leaves the entire height of scarp of that portion of the curtain, opposite to the ditch between the tenaille and the bastion flank, quite entirely exposed, from the same position, and rather liable to be breached. 5. From the very small size of the demi-lune, it gives but little cover to any portion of the enceinte scarp except the curtain. It is not sufficiently thrown to the front to give a good volume of cross-fire on the glacis in advance of the bastion salients; and the re-entering formed at this point, by the two adjacent demi-lunes, is, from the same cause, shallow and of but little strength. Owing to this last defect the assailant can easily breach and storm the enceinte at the same time as the demi-lune. Besides these defects the demi-lune is not provided with a permanent redoubt, a work necessary to enable the demi-lune to make a vigorous defense, by the support it affords the assailed. 6. From the width given to the demi-lune ditch, the covered-ways are exposed to a slant reverse fire, from which they are but badly screened by the traverses. Their command over the site is rather too little. Their main defect, however, is the small size given to the re-entering place-of-arms, and the failure to secure this important position for assembling troops for sorties by a permanent redoubt, by which any open attack of the covered-way could be repulsed. 7. The dimensions given both to the enceinte and demi-lune ditches present a formidable obstacle to an open assault, and render the assailant's passage of the ditch by the sap also more difficult. The demi-lune ditch, however, offers a wide opening through which the scarp of the bastion-face can be seen down to its foot from the assailant's batteries on the glacis crest in the prolongation of the demi-lune ditch. 8. The communications within the enceinte, and from it to the main ditch, are sufficient and convenient for the character of the defense designed. Those of the outworks are for the most part narrow, inconvenient, and but badly screened from the assailant's fire, and therefore do not furnish a good provision for an active defense beyond the enceinte. 9. The great command over the site, and the high relief given to the enceinte, are very much in favor of the defense both as to the effect of the fire on the assailant's approaches and for security against an escalade. But in attaining these objects Vauban has left exposed to the assailant's distant fire a considerable portion of the scarp wall, which, being breached, would render an open assaults practicable. See *Fortification* and *System of Fortification*.

VAUMURE.—In old fortresses, a low work under the wall in the nature of a *fausse-braie*.

VAUNT MURE.—In fortification, any false wall; a work raised in front of the main wall. Also written *Vaimure* and *Vamure*.

VAVASSEUR GUN.—The Vavasseur system consists of a steel tube with hoops of the same material. The strength is cast more upon the hoops and less upon the tube, which is quite thin and jacketed from the breech to a short distance in front of the trunnions, with a second tube shrunk upon it; the hoops encircle the jacketed and unjacketed parts, extending to the muzzle.

The drawing represents a 7-inch gun of this make.



It is built entirely of Firth steel, except the trunnion-band, F, which is made of wrought-iron. The tube, *A*, the jackets, *B*, *C*, *D*, and the breech-plug, *G*, are of cast-steel, the tube, *A*, being oil-tempered. The exterior rings, *E*, are forged and rolled like railway-tires.

The vent is at a distance from the bottom of the bore equal to two-fifths length of the cartridge. See *Ordnance.*

VAVASSEUR GUN-CARRIAGE.—This carriage, exhibited at Vienna, is unlike all others that have preceded it in several very important particulars; and though designed and constructed particularly for use on board of ships, deserves to be here noticed for the originality displayed in its conception and the ingenuity with which all the details have been carried out.

Top Carriage.—The cheeks are made in the usual way, each of two cheek-plates riveted together, with an iron frame between them, and held together by the transoms. A casting is made fast to the front bottom transom, and strikes against the rollers on the chassis, when the top carriage recoils. There are four truck-wheels, two in front and two in rear. The axle on which the rear wheels turn is an eccentric one, and has a handspike-socket, fitted on each end. By placing a handspike in either of these sockets, and bringing it down, the rear end of the carriage is raised, the weight is thrown on the four wheels, and the gun can be readily run forward or back on the chassis. The shafts have their journal-boxes in the cheeks, and form a part of the machinery for running the gun into and from battery. On the former shaft two spur-wheels are mounted, the teeth of which engage in oval holes in two plates riveted to the inner side of the chassis-rails. These wheels have cast on their inner side a second wheel of less diameter, the teeth of which engage in those of the pinion on the shaft: this shaft has eccentric bearings, and has mounted on it, outside of the cheeks, spur-wheels which engage in the pinion mounted on a short axle, the end of which is made square to receive the crank-handle.

The handspike-socket is connected at its upper end by a bar to the arm on the eccentric journals of the shaft, so that by bringing down the handspike, by which operation the top carriage is thrown on the truck-wheels, the eccentrics are by the same movement turned sufficiently to enable the pinion to engage with the teeth of the wheel cast on the side of the spur-wheel. Now, by turning the crank-handles the top carriage is moved up, or down, the chassis-rails. The motion of throwing the truck-wheels out of gear withdraws the pinions from engaging in the wheels, so that when the top carriage recoils the wheels turn, but do not communicate their motion to the shaft. The apparatus for giving the elevation to the gun consists of two straight steel racks attached at top of the gun by means of pins passing through pieces, which slide in V's on the heads of the racks, thus allowing for the motion of the pins, which describe arcs of circles around the trunnion. The body of the rack is turned a cylinder, and slides up and down in sockets formed in the cheeks of the carriage. The teeth are on the rear surface, and engage with those of the pinion, which is turned by means of a lever placed in the holes. To clamp the rack in any desired position, there are through-bolts, with nuts, provided with handles, by the turning of which through an arc of 120° the cheek-plates are pressed together sufficiently to pinch the body of the rack and hold it firmly in any required position as long as may be desired. The guide-hooks are fastened to the outside of the cheeks, front and rear, and pass under a projecting edge of the cap piece forming the top of the rail, there being just sufficient play allowed to permit the carriage to rise when thrown on the truck-wheels.

Chassis.

The rails are formed of boiler-plates riveted at top and bottom to cap pieces disposed and held together with the transoms. The angle-pieces are riveted to the inside of the rails near the top; they have oval holes, punched in them at regular intervals throughout their length. The trough is attached by means of trunnions to the front transom, while the rear end rests on the rear transom. It has bearings at each end for a screw. Angle pieces are riveted to the sides near the top to serve as guides for the nut. The traverse-wheel forks are secured to the outer side of the rails, thereby giving greater stability to the chassis. The chassis has an inclination of 1½°. It rests always on the front wheels, but the rear wheels are on eccentric axles, and are thrown in gear only when the chassis is to be traversed. When not in gear, the props rest on the traverse-circle. In order to throw both wheels in gear at the same time, the shaft extending across the chassis is provided with a bevel segment, and a handspike socket on each end. The eccentric axles have attached to their heads each a bevel segment, which engages with the bevel segments just mentioned. By placing a handspike in the socket near the middle of the shaft, or in either of the sockets on the bevel segments on the end of this shaft, and turning it through an angle of 60°, the eccentric axles are both turned at the same time, and the end of the chassis is raised and made to rest on the rear traverse-wheels instead of the prop. The arrangement for checking the recoil of the gun is peculiar to this carriage. It consists of a steel screw, square in cross sections, 30 inches pitch, extending nearly the entire length of the chassis. The front end of the screw has securely fastened to it a short conic frustum, having gun-metal bearing-surfaces sunk into its periphery. This frustum of a cone works in a wrought-iron drum, which is bored out to fit the cone, similar to a friction-clutch.

The drum is surrounded by a metal brake-strap, which is provided with a tightening screw, a pointer, and a scale graduated into ten parts, and numbered. A cast-iron nut, 20 inches long, fits the screw. At each end of the nut glands are provided, packed with felt to prevent the oil used for lubricating the screw from running out. In the middle of the nut the thread is cut away, forming a recess capable of holding about a pint of oil. When the screw gets rusty, as it will in standing exposed to the weather, it is only necessary to run the carriage along the length of the chassis before firing, when the felt-packing will wipe the screw, and the oil in this recess will lubricate it perfectly. On the top of the nut two rollers are placed, against which the casting presses when the gun recoils. The nut is not in any way fastened to the carriage, in order to avoid the liability to bend the screw by any vertical movement of the top carriage caused by the springing of the chassis-rails. This movement would have no effect on the nut or screw, but only cause the rollers to turn round. It is for this same reason that the screw is not fastened to the chassis-rails, but to the trough supported at its ends.

Action of the Compressor.

The tightening screw is turned through a given angle; the exact degree can only be determined by experiment. When the gun recoils, the top carriage presses against the nut, and this brings the surface of the conic frustum in close contact with the inner surface of the drum. As the nut cannot move to the rear without turning the screw, this last is forced to revolve on its axis, and with it also the drum. The pressure with which the brake-strap is pressed down on the drum by tightening the screw determines the friction between the drum and brake-strap, and consequently the recoil of the gun. After one or two shots fired, the exact amount of pressure will be determined, and when once adjusted for a given charge of powder and shot the compressor requires no further attention, but is self-acting, and always acts whenever the carriage recoils a half inch, no matter on what part of the chassis it may chance to be. The act of running the gun into battery releases the drum from the conic frustum, and the screw turns freely. If, in drilling, or for any reason, it be desired to run the gun from battery, it is necessary to prevent the conic frustum from coming in contact with the drum, and thus leave the screw free to turn. To do this a lever is fixed to the rear of the screw, which bears against the shoulder on the large screw. By giving a half turn to the lever the screw presses against the shoulder, and prevents the large screw from moving to the rear; the surfaces of the drum and conic frustum cannot come in contact; and so long as this is the case the screw is free to turn, and the carriage can be run from battery by turning the crank-handle. In order to stop the carriage at any point of the chassis, or control its motion at any time, as may be frequently necessary in running the gun into battery in a sea-way, a small brake is fixed on the rear end of the screw, and worked by a handspike placed in the socket. By this arrangement the carriage may be stopped instantly at any point of the chassis, and held there. From what has been here said, it will be seen that the compressor is readily adjusted to meet the varying wants of service under different circumstances, and when once arranged is perfectly automatic, and requires no further attention till some change is made in the conditions of its use; that the gun is run into battery without having to touch the compressor to throw it out of action, but if for drill or other purpose this latter be desired, it is readily effected by the half turn of the lever. From the experiments made both in England and France to test this carriage, it seems to have worked in the most satisfactory manner, being both simple and easy in its management, the gun being at all times entirely under control of the gunner. See *Gun-carriages*.

VAVASSEUR SYSTEM OF RIFLING.—In this system, the rotation is given by means of raised ribs in the bore, while the projectile itself has corresponding grooves cut along its cylindrical surface.

The ribs are three in number; their shape, and also that of the corresponding grooves, are shown in the drawing. There are no sharp angles either in the projectile or the bore of the piece.

The dimensions and particulars concerning the guns and rifling are given in the following tables:

Having the width of rib for one gun, to find that of another gun, when r' of the latter is known. w' = width of rib. $r' = \frac{1}{2}$ diam. inside of rib (col. c of table). 1.5 = rib of 12-in. gun. 5.7 = r' for 12-in. gun. Then $w' : 1.5 = r' : 5.7$. Suppose w' is required for 10-in. gun, when $r' = 4.75''$, $w' = r' \times$

$$\frac{1.5}{5.7} = .263r' = .263 \times 4.75 = 1.24925'', \text{ or } 1.25''$$

(column e of the table).

In this system the bore of the gun is not weakened by having grooves cut into it, and the projectile is also considerably stronger than those fitted with studs because the metal cut out of the body of the

twelve-inch projectile, for instance, by the countersinks for fixing the studs, is more than that cut out of the same projectile by the three grooves. There is also considerably less scoring in the bore, as the part most affected by the rush of gas in the part between the ribs is nearly one-third the whole circumference in width; the scoring is, therefore, much less local and takes place in a part not weakened by grooves cut into it, as is the case in grooved guns, where the grooves being the highest part of the bore act as channels along which the gas rushes. It is claimed that as the ribs in this system project from the surface of the bore, they are much more effectually cleaned than are grooves, by sponging, so that much less windage can be allowed. Late experiments to determine the relative value of long and short rifle-bearings have demonstrated the great superiority of the system.

GUN.						PROJECTILE.						
a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*k*	*l*	*m*	*n*	*o*
										WINDAGE.		
Pdr.	Diam. bore in.	Diam. inside ribs.	Depth of ribs.	Breadth of rib at point.	Radii joining bore and rib.	Body mean Diam.	Bottom of groove Diam.	Width of grooves at bottom.	Radii at corners of grooves.	Body of projectile.	Over grooves.	At sides of grooves.
4	2.2	2.	0.1	0.26	.03	....	....	....	.03	....	....	....
6	2.5	2.2	0.15	0.29	.95	....	....	....	.05	....	....	....
9	2.75	2.45	0.15	0.32	.05	....	....	....	.05	....	....	....
12	3.00	2.65	0.175	0.35	.05	2.95	2.6	0.39	.05	.05	.04	.04
20	3.75	3.35	0.2	0.44	.05	3.685	3.31	0.48	.05	.065	.04	.04
40	4.75	4.35	0.2	0.57	.05	4.685	4.31	0.61	.05	.065	.04	.04
60	5.5	5.10	0.2	0.67	.05	5 43	5.05	0.71	.05	.07	.05	.04
110	6.3	5.90	0.2	0.78	.05	6.22	5.85	0.82	.05	.08	.05	.04
115	7.0	6.6	0.2	0.87	.05	6.92	6.55	0.91	.05	.08	.05	.04
180	8.0	7.6	0.2	1.00	.05	....	....	....	.05	....	....	....
250	9.0	8.6	0.2	1.13	.05	....	....	....	.05	....	....	....
400	10.0	9.5	0.25	1.25	.08	....	....	....	.08	....	....	....
500	11.0	10.5	0.25	1.38	.08	....	....	....	.08	....	....	....
600	12.0	11.4	0.30	1.5	.10	....	....	....	.10	....	....	....

The twist of the rifling is one turn in thirty calibers for all sizes. The angle of the twist is 5°, 58′, 41.″6, and is thus obtained: In a right-angled triangle ABC let AB = n = the number of calibers in which the projectile makes one revolution = 30, BC = circumference of bore, θ = angle of rifling: Then

$$\tan \theta = \frac{BC}{AB} = \frac{\pi}{n} = \frac{3.1416}{30} = \text{nat. no. } 0.10472 \text{ log. } 9.020029 = 5^\circ\ 58'\ 41.''6$$

This arrangement necessarily involves a considerable amount of friction, the more so as both the metals which come into contact are hard. It is necessary that the projectiles should be fitted with peculiar precision, so as to preclude jamming on the one hand, and too much windage on the other. See *System of Rifling*.

VEDETTE.—A mounted sentry detached from a picket. Vedettes are placed in advance of the outposts of an army, to keep constant watch over the movements of the enemy, and to signal to the rear on the approach of danger. The proper time for the grand guard to take up its night post, is when it gets too dark for the day vedettes to see at any distance; they are then called in, and the position for the night is taken. If any apprehensions are felt of being betrayed to the enemy by spies, deserters, or inhabitants of the country, the guard must change its ground again, but the vedettes should remain. At night, the vedettes must be relieved at every hour, and visited every half hour. The relief rides along the chain of vedettes, and serves thus as a visiting patrol. If the enemy be near, the vedettes should be doubled; which is at all times recommended, where the strength of the guard will allow of it. In case a man desert, the fire must be put out, and the guard instantly shift its ground to some hundred yards' distance. The vedettes are to be made acquainted with this change, and urged to increase vigilance. Every desertion must be immediately reported. Double vedettes patrol among themselves in the following manner:

1 2 3 4 5 6
......0 0..........................0 0..........................0 0......
Vedettes.

No. 1 patrols to his left, and on his return, No. 2 proceeds to No. 3, and returns; No. 3 then patrols to No. 2, and on his return, No. 4 will go to No. 5, and return; 5 and 6, and all the other vedettes, do the same. If this be done, it is almost impossible that anything should pass unperceived. *In foggy weather it must never be omitted.*

When near the enemy, small patrols of a few picked men should, during the night, be sent out, in different directions, beyond the chain of vedettes, and get as close to the enemy as they can, unperceived. On approaching near enough, one man will dismount and listen with his ear to the ground. This is particularly recommended; as being the only means of ascertaining the secret movements of the enemy in the night—to discover which, the greatest exertions ought to be made.

Every person attempting to pass the outposts, must be detained till morning. Persons suspected of carrying any papers with them, are to be searched, and sent to the Commanding Officer, with a written statement of their case. Half an hour before daylight, the morning patrols will be sent out on the roads in front, and as soon as it is quite light, the guards and vedettes will take up their position for the day.

Vedettes should be placed by day on high ground, so as to afford them a commanding view, but always near tree or rock, so as to conceal them from the enemy; who, from the position of a single vedette, might guess at that of the whole line. In a mountainous country, where the ravines and narrow valleys cannot always be seen from the top of a hill, a vedette is sometimes placed at its foot.

When the vedettes are posted in such a manner as to be able to overlook their front, and see each other and the ground between them, so that nothing can pass them unperceived, they are placed as they ought to be.

In order to spare men and horses, no more vedettes than necessary are to be out. In a thick fog, the vedettes, stationed at a distance on the flanks, are taken off the hills, and placed on more suitable spots. The nature of the country may require that the position fixed upon, for the night, should be taken up during the day; in which case, the ground in front must be continually scoured, in all directions, by small patrols.

By night, the vedettes are taken off the hills, and placed on the roads, behind fords, bridges, ravines, etc., by which the enemy might approach the guard: and at the bottom of the hills, so as more easily to discern against the sky objects moving over the top. In clear moonshine, they ought to be near a tree or bush, to prevent their being seen by the enemy. In a close country, they should redouble their vigilance, for, it may happen that he will approach them unperceived, in spite of all their care. They must be advanced only just so far, as that their firing can be distinctly heard by the guard, even in a stormy night.

When a vedette discovers anything suspicious in the direction of the enemy, as, for instance, a rising of dust or the glittering of arms, he should move his horse round in a circle, at a walk: on which the Officer should instantly proceed to the vedette, accompanied by a Corporal and four men, and if he cannot distinctly discover by his spy-glass the cause of the dust, etc., he should send off the men that accompanied him, as a patrol, or go himself: for. if he sees troops, he should be able to report how strong they are, whether consisting of calvary, infantry, or artillery, and, particularly, in which direction they are marching. This report must be despatched, in writing, without delay.

The Commander of a grand guard shall never omit to report occurrences of this kind although they may have no connection with the securityof his own guard. Patrols and grand guards must always report the movements of any body of troops, no matter how small in number. If the vedettes positively observe troops marching towards them, but at a great distance, they ride the circle in a trot. The Officer's duty is as above stated. If the enemy's troops approach to within a mile, the vedettes circle in a gallop. The Officer then advances with his whole guard, immediately. If the enemy is so close at hand that the vedettes are obliged to gallop to their guard for their own security, they should first discharge at him both their carbines and pistols. Should a deserter approach, the vedette is to make a signal to the sentry at the guard, and a party will be immediately sent to bring him in.

As soon as the vedettes hear a suspicious noise, even though at a great distance, such as the rattling of carriages or artillery, the barking of dogs in the villages in front, or if they observe any fire, one of the vedettes must instantly report it to the Officer of the grand guard, in order that the circumstances may be inquired into by a patrol. Any person approaching the vedette at night, must be challenged in a loud tone and made to halt. Should the person refuse to halt, being twice challenged in a loud tone, the vedette is to fire, retiring, if in danger of being overpowered, by the road pointed out to him, etc.; vedettes will not allow a mounted man, nor more than one man at a time, to approach them, nor him nearer than three yards. And they will keep their cocked pistols directed all the while against him. The Officer of the grand guard will then be signalled for, and must be instantly there, and examine carefully whence came the person or persons, who sent them, and for what. For, when the enemy desires to surprise a grand guard, he frequently does so under the semblance of a friendly patrol, and therefore the Officer should particularly inquire to what Regiment they belong, the name of their Brigadier, Commanding Officer and Captains, where their Regiment is encamped, etc. If able readily and correctly to answer these questions, they may be allowed to pass.

No person coming from the enemy with a flag of truce, must be allowed to advance farther than the chain of vedettes. When a vedette makes the signal, the Officer of the grand guard meets the flag of truce with four men, and halts the bearer of it, if possible, in a bottom, or makes him face in the direction from which he came. For, it often happens, that the enemy's only intention is to make observations, or see how the grand guard is placed, in order to surprise it during the night. If the bearer of the flag only bring letters, they are to be receipted for and he is sent back. If he insist upon being allowed to proceed, permission must be first obtained; he is then blindfolded; a Non-commissioned Officer leads his horse; and he is thus conducted to the General's quarters. Should there be more than one person with the flag, one alone will be allowed to proceed to the rear; the remainder must stay where they are. A flag of truce ought to be treated with the utmost civility; refreshments should be offered, if at hand, but no conversation relative to the army, or its position, is to be permitted.

As deserters coming from the enemy may be seen at a distance, but cannot be known as deserters, a proportionate number of the guard must already have advanced to the line of vedettes to meet them. Deserters generally make themselves known by flourishing their caps and calling out "Deserter!" but this is not to be depended upon: their further behavior must be carefully watched. They are then disarmed and taken to the General's quarters, one, two, or three at a time. Whenever any private property is taken from a deserter, the act must be severely punished. Great caution must be observed at night, especially if they are in force. The vedettes must order them to halt at some distance, and by no means allow them to come too near. The guard advances; the deserters are ordered to approach, one by one, and are immediately disarmed. They are then taken to the rear. Deserters must be examined respecting the movements, etc., of the enemy.

When the grand guard is attacked, by day, the Officer immediately sends word to the rear, and communicates the fact to the grand guards on his flanks. He then advances with his guard, but warily, so as not to be cut off, and begins to skirmish with the enemy. It will seldom be practicable to advance further than the chain of vedettes. If obliged to retire, he must do it as slowly as possible, endeavoring to gain all the time he can, for the corps in his rear to turn out. If he has previously fixed upon places where to make a stand, now is the time to make use of them. The following is the best way of defending such places, (generally a bridge, ravine, or ford); we will suppose, in this case, a bridge: On arriving within three or four hundred yards of it, the Officer takes the gallop, and passing over it with the main body of his men, posts himself at a point as close as possible to, and with his right flank on it, leaving the passage clear. As soon as his skirmishers see that this has been done, they likewise gallop over the bridge, and face about again. The enemy is thus compelled to halt, and time is gained,—the grand object—on which may sometimes depend the honor and welfare of the whole corps. When the grand guards on the flanks are not attacked at the same time, they can be sometimes of service in acting upon the enemy's flanks, though not if the nature of the ground would endanger their being cut off. As a general rule, the grand guards that are not attacked, retire in a line with those that are engaged, and, while doing so, omit no favorable opportunity which offers of assisting the latter.

We have said that the vedettes, on discharging their fire-arms, must gallop back, *by a certain road*. This is a point of the utmost importance, and which must be well impressed on the night videttes—that in the event of their being suddenly attacked, they are not to retire in the direction of the grand guard, but a hundred and fifty yards to the right or left of it, and by a circuitous route, firing all the while, and doing all they can to mislead the enemy, and to draw him after them. The grand guard, by this means, gains time to mount, and to fall, with loud shouts, on the flank or rear of the enemy, who may be thus led to suspect that he has fallen into an ambuscade, be thereby puzzled, and perhaps lose some prisoners. After making such an attack, it will usually be best for the grand guard to fall back again along the road fixed upon for a retreat. The men must therefore be shown, during the day, both the road which the vedettes are to take, when attacked at night, and whereabout they are to rejoin the grand guard. The retreat, otherwise, is conducted in nearly the same way as by day, with only this difference, that there cannot be skirmishers in front, but only two or three men at the head. It is necessary to fire as much as possible, and wherever a stand can be made, an obstinate defense should be attempted. It is almost unnecessary to remark, that the attack, as soon as made, should be reported. See *Advanced-guard*.

VEHICLES.—Under this head are classed the carts usually used in the transport of stores, etc., on service. Country carts, or wagons, if procurable, form good carriage, either 2-wheel or 4-wheel. The 2-wheel cart is much recommended for the following reasons: The horses are nearer the load, and therefore the draught is easier; by the position of the horses, they are more under control. There are other advantages in this nature of cart, viz: one kind of wheel; more easily extricated in heavy ground; carries more in proportion; goes over more ground. There is a 2-wheel cart much used known as the Maltese cart, which appears to be a useful kind of cart. It can be fitted in various ways, and can be drawn by mules. A 4-wheel cart or wagon has the following advantage: It allows a more mixed description of animals, and takes up less room on column of march. Wheels can be made of the same size (equirotal.) It one horse breaks down, the other three can work. The general service wagon is drawn by four horses, and has equirotal wheels. The weight of the present wagon is 16 cwt. A new pattern has been introduced, weighing 23 cwt. See *Wagon*.

VEKILCHARES.—A word used among the Turks, which signifies the same as *Fourrier* in the French, and corresponds with Quartermaster.

VELES.—An auxiliary Roman soldier, armed with two long javelins, a sword worn on the right side, and with a *parazonium* or dagger on the left.

VELITES.—The light-armed Roman troops, who were first instituted during the Second Punic War, and were remarkable for their agility. In their engagements, the velites performed precisely the same part as that of the light troops which form the advanced-guards and advanced-posts of the present day. Watching and occupying the enemy before the main body is brought into play; then retiring and taking position to harass him farther, as opportunity may serve. The velites used only the casque, and a buckler of very stout leather, and bore the Spanish sword and a short javelin, termed the *hasta*, only half the length of the pilum, and used as a missile.

VELOCIMETER.—The employment of apparatus for measuring pressure, on which the powder acts by the intervention of a piston lodged in a passage made in a specified point of the bore, is attended with the inconvenience of making known only the local pressures developed at that point, and of giving but an imperfect idea of the succession of pressures developed in the bore, for it is certain that there are produced, in the mass of gases which fill the powder-chamber, turbulent movements which cause, each instant, considerable inequalities of pressure between the different points of that mass. It is, especially when we consider the lateral sides of the powder-chamber, that these inequalities are conspicuous, and it was ascertained long ago by the employment of the Rodman apparatus and those called "crushers," that with slow powders, especially, we observe very different pressures at different points along the chamber: the strongest indications are given with the apparatus placed a little forward of the initial position of the bottom of the projectile, and which are probably subjected to the excess of local pressure which produces, after a slight displacement of the projectile, a sort of condensed wave, caused by the retroaction of the gaseous mass on the bottom of the projectile. It was found, with the Rodman apparatus and the English powders called "pebble," that the pressures which would correspond with the deformations observed at this point are often double those measured, in the same manner, towards the middle of the chamber; a similar diversity, but not so great, exists also with the Wetteren powder. It is evident that it would be preferable to measure pressures developed on the bottom of the projectile itself, or else on the bottom of the bore, the knowledge of the forces developed at these points being calculated to give more useful data than that of the local forces produced at other points, which is of no special value. If we consider the pressures developed on the bottom of the projectile, we may hope to deduce these pressures from the knowledge of the law of the movement of this projectile in the bore, and we have sought, in consequence, to determine the spaces passed by the projectile during the very small successive intervals of time into which it was thought possible to subdivide the total time of its passage in the bore, which total time, as we now know, usually varies, according to the guns, between one and two hundredths of a second only.

If, as a first approximation, we neglect the mass of powder gases in motion, or if we suppose that the center of gravity of this gaseous mass remains invariable notwithstanding the displacements of the projectile and of the gun, we may admit that the gun and the projectile are displaced each instant in a direction opposite to one another, in quantities inver-sely proportional to their repective masses: we may then say that the gun is also a projectile displaced by the action of the powder gases, but whose movement is less rapid than that of the ball, and consequently much more easy to observe and register. In the present artillery systems the weight of the piece is, in fact, about 100 times the weight of the projectile; consequently, the displacements of the piece, in its recoil movements, is 100 times less than the corresponding displacements of the projectile. We must therefore seek to determine with precision the law of the recoil of guns, which law may lead to an approximate valuation of the pressures which are exerted on the bottom of the bore. General Rodman is the first who constructed a special apparatus for registering the law of this recoil, and who tried to use it in studying the laws of the combustion of powder; this apparatus, which could be used with a revolving cylinder, on which a stylus, operated under the influence of the piece in its recoil, was fitted to a gun pendulum. Rodman used it for determining the pressure which existed in the bore, when the projectile had attained the half or quarter of its final velocity: for this purpose he employed a graphic process. This method was unsatisfactory, and it does not appear that other operators have used it since. Rodman gave this apparatus the name of "velocimeter," and we have retained this name to designate the instruments which have been since constructed for the same purpose. The apparatus of this kind, constructed up to the present time appertain to different types, namely, the apparatus similar to the accelerographs, that is, employing, for a chronometric organ, a slide moved by a spring, the apparatus with revolving cylinder, and lastly the fork apparatus, these last capable of being set in motion either electrically or mechanically. When we have recourse to these apparatus it is best not to limit their employment to measuring the law of the movement of the gun during the first instants of its recoil, which instants correspond to the very short time that the projectile takes in passing through the bore, and it is natural to utilize them for registering the law of the recoil on a greater length, so as to be able to study the different circumstances of the working of the carriages. We can thus study specially, in carriages with a brake, the mode of action of the organs for moderating the recoil. We can also complete these apparatus by the addition of organs which transform them into veritable chronographs, and permit them to measure, for example, the durations of the trajectory of the projectile, and this addition has been applied to all fork velocimeters.

The velocimeter most frequently employed in the experiments made by the Marine Artillery Service at the proving ground of the Sevran-Livry powder-works, is an apparatus in which the simultaneous registering of the durations and the courses is given by a fork electrically supplied, which inscribes its tracings on a steel band drawn by the gun. This arrangement has the advantage of enabling tracings to be obtained whose length has no other limit than the length of the recoil of the gun. The apparatus, which is portable, not cumbersome, and susceptible of working in all positions, may also be easily complemented by the addition of electric registers, so as to indicate the course made by the band, at the moment when ruptures of the current are produced, caused by the gun or by the projectile, and especially the ruptures produced by the passage of the latter into the frame targets. It constitutes, in this case, a chronograph susceptible of replacing the apparatus of this kind which are generally used for measuring the velocity of projectiles. It possesses the advantage, over these latter, of being placed upon the firing ground, under the eyes of the experimenters, but, on the other hand, it requires a rather long time for calculating the results, which would not permit of its being employed advantageously in certain kinds of investigations, in which the charges employed have to be varied during the progress of the experiment, until a determined velocity is obtained for the projectile. The velocimeter with fork and electric registers may also be easily transformed into a chronograph for general use, independent of the recoil movement of the gun, and is capable of measuring the duration of phenomena entirely different. It suffices, for this purpose, to operate the traction of the band by any means whatever, by hand, for instance, arranging the velocimeter in such a manner that this same traction determines, at the desired moment, the production of the phenomenon to be registered. It is thus that this apparatus has been employed for measuring the comparative velocity of the transmission of fire, by means of different kinds of primers or even the velocity of the transmission of detonation in trains of dynamite, gun-cotton, or various other explosive substances.

Considering only the organs designed for registering the law of recoil, the apparatus is composed of a flexible steel ribbon of suitable length, which slides in horizontal bearings, fixed on a mahogany plane-table, which bears the whole apparatus. The bearings or slide frame is formed of two reglets of white brass, each provided, on their inner face, with a groove in which the edge of the steel ribbon enters; one of the reglets only is stationary, the other is kept in its place by the aid of screws entering into grooves which permit of varying the distance between them, so as to give the means of employing ribbons of various widths, according to the number of registers to be used.

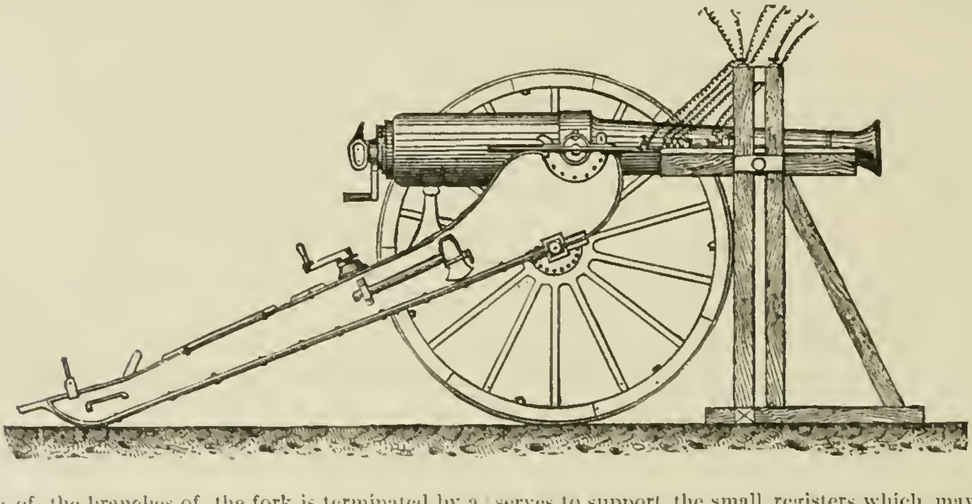
The ribbon is pierced with a hole at its extremity, and enters into the cleft of a small brass nipper, in which it is secured by means of a pressure-screw which passes through the hole. The nipper is itself screwed on the extremity of a steel wire flexible in every direction, but strictly inextensible, which is terminated at the other end by a small articulated eye-strap, which can be attached to the point of the gun or carriage whose recoil is to be studied. The plane-table is also fixed conveniently near the gun, on the support, as is shown in the drawing, so arranged as to keep it on a level with the point of attachment, the slide-frame being adjusted in the direction of the recoil. The ribbon, whose upper face is covered with lamp-black, is then drawn with the gun, and follows the movement of it, whatever may be its length. Above the ribbon is arranged horizontally a small arbor, which is mounted with a tight friction in two bearings, and is terminated by a small lever by which slight angular displacements are imparted to it. A pressure-screw, placed on one of the bearings, secures it completely in any desired position. This arbor supports, in its center, an electrically supplied vibrating fork, and arranged so as to receive the movement of the lever-arm which imparts to it the angular displacement of the arbor, without ceasing to vibrate regularly in all its positions. The electric supply movement is given to this fork by the improved process of Mr. Marcel-Deprez, in which the flexible plate on one of the branches of the fork oscillates between two thumb-screws, the one insulated, the other a conductor, which it touches alternately.

The arrangement of all the apparatus differs not otherwise from that of the ordinary forks of this kind, except that in these the organs of electric supply, electro-magnets, and the supports of the thumb-screws are mounted on a solid metalic frame, which supports also the fork, and which is terminated by a clamp, which a pressure-screw secures firmly on the arbor-support in any inclined position desired. The whole system may thus receive a lever movement, through the rotation of the arbor, without the vibratory movement of the fork being altered by it.

precision a curve which gives the courses of the gun as a function of time. If we take the first differences of the successive paths we deduce from them, by a simple proportional calculation, the corresponding velocities of recoil; and if we take the second differences, we easily obtain the accelerating forces when we know the masses set in motion. We may use, with this apparatus, a fork giving 1,500 simple vibrations a second; but the management is then a little difficult, and it is better to be satisfied with a fork giving 1,000 vibrations, which is very easy to set in operation, and whose movement is maintained a long time without any difficulty.

In order to make of this same apparatus a chronograph capable of measuring the durations of the trajectory of projectiles, either in the bore or in the air, it suffices to place near the fork small Marcel-Deprez electric registers, putting them in connection with the electric circuits designed to be broken by the projectile, and arranging them in such a manner that their pens trace as many parallel tracks on the surface of the ribbon in motion.

A small arbor of an insulating substance, placed parallel to that which bears the diapason, and movable like it, with a stiff friction, in two bearings,



One of the branches of the fork is terminated by a small, very finely-cut steel pen which, by this lever movement, may be brought into contact with the blackened face of the steel ribbon. A second similar pen, well mounted on a transversal rod which admits of being displaced laterally, can be brought in a stationary position by the side of the preceding one and placed on its exact prolongation when the fork is at rest; under these conditions, if the ribbon is displaced, the tracings produced by the two pens are superposed and form only one line. If the fork is set in vibration and the ribbon is first left stationary, the vibrating pen produces only a small transversal tracing, owing to the superposition of the successive tracings of its passage; but if the ribbon is displaced, drawn, for instance, by the gun, the tracings which correspond to each oscillation are separated and form an undulating curve, while the stationary pen leaves a tracing in a right line which constitutes the median of the sinusoid. The divergence of the successive points of contact of this median line, and the undulated tracing, shows the paths of the gun for intervals of time exactly equal to the duration of the simple vibration of the fork; and the registering is evidently produced over the whole extent of the movement imparted to the ribbon, provided that the latter is sufficiently long. The observation of the tracing is made by means of a microscope with a vertical axis and cross-hairs mounted on a slide, moved by a micrometic screw. By means of the measurements thus obtained we can construct with great

serves to support the small registers which may be placed side by side and connected with as many terminals, placed on the side of the plane-table, and to which the wires of the electric circuits are attached.

Putting, for example, one of the registers in electric communication with an interrupter designed to be encountered by the projectile on its leaving the bore, we obtain on the ribbon, drawn at this same moment, by the recoil movement of the gun, a tracing showing the moment of the projectile's leaving the bore.

By employing two other registers, put into communication in the same manner, with frame targets placed on the trajectory of the projectile, we determine the instants of the passage of this latter through these two frames, and thus we can measure its velocity at the same time as the duration of its trajectory in the bore. With the apparatus of the new model we can employ as many as five registers, and thus obtain five distinct signals, requiring only one signal from each register; we can then either place two other frame targets on the trajectory of the projectile, or employ other interrupters fixed in the bore, or else register other phenomena connected with the firing of the gun, by means or suitable arrangements, provided, however, that the signals to be registered are posterior to the first displacement from the recoil of the gun.

Although the Marcel-Deprez registers have an extremely rapid movement and a functional retardation which may be reduced to about one two-thousandth of a second, the degree of precision usually aimed at in these experiments would not permit of neglecting this retardation, and its value must be carefully ascertained for each register. See *Benton Velocimeter*, and *Small-arm Velocimeter*.

VELOCITY.—The common term employed to denote speed, or *rate of motion*. It is obviously greater the greater the space passed over in a given time. But, for its accurate measurement, we must distinguish between uniform and varying velocity. Nothing is easier than the measurement of uniform velocity. It is measured by *the space passed over in a unit of time*. Thus, we speak of velocities of 10 feet per second, 20 miles per hour, etc. But, for scientific purposes, it is best to keep, as far as possible, to definite units of time and space; and those most generally convenient are the *second* and the *foot*. The latter is defined, from the imperial yard, by Act of Parliament; the former is usually chosen as the interval between the beats of a mean-time clock. Unfortunately, its duration is not invariable; but, as ages must elapse before any sensible alteration takes place in its length, it may be used without inconvenience. If, then, v be the velocity of a point moving uniformly, we mean that v feet are passed over in each second, so that, if s represents the space passed over in t seconds, we have $s = vt$, a formula which contains the whole properties of uniform motion. It gives $v = \frac{s}{t}$; that is, to find the velocity of a moving point (when uniform), divide the space (in feet) described in *any* period of time by the number of seconds in the period. This will give the same result whether we take a million seconds or the millionth part of a second, as the period in question. This at once shows us how to proceed in measuring a variable velocity, such as that of a stone let fall, in which case the velocity constantly increases, or of a stone thrown upward, in which case the velocity constantly diminishes. That a moving body has at every instant, however irregular its motion may be, a definite velocity, is obvious, and is in fact matter of every-day remark. Thus when traveling in a railroad train we say, shortly after starting: "We are now going at the rate of a mile an hour;" not thereby meaning that it will take us an hour to complete the mile, but that *if we were to go on for an hour with the velocity we now have we should run a mile*. Again we may say: "Now we are going on at 30 miles an hour;" not thereby meaning that we have so much as 30 miles to travel, or that our journey is to last more than perhaps a few minutes, but that *an hour at the present rate would take us 30 miles*. In common language, then, our question is how to measure our present rate. If we could at any instant so adjust the steam power to the resistance of the air and the friction of the rails as to keep the rate unaltered, we should have uniform velocity, measurable with ease, as above shown. But as we cannot generally do this (though Attwood's machine enables us to do it in the case of a falling body), we are driven to some other expedient. Now it is obvious that the smaller the interval we take the less will our velocity have changed during its lapse, i. e., the more nearly will it have become uniform and measurable by the simple formula given above. That is, for a variable velocity we have $v = \frac{t}{s}$ as an approximation, which is more and more nearly true as t, and therefore s, is smaller. In the language of the differential calculus—whose fundamental notions as laid down by its great inventor were in fact derived from this very question, the velocity being simply the *fluxion* of the space described—we have $v = \frac{ds}{dt}$. Practically, by means of the electric chronoscope, we can now measure (very exactly) extremely small intervals of time, such, for instance, as the interval between the fall of the dog-head and the exit of the bullet from a rifle-barrel; so that a variable velocity now presents no formidable difficulty, as we can study and measure it *while it is almost absolutely uniform*. We define *average* velocity as the space described in any time divided by the number of seconds employed. This may not, except at one or more instants during the motion, represent the actual velocity; but it is a velocity with which, if uniform, the same space would have been described in the same time. We shall presently have an opportunity of usefully applying this definition to one interesting case of varying velocity. The *resolution* and *composition* of simultaneous velocities follows, almost intuitively from the most elementary geometrical notions. When a man is walking North-east at a uniform rate, it is obvious to common sense that he is progressing both northward and to eastward. What is his northward, and what is his eastward velocity? The answer is very simple. Suppose that in one second he walks from A to B, Fig. 1, then AB

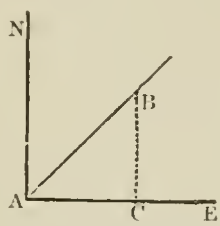


Fig. 2.

represents his whole velocity. But draw AN northward and AE eastward; also draw BC parallel to AN. Then AC is the space by which B is eastward of A, BC the space by which it is northward. Hence AC represents the eastward and CB the northward velocity (each being the space in its respective direction described in one second, and these are called *components* of the velocity AB. AB again is said to be *resolved* into AC and CB. The general proposition is this, that a velocity represented by one side of a triangle may be resolved into two, represented in magnitude and direction by the other sides of the triangle. One or both of these may be again resolved by a similar process; and we find, as the most general propositions on the subject, that velocities represented by all sides of a polygon (whether in one plane or not) but one, taken in the same order round, are jointly equivalent to a velocity represented by that one side, taken in the *opposite* order; also that a point which has, simultaneously, velocities represented by the successive sides of any polygon, taken all in the same order round, *is at rest*. The second law of motion enables us to interpret this geometrical theorem into the physical truths known as the triangle and polygon of forces in Statics. Rate of change of velocity is called *acceleration*. It is measured in the same way as velocity itself. Thus if the change take place in the direction of motion it affects merely the amount, not the direction of the velocity; and an acceleration a adds (or subtracts, if it be negative) a feet per second from the velocity affected. Thus it is found that gravity produces an acceleration of about 32.2 on all falling bodies; so that if a stone be let fall, its velocity after t seconds is $32.2t$. If it be *thrown* down with a velocity v, it velocity in t seconds is $v+32.2t$. If thrown upward with same velocity, in t seconds its velocity becomes $v - 32.2t$, so that it will stop and begin to descend after $\frac{v}{32.2}$ seconds have elapsed. The space passed over by the stone in t seconds is easily calculated by the help of the *average* velocity. For since in any of the above cases the velocity increases (or diminishes) *uniformly*, its average value during any interval is the average of its values at the beginning and end of the interval. Hence for the stone simply let fall: Initial velocity $= 0$, velocity after t seconds $= 32.2t$. Average velocity during the first t seconds $= 16.1t$. Hence space described in t seconds $= t \times$ average velocity $= 16.1t^2$, so that the spaces described are as the *squares* of the times.

But if the acceleration be not in the direction of motion, the direction and magnitude of the velocity will generally change. To exhibit this geometrically, Sir W. Rowan Hamilton invented the following beautiful construction of what he called the hodograph of the motion. Let O, Fig. 2, be any fixed point, and from it draw lines OP, OQ, etc., representing at

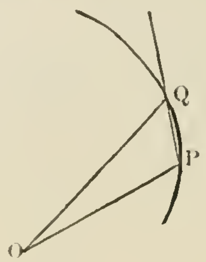
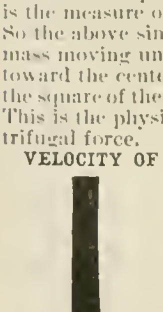


Fig. 2.

every instant in direction and magnitude the velocity of the moving point. The extremities of such lines will form a curve, such as PQ in the figure. If OP and OQ be any two of these, the *change* of velocity is represented (as above) by the third side PQ, of the triangle. As Q is taken nearer and nearer to P, PQ becomes more and more nearly the tangent to the hodograph, so that the tangent at P has the *direction* of the acceleration and the rate at which P moves round the hodograph is the *magnitude* of the acceleration. If we consider any uniform motion, we see that the hodograph is a circle (its radius being the magnitude of the velocity), and from this it is easy to see that *in uniform motion the acceleration is always perpendicular to the direction of motion.* If we consider uniform motion, with velocity V, in a circle of radius R, the hodograph at once shows that the acceleration is $\frac{V^2}{R}$ and is directed toward the center of the circle. Translated into physics, acceleration (multiplied by the mass of the moving body) is the measure of the force which acts on the body. So the above simple example shows that, to keep a mass moving uniformly in a circle, it must be drawn toward the center by a force proportional directly to the square of the velocity, and inversely to the radius. This is the physical explanation of the so-called centrifugal force.

VELOCITY OF COMBUSTION.—That space traveled over by the surface of combustion in a second of time, measured in a direction perpendicular to this surface. The diameter of the grains in "cannon powder" does not exceed 0·15 inch; the time required for the combustion of such grains, therefore, is altogether too transient to be ascertained by direct observation. The velocity of combustion may be determined by compressing the powder composition into a tube and burning it, or by burning the *press-cake.*



In the latter case, consider a prism of the cake of convenient length and about one inch square at the base, smear the sides with hog's-lard and place it on end in a shallow dish of water. The object of the lard is to prevent the spread of the flame to the sides, and the water is to prevent the lower end from being ignited by burning drops of powder. Set the upper end on fire, and note the time of burning of the column with a stop-watch beating tenths of seconds. In either way it will be shown that the composition, if homogeneous, burns in parallel layers, and that the velocity of combustion is uninfluenced by the size of the columns or by the temperature and pressure of the surrounding gas.

Now take a spherical grain of powder of homogeneous structure, and so hard pressed that the gas cannot penetrate it. Apply fire to any part of its surface; the flame will immediately envelop it, and burn away the first spherical layer; the radii of the grain undergoing equal reductions in equal successive portions of time. Then at the end of half the time required for the total combustion of the whole grain there will remain unconsumed a sphere of which the radius is one-half the original radius, but the volume will be only one-eighth the original volume (spheres being to each other as the cubes of their radii). At this epoch, therefore, seven-eighths of the grain will have been consumed. It will be seen from this, that for equal intervals of time, those taken in the first period of combustion give forth very much larger amounts of gas than those taken in the last, and that with a charge of such grains the gas is evolved in the inverse order desired: the evolution being greatest while the velocity of the projectile is least, and least while that velocity is the greatest; thus giving rise to excessive pressure at and near the seat of the charge. This may be remedied in some degree by increasing the size of the grain, the effect of which will be to diminish the amount of gas evolved in the first instant of time, and thereby diminish the pressure in the gun.

It may be shown by direct experiment that the burning of a grain of powder in a fire-arm is progressive, and that the size of the grain exerts a great influence on the velocity of the projectile. For instance, if *one* piece of the *press-cake* were placed in a small mortar and fired, little or no motion would be given to the projectile. If this piece be divided into seven or eight parts, the projectile will be thrown a short distance; and by increasing the number of the parts or grains, so will the effect of the powder on the projectile also increase.

The progressive burning of powder is further confirmed by the fact, that burning grains are sometimes projected from the gun with sufficient force to perforate screens of paper and wood at considerable distance. It is even found that they are set on fire in the gun and afterward extinguished in the air before they are completely consumed. The large grains of powder used in the 15-inch gun are sometimes thrown out burning to a distance of one hundred yards. The velocity of combustion of powder varies with the *purity, proportions, trituration, density* and *condition* of the ingredients, also with the pressure under which the powder is burned. To secure the greatest velocity of combustion, it is necessary that the nitre and sulphur should be pure or nearly so. This can always be effected by a proper attention to the prescribed modes of refining; but with charcoal it is different, for the part which it plays in combustion depends upon certain characteristics which are indicated by its color and texture. The velocity of combustion will be greater for red charcoal than for that which is black and strongly calcined; and for light and friable charcoal, than that which is hard and compact.

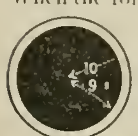
By varying the proportions the velocity of combustion is varied. The increase of sulphur tends to make a more violent explosion and a more quickly kindling mixture, as the sulphur is the kindling ingredient. Too much charcoal causes too slow burning. The diminution of the sulphur or nitre checks the rapidity of combustion, but may be made up by using more inflammable charcoal. The quality of the charcoal is powerfully affected by the temperature at which it is made. That made at a low temperature, or red charcoal, contains more hydrogen and less carbon, is more inflammable, and burns more rapidly, but, from its smaller proportion of carbon, must be used in greater quantity. It may be said that the charcoal is the varying ingredient; so that the proportions used at any time will depend upon the *quality* of the charcoal. In all naval powder, great care is taken to get a uniform quality of black coal, giving the nearest attainable approach to pure carbon.

Gunpowder, unlike nitro-glycerine, fulminate of mercury, and other detonating substances, is not a chemical compound but only a mechanical mixture. By the incorporating process during manufacture the three substances of which powder is composed are so intimately mingled that the eye cannot detect the presence of any particular one. They are, notwithstanding, only mixed, and the saltpeter can be readily dissolved out by water, or the sulphur sublimed in the form of a vapor, by the application of a moderate heat, leaving in either case the other two ingredients chemically unchanged. The more intimate the mixture, the more nearly does gunpowder approach to a chemical compound, and the more violent is its combustion; but there always must remain a vast difference between the most complete mechanical mixture and the most unstable chemical compound. For this reason the combustion of gunpowder is only very rapidly progressive and not instantaneous, as is the case with the violent explosives mentioned above. It is this difference that renders gunpowder so valuable as a propelling agent, for were it not for its comparatively mild action, no gun could be made sufficiently strong to resist its force. The material of the cannon would be broken before the inertia of the projectile could be overcome.

The density and hardness of the grains of powder are of quite as vital importance as their size and form, in determining the rate of ignition and combustion of a charge. By density is meant the quantity of powder actually present in a given bulk. It is important that this quality should not be confounded with hardness. A substance may be very hard and yet be of a low density. A powder with a very hard surface may be really less dense than another, the surface of which is softer. Of course very high density cannot be communicated without producing a considerable degree of hardness; but powder can be made hard without rendering it very dense, by pressing the dust in a comparatively dry state. Hardness seems to bear a direct relation to the power exerted in compressing, while density does not. Powder-dust, at a high degree of moisture, say 6 per cent., can be made very dense by application of moderate pressure, while that of 1 per cent. can only be brought to the same point in density by the exertion of enormous force. Of the two the latter will be the harder powder.

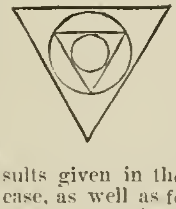
By moistening the composition with some pure water, alcohol, or vinegar, and then drying it completely, the velocity of combustion is increased. With pure water alone, this increase of velocity may amount to 0.1 of an inch. On the contrary, the velocity is diminished where oils, fatty or resinous substances, are added to the composition, or when it incloses water or other liquids.

When the form and size of the grains and the velocity of combustion are known, we can ascertain, at any given moment, the amount of powder consumed, since the velocity is uniform and independent of the surface. Take a spherical grain of powder of homogeneous structure, or in other words, one that will completely burn up in $\frac{1}{10}$ of a second. Apply fire at any point of its surface, the flame will immediately envelop it, and burn away the first spherical layer; if, for example, we suppose that the time of this partial combustion be $\frac{1}{10}$ of the time required to burn up the entire grain,



then the radius of the remaining spheres will be only $\frac{9}{10}$ of the first: but the volumes of spheres being to each other as the cubes of their radii, the primitive sphere will be to the one which remains after the burning of the first layer, as 1.0 is to 0.729, the cube of .9. Subtracting the second of these numbers from the first, we shall have 0.271, which expresses the differences of volumes of the two spheres, or the amount consumed in the first $\frac{1}{10}$ of time, compared to that of the entire grain. By making similar calculations on the other layers, we shall obtain the results contained in the table at top of page 550.

It will be seen from this, that for equal intervals of time, those taken in the first period of combustion give forth very much larger amounts of gas than those taken in the last. If, instead of a sphere, we suppose the grain to be a *polyhedron*, circumscribing a sphere, the burning layers being parallel, the decreasing grain will continue a similar polyhedron, circumscribing the sphere. The results given in the table will be strictly true for this case, as well as for grains of conical or cylindrical form, provided their bases be equal to their heights.



A general formula may be deduced to show the amount of gas developed at any instant of the combustion of a grain or charge of powder. For this purpose take a spherical grain of powder, and consider it inflamed over its entire surface. Let t represent the time of burning, from the instant of ignition to the moment under consideration: t', the time necessary to burn from the surface to the center, or total combustion: R, the radius of the grain. Since the combustion of the grain passes over the radius R in the time t', the velocity of combustion is equal $\frac{R}{t'}$, and for the time t, it will pass over the space $t\frac{R}{t'}$ or $R\frac{t}{t'}$; the radius of the decreasing sphere will therefore be $R\left(1-\frac{t}{t'}\right)$. The volume of the grain of powder and that of the decreasing sphere are $\frac{4}{3}\pi R^3$ and $\frac{4}{3}\pi R^3\left(1-\frac{t}{t'}\right)^3$, respectively: and their difference or the quantity of powder burned, will be equal to $\frac{4}{3}\pi R^3\left(1-\left(1-\frac{t}{t'}\right)^3\right)$.

The first factor of this expression represents the primitive volume of a grain of powder, and the other expresses the relation of the volume burned to the primitive volume. The same expression will answer for all of the grains of a charge of powder, if they are of the same size and composition; consequently, if we let A represent the volume or weight of the grains composing a charge of powder, the quantity remaining unburned after the time, t, will be represented by $A\left(1-\frac{t}{t'}\right)^3$; and the quantity burned, by $A\left(1-\left(1-\frac{t}{t'}\right)^3\right)$.

Although the grains of powder are not spherical, their sharp angles are partially worn away by rubbing against each other in glazing and in transportation; and the mode of fabrication and inspection reduces the variation in size within narrow limits, therefore, if we examine the influence which the actual form and size of the grains exercises over the phenomenon of combustion of powder, we shall find that the effect varies but slightly from that due to the

Time of burning	0.000	.100	.200	.300	.400	.500	.600	.700	.800	.900	1.000
Decreasing radii	1.000	.900	.800	.700	.600	.500	.400	.300	.200	.100	0.000
Volumes of grain	1.000	.729	.512	.343	.216	.125	.064	.027	.008	.001	0.000
Volumes burnt	0.000	.271	.488	.657	.784	.875	.936	.973	.992	.999	1.000
Volumes burnt in each 0".01	0.000	.271	.217	.171	.127	.091	.061	.037	.019	.007	0.001

spherical form. To apply to ordinary powder, take a grain of oblong form, like that of a spheroid, or cylinder terminated by two hemispheres; it will present a greater surface than a spherical grain of the same weight, and consequently the amount of gas formed from it in the first instants of time, will be greater, and the duration of the combustion will be less. It can be shown, however, that so long as the size of the grains is kept within the regulation limits, this influence will be slight. To do this, take an oblong grain the cylindrical part of which has a diameter of .054 in., let it be terminated by two hemispheres, and have a total length of .097 in. (these being the minimum and maximum size of a grain of French cannon-powder, respectively); all its weight will be about .07 grain, or $\frac{1}{210}$ of a *gramme*, and with a velocity of combustion of 0.48 it will take 0.056" to burn up completely. French war-powder is composed of grains of different weights, numbering about 310 to every *gramme*, or 15.4 grs. Troy. If, therefore, powder contain oblong grains of the size stated above, there must be others still smaller: if we suppose them to be in equal quantities, and the larger to be $\frac{1}{210}$ of the unit of weight, then the smaller must be equal to $\frac{1}{410}$ of the unit of weight; which would be equal to spheres with a radius of 0.028 inch. Comparing the quantities of gas developed in intervals of .008", or about $\frac{1}{8}$ of the time necessary for the combustion of the smallest grains, we obtain the result in the following table:—

fore the projectile leaves the gun. *If the size of the grain be increased, the effect will be to diminish the amount of gas evolved in the first instants of time, and to diminish the pressure on the breech.* This principle has been made use of lately to increase the endurance of large cannon. See *Combustion*.

VELOCITY OF RECOIL.—This is generally taken as the velocity imparted to the gun and carriage by the discharge of the piece. It is the greatest when the projectile leaves the muzzle. Let V''' be the maximum velocity of recoil, v the muzzle velocity of the projectile, w the weight of the projectile, w' the weight of charge of powder, W''' the weight of the gun and carriage. Then, if the momentum of the gun and carriage be taken equal to the momentum of the projectile,

$$W''' V''' = (w + C'w')\,v, \text{ or}$$

$$V''' = \frac{(w + C'w')\,v}{W'''}: \text{ where } C'$$

is a co-efficient varying in different guns, which may be determined by experiment. If the weight of the charge is $\frac{1}{n}$th the weight of the projectile, $w' = \frac{w}{n}$; and energy of recoil (or work done in recoil) $=$

$$\frac{w\,v^2}{2g} \times \frac{w}{W'''} \left(1 - \frac{C'}{n}\right)^2.$$

Kinds of grains of Powder.	Relation of the volume of powder burned, to the volume of the grains after a time of						
	0".008	0".016	0".024	0".032	0".040	0".048	0".056
Elongated grains, diamr. .054 in.; length, 0.098 in., 210 to the gramme, or 15.4 grs	0.310	0.555	0.737	0.864	0.946	0.987	1.000
Spherical grains of 410 to the gramme, or .056 in. diameter	0.357	0.616	0.794	0.907	0.968	0.994	0.999
Elongated and spherical grains as above, in equal quantities, forming a mixture of 310 to the gramme	0.333	0.585	0.766	0.885	0.958	0.990	0.999
Spherical grains of 310 to the gramme, or 0.063 in. diameter	0.330	0.580	0.758	0.875	0.948	0.985	0.998
Difference between mixed grains and spherical grains of the same mean weight	0.003	0.005	0.008	0.010	0.010	0.005	0.001

The differences in the results do not much exceed $\frac{1}{100}$, and may be neglected in practice; we may accordingly consider all the grains of a charge of powder as spheres of radii corresponding to their mean weight. *This mean weight is an important element, and may be determined by counting the number of grains in a given charge, and dividing the weight of the charge by this number.*

In war-powder the largest portion of each grain is burned in the first two-tenths of the time required to consume the entire grain: as it has been shown that a grain of ordinary cannon-powder requires 0.1 second for its combustion, the largest portion of the grain will be burned in the first $\frac{2}{100}$ of a second. If we consider the velocity of the projectile on leaving a gun, and the time necessary to overcome its inertia in the first period of its movement, we shall see that a very large portion of each grain is burned up be-

VELOCITY OF ROTATION.—The velocity of rotation required by a projectile will depend chiefly upon the *initial velocity*, the *form*, the *density*, the *distribution of the material*, and the *position of the center of gravity* of the projectile; therefore, there is a particular inclination of grooves which is best suited to each caliber, form of projectile, charge of powder, etc. This has not yet been fully determined by experience, and the consequence is that a wide diversity of twists is employed in different services and by different experimenters. A long course of very careful experiments is necessary to establish laws that could be generally applied.

As the initial velocity of a projectile is increased, so will the resistance of the air tending to overturn the projectile be greater.

Long projectiles require a more rapid rotary motion than short ones of equal weight, for the resultant of the air acts with a greater leverage as the length of the projectile is increased, tending to give it a rotation round its shorter axis. It is necessary to give a flat-headed projectile a greater velocity of rotation than a conoidal or *ogival*-pointed projectile; for the current of air meeting the projectile, instead of having merely, as with the latter form, to pass around the pointed head, presses with the flat head upon a surface almost at right angles to the previous direction of the current, and consequently exerts a very much greater force proportionally, tending to overturn the projectile.

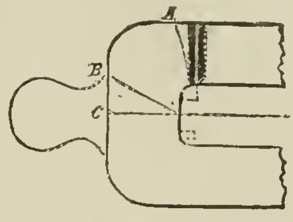
The greater the density of a projectile, the less will its velocity of rotation be decreased by the resistance of the air during the time of flight, because of its greater momentum. For instance, a leaden shot would retain its velocity of rotation longer than one of iron; consequently, as the densities of projectiles are increased, so may their respective velocities of rotation be diminished. A hollow, elongated projectile will be steadier during flight than a solid shot of equal weight, for, the mass being distributed farther from the axis, the radius of gyration is lengthened. Thus it is found in practice that elongated shells are steadier in flight than shot from the same gun, when the latter are of the same weight as the shell.

If the center of gravity of a projectile is very far forward, the resultant of the resistance of the air acting behind the center of gravity, the hinder part of the projectile would be pressed upward, if the velocity of rotation be very low, so that the axis might correspond very nearly during flight with a tangent to the trajectory. In this case an irregular motion of the axis will generally result from the opposite tendencies of the forces which act upon the shot; the air endeavoring to press up the hind-part of the projectile, while the rotary motion resists any change in the direction of the longer axis. With the center of gravity in this position, there is little fear of the projectile turning over even with a low velocity of rotation: but, in order that the axis may be stable, a rapid rotary motion must be given to prevent any "*wabbling*" which might arise from the cause just explained. Should the center of gravity be situated near the base, a very high velocity of rotation is requisite to compel the projectile to proceed head first.

A very high velocity of rotation is objectionable for the following reasons: that the strain upon the metal of the cannon will be very great, as the charge must be rather large, and the grooves will require a sharp twist, much resistance being thereby caused to the motion of the projectile; that the projectile, after grazing, will deflect considerably; and that, should the projectile be a shrapnel, the pieces would spread laterally to too great a distance to be effective. It will generally be sufficient, as far as accuracy is concerned, to give an elongated projectile such a velocity of rotation that the axis may be stable during the whole time of flight for the longest required range; should the rotation be not sufficiently rapid at any part of the trajectory, the axis of the projectile will become unsteady, and inaccuracy of fire will be the result. To determine theoretically the velocity of rotation which ought to be given to a projectile of definite form would be a very difficult problem, and therefore recourse must be had to actual experiment to obtain approximately the velocity required. See *Grooves*, *Initial Velocity of Rotation* and *Rotation*.

VELOCITY OF TRANSLATION.—Motion of translation refers to the motion of a projectile traveling through the air. The *velocity of translation* of a projectile is usually measured by its *linear* velocity in feet per second.

VENT.—That opening or passage in firearms, by means of which the charge is ignited. In modern muzzle-loading rifled guns the interior orifice is distant from the bottom of the bore 0.4 the length of the cartridge, this position giving the greatest projectile force to the charge. In breech-loaders the vent is axial, and in some cases the flame is conducted through a tube placed in the axis of the cartridge, so that ignition takes place near the center of the charge. The size of the vent should be as small as possible, in order to diminish the escape of the gas, and the erosion of the metal which results from it. All vents in the United States' Service are 0.2 inch in diameter. In bronze pieces which fire large charges of powder, the



heat of the inflamed gases would be sufficient to melt the tin, and rapidly enlarge its diameter. For this reason, they are bushed by screwing in a perforated piece of pure wrought copper, called the *vent-piece*. This arrangement allows the vent to be renewed when too much enlarged by continued use, or when closed with a spike. Copper vent pieces are especially necessary in rifle-guns, in consequence of the prolonged action of the gas arising from the heavy weight of projectile to be moved. Columbiads and mortars of the model of 1861, have each two unbushed vents, which are situated in two vertical planes on opposite sides of and parallel to the axis of the bore, and distant from it one-half the radius of the bore. The one on the left is bored entirely through; the other stops one inch short of the surface of the bore. When the open vent is too much enlarged by wear for further use, it is closed with melted zinc and the other is bored out. Each vent should endure at least five hundred service rounds.

The interior orifice of the vent is placed at a distance from the bottom of the chamber equal to a fourth of its diameter, or at the junction of the sides of the chamber with the curve of the bottom. Experiment shows that this position of the vent is more favorable to the full development of the force of the charge than any other along its length.

Many authors have attributed the injuries which are observed to take place about the lodgment of the projectile, to the position of the vent at the bottom of the bore, supposing that the evolution of the elastic gases begins at the upper portion of the charge, and that the projectile is consequently pressed down upon the lower side of the bore before it is set in motion. To remedy this, it was proposed to place the orifice at the center of the bottom of the bore; and to determine the merits of this proposition, special experiments were made at the Artillery Schools of Douai, Toulouse, and Strasbourg, on new guns of 24 and 16 lbs. caliber. The first gun had the ordinary, old-fashioned vent (*A*); in the second the orifice of the vent was placed at the center of the bottom, with its axis making an angle of 30° with that of the gun (*B*); and the third had its orifice at the center of the bottom, with its axis coincident with that of the gun (*C*). The several pieces were fired under the same circumstances, and the injuries noted with great care. It was found that the gun with the ordinary vent had only experienced slight injuries, while the others became unserviceable in a few rounds; as will be seen by an examination of the table on page 552.

The most probable explanation of these results is this: In guns with the ordinary vent, the gas which is developed in the first moments of combustion, expands freely into the space between the top of the cartridge and bore; it has therefore less tension when it passes over the ball, which will have been moved before all the charge is inflamed. In the two cases in which the orifice is situated at the center of the bottom, the gas formed cannot develop itself in the space over the charge, but it expands into the interstices of the charge with a greater tension than it had in the first case, and thereby accelerates the inflammation of the charge. From this it follows, that the ball is not moved from its place quite so soon as in the first case, but it begins to move at an epoch more nearly approximating that of the maximum tension of the gas of the charge; and the pressure, therefore, of the gas as it passes over the ball, will be greater: which will account for the greater depth of the lodgment. See *Cannon*.

branch, and is continued upwards on the rear surface of the transverse branch to the top.

The guide being placed with its center upon the center-mark of the gun, and the center-line of the longitudinal branch being made to coincide with the center scribed upon the cylinder, the rear lower end of the transverse branch will then coincide with the base-line, its extremities will indicate the centers of vents, and the rear edges of the sides will show their true direction.

VENTILATION.—In order to effect perfect ventilation, it is necessary not only to furnish an abundant

DEPTH OF LODGEMENT.

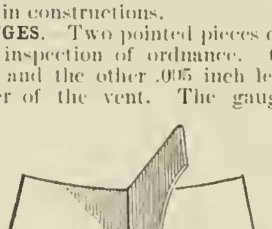
Position of the vent.	Strasbourg 24-pdr. Gun.	Toulouse 24-pdr. Guns.	Douai 16-pdr. Gun.
Vent in the axis	37 points after 40 shots	23 points after 6 shots 25 " " 30 "	8 points after 6 shots. 17 " " 30 " 24 " " 60 "
Vent inclined 30°	34 points after 60 shots	14½ " " 6 " 33 " " 30 "	14 " " 30 " 25 " " 90 "
Ordinary vent	•	3 " " 30 "	3 " " 60 " 4 " " 90 "

VENTAIL.—That part of the helmet which completely closes in the open part of the helmet. It is pierced for both sight and breathing, and is adjusted in such a manner that it can be raised or lowered, or can be removed altogether, at the pleasure of the wearer.

VENT-COVER. A strip of bridle-leather, used to strap over and protect the vent of a piece; a pin of copper or brass, fastened by rivets, usually enters the vent, to prevent the cover from slipping. It is fastened to the piece by a buckle and strap, the latter passing around the breech, the length of it depending upon the size of the gun.

VENT-FIELD. A flat tablet around the vents of guns of certain constructions.

VENT-GAUGES. Two pointed pieces of steel wire used in the inspection of ordnance. One is .005 inch greater and the other .005 inch less than the true diameter of the vent. The gauges usually



have shoulders or strong handles to prevent them from slipping into the vent. The diameter of the vent is measured by the gauges, the smallest of which must enter freely, and the largest not at all. See *Inspection of Ordnance*.

VENT-GUIDE.—A bronze instrument to be used with vents in guns of the Dahlgren pattern. When placed upon the gun, one of its branches coincides with the curve of the cylinder, and the other, starting form its center, lies along the cylinder in contact with it longitudinally. The lower edges of the branches are a right line and a curved line, making two right angles with each other. The length of that of the transverse branch is equal to the distance between the centers of the two vents. The rear surface of the transverse branch is curved and quadrilateral. Its sides are inclined so that their rear edges show the exact direction of the vents. Every point in the upper edge lies in the horizontal plane. The hight is sufficient to permit the edges to give an accurate direction to the drill. The upper edges of the other branch runs off in a sloping curve to its extremity. A center-line is drawn through the lower edge of the longitudinal

supply of *pure air*, but also to remove entirely the deleterious gases expelled from the lungs and the effete exhalations of the skin. To enable us to do this in the most thorough and effectual manner, it is important that we should take into consideration the amount of air required for respiration, the nature of the chemical changes produced in breathing, the kind and quantity of gases expelled from the lungs, and also their specific gravity. It is important also, to ascertain where pure air may be most advantageously introduced, and how and where the gases exhaled from the lungs may best be removed. The direction given to the current of air supplied is also a matter of vital importance. The quantity of air that should be furnished is one that merits the most careful consideration: first, with reference to healthfulness, and secondly, in reference to economy of expenditure. The vapors exhaled from the lungs and skin should also receive careful attention in conection with the humidity of the atmosphere. The amount of air expelled from the lungs of a healthy person varies from twenty-two to forty-four cubic inches at each expiration. Taking the mean, therefore, as an average, we have:

Average amount of air expelled at one expiration 33 cubic inch.

Average number of respirations per minute.............................. 15 " "

Average amount of air expelled per minute by each person.............195 " "

Or say a little over one-quarter cubic foot.

Average amount of carbon dioxide...5.5 per cent.

Average amount of carbon dioxide expeled per minute, one person...27 cubic inch.

Average amount of air expelled by 100 persons per minute...........49.500 " "

Or about equal to 28⅝ cubic feet.

Average amount of air expelled by 500 persons per minute.............143⅓ cubic feet.

Average amount of air expelled by 1,000 persons per minute............286⅔ " "

Average amount of carbon dioxide expelled by 1,000 persons per minute...15⅔ " "

Average amount of vapor exhaled from the lungs of one person, 15 grains per minute.

The atmosphere, when the temperature is raised from what may be considered an average of 50°) to

68°, has its capacity to hold moisture increased to an extent of three grains per cubic foot. The specific gravity of carbon dioxide is a little over fifty per cent. greater than that of air. One yard, or nine square feet, is considered ample floor space per individual in a barrack-room or hospital including aisles and waste room. Assuming the above statements to be correct, we are authorized to make the following deductions: First. The actual amount of air required for respiration is comparatively small. Secondly: that a much larger amount is required to carry off the exhalations of vapor and gas than is required for consumption in breathing. Third. We may assume, almost without argument, that the current of air should be vertical and downward. If the air be supplied in such a manner that the currents of air were horizontal, then the air breathed and expired by one person would be breathed over by his next neighbor, and so over and over again during its entire passage through the room. The carbon dioxide, which, from its greater specific gravity, lies upon the floor, would in this case remain undisturbed, and would gradually accumulate, except as it escaped from open doors or leakages in the floor, etc. The same would be equally true of the lighter gases, which would rise, but would have no provision for their escape. Without this vertical, downward current, it is impossible to secure the proper degree of warmth in the lower stratum of air, or that which lies upon the floor.

As the cold air, from its greater density, lies always next to the floor, and in rooms heated by stoves or any other *system* that does secure a regular and uniform change of the entire contents of the room at regular intervals, from the top to the bottom, it will be found that while the head and upper parts of the body are uncomfortably warm, with the lips, throat, and skin parched and dry, the eyes inflamed, with headache and pressure of the head, the feet are cold and damp. These difficulties are all easily and naturally obviated by a downward vertical current of air. The stratum of carbon dioxide upon the floor passes out as fast as generated, together with the cold, damp air about the feet, which is gradually displaced by air of summer temperature, carrying with it the surplus of moisture and the fetid exhalations from the lungs and skin.

We now come to the consideration of the quantity of air to be supplied. This is a point of great importance and merits most careful consideration. The evils resulting from imperfect ventilation are so numerous and great, that many have been led to the belief that the supply of fresh, pure air could scarcely be too great. Plans have therefore been made, in which it was contemplated to supply enormous quantities of air, and have only limited the quantity to a point less than that which produced sensibly evil effects. A casual consideration of this subject only will be sufficient to convince any one that the evils resulting from the latter are but little less than the former. A current of air that is insensible to a person in robust health, will seriously affect one in delicate health. If the supply be sufficient to give pure air, a larger quantity can do no more. We therefore assume that the minimum quantity that will secure thorough and perfect ventilation, is the point to be aimed at. A further consideration is the expense. If the expense is so great that no buildings except those of the first class, such as National and State capitols, and the like, can afford it, then ventilation for other buildings becomes practically impossible, the whole subject is brought into disrepute, and this greatly-needed reform seriously retarded. In some of the reports made in reference to ventilating the National Capitol at Washington, such enormous quantities of air have been considered necessary for ventilation as have been almost astounding. In one case, largely over half a million cubic feet per minute were considered necessary to ventilate the chamber of the House of Representatives alone. The outlay required for engines, blowing machinery, and all the necessary appliances to carry out these plans, required an appropriation of several millions of dollars. These vast sums seemed so startling that even Congress hesitated to launch out upon this new sea of expenditure. Not only was the first cost of such an establishment of an alarming nature, but the current expenses for keeping up an institution of such magnitude would be very great. The result has been, that to this day, this hall has remained without any adequate system of ventilation.

The quantity of air necessary to effect perfect and thorough ventilation should therefore receive careful attention; and while the supply should be ample, it should, if possible, not be impracticable. As before stated, the supply of air required for actual consumption in respiration is comparatively small; the amount required to carry off the exhalations of the lungs and skin are much larger. The carbonic acid discharged from the lungs is in the proportion of one to twenty of the air expelled from the lungs, and having a greater specific gravity is easily removed by exhaustion, and with the downward current is but little disturbed or mixed with the air. If the amount of fresh air supplied be twenty (20) times as great as is required for actual respiration, or equal to five cubic feet for each individual per minute, it will be found ample to take up and carry off all the surplus moisture and effete gases exhaled from the lungs and skin, and yet the current would be so slight as to be altogether imperceptible to any one, even in the most delicate health.

Allowing nine square feet of floor space to each individual, in an assembly room or church, in a room properly proportioned and with ceilings of a good height, it will be found that this amount of air, viz.: five (5) cubic feet per minute to each individual, will change the entire contents of the room every thirty minutes. This is sufficient for warming purposes with a good apparatus, even in the most intensely cold weather. So that we find five cubic feet per minute for each individual abundantly ample for every requirement, either for warming or for ventilation. The next important point for consideration is the best method of effecting this contemplated change. To a certain extent, ventilation and warming can be accomplished by hot-air apparatus in single rooms or small buildings; but even under the most favorable circumstances it is expensive, imperfect, and unreliable.

In large barracks and buildings of any magnitude, mechanical ventilation is the only system that can be relied on, and under any circumstances is the cheapest, as has been abundantly demonstrated in the deep coal mines in England. Various methods have been proposed and tried. In some cases air has been forced by some blowing machine through the heating apparatus and into the rooms to be ventilated, displacing a like quantity of air in the rooms. It will be seen at once that while this is far more certain than the hot-air arrangement alone, that it still has serious defects, inasmuch as no direct provisions are made to remove the deleterious gases. In other cases, in addition to the above, exhausters have been added. This arrangement is undoubtedly an improvement on either of the foregoing plans. This plan is, however, open to objection, inasmuch as this double system is complicated and expensive. With exhausters of sufficent capacity, arranged to exhaust from beneath, the warm air being supplied preferably through openings in the ceiling, with a sufficient number of registers distributed in the floor so as not to cause a current of air in any part of the room, in connection with an exhauster, which is positive in its action, displacing a fixed and definite quantity of air at every revolution, the entire contents of the room or building would be changed in a fixed length of time, which would be controlled at the option of the person having charge of the building. The exhaust plan is preferable to any other, not only on account of its simplicity, but because it exhausts the carbonic acid and other deleterious gases at once from the room, without mixing it with the air in the room, because it produces the downward vertical current of air in the simplest manner possible, because the tendency is to produce less sensible currents of air in the room than any other system, and because this system secures more perfectly a uniform temperature in all parts of the room or building than any other, and because it is equally as well adapted to summer as winter ventilation. Fig. 1 shows the manner in which Root's

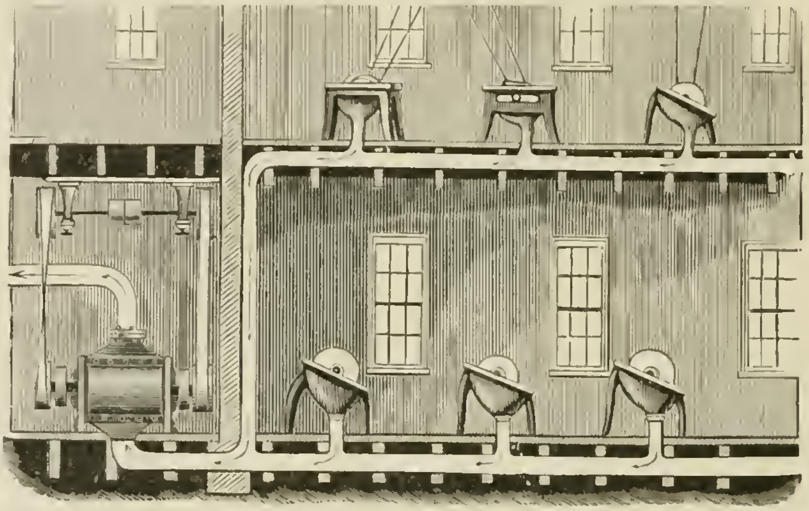


Fig. 1.

positive blower is used for exhausting dust from emery wheels, grindstones, etc., in armories or other places where a large amount of dust is made. This plan works equally well for carrying off unhealthy or offensive odors, or fumes from acid or lead works, or smoke from forge fires, etc. It is frequently used to ventilate water-closets, by exhaustion, in large factories, asylums, etc.

The Blackman wheel and air propeller is a great advancement in the way of ventilating contrivances. The amount of air moved in all air-moving machines, has relation to the area of the feed, and delivery sur-

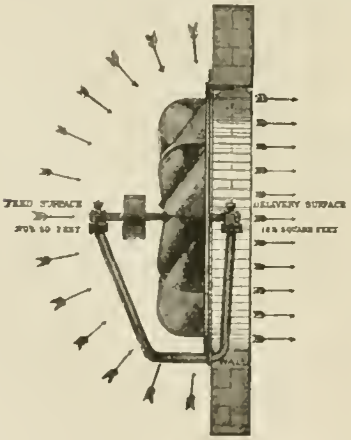


Fig. 2.

faces or orifices, the entire surfaces of the air propeller, front, back and sides, is either feed or delivery, and therefore gives the greatest volume at the smallest outlay of power. Being constructed on this new principle, the Blackman wheel makes possible the economical and satisfactory ventilation of buildings of every description, and the removal of foul or hot air, smoke, steam, gas, or other objectionable atmosphere, as well as to regulate the temperature of every building. Also, the rapid drying of any material at either a high or low temperature. Appliances for moving air in limited quantities by means of power have been in use to a small extent for some years; but until the invention and perfection of this machine, no very economical scientific system was known, or possible for moving large volumes of either hot or cold air at pleasure, distributing it under absolute control to suit the varying conditions of the different places, according to their different uses, and regardless of location. Because of this new feature possessed by this wheel or propeller, air can be moved at the rate of 16,000 cubic feet per minute, or one million feet, per hour, for each actual horse-power employed, and can be either drawn or blown through pipes at moderate pressure; at 370 revolutions per minute, a 48 inch diameter wheel or propeller will remove 30,000 cubic feet of air per minute, with one and eight tenth horse power, thus giving large volume with small power, and taking about one-fifth of the power required to

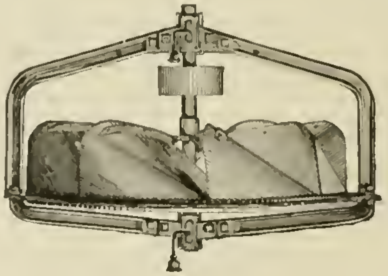


Fig. 3.

remove the same amount of air by the blast fan. The distinctive feature of this contrivance lies in the formation of its blades, which, when in revolution, strike with their edges the air confronting it, scooping or grasping whole volumes, in a manner which makes it impossible to recede, and by a spiral movement cuts its way into it and forces it from the building by the channels selected, this wheel takes in air at right angles, as well as parallel with its axis or shaft. The construction of its blades forms a peripheral flange, or end bucket, which prevents all radial escape of air, and causes a direct inward flow all over the large area created, thus making its feed area $66\frac{2}{3}$ per cent. greater than any other form of ventilating wheel known. Vertical and horizontal views of the wheel are shown in Figures 2 and 3. See *Fanner*.

VENT-IMPRESSIONS.—The implements required for taking permanent vent-impressions in lead, are a *soft wire* about 0.07 in. in diameter, and three or four fathoms long. A *lever* about twice the length of the bore, about 3 inches in diameter, and shod to suit the curve of the bore nearly. A small *button* of soft lead, judged to be of sufficient size to fill the vent at least one inch from the bore. This is to be pierced lengthwise to receive the wire.

To obtain the impression shove the wire through the vent, and let it pass along the bore and out at the muzzle; put it through the leaden button and tie a knot at the end. Draw the wire back through the vent until the leaden button is introduced firmly into the inner orifice. Apply the lever, making its shoe bear on the button, and force it well in by repeated blows, the muzzle being the fulcrum. This done, disengage the button by pushing in the priming wire.

In taking impressions of the vent and cracks, each button in turn is used as a pattern for molding its successor, allowing for the progressive enlargement of the vent or the cracks emanating from it. When the crack shows itself, the head of the button should be so enlarged as to include it. These examinations should take place after every twenty fires at least, and more frequently when any unusual enlargement of the vent or extension of cracks are developed, and indicate its speedy destruction. Before each examination the bore of the gun is carefully washed and dried. See *Gutta-percha Impressinos*, *Impression-taker*, and *Inspection of Ordnance*.

VENT-PIECE.—1. A plug of copper containing the vent, and screwed into its position in the gun. 2. A small piece of iron or steel, which, when dropped through the *vent-slot*, or opening in the top of the gun to its position, and pressed by the breech-screw (in Armstrong gun) tightly against the end of the powder-chamber, effectually closes the bottom of the bore.

VENT-PLUG.—A plug or stopper used for closing the vent of a gun. It sometimes replaces the vent-cover.

VENT-PUNCH.—Sometimes the vent obstructions cannot be withdrawn by the gunner's gimlet, or an iron plug may have been inserted, in which case it is forced in with the *vent-punch*. This is a short wire of the same size as the gunner's gimlet, cut off square at one end, and with the other brazed into an iron head. The head has a hole in it, through which a nail or piece of wire may be inserted, to aid in withdrawing the punch from the vent.

VENT-SEARCHER.—A hooked steel wire about half the diameter of the vent, bent to a right angle at the lower end and pointed. The vent is examined for roughness or for cavities in the metal by means of the searcher, the point of which should feel every portion of it carefully. See *Inspection of Ordnance*.

VENT-SERVER.—An article used for serving the vents of guns, 64-prs. and upwards, in lieu of serving the vent with the thumb. It is made of brass, the part which enters the vent being encased with a thick, conical piece of leather. A lanyard is attached to it.

VENT-SLOT.—The opening in the top of a gun, through which the vent-piece is dropped.

VENT-TUBE.—In the German built up guns, and others of similar construction, the vent is in the direction of the axis of the bore, and is filled with a vent-tube; this is made of steel, cylindrical, and is lined with copper, more or less conical, and fits exactly into its place in the wedge; this place is enlarged at the rear, and fitted with a thread for the *primer-tube screw*. It has also a very broad flange upon whose rear side the lock for confining the friction primers is placed This consists of a flat cover which has a cut in it for the wire of the friction-primer, and it has a button on the top for handling it. It turns easily on its hinge, and is hollowed out on the side of the vent, so that it may be raised by the escaping gas and thrown aside. The whole lock is placed in a hollow of the wedge, so that it can be moved at pleasure without interfering.

VERAT.—A 12-pounder gun of 17 calibers, weighing 2300 pounds, having a charge of 8 pounds.

VERBAL ORDERS.—Orders commonly sent on the the field of battle by the General to any officer in command of a particular portion of the army with whom he wishes to communicate Such orders are generally sent through an Aide-de-Camp, and must be considered equally binding with written ones.

VERDICT.—The opinion or decision arrived at by the Members of a Court-Martial as to the guilt or otherwise of the prisoner. See *Finding*.

VERDOY.—In Heraldry, a term indicating that a bordure is charged with flowers, leaves, or vegetable charges. Thus, a bordure argent verdoy of oak-leaves proper, is equivalent to a bordure argent charged with eight oak-leaves proper.

VERDUN.—A variety of the civic sword, having a long straight and narrow blade. When placed erect, they would reach from the toe to the middle of the chest of a man of ordinary height, and were evidently worn only when the wearers were in their saddles.

VERGETTE.—In Heraldry, a pallet or small pale: hence, a shield divided by pallets or pales.

VERNIER.—A scale by which a linear or angular magnitude can be read off with a much greater degree of accuracy than is possible by mere mechanical division and subdivision. It derives its name from its inventor, Pierre Vernier, "Capitaine et Chastellaine pour sa Majesté au Chasteau Dornans," who gave a description of it in a tract published at Brussels in 1631. The principle of this invention is essentially as follows: AB (Fig. 1) is a portion of the graduated

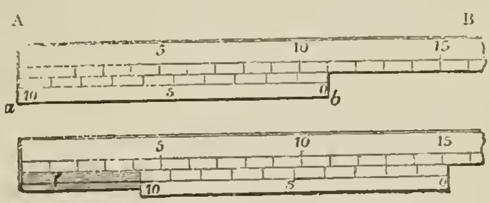


Fig 1.

scale of an instrument showing divisions and subdivisions; *ab*, a small scale (called the *vernier*), made to slide along the edge of the other, and so divided that *ten* of its subdivisions are just equal to *eleven* of the smallest divisions of the scale AB; then each division of the vernier is equivalent to $1\frac{1}{10}$ of a subdivision of AB; and consequently, if the zero-point of the vernier be (Fig. 1, A) opposite 11 on AB, the 1 on the vernier is at $9\frac{9}{10}$ ($1\frac{1}{10}$ below 11), 2 on vernier is at $8\frac{8}{10}$ ($2\frac{2}{10}$ below 11), etc. Also, if the vernier be slid along so that 1 on it coincides with a division on the scale, then 0 on the vernier is *one* tenth above the next division on the scale; if 4 on the vernier coincide with a division on the scale, the 0 of the vernier is *four* tenths above the division. The vernier is applied to instruments by being carried in the extremity of the index limb, the zero on the vernier being taken as the index-point; and when the reading off is to be performed, the position of the zero-point, with reference to the divisions of the scale, gives the result as correctly as the mechanical graduation by itself permits, and the number of the divisions of the vernier which coincides with a division of the scale supplements this result by the addition of a fractional part of the smallest subdivision of the scale. Thus (Fig. 1, B), suppose the scale-divisions to be degrees, then the reading by the graduation alone gives only a result between 15° and 16°; but since the 2d division of the vernier coincides with a graduation on the scale, it follows that the zero-point is $\frac{2}{10}$ of a division of 15°, and that, therefore, the correct reading is 15.2°.

It will be at once seen that by merely increasing the size of the vernier, as, for example, making 20 divisions of it coincide with 21 on the scale, the latter may be read off to twentieths; and a still greater increase in the size of the vernier would secure further accuracy.

The above is the vernier as proposed by its inventor, and it was employed very long after his time; but in the more recently constructed astronomical and geodesical instruments a vernier is employed which has one graduation *more* (Fig. 2) than the corresponding portion of the scale. A little consideration will show that the only effect of this modification is to enable the vernier to be graduated toward the same direction as the scale, and thus save a little confusion in the reading off. In the small instruments, or where the utmost accuracy is required, a small magnifying lens is fixed over the vernier, to enable the observer, in cases where no two graduations coincide (which is generally the case), to estimate the amount of error introduced by assuming that the two graduations which approach nearest to coincidence actually coincide.

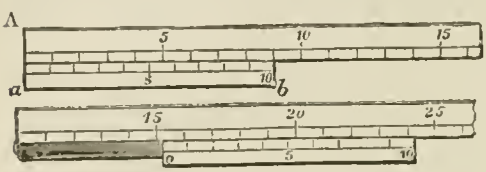
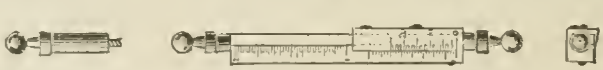


Fig. 2.

Of the various methods for subdivision which were in use before the introduction of the vernier, the most important were the *diagonal scale* and the *nonius*. The latter, so called from its inventor, Petrus Nonius (Pedro Nunez), a noted Portuguese mathematician, who described it in a treatise *De Crepusculis Olyssipone*, published in 1542, consists of 45 concentric circles described on the limb, and divided into quadrants by two diameters intersecting at right angles. The outermost of these quadrants was divided into 90, the next into 89, the third into 88, etc., and the last into 46, equal parts, giving on the whole a quadrantal division into 2,532 separate and unequal parts (amounting on an average to about 2′ intervals). The edge of the bar which carried the sights passed, when produced, through the center, and served, consequently, as an index-limb; and whichever of the 45 circles it crossed at a graduation, on that circle was the angle read off; for instance, if it cut the 7th circle from the outside at its 43d graduation, the angle was read off as $\frac{43}{84}$ of 90°, or 46° 4′ 17½″.

VERNIER-GAUGE.—An instrument used in connection with the testing-machine. It is similar in principle of construction to the microscopic-gauge, except that the glass slides are replaced by a steel scale and a vernier. The former is divided into fortieths of an inch, and by means of the vernier, thousandths of an inch can be read. The microscopic-gauge is used until the elastic limit of the specimen

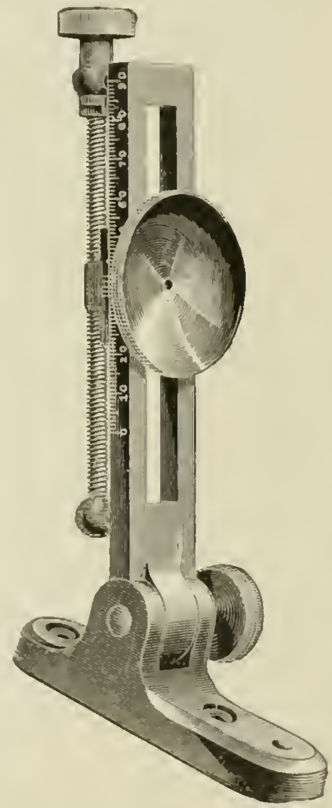


is reached, after that the vernier gauge is employed. These gauges can be adjusted to any length of specimen beyond 2½ inches by means of additional sections of the rod.

In measuring the deflections of specimens under a bending-stress the gauge is attached to the straining stirrup and to the bed of the machine. See *Microscopic-gauge* and *Taper-rule*.

VERNIER SIGHT.—To insure accuracy, the rear-sight is made with a vernier scale operated by a screw, by which an alteration of even the one-thousandth of an inch can be made in the elevation, the result being exact. On the Remington rifle, each minute on the vernier is $\frac{1}{32}$ of an inch, and corresponds upon a 34-inch barrel with $1\frac{1}{28}$ of an inch, at each 100 yards. A circular eye-piece, with a small peep-hole in the center, is screwed to a slide, which is graduated. The long screw serves to hold the sight firmly at a certain point; while the thumb-screw provides an easy method of detaching it from the rifle, if it should not be wanted at times.

Many riflemen prefer to have the peep-hole of a more considerable size than that shown in the drawing, in order to get more light when taking the sight. In the rear-sight of the Metford and other rifles, discs having different sized apertures may be used; and experience shows that good shooting is frequently



done, in foggy or dark weather, when the disc is removed entirely, so as to leave an aperture of nearly a quarter of an inch.

The *vernier-sight* is usually placed upon the small of the stock. When shooting from certain positions on the back, it will be convenient to have it placed upon the heel of the butt. When the latter is the case, it makes the distance between the two sights nearly a third greater than when placed upon the small of the stock, and consequently a proportionally greater allowance both for elevation and wind will be required.

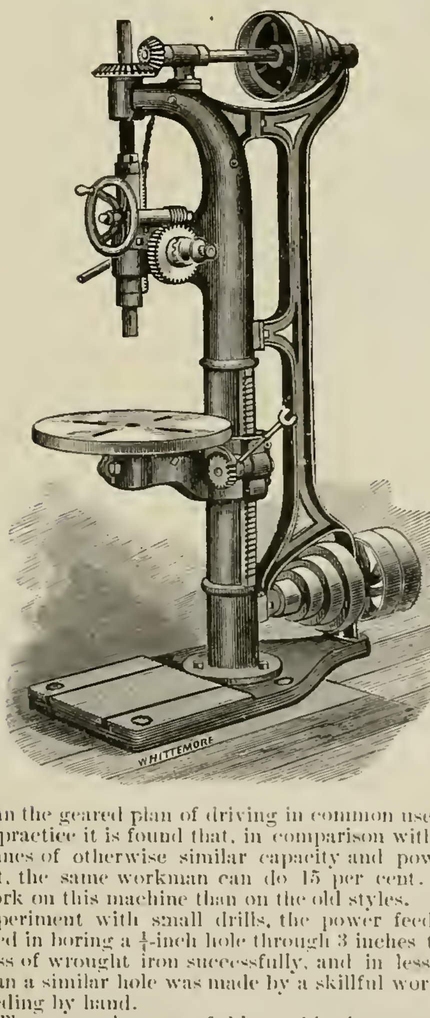
In using the *vernier-sights* at long ranges, the rifleman must, as it were, feel the pulse of the weather with them. Every change of the wind and weather must be watched, and met by moving the sights, the aim being kept in the same place; and any tendency of the shots to fly high or to drop, from unknown causes, must be anticipated and checked in the same manner.

The makers of many rifles are not sufficiently careful in regard to sighting them. While every rifle varies slightly, from the difference in the shape of the barrel or stock, the sights are made exactly alike, and it is no easy task to find out the exact allowances required. In consequence, one rifle is no guide to another of precisely the same make.

VERRUTUM.—A pilum with a trilateral head 5 inches long, and a shaft 3½ feet in length.

VERT.—In Heraldry, coats of arms are distinguished from one another not only by the charges or objects borne on them, but by the color of these charges, and of the field on which they are placed. *Vert* (green) is indicated in uncolored heraldic engravings by diagonal lines from dexter chief to sinister base.

VERTICAL DRILL.—A boring-machine in which the action of the tool is performed in a vertical plane. The double-geared vertical drills, patented by Wm. Sellers & Co., are admirably adapted for all descriptions of metal-boring in the arsenal or armory. For holes of 1½ inches and under in cast-iron the machine has its spindle driven by belt only, but is provided with back gear to be used for heavier work. This belting system has been found to work much better



than the geared plan of driving in common use; and in practice it is found that, in comparison with machines of otherwise similar capacity and power of cut, the same workman can do 15 per cent. more work on this machine than on the old styles. In an experiment with small drills, the power feed was used in boring a ¼-inch hole through 3 inches thickness of wrought iron successfully, and in less time than a similar hole was made by a skillful workman feeding by hand.

The supporting post of this machine is rectangular, and the bracket carrying the compound table is gibbed to a plain surface. The raising and lowering of the table are effected by a screw placed at one side of post in such a position as to enable the table to swing about it as on a hinge, after slacking the shoe on the opposite side of the bracket. This enables the compound table to be readily removed for the introduction of such work as can more conveniently rest on the floor plate, which is 22½" wide, and has slots for holding-down bolts. The raising screw is driven by power, operated by a hand lever at the side of the upright, so as to give the utmost facility of adjustment. On the counter-shaft there are 10 inches by 4 inches fast and loose pulleys making 110 revolutions per minute. Cone pulley has four changes of speed. The stroke of the spindle has a motion of 17½ inches. The feeds are proportioned to the kind of drilling to be done. When the back gear is not in use, and small drills are to be driven, the range of feeds is through a finer series than when the back gear is being used, and large drills or boring bars are to be driven.

The drawing shows a convenient form of the machine for light work. This form has the wheel speed and counter-balanced spindle with the quick return movement. The greatest distance from the spindle to the base plate is 43 inches. The diameter of spindle is $1\frac{9}{16}$ inches. Total weight, 700 pounds. See *Boring-machine*, *Drilling-machine* and *Radial Drill*.

VERTICAL FIRE.—The fire from ordnance at high angles, for instance, from mortars, which being generally fired at an angle of 45°, the shells are observed to attain great height in their flight and to descend at considerable angles. The fire of shells from mortars at high angles of elevation is most uncertain as regards accuracy; the reasons of this are that the shells, having comparatively low velocities, but long "times of flight," are peculiarly liable to considerable deviations from wind and other disturbing causes; also, that the angles of descent of mortar shells, fired at the usual angle of 45°, are so great that, unless the object be of some extent, an error in range of a few yards over or under might render the shell useless, whereas, when a projectile is fired at a low angle of elevation, so much ground is covered by it, before and after grazing, that a few yards under or over would not probably prevent it striking the object. The very greatest care is required in weighing out the charges, for if this is performed carelessly, considerable difference will occur in the ranges. In vertical fire, as the object cannot be seen, and the piece is generally short, it is very difficult to lay the mortar exactly in the same line for a number of rounds, but if laying could be performed with the greatest accuracy, still irregularities would always occur in practice with projectiles fired at high angles and with low velocities.

VERTICAL TESTING MACHINE.—A form of testing machine extensively employed in arsenals and founderies for ascertaining the strength of flat, round and square metals. The drawing shows an improved machine of this class with the following:—

DIMENSIONS.

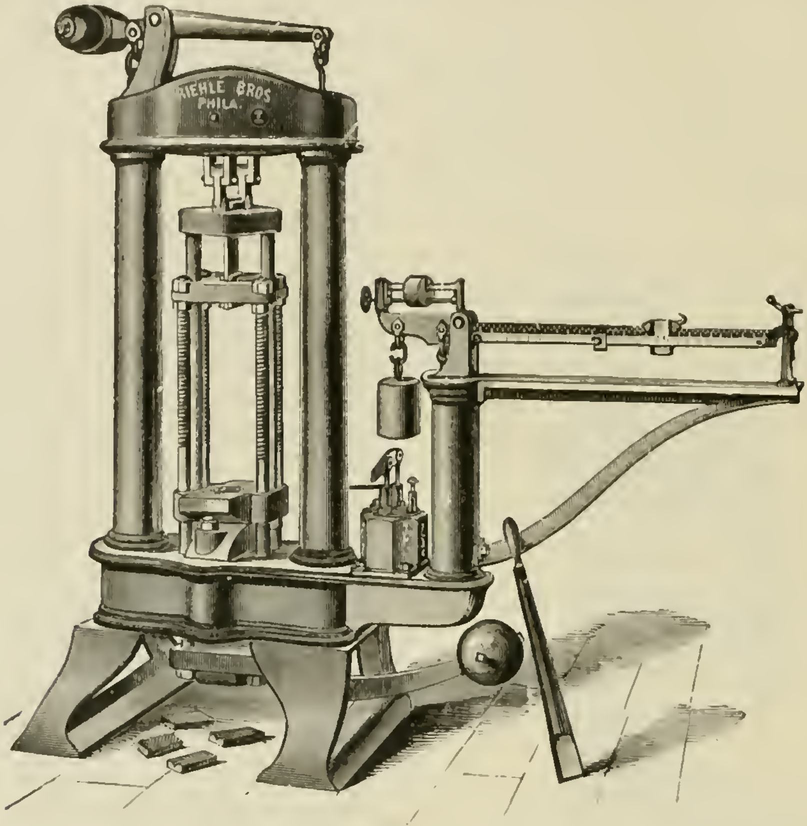
Extreme height	8 ft
Extreme length	7 f .
Extreme width	2 ft. 6 in.
Weight	2,250 lbs.

ADAPTATION.

Tensile specimens	6 in. to 24 in. long.
Round specimens	1 in. diam or less.
Square "	1 in. × 18 in. or less.
Flat "	2 in. or less × $\frac{3}{4}$ in. or less.
Transverse "	12 in long.
Compression "	20 in. high or less.
" surfaces	6 in. × 6 in.
Motion of plunger	8 in.

The machine is provided with long screw bolts that connect the tools with the plunger of jack. This arrangement admits of much longer test pieces being tried than formerly. Another improvement is the balanced plunger, which returns to its original position without any delay after the test is made.

This machine is constructed entirely of iron, steel, and brass, and is compact, strong, and accurate. The weighing levers are all above and connected with the beam by rods passing through the columns. The strain is applied by hydrostatic power, and ascertained by keeping the weighing beam in equipoise by the simultaneous use of the pump and the poises on the beam with the poises. No loose weights are required, all the weight being indicated on the beam.



The wedges holding tensile specimens are peculiar in shape, so as to ensure a straight pull. The capacity of the machine is 50,000 pounds. See *Testing-machines*.

VERTICAL VELOCITY. A projectile's velocity at any point resolved in a vertical direction. Thus, if V be the velocity of a projectile moving at an angle A to the horizon, the vertical velocity = V sin. A. See *Velocity*.

VERVELS. Small rings attached to the ends of the jesses of a hawk, through which a string was passed to fasten them to its leg. They occur as a heraldic charge. Also written *Varvels*.

VETERAN RESERVE CORPS. An organization in the United States, established during the Rebellion, but now discontinued. It was composed of men honorably discharged on account of wounds or disabilities, of men absent from their Colors in Hospitals or Convalescent Corps, and of men disabled by wounds or disease, but still in the field. In May, 1865, the body consisted of 762 Commissioned Officers and 29,852 men. The duties of the Veteran Corps were varied, and included such works as hospital and garrison service and patrol duty. They were serviceable in taking the place of efficient soldiers who were needed in the field.

VETERANS.—Old soldiers past the prime of active manhood, and incapable of taking the field. Their discipline and steadiness, however, admirably fit them for garrisons and fortresses, and for the instruction of young troops. The Veteran Battalions in England did good service during the French war as Home Guards, releasing the active troops for foreign service. The army estimates for 1879-80 made provisions for an army reserve (including pensioners) of 46,000 men. But from the short periods during which men serve as soldiers, and the number of officers who quit the army on reaching the rank of Captain, it is almost certain that very large Veteran Corps could be formed from civil life in any case of national emergency.

VETERINARY ART.—The art of healing or treating the diseases of horses. It comprehends a knowledge of the external form as well as the internal structure and economy of the animal, and embraces whatever relates to the diseases to which he is liable, together with an accurate knowledge of the principles and practice of feeding and exercising. Veterinary Surgeons are alone competent to treat all grave cases of wounds and diseases in horses. The soldier, however, may prevent accidents by watchfulness, recognize the existence of ailments, and by prompt care frequently relieve the animal entirely. The locations and effects of many of the ailments herewith noticed will be better understood by a reference to the drawing which follows. The treatment recommended in the several cases are approved by Dr. B. J. Kendall, the leading Veterinarian of America, and are worthy of careful consideration. The more frequent ailments or disorders, with the symptoms and treatment, will be presented in order.

BOTS.

The stomach seems to be the most natural nursery for the protection and the propagation of the stomach bot. When the eggs have remained in the stomach for a year they become a perfect chrysalis, then release their hold of the stomach and are expelled. They will be provided with wings in a short time, and will fly about commencing the propagation of species which pass through the same period of incubation.

They are two kinds:—*Stomach* and *fundament bots*. The stomach bots are the result of turning horses into pasture in the summer months, and are produced from the eggs laid on the fore legs of the horse by the bot fly.

Symptoms are an unthrifty coat, and loss of flesh after running out to pasture.

Treatment.—Improve the general condition of the horse, and give the following tonic medicines: Pulv. gentian ¼ lb., pulv. copperas ¼ lb., pulv. fenugreek ¼ lb., pulv. elecampane ¼ lb. Mix well, and give a large tablespoonful once a day.

The fundament bot, like the stomach bot, is also the result of running out to grass. Instead of the eggs being deposited on the legs they are deposited on the lips of the horse. They are found in the rectum, and often seen under the tail.

Treatment.—Make injections of raw linseed oil, or of tobacco smoke.

BRONCHITIS.

This disease consists in an inflammation of the air passages of the lungs. It is a very common disease among horses, and is sometimes confounded with inflammation of the lungs (or lung fever), distempers and colds. The *symptoms* begin with a chill, fever, harsh cough, labored breathing, mouth hot and dry, and with loss of appetite; and in one or two days a discharge from the nostrils will be observed.

Treatment.—Give the horse a good, comfortable place, (not too close nor the reverse.) Give 15 to 20 drops tincture of aconite root and repeat every four hours until six doses have been given, which will probably relieve the fever. Let the horse have a plenty of cold water to drink. After the fever has subsided (which will probably be about the second day), give a few powders of the following: Mix pulv. licorice root, pulv. fenugreek and pulv. gentian, two ounces of each, and divide into six powders and give in feed two or three times a day.

CAPPED ELBOW.

This enlargement on the point of the elbow is on the side of the chest just behind the shoulder. It is a tumor (or sometimes a simple abscess) caused by direct pressure against the calk or heel of the shoe: particularly when the latter is allowed to protrude too far backward. Pads are made by harness-makers which are quite useful in protecting the parts while the horse is lying.

Treatment. If the tumor is soft and shows signs of containing pus, it would be well to open it and allow the matter to escape. Some Veterinary Surgeons recommend that the tumor be dissected out with a knife and then treated as any simple wound by keeping clean until it heals.

CAPPED HOCK.

This is a soft swelling on the point of the hock-joint. It is caused by kicking in the harness or stable, or by being kicked by another horse, and rarely causes any lameness.

Treatment.—The same as in the case of the *capped elbow.*

CAPPED KNEE.

Capped knee is caused by a kick or other injury to the knee.

Symptoms.—A soft tumor in front of the knee, and severe lameness.

Treatment.—If left alone it would probably burst and leave a permanent blemish. If the tumor is hot bathe first with cold water to reduce the heat or bind on cloths wet with cold water and change often, then proceed as with *capped elbow.*

COLIC.

This is a common as well as a very dangerous disease. There are two forms:—*Spasmodic* and *flatulent colic.*—The former is of a spasmodic nature, and will, in severe cases, run into inflammation of the bowels and cause speedy death, if not relieved. It is caused by drinking cold water when in a heated condition, costiveness, unwholesome food, undue quantity of food, etc.

Symptoms.—The horse is suddenly attacked with pain, and shows evidence of great distress, shifting his position almost constantly, and manifesting a desire to lie down. But in a few minutes these symptoms disappear, and the horse is easy for a short time, when they return with increasing severity until the horse cannot be kept upon his feet. A cold sweat generally breaks out over the body, the legs and ears remaining at about the natural temptature. He looks around to his flanks, mostly at the right side, as if pointing out the seat of the disease, scrapes the ground with his forward foot, and will almost strike his belly with his hind foot. As the disease advances the horse will frequently throw himself down with force, look anxiously at the sides and sometimes snap with his teeth at his sides, and strike upwards with his hind feet as they do many times with inflammation of the bowels.

Treatment.—Relieve the pain by giving one ounce sulphuric ether, two ounces of tincture opium (laudanum) and a pint of raw linseed oil, and, if not relieved in an hour, repeat the dose. If there is not relief in a reasonable length of time after the second dose is given, some Surgeons recommend bleeding from six to ten quarts from the neck vein, but it is *rarely* necessary to do this. Occasionally walk the horse about to excite the bowels to action.

An excellent remedy, which is always at hand, is one heaping tablespoonful of saleratus mixed with milk, and given at one dose.

CORNS.

These are occasioned by the bruising of the sensitive parts of the foot by the contraction of the hoof, and if neglected, will produce severe lameness or even *quittor.* They are indicated by the horse's placing one foot in advance of the other and resting upon the toe.

Treatment.—Cut away the hoof so as to relieve the pressure, cut out and cauterize the corn. Apply flaxseed poultices and hoof ointment, and shoe carefully when the foot will permit it.

CURB.

This is a disease of the hock-joint, and consists of an enlargement or gradual bulging out at the posterior part of the hock. It is generally caused by a strain from galloping on uneven ground, wrenching the limb, prancing and leaping. It is one of the evils which usually occur among the better breed of horses. Pulling horses up suddenly on their haunches is asserted to be a frequent cause of curb.

Treatment. Perfect rest: if hot, bandage it and keep it constantly wet with *cold water* and saltpeter for a few days until the inflammation has ceased, then apply good liniment.

DIARRHŒA.

When this disease is not attended with pain, griping or pawing, as in colic, it will generally require no treatment; but if it continues, and the horse shows signs of pain or colic, there is reason for the belief that there is some irritating poison retained in the bowels.

Treatment.—Give twenty drops of tincture of aconite root in a little water, and follow with a powder as given below, every three hours, until the horse is better. Take prepared chalk, 5 drachms; catechu, pulverized, 1 drachm; pulverized opium, 10 grains; mix, and give as stated above. Give plenty of good cold water to drink. When the diarrhœa is better, give bran mash for a few days, and add a little ground flaxseed if convenient.

DISTEMPER.

This form of sore throat is characterized by swelling between the bones of the lower jaw, which terminates in an abscess. It is caused by a specific poison in the blood, which but few horses escape.

Treatment.—The opinions of different Veterinarians vary in regard to the treatment, some recommending poultices while others forbid it, etc., but the following plan is undoubtedly as good as any. Give grass or soft feed and but little, if any medicine, and if thought best to do anything to hasten the suppuration apply warm poultices, or some like blistering. The appetite will return when the abscess breaks or is opened.

EPIZOOTIC.

This disease attacks many animals at the same time, and originates in one common cause.

Treatment.—Take of pulv. licorice 1 lb., elecampane 1 lb., pulv. fenugreek $1\frac{1}{2}$ lbs., pulv. gentian $\frac{1}{2}$ lb., pulv. anise seed $\frac{1}{4}$ lb., ginger $\frac{1}{4}$ lb., black antimony $\frac{3}{4}$ lb., pulv. saltpeter $\frac{1}{2}$ lb., sulphur $\frac{1}{2}$ lb., epsom salts 1 lb., pulv. rosin $\frac{1}{4}$ lb., hard wood ashes $\frac{1}{2}$ lb., copperas $\frac{1}{4}$ lb.; mix well, and give a tablespoonful three times a day at first, and then only twice each day.

FOUNDER. (LAMINITIS.)

This disease is inflammation of the sensitive laminæ of the foot, of which there are two kinds, acute and chronic, the latter being a continuation of the former. The acute form is invariably cured, if properly treated, but the chronic form is generally considered incurable; it can be relieved very much, but the feet are always afterward sore and tender in front. It is caused by drinking cold water, when overheated and tired from over work, standing in a cold air (or where the wind will strike the horse) while warm, driving through a river while warm, long and hard drives over dry roads, etc.

Symptoms.—The horse will stand upon his heels, with fore feet and legs stretched out as far as he can get them, so as to throw the weight off as much as possible; and he can scarcely be made to move. The horse has fever and considerable constitutional disturbance, in the acute form of the disease.

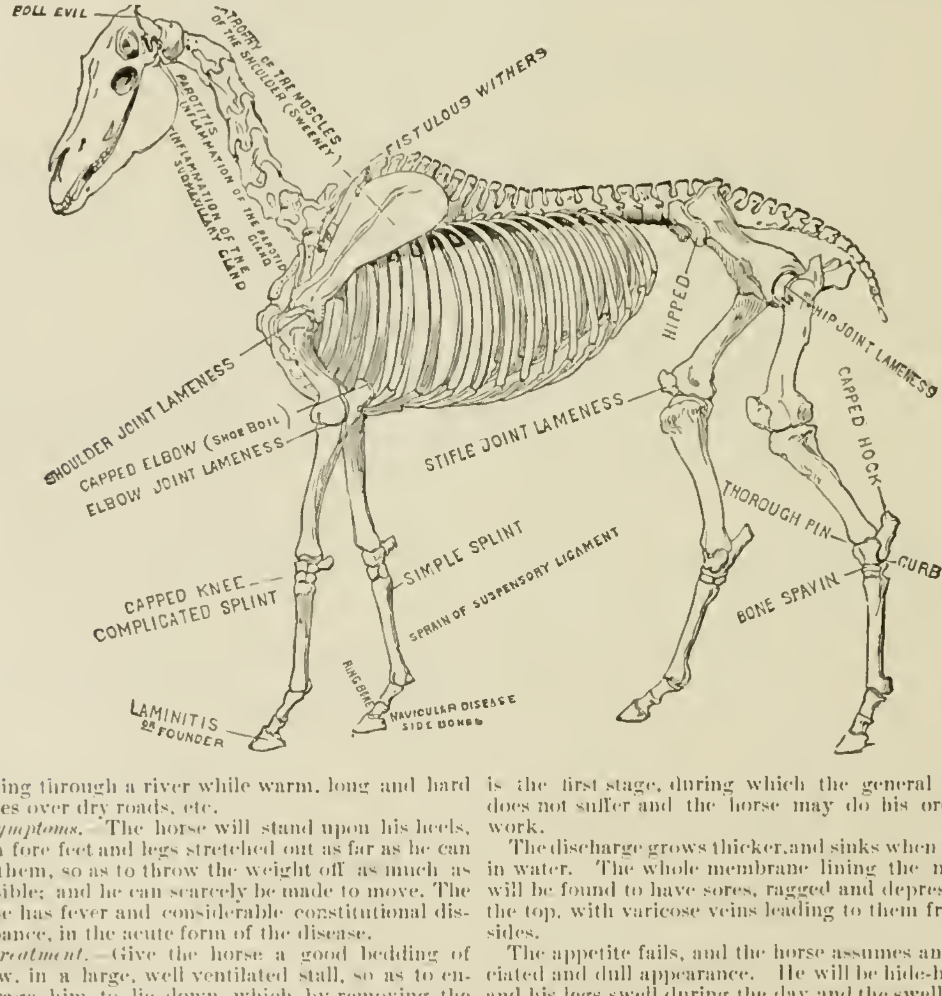
Treatment.—Give the horse a good bedding of straw, in a large, well ventilated stall, so as to encourage him to lie down, which, by removing the weight from the inflamed parts, will relieve his sufferings very much and assist in hastening the cure. As soon as his bed is fixed, give him twenty drops of the tincture of aconite root in half a pint of cold water, poured into his mouth with a bottle having a strong neck, and repeat this dose every four hours until six or eight doses have been given. Also apply a cloth wet in iced-water to the feet, and keep wet with the same for several hours until the severe pain has been relieved. Wet the cloths often, and continue for 2 or 3 days, or longer if necessary. Give plenty of cold water to drink. The above treatment should be adopted as soon as possible after the horse has been attacked with founder. Let the horse have rest until he has fully recovered. Give grass or mashes for 2 or 3 days and then give a good and fair amount of feed.

GLANDERS.

This disease is alike fruitful of evil to man and beast, and is generally considered incurable.

A horse may have latent glanders for years, and work well, the disease being during this time as contagious as in its developed state. The cause of glanders is somewhat varied in different cases, and may be attributed to filth, starvation, or to a debilitating disease, as lung fever, catarrh or any disease capable of generating pus, which being absorbed into the circulation forms a ferment within the blood.

Symptoms.—The membrane lining the nostrils assume a leaden or purple color, accompanied by a thin, acrid, transparent and odorless discharge. This is the first stage, during which the general health does not suffer and the horse may do his ordinary work.



The discharge grows thicker, and sinks when placed in water. The whole membrane lining the nostrils will be found to have sores, ragged and depressed at the top, with varicose veins leading to them from all sides.

The appetite fails, and the horse assumes an emaciated and dull appearance. He will be hide-bound, and his legs swell during the day and the swelling go down at night.

Treatment.—Give from one-half to one ounce doses of sulphite of soda at night, in cut feed, for several weeks and five grains Spanish flies (powdered) with it. Give, at the same time, every morning and noon, a powder consisting of three drachms powdered genitian; and two drachms powdered sulphate of copper. Give the medicines for a long time, not only to cure the disease but to improve the general health. Give a good liberal feed, and change the food often.

GREASE HEELS.

This disease of the heels and legs of horses is characterized by a white, offensive, and greasy discharge from the heels of the horse. The skin becomes hot, tender, and swollen, and sometimes sloughs away, leaving an ugly sore. It is caused by the sudden changes of the temperature of the earth, whether it be from heat to cold or from wet to dry. This disease generally follows wet streets, stables or lands.

Treatment.—Keep the legs dry and cleansed well with castile soap and soft water; then apply, once a day, verdigris, one half oz; rum or proof spirits one pint; mix and shake well before applying.

HIDE-BOUND.

A term used to denote the adherence of the skin to the ribs, when the horse is diseased. It usually arises from a deficiency in the quality or quantity of food, and is commonly an attendant on lingering diseases.

Treatment.—Give mixed feed—cut hay, bran and corn meal, wet with just enough water to cause the whole to keep together.

The following powders should be given in the feed, every night, for two weeks:

Powdered gentian root three drachms, powdered sulphate of iron, two drachms. Mix, and give for one dose.

INFLUENZA.

An epidemic disease occurring in the spring of the year.

Symptoms.—A chill, succeeded by increased heat of the body, and fever, cough, discharge of mucus from the nose, loss of appetite, great prostration, followed in a day or two with swelling of the legs, and, in some bad cases, of the belly, breast, etc. These symptoms vary some in different cases.

Treatment.—Cover the horse with a good blanket, and place him in a good, comfortable stable with proper ventilation but not too cold. Give 20 drops of tincture of aconite root in a little cold water every four hours until four or five doses have been given, and allow the horse plenty of good cold water to drink.

Then give the following: powdered gentian, four ounces, powdered fenugreek, four ounces, and powdered licorice root two ounces. Mix, and divide into twenty-five powders and give two or three each day. Allow the horse to have rest until he has fully recovered.

INTERFERING.

This is usually the result of weakness of the horse, although the blacksmith is frequently blamed for it, and perhaps justly sometimes, on account of being somewhat careless when the interfering might have been avoided, with a little care. Yet the cause is generally weakness.

Treatment.—Give the strengthening powder mentioned for treatment of bots, and feed well.

LAMPERS.

A swelling of some of the lower bars of a horse's mouth; so named because formerly removed by burning with a lamp or hot iron. Written also *lampass.*

Treatment.—Pinch or cut the bars until they bleed, and then rub in a little table salt, which is much better than rubbing the mouth with a red-hot iron.

NASAL GLEET.

This is a chronic discharge from the nostrils, of a whitish, muco-purulent matter. It is generally caused by neglecting to treat catarrh and colds properly. The horse may look well and feel well, and the general health be quite good.

Treatment.—Give a course of tonic powders, and feed well. Powders like those recommended in the treatment of bots will do well.

QUITTOR.

A chronic abscess in the hoof, caused by a bruise or prick of the sole, or from the calk of one foot being pressed into the coronet of the other, confined pus from suppuration, corn, etc.

Symptoms.—The horse is very lame on account of the inflammation before suppuration takes place, but it is relieved somewhat as soon as the quittor has burst.

Treatment—This should begin as soon as any lameness is discovered from any of the above named causes, and the inflammation stopped if possible before suppuration takes place. Keep the hoof clean and apply a solution of carbolic acid, one oz., to water, one quart.

Poultices of flaxseed meal are sometimes very useful

RING-BONE.

This is the result, usually of weakness, hereditary predisposition, or of a peculiar formation of the pastern joints which makes them poorly adapted to hard work; and therefore a provisional callous (or bony substance) is thrown out as a provision of nature to strengthen parts which are too weak.

Treatment.—Rest should be enjoined, and cold bran poultices or swabs, kept cool and moist by any refrigerant mixture, applied continuously until heat and tenderness are removed, when the fetlock is to be fired or dressed with fly-blister, or the ointment of the red iodide of mercury.

SANDCRACK.

Sandcrack is a splitting or fracture of the horny fibers of the horse's hoof, extending usually from above downwards; when reaching to the quick it causes lameness, and in all cases it constitutes unsoundness. Horses, with thin, weak, brittle feet, spoilt by much rasping, and rattled on the hard roads, furnish the majority of cases.

Treatment.—The horn must be thinned for about an eighth of an inch on either side of the crack; across the upper and the lower ends of the crack, to prevent its extension, the firing-iron should be drawn, making a line nearly through the horny crust. The opening may further be held together by winding round the foot several yards of waxed string, or fine iron wire. Except in very bad cases, slow work on soft land may be permitted, but road work is injurious. The growth of healthy horn is promoted by applying round the coronet, at intervals of ten days, some mild blistering liniment.

SADDLE GALLS.

These are sores produced by the saddle or by any other part of the harness.

Treatment.—The cause should be removed by attending to the saddle or other part of the harness, and adjusting it so as to remove the pressure. If possible get laudanum two ounces, tannin two drachms, and mix and apply twice a day.

SPAVIN.

A disease of horses which occurs under two different forms, both interfering with soundness. In young, weakly, overworked subjects, the hock-joint is sometimes distended with dark-colored thickened synovia or joint-oil. This is bog or blood spavin.

Treatment.—Wet bandages, occasional friction, a laxative diet, and rest, should for several weeks be diligently tried; and if such remedies prove unsuccessful, the swelling must be dressed with strong blistering ointment or fired.

The second variety of spavin is the more common and serious. Towards the inside of the hock, at the head of the shank-bone, or between some of the small bones of the hock, a bony enlargement may be seen and felt. This is bone spavin. At first, there is tenderness, heat, swelling, and considerable lameness; but as the inflammation in the bone and its investing membrane abates, the lameness is less perceptible, although the animal continues to drag his leg and go stiffly.

Treatment.—In recent and slight cases, cold water should be applied continuously; but in serious cases, when the limb is swollen and tender, hot fomentations are best. For several days, they must be perseveringly employed. When the limb is again cool and free from pain, an iodide of mercury or fly-blister should be applied, and the animal treated to three months' rest in a small paddock, the end of a barn, or a roomy loose-box. In persistent cases, firing or setoning usually gives much relief. If Kendall's *Spavin Cure* is obtainable, its application will do away with the necessity of any further treatment, in as much as it is a sure cure for the most aggravated cases.

SPLINT.

This is a small, bony enlargement, generally situated on the inside of the fore-leg, about 3 or 4 inches below the knee joint, and occurs frequently in young horses when they are worked too hard. The *treatment* should be the same as for bone spavin.

STAGGERS.

A disease of horses resulting from some lesion of the brain, which causes a loss of control of voluntary motion. As it generally occurs in fat horses which are well fed, those subject to these attacks should not be over-fed. The cause is an undue amount of blood flowing to the brain.

Treatment.—The aim of the treatment should be to remove the cause. In ordinary cases give half a pound of epsom salts, and repeat if necessary to have it physic, and be careful about over-feeding. In mad staggers it would be well to bleed from the neck in addition to giving the epsom salts.

STIFLE-JOINT LAMENESS.

This is not one of very common occurrence, but occurs occasionally in colts kept on uneven ground, which induces dislocation of the stifle, or patella, which slips off from the rounded heads of the bones when the horse steps.

It sometimes occurs in horses which are kept on bad food, or in those which are constitutionally weak.

Treatment.—Any flurry may restore the bone to its proper place, in colts, but for cases which do not become replaced, secure the horse and push the dislocated patella inward with both hands. Feed well and give the horse 5 or 6 weeks' rest, or place him in a level pasture, and have him shod, with a piece of iron projecting from the toe, especially if the toe has been worn off. Proceed as with spavin, to remove the soreness and pain.

SWEENEY. (*Atrophy.*)

This is a wasting away of the muscles of the shoulder, and is said to be caused by some disease in the foot or leg.

Treatment. Treat any disease found in the foot or leg as directed in other parts of this book. Apply to the shoulder soft soap with a little salt added, four or five times a week, and rub well.

THOROUGHPIN.

An affection accompanying blood spavin, and generally caused by excessive labor.

Symptoms.—A round tumor going through the leg and appearing on the outside and in front of the joint of the hock. Thoroughpin is the same disease as blood spavin, on a more extensive scale, causing the enlargement to extend through the joint from one side to the other. The *treatment* is the same as for spavin.

THRUSH.

This is a diseased action of the sensible frog, secreting pus instead of horn.

Treatment. Wash the feet with soap and water and apply ointment (equal parts of lard and tar melted). If neglected it will run into canker, its more serious form.

YELLOW WATERS.

This affection is the result of liver diseases, and has derived its name from the characteristic color of the membranes of the eyes, nose and mouth, which have a peculiar yellowness that is caused by the liver being diseased, so that its natural functions are not properly performed, and a large amount of bile is thrown back into the blood, instead of being carried off in its natural way, and only eliminated partially through the kidneys. It occurs most often in horses which are highly fed and have nothing to do.

Treatment.—Give ginger, two drachms; powdered mandrake root, one drachm, powdered aloes, four drachms; mix, and give at one dose. Feed the horse with soft feed and grass to loosen the bowels. Repeat the above dose as often as shall be necessary, which, in most cases, perhaps, would be about every other day.

For a more detailed account of this subject, consult the "Horse and his Diseases," by Dr. B. J. Kendall, Vermont, U. S. See *Horse* and *Horse Medicines*.

VETERINARY DEPARTMENT.—One of the Civil Departments of the English Army. It is placed under the charge of a Principal Veterinary Surgeon, who is responsible for the working of his Department. It is composed of Staff Veterinary Surgeons, Veterinary Surgeons of the 1st class, Veterinary Surgeons, and Veterinary Surgeons on probation. The Principal Veterinary Surgeon, who is stationed at Woolwich, is the sole Administrative Head of the Department. He superintends and directs the professional and departmental duties of the Veterinary Surgeons of the army as circumstances may require; he exercises general control over all stores of the Department. In addition to enforcing obedience to regulations, he issues such instructions as may seem necessary to meet specialties. Candidates for the Veterinary Department have to pass an examination before a Board of Military Veterinary Surgeons; if qualified, the seccessful candidates are admitted on probation. After 5 years' service they must pass an examination to be eligible for promotion to the rank of Veterinary Surgeon of the 1st class, and after 15 years' full-pay service in that rank they are eligible for promotion to that of Staff Veterinary Surgeon. The senior Staff Veterinary Surgeon, at a station, is responsible to the Principal Veterinary Surgeon that the duties of the officers undea his control are properly carried out. All returns and reports are sent to the Staff Veterinary Surgeon, who again renders the necessary returns, etc., to the Principal Veterinary Surgeon. Veterinary Surgeons are permitted to retire on half-pay after 25 years' service. Veterinary Surgeons and Surgeons of the 1st class are placed on the retired list on attaining the age of 55 years, and Staff Veterinary Surgeons when they have attained the age of 65 years.

VETERINARY SUPPLIES.—These consist of such horse medicines and instruments as are provided for in the Standard Supply Table for the animals of an army. In the United States Service, at the headquarters, depots, or larger posts of cavalry regiments, the standard supplies of instruments and medicines are under the charge of the Quartermaster, to be issued by him to the smaller commands of the regiment, in such quantities and of such articles as may be deemed requisite, conformably to the allowance fixed by the Standard Supply Table.

Veterinary medical supplies and instruments, for hospital use, remain in the hands of the Post Quartermaster, to be issued from time to time and in such quantities as are needed by the companies. Post Quartermasters take up all instruments and veterinary medical supplies, and report, when possible, to whose account they are to be credited.

The United States Standard Supply Table, with the allowances for Field and Hospital Service is given on pages 563 and 564.

The pocket-case should contain—one three-bladed fleam; one scissors, flat; one scissors, curved; one artery-forceps; one long-shank probe-pointed bistoury; one trocar; one finger-knife; one seaton-needle, closing in handle; one frog seaton-needle, in two parts; one seaton-needle, in three parts; one scalpel; one director; one retractor; one straight bistoury; one dressing forceps; one porte caustic; one tenotomy-knife; one tenaculum; six assorted drawing-knives; three lancets; sixteen needles, straight; six needles, half-curved; one needle-holder (Russian); two oz. sadler's silk; one oz. silver suture-wire, No. 26.

Articles.	Quantities for three months. For Field Service. 100 horses.	200 horses.	500 horses.	1,000 horses.	For Hospital Service. 100 horses.	200 horses.	500 horses.	1,000 horses.
MEDICINES.								
Acid, Arsenious (Arsenic)........oz.	1	1	2	2	2	2	3	3
Acid, Carbolic, Crystalized........oz.	12	14	16	32	14	16	32	64
Acid, Carbolic, for disinfection........lbs.	2	2	4	8	2	3	6	10
Acid, Muriatic........oz.	8	8	16	16	16	16	24	24
Acid, Nitric........oz.	4	8	12	12	8	8	12	16
Acid, Salicylic........lbs.	2	3	3	4	3	4	5	7
Acid, Tannic........lbs.	⅛	¼	¼	½	¼	½	¾	1
Aconite, Tincture of........lbs.	½	½	1	1	1	1	2	3
Alcohol........galls.	2	3	4	6	4	6	8	9
Aloes........oz.	10	20	25	30	20	30	40	45
Alumina and Potassa, sulph. (Alum)........lbs.	½	1	1½	2	2	2½	3	4
Ammonia, Acetate of........lbs.	1	1½	2	2½	2	2½	3	4
Ammonia, Aromatic spirits of........lbs.	1	2	3	4	2	3	5	7
Ammonia, Solution of (Hartshorn)........galls.	1	2	3	4	3	4	5	6
Ammonia Carbonate of........lbs.	3	4	5	6	4	4½	5	5½
Antimony and Potassa, Tartrate of (Tartar Emetic)........oz.	1	2	2	3	2	2	3	4
Atropia, Sulphate of........oz.	⅛	⅛	⅛	⅛	⅛	⅛	⅛	¼
Belladonna, Alcoholic Extract of........oz.	3	3	3	4	4	5	5	5
Blistering Liquid........qts.	1	2	3	4	2	2½	3½	4
Borax........lbs.	1	1½	3	4	2	3	6	8
Camphor........lbs.	2	2½	3	3½	3	3½	4	4½
Catechu........lbs.	½	½	1	1½	1	1	2	3
Castor Oil........galls.	1¼	2	3	4	2	3	4	6
Chalk, prepared........lbs.	1	2	4	6	2	4	6	8
Chloroform, purified........lbs.	2	3	4	5	3	4	5	6
Cinchona Bark, powdered........lbs.	1	1	2	3	2	2	3	4
Cinchona, Fluid Extract of........lbs.	4	5	6	6	4	5	6	8
Colchicum Seed........lbs.	½	½	¾	1	½	1	1¼	1½
Collodion........lbs.	¼	½	¾	1	¾	1	1½	1½
Copper, Sulphate of (Bluestone)........oz.	2	4	4	6	4	4	6	8
Cosmoline, Veterinary........lbs.	2	4	8	10	15	20	25	30
Ether, Sulphuric........lbs.	4	6	8	10	4	6	10	12
Ether, Spirit of Nitrous (Sweet Spirits of Nitre)........qts.	1	2	8	12	2	4	8	16
Flaxseed Meal........lbs.	20	30	40	50	40	50	60	70
Ginger, powdered........lbs.	2	2½	3	3½	3	3½	4	4½
Iodine........oz.	3	3	4	5	3	4	5	5
Iron, Sulphate of........lbs.	½	½	¾	1	½	¾	1	1½
Iron, Tincture of the Chloride of........lbs.	2	2	3	4	2	3	4	5
Jalap........lbs.	½	¾	¾	1	¾	1	1¼	1½
Lead, Acetate of (Sugar of Lead)........lbs.	1	2	3	4	2	4	6	8
Linseed Oil........galls.	1	2	4	6	2	4	6	8
Magnesia, Sulphate of (Epsom Salts)........lbs.	16	24	32	40	24	32	40	48
Mercurial Ointment........lbs.	1	2	3	4	2	3	4	5
Mercury, Biniodide........oz.	2	2	4	6	2	3	5	6
Mercury, Corrosive Chloride of (Corrosive Sublimate)........oz.	2	2	3	4	2	3	4	4
Mercury, mild, Chloride of (Calomel)........lbs.	1	1½	2	3	2	2½	3	3½
Morphia, Sulphate of........oz.	½	1	1½	2	1	1½	2	2½
Nux Vomica, Alcoholic Extract of........oz.	3	3	3	4	4	5	6	8
Olive Oil........galls.	1	2	4	6	2	4	6	8
Opium, powdered........lbs.	1	1	2	2½	1	1½	2	3
Opium, Tincture of (Landanum)........qts.	2	3	4	6	3	4	6	8
Pepper, Cayenne (red), ground........lbs.	½	½	1	1½	1	1½	2	2½
Potassa, Chlorate of........lbs.	2	2	2½	3	2	2½	3	4
Potassa, Nitrate of (Saltpetre)........lbs.	2	4	8	10	4	8	16	32
Potassium, Iodide of........lbs.	2	3	6	8	3	4	8	10
Quinia, Sulphate of........oz.	5	6	7	8	6	7	8	10
Rhubarb, powdered........lbs.	½	½	1	1½	½	1	1½	2
Rosin........lbs.	3	4	5	6	4	6	7	8
Silver, Nitrate of, crystals........oz.	1	1	1	2	1	2	2	3
Silver, Nitrate of, fused (Lunar Caustic)........oz.	1	1	2	2	1	2	3	4
Soap, Castile........lbs.	15	20	30	40	30	40	50	60
Soda, Bicarbonate of........lbs.	4	6	8	10	4	8	12	16
Soda, Hypophosphite of........lbs.	½	¾	¾	1	1	1½	1½	2
Sulphur, washed........lbs.	1	2	3	4	2	4	8	12

Articles.	Quantities for three months. For Field Service. 100 horses.	200 horses.	500 horses.	1,000 horses.	For Hospital Service. 100 horses.	200 horses.	500 horses.	1,000 horses.
Sulphur, in rolls...lbs.	1	2	3	4	2	4	8	12
Turpentine, Oil of...galls.	1	2	3	4	2	3	4	6
Zinc, Chloride of...lbs.	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$
Zinc, Sulphate of...lbs.	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	1
DRESSINGS.								
Bandages, 4-inch...doz.	3	5	8	10	4	6	10	12
Catgut, carbolized, for ligatures...yds.	6	8	10	12	8	12	16	20
Flannel, red, coarse...yds.	4	6	8	12	8	12	16	24
Lint, patent...lbs.	4	6	8	10	4	8	10	12
Oakum...lbs.	30	35	40	45	35	40	50	60
Pencils, hair...doz.	1	$1\frac{3}{4}$	2	$2\frac{1}{2}$	1	2	$2\frac{1}{2}$	3
Silk, ligature...oz.	$\frac{1}{2}$	$\frac{3}{4}$	1	2	1	$1\frac{1}{2}$	2	4
Sponges, coarse and fine, each...lbs.	1	2	4	8	2	4	6	10
Ticking (muslin twilled)...yds.	5	8	12	16	8	12	20	30
Tubing, rubber, ¼ inch...yds.	.....	.....	.....	.....	3	3	4	8
Wire, silver, No. 26, for ligatures...yds.	6	8	10	12	8	12	16	20
INSTRUMENTS.								
Ball forceps...no.	1	1	1	1	1	1	1	1
Bone-saw, small...no.	1	1	1	1	1	1	1	1
Catheters, gum, with stylet...no.	1	1	1	1	2	2	2	2
Cork-screws...no.	1	1	1	1	2	2	2	2
Dissecting-case...no.	1	1	1	1	1	1	1	1
Drenching-horn, tin...no.	1	1	1	2	2	2	2	2
Firing-irons (point and line) each...no.	1	1	1	1	1	1	1	1
Funnels, rubber...no.	1	1	1	1	2	2	2	2
Funnel, tin...no.	1	1	1	1	2	2	2	2
Foot instruments (a set)...no.	1	1	1	1	1	1	1	1
Graduate glasses, glass, 6-oz...no.	1	1	1	1	1	1	1	2
Graduate glasses, glass, minum...no.	1	1	1	1	1	1	1	2
Hobbles, casting...no.	1	1	1	1	1	1	1	1
Hones...no.	1	1	1	1	1	1	1	1
Measures, tin...set.	1	1	1	1	1	1	1	1
Mortar and pestle (wedgewood ware)...no.	1	1	1	1	1	1	1	1
Needles, Surgeons'...no.	12	12	24	24	1	24	36	36
Needles, for wire sutures...no.	12	12	12	1	1	12	24	24
Panniers, to be filled from stock on hand, similar in make to those of the Medical Department...no	1	1	1	1	......	......	......	......
Pill-tiles...no.	1	1	1	1	1	1	2	2
Pocket-case*...no.	1	1	1	1	1	1	1	1
Post-mortem case...no.	1	1	1	1	1	1	1	1
Probangs, two pieces of celluloid...no.	1	1	1	1	1	1	1	1
Saddle-bags, Physician's for small detachments. To be filled from stock on hand...no.	1	1	1	1	......	......	......	......
Scales and weights, prescription...no.	1	1	1	1	1	1	1	1
Scales and weights, shop...no.	1	1	1	1	1	1	1	1
Scissors, curved...no.	1	1	1	1	1	1	1	1
Scissors, straight...no.	1	1	1	1	1	1	1	1
Slings, suspending...no.	1	1	1	1	4	1	1	1
Spatulas...no.	2	2	2	1	2	2	4	1
Speculum, mouth...no.	1	1	1	1	1	1	1	1
Syringes, hypodermic...no.	1	1	1	1	1	1	1	2
Syringes, rubber, 2-oz...no.	1	1	1	1	1	1	1	2
Syringes, rubber, 8-oz...no.	1	1	1	1	1	1	1	2
Syringes, rubber, 24-oz...no.	1	1	1	1	1	1	1	2
Thermometer, clinical...no.	1	1	1	1	1	1	1	1
Tooth-chisel...no.	1	1	1	1	1	1	1	1
Tooth-forceps, large...no.	1	1	1	1	1	1	1	1
Tooth-forceps, small...no.	1	1	1	1	1	1	1	1
Tooth-rasps...no.	1	1	1	1	1	1	1	1
Tracheotomy-tube, self-retaining...no.	1	1	1	1	1	1	1	1
Trephine...no.	1	1	1	1	1	1	1	1
Urinometer...no.	1	1	1	1	1	1	1	1

The tables are ample and sufficiently varied for ordinary practice, but in order to provide for the necessities of epidemics,and to indulge,as far as practicable, individual preference and training, a special requisition for articles not on the Supply Table,with an explanation of the nature of the emergency or case rendering it necessary,may be forwarded to the Quartermaster General for his action. The panniers should,like those in use by the Medical Department, be so arranged as to contain only articles that are on the Supply Table. They should contain the articles of medicines in quantities allowed for one hundred horses in field service for three months, and a pocket-case,ball-forceps, cork-screw,6-oz. graduate glass, prescription scales, two spatulas and 16-ounce syringe. See *Horse Medicines.*

VETERINARY SURGEON.—An officer of a cavalry regiment, or in the artillery, who is charged with the supervision of the horses, and with their cure, if in need of medical aid. In the English Army,a Veterinary Surgeon is required to produce proper testimonials of qualification, and to pass an examination. On appointment, he receives 10s a day, and ranks as Lieutenant. By service, his pay rises to £1, 3s. a day, and his relative rank to that of Major. After 25 years' service, he becomes entitled to retire on his half-pay.

In the United States Service, there is one Veterinary Surgeon allowed to each of the regiments of cavalry; and the 7th, 8th, 9th, and 10th regiments of cavalry have an additional Veterinary Surgeon. These surgeons are recognized as civilians. Appointments as Veterinary Surgeons are confined to the graduates of established and reputable Veterinary Schools or Colleges. They are appointed by the Secretary of War, in numbers not to exceed the legal establishment, and only on recommendation from the Commanding Officer of the regiment, supported by the requisite proofs of learning and skill, and by approval of intermediate Commanders. The visits of inspection and instruction by the Veterinary Surgeons are made under the direction of the Commanding Generals of Departments and Divisions.

A Veterinary Surgeon from time to time visits all the companies of the regiment to which he belongs; instructs the Farriers and enlisted men in the proper and humane care of the horse, in order to the prevention and treatment of diseases; especially to teach the anatomy and pathology of the foot. He illustrates his instructions by dissections and specimens, to show the nature and uses of all parts of the horse's foot, and he also teaches the principles and practice of horseshoeing.

Veterinary Surgeons and Farriers are encouraged to make and preserve collections of specimens obtained from *post mortem* examinations, illustrating the anatomy and pathology of the horse, in order to popularize and disseminate a knowledge of those important subjects in the Army.

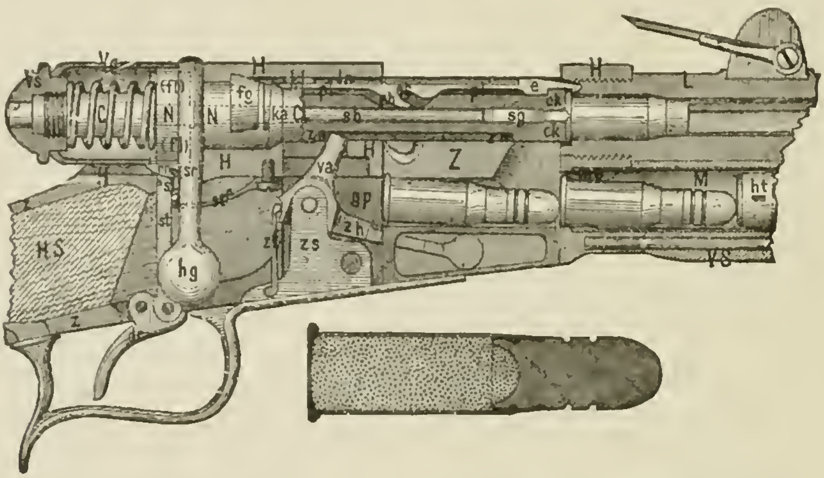
In order to encourage thoroughness and system in the study and treatment of the diseases of the horse, as well as to furnish information regarding the management of the Veterinary Department of the Army, a monthly report of sick and wounded for each company and battery, similar to that adopted by the Medical Department, is forwarded by Veterinary Surgeons and Company Farriers, through the Company and Post Commanders, to the Quartermaster General.

VETTERLIN RIFLE.—The Vetterlin repeating-rifle of the Swiss Service is a Swiss invention, the distinguishing peculiarity of which is the union of a cartridge magazine with a sliding-bolt breech system. The drawing very clearly shows the system with the breech closed, as seen from the right side. The letter, H, represents the receiver or the frame to which all the remaining parts are attached. The rear of the receiver terminates in two tangs, top and bottom, between which the point of the butt-stock, H S, is inserted and held by a screw passing from the lower to the upper tang. The barrel is screwed into the forward part of the receiver in the usual way. The magazine attached to the underside of the barrel, and is capable of holding 11 cartridges end to end. The line of cartridges is pressed toward the opening of the receiver by a light spiral spring which terminates in a cap, *h t*. This spring is known as the magazine feeding-spring. The cartriges are transferred from the magazine to the chamber of the barrel by the combined action of the carrier-block, Z, and the breech-bolt which operates it through the agency of the bent lever pivoted on the part, *z s*. As the breech-bolt is withdrawn the carrier-block rises in its vertical cut in the receiver, H, with the cartridge in it, when the breech-bolt is pressed forward the cartridge is pushed into the chamber and the carrier-block falls back to its first position ready to receive another cartridge from the magazine. The body of the breech-bolt is a steel tube, C. Into the central hole of this tube is inserted the firing-pin, *s b*. The point of the firing-pin rests in the crotch of the firing-pin fork, *s g*, which is inserted into a horizontal slot of the body of the breech-bolt. The prongs of this fork lie in two grooves on opposite sides of the solid head of the breech-bolt, *c k*, *c k*. The object of the two prongs is to strike in two places the fulminate of the cartridge, which lies in the rim of the head. The firing-pin is impelled by a spiral mainspring, which presses against the grooves of the wings *fl*, *fl*. These parts are covered by the lock-case, V *g*, which is secured in place by the flange of the lock-nut, V *s*, by being screwed to the end of the breech-bolt. The point of the firing-pin, *s b*, when it projects from the lock-nut, shows that the firing-pin is at full cock. Full and half-cock notches are attached to the lower wing of the firing-pin. The sear-spring and its screw are shown at, *s t f*, and the trigger is shown at, *d r*. A short sleeve, N N, envelopes the body of the breech-bolt. To this sleeve are attached the handle of the breech-bolt, *h g*, and the two locking wings, *f g*, *f g*. The former is used to work the breech-bolt, while the latter are employed to lock it into corresponding grooves in the receiver, ready for firing. The forward end of the sleeve, N, abuts against the collar, K *a*, which is solidly united to the body of the breech-bolt. The abutting shoulder of this collar is of slight helical form to secure the tight fit of the locking-wings against the shoulders of their corresponding grooves in the receiver. The upper surface of the body of the breech-bolt has a groove into which fits the cartridge-shell retractor, *e*. The projecting part of the extractor fits into the groove, *l n*, of the receiver at the same time a cross-key serves as a stop to keep the breech-bolt from being withdrawn from the receiver. The other end of the extractor acts as a stop for the rotary motion of the sleeve, N. The extractor is held in place by a hook which passes under the cross-pin. In the groove on the under side of the breeck-bolt works the point of the small arm, *r a*, of the crooked feed-lever. The long arm *z h*, of this feed-lever works in a horizontal groove in the carrier-block Z, and raises it and depresses it when the forward or rear end of groove strikes against, *r a*.

The cut in the end of the barrel is for the hook-end of the extractor to work in. The projection, *m s*, serves as a stop to prevent the feed-spring cup from passing beyond the magazine-tube. A movable piece, attached to the left side of the receiver by means of a screw, is employed to cut off the cartridges in the magazine from the carrier-block when the piece is to be used as a single breech-loader, in which event the cartridge is inserted into the carrier-block from an oblong hole on the right side of the receiver. This hole is covered when not in use by a swinging piece. The empty shell, after firing, is drawn back by the extractor attached to the breech-bolt, and thrown out clear of the receiver by the upward motion of the carrier-block, the upper portion of which is made of suitable shape for the purpose. A sliding-piece called the dust-cover, serves to keep dust out of the working parts of the piece when not used. The cartridge-case is drawn out of sheet-copper, and the priming of the fulminate is carried in the rim of the head. The following are the principal dimensions and weights of the Vetterlin rifle:—Caliber, 0.41 inch; number of grooves, 4 ; the depth of grooves, 0.0086 inch; the width of grooves, 0.0177 inch; twist of grooves, 26 inches; length of barrel, 33.14 inches; the length of arm without the bayonet, 51.18 inches; the length of arm with bayonet, 70.08 inches; weight of the arm without bayonet, 10.14 pounds; weight of the arm with the bayonet, 11.02 pounds; weight of powder-charge, 60 grains, (No. 4 Swiss;) weight of bullet, 315 grains; weight of cartridge complete, 470 grains; weight of the rifle with the magazine filled, 12.12 pounds; the initial velocity is 1,341 feet. The angle of sight given in minutes, for different ranges from 100 to 1,000 meters is as follows: 100; 200, 300, 400, 500, 600, 700, 800, 900, 1000, meters; — 12.16, 25.86, 41.15, 58.16, 77.13, 98.16, 121.46, 147.20, 175.60, 206.90, minutes. Extensive experiments were made in Bavaria in the spring of 1872 by a Military Commission in order to compare the rapidity of fire of the Swiss Vetterlin repeating-rifle and the Bavarian Werder rifle, which is a single breech-loader. It required 30 seconds to load the Vetterlin rifle, putting 11 cartridges in the magazine and 1 in the chamber, and 16 seconds to discharge the 12 shots. As a single breech-loader, the same arm was discharged 12 shots per minute. In the hands of experienced soldiers the rapidity of the Vetterlin and Werder rifles, both as single breech-loaders, was as 16 to 18 shots in one minute. See *Small-arms*.

VEUGLAIRE. An early form of cannon in which the chamber and barrel were formed of separate pieces. It followed the *bombarde*—(a can open at both ends when first made)—although a few pieces now existing would indicate that it was of earlier origin and date of manufacture.

VIADUCT. A structure for conveying a roadway across a valley or low level, being so called in distinction from an *aqueduct*, which is an erection of the same description for the conveyance of water over a hollow. It is in every respect similar to an extended bridge. The great extension of railways within recent years has rendered the use of viaducts much more common than formerly. These are of every kind of construction—of wood, iron, stone, and brick work. A railway enbankment is also a species of viaduct; but the term is limited to those structures which are more or less open, and rest upon piers. A very peculiar example is that over the Moine, near Nantes in France. The piers are all perforated by a pointed arch, which intersects the main cylindrical arches, and forms a groined roof, similar to that of a Gothic cathedral. This viaduct consists of 15 arches, and is 348 ft. in length and is all built of fine granite. See *Tunneling*.



VICE PRESIDENT.—An officer of the U. S. Government, whose official function consists in presiding over the Senate, where he can vote only in case of a tie, and who succeeds to the presidency upon a vacancy in the latter office. He is elected with and in the same way as the President ; and if there has been no election of a Vice-President by the Electors, a majority vote in the Senate, if there be a quorum of two-thirds present, will elect him. In the absence of such a majority he is elected from the two candidates receiving the largest senatorial vote.

VICEROY. A title popularly given to any officer who is delegated by a Soveriegn to exercise regal authority in his name in a Dependency, as the Lord Lieutenant of Ireland—who, however, is never officially so styled. It was the proper official designation of the Governors of Naples, Spain, and Peru, under the old Spanish Monarchy. See *Khedive*.

VICTORIA CROSS. The peculiarities of this decoration, which was instituted on the termination of the Crimean campaign of 1856, are, that it may be granted to a soldier of any rank, and for a single act of valor. The Cross of the Legion of Honor, as was

Victoria Cross.

felt during the Crimean campaign, served a purpose in the French Army which was served by none of the decorations,and it was in imitation of it that the Victoria Cross was founded with the inscription, "For Valor," and which can be given to none but those who have performed in presence of the enemy, some signal act of valor or devotion to their country. The general distribution of the crosses earned in the Crimean war took place in Hyde Park on the 26th June, 1857. The recipients were 62 in number. The Victoria cross is in the form of a Maltese cross, and is made of bronze. In the center is the royal crown, surmounted by the lion, and below, on a scroll, the words, "For Valor." The ribbon is blue for the navy, and red for the army. On the clasp are two branches of laurel, and from it the cross hangs, supported by the initial "V." The decoration is accompanied by a pension of £10 a year.

VICTORY.—The overthrow or defeat of an enemy; success in contest. In Roman mythology, Victory is described as a goddess, called Varro, the daughter of heaven and earth. Her altar was preserved in the Curia, or Senate House, of Rome; and its destruction was the subject of one of the latest contests between Christians and Pagans.

VICTUALS.—Food or sustenance allowed to the troops, under certain regulations, whether they are on shore or embarked in transports. The Articles of War provide that whosoever relieves the enemy with money, victuals, or ammunition, or knowingly harbors or protects an enemy, shall suffer death, or such other punishment as a Court-Martial may direct. See *Dietary*, *Food*, and *Ration*.

VIEWER.—An examiner of small-arms, and stores generally. At the Government establishments of Enfield and Birmingham, there is a staff of viewers for the purpose of examining small-arms after they have been manufactured. In the Royal Gun Factory, at Woolwich, there are also viewers whose duties are to examine every article during the different stages of the manufacture of a gun, to ascertain that the gun is manufactured properly, and to the correct dimensions. All work not strictly done in accordance with the working drawing is brought by the viewer to the notice of the Superintendent.

VIEW OF A PLACE.—A reconnaissance of a forti- about it, as hills, valleys, rivers, marshes, woods, fied town, its situation, and the nature of the country hedges, etc.; taken in order to judge of the most convenient place for opening the trenches, and carrying out the approaches; to find out proper places for encamping the army, and for the park of artillery.

VIGILANCE.—Watchfulness, care, or circumspection. A General in command of an army should possess all these qualities, and be ever on the *qui vive* to guard against surprise. Previous training, such as constant service in the field and through the different stages of his career, will conduce much to give an officer in command that vigilance necessary to be possessed by the leader of a force.

VIGNE.—In ancient times: a shed, or gallery with a roof and sides, made of double hurdles, 18 or 20 feet long, and 7 or 8 feet wide, upon wheels. Vignes were used to establish a covered communication between the towers, testudos, etc., of the besiegers.

VIKING. A name given to the piratical Northmen who infested the coasts of the British Islands and of France in the 8th, 9th, and 10th centuries. This word is quite unconnected with "King," being derived from the Scandinavian *vik*, a bay; and this class of marauders were so called because their ships put off, not like the King's ships, from the lawful harbor, but from the bay.

VILLAGES.—Farm houses, villages, or walled enclosures, when within the limits of a position taken up by an army, can be made strong adjuncts to it, owing to the ease with which they can be converted into strong posts, and the short time required for this purpose. Their importance will, however, depend upon the materials of which they are constructed. When of wood, they will not be well adapted for defense, because they can readily be fired; those built of stone, with stone enclosures, are the best. When commanded by high ground within cannon range, which may be occupied by the enemy, their value as an accessory means of defense is also greatly reduced. Villages have at all times played a very important point in battles. The history of war is full of the accounts of sanguinary struggles for the possession of villages. The villages of Aspern and Essling, with the trench connecting them, saved Napoleon from destruction in 1809. The neglect of the villages in front of Leipsic, undoubtedly helped to bring about the great defeat he sustained there. In more recent wars the struggles round the villages of Solferino, Woerth, Vionville, may be quoted.

The whole village, or such portion of it as may be deemed advantageous, must be used as the reduit or redoubt, and must be loop-holed and put in defense. The streets being barricaded, traverses, etc., made. But while doing this, arrangements must be made for placing the first or shooting line outside the village. A village is usually surrounded more or less with enclosures, such as hedges, walls and fences; when these can be taken advantage of, they should be used, and an enceinte formed round the villages by their use combined with that of shelter-trenches; in the selection of fences for this purpose, and in the construction of shelter-trenches, care should be taken to place them sufficiently far from the houses of the village to prevent the troops lining them being struck by splinters. A distance of forty yards will suffice for this. But it is also desirable that when the defenses forming the outer line are carried, the defenders should be able to fire into it from the houses, consequently it will be better to place the outer line at one hundred and fifty or two hundred yards from the houses; if such an arrangement does not give too great an extension to the front; if such be found to be the case, the distance between the outer and inner lines may be reduced one-half. The form which the outer line takes must always be an irregular one. If possible, a closed redoubt, even of the weakest profile, should be placed at the angles. Artillery may be placed in these redoubts, but it is much better in most cases not to do so, but to put the guns under epaulments in rear of the village in such places as will enable them to flank it and cross fire in front. In the defense of villages and woods, mitrailleuses will be of great advantage, their lightness enabling them to be readily moved by hand from place to place, and the very efficacious fire they give over a limited area renders them suitable for such purposes. It has always been laid down as a rule that obstacles which detain an enemy under fire are of importance. But obstacles for such a purpose are very apt to give an attacker shelter where he may establish himself, and should be very carefully considered before being used. The most dangerous and difficult ground for troops to advance over is undoubtedy a gentle slope completely seen and perfectly open, and in placing a village in a state of defense, the more open the ground is, in front and to the flanks, the better. All obstacles may be viewed as opposing the enemy's advance, hampering the defenders if they take the offensive, and furnishing cover to the attackers. The position of obstacles must therefore be carefully considered; perhaps the most efficacious kind of obstacle is a wire entanglement, as it affords no shelter and is not affected by artillery fire. But a wire entanglement completely forbids the action of cavalry; a few men armed with breech-loaders, and surrounded by wire, would be perfectly safe from a cavalry attack.

In examining a village prior to putting it in a state of defense, the following points should be chiefly considered: *a*. The nature of the ground round the village, the amount of cover offered to an attack, the nature of the fences, and whether suitable for defensive purposes or not. *b*. The line to form the outer enceinte should be carefully examined, and such walls, hedges or fences, as may be available for forming a portion of the line, should be selected, and the places where shelter-trenches or earthworks are required should be marked. *e.* The houses forming the inner enceinte should be selected, those with timber out-buildings being avoided if the woodwork cannot be pulled down. The roads leading through the village should be examined, the places for barricades selected, and fresh openings and passages made where requisite. It is essential that these points should be quickly determined on. There are two errors which officers are apt to fall into under such circumstances; one acting hastily and undertaking too much work for the time and means at their disposal, the other thinking too long of what they are going to do. The outer line should be begun first, and so soon as it is in a fair way of being completed in time, men may be set to work on the other portions.

If the village is held as a *detached* post it should be carefully surrounded, and everything done to make it as secure as possible, for the troops placed in it have, in such a case, nothing but their own exertion to depend upon. When held as an *advanced* post, the village gets support from the general line of battle, and should be made as strong as possible on three sides, but on the side nearest the defender's position should be open, having a line of shelter-trench, about two hundred and fifty yards in rear of it, with epaulments for artillery, so that the enemy, when the village is captured, will not be able to use it as a *point d'appui* for further operations. Such a line of shelter-trench in rear of the village will effectually prevent the attackers flank attack (which he is sure to make) from getting into the rear of the village, and will further cover the retreat of the troops engaged in its defense. Any defensive work may be carried by surprise, or by some accident, such as thick weather, which enables the attackers to come close up; but the moment it is captured is always the very best time for driving out the intruders, before they have time to get into order; hence the garrison of all works, great or small, should have a reserve ready to act rapidly. In defending a village the places where supports are to be placed should be carefully selected, they will be safer when placed in small bodies clear of the village, and immediately behind the troops they are to support. When time is available it will be judicious to cover them by shelter- trenches. Although the houses composing the village should be loopholed, troops should not be put into them until the last moment, the men to occupy the different places should be carefully told off, and when the attack gets sufficiently near, they should be taken into the village in small numbers, and carefully posted in the houses by officers. For this purpose a rough sketch of the village should be prepared, and the position of the different bodies intended to hold it should be noted. At this stage of the attack the assailant's artillery will probably have moderated its fire, being partially masked by its own infantry, and hence the men, who should previously have been as much as possible under shelter, will come up fresh and in good heart.

So soon as the main body of the troops engaged in the defense of the village are taken into the village, their place in the rear should be supplied by troops from the second line, who should line the shelter-trench in rear of the village, and throw forward a strong line of skirmishers between the trench and the village. Feeding the fight in this manner invariably helps the defenders, who are much less likely to be demoralized, when they know fresh troops have come up to support them from the rear. It obtains thus for the defense, a part of the advantage which the offensive always possesses, namely, the moral effect of a forward movement, and preserves the same *general* distribution of troops, both for attack and defense. Important as villages are, too much value must not be assigned to them. And here, as everywhere, a recurrence to first principles is of importance. Fortification is the art of enabling a small body of men to resist a large force. If the fortification or village requires more men to defend it than would be assigned to a similar front of open ground, it really does more harm than good. Shutting up too many men in a village is a great error. The object of holding a village is twofold. 1st. To deny the covers it offers to the enemy. 2d. To make a certain point secure, and thus liberate men, who otherwise would be employed at that point as defenders, for offensive action. This latter is the true principle on which all field fortification should be carried out.

If too many men are placed in a village, and the general line of battle is forced, the men garrisoning the village can do little or nothing to restore the battle, and if the second line and reserve fail to drive the enemy back it is likely that the defenders of the village will be captured. Blenheim affords an example of this. The French General Tallard placed a large force of infantry in the village, situated in a loop of the Danube; when Marlborough forced the French line, the infantry in Blenheim were completely cut off, and had to surrender. Field fortification can never be a panacea for weakness. And it never ought to be viewed otherwise than in its tactical relation to the general action of the troops fighting. By judiciously using it, it becomes an important and valuable auxiliary. The true key to all such questions is to be found by keeping steadily in view that the *passive defense of any position by an army is an absurdity.* When an inferior force finds itself in presence of a superior, and compelled to fight, it is in danger of having its flank turned by the extension the larger army can afford to make. To obviate this danger, the army acting on the defensive may, by a judicious use of villages and field-works, seek to extend their line, and concentrate the mass of this force where it can strike an offensive blow; the chief use of fortifications should be to assist this by so strengthening a portion of the line of battle that it may be held by a reduced number of men.

The attack of a village is a difficult and generally a costly operation, and should be attempted only when the object justifies the loss. Many of the hardest fought actions have been those where the attack and defense of villages formed a prominent feature. At Ligny twenty Prussian battalions struggled for the whole day against thirty-two French battalions, and much of the loss both sides suffered was round the village of Ligny itself. A direct attack upon the troops in a position of this nature will rarely be successful. Rather seek elevated ground, preferably on the flanks, from which a strong artillery fire may be brought to bear; or, direct the attack upon other points of the enemy's position, which, if carried, will cause the troops occupying the village to abandon it, or run the risk of being cut off and captured. That the farm and inclosures of La Haye Sainte, on the battle-field of Waterloo, formed a strong and important post in the allied position, is made clear by the great efforts put forth and the severe losses sustained by the French, in their efforts to carry them. The recent Franco-German war offers many examples of villages, woods, and posts, being defended, and advantageously made use of by the Germans, especially in the blockades of Paris and Metz: in every case the principles on which these posts were held were identical, viz., the exterior of the wood or village was held strongly by a thick line of skirmishers, and an interior trench, or defense of some kind, was invariably provided. Thus, if the first line of defense was carried, the second helped the reserve in retaking the first; in every case such posts were used not as the defense itself, but as adjuncts to the defense, and as means of holding certain important points while the troops acted on the offensive. In preparing defenses of this nature it is essential that the line of retreat of the troops be marked out, so that when the men fall back they may not interfere with the fire of those in rear of them; and it is further essential that distinct notices be clearly put up detailing the names of the various districts into which the defenses are divided, and pointing out the nearest road to those districts. No amount of zeal, courage, devotion, or knowledge compensates for the neglect of such details.

The attack on Le Bourget, at Paris, is a good example of the attack on villages. Le Bourget is a village of some length, the gardens of which are surrounded by long straight walls six feet in height, intersecting each other at right angles. These were prepared for defense by loop-holing and heaping up earth, and the entrance to the village was barricaded. The attack was undertaken from three sides, viz., from Blanc Mesnil, Dugny, and along the road between them. The two flanking columns sent to the front clouds of skirmishers, which gained ground at the double, and then threw themselves down. The supports and reserves followed these, spread out in extended order, and also at the double. As these latter threw themselves down to rest, the skirmishers again ran forward, and at the same time bore off toward the flanks. When they arrived within range, they again threw themselves down, and opened fire upon the enemy. The gaps which occurred from drawing off toward the flanks were filled up by extending subdivisions. In like manner the flanks were prolonged by single companies advancing one after the other, but always in extended order, so that the concentric attack which had moreover—as the enemy was approached—become denser in character, kept always assuming a more enclosing form. Each of the extended bodies of troops took advantage of whatever cover afforded, in order to rally behind it and collect together. Thus in front of the north-east flank a row of dung-heaps had been left upon the field, which afforded a rallying place for an entire company, which opened from behind these a destructive fire upon troops who came forward to attack. On the other flank the bed of the brook Le Moleret afforded a slight protection and was at once turned to account by a few formed companies, in order to cover an onset against a counter-attack delivered from Drancy. The mechanism of the attack consisted principally in *the rapid change from open to close order directly the most trifling cover admitted of the rallying of a subdivision or company. On the other hand, every advance over open ground took place in widely extended skirmishing lines, which moved on like ants.* The right wing was left behind; the center had not sufficiently extended itself, and had renounced old forms too little, and its losses were enormous; but the attacking left wing, under Lieutenant Colonel Graf Waldersee, pressing forward in long thin lines, succeeded in making good an attack of skirmishers up to the garden walls, in silencing the fire from them, and in breaking into the long village, both from its flanks and rear. Its defenders now gave way, General Budritzky was able to enter from the front, and the right flank column to reach the rear entrance without very severe loss. See *Strategy*.

VINEGAR.—An impure form of acetic acid, obtained from wine, cider, beer, or other liquors, by acetous fermentation; also from wood, by distructive distillation. Vinegar is used in the composition of stars for signal rockets.

In transportation by water, vinegar is essential to the comfort of horses, and should be freely used by sponging their mouths and noses repeatedly, and also their mangers. A small portion of vinegar drank with water supplies the waste of perspiration of men in the field. It is better than rum or whiskey; it allays thirst, and men who use it avoid the danger of drinking cold water when heated, and are not fevered as they are too apt to be by the use of spirituous liquors.

VIOLENCE.—Any officer or soldier who shall offer any violence against his superior officer, being in the execution of his office, on any pretence whatsoever, punished by death or otherwise, according to the nature of his offence. Violence to any person who brings provisions to the camp, garrisons, or quarters to the forces of the United States employed in any part out of the said States, punishable in like manner.

VIRETON.—An early bolt furnished with feathers, on thin pieces of wood or iron, which were arranged in a curved direction round the shaft, so as to impart a rotary motion to the bolt.

VIRGIN SYSTEM OF FORTIFICATION.—This system advocates the surrounding of cities by walls only, and constructing small fortresses or citadels exclusively military. The enceinte is bastioned with a triple flank, with terrepleins respectively 2, 14 and 24 feet above the ground, and parapets 6 feet high. They are at such a distance apart as not to interfere with the service of artillery, and they not only defend the ditch and overlook the enemy's batteries, but also can direct reverse fire on the lodgment of the bastion of attack, provided its upper flanks have been leveled in time. The bastions are protected against ricochet by a bonnet at the salient. The curtain forms a re-entering angle, and serves with the tenaille to give a well directed fire on the outworks. The interior defense is admirably organized, by means of bastioned towers, and a donjon with 24 guns on each face. The outworks consist of ravelins, counterguards, tenaillons and covered-way, without traverse. See *Fortification*.

VIROLE.—In Heraldry, the hoops, ring, or mouthpiece of a bugle or hunting-horn.

VISCOUNT.—Originally the officer who acted as deputy to the Earl, the Earl being the King's immediate officer in his country. When the title, Earl, originally personal, became hereditary, which took place in England under William the Conqueror, a deputy had necessarily to be appointed in cases where he was a minor, or otherwise incapacitated from discharging the duties of his office. This deputy gradually became a permanent officer, otherwise known as the Sheriff whose Latin designation continued to be *Vicecomes*. The hereditary title of viscount is a degree of nobility unconnected with office. It was first granted in England to John Beaumont, created a peer by the title of Viscount Beaumont in 1440. A Viscount is now the fourth degree of nobility in the United Kingdom. His coronet consists of a chased circlet of gold, round which are ranged an indefinite number of pearls, nine of them being most generally shown, smaller than those of a Baron's coronet, and in contact with each other. The mantle is scarlet, and has two doublings and a half of ermine. A Viscount is styled "Right Honorable"; his wife is a Viscountess; his eldest son has no courtesy title of peerage; but all of his sons and daughters are commonly styled "Honorable."

Viscount's Coronet.

VISIERE.—A movable plate, pierced with narrow openings, inserted between the front rim of the helm and the upper part of the *bavière*, to fill in and defend the space left open before the face of the wearer. See *Visor*.

VIS INERTIAE.—The propensity of a body to remain in its actual condition, whether of motion or rest, and to resist change.

VISITING OFFICER.—An officer whose duty it is to visit the guards, barracks, messes, hospital, etc. The same as Orderly Officer.

VISITING-ROUNDS.—These embrace both officer's and ordinary rounds. In officer's rounds, the officer guarding is preceded by a drummer carrying a lantern, and followed by a Sergeant and a file of men. Ordinary rounds consist of a Sergeant and a file of men. See *Grand Rounds*.

VISOR.—The visor, otherwise called the beauvoir or beaver is the part of the helmet of the Middle Ages which protected the face. It was perforated to admit light, and movable, so that it could be raised or put down at pleasure. According to the rules established in the latter Heraldry, the helmet of a Knight, when placed over his shield of arms, has the visor up, while that of Esquire has the visor down.

VIS VIVA.—The *vis viva* of any body is its mass multiplied by the square of its velocity; "work" or dynamical effect supposes a body moved, and a resistance overcome; and either of these without the other is insufficient to constitute work. The work produced by a pressure moving a body through a certain space is defined to be the product arising from multiplying the pressure by the space through which this pressure acts.

The 'vis viva' of a body in motion is the whole mechanical effect which it will produce when it is brought to a state of rest, without regard to the time occupied, and it varies as the weight of the body multiplied by the square of its velocity. This mechanical effect or work accumulated in the moving body is represented by the weight which it is capable of raising one foot high, and is equal to the weight of the moving body multiplied by the square of its velocity, and divided by twice the force of gravity or, $\frac{Wv^2}{2g}$

Thus, if a shot of 165 lbs. weight be moving with a velocity of 1170 feet per second, the work accumulated in it will be represented by

$$\frac{165 \times 1470 \times 1470.}{2 \times 32.1908}$$

which is equal to 5,536,040 lbs. or 2472 tons.

That is to say, the force stored up in this shot is capable of lifting the weight of 2472 tons one foot high.

VITRIFIED FORTS.—The name given to certain remarkable stone inclosures bearing traces of the action of fire, about fifty of which exist in the various parts of Scotland. They are generally situated on a small hill, overlooking a considerable valley, and consist of a wall, which may have originally been about 12 feet in height, inclosing a level area on the summit of the hill. The most remarkable feature of these structures is, that the wall is always more or less consolidated by the action of fire—in some cases only to the extent of giving a glassy coating to its inner side, while in other instances the vitrification has been more complete, the ruins assuming the character of vast masses of coarse glass. Structures of this kind are to be found at Noath and Dunnideer, in Aberdeenshire; Craig Phadrick, Tordun and Glenever, in Inverness-shire; Knockfarril, in Ross-shire; Creich, in Sutherlandshire; Dunskeig, in Argyleshire; Finhaven, in Forfarshire; and elsewhere, but principally in the northern countries. They were first noticed by Mr. John Williams, in his *Account of some Remarkable Ancient Ruins lately discovered in the Highlands and Northern Parts of Scotland*, published in 1777. Mr. Williams' observation led him to conclude that they were artificial structures intentionally vitrified by a partial melting of their materials. Mr. Williams' views were combated by other writers, who contended that the supposed forts were of volcanic origin, a supposition quite irreconcilable with their obviously artificial character. In 1828 the subject engaged the attention of the society of antiquaries of Scotland, a series of careful observatians being made by Dr. Samuel Hibbert, one of the Secretaries of that body; and the conclusion arrived at was, that while the structures were artificial, the vitrification was an accidental effect, which might have arisen from such causes as the frequent kindling of beacon fires as signals of war and invasion, or of bonfires forming a part of festive or religious rejoicings. The alkali produced from the accumulation of the ashes of continually blazing wood-fires would be a powerful aid to the fusion of stone. The view originally taken by Mr. Williams has since been supported by Dr. John M'Culloch, who argues that the character of the works shows them to have been designed for defensive military posts, and observes, that in some cases where the most accessible materials for a stone-fort are incapable of vitrification, stones more capable of being vitrified have been brought from a distance. Dr. Petrie has noted one vitrified fort in the county of Cavan, and four in the county of Londonderry, and he conjectures that they belonged to the Irish Picts. A single instance, that of the "Camp of Péran" in Brittany, occurs in France. In this case, only the central portion, or core, of the wall is vitrified, and in it a Roman roofing tile was found, by M. Lukis, firmly attached to the melted stone. A number of the hill-forts of Bohemia have also been found to be constructed with a core of vitrified stones occupying the center of the walls. Dr. Fodisch attributes them to the bronze age and to a Celtic race. More detailed descriptions of these Irish, Breton and Bohemian examples, however, are necessary to enable us to pronounce definitely as to their identity with those of Scotland. But there seems to be little doubt that the vitrification in them all was the work of design, though produced, it may be, by different methods, and with structural intentions, not quite the same.

VIVANDIERE.—In Continental Armies, and especially that of France, a female attendant in a regiment, who sells spirits and other comforts, ministers to the sick, marches with the Corps, and contrives to be a universal favorite. Although the familiar friend to all, these women contrive to maintain themselves respectable, and generally respected; and a Corps is usually extremely jealous of the slightest discourtesy shown to its Vivandière. The woman wears the uniform of the regiment, short petticoats replacing the man's tunic.

VOIDED.—In Heraldry, a term applied to an ordi-

2 1 3

nary when its central area is removed, so that the field is seen through it, and little but a mere outline remains, as in the example No. 1—Azure, a saltire voided argent. When the ordinary has its outer edge formed of any of the lines of partition other than dancetté, wavy, or nebuly, the voiding is nevertheless plain, as in No. 2—Azure, a chevron engrailed voided or. An ordinary voided and couped differs from an ordinary couped and voided, in so far as the former is open at the extremities, and the latter enclosed. One ordinary may sometimes be voided in the form of another, as a cross voided per pale in the example No. 3.

VOIDER.—In Heraldry, that one of the ordinaries whose figure is very much like that of the flanch or flasque.

VOIGT SYSTEM OF FORTIFICATION.—This system adopts the tenaille with casemated redoubts in the re-entering angles; a second enceinte is formed of detached counterguards. In the capital of the redoubts are ravelins and tenailles. The latter served Carnot as models.

VOIRE DIRE.—In English law, when a witness is supposed to be liable to objection for incompetency or otherwise, he is first sworn, not in the cause, but on the *voire dire*, that is, to answer questions relating to his incompetency; and if it is apparent that he is incompetent, he is discharged without further examination.

VOLANT.—1. In Heraldry, flying. A bird volant is represented flying bendways toward the dexter side of the shield; and its position may be distinguished from that of a bird rising, by the legs being drawn up toward the body. 2. A piece of steel on a helmet, presenting an acute angle to the front.

VOLEE.—In loading the great bombards, it was necessary to charge the chamber, a piece distinct from the body of the cannon, and separated from it by the *volée*. Then the loaded chamber was brought to the body of the cannon and adjusted to it.

VOLKER SYSTEM OF FORTIFICATION. This system of the Dutch School proposes a very large ravelin, triple flanks and the fausse-braie.

VOLLEY. The simultaneous discharge of a number of small-arms. The same operation from cannon is called a salvo.

VOLTIGEURS.—Picked companies of irregular riflemen in the French regiments. They are selected for courage, great activity, and small stature. It is their privilege to lead the attack.

VOLUNTEERS.—Militia exists in every State of the Union. It is a regular, unpaid force, composed generally of men engaged in such private business operations as must always prevent their being employed except in their immediate vicinage. But in cases of riot, or the defense of their own firesides, town or city, experience has shown it to be a most reliable organization. There is, however, another class of troops, also called volunteers, which have from time to time been raised by Congress for temporary purposes. Such troops are properly United States and not State troops. The manner in which their officers are to be appointed is therefore always designated by Congress. The statistics of the Mexican war published by Congress furnish the following startling facts:

Regular Army.	Aggregate Force.	Length of Service.
Old Establishment,	15,736	26 months.
Additional Force,	11,186	15 "

The old establishment of the regular army, with an aggregate of 15,736 men during 26 months' service, lost by discharges for disability 1,782 men; by ordinary deaths, 2,623 men; and by deaths from wounds in battle, 792 men. The additional regular force, with an aggregate of 11,186 men during 15 months' service, lost by discharges for disability 767 men; by ordinary deaths, 2,091 men; and by deaths from wounds in battle, 143 men. The volunteer force, with an aggregate of 73,532 men during an average of 10 months' service, lost by discharges for disability 7,200 men; by ordinary deaths, 6,256 men; and by deaths from wounds in battle, 613 men. The number of wounded in battle were: In the old establishment, 1,803 men; in the additional regular force, 272 men; and in the volunteers, 1,318 men. The number of deserters was, in the regular force, 2,849 men; and in the volunteer force, 3,876 men.

These statistics require no commentary to show the waste of life and money in employing volunteers. But without explanation they do not show the numbers of each discription of force engaged in the different battles of Mexico, or how, with such a large aggregate of forces employed in Mexico, Taylor's battles were fought with never more than 6,000 men, and Scott had at his disposition only about 11,000 men for the march from Puebla and the capture of the City of Mexico. An analysis of the aggregates of forces engaged in those battles is therefore necessary, to ascertain by whom they were won, and this will lead to a subsequent inquiry, which will show why such ostentatious aggregates furnished so small a body of men for the great operations of the war. The first reason was undoubtedly the defective plan of campaign upon which the war was begun. Immediately after the victories of Palo Alto and Resaca de la Palma, the public mind was inflamed. The volunteer system caused great numbers to flock to the standard of the country. The pressure upon the administration was great for their reception. General Taylor was flooded with volunteers for whom he could find no employment. A plan of campaign was therefore devised in Washington, for marching on New Mexico, marching on Chihauhau, marching on Monterey, and marching on California, with different detachments, thus hastily collected together without taking the necessary measures to organize and instruct the troops, and without first providing the *material* indispensible for such long marches. The plan was therefore defective in all those respects, but still more defective in its predominant idea of striking at remote frontiers of the enemy instead of marching on his capital. It was like pricking the fingers of man instead of pointing a dagger at some vital part. The second and paramount reason why with such large aggregates of forces mustered into service so few were employed in battles, is the failure of the law to provide for a well-digested system of national defense prepared in peace, which would enable Congress and the Executive to meet any crisis in foreign affairs. This want caused the reception into service of 12,601 volunteers for 3 months at the beginning of the war with Mexico. These lost 16 men killed in battle and died of wounds; 129 by ordinary deaths, 922 by discharge, and 546 by desertion. Those killed in battle belonged to the Texas horse and foot, and they alone were engaged with an enemy.

Upon the declaration that war existed by the Act of Mexico, Congress, however, authorized the President to accept volunteers for twelve months or for the war. He accordingly received 27,063 men of this class for twelve months. They lost during their service, killed in action or died of wounds, 439 men; by ordinary deaths, 1,859 men; by discharges 4,636 men; and by desertion, 600 men. Some of this class of volunteers rendered most effective service at Monterey, Buena Vista, Vera Cruz and Cerro Gordo. The great mistake committed in regard to them was in receiving them for the short period of twelve months. Generally mustered into service in June, 1846, they were entitled to discharge in June, 1847, at a moment when their services were much needed, in order to strike a decisive blow at the capital of Mexico. Every effort was made to re-engage them, but without success; and General Scott, who had been employed to conduct military operations on the line from Vera Cruz to the capital, reluctantly put over 3,000 of these men in march from Jalapa to the United States in May, 1847, when he had ascertained that his column was not likely soon to be reinforced by more than 960 army recruits, and the services of those volunteers for the short remainder of their time could therefore no longer be usefully employed. Meanwhile the Administration, having late in 1846 awakened from its dream of conquering a peace, by directing blows against extremities of Mexico, had at last adopted the plan of striking at the vitals of their enemy. General Scott was put in command. Some volunteers were at once mustered into service for the war, but in insufficient numbers. Out of the whole force raised for the war, General Scott only received in time for his operations a regiment from New York, two from Pennsylvania, and one from South Carolina, and one company under Captain Wheat, who alone re-engaged themselves from the whole number of twelve-months volunteers; and these were the only regiments of volunteers, which took part in the battles in the valley of Mexico, and the capture of the city, September 14, 1847, which secured the conquest of peace.

In Great Britain, the volunteers consist of a large body of men, a great citizen army, which, with the militia and the reserves, form part of the auxiliary forces of the country. This force gives its services gratuitously, as the men receive no pay, as long as it is not embodied; but the arms are supplied by the Government, and a small sum is voted annually by Parliament to defray the necessary expenses of the clothing, etc., of the various corps and to provide for the pay of the Staff. The oldest volunteer corps is the *Honorable Artillery Company*. It was instituted in 1485; it ceased, however, to exist after a time, and was revived in 1610. In the civil war of 1641-8, the company took the side of the Parliament, and greatly contributed towards its success. Although

Aggregate of the Regulars and Volunteers employed during the Mexican War, with their average duration of Service, and the Casualties incident to each description of Force.

	Forces employed & mustered into service.		Discharges.				Deaths.										Wounded in battle.				
	Aggregate number of officers and men.	Average length of service during the war.	By expiration of service.	For disability.	By order, and civil authority.	Aggregate number of discharges.	Killed in battle. Officers.	Killed in battle. Men.	Died of wounds. Officers.	Died of wounds. Men.	Total killed and died of wounds. Officers.	Total killed and died of wounds. Men.	Ordinary. Officers.	Ordinary. Men.	Accidental.	Aggregate number of deaths—Officers and men.	Officers.	Men.	Aggregate.	Resignations.	Desertion.
		Mo.																			
Old Establishment..........	15,736	26	1,561	1,782	373	3,716	41	422	22	307	63	729	49	2,574	139	3,554	118	1,685	1,803	37	2-247
Additional Force...........	11,986	15	12	767	114	833	5	62	5	71	10	133	36	2,055	30	2,264	36	236	272	92	602
Aggregate of regular army	26,922	.....	1,573	2,549	487	4,609	46	484	27	378	73	862	85	4,629	169	5,818	154	1,921	2,075	129	2,849
VOLUNTEER FORCE.																					
General Staff..................	272	....	....	....	47	47	1	.....	.....	.....	1	....	16	....	.....	17	.....	....	....	48	....
Regiments and Corps.......	73,260	10	50,573	7,200	1,969	9,169	46	467	.....	100	46	567	(*)	*6,256	192	70,61	129	1,189	1,318	279	3,876
Aggregate of Regular and Volunteer Forces..........	00,454	.....	52,146	9,749	2,503	13,825	93	951	27	178	120	1 429	101	10,885	361	12,896	283	3,110	3,393	456	6,725

* In the reports of the deaths of volunteers of ordinary disease, officers are not discriminated.

still called artillery, it comprises artillery (horses and field-batteries) and cavalry. The origin of the volunteers dates from 1793–4, when they were first enrolled in consequence of a threatened invasion from France. Between 1798 and 1804, this force numbered 410,000, of which 70,000 were Irish. After this date, as the immediate danger ceased, the force gradually diminished. The volunteer force as now established arose in 1858, though a few corps were raised previously. In 1859, 150,000 men organized themselves into volunteer corps of riflemen. In the following year, the Government gave this national movement assistance by appointing paid Adjutants and Drill Instructors, and by the establishment of a Staff of Inspectors, under the control of an Inspector General of Volunteers (now of auxiliary forces). The regulations appertaining to this force are contained in the Volunteer Acts of 1863, subsequently modified in 1868 and 1869, and in the Regulation of Forces Act of 1871. Volunteers are localized by corps, so many being attached to each brigade forming subdistricts of the army. According to the regulations, when sixty men can be got together, a company may be formed, which is entitled to a Captain and two Subaltern Officers. If six companies can be raised, they constitute a battalion, for which the Government provides an Adjutant. This officer, if not commissioned as Captain in the regular army, is granted the temporary rank of Captain. When there are a number of detached companies in a district, they are grouped into an administrative battalion. See *Militia.*

VORANT.—In Heraldry, a term applied to an animal represented as swallowing another; as, sable, a dolphin naiant; vorant a fish proper.

VOUCHER.—A paper or document which serves to vouch the truth of accounts, or to confirm and establish facts of any kind. In the United States service original vouchers must accompany the accounts. Duplicates cannot be admitted, unless accompanied by satisfactory evidence of the loss or destruction of the originals, or that their retention is indispensable to the performance of duty by an officer acting under orders. In case of lost vouchers, parole testimony, or the affidavit of the disbursing officer, cannot be accepted by the accounting officers as equivalent to the vouchers necessary to the proper settlement of an account. When originals cannot be furnished, copies duly certified as true by a disinterested officer may be accepted. If no other officer than the payor or payee is at the post when payment is made, both must certify to that fact, and also to the correctness of the copy. Vouchers for disbursement of money specify the quantity and price of each article bought, the name and business-place of the person from whom it is procured, the date and manner of purchase, etc. When the vouchers are for services rendered, and in like cases, they state the nature and period of the service, rate of pay per day or month, etc.

The following is the form of a voucher used in transferring funds:

..............................at ....
this..........................day of........................., 18 ,
.... Quartermaster..................U. S. A.,
the sum of...dollars
and...........cents, Quartermaster's funds, for which I am accountable to the Treasury of the United States, viz.:

For regular supplies—appropriation for		....
fiscal year ending June 30, 188		....
For incidental expenses,	" "	....
For cavalry and artillery horses,	"	....
For barracks and quarters,	"	....
For transportation of the army,	"	....
For clothing and equipage,	"	....
For stoves,	"	....
For national cemeteries,	"	....
Total		....

....
............Quartermaster............, U. S. A.

(Signed in duplicate.)

Accounts and vouchers are as a general rule made out in duplicate; occasionally in special cases in triplicate. The number executed must be distinctly stated on each copy. One copy is retained in all cases for the protection of the officer, one is forwarded to the Chief of the Bureau. See *Abstract.*

VOUGE.—A strong pike or staff having at its extremity a long point. It was carried by the foot soldiers in the Middle Ages.

VOULGE.—A broad-bladed and long-hafted weapon. Though rarely met with now, this weapon was one of the most ancient among the Swiss, and also much sought after in France during the 15th century, at which time there existed a regiment of infantry called *Voulgiers*, who were armed with this weapon. A great many archers also carried them. The name *voulge* has been improperly given to the *boar-spear*, the shape of which bears not the least resemblance to the voulge of ancient warfare.

VULNED.—A heraldic term, applied to an animal, or part of an animal—as, for example, a human heart, wounded, and with the blood dropping from it. A pelican in her piety (see Pelican) is sometimes described as vulning herself.

W

WABBLING.—When the axis of the projectile does not correspond with that of the bore of the gun, the the axis of rotation will be variable, and the deflection of the projectile uncertain. Should the axis of the shot, on leaving the bore, be unsteady, the projectile will have the *wabbling* motion so frequently observed in experimental practice.

WADHOOK.—An instrument which froms part of the stores attached to a battery, and used for searching the bores of guns and withdrawing from them anything that would impede the loading.

WADMILTILTS.—Strong rough woollen cloths, used principally for covering powder barrels and protecting ammunition generally. A barrel of powder wrapped in a wadmiltilt is safe from the explosion of two similar barrels in the open, at a distance of 10 feet, but it is unsafe when not so wrapped at 15 feet.

WAD-PUNCH.—The tubular steel punch used for cutting gun-wads, etc. A similar punch is used by harness-makers and others.

WADS.—Wads are used to prevent the ball from rolling out in firing at a depression. When making wads the hay or junk, after having been picked, is compressed by being beaten in a small mould, until it assumes the requisite dimensions: it is then taken out, by raising the upper part of the mould, and wrapped closely with rope-yarn passed over it in the direction of the axis of the cylinder, and fastened by a few turns round the middle of the wad; after which it is placed in a larger mould and again beaten with the mall and drift: the diameter of the wad when finished is verified by a wooden gauge corresponding to the large gauge of the shot.

Ring-wads or grommets are to be preferred where the object of a wad is merely to retain the ball in its place. They consist of a ring of rope-yarn about .7 inch thick, with two pieces of strong twine tied across it at right angles with each other. The size of the ring is the full diameter of the bore, in order that it may fit tight. These wads may be attached with twine to the straps or to the balls, or they may be inserted, like other wads, after the ball. These wads may be made of straw formed into rings of the proper size and wrapped with twine and tied to the ball.

For *firing hot-shot*, a hay wad, soaked in water, is interposed between the powder and shot. The wad is made by twisting the hay into a rope, winding the rope into a coil, which is driven into wooden moulds of the proper size. To preserve the size and form of the wad, it is afterward wrapped tightly with rope-yarn. See *Ammunition*.

WAFFENROCK.—A sort of loose frock made without sleeves, and worn over the coat of mail. It reached as far as the knee, and on it were embroidered the armorial bearings of its owner.

WAGER OF BATTLE.—This relic of legal barbarism is happily of the things of the past, having been abolished by Act of Parliament, and might have been passed over with a brief notice, had it not been for a circumstance which we shall presently mention, and which affords a curious and striking illustration of a principle peculiar to the character of English law, as distinguished from the legal systems of other countries. The Trial by Battle was a proceeding by way of appeal, and it obtained in civil and criminal cases, and also in military matters, to which, indeed, it was more appropriate. It consisted of a personal combat between the parties in presence of the Court itself, and it was grounded on the impious idea of an appeal to Providence, the expectation being, that Heaven would give the victory to the innocent or injured party. In civil cases, the battle was won by champions, and not by the parties themselves; but in criminal cases, the parties fought in person, unless the appellor were a woman, a priest, an infant, or a man of the age of 60, or lame, or blind, all of whom might refuse the wager of battle, and compel a trial by jury. Peers of the realm also could not be challenged to wage battle, on account of their personal dignity, nor, by special charter, could the citizens of London, fighting being considered foreign to their education and their employment. Whether by champions or in person, the mode of proceeding was the same. The appellee, or defendant, as he might be called, threw down his glove, and declared that he would prove his right, or defend himself with his body. The appellor, or prosecutor, in accepting the challenge, took up the glove, and replied that he was ready to make good his appeal, body for body; and thereupon the parties, holding each other's hands, joined issue before the Court in a very solemn and formal manner. The weapons used were batons or staves an ell long, and a four-cornered leathern target, and the combatants were obliged to swear that neither of them would resort to sorcery or witchcraft. The battle lasted till the stars appeared in the evening, and the party who by that time had either killed or got the better of his opponent, was then considered the successful suitor of justice. In a charge of murder, if the accused was slain, it was taken as proof of his guilt, and his blood was attainted; and if so far vanquished as not to be able or willing to fight any longer, he was adjudged guilty, and sentenced to be hanged immediately.

So late as the year 1818, this barbarous procedure was solemnly decided by the Court of king's bench to be a valid and a legal mode of trial, which the king's subjects were free to adopt. Of course, the principle was, that all laws, no matter how unsuitable to the times, could be enforced, unless expressly repealed by Act of Parliament. As a matter of curiosity we may give the names of the parties (they were of the laboring-class) who seriously submitted their contention in the above form before Lord Chief-Justice Ellensborough and his brother Judges of the period. The case is that of Ashford *v.* Thornton, and is reported in the first volume of Barnwall & Alderson's *Reports*, p. 405. As we have stated, the Court decided in favor of the validity of the trial, one of the Judges remarking that sufficient had not been stated to induce their Lordships to refuse the battle, and another more plainly and equivocally observed that the defendant was "entitled to this his *lawful* mode of trial." But Lord Ellenborough put the matter more clearly by stating that "the general law of the land is in favor of the wager of battle and it is our duty to pronounce the law as it is, and not as we may wish it to be; whatever prejudices, therefore, may justly exist against this mode of trial, still as it is the law of the land, the Court must pronounce judgment for it." Happily, the pugnacious litigant who obtained this judgment was induced to go no further, and the above statute was passed, by which the shocking ordeal was wholly abolished. In Scotland, we believe the matter would have been differently disposed of; for the Judges there, following the doctrine of the Roman law, would have held the proceeding to have been in desuetude and obsolete, and there the matter would have ended. Mr. Rush, the then American Envoy to the British Court, thus justly remarks on this case in his *Residence at the Court of London* (published 1833). "To repeal laws belongs to the Legislature. Courts expound and apply them. Free government is complex and works slowly; tyranny is simple, and does its work at once. An absurd law may sleep in free code, because overlooked; but whilst there, it is the law. It is so, I suppose, that we must reason; and generally, the reason would be right. Yet it might have been thought that, in a case like this, long disuse added to obvious absurdity, would have worked the silent repeal of the law, according to the doctrine of desuetude under the Roman code."

WAG-NUK.—A weapon employed for *striking*, as a tiger with his claws. It was invented in 1659, and was used by bandits in assassination, the wounds inflicted by it resembling those made by the claws of a tiger, suspicion was diverted from the real authors of the crime. It was not a *poniard*, as commonly supposed.

WAGON.—A carriage on four wheels, drawn by horses, and used for transport of heavy goods. The following are the principal wagons in the military service,the use of which are briefly described as follows: *Ambulance-wagon.*—Used for the carriage of the sick and wounded. *Ammunition-wagon.*—In the artillery service,a carriage with limber attached, which accompanies each gun of a movable battery. It contains the larger proportion of the ammunition of the battery. Light field-batteries have one wagon to each gun on the peace establishment, and two on the war establishment,which enables a battery to go into action with a good supply of ammunition per gun. *Baking-wagon.*—A wagon in which the bread of the troops is kneaded along the line of march; it carries the necessary dough troughs and baking implements. *Boat-wagon.*—Attached to the pontoon trains, for the transportion of one boat and a certain portion of bridging material. *Bread and meat-wagon.*—A wagon for holding and carrying in the field all such supplies as give the name to this nature of carriage. *Forge-wagon*—Composed of a limber and carriage; the limber is the universal limber, but has one long box instead of two. The body of the wagon contains the bellows and all the other articles necessary to complete the forge. One is attached to each battery of artillery; two to each mounted troop of engineers, and one per cavalry regiment. *General service-wagon.*—For general use with a siege-train; there are 4 wagons of this nature, 2 without and 2 with springs. What is known as the G.S.W. mark I. without springs has equirotal wheels, fore and hind. It carries a spare wheel and has fittings to transport intrenching tools; also, when required, it is able to take a field forge. It has a long body covered with waterproof canvas; it is capable of carrying 1½ tons; and is fitted for shaft or pole draught. *Miner's wagon.*—Attached to the Engineer branch, to carry mining and intrenching-tools. *Officer-wagon.*—Belongs to the Engineer branch, and is used as a telegraph office. It may be used also as an office-wagon, printing-wagon, lithographic-wagon, or photographic-wagon. *Platform-wagon.*—A wagon used for every description of heavy stores, etc. *Pontoon-wagon.*—Carries a pontoon and a portion of the bridging material on the march. *R.A. wagon.*—Fitted to carry a spare wheel, intrenching-tools, carbines, two swords, stores, and a drag shoe with chain; it has certain fittings to enable it to be used as a forge-wagon. One wagon is attached to each battery, and is fitted for either single or double draught. *Rocket-wagon.*—Intended to carry Hale's rockets: it only differs from the ordinary field ammunition-wagon in the boxes being made deep enough to receive 25 rockets each. *Siege-wagon.*—A general service-wagon. It is fitted with movable trays, for the transport of shot and shell. *Heavy sling-wagon.*—This wagon is used in the artillery service for transporting guns from 12 to 23 tons in weight. It is similar in construction to the service-wagon, but it is made of African oak scantling of much larger dimension, and is fitted with breaks similar to those on the 12-ton sling-wagon, but worked by levers and eccentrics: the perch is fitted with a differential block and chain; and the axletree-arms are special for the wheels. The 12-ton sling-wagon is made of wrought-iron. *Store-wagon.*—Similar to the miner's wagon. It has a movable head covered with canvas. It is issued for carrying stores of all sorts, intrenching tools, etc, of a siege-train. *Trestle-wagon.* The same as the pontoon wagon: it carries part of the superstructure of the bridge without a pontoon. *Water-wagon.*—Used to carry water for troops on the march, or in quarters. It contains a barrel for holding the water. It is fitted for single, double, or pole draught. *Wire-wagon.*—A wagon attached to Engineer troops. It contains the wire and all othe articles for setting up a telegraph line along the line of march.

WAGON-MASTER.—A person in charge of one or more wagons, and especially of those used for transporting freight, as the supplies of an army, and the like. The Quartermaster General is authorized to employ from time to time as many Forage masters and Wagon-masters as he may deem necessary for the Service, not exceeding twenty in the whole, who shall be entitled to receive forty dollars per month, and three rations a day, and forage for one horse; and neither of whom shall be interested or concerned directly or indirectly in any wagon or other means of transport, employed by the United States, nor in the purchase or sale of any property procured for or belonging to the United States, except as an agent of the United States.

WAGON-TRAIN.—An indispensable companion of an army under this or some other title. It serves to convey the ammunition, provisions, sick, wounded, camp-equipage, etc. At the present time, in the British Service, the Army Service Corps performs this function, although in China (1860) and New Zealand (1862–5) the Commissariat provided and organized its own wagon-service.

WAHRENDORF BREECH-LOADER.—This plan of closing the breech was invented in 1846, in connection with the *Wahrendorf* system of rifling and projectiles. The breech-plug is held in by a horizontal bolt passing through the breech. It is obvious that these parts cannot be handled with great rapidity.

WAHRENDORF GUN.—Baron Wahrendorf invented a 24-pounder gun, which is loaded at the breech. It is mounted on a cast-iron traversing carriage; and, taking little room, it appears to be very fit for casemates. The upper part of the carriage has, on each side, the form of an inclined plane, which rises towards the breech, and terminates near either extremity in a curve whose concavity is upwards. Previously to the gun being fired the trunnions rest near the lower extremity; and on the discharge taking place, the gun recoils on the trunnions, along the ascending plane, when its motion is presently stopped. After the recoil, the gun descends on the plane to its former position, where it rests after a few short vibrations. The axis of the gun constantly retains a parallel position, so that the pointing does not require readjustment after each round. The gun was workd easily by eight men, apparently without any strain on the carriage. With a charge of 8 lbs., and with solid shot, the recoil was about 3 feet, and the trunnions did not reach the upper extremity of the inclined plane, though the surface was greased. This gun differs in some respects from that of Cavalli. Its whole length is 8 feet 11 inches, and its greatest diameter 2 feet 3 inches. The diameter of the bore is 6.37 inches, from the muzzle to within 6 inches of the chamber, in which space it has a conical form. The diameter of the chamber is 7¼ inches. A rectangular wedge, 12.2 inches long, 8.1 inches broad, and 4.25 inches thick, is made to slide toward the right or left hand, in a perforation formed transversely through the breech, for the purpose of covering, after the gun is loaded, the aperture by which the charge is admitted into the bore.

WAILING.—A mode of basket work, pursued in forming a gabion, and in which the braid or plait is formed with more rods than two.

WAIST.—A term applied, in artillery, to the loss of space consequent on the indentation of the sides of certain carriages to permit a fair angle of lock, when the front wheels are high.

WAIST-BELT.—A belt worn round the waist, by which a sword or bayonet is suspended. It usually supports the cartridge-box, or is sometimes provided with loops, and carries from 20 to 50 cartridges. See *Belt*, *Cartridge-belt*, and *Sword-belt*.

WAIVING AMAIN.—A salutation of defiance, as by brandishing weapons, etc.

WALING.—When the web of a gabion is made with more than two rods at a time, the process is called *waling*.

WALK ABOUT.—The military expression used by British officers when they approach a sentinel, and think proper to waive the ceremony of being saluted.

WALKING CRANE.—Cranes of this type are built of any desired capacity from 1 to 10 tons, and for operation either by hand or by power. The base consists of two wrought-iron girders united by riveting and carrying between them the truck wheels which support the crane. Rising from the center of the base is a cast-iron column, and revolving around this is the mast, consisting of two channel irons, united by suitable castings at top and bottom, and containing the rollers by which the mast is supported as it revolves. The boom is also formed of two channel irons, and from its outer end is suspended the running block, the chain from which passes over a sheave at the end of the boom to the hoisting gear attached to the mast near its head, the slack chain falling from this to a receptacle at the foot of the boom.

The mechanism of this crane, when operated by power, is arranged as shown in the engraving. Power is transmitted by a driving rope passing around a wheel on top of the vertical shaft forming the axis of the crane, this shaft thus moving continuously in one direction at a constant speed. By a series of Weston disc clutches, controlled by suitable levers within easy reach of the operator, the power is made available for hoisting and lowering, and for propelling the crane in either direction upon its track. Rotation of the crane is effected in the usual way by pushing or pulling the suspended load. The levers are so arranged that the operator may either walk beside the crane as it moves, or may travel upon it. The crane is supported longitudinally by the extended wheel base of the truck, and transversely by rails bolted to the roof or ceiling, between which travels the horizontal truck or guide frame attached to the head of the mast. When arranged for operation by hand, the hoisting gear of this crane is similar to that of the pillar crane, and the longitudinal travel of the crane is very readily effected by a separate crank, operating mechanism very firmly attached to the base.

Walking Crane.

Cranes of this type are adapted for use in machine shops, for setting work in the various machine tools and for transferring it from one tool to another, and also in mounting ordnance, for transferring parts to the place of work, and for setting them in position. For work of this description these cranes are exceedingly convenient and economical. See *Cranes*.

WALLACE INTRENCHING-TOOL.—Numerous light intrenching-tools have been invented from time to time, and many of them have been tried. Some have failed from being too complicated, some from being too heavy, others from want of strength. The tool represented in the drawing possesses the four essentials of a very serviceable intrenching-tool, viz.: strength, portability, handiness, and power. It is well adapted for use in every kind of ground, rocky or soft. With it the soldier is able to cut roots and lever up stones; to break open boxes and barrels, and, at a *pinch*, loophole walls. As a specimen of the official trials of the Wallace tool it will be enough to say that in ordinary soil a shelter *pit* was dug in six minutes, and a shelter *trench* in twenty minutes. On a consolidated parade ground one hour proved enough for the regulated trench; several gun-pits and epaulements were thrown up, and, as an experiment, a 14-inch brick wall, strongly constructed, was loopholed in forty minutes. The tool is found use-

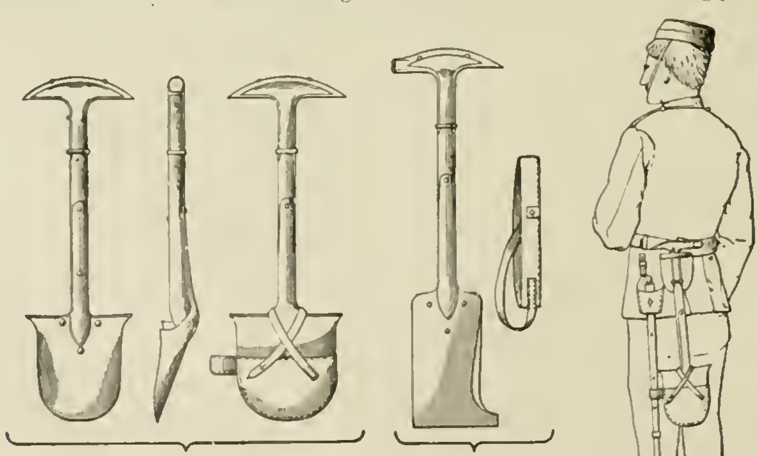


Fig. 1. *Fig. 2.*

ful not only for cavalry—where it saves considerable weight—and infantry in the field and camp life for marines and naval brigades on shore, but also for steam launches, for mining purposes, and for carriage or gun-limbers. It has also been adapted for the use of the Ordnance Survey by the addition of a hammer and bill-hook (Fig. 2), and in this form can with advantage be carried either by the pioneers or by a proportion of the rank and file. It weighs about 2¼ pounds, and measures 23 inches in length: and simple as it appears (Fig. 1), it is not easy to make. It is a marvel of strength and power for its size and weight, and most convenient for its handiness and general adaptability. The drawing shows the manner of its construction, and how it is borne by the soldier. See *Intrenching-tool.*

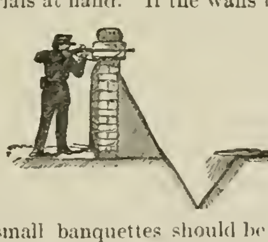
WALLET.—A kind of bag, introduced into the service in lieu of the holster. Wallets form part of the horse furniture of the Staff and Regimental Staff of the English Army. All cavalry regiments, except the Household Cavalry, use them. They are made of brown leather, and covered, like holsters, with a bear skin. Wallets have also been introduced into the Indian Army.

WALL-KNOT.—A knot made at the end of the lever and prypole rope, to prevent it from being drawn through the hole in the lever.

WALLOON GUARD.—The body-guard of the Spanish Monarch; so called because formerly consisting of Walloons.

WALL-PIECE.—A very small cannon (or, in ancient times, an arquebus) mounted on a swivel, on the wall of a fortress, for the purpose of being fired at short-range on assailants in the ditch or on the covered-way. There are distinct evidences that the great wall of China was originally constructed for the reception of wall-pieces. They may be said to be obsolete, though sometimes issued in India to an expedition proceeding on service. Wall-pieces are considered to be useful, after the capture of a native fort, to strengthen its defense. At the late siege of Strasburg, the Germans made considerable use of this nature of arm.

WALLS.—The chief method of putting walls into a state of defense is by means of loopholes formed according to circumstances, depending on the heights of the walls. In works on the construction of military posts, it is suggested that loop-holes should be formed on the tops of walls which may be about 4 feet high, with sandbags, blocks of wood, stones, or other materials at hand. If the walls be too high to



fire over, small banquettes should be made, or the loopholes may be cut down into the top part of the wall. In any case, small ditches should be dug on the enemy's side of the wall. Besides the ditch outside, when walls are 7 or 8 feet high, one in the rear should be dug to give sufficient cover to the defenders, and to prevent the enemy from firing over. With lofty walls, two tiers of fire may be obtained by forming banquettes, so as to enable the defenders to fire over the wall or through loopholes at the top, and by cutting loopholes for the lower tier nearly on a level with the ground. Trenches must be dug in rear of the walls to allow of the defenders using the lower loopholes; but on no account must there, in this case, be ditches excavated in front of the walls, unless they be made deep enough to prevent an enemy in them from firing through the loop-holes. With low walls the ditches must be formed close up, and the earth spread. Loopholes should always be at least 6½ feet above the ground or bottom of the ditch on which the attackers can stand. The proper defense of walls will generally suggest itself to most officers; the foregoing merely gives an outline of what ought to be done. Similar means may be adopted for rendering hedges protective, whereby the defenders can shelter or screen themselves from the fire of the enemy. See *Hedges.*

WAMBEYS. A thickly quilted tunic stuffed with wool, and worn by knights under the hauberk, as a padding for the armor. As it was sufficiently strong to resist ordinary cuts, it was sometimes worn without other armor. The surcoat was also quilted or *gamboised* with cotton wool, as in that of the Black Prince, still hanging above his tomb in Canterbury Cathedral.

WAMPUM. The name given to shells and shell-beads, used as money, and worn for ornaments in strings and belts by the North American Indians.

WAPENSHAW.—A periodical gathering of the people, instituted by various Scots statutes, for the purpose of exhibiting their arms, these statutes directing each individual to be armed on a scale proportioned to his property. There are numerous Scots Acts of the 15th and 16th centuries, regulating the subject of wapenshaws. In the time of war or rebellion, proclamations were issued charging all Sheriffs and Magistrates of burghs to direct the attendants of the respective wapenshawings to join the King's Host. During the reign of the later Stuarts, attendance on the wapenshaws was enforced with considerable strictness; and in addition to military exercises, sports and pastimes were carried on by authority at these gatherings. The Covenanters, in consequence of these sports being of a kind disapproved of by them, did what they could to discourage attendance on the wapenshaws. Also written *Wapinschaw.*

WAR.—A contest carried on between the armed forces of two States or Nations, after every endeavor has been resorted to, by one side or the other, and often by friendly powers, to bring about a reconciliation. Wars are various in their occasions and objects, sometimes breaking out in consequence of disputes about territorial possesions or material interests; at other times, having reference to the establishment of some important point of civil or religious liberty. In all cases, the aim of each contending party is to weaken and overthrow the opposing party. At one time the art of war was supposed to consist very much in wearing out the enemy by a slow process of exhaustion, and thus wars were much protracted; but more recently the greatest Generals have adopted the method of rather endeavoring to strike sudden and terrible blows, by which the war is sooner brought to a termination: and this method, although it may often have been adopted without regard to considerations of humanity, is, in all probability, less productive of suffering to mankind than the other.

Among rude nations, wars are conducted by tumultuary hosts, suddenly congregated, and in general, either after defeat or victory, soon dispersed. But the wars of the more civilized and powerful nations have long been conducted by armies carefully trained and disciplined: and in the case of maritime powers, by means of fleets at sea as well as of armies on land.

In the progress of society, certain *usages of war* have come to be generally recognized. These, of course, have varied at different times, and in different parts of the world, according to the state of civilizatio and the prevalent feelings of the time: they are also subject to modification from causes less general. But the changes which have taken place in them during the lapse of ages have been in general favorable to the interests of humanity. Prisoners of war are no longer put to death, nor are they reduced to slavery, as was once very frequently the case, but their treatment has become generally more and more mild and kind. It is a well understood rule, however, that a prisoner of war obtaining his liberty by exchange or otherwise, with the condition of not serving again during a fixed period against the same power, forfeits his life if he is found so serving and is again taken prisoner. Amongst all civilized nations, quarter is granted in battle whenever it is sought; and there are certain usages universally prevalent with regard to the capitulation of fortified places, and of bodies of troops hopelessly hemmed in by superior forces, etc.

IMPROVEMENTS IN FIREARMS.

The invention of gunpowder has effected great changes in the whole art of war; but the introduction of fire arms has rendered battles less sanguinary and ferocious than they previously were. While fire-arms were yet unknown, warlike engines of various kinds were employed; but close combat was more general, and often more protracted, and the passions of the combatants had thus in ordinary battle more of that exasperation which fearfully characterizes the storming of a town. The effect of all modern improvements in fire arms has been to modify tactics, the principles of strategy remaining the same. Lines of battle have to be formed at much greater distances from the enemy than formerly, they are also much more extended. Campaigns and battles are shorter, more quickly decided, and more decisive. Wars are reduced in length; theaters of war are consequently more limited, and the sufferings produced by wars are lessened. The effects of war are not so disastrous.

RAILROADS.

Railways have of late years increased to such an extent as to be of considerably higher importance than roads in a military point of view for certain periods in a campaign and in certain directions. Roads are still of greater importance in all opertions carried out *near* the enemy; but for the concentration of armies, for the rapid movements of troops from one theater of operations to another, from all movements from the rear of an army in the broadest acceptation of the term, for the transport of every kind of *matériel* and supply, railways rank higher than roads in importance.

Whatever facilitates the movements of armies during a war, or aids their supply, will be an important factor to the successful termination of the war. Railroads facilitate the concentration and movements of troops, and admit of supplies being collected from a great extent of country, consequently they will have a marked influence on future wars, as they have had in the past.

Formerly many months were required to concentrate the troops which were to form an army, and as many more were frequently necessary to place the army in the theater of active military operations. By the use of railroads this may now all be accomplished in as many days. Ten hours will now carry a whole division as far as ten days formerly would. When it is considered that bad weather will rarely interfere with the working of a railroad, and that the same cause may entirely stop operations when the troops are obliged to march, the influence of railroads on military movements will be more fully appreciated. In 1864, the Germans rapidly collected a very superior force against the Danes, and ended the war almost as soon as it can be told. In 1866, the Prussians, in twelve days, concentrated over two hundred thousand men and the appropriate number of horses and guns on the Bohemian frontier, and in a short time their opponents, the Austrians were ready to sue for peace. In 1859, the French army was taken from France into Italy in eight days. Such are some of the advantages to the offensive resulting from the use of railroads. These campaigns were shortened by the facility and rapidity with which the troops, supplies, ammunition, etc., were transported to the seat of war. It is evident that these advantages will be greatly multiplied as the number of available lines of railroads is increased. On the defensive, railroads, especially if parallel to the line of defense, may be used to advantage to post strong detachments to watch all the points of the frontier threatened by the enemy; then, when the latter has developed his point of attack, to again rapidly concentrate the troops to meet him. If the army is defeated, all available re-enforcements may be hurried to its aid.

When troops are moved by rail even forced marches do not produce stragglers; the number of effectives is therefore increased. The same number can be depended upon after a movement of several hundred miles as were available before its commencement. During our civil war, and after the battle of Chickamauga, twenty-three thousand men, (Hooker's corps), were moved from Virginia to Alabama a distance of one thousand one hundred and ninety-two miles in seven days. It would have required, under the most favorable circumstances, eighty days to have marched this distance.

For the movement of troops through an enemy's country railroads cannot be depended upon to any great extent, owing to the facility with which they can be destroyed or temporarily damaged by the enemy. By their use the fractions of an army might be separated and disaster follow. They are, however, invaluable for supply; for, even if the enemy has destroyed them as he retired, they can be readily repaired by the army as it advances, and be used for the transportation of supplies and re-enforcements. The value of these means of supply is evident when we consider the use made of the railroads from Louisville to Nashville and Chattanooga by General Sherman during his Atlanta campaign.

The value of railways is also fully recognized in war quite as much, if not more so, than in time of peace. The Atlanta campaign would simply have been impossible without the use of the railroads from Louisville to Nashville—one hundred and eighty-five miles—from Nashville to Chattanooga—one hundred and fifty-one miles—and from Chattanooga to Atlanta—one hundred and thirty-five miles. Every mile of this "single track" was so delicate, that one man could in a minute have broken or moved a rail, but our trains usually carried along the tools and means to repair such a break. That single stem of railroad, four hundred and seventy-three miles long, supplied an army of one hundred thousand men and thirty-five thousand animals for the period of one hundred and ninety-six days. To have delivered regularly that amount of food and forage by ordinary wagons would have required thirty-six thousand eight hundred wagons of six mules each, allowing each wagon to have hauled two tons twenty miles a day, a simple impossibility in roads such as then existed in that region of country. Therefore, we reiterate that the Atlanta campaign was an impossibility without these railroads; and only then, because we had the men and means to maintain and defend them, in addition to what were necessary to overcome the enemy. This subject of railways is considered to be of such importance in military operations that some European nations have gone so far as to provide platforms for loading cars with troops and *matériel*, and also prescribe a railway drill. The troops are exercised in getting on and off the cars, loading animals, supplies, etc.

THE ELECTRIC TELEGRAPH.

The electric telegraph influences military operations by aiding the rapid communication of orders and the prompt transmission of intelligence. By its aid the Commander-in-Chief may be informed about what is taking place along his whole front at any one time; he is thus enabled to make his dispositions more intelligently, as he can order the movement of his troops necessary to meet all contingencies. A movement which might be proper under certain circumstances or when he knew what was transpiring at a certain point, might be highly injudicious or even lead to disastrous results when he became acquainted with certain other facts or occurrences at different points of the line. Movements of the enemy which might be accomplished before any information could reach the Commanding General by the ordinary methods of communication on the battle-field, might, by the use of the field-telegraph, be provided for and successfully combated.

The telegraph aids combined attacks by keeping the General informed at every moment of the movements of the different fractions of the army, and thus enables one head to direct the maneuvers of both columns, rendering simultaneous action possible. It saves the labor and fatigue incident to the unnecessary marches which are frequently undertaken upon false information: they can be stopped at once, or at any stage of their execution, and other dispositions made. Time, always one of the most important factors in military movements, on the modern battle-field more than ever enters into the considerations which influence the final result, on account of the great rapidity with which events culminate and follow each other. Consequently the necessity of promptly forwarding orders and information cannot be over-estimated. Troops may be sent at just the right moment to decide the struggle. Equally important may be a system of signals.

The value of the magnetic telegraph in war cannot be exaggerated, as was illustrated by the perfect concert of action between the armies in Virginia and in Georgia in 1864. Hardly a day intervened when General Grant did not know the exact state of facts more than fifteen hundred miles off, as the wires ran. During the operations at Spottsylvania, and on the North Anna, at Cold Harbor, in the march from Cold Harbor to City Point, and in the battles in front of Petersburg in June, the field-telegraph lines were worked with great success, and invaluable aid was thus rendered to the Government. General Grant and General Meade were kept in almost constant communication with each other and with the different corps of the army. The field-telegraph lines have worked many times in the face of the enemy, exposed to fire, without shelter, have been kept up day and night whenever required, etc. In all wars of this and future ages, the electric telegraph will be greatly used. It must be remembered that a telegraph operator can with a small pocket instrument tap the wires anywhere, and learn the messages passing along them. A few such men living concealed within the enemy's territory could obtain more news than dozens of ordinary spies. Immediately before or during an action an enemy may be deceived to any extent by means of such men: messages can be sent ordering him to concentrate upon wrong points, or by giving him wrong information you may induce him to move as you wish. The telegraph was used in all these ways during the American war between North and South.

FIELD-WORKS AND SHELTER-TRENCHES.

One of the most important facts developed by the introduction of the rifle and the breech-loader is the necessity of providing some means by which troops can be sheltered from their fire. The first and great use of shelter-trenches was at Sebastopol; and in our Civil War they attained a development hitherto unknown, not only important points like Washington, Richmond, Vicksburg, etc., being converted into great intrenched camps, capable of sustaining long sieges, but also every bivouac in the presence of the enemy being fortified by a shelter-trench of some kind; in the Prussian wars of 1866 and 1870 they were also used, though not to so great an extent; but in the late war in Turkey the combination of trench and breech-loader attained such a perfection that the whole campaign may be said to have consisted—tactically—of the attack and defense of more or less hastily fortified positions. The Russians began the campaign relying on their bayonets and despising the spade. The Turks, on the other hand, had an evident pride in their fortifications and a full appreciation from the beginning of their value.

The Russians refused to employ the spade until its lessons had been forced upon them by a very rude experience of the murderous fire of the modern breech-loader from behind trenches. One side erred by excessive prudence and its bad effect upon the morals of the men, and the other by recklessness and its attendant slaughter. The case in which the Russian troops under General Wilhelminof received an attack of the Turks in hastily made trenches and repulsed it with volley-firing, inflicting a loss ten times greater than their own, have been fully described. All these trenches were mere scratchings, about a foot deep and twice as wide, the loose earth being thrown up in front; and they are striking examples of what steady troops, armed with breech-loaders, can accomplish behind a rude fortification.

When the investment of Plevna was begun a large number of spades and shovels were, of course, sent forward from Russia and Roumania and distributed to the troops. After the surrender of Plevna General Skobeleff ordered the men in his division to keep these spades and shovels and carry them on their persons, they were heavy, they were uncomfortable, they were in every way inconvenient, but each man had learned by hard experience to feel that his individual life depended upon his musket and his spade; and he took good care to lose neither the one nor the other.

We may look then to see every nation adopting in time of peace some half-measure, such as the short-handled small spade, the trowel-bayonet, etc., but it is more than probable that the next great war on this continent, or in Europe, will bring about the same practical experience as in the one in Turkey, viz., that all personal inconvenience must be sacrificed to the vital necessity of having the most efficient intrenching-tools, *i. e.*, a common pick and a big spade, and that, once convinced of their great value, the troops will carry them most cheerfully.

In this present manner of fighting everything depends upon the exertions put forth by the *individual* soldier, and not as formerly upon the action of the *mass*. To develop this individual action to the greatest extent a high order of intelligence is absolutely necessary, for the soldier must accustom himself to decide certain questions which were formerly decided for him. He should know for example when to reserve his fire and when to deliver it so as to produce its maximum of effect: when to take advantage of cover, and when to leave it; at what moment he should put forth his greatest efforts, which properly and timely developed usually decide the result. All these qualities will follow from a proper system of instruction and the proper practical application of the knowledge thus gained on the drill ground.

It cannot be too often repeated that the training of the soldier, if the full advantage of modern arms is to be obtained, must be of a far higher character than it has ever before been, not only must he be able to move and act with others, so that if requisite the full force of a large body in perfect order, acting under one will, may be brought to bear on one point, but he must have confidence in his own individual action. To be able to attain these necessary qualifications, not only must the man originally have an elementary education, without which he cannot grasp what he has subsequently to learn, but he must be carefully trained to use his own powers of mind and body. Here lies the main difference produced by giving to the soldier improved weapons; to use them properly the man himself must be improved.

We will probably now have but few instances of grand results obtained with inferier numbers as exemplified in the campaigns of Napoleon, Frederick the Great, and others, because the old formation in battle was well adapted to the purposes of men of genius like them; their troops being massed could be held well in hand and then launched forth at just the proper time to produce the greatest result. The line of battle was then so contracted that the Commander could supervise the whole field and control the dispositions of his entire command. Now these direct attacks will rarely be successful unless attended with great losses, consequently flank attacks must be depended upon, and as strong front demonstrations must be made in order to hold the enemy in position until the flank attack is developed, superior numbers on the field of battle will, as a rule, be necessary to success. The line of battle required to accomplish this turning movement will necessarily be very much extended, consequently less under the direction of the Commander-in-Chief, and this state of affairs will require great excellence on the part of the subordinate commanders to exercise the judgment required to properly support the movement, and the same principle extended will require intelligence in the lower grades, even down to the private in the ranks.

The genius of the Commander will be exerted before the battle in maneuvering for position, in order to force his adversary into the most unfavorable position possible—or in the province of strategy—and on the field of battle in determining the points of the enemy's line which can be most successfully attacked, and the proper time to put forth the greatest efforts, usually after the flank or turning movement has begun to produce its effect on the enemy.

It is requisite that if the full advantages of armies carefully trained in piece are desired by the State that maintains them, officers must know more than their own special arm of the service; and this is perhaps more essential for officers of those arms of the service (cavalry, artillery, and engineers) which are auxiliaries to the main force—infantry—than for infantry officers themselves. And this is all the more requisite now, when the power breech-loaders have given to infantry is considered. However desirable it is that officers should know more than their own branch of the service, and should understand the nature and action of other arms, yet it is a mischievous error for any arm of the service to seek to undertake the duties of others.

A correct tactical action is one in which the powers and peculiarities of each arm of the service shall be developed to attain one object. A General looks on the different arms as instruments for attaining his object, precisely as a carpenter regards his tools; but no good carpenter would use his chisel as a saw, or his mallet as a hammer. Therefore, although officers must know and understand something of the duties of the various branches of the army, any attempt to make these branches interchangeable, to make artillery work as cavalry, infantry as artillery or engineers, is to use a thing for a purpose it is not intended for, at all times a slow and costly operation, producing a minimum amount of result with a maximum expenditure. In armies, infantry undoubtedly takes the lead, and to its action that of the other arms must be subordinated. An intimate knowledge of infantry tactics consequently becomes most essential for officers of the auxiliary arms—cavalry, artillery, and engineers—it being their duty to aid and facilitate the action of the infantry, and they must seek, not what is most advantageous and best viewed from a cavalry, artillery, or engineer point of view, but what is best viewed from an infantry point of view.

The effective range of field-artillery may be taken as from two thousand to three thousand paces. At the former distance and up to two thousand five hundred paces, its effect is very considerable; beyond that range, unless in special states of the weather, or under peculiar circumstances, the effects of the shot cannot be detected, and it becomes consequently impossible to correct the gun. Down to eight hundred yards the action of artillery is very destructive, within that distance its effect may be considered to diminish, and within that distance the effect of the breech-loading rifle begins to get very formidable, consequently the effective fire of artillery may be said to begin just at the range that musketry becomes wild. Hence, it should be borne in mind that artillery should rarely or never come within one thousand to one thousand two hundred yards of infantry, and conversely, infantry should not be allowed to come within that distance of guns, except in special cases, when it may be judged requisite to sacrifice the guns to the necessity of checking the enemy's advance. When a mass of artillery is deployed it will be well to have the batteries not in one great line, but, so far as the ground admits, in échelons of two or three batteries, so as to allow troops to pass through if requisite.

Artillery on the defensive should be placed to command all the approaches to the weak points, as well as all the ground within effective range; it should not interfere with the movement of the troops it is intended to support; positions with sheltered places in front from which the enemy's infantry may obtain an effective fire on the gunners should be avoided; when the batteries are so placed that they can obtain a cross-fire on the ground over which the enemy must advance to the attack, the effect of their fire will be greatly increased. The long ranges now obtainable admit of the batteries being placed at much greater distances apart than formerly, and still have an effective cross-fire over the ground in front. Positions which are unfavorable for the enemy's artillery fire should be selected when practicable. When the ground immediately in front of the battery is soft or marshy, is cut up by shallow ditches, or is plowed ground, the effects of the enemy's artillery fire will be greatly lessened. After a battery has been placed in position and it is possible to do so, the distances to prominent points on the ground over which the enemy must advance should be measured and noted; the guns should then be masked from the enemy's view and arrangements made to protect the gunners. Heights with a gentle slope towards the enemy—about one in one hundred—and which break more abruptly to the rear, are favorable positions for artillery; they give commanding positions for the guns, and afford facilities for concealing and protecting them when placed just behind the crest.

The moment a battery takes up a defensive position its Commander must ask himself: Where is the enemy most likely to place his guns first? And as he advances, where will he place them next? Having answered these questions, he must at once measure his range and carefully study the problem before him, which is to place the attacking guns *hors de combat*. Artillery on the offensive should on the contrary, while striving to keep up as accurate a fire as possible fire more rapidly, its object being to overwhelm a certain place with projectiles prior to the infantry attack. During the crisis of the action the artillery fire should be directed on the attacking columns; this principle has no exception, unless some of the attacking batteries are doing much harm to the defenders, when they may be fired at also.

At the opening of an engagement the artillery, by directing its fire upon several points of the enemy's position, misleads him as to the true point of attack; prevents him from massing his troops at the proper place; covers the movements and formations of the other arms as they prepare for the attack; then massed at the proper moment it scatters and demoralizes the enemy's troops at the point of attack, thus preparing the way for the action of the infantry and cavalry. Napoleon said: "He who is capable to bring suddenly and unknown to the enemy, upon the most important points, an unexpected number of guns, is certain of success."

One noticeable feature of modern battle-fields is the great extent of the line of battle as compared with those battles fought before the introduction of the breech-loader; the consequence is that corps and divisions have to act more independently than formerly, when the whole battle-field was under the eye and control of the Commander-in-Chief. Each corps and division should therefore be provided with its own artillery; six batteries at least being assigned to each division, and six batteries being taken to form the corps artillery.

The effect produced by artillery fire is more moral than real; on raw troops its effects are very demoralizing. It is well to impress this fact upon the minds of soldiers, as it may do much towards rendering them steady and less liable to disorder when under artillery fire.

At the battle of Gravelotte the Prussian troops assailed the French position, and their losses from the effects of artillery fire were only six per cent. of the total number killed and wounded: while the infantry bullet was the cause of over ninety per cent. of their loss.

The science of war, or the knowledge of military tactics upon an extensive scale, is perhaps the most comprehensive operation of the human mind, and demands the full exercise of all its powers. To be equal to the multifarious branches of this unbounded art, the strictest attention must be given to military discipline. The best authors both ancient and modern, must be resorted to for information, and when the mind has been well stocked with the sound principles of theory, practice and experience must follow, in order to confirm what has been carefully selected from the first authorities, and maturely digested. Courage, zeal, prudence, and discretion must likewise be the constant companions of those persons who would distinguish themselves in war; and it ought never to be forgotten that a scrupulous adherence to morality, a rigid observance of every social duty, and a manly subjugation of the many passions by which different men are differently agitated, must constitute the character of a real warrior. These are the qualifications by which the science of war is distinguished from every other pursuit in life; and without these qualifications, a conqueror can neither be called a hero nor an able General, but only a lucky soldier. See *International Law*, *Strategy*, and *Tactics*.

WARASDINS. A kind of Sclavonian soldiers, who are clothed like the Turks, with a sugar-loaf bonnet instead of a hat.

WAR-BEAT.—Worn down by service. Also written *war-beaten*.

WAR-CRIES. Cries of mutual recognition and encouragement formerly used in battle, each nation, tribe, or clan, having its own. The war-cry, *cri de guerre* of the French, the slogan or ensenzie of the Scotch, is of the remotest antiquity. "The Sword of the Lord and of Gideon"—the battle-cry of the Israelites when engaging the hosts of Midian in the valley of Jezreel—is perhaps the earliest record of the use of the war-cry. Each nation usually invoked its patron saint: but in war, each party had its separate cry. The "droit de bannière" and the "cri de guerre" were conjointly the attributes of nobility. Of Sir Simon de Felbridge, for instance, it is said, he was a gentleman "de nom, d'armes et de cry." "Percy! Percy!" was the rallying-cry of Otterbourne; and the cry of "A Warwick! a Warwick!" decided the fate of Banbury Field. So widely did the practice prevail in England that, in 1495, an Act of Parliament was passed forbidding all these cries as productive of discord, and enjoining all noblemen and their retainers thenceforth to call on "St. George and the King."

The ancient war-cry of the Kings of England was, "Montjoie, Notre Dame, and St. George!" that of the French was, "Montjoye, Saint-Denis!" and that of the Spanirds, "San Iago!" In the feuds of the Middle Ages, each party had a distinctive war- or rallying cry; thus, in Scotland, the retainers of the houses of Douglas and Home rushed into the battle with the cry of "A Douglas! a Douglas!" or "A Home! a Home!" "Esperance, Percy!" was that of Hotspur at the battle of Shrewsbury, and "Set-on!" and "Abo!" of Seton, Earl of Morton. The cries of "Crom-a-boo!" and "Butler-a-boo!" were from an early period the cries of the Irish, and were especially prohibited. "Laundaig Abo!" "The Bloody Hand!" "Strike for O'Neil!" were the battle-cries of the wild followers of Shan O'Neil. It is stated that "Dieu et mon droit!" was probably a war-cry long before it was adopted as a royal motto, for Richard I. is recorded to have said, "Not me; but God and our right have vanquished France at Gisors."

"The Puritans," writes the author quoted above, "brought in Scripture words; and the war-cry of the tribes who revolted against the house of David, "To your tents, O Israel!" was adopted by the republicans of the seventeenth century. At the battle of Hylton-on-the-Wear, in 1644, the field-word of the Scots was, "The Lord of Hosts is with us!" that of the Marquis of Northampton, "Now or never!" Although war-cries have come into general disuse in modern times among the armies of civilized nations, they have been revived, in certain circumstances, as an encouragement in battle. The "Shoulder to shoulder, Highlanders!" is well known in the Highland regiments; the soldiers of Napoleon were accustomed to charge with shouts of "Vive l'Empereur!" or later, "Vive la France!" "Vaterland! Vaterland!" and "Hurrah!" could be heard as a rallying-cry of the Germans on many a battle-field during the last wars. And in the British army the war-cry of the soldier is "Hurrah!"

WARD BURTON RIFLE.—A breech-loading small arm having a fixed chamber closed by a movable breech-block which slides in the line of the barrel by direct action. As a single loader the piece is opened by turning up the handle of the breech-bolt so as to disengage the threads of the sectional screw, and then withdrawing the bolt. The motion of turning up the handle, in opening the piece, serves to revolve the firing-pin on its axis, and to cause a spiral shoulder near its head to bear against a corresponding surface into which the back of the firing-pin guide is formed. The point of the firing-pin is thus retracted from the face of the bolt in the closing of the piece, so as to avoid the accidental explosion of the cartridge during this operation. In turning down the handle these shoulders are no longer opposed, and the firing-pin may then be driven forward in the usual way. For a similar reason, the face of the bolt is made somewhat concave.

The piece is fired by a concealed lock moved by a spiral mainspring. The piece is cocked by compressing the mainspring by means of the firing-pin, which resting upon it, and catching on the sear-bolt in closing, is held back against the resistance of the mainspring, while the breech-bolt passes by, to the extent of the throw permitted the firing-pin. To fire the piece, the sear-bolt is drawn down out of the way by the trigger. To prevent the sear-bolt from accidentally slipping off the shoulder on the firing-pin, when the mainspring is compressed, the surfaces in contact are internotched, the annular groove so formed on the firing-pin, being cut, so as to permit the passage of the sear-bolt, when the breech bolt is turned down into the position of firing. Extraction is accomplished by a spring-hook recessed on top of the bolt, and riding over the rim of the cartridge in closing, and ejection by a loose pin playing through the face of the bolt diametrically opposite to the extractor. This pin strikes the front of the sear-bolt in opening the piece. It thereby impinges against the lower edge of the cartridge head, and throws the cartridge-shell upward around the hook of the extractor, by which it is held, until it is clear of the gun. The piece may be dismounted by turning aside a stop-screw beneath the horizontal arm of the trigger. The sear-bolt may then be pulled down out of the slot in the bottom of the breech-bolt, so that the bolt may be withdrawn.

As a magazine-gun, it is opened as just described; and in drawing back the breech-bolt the front end of the slot in its lower surface strikes the upper lever-arm of the carrier, and throws up the tray in which its front part is formed. This tray supports a cartridge slantingly, so that the upper portion of the cartridge-head shall project slightly above the bottom of the groove in which the bolt slides, while the point of the bullet is opposite the mouth of the chamber. The carrier is kept in this position by the action of the carrier-lever spring.

By reversing the movement of the bolt, its face catches against the head of the cartridge and shoves it up the incline of the carrier into the chamber. As its movement is completed the back end of the slot strikes the carrier-lever and forces down the carrier opposite the mouth of the magazine. In its descent it strikes a spring-catch magazine-stop operating to restrain the issue of the cartridges from the magazine, and allows one to come out upon the tray.

The issue of cartridges from the magazine may be cut off by a slide operated by a projecting thumb-piece. The piece may then be used as a single-loader, holding the magazine in reserve.

The head of the follower is covered with India rubber in order to serve as a cushion for the rebound of the cartridges in firing.

The magazine is charged from below by drawing back the bolt, thus raising the carrier and exposing the mouth of the magazine for the successive introduction of the cartridges.

This arm uses a special ammunition, the general plan of which is that of the cup-anvil service-cartridge. The fulminate is protected from accidental ignition in the magazine by being placed at the apex of a central packet formed in the cartridge-head.

WAR DANCE. A dance among savages preliminary to going to war. Among the North American Indians it is begun by some distinguished chief, and whoever joins in it thereby enlists as one of the party engaged in a warlike excursion. The war-dance is also indulged in upon the close of any successful expedition, as well as for pleasure.

WARDEN. An officer appointed for the naval or military protection of some particular district of country. In order to keep the districts of England adjoining to Scotland and Wales in an attitude of defense, great officers, called Lords Wardens of the Marches, were appointed, to whom the duty of protecting the frontier was committed. From this source originated the name *ward*, applied to the subdivisions of the counties of Cumberland, Westmoreland, and Durham a term afterwards extended to divisions of a city, town, or burgh adopted for municipal purposes. The Custodier of Dover Castle was created by William the Conqueror Warden of the Cinque Ports, and guardian of the adjacent coast; an office comprising extensive jurisdiction, civil, naval, and military, the greater part of which was taken away by later Acts.

WAF)EPARTMENT. The entire administration of the military affairs of the nation. It includes in England the purely military command under the Commander-in-Chief, and the civil administration under the Surveyor-General of the Ordnance and the Financial Secretary. This latter includes the manufacture of warlike stores, and their custody; the formation of defensive works; the paying, feeding, punishing, curing, arming, carrying, etc., of the army. The national surveys form also a portion of this Department. The whole Department is controlled by the Secretary of State fo" War. See *Department of War*, and *War Office*.

WARDER.—A trunch(...n, or a staff of command, carried by a King or any Commander-in-Chief, the throwing down of which seems to have been a solemn act of prohibition to stay proceedings.

WARDHOLDING. The military tenure of land in Scotland under the feudal system, by which the vassal was bound to serve the superior in war whenever called on to do so. As the military duties of the vassal could not be performed when he was under age, the superior had a right both to the guardianship of his person and to the possession of his fee during his minority. An arrangement, however, was frequently made by which this right was commuted into an annual payment, in which case the fee was said to be held in *taxed ward*. When an unmarried vassal succeeded, the superior was entitled to a sum proportionate to the value of the estate, called the *avail of marriage*; and a larger sum, called the *double avail of marriage*, was due when the superior named a wife for his vassal, and the vassal, rejecting her, married another woman. If a vassal alienated his lands or the larger portion of them without consent of his superiorr the fee fell to the superior by what was called the casualty of *recognition*, which was a check on vassals impoverishing themselves to such an extent as would render them unfit to perform feudal services. Wardholding was abolished, as a system hazardous to the public tranquility, such fees as were held ward of the Crown being converted into blanch-holdings, and those held of subjects becoming feu-holdings, a yearly sum being made payable to the superior, as a recompense for the casualties which were done away with.

WARE COMBINATION FUSES. The fuse shown in Fig. 1, consists of a metal stock, A, open at the

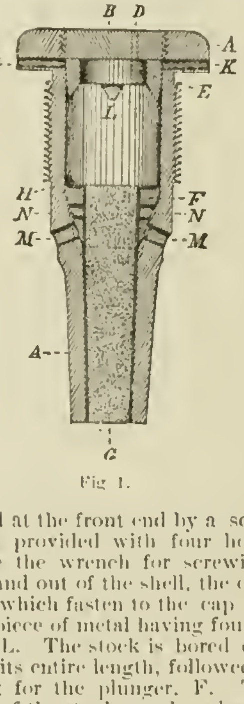


Fig 1.

rear, but closed at the front end by a screw-cap, B. The cap, B, is provided with four holes, two of them to receive the wrench for screwing and unscrewing it in and out of the shell, the other two for the pins, D D, which fasten to the cap the igniter, E, an annular piece of metal having four projecting points marked L. The stock is bored cylindrically for nearly half its entire length, followed by a conical-shaped seat for the plunger, F. The plunger and remainder of the stock are bored slightly conical to receive and hold firmly the time-fuse, G. Around the top rim of the plunger is cut an annular channel to receive the fulminate wafer, H. The fuse operates as follows: Upon movement of the shell, the igniter, E, frees itself from the cap, B, moves down upon the plunger, F, and its point, striking the fulminate wafer, H, ignites the fuse, G; when the motion of the shell is arrested, the plunger, F, fuse, G, igniter, E, and loose powder in the shell move forward to the cap, B, the igniter, E, closing the four small radial air-holes, K, in the head of the stock, preventing water and dirt from entering and extinguishing the fuse. This forward movement of the fuse and plunger allows the gas from the fuse composition free communication with the interior of the shell, to further facilitate which small radial holes, M, and N, are bored in the plunger and stock.

The fuse, shown in Fig. 2, consists of a metal stock, A, closed at upper end by a screw-cap, B; on the shoulder, C, near the bottom of the cylindrical space in the stock, rests a metal ring, D, having a recess turned in its upper surface to receive the fulminate wafer, E; between the ring and shoulder lies a soft metal ring or gas-check, F. The plunger, G, bored slightly conically to receive the time-fuse, H,

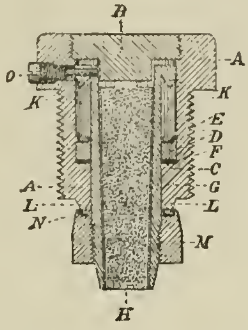


Fig. 2.

has at its upper end four projecting arms, terminating on the under side in sharp points, K. From the bottom of the stock projects the four points, L. To the lower end of the plunger is secured a metal ring, M, on the upper surface of which is cut a recess to receive the fulminate wafer, N (like E). The plunger is held in place by the safety-pin, O. There are also in the projecting end of stock four radial holes for escape of gas.

The fuse is intended to act as follows: When the projectile is set in motion, the plunger by its inertia is carried back, sheering off the safety-pin, O; the projecting points, K, strike the fulminate, E, which ignites the time-fuse. When its motion is arrested the plunger moves forward bringing the metal ring, M, and fulminate N, against the sharp points, L, igniting the powder charge, which is also thrown forward and surrounds the ring. See *Fuse*.

WAR ESTABLISHMENT.—The augmentation of regiments to a certain number, by which the whole army of a country is considerably increased, to meet war exigencies.

WAR FORK.—A weapon first employed in the fifteenth century. It consisted of a metal fork with several prongs, made fast at the end of a long pole or shaft. Sometimes a hook for scaling purposes was made to form a part of the fork. It is mentioned in the siege of Mons, in 1691, where the Grenadiers of the elder Dauphin's regiment, under the command of Vauban, assaulted a breastwork and carried away the Austrian forks. To recompense their bravery, Louis XIV. gave the Sergeants of that regiment the right of carrying a fork in place of the halberd.

WAR GAME.—The "Kriegsspiel" or war game, in its present form, was originally the invention of a civilian, Herr von Reiswitz; the details were carefully worked out by this gentleman's son, who was a Prussian Artillery Officer. The *Militair-Wochenblatt*, of March 6th, 1824 contains a notice, signed by Field-Marshal von Müffling, which speaks in high terms of the instruction and advantage to be derived from the game. Although, therefore, the game is no novelty, it is only recently that its importance has been fully recognized out of Germany; the increased importance which is now attached to it may be, in some measure, due to the feeling that the great tactical skill displayed by Prussian officers in the late war had been, at least partially, acquired by means of the instruction which the game affords. However this may be, it is certain that within the last few months increased attention has been paid to the game not only in England, but on the Continent; the numerous articles on the subject in English and foreign military periodicals abundantly testify to the truth of this statement. In point of fact, the names of the officers who have patronized the game are a sufficient guarantee of its practical utility: Some 20 years ago a society of officers was formed at Magdeburg for the special object of playing the game; the chief of this society was Count von Moltke, then Chief of the Staff of the 4th Army Corps. General Blumenthal attaches great importance to it. In Austria also the game has met with the approval of the most distinguished officers of the army. Apart from the tactical instruction which it is the primary object of the game to impart, it teaches officers to realize the space occupied by troops, either when deployed or on the march, and the time required to transport bodies of men from one point to another; it also excites a spirit of emulation, and leads to the frequent discussion of military questions of importance. Several different codes of regulations for the conduct of the game have appeared, which differ in points of detail, although the principles maintained throughout are the same. The code we describe is, for the most part, a free translation of the "Anleitung zum Kriegsspiel," by Captain W. von Tschischwitz, of the Prussian Army. A good many points have, of course, been altered to suit the organization and tactics of the English Army, the following proposed regulations for the conduct of the game having been compiled at the Topographical and Statistical Department of the War Office, by Captain E. Baring, Royal Artillery, after communication with Officers of the different Arms.

1. The war game is intended to afford a representation of military maneuvers on a map drawn to a large scale, the troops engaged being indicated by small moveable metal blocks.

2. Rules for the movement of the troops and for their conduct in action, as well as for the method of calculating the losses which are to be supposed to occur under various circumstances are laid down in pars. 14 to 61. These rules are intended to impart, as far as possible, a sense of reality to the mimic maneuvers.

3. In conducting this game the same difficulties are encountered as in the conduct of maneuvers in the field in time of peace, that is to say, it is impossible to introduce the element of superior courage or training on the part of one or other of the opposing forces, and it is most difficult to realize the full effect of Infantry and Artillery fire. In order, however, to introduce these important elements into the game as far as possible, Tables have been compiled which are used in conjunction with dice.

DESCRIPTION OF PLANS, MARKERS REPRESENTING TROOPS, ETC.

4. The maps are drawn to a scale of 6 inches to a mile. The woods are colored green; the main roads, viz., those which are metalled and are more than 18 feet wide, dark brown; other roads, light brown.

5. The troops are indicated by metal blocks, one set being colored red and the other blue. In handling these blocks it is desirable to avoid touching the colored surface as much as possible, to prevent it becoming defaced; two pairs of pincers are provided with each box, which will be found convenient for the purpose of removing the blocks. The blocks are made to scale in so far as length of front is concerned, with the exception of those which represent a company, a patrol, and a sentry or vedette; the size of these latter has been somewhat exaggerated. The Pontoon Train, Telegraph Troop, and Equipment Train of the Engineers are drawn to scale, each being in column of route.

6. Each box contains sufficient metal blocks for the maneuvers on either side of an Army Corps constituted as shown in table page 584.

Each Brigade of Infantry consists of 3 battalions, each of 1,099 officers and men. A Company of Infantry consists of 3 officers and 130 non-commissioned officers and men; there are 8 companies in a battalion. The Cavalry Brigade consists of 3 Regiments and 1 Battery of Horse Artillery. A Regiment of Cavalry consists of 634 officers and men and 559 horses (79 officers, 480 troop). A Squadron consists of 5 officers and 120 mounted non-commissioned officers and men; 4 squadrons form a regiment.

	Men.	Horses.	Guns.
3 Divisions of Infantry......	27,000	3,411	36
1 Brigade of Cavalry..........	2,093	1,881	6
Reserve Artillery.			
3 Batteries, Horse Artillery..	573	612	18
3 Field Batteries	609	552	18
1 Artillery Reserve Ammunition Column....................	128	126	....
Reserve Engineers.			
1 Company.........................	124	8	....
1 Equipment Troop.............	241	117	....
1 Pontoon Train..................	251	154	....
1 Telegraph Troop..............	249	120	....
Total (Exclusive of Staff).	31,271	6,981	78

Each Division of Infantry is constituted as follows:

	Men.	Horses.	Guns.
2 Brigades of Infantry.........	6,594	60	....
1 Battalion of Rifles............	1,099	10	....
1 Regiment of Cavalry.........	634	559	....
2 Batteries, Field Artillery...	406	368	12
1 Company, Engineers.........	124	8	....
1 Infantry and Artillery Reserve Ammunition Column.	143	142	....
Total........................	9,000	1,137	12

A Battery of Horse Artillery consists of 6 9-pdr. guns, 9 ammunition-wagons, 1 forge-wagon, 1 store-wagon, 1 general service-wagon, 1 store-cart, 1 cavalry ball cartridge-wagon. Total, 20. 191 officers and men, 204 horses.

A Field-Battery of 9-pdr. guns consists of— 6 guns, 12 ammunition-wagons, 1 forge-wagon, 1 store-wagon, 1 general service-wagon, 1 store-cart. Total, 22. 203 officers and men, 184 horses.

The Artillery and Infantry Reserve Ammunition Column consists of 27 wagons of different kinds. The Artillery Reserve Ammunition Column consists of 21 wagons of different kinds. It carries the reserve ammunition for the 3 Field Batteries and 3 Horse Artillery Batteries in reserve. A Company of Engineers consists of 121 officers and men. An Equipment Troop of the Engineer Train consists of 33 wagons and carts of different kinds, and carries tools for three companies of Engineers. The troop is divided into 3 sections, each of which carries tools for 1 company. The Pontoon Train carries material for the construction of a bridge 120 yards long, capable of supporting Siege Artillery. The Telegraph Troop carries at all times about 36 miles of wire.

7. The ivory scale admits of measurements being made in yards or in paces.

8. A suitable scale shows the intervals between contours at different degrees of slopes from 5° to 25°; all measurements must, of course, be made from the *left* of each line on the scale, and care must be taken to ascertain whether the contours on the map are drawn at intervals of 25, 50, or 100 feet. The diagram at the back of the scale shows the section of the different slopes from 5° to 45°.

9. A specially prepared metal scale is made for use in the case of short moves.

10. The pieces should be moved by the Umpire, or his assistants, and not by the players themselves.

DESCRIPTION OF TABLE FOR DECIDING ON THE RESULT OF ENGAGEMENTS, ETC.

11. In deciding as to whether an attack has succeeded or failed, the nature of the ground, the numerical strength of the opposing forces, and their condition, that is to say, whether the troops are fatigued or fresh, whether disordered, or the contrary, etc., have all to be taken into consideration. In order to facilitate a decision with reference to these points, an ordinary die is used in conjunction with a prepared Table. It will often occur that one of two opposing forces has a considerable *prima facie* advantage over the other by reason of numerical superiority, position, or some other cause; at the same time, although the defeat of the party which is placed at a disadvantage is probable, the uncertainty of war is such that it cannot be said that his defeat is certain unless the disparity of numbers, the difference in the reciprocal position of the opposing forces, or some other equally important condition gives advantages to one side of such a nature as to render success on the other side impossible. The object which it is sought to attain in the application of the Table is to represent, as far as possible, these *chances of war*, or, in other words, to represent in the mathematical language of favorable and unfavorable chances the degree of probability with which success or failure can be predicted under various conditions. The method of applying the Table is very simple.

It will be observed that the Table is divided into three principal columns, headed respectively red, faces of the die, and blue. The two outer columns are somewhat similar. The one marked red, intended to be used only by the force which is characterized by that color, is divided into two sub-columns, headed "Number of Index Points" and "Odds for or Against." The other outer column, subdivided in a similar manner, is for the use of the force having blue for its distinguishing color. These vertical columns are separated across the diagram by horizontal lines enclosing spaces in which are marked the different combinations of "odds" which can occur. On examining the arrangement it will be seen that the column for red is marked 5: 1 against, 4: 1 against, and so on through the series ending with 5: 1 on. In the same way the column for blue is marked 5: 1 on, and so on through the series ending with 5: 1 against. The arrangement is obvious, for supposing red to cast the die, and it is decided that he is to throw with — 11 Index Points, or, in other words, that the odds against the success of his enterprize are 2: 1, it is evident that the odds in a blue's favor are 2: 1 on, which, by carrying the eye across the Table, is seen to be the case.

To decide any question by means of the Table, it is in the first instance necessary to determine the number of Index points + or — with which the thrower is to cast the die or, in other words, what are the chances for or against the success of the particular enterprise in question. The method of determining the chances under different circumstances is laid down in paragraphs 14 91. The column marked "Faces of the Die" is sub-divided into 6 sub-columns corresponding to the faces. The letters R. T. D. are abbreviations for repulses, defeats and total defeats; the numerals refer to the losses of the defeated side in men. The numbers above the letters refer to losses per battalion, those below per squadron. These losses are those caused by the *arme blanche, i. e.*, by the bayonet or saber; in order to estimate the loss caused by previous fire, reference must be made to the Table. Thus, if the odds are 2: 1 against red, or he throws with — 11 Index Points and the die turns up 3, the side represented by that color, or blue in this case, wins and defeats red, inflicting a loss on his troops of 18 men per battalion, or 4 men per squadron; if 4 turns up, red wins and repulses blue, with a loss to blue of 12 men per battalion or 2 men per squadron.

In order to make the foregoing description more clear, it will perhaps be as well to give a couple of examples of the manner in which the Table is applied. In the first instance, however, it is necessary to state that in so far as mere numerical strength is concerned, a battalion of Infantry column is supposed to have the same chances of success as a regiment of Cavalry, or as 4 companies of Infantry in extended order, or as half a battery of artillery.

Example I.—Eight blue squadrons surprise and attack a red battalion in column. In applying the Table, in order to decide on the success or failure of the attack, what number of Index Points should be used? In so far as numerical strength is concerned a battalion of Infantry is considered to have the same chances of success as 4 squadrons; in this case, therefore, as there are 8 squadrons opposed to one battalion of Infantry, the chances are 2 : 1 against the Infantry, or the number of Index Points the red Infantry should have would be — II. But according to the rule laid down in paragraph 33, when Cavalry attacks Infantry in column, it loses 4 Index Points, or, which is the same thing, the Infantry gain 4 Index Points; therefore the number of Index Points the red Infantry should have would be 2 + 4 = + II. But by the rule laid down in paragraph 26 troops which are surprised forfeit 2 Index Points, therefore the number of Index Points the red Infantry have must be reduced by 2, the final number is therefore + 2 — 2 = 0, or the "odds" are even for or against the enterprise, and if the die turns up ⠂, ⁝, or ⁘ blue wins, if :, ::, or ⁞⁞ red wins. As regards the loss sustained by the Cavalry in attacking from the fire of the Infantry, it may either be calculated by means of the Table, or the rule laid down in par. 33 may be applied, that is to say, that a loss of 15 men per squadron is supposed to be incurred if the attack is successful, or a loss of 20 men per squadron if unsuccessful. If the charge of Cavalry is successful, and the men remain in conflict with the Infantry, the latter by, virtue of the rule laid down in par. 33, lose a quarter of their strength for every move (that is, as will be hereafter explained, for every period of two minutes) during which the *mêlée* lasts; the Cavalry lose 5 men per squadron for every move during which the *mêlée* lasts.

Example II.—Three red squadrons of Cavalry, which have been much shaken, are attacked by two intact blue squadrons; the action takes place on a hill which slopes about 10°; the force of 2 squadrons occupies the lower, the opposing force the higher ground. In deciding the result of the action by means of the Table, what number of Index Points should be used? If both forces were intact, it is clear that the chances of success would be unfavorable to the forces which are numerically inferior in the proportion of 3 : to two, hence the blue squadrons would throw with — I; but this latter force gains an advantage of one Index Point from the nature of the ground (*see* paragraph 38), and of two further Index Points, from the fact that the red squadrons are much shaken. Hence the final number of Index Points for the blue would be — 1 + 1 + 2 = + II, or the odds are two to one on blue. As the Index Number employed in this case is + II, it is necessary, in the first instance, to determine, by means of the Table, whether the decision takes place in the same move as that in which the charge is effected, or whether it is delayed to the subsequent move (*see* par. 39). Blue is anxious that there should not be any delay, therefore if :, ⁝, ⁘, or ⁞⁞ (blue colors) turn up, the result is to be taken by that very throw, but if ⠂ or :: (red colors) turn up, then the decision will not take place that move. In the next move the die is again cast to determine which side is victorious; suppose ⁝ be thrown; a blue square stands vertically beneath ⁝, blue is therefore victorious and defeats the force of three squadrons, inflicting a loss of 4 men per squadron for each move during which the *mêlée* lasts; that is, with a total loss of 8 men per squadron; the 2 victorious squadrons suffer a loss of 4 men per squadron by virtue of the rule laid down in paragraph 39. Now, suppose that the victorious Cavalry pursue for the period of 2 moves, the beaten party would in these two moves incur a further loss of 16 men per squadron, and would then be deemed "totally defeated;" that is to say, by virtue of the rule laid down in par. 22, it would not be capable of offering resistance until 8 moves had elapsed, or of re-assuming the offensive till 16 moves had elapsed. The victorious Cavalry would incur a loss one sixth as great as the beaten party; that is to say, they would lose 3 men in the pursuit. If, immediately after the pursuit were discontinued, the pursuers were attacked by another force, the Umpire would have to decide whether the former were to be considered as "slightly shaken" or "much shaken" (par. 24). Probably he would decide that they were "much shaken."

TABLE FOR CALCULATING THE LOSSES CAUSED BY INFANTRY AND ARTILLERY FIRE.

12. This Table is intended to afford a means of calculating the losses occasioned by the fire of Infantry and Artillery. In the case of the Artillery, the numbers given in each square represent the loss occasioned during a period of one move. (That is to say, during 2 minutes: See Par. 17.) by a battery of 6 guns; in case of the Infantry, the numbers given in each square represent the losses occasioned by one battalion in line, or by 4 companies in extended order during a period of one move. Troops under cover or in extended order suffer only one-third of the loss given in the Table; Infantry *in line*, when exposed to the fire of shrapnel or common shell incur one-half of the loss shown in the Table; on the other hand, Cavalry suffers a loss one-fifth greater than that given in the Table. The *number* of troops against which the fire is directed does not, of course, affect in any way the loss occasioned in a given time, provided the aim be correct, and has not, therefore, to be considered in applying this Table, but the *formation* is a matter of great consequence, and must always be taken into account. The losses occasioned by a greater or less force than a battalion in line, 4 companies in extended order, or a battery of Artillery, can of course readily be calculated from the data given in the Table by multiplying or dividing.

It will be observed that the Table is divided into two principal parts, one headed "good effect," and the other "bad effect:" it remains with the Umpire to decide which of these two parts shall be employed in any particular case; in coming to a decision on this point he will be influenced by the size of the object against which the fire is directed, the relative position of the opposing forces, etc. Although, as has already been mentioned, the *number* of troops against which the fire is directed does not affect the loss occasioned in a given time, *provided the aim be correct*, it is of course clear that the chance of aiming correctly varies according to the size of the object against which the fire is directed; for instance, a single shell bursting in the midst of a battalion in quarter-column would probably place as many men *hors de combat* as one bursting in the midst of a brigade formed in a contiguous quarter-column of battalions; but, inasmuch as the former is of smaller dimensions than the latter object, it is more difficult to hit. As regards the relative position of the troops engaged, the following, which is extracted from Sir Garnet Wolseley's "Soldier's Pocket-Book," may be found useful:

"5°—Fire of Infantry and Artillery more effective down than up-hill.

"10°—Effectual and constant fire of Artillery up-hill ceases.

"15°—Fire of Infantry in close formation up-hill is without effect. Fire of Artillery up-hill totally ceases.

"20° Infantry can only fire up-hill singly with effect."

Each portion of the Table is further divided into six vertical columns, each headed by one of the figures on the six sides of a die. The manner of applying the Table will, perhaps, be best explained by an example. Suppose a half battery of 9-pdr. guns to have been firing shrapnel at a line of Infantry skirmishers for four minutes (2 moves) at 850 yards, the range being known, and the Umpire having decided that the effect of the fire may be considered as "good:" the die is cast; supppose [ ] to be thrown; from the Table it appears that 32 men are placed *hors de combat* in one move by a battery of 9-prs. firing shrapnel at the given range; hence 64 men would be placed *hors de combat* in 2 moves. A half battery will therefore place 32 men *hors de combat* in two moves; but inasmuch as the Infantry are in extended order, they only incur a loss one-third as great as that given in the Table, that is to say, they lose 11 men. As the ranges must in almost all cases, be estimated, and are not in the first instance accurately known, the officer who orders firing to commence must be called upon to give his estimate of the range; should he judge it incorrectly, the fire is supposed to produce no effect during the first move of its duration. In actual war, the Artillery would be able to correct its range by seeing where the shells burst; if, therefore, the officer in command of a battery in action should estimate the range incorrectly, the Umpire should inform him whether he has under or over-estimated it, and allow him to estimate it a second time in the next move, and so on until the correct range be found; until this be done the fire is not to be considered as producing any effect. As regards the fire of Infantry, if the range be judged incorrectly, the Umpire must use his discretion as to whether a correction may be made or not, and also as to whether the fire is to be allowed to produce any effect in subsequent moves, or whether it is to continue ineffective.

If curved fire be used and the range be estimated correctly, it is supposed to take effect, but the party firing is not to be informed that such is the case. After the fire has lasted for a period of two moves, a Table is to be employed to decide whether any movement on the part of the troops exposed to the fire has withdrawn them from its range, or whether they are still exposed to it. The party firing throw with — 1, that is to say, their fire continues effective if they win the throw, but is considered ineffective if they lose it. In the case of curved fire, if the range be wrongly estimated, the fire is to be considered as producing no effect, but the Umpire must use his discretion as to allowing any correction in the range to be made.

TABLE FOR NOTING TIME AND LOSSES.

13. A suitably prepared Table is intended to afford a means of noting the number of moves which have elapsed, and also of recording the losses which are sustained in the course of the maneuvers. One of these Tables pasted on a board is provided with each box, together with a few pins. The moment at which the troops on either side are to begin to move may either be left to the discretion of the officers in command, or it may be decided by the Umpire; in either case the time at which the first movement takes place is recorded in the Table in a manner which will best be described by a couple of Examples:—(1) Supposing the first move to be at 3:30 A. M.; a pin would be stuck in the circle numbered 3 of the column headed "hour," and another pin in the circle numbered 15 of the column headed "move." (2) Supposing the first move to be at 5:40 A. M.; a pin would be stuck in the circle numbered 5 of the column headed "hour," and another in the circle numbered 20 of the column headed "move." The pin in the column of moves is shifted lower as the game proceeds until the circle numbered 30 is reached, when the pin in the column recording the hour is shifted one circle lower, and the record of moves recommences at the top of its own column. As each move occupies 2 minutes, it is clear that at the end of 30 moves, an hour must have elapsed. The losses are recorded in a precisely similar manner; supposing, for instance, that in the first move after the actual fighting commences, the Horse Artillery of the "red" side lose 3 men at the Cavalry 6, a pin would be stuck into the circle numbered 3 of the column headed "Horse Artillery" on the "red" side of the Table, and another into the circle numbered 6 of the column headed "Cavalry" on the same side; these would, of course, be shifted as fresh losses were incurred. It will be observed that in the case of the Infantry and Engineers, the numbers stop at 40; the reason being that when 40 men have been placed *hors de combat*, one company is supposed to be rendered non-effective for further action, and must be given up to the Umpire; in the case of the Cavalry, the loss of 60 men is supposed to entail the loss of a squadron; in the case of the Artillery, the loss of 25 men is supposed to be equivalent to the loss of one gun. The yellow pins are used to note the moves and hour; the losses on the red side are scored with the red, those on the blue side with the blue pins.

RATE OF MARCHING.

14. Infantry on the march moves at the rate of 200 paces in a move: when advancing to the attack of a position without firing, 250 paces; when advancing firing from a standing position, 100 paces; when advancing firing from a lying position, and running from one spot affording shelter to another, 50 paces; at the double, 350 paces in a move. No more than 3 moves out of 8 may be made at the double, and to every move at the double there must succeed one at the ordinary marching pace. In a thick wood, Infantry are not to be allowed to advance more rapidly than 100 paces in a move. A Field Battery at a walk advances at the rate of 200 paces in a move, or at the rate of 400 paces in a move when trotting and walking alternately; 8 moves out of 10 may be allowed at this latter rate. During an engagement a battery advances walking at the rate of 250 paces in a move; trotting, at the rate of 600 paces in a move; 2 moves out of 10 are the maximum number allowed at the latter rate; in exceptional cases, 1 move out of 10 may be made at a gallop of 800 paces to a move. Cavalry and Horse Artillery advance at a walk at the rate of 200 paces in a move; alternately trotting and walking, 400 paces; at a trot, 600 paces; after every 10 moves at this latter pace, at least 5 subsequent moves must be at the rate of 200 paces; at a gallop, 900 paces; only 2 moves out of 10 are allowed at this latter pace; it can be used by orderlies, individual officers, etc. In the case of long marches, executed beyond the immediate field of battle, Cavalry and Artillery may be allowed to advance for 40 moves, at the rate of 400 paces to a move; after which the subsequent 20 moves must be at the rate of 200 paces. As an instance of what Horse Artillery can do when the necessity arises, the two Horse Artillery Batteries of the IIIrd and VIIth German Army Corps in the campaign of 1870-71 marched from Ottweiler to Saarbrücken, a distance of 21 English miles, in 3 hours, reaching the battle-field of Spicheren in fighting condition. In a thin wood they may be allowed to advance at the rate of 200 paces. Cavalry and Artillery movements in a thick wood are considered altogether impossible. If the roads are bad, the country hilly, the night dark, or any other special circumstances exist which would influence the rate of marching, the Umpire can introduce any modifications he pleases. He can also decide as to the duration, etc., of forced marches. During the progress of an engagement the Umpire may allow Infantry, Cavalry, and Artillery to advance at a walk at the rate of 250 paces to a move, if he considers that the nature of the ground would admit of so rapid an advance.

It will be as well to state here the amount of roadway occupied by troops on the march; the figures in each case show the amount of roadway which would be occupied without making any allowance for the opening out of the columns; the allowance which must be made on this account must necessarily vary considerably, according to the state of the road and other accidental and adventitious circumstances; but in the case of large bodies of troops, one-third the total length of the column may generally be regarded as a *minimum* allowance. The Umpire must pay great attention to the rapidity of march and the length of roadway occupied by the columns; the former is very frequently over-estimated, and the latter under-estimated. Colonel Lewal, of the French Army, has gone at great length into the subject of the length of roadway occupied by troops on the march, in his "Conférence sur la Marche d'un Corps d'Armée;" he estimates that the total length of roadway occupied by any large body of troops would practically be two-thirds as much again as that occupied if the regulated distances were maintained, and estimates that the length of roadway occupied by an Army Corps consisting of 39,323 men, in three divisions, would be as follows:—

	Yards.
Cavalry Advanced Guard	2,156
Interval	2,187
Infantry Advanced Guard	4,626
Interval	3,062
Main Body	12,332
Interval	951
Reserve	10,081
Interval	6,201
Train	16,191
Interval	328
Rear-Guard	1,048
Total	59,163
	or about 33⅓ miles.

In this calculation the interval of 6,201 yards between the Reserve and the Train, which might appear excessive, is occupied by Cavalry for 1,381 yards of its length. Colonel Borbstaedt, in his account of the war of 1866, states that a Prussian Army Corps (42,512 men, 13,802 horses, 90 guns, 1,385 carriages of different kinds) on the march takes up about 27 miles of roadway, 18 miles being occupied by the troops themselves, and 9 miles by the train. As regards rapidity of movement, a few instances will suffice to show how slow is the advance of any large body of men as compared with the ordinary walking pace of an individual man. In 1866, the Austrian 8th Army Corps took 14 hours to march from Kasow to Nedelist, near Königgrätz, a distance of about 12 English miles, and the same Corps in retreat took 16 hours to march 13 miles, namely, from Zadwersitz to Bokowitz; in the latter case the road was through a very hilly country. On the day of the battle of Sadowa every effort was made to hasten the march of the Crown Prince of Prussia; the weather was bad, and the country hilly; the advanced guard of the 1st Division of the Guard moving across country, marched from Daubrawitz to Jericek, a distance of 6 miles, in 2½ hours. Of these troops a French Officer says—"qu'ils marchaient à "une allure extraordinairement accelérée.". The main body of the Army of the Crown Prince marched considerably slower. The 1st Corps, which bivouacked on the night before the battle at Chranstow, took, according to Colonel Borbstaedt, 9 hours to march 8 miles, and the 2d Division of the Guard, which bivouacked at Rettendorf, marched 11½ miles in 10 hours. Colonel Reinländer, in his "Vorträge über die Taktik," estimates that 13 or 14 miles is an ordinary day's march for an Army Corps.

A battalion of Infantry occupies 334 yards (400 paces) of roadway. A squadron of Cavalry in fours occupies 56 yards (67 paces) of roadway, in sections 112 yards (135 paces), in half-sections 224 yards (270 paces.) Roads are rarely sufficiently broad to allow of Cavalry moving by fours, as a certain margin must always be allowed for the passage of the orderlies, Staff Officers, etc. Colonel Lewal says that of 109 roads in Germany—

5 are	16.4 feet broad.	
9 ,,	19.7	,,
28 ,,	23.	,,
7 ,,	24.	,,
35 ,,	26.25	,,
11 ,,	29.53	,,
13 ,,	32.81	,,
1 is	39.37	,,

The front of Cavalry in fours is, of course 24 feet. A battery of Horse Artillery in column of route occupies 420 yards (500 paces) of roadway; a battery of Field Artillery (19-prs.) 470 yards (564 paces); an Artillery and Infantry Reserve Ammunition Column, 430 yards (486 paces); an Artillary Reserve Ammunition Column, 384 yards (460 paces). A company of Engineers occupies 42 yards (50 paces) of roadway: a Pontoon Train, 619 yards (743 paces); a Telegraph Troop, 408 yards (490 paces); an Equipment Troop, 225 yards (270 paces).

CONSTRUCTION AND REPAIR OF BRIDGES, ETC.

15. A period of 2 moves is considered sufficient time to level the sides of a ditch and to render the passage of troops practicable. The repair of bridges over ditches not more than 12 feet wide takes 4 moves. The construction of a floating or trestle-bridge takes 15 moves for every 50 paces, if all the material is ready at hand; if not from 5 to 10 moves longer. The construction of a pontoon bridge takes place from 8 to 12 moves for every 12 paces. If the bridges have to be constructed under fire, from 4 to 6 moves more are required: if the fire is very heavy and is unanswered, reference is made to a Table to decide whether the construction of the bridge is possible or not: the party wishing to construct the bridge throw with — II, that is to say, the construction of the bridge is considered impossible or possible according as the face of the die corresponds with the enemy's color or with their own. In all these cases the Umpire will often have to exercise his discretion as to what is to be permitted and what disallowed.

METHOD OF CONDUCTING THE GAME.

16. If it is only intended to represent maneuvers on a small scale, 3 persons are sufficient to conduct the game, one to act as Umpire and the other two to command the two opposing forces. In the case of maneuvers on a large scale the Umpire should have the assistance of two subordinates; subordinate officers should also be attached to the officers in supreme command of the two opposing forces; these latter generally confine themselves to giving general directions as to the nature of the movements to be executed, the detail being conducted by the subordinate officers. The Umpire exercises a general supervision over the game: he must on no account allow the game to be hurried, or movements to be executed without the proper measurements being made, he must see that the rules are correctly applied, and must decide any doubtful question which may arise to the best of his discretion; during the progress of the game he is to point out and criticise any dispositions which he considers faulty, and at the conclusion of the game he is to decide which party has the advantage, and to make such general remarks on the previous operations as he may consider suitable. Before the commencement of the game the Umpire imparts the general nature of the operations to each of the officers commanding, together with the special object which each is to endeavor to attain. It will generally be advisable to issue the "general" and "special" ideas on the day before the game takes place in order to give officers sufficient time to study the map carefully.

The "general idea" should usually contain the strategical conception on which the operations are based, together with the general object which each side is to endeavor to attain; the base and principal line of operations on either side should be stated; the "general idea" is issued to both sides, and should not, of course, contain any special information which in actual war would be in possession of only one of the two opposing forces. The "special idea" should be the natural sequence of the "general idea"; the "special idea" of one force will, of course, be different to that of the other; each should contain—(1) the strength and composition of the forces; (2) the spot at which it has arrived; (3) the date and hour; (4) the immediate objective point in view; (5) any information of the movements, strength, and disposition of the enemy which may be in the possession of the Commander of the force; (6) the orders which the Umpire requires should be communicated to him in writing. Although no absolute rule need be laid out, it will generally be found desirable to fix some hour in the evening as the supposed time at which the troops are handed over to the commanders of the opposing forces, and to require each to send in to the Umpire his dispositions for that evening and his orders for the following morning.

After each Commander has carefully studied the general and special idea which has been communicated to him, he sends the dispositions which he proposes to make in writing to the Umpire; he should state the manner in which he proposes to divide his force into advance guard, main body, reserve, and, when necessary, rear-guard; he should indicate the general line of outposts, and should name the detachment which is to furnish them; a diagram, showing the disposition of the camp or bivouac, should always accompany the statement which is sent in to the Umpire; it may conveniently be placed on the margin; lastly, the divisional or brigade orders should be given; they should be precisely similar both in form and substance to those which would be issued in the field, and are not to contain any points of detail on which it would be the province of subordinate officers to exercise their discretion; the exact position to be occupied by the officer in command should always be stated. The Umpire then distributes to each officer in command the requisite number of metal blocks representing battalions, squadrons, batteries, etc., and occasionally receives from them some further information as regards their intended dispositions. The officers in command then divide their forces into advanced guard, main body, reserve, etc., and communicate the special object of the intended maneuvers to their subordinates.

In order that the game may present as truthful a picture of actual war as possible, it is very desirable that officers in command should only be allowed to see on the map so much of the movements of their opponents as would be apparent to them in the field; the movements of troops which would be hidden from their view in time of war must, therefore, be hidden on the map, or, which is the better course, if the maps are in duplicate, each Commander may be made to occupy a separate room, with separate maps; in this case it is the duty of the Umpire and his assistants, who can, of course, move from room to room, to see that any movements made in the presence of an enemy, and which would be visible to the latter are faithfully represented by duplicate blocks of metal on the opponents map. The Umpire decides as to what troops are visible to the enemy. In moving by day over an open, flat country, the movements of all troops within 3,000 yards of the enemy are supposed to be visible; in enclosed, hilly, or wooded country, the Umpire must decide on the movements which are mutually visible on either side.

17. The game is played by *moves*, each of two minutes. From the moment the game commences (that is, at the first move) all direct personal communication between the officers Commanding-in-Chief and the commanders of divisions, brigades, etc., is to cease, except when the Commander-in-Chief and the subordinate officer to whom an order is to be communicated are actually present at the same spot; the position of the Commander-in-Chief is indicated by an upright metal block. With this exception all orders and questions must pass through the Umpire, who communicates them in due time (*see* par. 14) to the person for whom they are intended. The time which is required to carry out orders is estimated by the rules laid down in par. 14. Orderlies carrying messages and individual officers may be allowed to move at the rate of 800 or 900 paces in a move. If a Field Telegraph is available, a short message is supposed to take 2 minutes (1 move) in transmission.

18. At the commencement of the game, the time is noted on the Table by means of pins in the manner already described (par. 13). The Umpire takes a note of the time at which reports or orders are dispatched, of the number of the move in which any body of troops is beaten, and of the number of the move in which it will have rallied for defense, or will be capable of again assuming the offensive, as the case may be, etc. Every subordinate Commander of troops must, in the first instance, carefully consider what he intends to do before he moves; he then informs the Umpire or his assistants of his intentions; the actual measurements are made by the latter, who also move the pieces; the players themselves are on no account to move the pieces; the *formation* in which any body of troops is to move should invariably be stated before moving. All conversation is, as far as possible, to be avoided, as it tends to lengthen the duration of the game unduly, renders it a matter of greater difficulty for the Umpire to perform his duties satisfactorily, and often serves to confuse the commanders. So soon as the Umpire has given notice of the commencement of a new move, no further correction is to be allowed in the move immediately preceding.

19. Whenever troops fire or are about to attack, notice must be given to the Umpire, who decides on the Index Number which is to be used, states, at the proper time, the result which is given by the throw of the die, and marks the loss incurred. If, in accordance with the rules laid down in par. 13, one side loses a company, a squadron, or a division of Artillery, a block representing the body of troops lost, must be handed over to the Umpire. When large bodies of troops are engaged, it is desirable that the Umpire should from time to time correct the number of men on the map, in order that not more should appear than would actually be the case, allowing for men placed *hors de combat*. When it becomes necessary to detach small bodies of men, the Umpire will, at the request of the Commander of one or other of the opposing forces, furnish him with the requisite metal blocks in exchange for others; thus, one block representing a half battalion may be exchanged for four blocks representing companies, and so on.

20. During an action, the following is the order of proceeding: the moves are made first, the failure or success of an attack is next decided, the losses are then reckoned and noted, and, if necessary, metal blocks proportionate to the loss incurred are given up to the Umpire. If the Umpire is aided by an assistant, the latter makes the calculations as regards losses. The decision of the Umpire is, in all cases, *final*, neither must any discussion be on any account allowed during the progress of the game, as to the correctness or otherwise of his decision.

21. When the opposing parties are at a considerable distance from each other, the Umpire can allow several moves to be made at once, if he thinks it desirable to do so. This course may also be adopted in the case of engagements of minor importance which will have but little influence on the general course of events; in such cases the Umpire may allow several moves to be made at once, after which recourse is had to the Table to decide the result of the engagement.

RULES FOR THE CONDUCT OF ENGAGEMENTS.

22. Whenever troops are "repulsed" or are "defeated," or are "totally defeated," the blocks of metal

which represent them are turned upside down until such a time as they are considered fit to come into action again. Troops which are merely repulsed are supposed to be capable of resistance after the lapse of 2 moves, and to be capable of again assuming the offensive after a lapse of 4 moves. Defeated troops are supposed to be capable of offering resistance after the lapse of 4 moves, and to be capable of again assuming the offensive after a lapse of 8 moves. Troops which are totally defeated are supposed to be capable of offering resistance after the lapse of 8 moves, and to be capable of again assuming the offensive only after the lapse of 16 moves. If the troops which have been repulsed are attacked during the first 2 moves in retreat by a force consisting of half their own strength, the chances of success are supposed to be equal, and 0 is the Index Number which must be employed in the application of the Table; the same Index Number is used if defeated troops are attacked during the first 4 moves in retreat by a force equal to one-eighth of their own strength, or if totally defeated troops are attacked in the first 8 moves in retreat by a force equal to one-eighth of their own strength. If troops which are merely repulsed reach a hedge or any other obstacle which would enable them to rally during the first 2 moves in retreat, they may be allowed to do so and to receive an attack, but in applying the Table to decide on the success or failure of the attack, the attacking troops obtain the advantage of 5 Index Points; if the attack succeeds, the defenders are to be considered as totally defeated, even if a face turns up which corresponds with the letter D.

23. *Fresh* troops are such as have not been in action for at least 10 moves.

24. In the application of the Table, troops which are slightly shaken are considered as losing 1 Index Point during 3 successive moves. Troops which are much shaken are considered as losing 2 Index Points during the first 3 successive moves, and 1 Index Point during the next 3 subsequent moves. Whether troops are to be considered as "slightly shaken" or as "much shaken" depends on the amount of fire to which they have been exposed, and will in most cases be decided by the Umpire. Troops which have been repulsed or defeated are to be considered as "much shaken" during the period in which, according to par. 22, they are only capable of offering resistance and not of re-assuming the offensive; during the 3 subsequent moves they are to be considered as "slightly shaken." Infantry which has been engaged for a moderately long period in a fight about a village, etc., is to be considered as "slightly shaken"; if the combat has been obstinate, as "much shaken." Cavalry is to be considered as "slightly shaken," if it moves for any considerable distance at a rapid pace, and as "much shaken" if it has attacked several times.

25. If the Infantry or Cavalry, which have just gained an advantage, are attacked in the first move after their victory by fresh troops, the Infantry forfeit 1 Index Point, and the Cavalry 2 Index Points in the application of the Table.

26. Troops which are attacked by surprise forfeit 2 Index points in the application of the table if in line or column, and 4 Index Points if in extended order.

27. If an attack be supported by a second line—which, in the case of Infantry, must be not more than 300, in the case of Cavalry from 400 to 800 paces distant, and in either case half as strong as the first—the first line can be "repulsed" only.

28. *Infantry against Cavalry.*—Infantry in line when attacked by infantry in column obtains an advantage of 1 Index Point in the application of the Table. If, however, the decision arrived at is adverse to the force in line, it is to be considered as "totally defeated" even if there be a second line in support.

29. If any body of Infantry contemplates an advance against another body of Infantry posted on flat open ground, then at 400 paces distance the odds are even, at 300 paces they are 3 : 2 against the assailant, and at 200 paces 2 : 1 against him. The Index Numbers to be used by the assailant are therefore 0, — I and — II. The assailant must throw at each distance; he may try his luck the second time in the following move if unsuccessful on the first occasion, but if the die again turns up unfavorably he must then give up further attempt. If the attack should be supported by a flank attack, the assailant gains an Index Point. The Umpire may vary the Index Number in the event of the ground being of such a character as to favor one or other of the contending forces. If the Infantry be covered by artificial or natural protection, the rules laid down in paragraphs 48-54 for the attack on villages must be applied. If the attack fails the troops which have been repulsed cannot be employed to attack again for 10 moves. If the attack is renewed with successive bodies of fresh troops, an advantage of 1 Index Point must be credited for each successive attack. In the event of one side being totally defeated, the victor suffers a loss of a third, in other cases of one-half, of the loss of the vanquished side.

30. If two stationary forces of Infantry open fire on each other on open ground, and the range is known to both parties, one side or other must be made to retreat after the fire has continued during 1 move if at a distance of from 100 to 200 paces, during 2 moves if at 300 paces, during 3 moves if at 400 paces, during 4 moves if at from 500 to 600 paces. The question as to which side is to retire is decided by the Table in the usual manner, the proper Index Number being chosen with reference to numerical strength, position, etc. If the range is not known on either side, or if it be only known to one side, or if either or both sides are under cover, the Umpire decides on the moment at which application is to be made to the Table with a view to causing one or other side to retreat. In such cases the party to whom the decision is adverse is simply "repulsed," and is not to be considered as "defeated" in the sense in which the term is employed in the rules of the game.

Infantry against Cavalry.—Infantry are allowed to attack with the bayonet any force of Cavalry which are considered as incapable of assuming the offensive (*see* par. 22); in such cases the Infantry obtain an advantage of 2 Index Points in the application of the Table.

Infantry against Artillery.—If Artillery which is not covered by any natural or artificial protection is attacked in front by Infantry advancing over open, even ground, the following Index Numbers are used in the application of the Table: If the attack is made by skirmishers, and no less than three companies attack one battery, 0 is the Index Number if at 600 paces; I, if at 400 paces; II, if at 200 paces. If a force of not less than half a battalion of Infantry in line, attacks a battery firing at known ranges, 0 is the Index Number if at from 1,000 to 600 paces; I, if at 300 paces; II, if at 200 paces. In all the above cases the Infantry throw with a + sign. If the attack be made by Infantry in quarter-column, 0 is the Index Number at from 1,000 to 800 paces; I, at 600 paces; II, at 400 paces; III, at 200 paces, the Artillery in each case throwing with a +sign.

In all cases in which a front and flank attack are combined, the Infantry gain an advantage of 1 Index Point in the application of the Table. If the decision arrived at by reference to the Table is adverse to the Artillery, after skirmishers have approached to within 400 paces, or Infantry in line have approached to within 300 paces, the guns are to be considered as captured. Skirmishers, if their attack fails, are not to be allowed to attack a second time, but they may lie down on the ground without retreating. If the Table gives a decision adverse to Infantry advancing in column against Artillery, the column must retire to a distance of 1,500 paces from the battery, or until it can get under cover; the column may not advance to the attack of the guns a second time until a period of at least 15 moves has elapsed. If the numerical strength of the Infantry be very preponderating or if any other special circumstances tend to modify the scale of chances, the Umpire can make such alterations in the foregoing regulations as he may think fit. If a force of Infantry captures a battery, but is driven back immediately after the capture has been effected, the battery loses 12 men, and, after a lapse of 4 moves, may maneuver or come into action, but if the Infantry remains in possession of the guns during the space of one move, the battery may not maneuver or come into action until 8 moves have elapsed; for every additional period of one move that the Infantry remains in possession of the guns, an additional 6 moves must be allowed to elapse before the Artillery are to be considered as capable of taking part in the battle after the recapture has been effected. If the Infantry remains in possession of the guns for a longer period than 4 moves, the latter are to be considered as incapable of taking any further part in the battle, even supposing them to be eventually recaptured. During each of the first 4 moves in which the Infantry are in possession of the guns the loss of the Artillery is to be estimated at 20 men per move. If Infantry, either lying or standing under cover, open fire at known ranges on Artillery in action, reference must be made to the Table after every 2 moves, to decide, in the first place, whether the guns can maintain their position in spite of losses, which are to be reckoned independently—and, in the second place, if the Infantry is firing at close range, whether the guns are to be allowed to limber up and retire or not. The Index Numbers to be used in the application of the Table in order to decide whether the guns can maintain their position or not are—I, if the Infantry is at a distance of from 500 to 600 paces; II, if at 400 paces; III, if at 300 paces. The Index Numbers which are to be used to decide whether the guns are to be allowed to retire, are—I, if the Infantry is at 400 paces; II, if at 300 paces. In all the above cases the Infantry throw with a + sign. If guns, which are not under cover, allow a force of Infantry to approach unobserved to within 200 paces of them, they are supposed to lose so many horses and men during the move which immediately follows the commencement of firing on the part of the Infantry, that either a portion or the whole of the guns (according to the decision of the Umpire) must be left on the ground, and, after the lapse of 2 moves, are to be considered as captured by the Infantry, without any loss having been incurred by the latter. If guns wish to move up into action under a fire of Infantry when the latter know the range, reference must be made to the Table in order to decide on the possibility or otherwise of such a maneuver being executed. The Index Numbers to be used are:

0.	If the Infantry is at	600	paces.
I.	" "	500	"
III.	" "	400	"
V.	" "	300	"

The Artillery in each case throw with a — sign. If the range is unknown to the Infantry, the guns may move up into action without any reference being made to the Table.

33.—*Cavalry against Infantry.*—Infantry in line or column which has not been exposed to fire obtains an advantage of four Index Points in the application of the Table, if attacked by Cavalry; if in rallying squares or "slightly shaken," the Infantry obtains an advantage of 2 Index Points; if "much shaken," the Cavalry obtains an advantage of 2 Index Points. If Infantry, having repulsed an attack of Cavalry are, during the next move, attacked by "fresh" Cavalry (*see* par. 23), the latter obtain an advantage of 1 Index Point. A line of skirmishers, lying on the ground, are not supposed to incur any loss from an attack of Cavalry unless an actual *mêlée* ensues; in which case the skirmishers obtain an advantage of 1 Index Point. The loss sustained by Cavalry in attacking Infantry can either be estimated by means of a Table, bearing in mind the proportionate amount of fire to which the former are exposed in any particular case, or a loss of 15 men per squadron may be allowed if the Cavalry be victorious, and of 20 per squadron if it be defeated, without reference to the Table. If Cavalry attack Infantry successfully, the loss occasioned to the latter, per battalion, by the *arme blanche*, is shown by the figures in the Table, in the top row of each partition. If the attack does not succeed, the Cavalry are to be considered as merely repulsed, but if, in retreat, the force is pursued by hostile Cavalry during the entire space of 1 move, it is to be considered as "defeated;" if it is pursued during the entire course of 3 moves it is to be considered as "totally defeated." If an attack of Cavalry on Infantry succeeds, the latter is invariably to be considered as "totally defeated," and for every period of 1 move, during which the *mêlée* continues, the Cavalry incur a loss of 5 men per squadron, the Infantry a loss of one-fourth of their strength. If Cavalry, whilst engaged hand-to-hand with Infantry, are attacked and repulsed by other Infantry, they are to be considered as "defeated;" if attacked and repulsed by Cavalry, they are to be considered as "totally defeated."

34. Every Cavalry attack (which must be in the proportion of at least 1 squadron against a battalion) which the Infantry do not await stationary is to be considered as successful. In the case of engagements between smaller bodies of Infantry and Cavalry, the Umpire must decide the issue. If Infantry which is threatened by Cavalry can, in the period allotted to 1 move, reach some adequate cover—which must not be at a greater distance than 400 paces—they may be allowed to run towards it, but if, at the instant of commencing the retreat the Cavalry are within 600 paces, the Infantry are to be considered as "totally defeated," and as having incurred a loss of 20 men for every squadron which attacks.

35. If Cavalry charges Infantry in motion at a distance of not more than 400 paces, the former is always to obtain an advantage of 2 Index Points in the application of the Table. Bridges or ditches which are held by skirmishers are to be considered as insurmountable obstacles for Cavalry if the ground in front of them is open for 500 paces or more; if not open for so great a distance, the Index Number III is to be used in the application of the Table to decide the matter; the Cavalry throw with a — sign. If a body of troops, in line or column, is posted in rear of a bridge, the Umpire must decide whether it would be possible for the Cavalry to force the passage or not.

36. Application must be made to the Table to decide whether Cavalry may be allowed to remain in position in the presence of skirmishers. The Index Numbers to be used, if the skirmishers know the range, are II if at 600, III if at 500, and IV if at 400 paces; the Cavalry throw with a — sign. It is considered impossible for Cavalry to remain in position in the presence of skirmishers at less than 400 paces. Cavalry may always be allowed to ride by Infantry if posted at a distance exceeding 600 paces; if Cavalry wishes to ride by Infantry, posted nearer than 600 paces, the Table must be used to decide on the possibility or otherwise of the maneuver being executed; the Index Numbers to be used if the Infantry know the range, are:—at 600 paces—0, if the Cavalry rides by at a gallop, I when at a trot; at 500 paces—I if at a gallop, II if at a trot; at 400 paces—II if at a gallop, III if at a trot. In all these cases the Cavalry throw with a — sign. Cavalry are never to be allowed to ride by Infantry posted at a less distance than 400 paces except in pursuit, and then only by the special permission of the Umpire. Cavalry are never to be allowed to ride by Infantry at a walk

when the latter are posted at a less distance than 600 paces. In all cases in which the possibility of Cavalry riding by Infantry is decided in the affirmative, the losses which will be incurred in doing so are to be reckoned independently.

37.—*Cavalry against Cavalry.*—If the officer commanding a force of Cavalry resolves to attack another force of the same arm, he must notify his intention to the Umpire, who then communicates it to the other side, and requests the officer commanding the force about to be attacked to inform him of his intentions, that is to say, whether he will retire or advance to a counter-attack, etc. If the attack does not take place, the party which declines the engagement must be made to retreat. If the party threatened with attack resolves to accept battle, it is incumbent on each side that they should move for at least 300 paces in the direction in which each respectively informed the Umpire that it was his intention to move, and until this is done it is not in the power of the Commander on either side to retreat or otherwise to alter his original order.

38. If a force of Cavalry, in attacking, has to leap any ditches when within 400 paces of the enemy, it forfeits 1 Index Point in the application of the Table. Cavalry charging down a slope of 10° forfeits 1 index Point. To charge up or down a slope of 15° or more is considered impossible. One squadron attacking in flank is to be considered as producing as much effect as two squadrons attacking in front. If a force of Cavalry, when in the act of making a flank movement is attacked by Cavalry, it is invariably to be considered as defeated.

39. The result of an engagement between two forces of Cavalry is decided by means of the Table, the Index Number being chosen with due regard to the relative numerical strength of the opposing forces, their condition, the nature of the ground which each has to pass over, etc. If the Index Number should chance to be 0 or II, it is, in the first instance, necessary to cast the die in order to determine whether the decision takes place during the same move as that in which the charge is executed, or in the move immediately following it. With other Index Numbers if a blank turns up the decision is delayed to a subsequent move. Cavalry which is "totally defeated" must retire at a gallop, and, for the first two moves after its defeat, straight to the rear: it is not to be allowed to halt until it either reaches its supports or until it has quitted the immediate battle-field. Cavalry which is "defeated," or merely "repulsed," must also retire at a gallop, and, during a period of 1 move immediately following its repulse, must move straight to the rear. After retiring for a period of 1 move in this direction, the officer commanding may adopt his own pace, and may change direction in whatever manner he thinks fit. If Cavalry which has been "totally defeated" is pursued by other Cavalry, it is to be considered as totally routed and dispersed. If Cavalry which has been "defeated" is pursued by other Cavalry, it is to be considered as "totally defeated" after the pursuit has lasted during a period of 2 moves. If Cavalry, which has been merely "repulsed" is pursued by other Cavalry, it is to be considered as "defeated" after the pursuit has lasted during a period of 2 moves. During the first four moves in pursuit, the force which is pursued is always to be supposed to gain 100 paces on its pursuers. If beaten Cavalry encounter any considerable obstacle (amongst which is included a rise in the ground of 20° and upwards) during its first move in retreat, it loses half its strength, and after a lapse of 3 moves, is to be removed from the map and entirely disappear from the game. If it encounters any such obstacle during its second move in retreat, the losses which it experienced in the attack are to be doubled. The loss per squadron in each move, which is incurred in any *melée* prior to the result of the engagement being decided, is given on the *lower* of the three lines in each partition of the Table. The party which is victorious incurs a loss half as great as that of the beaten party, in those cases in which the latter is "defeated" or "repulsed": if the beaten party be "totally defeated" the victors only incur a loss one-third as great as that of the beaten party. For each move during which the pursuit continues, the beaten party lose as many men as they originally lost in each move during which the *melée* lasted; the pursuers in each move lose one-sixth as many men as the pursued. If a second line is in support, beaten Cavalry are never to be considered as more than "repulsed"; they may be allowed to rally behind their second line. Squadrons acting singly may be allowed to retreat over bridges, etc., but in doing so, they incur a loss double as great as that which they experienced originally in the attack. As regards the attack of victorious Cavalry by fresh troops,—*see* par. 25.

40. *Cavalry against Artillery.*—The Cavalry, which makes a front attack on Artillery in action, forfeits 4 Index Points. Guns in action in the open, if attacked by Cavalry in flank, are always to be considered as captured if the Cavalry approaches unobserved to within charging distance. If the guns are under any natural or artificial cover, and are attacked in flank by Cavalry, they are to be considered as captured if their position is attacked by other troops in front simultaneously with the Cavalry attack in flank. Artillery in motion, when overtaken by Cavalry, is always to be considered as captured. If a force of Calvary wishes to ride by guns in action at a distance of from 400 to 700 paces, application must be made to the Table to decide on the possibility or otherwise of the execution of the maneuver, the Index Number II being employed; the Cavalry throw with a—sign. Cavalry are not to be allowed to pass within 400 paces of guns in action except when in pursuit, and then only by special permission of the Umpire. In all cases in which Cavalry ride by Artillery in action within range of the guns, the losses incurred by the former are to be calculated.

41. As regards the re-capture of guns after they have been captured by Cavalry, etc., the rules laid down in par. 32 for the conduct of Infantry in such cases apply also to Cavalry.

42. *Cavalry Fighting on Foot.*—In exceptional cases Light Cavalry may be employed to act on foot for the occupation of defiles, etc. The Umpire must decide arbitrarily whether, in any particular case, such a course of action is to be permitted or not.

43. It is supposed that all those who take part in the game are acquainted with the circumstances which render it desirable to employ common shell, shrapnell, or case,—with the conditions which render any particular kind of fire productive of greater or less results, and with the other general principles involved in the application of Artillery. The proportionate losses caused by the fire of guns at different ranges are given in the Table. It would be quite impossible within the limits of this article to enter at length into the subject of the most suitable method of employing artillery in the field, more especially since the tactics of Field Artillery have recently undergone, and are still undergoing, great and important changes. The following extracts from Colonel Owen's Modern Artillery may, however, give some of the general principles which are generally received on the subject:—The objects of Artillery in the field are—(1.) To *prepare* the way for the action of other arms by creating disorder and confusion in the enemy's ranks, dismounting his guns, destroying slight obstacles, or rendering cover untenable. (2.) To *support* troops of other arms in their movements, by preceding an attack, forming a rallying point in case of repulse, checking advancing columns of the enemy, harassing a threatening foe covering a retreat, or defending the key of an important position. (3.) To *decide* an action by the concentration of a number of batteries on an important point. In choosing a position upon the field for Artillery, the follow-

ing principles should be borne in mind, viz., that the guns should command not only the approaches to the weakest points of the position, but also, if practicable, the whole of the ground within range; that they should not inconvenience the manenvers of the troops they support; and that they should be as far removed as circumstances will permit out of range of any place which might afford a shelter for the enemy's Infantry, and from whence the latter could harass the gunners. If this, however, be impracticable, one or more guns must be told off to keep down the enemy's fire. The fire of guns should always be *concentrated* or *converging* when practicable. In taking up a position with Field Artillery it is very necessary to consider the formation of the ground and nature of the soil, not only of the part of the field the battery is to occupy, but also of that surrounding it. For precision in firing, the ground on which the guns are posted should be tolerably level, and should not have too great a command over the space which the enemy must cross over to the attack, as a *plunging* fire is little destructive. A gently falling slope of 1 in 15 is to be preferred; the fire of artillery produces the most effective results on a slope of about 1 in 100. Batteries should not be placed on stony ground, as the enemy's shot makes the stones fly in all directions, often causing considerable damage; marshy ground in front of a battery is good, should the latter not be likely to advance, as the shot will either penetrate or ricochet but little from it.

44. If a force of Artillery wishes to come up into action in the presence of other guns in action within a range of 1,500 yards, application must be made to the table to decide on the possibility or otherwise of the execution of the maneuver. If the enemy's Artillery know the range, the following Index Numbers are to be employed by the Artillery desirous of moving up:—

From 1,200 to 1,500 yards,	0
" 1,000 " 1,200 "	I
" 800 " 1,000 "	II
" 600 " 800 "	III
" 400 " 600 "	IV
" 300 " 400 "	V

If the enemy's Artillery are not acquainted with the range, the other side may move its guns up into action in the presence of hostile fire without any reference to the Table. If the ranges are known to the one side, and the decision arrived at by reference to the Table is in favor of the possibility of the other side bringing its guns into action in spite of the fire of its adversary, the loss which it will incur in doing so must be calculated independently. Guns are never to be allowed to move up in action in the presence of hostile Artillery in action at a less range than 300 yards.

45. In every action of Artillery against Artillery at ranges of 1,500 yards and under, reference must be made, after a certain interval, to the Table to decide on which force of Artillery is to fall back; the Index Number which is to be employed in deciding the question must, as usual, be determined with reference to relative numerical strength, position, etc. The interval after which reference must be made to the Table varies according to the range; if the range is known, reference must be made to the Table—if at 400 yards, after 2 moves; if at 600 yards, after 3 moves; and if at 1,200 yards, after 4 moves. The mutual losses occasioned by the fire of the guns on either side must also be reckoned.

46. Artillery which, according to pars. 44 and 45, has been beaten, must retreat, and may not be brought into action again for an interval varying from 5 to 15 moves, according to the loss sustained. If, however, the Commander of the force to which, by the application of the rules laid down in par. 45, the decision of the Table has been adverse, is still unwilling to retreat, notwithstanding his partial defeat, the guns may be allowed to continue in action for a further period of from 2 to 4 moves, the exact period being decided by the Umpire. Reference must then be again made to the Table, in the application of which the Artillery which preferred to continue in action rather than retreat, forfeits 2 Index Points, and, should the decision be again adverse, must be forced to retreat, and cannot be again brought into action for a period varying from 10 to 30 moves according to the loss which has been sustained. Enfilade fire is always to be considered as twice as effective as direct fire.

ATTACK AND DEFENSE OF VILLAGES, DEFILES, FORTIFIED POSITIONS, ETC.

47. In considering the defense of villages, woods, ect., it is supposed that, generally speaking, 1 company in extended order is sufficent to occupy a front of from 250 to 200 paces; if, however, the position is to be strongly occupied a battalion must be devoted to every 600 paces of front.

48. Before the attack is undertaken the possibility or otherwise of the advance of the assailants must be decided by the rules laid down in par. 29.

49. An attack may be made either in extended order (*i.e.*, by skirmishers), in line or in column. If the attack be made in extended order the assailants forfeit 2 Index Points in the application of the Table when the advance to the attack has been preceded by the fire of skirmishers during a period of 5 moves; if the advance to the attack has been preceded by the fire of skirmishers for any period less than that extending over 5 moves, the assailants forfeit 4 Index Points. Every attack in line on villages, woods, defiles, ect., should be preceded by the fire of skirmishers or of Artillery for a period of at least 10 moves, after which, if the attack is made at once, the assailants forfeit 2 Index Points in the application of the Table. For every subsequent period of 5 moves, during which the fire of the Infantry or Artillery last previous to the advance of the attacking column, the assailants gain an advantage of 1 Index Point. If a case should arise in which a line or column advances to the attack without any period of preparatory Infantry or Artillery fire, or if such fire has not been maintained for a period of at least 5 moves immediately preceding the attack, the assailants forfeit 4 Index Points. Before the proper Index Number is applied to decide on the success or failure of a bayonet attack, reference must be made to the Table to decide whether the result would be determined in the course of the particular move in question or whether it would be delayed to a subsequent move; for this purpose the Index Number 0 is used. This rule does not, of course, come into operation until the attacking force has approached to within the distance which could be traversed in one move. In the case of a bayonet attack the losses incurred are supposed to continue in the proportions laid down in the upper lateral column of each partition in Table during each move throughout which the hand-to-hand combat lasts.

50. If, immediately after the repulse of an attack, the assailants attack again with fresh troops, they obtain an advantage of 1 Index Point in the application of the Table, and an additional Point for every subsequent attack made immediately after a repulse, but the same troops, having been once repulsed, cannot be again employed in the attack until at least 10 moves have elapsed.

51. If the outskirts of a village are strong by nature, or if the village is surrounded by walls which have not undergone any previous special preparation for defense, the assailants, provided they have complied with the rules laid down in par. 49 as regards the period during which the fire preparatory to the attack must last, forfeit 3 Index Points in the application of the Table. If the walls have previously undergone any special preparation for defense the village cannot be taken without the aid of Artillery.

52. If there exists any natural or artificial trench within the village, which would form a second line of

defense, the defenders may be allowed to rally there' and the attack of the assailants on this inner defense must be preceded by a period of at least 5 moves of firing.

53. If, after the outskirts of a village have been carried, the supports on either side engage, the results of the engagement must be decided by reference to the Table, the proper Index Number having been chosen, bearing well in mind the relative numerical strength of the opposing forces, their position, etc. The only exception to this rule is the case in which the streets of a village form a defile: the regulations for the application of the Table in such a case are given in par. 54.

54. The rules which have been laid down for the attack of a village hold good for an attack on a defile, with this exception, that, in the event of an engagement between the supports, the numerical superiority of the supports on either side is not to be taken into account unless the one support is at least *twice* as numerous as the other; in this latter case the Index Number to be employed in the application of the Table is II; the less numerous body will throw with a — sign; in all other cases the Index Number to be employed is 0.

As regards the length of time which a fire must be kept up preparatory to the attack on a wood or on a defile, the same rules hold good as have been laid down for the attack of a village.

55. In the case of an attack on heights, if the slope of the ground be not greater than 5° it need not be taken into account; for every subsequent rise of 5° the assailants forfeit 1 Index Point in the application of the Table.

If any defensive preparations have been made, the rules laid down for the attack on a village hold good for the attack on heights; if no special defensive preparations have been made the rules laid down in pars. 28 and 29 obtain.

DEBOUCHING FROM A DEFILE.

56. As regards the debouching of a force of all arms in the presence of an enemy, the Umpire must decide whether it may be allowed to take place in the presence of Infantry posted at 300 paces or less from the mouth of the defile, or in the presence of Artillery if at 600 paces or less. In other cases application must be made to the Table. The proper Index Numbers to be used are, if in the presence of Infantry who know the range,— at 400 paces, III; at 500 paces, I; at 600 paces, 0: if in the presence of Artillery in action, who know the range:

At					
from 700 to 800 paces for	Artillery	debouching,	V.
" " " "	Cavalry	"	IV.
" " " "	Infantry	"	III.
" 900 " 1,200 "	Artillery	"	III.
" " " "	Cavalry	"	II.
" " " "	Infantry	"	I.
" 1,200 " 1,600 "	Artillery	"	II.
" " " "	Cavalry	"	I.
" " " "	Infantry	"	0.
" 1,600 " 2,000 "	Artillery	"	0.
" " " "	Cavalry	"	0.

In all the above cases the troops, whose object it is to debouch from the defile, throw with a —sign. If, during the movement, the enemy's Infantry or Artillery are, to a certain extent, held in check by the fire of other portions of the force debouching from the defile, or if the range is unknown to the enemy's Artillery, or if the enemy has posted a force of Cavalry within 400 paces of the mouth of the defile, and the other side endeavor to debouch a force of Cavalry and Artillery, unsupported by Infantry, the Umpire must decide on the course to be pursued. If a force of Cavalry be posted within from 400 to 800 paces of the mouth of the defile, and the other side endeavor to debouch a force of Cavalry and Artillery unsupported by Infanrty, application must be made to the Table to decide whether the movement can be executed or not; the proper Index Number in this case is II; the force wishing to debouch from the defile throws with a— sign

BURNING OF BUILDINGS AND VILLAGES.

57. After two guns have fired at wooden buildings for a period of 4 moves, the Index Number—I, in the Table, is employed by the Artillery to determine whether the buildings may be supposed to be set on fire or not; if they win, the buildings are supposed to burn: if not, the guns continue to fire for another move, after which the Index Number 0 is employed in deciding the question; if they win, the buildings are supposed to burn; if not, the guns continue to fire for a sixth move, after which the Index Number + I is employed to decide the question: if the Artillery have not won at the end of the 6th move, the Index Number + II is used, after the termination of the 7th move, to decide the question, and so on until in the 10 move the Index Number + V is reached; if in the 10th move, the Artillery do not win, the throw must be repeated in each subsequent move until such time as they do, when they are supposed to have succeeded in setting fire to the buildings. After 2 moves have elapsed from the time of setting fire to the buildings, reference must be made to the Table to decide whether the fire has spread or not, the same Index Number being used as that whose application resulted in the success of the Artillery in setting fire to the buildings originally. If the Table gives a decision adverse to the spreading of the fire, in the next move the Index Number + I must be employed to decide the question; if the decision is still adverse to the spreading of the fire, after 2 further moves the question must be again tested, + II being the Index Number employed on this occasion, and so on, the Index Number being increased by 1 Index Point after every 2 moves until such a time as a decision is arrived at favorable to the conclusion that the fire has spread. When 3 moves have elapsed from the time that this result is obtained, application must again be made to the Table to decide whether or not the fire has been extinguished; for this purpose the Index Number 0 is employed; if the Artillery win after 5 moves have elapsed, the troops occupying the buildings or village must abandon them and no troops are to be allowed to march through the village; if the Artillery lose, the process of deciding by means of the Table whether the buildings or village have been again set on fire must be repeated. If 4 guns are brought into action the same method is adopted as laid down for the action of 2 guns, but the Index Number used in the first instance is 0: if 6 guns are employed the Index Number to be used in the first instance is + I, and so on. If the houses are of stone or brickwork, and are strong and well built, the periods for the successive applications to the Table are doubled.

DESTRUCTION OF BRIDGES, BARRICADES, ETC.

58. The destruction of bridges, barricades, &c., by Artillery fire is decided by reference to the Table, after the fire has continued during a period of from 2 to 8 moves, the time varying according to the strength and size of the object against which the fire is directed, the number of guns brought into action, etc. The Index Number to be employed on these occasions is 0. Whenever the object against which the fire is directed is visible, and when the Artillery win, it is supposed to be destroyed: when they lose, the guns fire during the 2 entire subsequent moves, after which the die is again cast; when they lose again, all the guns fire during the 2 subsequent moves, when the die is again cast, the Index Number remaining the same throughout: if they again lose, it is supposed that the destruction of the object cannot take place during the next 15 moves; at the end of that period the same process is again adopted for deciding whether the object has been destroyed or not. When the object is not visible from the position occupied by the guns, but its position and distance are known, the same rules are applied as have been laid down with regard to the destruction of visible objects, with the exception that, if the

Artillery lose twice running, the destruction of the object in question is supposed to be impossible during the next 20 moves, after which the process of deciding by means of the Table may be recommenced. In all these cases the Umpire must decide whether the destruction of the object by the fire of Artillery is possible or not. If the distance from the guns of the object to be destroyed is unknown to the Artillery, the Umpire is to be guided by the rules laid down in par. 12. The Umpire must decide with reference to the success or failure of any attempt to burn, blow up, or otherwise destroy a bridge, barricade, etc., and also as regards the time which would be required in carrying out any such undertaking.

PRISONERS.

59. Any body of troops, whose retreat in every direction is cut off, is supposed to be taken prisoner, if it consists of less than one-third the strength of the force by which it is surrounded. If it consist of more than one-third as many men as the force by which it is surrounded, application must be made to the Table to decide the question; the Index Number used is II; if they lose, the detachment must lay down its arms; if they win they must be attacked, and the issue decided according to relative strength, etc., by the application of the rules which are already prescribed.

60. Every body of prisoners must be escorted by a guard at least one-tenth as numerous as the prisoners themselves. If the escort is attacked by any party one-half as strong as itself, the prisoners are to be released. In exceptional cases, the Umpire must decide on what course is to be pursued

NIGHT ATTACKS.

61. When a night attack takes place the Umpire must decide at what distance troops are to be considered as visible to each other, and what blocks representing troops are, therefore, to be placed on the map, so that the opponents are made aware of the presence of the forces which these blocks represent. Firing at long ranges is not supposed to produce any result: the maximum ranges at which fire is supposed to be productive of result is 300 paces for Infantry, 600 paces for Artillery, and, whatever be the range, the losses incurred are to be estimated at only half of what would be incurred by day. The effect of the fire of guns, however, which have been laid in the direction of defiles, etc.: by daylight is not supposed to undergo any diminution. All troops which are defeated in a night attack are to be considered as "totally defeated."

It will, perhaps, be as well to give an example of the instructions which are issued previous to the game. A game based on the following "Ideas" was recently played at the United Service Institution:

General Idea.—Two armies have invaded Bohemia, one by the road Lieban-Trautenau: the other by the road Zittau-Reichenberg-Turnau-Gitschin. The defenders have been defeated on both lines, and are falling back, apparently with the object of concentrating behind the Elbe. The invading armies wish to effect their junction.

Special Idea for the Invading Force (Blue).—The Commander of the Right Army, whose head-quarters are at Gitschin, sends forward a division constituted as follows: 7 Battalions of Infantry (800 men each), 8 Squadrons of Cavalry (150 men each), 3 Batteries (18 guns) Light Field Artillery, 1 Battery (6 guns) Horse Artillery, 2 Companies Engineers (125 men each), and 1 Pontoon Train. Total, 8,000 men. These arrive at Horitz on the evening of June 1st. The Commander has received orders to advance early on the 2d, to seize the bridges at Königinhof and Schurz without delay, and, if possible to push forward to Rettendorf and Gradlitz. At 5 A. M. on June 2d he receives a telegraphic communication from the Commander of the advanced-guard of the Left Army to the effect that he is in possession of Trautenau, with his outposts at Neu-Rognitz, but that he is in the presence of a superior force, and does not anticipate that he will be able to attack till mid-day. He knows that a hostile force of about 8,000 men is between Horitz and Königinhof.

Special Idea for the Defending Force (Red).—The Commander of the Defending Army, feeling himself unable to prevent the junction of the two invading armies, is concentrating behind the Elbe between Josephstadt and Königgrätz, with the ultimate intention of retiring behind the Adler and giving battle in a position between Hohenbruck and Königgrätz. He wishes to delay the junction as long as possible, and, with this object, leaves a force of 16,000 men at Königinhof. Of these 9,000 are detached to guard the Trautenau road, and on the evening of June 1st are in position near Burgersdorf; the Commander of this force reports at 6 A. M. that the enemy are not in force in his immediate presence, and that he anticipates being able to maintain his position for 6 hours. The remainder are stationed in advance of Königinhof on the Miletin road with outposts reaching as far as Trotin; this force is constituted as follows:—7 Battalions of Infantry (800 men each), 4 Squadrons of Cavalry (150 men each), 3 Batteries Light Field Artillery (18 guns) 2 Companies of Engineers (125 men each). Total, 7,000 men. The Commander of this force knows that a force of from 7,000 to 10,000 men are advancing from Gitschin to Horitz, and were within 3 miles of Horitz at 5 o'clock on the evening of the 1st.

Each Commander was directed to give his dispositions for the evening of the 1st and his orders for the next day in writing to the Umpire about 24 hours before the game was actually played. The combination which was thus supposed to exist was somewhat difficult, and called for the display of considerable tactical skill on the part of those engaged, who, in this particular case, were officers of experience. It would be well, however, as a general rule, to adopt a similar combination,—at all events to commence with,—and to manipulate a smaller force, say 2,000 or 3,000 men on each side. Even after a close and attentive study of the rules, any officer who acts as Umpire or Assistant Umpire will find that without a good deal of practice it is difficult to apply them satisfactorily. Officers are, therefore, strongly recommended to begin with combinations of the simplest description.

SUMMARY OF SOME OF THE PRINCIPAL RULES.

1. The decision of the Umpire is in all cases *final* (par. 20.)

2. No discussion is allowed during the game: all conversation is, as far as possible, to be avoided (pars. 18 and 20).

3. The Umpire decides on what troops would be seen by the enemy (par. 16).

4. No verbal communication is allowed between the Commander-in-Chief and his Subordinates: all orders must be sent by orderlies, and are not communicated to the officers to whom they are directed until the proper time (according to the rules laid down in par. 14) has elapsed. The only exception to this rule is the case in which the Commander-in-Chief and his Subordinates are simultaneously present at the same spot. Whenever a Field Telegraph is available, a short message takes one move in transmission (par. 17)

5. The Umpire will, at request of the Commander of one of the opposing forces, give blocks representing small bodies of men (*e.g.*, companies, half-batteries, patrols, etc.) in exchange for those representing any larger bodies (*e.g.*, half-battalions, batteries, squadrons, etc).

The order of procedure is (par. 20):

1. The Umpire states the number of moves to be made.
2. Each Commander in succession states what movements he wishes to make: the forces are then moved by the Umpire or his assistants (par 18).

3. The Umpire decides on the success or failure of an attack, etc., by means of the Table.
4. The losses are reckoned and noted on the Table and, if necessary, metal blocks proportionate to the losses are given back to the Umpire.

As soon as the Umpire has given notice of the commencement of a new move, no further correction is to be made in the move immediately preceding.

6. Notice must always be given to the Umpire when firing commences, or when an attack or charge of Cavalry is about to take place (par. 37).

Rate of Marching (par. 14).

	Paces in a Move.	Proportion of Moves allowed.
Infantry (ordinary pace) ...	200	—
" (step-out)	250	Umpire decides
" (double)	350	3 in 8. Each separate move to be succeeded by one at 200 paces.
" advancing firing from a standing position	100	
" advancing firing from a lying position wherever cover can be obtained	50	—
Infantry marching through a wood	100	—
Cavalry and Horse Artillery at a walk	200	—
Cavalry and Horse Artillery alternately trotting and walking	400	
Cavalry and Horse Artillery at a trot	600	5 in 10.
Cavalry and Horse Artillery at galop	900	2 in 10.
Field Artillery at a walk ...	200	—
" alternately trotting and walking ...	400	8 in 10. / 2 in 10.
Field Artillery at a trot ...	600	
" at a galop (in exceptional cases only) ...	800	1 in 10.
Orderlies and Individual Officers	900	—

In the case of long marches Cavalry and Horse Artillery may move at the rate of 400 paces per move for 40 moves, to be followed by 20 moves at the rate of 200 paces per move.

If the roads are bad, the country hilly, the night dark, or any other special circumstances exist, which would influence the rate of marching, the Umpire can introduce any modifications in the above rules which he may consider desirable.

Space occupied by Columns on the March (par 14).

	Paces.
A Battalion of Infantry...	400
Half a Battalion of Infantry	200
A Company of Infantry	50
A Squadron of Cavalry in fours	67
" " in sections	135
" " in half sections ...	270
A Battery of Horse Artillery in column of route	500
A Battery of Field Artillery in column of route	564
An Artillery and Infantry Reserve Ammunition Column in column of route...	516
An Artillery Reserve Ammunition Column in column of route	460
A Company of Engineers	50
One-third Pontoon Train	248
Half Telegraph Troop	245
One-third Equipment Troop	90

The distance given above suppose the regulated intervals to be preserved. It will generally be necessary to add to these figures in order to allow for the unavoidable extension of the columns on the march. The proportionate distance to be allowed on this account varies according to circumstances, and must be decided in each case by the Umpire. An allowance of one-third the regulated length of the column is generally considered the *minimum* amount of extension.

Construction and Repair of Bridges (par. 15).

	Moves.
To level the sides of a ditch and render the passage of troops practicable	2
Repair of bridge not more than 12 feet wide	4
Construction of a floating or trestle-bridge if all the material be at hand. For every 50 paces . . .	15
Construction of a floating or trestle-bridge if the material is not at hand.	20 to 25
Pontoon bridge. For every 50 paces	8 to 12
All bridges constructed under fire .	4 to 6 (additional)
" " " " " very heavy fire, which is unanswered .	Table decides.

	Capable of Resistance.	Can assume Offensive.
Troops repulsed	After 2 moves.	After 4 moves.
" defeated	" 4 "	" 8 "
" totally defeated . .	" 8 "	" 16 "

See *Kriegsspiel* and *Strategos*.

WAR-HAMMER.—An ancient weapon consisting of a spiked hammer placed at the end of a long shaft or pole. The foot-soldiers' war-hammer is of great antiquity, going back to the so-called stone and bronze ages. The short-handled horseman's hammer which the Knights carried, like the Mace, at their saddle-bows, is almost as ancient. Frequently, swords, three or more feet in length would form the apex of the whole.

WAR-HORSE.—A horse used in war; the horse of a cavalry soldier; especially, a strong, powerful, spirited horse for military service; a charger.

WARLIKE VIRTUES.—These are Love of our Country, Courage, Valor, Prudence, Intrepidity, Temperance, Disinterestedness, Obedience, Wisdom, Vigilance, and Patience. In the celebration of the anniversary of the destruction of the Bastile, which took place at Paris, July 14, 1789, the French characterized these eleven virtues by the following emblems:—a pelican, a lion, a horse, a stag, a wolf, an elephant, a dog, a yoked ox, an owl, a cock, and a camel.

WAR OFFICE.—The office of the British Secretary of State for War, and the center on which pivots the entire administration of the army. It is divided by the "War Office Act" of 1869 into three great departments—the Military, the Ordnance, and the Finance—under respectively the Officer Commanding in Chief, the Surveyor General of the Ordnance, and the Financial Secretary. All are ultimately responsible to the Secretary of State for War, who has, for his immediate assistance, one parliamentary and one permanent Under-Secretary of State.

WAR-OFFICE REGULATIONS.—The royal warrants regulating the pay, retirement, and allowances of officers and men of the army, together with the instructions to Paymasters and others considered necessary for the proper carrying out of the warrant.

WAR OF THE ROSES.—A disastrous civil contest which desolated England during the 30 years from 1455 to 1485, sacrificing 80 Princes of the Blood, and the larger proportion of the ancient nobility of the country. It was so called because the two factions into which the country was divided, upheld the two several claims to the throne of the houses of York and Lancaster, whose badges were the white and the red rose respectively. After the House of Lancaster had possessed the throne for three generations, Richard, Duke of York, whose title to the throne was superior to that of Henry VI., began to advance, at first somewhat covertly, his claim to the throne. In 1454 he was appointed Protector of the Realm during Henry's illness, and on the King's recovery he declined to give up his power, and levied an army to maintain it. The accession of Henry VII. may be said to have terminated the War of the Roses, although the reign of Henry was from time to time disturbed by the pretentions of Yorkist impostors.

WAR-PAINT.—Paint put on the face and other parts of the body by Savages, as a token of going to War.

WAR-PATH.—The route taken by a party going on a warlike expedition,—usually applied to hostile Indians.

WARRANT.—A writ of authority. Warrant Officers are such as are immediately below Commissioned Officers, exercising their authority by warrant only. Cadets are Warrant Officers. They may be tried by Garrison Courts-Martial; but by the custom of war a Court-Martial cannot sentence a Warrant Officer to corporal punishment or reduction to the ranks.

WAR-REBELS.—Persons within an occupied territory who rise in arms against the occupying or conquering army, or against the authorities established by the same. If captured, they may suffer death, whether they rise singly, in small or large bands, and whether called upon to do so by their own, but expelled, government or not. They are not prisoners of war; nor are they, if discovered and secured before their conspiracy has matured to an actual rising, or to armed violence.

WARRIOR.—One engaged in war or military life; one noted for valor and prowess. The term is commonly applied to Indian Chiefs and Braves.

WAR-SCOT.—A contribution for the supply of arms and armor, in the time of the Saxons.

WAR-SCYTHE.—This weapon is nothing but the agricultural scythe slightly straightened, so that the blade is in a line with the shaft. It is single-edged, the point slightly curved towards the sharp edge. In Austria, during the Jacquerie war, all the smiths detected in turning agricultural implements into weapons were punished with death.

WAR SHIPS.—For the study of naval construction and marine engineering, the most important field of observation is Great Britain. England is in the fore-front as the leader and model to all European naval powers. In addition to their magnificently equipped public dock-yards, the patronage of the Government has sufficed to keep in existence and to increase the supplemental resources which relieve and aid the national establishments, in time of peace, and which in time of war would be to them of priceless value. It is owing to this patronage, and to foreign orders for ships of war, in no small measure, that on the Thames, the Mersey, the Clyde and the Tyne are found unrivaled establishments fully equipped, with expanded and developed resources, requisite for modern war-ship construction. Besides the numerous ships designed and built yearly for the British Flag, English ship-yards have produced, and are still producing, war ships for other nations. Nearly every considerable naval power, except the United States and France, has employed English designers, English ship-builders, engineers, and gun-manufacturers. It was here that the *König Wilhelm*, *Kaiser*, *Deutschland*, and other ships for the German Navy were built. Turkey obtained from the Clyde and the Thames a large proportion of her armored fleet, including all the most powerful vessels. Russia, Spain, Holland, Italy, Denmark, Greece, Portugal, Brazil, Chili, Peru, and Japan all come to England to have armored ships of war constructed. The Sheffield works not only supply armor-plates for these ships, but also plates and materials for war-vessels built in continental countries. The Elswick works and Whitworth manufacture guns solely for foreign orders. Besides this, all nations above named are customers of the English ship-yards and engineering works to supply vessels for their mercantile marine. In London may be found naval *Attachés* of nearly all important nations, observing the progress and changes in naval construction. The following description of the armored sea-going ship *Inflexible*, from the report of Chief Engineer J. W. King, United States Navy, will serve to point out the requisities of the most powerful fighting ships armed and now afloat in the world. A careful reading will convey as correct knowledge of them as can be obtained without working-drawings in detail.

The modern man of war is much more than an armored steamer; she is a great engine of destruction, clad in heavy armor, provided with huge guns which are operated by machinery, driven by powerful engines, and fitted with machinery for purposes of all kinds. Year by year the thickness of armor and weight of naval artillery go on increasing together. Mechanical appliances have more and more replaced manual labor, and at the same time the forms of ships have been adapted to the work they have to do and to the conditions under which they must act. No war vessel yet designed has departed so widely from pre-existing types, and in none has so enormous a stride been made, in offensive and defensive power, as in the one about to be described.

The *Inflexible*, which was commenced at Portsmouth dockyard in February, 1874, and launched April, 1876, is a twin-screw, double-turret ship, with a central armed citadel. She was designed by Mr. Barnaby, the director of naval construction at the Admiralty, and at a meeting of the Institution of Naval Architects in London he describes the vessel in the following language: "Imagine a floating castle 110 feet long and 75 feet wide, rising 10 feet out of water and having above that again two round turrets, planted diagonally at its opposite corners. Imagine this castle and its turrets to be heavily plated with armor, and that each turret has two guns of about eighty tons each. Conceive these guns to be capable of firing, all four together, at an enemy ahead, astern, or on either beam, and in pairs toward every point of the compass. Attached to this rectangular armored castle, but completely submerged, every part being 6 to 7 feet under water, there is a hull of ordinary form with a powerful ram bow, with twin screws and a submerged rudder and helm. This compound structure is the fighting part of the ship. Sea-worthiness, speed, and shapeliness would indeed be wanting in such a structure if the same had no addition to it; there is, therefore, an unarmored structure lying above the submerged ship and connected with it, both before and aft the armored castle, and as this structure rises 20 feet out of water from stem to stern without depriving the guns of that command of the horizon already described, and as it moreover renders a flying deck unnecessary, it gets over the objections which have been raised against the low free-board and other features in the *Devastation*, *Thunderer*, and *Dreadnought*. These structures furnish also most luxurious accommodations for officers and seamen. The step in advance has therefore been from 14 inches of armor to 24 inches; from 35-ton guns to 85 tons; from two guns ahead to four guns ahead; and from a height of 10 feet for working the anchors to 20 feet. And this is done without an increase in cost, and with a reduction of nearly 3 feet in draught of water. Our belief is that in the *Inflexible* we have reached the extreme limit in the thickness of armor for sea-going vessels."

The length of the vessel between perpendiculars is 320 feet, and she has the extraordinary breadth of 75 feet at the water-line; depth of hold, 23 feet 3½ inches; free-board, 10 feet: mean draught of water, 24 feet 5 inches, (23 feet 5 inches forward, and 25 feet 5 inches aft); area of midship section, 1,658 square feet; and displacement when all the weights are on board, 11, 407 tons, being the largest of any man-of-war hitherto constructed. She is, as before described, a rectangular-armored castle; the whole of the other parts of the vessel which are unprotected by armor have been given their great dimensions for the simple purpose of floating and moving this invulnerable citadel and the turrets by which it is surmounted. Her immense bulk, unprecedented armament, powerful machinery, and the provision for ramming, and for resisting the impact of rams as well as of shot and shell, have made it necessary that strength and solidity should enter into every part of the structure.

HULL AND APPENDAGES.

While the cellular compartments of the double bottom have a little less depth than in the *Devastation* class, they are built up of heavier angle-irons and plating, and steel has been very largely employed for the purpose of securing great strength with comparative lightness of material. The hull is composed of flat and vertical keels, transverse and longitudinal frames, inner and outer bottom-plating. The vertical keel is formed of steel plates $\frac{3}{4}$-inch thick by 40 inches deep, and the flat keel-plates are of iron in two thicknesses of $\frac{13}{16}$ inch and $\frac{3}{4}$ inch the two being connected by angle-irons 5 by 5 inches by $\frac{3}{4}$ inch. On the upper edge of the vertical keel the angle-irons by which it is fastened to the inner bottom-plates are three inches by $3\frac{1}{2}$ by $\frac{1}{2}$ inch. The frame-work of the vessel below the armor is composed of longitudinal and transverse frames. The former, eight in number, are formed of steel plates $\frac{7}{16}$ inch in thickness, the shelf-plate being of iron $\frac{1}{2}$ inch thick. These frames extend as far forward and aft as is deemed practicable. Within the double bottom which extends through 212 feet of the ship's length, the transverse frames are solid, and are made water-tight at intervals of 20 feet. There are also intermediate bracket-frames placed 4 feet apart. Throughout the double bottom the transverse frames, which are likewise 4 feet apart, are of the thickness of $\frac{3}{8}$ inch, but are considerably lightened by having holes cut through them, the upper parts at the same time being much narrowed. Additional intermediate frames are worked in the engine-room in order to secure greater strength. The angle-irons forming the frames vary from $5\frac{1}{2}$ inches by 3 inches by $\frac{1}{2}$ inch to 3 inches by $3\frac{1}{2}$ by $\frac{1}{2}$ inch. The outer skin plating of the bottom varies from $\frac{15}{16}$ inches in the garboard strakes to $\frac{5}{4}$ inch, with the exception of the ends, where the thickness is increased to $\frac{7}{8}$ inch, and behind the anchors, where the plating is doubled. The plating of the inner bottom, which extends through the length of the double bottom, and which, like the outer bottom, is made perfectly water-tight, is of the uniform thickness of $\frac{3}{8}$ inch, except under the engines, where it is $\frac{7}{16}$ inch. As is usual in iron vessels, the stern of the *Inflexible* consists of a solid iron forging scarfed at its lower end to the keel-plates. The stern-post and after-pieces of keel, which are formed of the best angle-iron, were also made in a single forging. The rudder is a solid iron frame filled in with wood and covered with iron plates. In consequence of its immense weight—some 9 tons—it is made to work upon double pintles in combination with ordinary pintles and braces. It is moved by a tiller 4 feet 6 inches below the water. Indeed, the whole of the steam steering-gear will be placed below the water-line and armored deck, so that it will be impossible for the rudder-head to be injured by shot or shell during an engagement. To receive the propeller-shafts two iron tubes are constructed, one under each quarter. The fore parts of these tubes, where they leave the run of the ship, are supported by the frame-work of the hull, which is bossed out in a suitable form for the purpose, the after parts being supported by stouts from the ship's bottom.

There are four decks—the lower, middle, upper, and superstructure decks—the last being a middle-line erection placed forward and aft above the upper deck for working the ship, carrying and lowering the boats, etc. Outside the citadel the lower-deck beams are covered with iron 3 inches thick. This deck is depressed at the fore end so as to meet that part of the bow which is intended for ramming, thus conferring upon it greatly increased strength and resistance when engaged in butting an enemy's ship. It may be here stated that the ram of the *Inflexible* is of the spur kind, and though it is fixed at the present time, it will eventually be made to unship during ordinary cruises. The middle-deck flat consists of $\frac{1}{4}$-inch plating covered with 3-inch deal planks; while the upper-deck beams in the vicinity of the citadel are covered with 3-inch plating, and in other places with $\frac{1}{2}$-inch plating. The beams, pillars, and bulk-heads for supporting the various decks and platforms, and forming the different compartments and rooms, are arranged and fitted so as to give the greatest possible strength to the sides of the vessel. The largest beams are on the main deck. They are 14 inches deep, while those on the upper deck are 10 inches, and those on the lower deck are 12 inches deep. Every beam is either supported by wrought-iron tube-pillars or is trussed where pillars cannot be erected, the strongest being under the turrets. The two superstructures themselves in no wise add to the power of the ship, either for attack or defense. Their purpose in the economy of the ship is to afford accommodation for the officers and crew: and as the structures are erected on the upper deck, this will be of the best kind, with abundance of air and natural light. Their dimensions are: fore superstructure, extreme length, 104 feet 4 inches; breadth, 21 feet 4 inches; after superstructure, extreme length, 105 4 inches; breadth, 30 feet. The frames are formed of angle-iron, 7 inches by 3 inches, placed 4 feet apart, and between them are intermediate frames made of angle-iron about 4 inches by 3 inches. The ends are covered with $\frac{3}{8}$-inch plates, and the whole surface with 3-inch deals. The cabin-walls are all coated with Welch's wood-faced cement, as a protection against the results of atmospheric condensation. The officers and men together will number 350. As a protection against the casualties of war and the sea, the hull is divided by means of the transverse and longitudinal bulk-heads into no fewer than 135 water-tight compartments, and arrangements will be made for quickly removing therefrom any water that may collect within them through collision or other cause. Powerful steam-pumps, among which may be mentioned two of Friedman's patent ejectors, capable of discharging 300 tons of water each per hour, are fitted. All the bulk-heads are provided with water-tight doors of an improved pattern, sluice-valves, man-holes, and water-tight scuttles. Water-tight doors can also be fitted, when necessary, to the bulk-heads passing through the coal-bunkers. Each of the water-tight compartments has been tested by hydraulic pressure. Great attention has been bestowed upon the question of ventilation, which in ships of the *Devastation* class and, indeed, in all monitors of low free-board, has been a source of considerable discomfort and embarrassment. In the *Inflexible*, the fresh air is drawn into the midship part of the vessel through a series of downcast shafts, by means of eight powerful fans worked by four of Messrs. Brotherhood & Hardingham's patent three-cylinder engines. The air is then conducted into main pipes, which run around the sides of the hull to the extremities, and from these, subsidiary or branch pipes discharge the air in ample quantities to every part of the ship.

DEFENSE.

The protected portion of the ship is confined to the citadel or battery, within whose walls are inclosed the engines and boilers, the turrets, the hydraulic loading-gear, the magazines, and in fact all the vital parts of the vessel. It measures 110 feet in length, 75 feet in breadth, and is armored to the depth of 6 feet 5 inches below the water-line, and 9 feet 7 inches above it. The sides of the citadel consist of an outer thickness of 12-inch armor-plating, strengthened by vertical angle-iron guides 11 inches wide and 3 feet apart, the space between them being filled in with teak backing. Behind these girders, in the wake of the water-line, is another thickness of 12-inch armor, backed by horizontal girders 6 inches wide, and supported by a second thickness of teak backing. Inside this are two thicknesses of 1-inch plating, to which the horizontal girders are secured; the whole of the armor-backing and plating being supported by and bolted to transverse frames 2 feet apart, and composed of plates and angle-irons. It will thus be seen that the total thickness of armor at the water-line strake is not less than 24 inches. The armor-belt, however, is not of uniform strength throughout, but varies in accordance with the importance of the protection required, and the exposure to attack. Consequently, while the armor at the water-level is 24 inches in two thicknesses of 12 inches each, above the water-line it is 20 inches in two thicknesses of 12 inches and 8 inches, and below the water-line it is reduced to 16 inches in two thicknesses of 12 inches and 4 inches. The teak backing with which it is supported also varies inversely as the thickness of the armor, being, respectively, 17 inches, 21 inches, and 25 inches in thickness, and forming with the armor, with which it is associated, a uniform wall 41 inches thick. The depth of armor below the load water-line is 6 feet 5 inches, but as the vessel will be sunk a foot on going into action by letting water into its double bottom, the sides will thus have armor protection to the depth of 7 feet 5 inches below the fighting-line. The outside armor is fastened by bolts 4 inches in diameter, secured with nuts and elastic washers on the inside. The shelf-plate on which the armor rests is formed of ½-inch steel plates, with angle-iron on the outer edge 5 inches by 3½ inches by $\frac{9}{10}$ inch. The armor on the fore bulk-head of the citadel is exactly the same in every respect as that on the sides, but the armor of the rear bulk-head is somewhat thinner, being of the respective gradations of 22, 18, and 14 inches, and forming with the teak backing, which is 16, 20, and 24 inches, a uniform thickness of 38 inches. It may also be useful to mention that before and abaft the citadel the frames are formed of 7-inch and 4-inch angle-irons, covered with $\frac{9}{16}$-inch plates. The total weight of the armor, exclusive of deck, is 2,250 tons, and the total weight of armor, inclusive of deck, is 3,155 tons.

TURRETS.

The most singular feature in the design of the ship is the situation of the turrets. In the *Devastation* and *Thunderer*, and, in fact, all monitors afloat, the turrets are placed on the middle line, an arrangement which, though advantageous in some respects, possesses this signal disadvantage, that in double-turreted monitors only one-half of the guns can be brought to bear on the enemy either right ahead or directly astern. In the *Inflexible*, however, the turrets rise up on either side of the ship *en échelon* within the walls of the citadel, the forward turret being on the port side and the after turret on the starboard side, while the superstructures are built up along a fore-and-aft line of the deck. By these means the whole of the four guns can be discharged simultaneously at a ship right ahead or right astern, or on either beam, or in pairs toward any point of the compass. Besides these important advantages, the guns of each turret can be projected clear of the ship's side—in the case of the one turret to port, and in the case of the other turret to starboard. They can then be depressed enough not only to strike a vessel at close quarters, below the line of her armor, but even to fire down upon her deck, should the enemy be ranged alongside. The walls of the turrets, which last have an internal diameter of 28 feet and an external diameter of about 33 feet 10 inches, are formed of armor of a single thickness of 18 inches, (the thickest ever manufactured, with the exception of the 22-inch experimental plate which was rolled at Messrs. Cammel & Co.'s works, at Sheffield, for the turrets of the Italian frigates,) with backing of the same thickness, and an inner plating of 1 inch in two equal thicknesses. All experience has proved that, for many reasons, this arrangement is the best. The wood backing distributes the blow when struck, deadens the vibrations, protects the fastenings, and stops the splinters, while the inner iron is also of advantage, since it renders the backing more compact, and also assists in arresting the passage of *débris*. The height of the turret-ports from the load-line is 12 feet, and a foot less from the fighting-line, and all the plating in the wake of the guns is considerably strengthened.

OFFENSE.

A very special interest attaches to the armament of the *Inflexible*, not only because it consists of guns vastly more powerful than any yet mounted afloat, but because these guns are carried and worked on the new and remarkable hydraulic system which has hitherto only been tried in the fore turret of the *Thunderer*. Each turret weighs no less than 750 tons (including the guns), and having to deal with a moving mass of such enormous weight, and with the superadded difficulty of a floating, and therefore unstable, platform on which to revolve, it was determined to commence at this point with the adoption of the hydraulic system of Sir William Armstrong, as developed for gunnery purposes by his partner, Mr. George Rendel. The revolution of the turrets accordingly will be accomplished by hydraulic machinery, in a manner similar to that employed by the Elswick firm for turning swing-bridges and great cranes. In such cases the weights dealt with have already exceeded that of the turrets of the *Inflexible*; and so complete is the control afforded by hydraulic machinery in the movements of heavy masses in these analogous cases, that it is believed the turrets will, by this machinery, be rotated at any speed, from a complete revolution in one minute, down to a rate as slow and as uniform as desired. The advantage of the high speed is plain; that of the slow but regular rotation will be apparent, when it is remembered how much delicacy of adjustment is necessary for following with the aim an object moving rapidly and at a distance. Although the 81-ton guns will be worked on a system similar to that adopted in the case of the 38-ton guns of the *Thunderer*, yet as the design of the *Inflexible* had not been completed before the decision to work the guns by hydraulic power was formed, a much more complete hydraulic gunnery arrangement has become possible. The sponging and loading apparatus is still, as in the *Thunderer* to be placed at duplicate fixed stations outside the turrets, and under the protection of the armored deck of the vessel. The muzzles of the guns are brought to the loading mechanism by revolving the turret and slightly depressing the guns. But there is no special loading-port as in the *Thunderer*. All that is necessary is to depress the guns to the small angle required for bringing the muzzles below the level of the deck, which, still further to reduce this angle, is raised and inclined upward at the base of the turrets so as to form a sort of glacis, and to give cover to the muzzles without involving any considerable depression of the gun. By this means the objection brought against the greater depression of the guns of the *Thunderer* is avoided. A more important novelty is the manner of mounting the 81-ton guns in the turrets. Hitherto it has been the practice to place all heavy guns upon an iron structure, called the carriage, on which they rest by means of the trunnions. This carriage bears, besides the gun, the mechanism for elevating and depressing the gun, and for "tripping," and also in part the mechanism for checking recoil. Besides the carriage, again, there is the slide upon which the carriage runs. Now in the system adopted for the *Inflexible*, Mr. G. Rendel has taken the bold step of dispensing altogether with a carriage, properly so called.

Two guns will be mounted side by side in each turret. Each gun will be mounted so as to be supported on three points. The trunnions will rest on blocks sliding on fixed beams bolted down to the floor of the turret, while the breech will rest on a third block, sliding like the others between guides upon a beam or table. Behind each of the trunnion-blocks, in the line of recoil, are two hydraulic cylinders, connected with them by piston-rods. The cylinders communicate by a pipe, on which there is a valve, which, on the recoil of the gun, opens and allows the pistons to run back slowly, checking the recoil. By reversing the apparatus, the gun can be run out again. The beam on which the breech rests is supported by a third hydraulic cylinder, fixed vertically beneath it in the turret. By this means, the breech can be easily raised or lowered, thus elevating or depressing the muzzle of the gun, which pivots on its trunnions with a large preponderance toward the breech. In order to load, the muzzle is depressed until it comes opposite to an opening made in the upper deck before the turret. A hydraulic rammer works in guides through this hole, and the rammer-head is hollow, and is so constructed that when it is driven into the recently-fired gun, and comes in contact with the sides of the powder-chamber, a valve opens, and it discharges through a number of holes small jets of water, thus acting as a sponge, and extinguishing any remnants of the charge or of the products of the explosion which may have remained smoldering in the bore. It is then withdrawn, and a hydraulic shot-lift raises up to the muzzle of the gun the charge, the projectile, and a retaining wad, and then a single stroke of the rammer drives them into the gun and home to the base of the bore. Again the rammer is withdrawn, the hydraulic piston under the breech of the gun elevates the muzzle, the turret swings around, and the shot is fired. A 9-inch gun, mounted experimentally in a turret at Elswick, and loaded on this system, was brought to the loading position, sponged, loaded, and brought back to the firing point in forty seconds. Comparatively equally rapid loading was effected with the 38-ton gun during the experimental trial of the hydraulic gear on board the *Thunderer*. Thus, the first advantage of the system is rapidity of fire; the second is economy of labor. One man only for each gun is stationed in the turret, another works the hydraulic rammer on the main deck, six or eight others are employed in bringing up the ammunition to the shot-lift by means of a small tram-way. There are two sets of loading-gear for each turret; but even if both were put out of order, the gun could still be loaded with an ordinary rammer and sponge by a number of men stationed on the main deck. The adoption of the system enables very heavy guns to be carried in comparatively small turrets. Those of the *Inflexible* are very little larger than those of the *Devastation*, so that with the old plan of having a numerous crew in the turret and running in the gun in order to load it by hand, only the 38-ton gun could be carried. As it is quite possible that the *Inflexible* will be armed with even more tremendous weapons than the 81-ton guns, this has been held in view in designing the ship; and, by a slight modification, it will be possible to mount in each of her turrets a pair of 160-ton guns, with a length of 30 feet and a caliber of 20 inches. The armament of the *Inflexible* will be composed of four of the heaviest guns (except those making for the Italian vessels) ever constructed, of which the experimental 81-ton gun completed at Woolwich, and tested, is the type. The tube, which forms the core of the gun, is bored out of a solid ingot, which cost £1,700. The bore is 24 feet long, and rifled from the muzzle to within a short distance of the base of the tube, where the unrifled portion forms the powder-chamber. The greatest external diameter of the gun is 6 feet, and at the muzzle it is 2 feet in diameter. The full caliber of the piece is 16 inches. The experimental gun was first bored out to 14½ inches and tested; for a second series of experiments it was given a caliber of 15 inches, and then bored to the full caliber of 16 inches and finally tested.

The gun is rifled with 13 grooves, each having an increasing pitch from 0 to 1 in 35 calibers. The service powder-charge is 370 pounds of 1.5 inch powder. The weight of the projectile for the service-shell is 1,700 pounds, and the bursting charge about 100 pounds of powder. The details of the series of proof-trials at Woolwich, also the tests at Shoebury-

Number of rounds.	Size of powder.	Weight of charge.	Weight of projectile.	Muzzle velocity per minute.	Mean pressure in gun.	Total energy developed.
	Cubic inches.	*Pounds.*	*Pounds.*	*Feet.*	*Tons per square inch.*	*Foot-tons.*
1	1.5	310	1,700	1,486	20.1	26,030
2	1.5	350	1,700	1,505	20.4	26,740
3	1.5	350	1,700	1,502	20.3	26,630
4	1.5	350	1,700	1,467	19.6	25,406
5	1.5	350	1,700	1,475	18.4	25,683
6	1.5	350	1,700	1,493	21.	26,314
7	1.5	360	1,700	1,487	18.8	26,103
8	1.5	370	1,700	1,495	19.9	26,385
9	1.5	350	1,700	1,518	20.5	27,203
10	1.5	370	1,700	1,523	20.3	27,383
11	1.5	360	1,700	1,519	21.3	27,239
12	1.5	360	1,700	1,518	20.0	27,203
13	1.5	370	1,700	1,519	19.8	27,239
14	1.5	370	1,700	1,517	20.7	27,168

ness, have been widely published. Still, for reference, it is believed advisable to give here the results of the trials last made with the caliber of 16 inches, that at which the gun is to be used in actual warfare. (See table on preceding page.)

The experiments for range and accuracy were conducted at Shoeburyness, and are reported to have met the unqualified approval of the authorities. When the last experiments were concluded, viz. October 4, 1876, the 81-ton gun had fired 140 rounds, and it may be interesting to summarize the amount of ammunition that has been thus expended. With its normal caliber of 14.5 inches it fired 4,660 pounds of powder and 27,052 pounds of iron in 21 rounds. With a caliber of 15 inches it fired in 32 rounds 8,223, pounds of powder and 45,712 pounds of iron. With the same caliber, but with a powder-chamber of 16 inches, in 21 rounds it disposed of 6,020 pounds of powder and 30,810 pounds of shot. With its present uniform bore of 16 inches, and while at Woolwich, it fired 8,870 pounds of powder and 149,-981 pounds of iron in 27 rounds. This gives 27,773 pounds of powder and 149,555 pounds of iron expended at Woolwich in 101 rounds. At Shoeburyness the gun has fired 39 rounds with 14,430 pounds of powder and 66,301 pounds of iron. This gives a total number of 140 rounds, 42,203 pounds of powder, and 215,855 pounds of iron. Some idea of the amount of ammunition required for the 81-ton gun may be formed when it is estimated that in an action, if the *Inflexible* would fire only ten shots from each of the four guns, she would use up 14,800 pounds of pebble-powder, and hurl upward of 30 tons of projectiles, at a cost of about $6,320. The cost of the gun, exclusive of carriage and the machinery for working it, was estimated at £15,000, and the factory-plant and experimental trials at £10,000. The actual cost of each of the eight guns will be best known when all are manufactured.

MOTIVE MACHINERY.

The machinery was constructed by Messrs. John Elder and Co., of Glasgow. Each screw is driven by an idependent set of compound engines with three vertical inverted cylinders of the collective power of 4,000 horses, giving an aggregate power of 8,000 horses (indicated) for both sets of engines. The diameter of the high-pressure cylinder is 70 inches, and the diameter of each low-pressure cylinder is 90 inches; the former is placed between the two latter. They are steam-jacketed and are connected together by stay-bolts continued to bulkheads, so as to serve as ramming-chocks. The pistons have a stroke of 4 feet, and the number of revolutions expected is 65 per minute. The piston-rods are double, and are connected by crank cross-heads. They are each 7 inches in diameter, the connecting-rods having a diameter of 9 inches and a length of 7 feet 6 inches. The valves are of the piston kind. They are worked by link-motions and levers, and are reversed by an ingenious combination of steam and hydraulic power. The engines at starting are assisted by auxiliary steam-gear, the valves of which are fitted to the receiver. The steam from the low-pressure cylinders is exhausted into independent surface-condensers, having a total cooling surface of 16,000 square feet. The steam is condensed in the interior of a series of tubes of ¾-inch external diameter, of which each condenser has no less than 6,650. The condensers are constructed to be worked as common condensers. The circulating-pumps are actuated by separate engines, each having its own feed, bilge, and air-pumps, worked by levers from the cross-heads. The air-pumps are made of gun-metal, with a diameter of 34 inches and stroke of 2 feet 3 inches, the water being discharged below the armor-deck. With respect to the centrifugal pumps, it may be mentioned that they are judiciously placed at so high a level in the vessel that in the case of leakage occurring, by which the ship's bottom may be flooded to as great a depth as twelve feet, they can be worked with perfect freedom. There are also double-acting hand-pumps, each two coupled; feed donkey-engines, each with a double-acting pump 4 inches in diameter; bilge donkeys, each with the double-acting pumps, six inches in diameter, and fire-engines, with the double-acting pumps 8½ inches in diameter. It may be mentioned that the engines which work the circulating pumps are also made to pump out the bilge, in the event of the ship springing a leak or sustaining damage from being rammed; that the centrifugal pumps are to be sufficiently powerful to perform the same work in case of emergency; and that a Kingston valve is fitted through the bottom in connection with each fire-pump.

Each cylinder is fitted with an expansion valve, having a variable cut-off, with an extreme range of from one-sixth to one-half stroke. These valves are cylindrical gridiron valves, of phosphor bronze, 3 feet in diameter, working on cast-iron gridiron seats, and giving a minimum of clearance between the expansion-valve and main-slide. They are worked by an eccentric on the crank-shaft and a slotted lever, and are all connected to a shaft in front of the engines, so that they may be thrown out by a single handle. Each engine is also fitted with a common injection apparatus. The crank-shaft is formed of three pieces, the diameter of the bearings being 17½ inches. The propellers will be about 20 feet in diameter, and will be worked outwards, the thrust being at the after end. The shaft tubes are of wrought-iron, supported by struts, while the shafting will be made of Whitworth fluid-compressed steel, with solid couplings. It will be hollow, the inner diameter being 10 inches and the outer 16 inches. The faces of the high-pressure cylinders are formed of phosphor-bronze 2 inches thick; the liners of the cylinders are also constructed of the Whitworth compressed steel, which possesses properties rendering it not only extremely light but at the same time much more trustworthy than the ordinary metal used for this and shafting purposes. Each engine is fitted with a governor, to prevent racing in stormy weather; and in addition to the hand-gear, small auxiliary engines are erected for turning the main engines.

BOILERS.

The steam is furnished by twelve boilers, eight single-ended and four double-ended. They are constructed of the best Lowmoore plates, tested to 21 tons lengthwise and 18 tons crosswise, and the pressure of steam to 60 pounds per square inch. The four double ended-boilers are 17 feet long, 9 feet 3 inches wide, and 14 feet 3 inches high, with four furnaces in each. Four of the single-ended boilers are 9 feet long, 13 feet 7 inches wide, and 15 feet 6 inches high, with three furnaces each, and the four remaining single-ended boilers are 9 feet long, 11 feet wide, and 13 feet 4 inches high, with two furnaces, each having a separate fire-box. All the boilers are clothed with four thicknesses of boiler-felt, and covered with galvanized sheet-iron, and are stayed to prevent their moving by concussion when the ship is engaged in ramming. They are supplied with water by four feed-pumps, which are attached to each engine, the pumps being 7½ inches in diameter, and having a stroke of 2 feet 3 inches. In the event of the feed-pumps receiving injury, the boilers are provided with four small auxiliary engines, (one in each boiler-room,) and having separate connections with the boilers. The two auxiliary engines which are used for washing the decks are also arranged to work the fire-engines in the engine-room. The safety-valves are fitted with springs upon an improved plan. The smoke-pipes, of which there are two, are 65 feet high from the dead-plate of the lower furnaces. The bunkers, which are placed at the water-line along the unarmored sides of the ship, where the entrance of shot or water cannot injure them, are built to store 1,200 tons of coal, and are so disposed that their contents can be approached from the upper and lower compartments independently of each other.

RIG.

The *Inflexible* also possesses sail-power, with respect to the advantages of which,however,considerable diversity of opinion exists. She is brig-rigged, having two iron masts,but no bowsprit or stay gear. The fore-mast is 36 inches in diameter,and measures 83 feet 6 inches from the deck to the head,while the main-mast has a diameter of 37 inches, and a height of 96 feet. Each has a top-mast and top-gallant mast, with lower yard, top-sail yard, and top-gallant yard. The total size of sails 18,470 square feet. In time of war it is ordered that the ship will carry no masts, except for signal purposes. The anchors, of which there are four, are of Martin's self-canting pattern. The estimated weight of the hull is 7,300 tons. The engines weigh 614 tons. The propellers, shafts,and stern-fittings weigh 151 tons each; the boilers,smoke-pipes,casings,&c.,522 tons,and the water in the boilers when ready for steaming is estimated at 190 tons.

COST.

The cost is estimated as follows:

Materials	£269,000
Engines and appendages	100,150
Boilers	20,606
Labor	132,000

As a new type of a man-of-war, all the leading features of the *Inflexible* may be summed up as follows: The armor is confined to the central fighting portion and to the main substructure which floats the ship. An armored deck 7 feet under water divides the vessel into two separate portions. The unarmored ends are so constructed that the vessel will float even when they are penetrated by shot. The ship has a wide beam and a comparatively light draught of water. The deck-houses give a high bow and stern,and the turrets are so arranged as to enable all four guns to be fired both ahead and astern,or on either beam.

The *Inflexible* has been accepted as the type of the British future line-of-battle ships,and the Admiralty have determined on building others, two of which are already under process of construction, viz. the *Agamemnon* at Chatham,and the *Ajax* at Pembroke. These sister vessels are to be of reduced dimensions.

They will be 280 feet long, 66 feet wide, and will have a displacement of 8,500 tons, with a mean draught of water of 25 feet. They are to carry armor 18 inches thick,and an armament of two 38-ton guns in each of the two turrets. The indicated horse-power is to be 6,000.

In perusing the foregoing description of the *Inflexible* it has been seen that her double bottom is divided and subdivided into an unusual number of spaces, and that the water-tight bulkheads have been introduced to an extent not before attempted, and in fact almost every conceivable precaution has been taken to make her secure against the ram and the torpedo. If, however, she should be fairly struck by several powerful fish-torpedoes, it is quite probable she would be crippled ,water-logged, or even sunk. The question therefore presented is, whether two vessels of smaller dimensions,each carrying two 81-ton guns instead of four, would not have been the safer, and in some respects a better investment.

WAR-SONG.—A song exciting to war, especially among the American Indians,a song at the war-dance, full of incitements to military ardor.

WAR-TRAITOR. A traitor under the law of War, or a War-traitor,is a person in a place or district under martial law who, unauthorized by the military Commander,gives information of any kind to the enemy or holds intercourse with him. The war-traitor is always severely punished. If his offence consists in betraying to the enemy anything concerning the condition,safety,operations or plans of the troops holding or occupying the place or district,his punishment is death.

If the citizen or subject of a country or place invaded or conquered gives information of his own government, from which he is separated by the hostile army, or to the army of his government, he is a war-traitor, and death is the penalty of his offense. All armies in the field stand in need of guides, and impress them if they cannot obtain them otherwise. No person having been forced by the enemy to serve as guide is punishable for having done so. If a citizen of a hostile and invaded district voluntarily serves as a guide to the enemy,or offers to do so, he is deemed a war-traitor, and shall suffer death. A citizen serving voluntarily as a guide against his own country commits treason,and will be dealt with according to the law of his country. Guides when it is clearly proved that they have misled intentionally, may be put to death.

All unauthorized or secret communication with the enemy, is considered treasonable by the law of war. Foreign residents in an invaded or occupied territory, or foreign visitors in the same,can claim no immunity from this law. They may communicate with foreign parts,or with the inhabitants of the hostile country, so far as the military authority permits, but no further. Instant expulsion from the occupied territory would be the very least punishment for the infraction of this rule.

A messenger carrying written despatches or verbal messages from one portion of the army, or from a besieged place, to another portion of the same army, or its government, if armed, and in the uniform of his army, and if captured while doing so, in the territory occupied by the enemy, is treated by the captor as a prisoner of war. If not in uniform, nor a soldier, the circumstances connected with his capture must determine the disposition that shall be made of him. A messenger or agent who attempts to steal through the territory occupied by the enemy, to further, in any manner, the interests of the enemy, if captured, is not entitled to the privileges of the prisoner of war, and may be dealt with according to the circumstances of the case.

While deception in war is admitted as a just and necessary means of hostility, and is consistent with honorable warfare, the common law of war allows even capital punishment for clandestine or treacherous attempts to injure an enemy, because they are so dangerous, and it is so difficult to guard against them. The law of war, like the criminal law regarding other offenses, makes no difference on account of the difference of sexes, concerning the spy, the war-traitor, or the war-rebel.

Spies, war-traitors, and war-rebels are not exchanged according to the common law of war. The change of such persons would require a special cartel, authorized by the government, or,at a great distance from it, by the Chief Commander of the army in the field. A successful spy or war-traitor safely returned to his own army, and afterwards captured as an enemy, is not subject to punishment for his acts as a spy or a war-traitor, but he may be held in closer custody as a person individually dangerous. See *Traitor*.

WAR WHOOP. The cry or shout uttered by Indians in war. Any murder is not considered satisfactory, by any means,unless the perpetrator is enabled to sound the *war-whoop* and *scalp* his victim. The war-whoop — a shrill piercing note on the highest key of the voice, with a rapid vibration, made by striking the hand or the fingers against the lips — is sounded just as the final dash is made or as the weapon is raised for the deed. Scalping is accomplished by grasping the hair above the top of the head, raising it with the skin to which it is attached, and quickly cutting the latter loose. Scalping *alone* is not fatal.

WARWOLF.—In ancient military history, an engine for throwing stones and other great masses.

WATCH.—The Non-commissioned Officers and men on board transports are usually divided into three watches, one of which must be constantly on deck.

WATCH AND WARD.—The charge or care of certain officers to keep a watch by night and a guard by day in towns, cities and other districts, for the preservation of the public peace.

WATCH TOWER. A tower on which a sentinel is placed to watch for enemies or the approach of danger.

WATCH WORD.—The word given to the sentinels and to such as have occasion to visit the guards. It is used as a signal, by which a friend is known from an enemy, or a person who has a right to pass the watch from one who has not. See *Countersign* and *Parole*.

WATER. Water is one of the primary wants of human life, no less essential than air and food; hence the strong and religious interest that has always been attached to the means of its supply. In the earliest records of civilization, we read of the digging of wells, and of quarrels about the possession of them. The "pools of Solomon," near Bethlehem, which remain now almost as perfect as when they were built, were connected with a scheme for supplying Jerusalem with water In Assyria and Persia, from the earliest times, water has been conveyed to towns from astonishing distances in open channels or canals, and in subterranean tunnels, or *kanats*. In Egypt also, and in China gigantic works for conveying water, both for domestic use and for irrigation, have been in existence from remote antiquity. Nor were these undertakings confined to the eastern hemisphere; we have evidence of the existence of kindred works in pre-Christian America. The ancient city of Mexico, which was built on several islands near the shore of the lake, was connected with the mainland by four great causeways or dikes, the remains of which still exist. One of these supported the wooden aqueduct of Chapolquepec, which was constructed by Montezuma and destroyed by the Spaniards when they besieged the city. Hydraulic works on a great scale had also been executed by the Uncas of Peru. Of all the ancient nations, the Romans paid the greatest attention to the supply of water, and carried the costruction of *aqueducts* to the greatest perfection and magnificence. If we accept the supply of New York from the Croton river, and that of Glasgow from loch Katrine, the efforts to supply modern cities are as yet insignificant compared with those of the Romans.

Rain-water, as it is formed in the upper regions of the atmosphere, is the purest that nature supplies but in descending, it brings with it whatever impurities are floating near the surface, which in the neighborhood of towns, are numerous, consisting of various gases, together with soot and other floating particles, organic and inorganic. Rain water has a strong affinity for organic impurities—that is, the corrupting ingredients derived from vegetable and animal bodies, and which are diffused over every surface in the vicinity of living beings; hence, when collected from the roofs of houses, it has a tendency to rapid putrefaction. Being free from saline ingredients, it is excellent for washing, but is not generally pleasant to drink. But if we resort to a barren district of rock, destitute of vegetation, ana remote from the pollution of towns, we may obtain water with comparatively little organic impurity. Notwithstanding several defects, it happens in various places that a surface-supply is the best that can be had.

The water obtained from running streams is in part what has flowed immediately from the surface, and in part the water of springs, shallow or deep. In any case, a considerable amount of contact with the ground has taken place, and in consequence saline or organic matter is liable to be dissolved in a greater or less degree. .The extent of the impregnation, as well as the kind of material dissolved, will depend on the rocks and strata of the river-basin. River-waters, besides the qualities they derive from their primative sources, are apt to contain mud, decayed leaves, the exuviæ of fish, and other matters in suspension, and are thus deficient in the clearness and transparency so essential to the satisfaction of the eye in a drinking-water. Moreover, the water partakes of the extremes of summer and winter temperature. But the great objection to water from rivers is their general pollution from the manure used upon the land, sewage, and manufactures, so that there are now few rivers left from whose lower course a supply could be taken for domestic purposes. On the other hand, the supply from one of our large rivers is boundless and unfailing; and it conveys the surface-drainage and spring effusions of a large tract of country, without incurring any trouble or expenses as to the original sources. Rivers that issue from lakes are generally the purest, as the suspended matter has time to be precipitated.

The qualities that recommend water to the eye and to the palate belong in a pre-eminent degree to spring-water. It is clear, sparkling, and of an agreeable and uniform temperature at all seasons of the year (about 50° Fahr.); it is well aerated, and is totally free from the offensive taint so common in all other waters, as well as devoid of the animalcules generated by organic impurity; and where a sufficient number of springs can be collected to suffice for a town, it is the most desirable of all sources of supply. About a quarter of the water brought to Edinburg is spring-water collected on the slopes of the Pentlands.

The quality of hardness in water is very commonly recognized by the difficulty experienced in washing, and by the amount of soap necessary to form a lather. This quality is injurious also in the preparation of food; but its action is most universally felt in washing operations. It occasions the chapping of the skin, an enormous waste of soap, and extra labor, and a corresponding wear and tear of clothes. Every grain of chalk contained in water decomposes 10 grains of soap; and thus the hardening matter contained in 10C gallons of water, such as is supplied to London, will destroy 35 oz. of soap- that is, the first 35 oz. of soap added to this quantity of the water will disappear without forming any lather, or having any cleansing effect. Soap is a compound, formed of an alkali (soda or potash) joined to an oily acid. When a salt of lime, then, is present in the water, the lime decomposes the soap and forms a lime-soap, which is insoluble, and has no detergent properties.

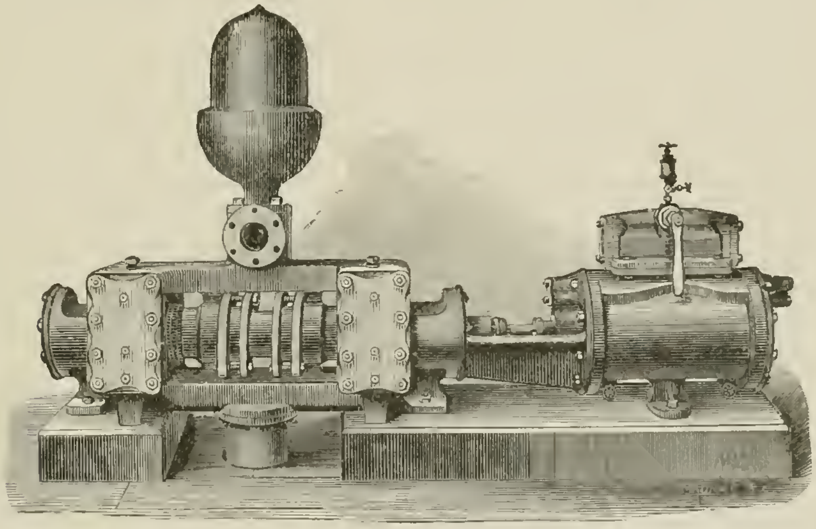
Next to washing, the deleterious consequences of hardness are felt in various culinary operations, especially in the furring of boilers and cooking utensils, and in the infusion of tea. It is a fact of universal experience that hard water requires more tea than soft water to make an infusion of the same strength, and also renders the infusion muddy. Subcarbonate of soda in crystals, by decomposing the earthy salts, improves the water; but if more is added than that which will exactly decompose the earthy salts present, it injures the fine flavor of the tea. It may be stated generally, that for the purposes of washing and cooking, a water of less than 6° is soft, but above this point the hardness becomes objectionable. At 8°, the water is moderately hard; at 12°, it is very hard; at 16°, the hardness is excessive; and much above this, it is intolerable.

The contamination of water by vegetable and animal substances takes place in various ways. The most obvious and abundant source of this class of ingredients is the sewage and refuse of towns; and next in order may be ranked the contact with soils rich in organic matter. Among organic impurities may be classed offensive gases, such as carbureted, sulphureted, and phosphureted hydrogen; vegetable fibers in a state of rottenness; putrefying products of the vegetable or animal kingdoms, starch, muscular fiber etc., urea and ammoniacal products; vegetable forms—algæ, confervæ, fungi, etc.; animalcules—infusoria, entomostraceæ, annelidœ or worms, etc. Water falling on a growing soil, and running off the surface to lie in stagnant ponds, is in very favorable circumstances for being tainted with vegetable and animal life. Water-plants will spring up and feed numerous tribes of animalcules, and each pool will be a constant scene of vitality. In such a state the water is usually unfit for drinking; the palate instantly discerns a disagreeable taint, and no one will use it who can do better. The surface water of a district overgrown with peat-moss has usually a peaty flavor, as well as a dark and dirty color. The infusion of peat does not breed animalcules, being a strong antiseptic; but it is an objectionable ingredient nevertheless. Very slow filtration has been found to remove the color of the infusion in some degree, but not entirely. Lime removes the peat most effectually, but there is both expense and risk in applying it. It is perhaps doubtful whether any specific unwholesomeness can be justly attributed to peat-water; but it is unpalatable, and the use of it is shunned by the inhabitants of peaty districts, and even by cattle.

The mechanical impurities of water, or the solid particles rendering it muddy or milky, may in most cases be removed by mechanical means. The two processes for this purpose are *subsidence* and *filtration*. The effects of subsidence are strikingly seen in the case of rivers that pass through lakes. The subsidence of solid particles depends on their own weight, as compared with the weight of an equal bulk of water. To favor the process, the most perfect stillness should be allowed. It is expedient to have partitions placed in the subsiding reservoirs at short intervals, more effectually to prevent the agitation of the water. The water should be run off from the top and not from the bottom. By making the bottom of the subsiding reservoir form a declivity from opposite sides, and providing means to let off the water occasionally from its lowest depth, it is possible to get quit of the subsided mud. It is always found of advantage in clearing water from solid particles, whether by subsidence or by filtration, to mix together streams of different qualities.

In constructing an artificial filter on a large scale, a basin is formed, having the floor nearly level, but slightly inclining toward a center line, and made water-tight by puddling the bottom and sides with clay. On the floor is laid a series of layers of gravel, coarse at first and getting gradually finer upward; next, a layer of slate-chips or seashells, then one of coarse sand, on which is placed the actual filtering layer of fine sand. The depth of this layer is from twelve to thirty inches, that of the entire mass from four to six feet. The water being admitted gently on the top of the sand, sinks down and is conducted by a series of channels, generally of tile-pipes, into the main drain. A filter in a clear state will pass from twelve to eighteen vertical feet of water in twenty-four hours. The solid matter intercepted does not penetrate more than three-fourths of an inch into the sand, so that, by removing a very thin film from the surface, the filter is again clean. What is scraped off the top is capable of being washed and put again to use. "This process of filtration," says Prof. Clark, "is efficacious in removing mechanical impurities to an extent that could scarcely be believed without seeing the process."

The cleansing power of sand can hardly be accounted for on the theory of mere mechanical interception. Though there is no chemical action, strictly speaking, there is no doubt that the attraction of adhesion is at work—a power that plays a greater part in natural processes than has generally been assigned to it. Some substances manifest this adhesive attraction more strongly than sand, and have therefore still greater efficacy as filters; though practically and on the large scale, sand is the most eligible. Powdered charcoal has long been known as a powerful filtering medium, attracting and detaining especially organic matter. Animal charcoal, or that derived from burning bones, is still more efficacious than wood charcoal. A filter of animal charcoal will render London porter almost colorless. According to recent researches, it would seem that loam and clay have similar properties, and may be made available as filters. Professor Way states that "they have powers of chemical action for the removal of organic and inorganic matters from water to an extent never before suspected." The filthiest liquids, such as putrid urine and sewer-water, when passed through clay, dropped from the filter colorless and inoffensive. The clay used was that known as pipe clay.



Although, by means of sand and other filters, or of the liming process, organic contamination of water may be much reduced, there still remains enough to render the water unsafe for use. Is water, then, once corrupted with organic matter, hopelessly and permanently so? This question can be answered in the negative. Filthy water has a tendency to purify itself, and this in two ways. In the first place, in any shallow stream of polluted water, such as the kennels of a street, there may be observed long brushes of a sort of slimy vegetation adhering to every projection of the bottom. All this matter has been disengaged from the water, which thus flows away so much the purer. The second and most effective part of the natural purification consists in the actual decomposition of the impurities. The nitrogen of the decaying matter then goes to form nitric acid, which, uniting with bases, forms salts of the class called *nitrates*, of which saltpeter is one. Thus, what was in a state of putrefactive change, offensive to the senses, breeding loathsome insects, and causing dangerous disorders, is changed in course of time into a stable and harmless product. This process is constantly going on in rivers and other waters containing organic matter. In the case of streams passing through populous districts, the contamination goes on at a rate far beyond the power of natural purification; but we can easily conceive how a river, very much contaminated with organic impurities at one part of its source, may after flowing a long way through an uninhabited tract, be almost restored to its natural state. The process is one of oxidation, and takes place at the expense of the free oxygen, of which, in healthy,normal water, there ought to be 29 per cent. of the entire volume of gases held in solution. The oxidation is much favored and hastened when the water percolates or filters very slowly through porous beds of earth. If the filtration has been sufficiently prolonged to convert all the decaying matter into carbonic acid or nitrates, the water will be pure, as far as the organic taint and the presence of animalcules are concerned,and will, in fact, be neither disagreeable nor unwholesome, the amount of the dissolved carbonates or nitrates being unimportant.

Into the engineering operations connected with the conveyance of water from its source to the town or garrison to be supplied, we need not enter, beyond noticing that when the source is below the level of the houses, steam or other power is necessary to lift or propel the water to the necessary height; while in the more general and more desirable cases of the source being higher than the place where the supply is to be delivered, the water is made to flow by its own gravitation, either in a channel or culvert with a continuous descent, as in the ancient aqueduct, or in the simpler and more economical modern plan of a line of cast-iron pipes following the inequalities of the surface. In many cases, both principles are employed, the water flowing for the most part in a gently-sloping conduit, tunneled through hills where necessary, and being carried through valleys in tubes descending and ascending—an inverted siphon, as it is called. The Croton aqueduct, which supplies New York, is carried across the Manhattan valley, upward of 100 feet deep, in this way. The Glasgow supply from loch Katrine flows mainly in a sloping channel carried through tunnels and over bridges; but there are four miles of iron pipings across valleys. The drawing shows the Cameron double-plunger steam-pump, which, from its extreme simplicity, strength, and durability, is eminently adapted for supplying garrisons, and for mining and other important engineering operations where it is desirable to pump large quantities of water. The pump is designed with large water passages and valve areas, so as to reduce water friction to a minimum.

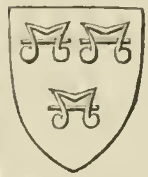
The extent of the storage in reservoirs depends on the nature of the supply. If water is derived from perennial springs, whose minimum flows equal the maximum demand,the storage may be the least possible. If a river is the scource,the reservoirs should be large enough to hold such a stock as will carry the consumers over the periods when the river is polluted by rains; they should also be large, on the principle of allowing time for purification by subsidence, especially if artificial filtration be not employed. In places where the supply is obtained from surface drainage, or from a small stream, the practice is to build reservoirs capable of containing a five or six months' supply,it being necessary to provide against the greatest droughts that ever happen in any season. The reservoirs should be deep,so as to prevent vegetation, and all the distributing or service reservoirs should be roofed. See *Hydraulic Power*.

WATER BARRELS.—Barrels used for the conveyance of water in camps or cantonments where carts are not at hand.

WATER-BATTERY.—A battery nearly on a level with the water.

WATER-BUCKET.—These buckets, for forge and battery-wagons, all have bottoms and staves of oak, hooped with three iron hoops, riveted at the ends and to the buckets. The ears are let into the sides, and secured each with a rivet. The ends of the bail are bent and hooked into the ears, and at the top it is connected by a swivel to a single link. A much lighter and quite as durable a *water-bucket* is made of leather, the seams sewed and riveted together, and the whole painted. For garrison service, the bucket is made in a similar manner, but the handle has no link and swivel attached to it.

WATER BUDGET.—A heraldic bearing in the form of a yoke with two pouches of leather appended to it, originally intended to represent the bags used by the Crusaders to convey water across the desert, which were slung on a pole, and carried across the shoulders. The Trusbuts, Barons of Wartre in Holderness, bore *Trois boutz d'eau*, three water-budgets, symbolizing at once their family name and baronial estate; and by the marriage of the heiress, similar arms came to be assumed by the family of De Ros, who bear gules, three water-budgets argent.



Water-budget.

WATER-CALL.—A trumpet sounding, on which the Cavalry assemble to water their horses. See *Watering Horses*.

WATER-CAP.—An important element of the time-fuse, made of copper and cylindrical in shape. The upper end has a recess .11 inch deep, in which there are three holes, one going half-way through the cap and connecting with the side-holes; the other two are made to hold a small piece of quick-match. There are two holes in the sides of the cap opposite to each other and connected by a small channel; and one hole leading from the bottom of the cap to those through the sides, but to the one opposite to that to which the hole from the top leads. Thus the water-cap is perforated with a channel, which is filled with mealed powder. This communicates fire to the composition in the paper case, and the angles of the channel prevent the entrance of any matter, such as sand or water, over which the shell may ricochet. The recess on the top has two small pieces of quick-match, each secured in its own hole, and a small quantity of powder poured into the recess and pressed down, so that the outer surface is primed with mealed powder and strands of quick-match, which are ignited by the scorching flame that rushes over the projectile upon the firing of the charge in the gun. See *Fuse-plug*.

WATER-DECK.—A covering of painted canvas for the saddle, bridle, and the like, of a dragoon's horse.

WATERING BRIDLE.—A bridle employed in the military service, having a snaffle-bit. To put on the watering-bridle, take the two reins in the right hand, the bit in the left, approach the horse on the near side, slip the reins over the horse's head and let them rest on his neck; reach under and put the toggle of the bridle through the right halter-ring, insert the left thumb into the side of the horse's mouth above the tushes, and press open the lower jaw; insert the bit and pass the toggle through the left halter-ring. The bit should hang so as to touch, but not draw up, the corners of the mouth. The hitching-strap is passed around the horse's neck and tied securely, or is unbuckled and left at the manger or picket-line. The horse is unbridled by passing the reins over his head and taking the toggles out of the halter-rings. See *Bridle*.

WATERING BUCKET.—A bucket formed of sole-leather and used for watering the horses.

WATERING HORSES.—Horses must be watered quietly and without confusion; the manner in which this duty is performed is a good test of the discipline of a mounted command. Horses are to be led or ridden at a walk, to and from water, depending upon its distance from the stable. At the drinking-place, no horse should be hurried, or have his head jerked up from the water, until he has done drinking. In the field, or on the march, the watering is from the most convenient running water; in garrison it is usually from troughs. In warm weather, water drawn from a cold well or spring, before being used, should stand long enough for the chill to pass off. The horses are watered under the immediate direction of the first-sergeant, but, if they are liable to meet those of other commands at the watering-place, a Commissioned Officer should replace him. During the hot months, horses are watered thrice daily; in the morning, at noon, and just before grooming in the afternoon. At other times, two waterings are enough: after morning and at evening stable-duty. In very cold weather, once a day, at noon, is sufficient. It is to be always remembered that a horse will rarely drink enough very early in the morning. The daily allowance of water for a horse is four gallons. On the march horses are watered with buckets carried on the carriages; the oftener this is done the better, as it is not usually known when another watering-place will be reached. On the plains, where horses are to make a day's march without water, they will always be watered after being fed, just before leaving camp in the morning. If a mounted command has to march a long distance without water, so that it will be necessary to encamp *en route*, the animals are well fed but denied water until just before starting, when they are permitted to drink freely. The command marches in the afternoon, and does not encamp until it has accomplished at least half of the distance, and moves early the next morning to reach water.

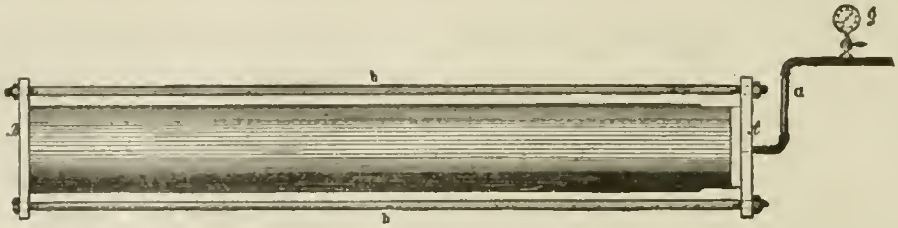
WARTERING-PLACE.—Any place selected in a camp from which the supply of water is obtained either for drinking, cooking, washing, or for bathing purposes. Great care should be exercised, when the supply is obtained from running streams, that the water for the washing supply does not run into the water for drinking. The points where water for drinking and cooking is drawn from, and those where horses and cattle are taken to be watered, should be well marked out, the latter being below the former, and again below this the place where washing and bathing is carried on. When there is scarcity of water, sentries are posted over the wells or streams from which it is drawn.

WATER PROOFING.—Besides the application of caoutchouc, peculiar methods have been employed to render cloth impervinos to water, at the same time allowing the passage of air, the absence of this property in the impermeable caoutchouc manufactures have been found disadvantageous. Two plans are adopted for water-proofing woolen cloths, without rendering them quite impervious to air—the first is to dip the cloth in a solution of soap, and thoroughly rub it into the texture, after which it is dipped into a solution of alum; a decomposition of the soap and alum is effected, and the minute openings between the fibers are in some way partially filled so as to exclude water. In the second plan, the cloth is dipped into a solution of gelatine or isinglass, and afterwards in a solution of galls. A kind of tanning process is the result, the gelatine which has pervaded the cloth being rendered as insoluble as leather by its union with the tannin of the galls. See *Caoutchouc*.

WATERPROOF PAPER.—Paper that has been impregnated with a solution of beeswax disolved in rectified coal-tar naphtha, in the proportion of 2 lbs. of wax to 1 gallon of the solvent. This has been proposed by Mr. Abel F.R.S. The waterproof bags for Snider-Enfield rifle ammunition are formed of two sheets of paper made perfectly waterproof by an even intermediate layer of india rubber. This paper is cut to the size required, and the ends and sides joined by coating the overlaps of ¾-inch with india-rubber cement, which, when dry, are pressed together with an elastic roller. The india-rubber solution is composed of Naphtha, 98¾ lbs., India-rubber, 21¼ lbs and the cost of making 1000 of these bags is estimated at £1 0s. 2¼d.

WATER-SHELL.—A common shell filled with water, having a gun-metal cylinder screwed into it, containing ½ oz. of gun-cotton. This nature of shell, which receives its name from being filled with water instead of gunpowder, is the invention of Mr. Abel, F.R.S. The experiments carried on with this shell by the Committee on Explosives, a few years ago, proved it to be a valuable invention; and this has been further confirmed in the artillery practice at Okehampton (in August, 1875). The shells so filled and fired, as compared with gunpowder, show a preponderance of destructiveness, the water shell bursting, as was shown, into 300 fragments; whereas the same shell filled with gunpowder only split into 30 pieces. The mode of bursting this shell is by means of a detonator consisting of *dry* gun-cotton (*wet*, it appears, will answer as well), enveloping a small cap of fulminate of mercury inserted in the apex of the fuse-hole, in addition to the ordinary fuse. The theory of the employment of water as the disruptive agent of shells is explained as being based upon its power of transmitting the force developed by a sudden explosion of detonation, thus bringing it into operation at the same instant upon every part of the walls of the shell. Mr. Abel, in his paper on "The Recent History of Explosive Agents," states that, in the course of the trials made by him on the subject of bursting shells with water, the detonative effect produced by small detonating charges when exploded in shells which were filled up with water and entirely closed was proportionate, not simply to the amount of explosive agent used, but also to the suddenness of the concussion imparted to the water by the explosion. Thus, 0.25 oz. of compressed gun-cotton, detonated in a shell filled with water, broke it up into nearly eight times the number of fragments obtained by exploding a shell of the same kind full of gunpowder (viz., containing 13 oz.). When picric powder, which is also a very violent explosive agent, though much less sudden in its action, was detonated in one of these shells in the same way as the small charge of gun-cotton, 1 oz. (or an amount four times greater than that employed by the latter substance) burst the shell into about the same number of fragments as were produced by the 13 oz. of gunpowder (instead of about eight times the number), produced by means of 0.25 oz. of gun-cotton. But even more striking results have been obtained on this point. Thus, a 16 pr. shell, filled with about 16 oz. of gunpowder, was broken by the explosion of the charge into 29 fragments. The detonation of ¼ oz. of gun-cotton confined in a shell of precisely the same construction and weight, the chamber being filled up with water, burst the shell into 121 fragments, which were violently dispersed. A corresponding charge of gun-cotton, confined in a third similar shell, filled up with water, broke it into 300 fragments, and in addition there were 2 lbs. 1 oz. of the shell, almost pulverized by the force of the explosion, brought to bear upon the metal through the agency of the confined water. These results are quite conclusive as to the manner in which the action of the water shell is brought about, and show that only such a brisk explosive as gun-cotton, or disruptive agents of similar character, would be useful as a bursting charge for the water shell.

WATER-TEST.—A hydraulic test applied to cylinders and tubes in the foundry. In the construction of the coiled wrought-iron tubes for conversion of Rodman 10″ smooth-bore guns into 8″ rifles, the tubes are subjected to a water-test of 140 pounds to the square inch. The apparatus for applying the water-test is shown in the drawing. It consists of two cross-heads—A and B—fitted to the ends of the tube, and which are enabled to sustain the pressure applied through the medium of the connecting-rods, *b*. The cross-head A closes the bore water-tight, and is also pierced with an aperture for the entrance of water-



pipe, *a*. The water is forced in by means of a steam-pump, and the degree of pressure is registered by the gauge, *g*. See *Coiled Tubes*.

WATER WHEELS.—The value of a water-power depends much upon the nature of the source of supply whether steady or otherwise. Where streams supplying water-power are liable to fall off much in dry weather, large impounding reservoirs are necessary to keep the mills from being stopped during the summer. These, however, being generally expensive concerns, are seldom made for one mill, but rather by some association of mill-owners; and often by a water company or commission for supplying a town with water, to afford compensation to the mills by storing up flood-water, for what is abstracted for the use of the town. On small streams there is generally a pond provided fit to hold a night's water, or perhaps, even a Sunday's, in addition; but

put in motion either by the water acting on blades or floats by impulse derived from its great velocity acquired in falling, or by the weight of water being applied to one side of the wheel. The former mode of applying the water is generally adopted in low falls, say under six feet or thereabouts, and to what is called an undershot wheel—*i. e.*, a wheel where the effective head of water is below the center; and to make the application efficient, that portion of the periphery of the wheel measuring from the point of impact of the water to a point directly below the center, requires to be surrounded by a casing generally of stone, but sometimes of cast-iron, called the arc, closely fitted to the extremity of the floats, so as to prevent any considerable escape of water. The wheel which may be either of timber, or of cast-iron, or partly of both, consists of axles, arms, and floats, which are very generally radii of the circle, but are sometimes set a little obliquely to the radius, pointing up stream; and generally there are also a sole, (being a lining around the circumference at the lower

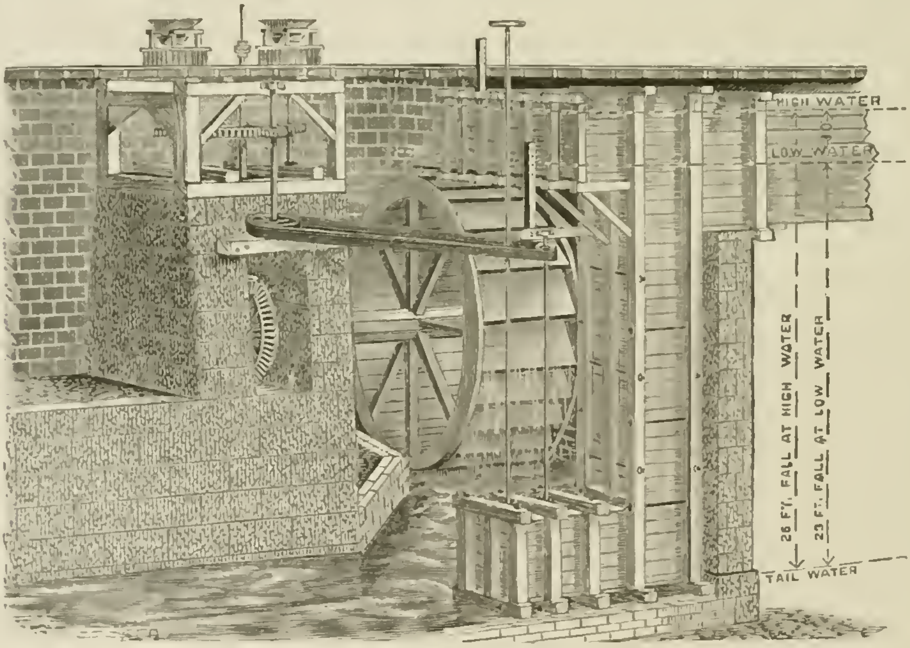
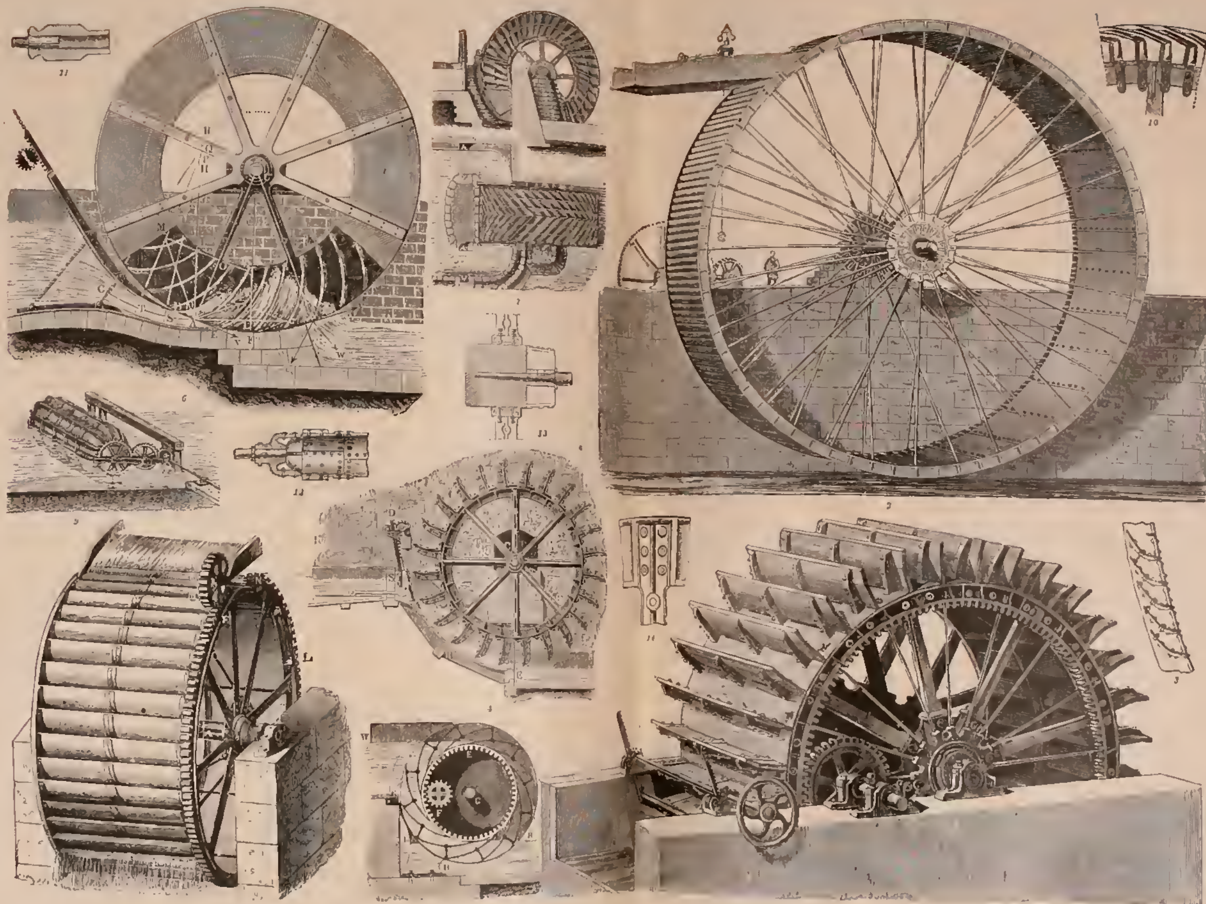


Fig. 1.

in the case of a large river, there is only a weir or dam across the river to direct the water into the intake lade. When the inclination in the bed of the stream is small, the lades require to be proportionately long, to give sufficient fall, and are often above a mile long or more from the intake to the lower end of the tail or discharge lade, where the water is returned to the stream. The rise and fall of the tide has been frequently used for driving water-wheels.

The most usual, and generally the most eligible, mode of applying water to the driving of machinery is by means of a vertical wheel; and the wheel is

edge of the floats, having openings for the escape of air); and a shrouding or circular plate at each side of the wheel, and of just the same depth as the floats. Sometimes, when there is a very little fall beyond the mere current of the stream, the floats simply dip into the water like the paddles of a steamer, in which case no sole or shrouding is required; and to make allowance for the rise of the water in the tail-lade during floods, which is generally called *back-water* and seriously impedes and sometimes stops the motion of the wheel, occasionally the wheel and its arc are so constructed as to be capable of being raised



WATER-WHEELS. 1. Overshot water-wheel. 2. Backshot water-wheel with partitioned feed (11 metres in diameter, the second largest in the world). 3. Arrangement of buckets of No. 2. 4. Center-feed water-wheel with trap. 5. Bucket-wheel with upper-feed. 6. Undershot water-wheel on Poncelet's plan. 7. Sagebien's water-wheel. 8. Zuppinger's water-wheel. 9. Colladon's swimming water-wheel. 10. Arrangement of bucket in an undershot "ventilated" wheel. 11 to 13. Construction of buckets for water-wheels, of cast-iron, tin or wood. 14. Joints of a cast-iron water-wheel.

or depressed together, without throwing the machinery out of gear. This is done in the case of the Inverness water-works, where the wheel is liable to be much affected by the rising and falling of the river Ness. Sometimes in this country the machinery is all on board a vessel moored in a river, so as to rise and fall with the level of the water, and thereby keep its water-wheel always immersed to the proper depth. At the old London bridge waterworks the wheels, which rose and fell with the tide, were worked by the current of both the flood and ebb.

The other mode of applying the water to a vertical wheel by making it act by its gravity, is the more perfect and economical mode, where circumstances will admit of it, and is generally adopted in falls of any considerable height, say of six feet and upward, and where the water can be let on above the level of the center. The wheels are called respectively *breast* and *overshot wheels*, according as the water is let on more near to the level of the center or to the crown extent, meets with obstruction by moving against the current. The *pitch-back overshot* is a modification of the last, making the water to pass alongside the wheel, and then to return and be let on the top of the wheel in the contrary direction. This requires longer and more complicated troughs, and by the change in direction, part of the impulse from the water is lost, but the bottom of the wheel moves in the direction of the tail-water, and is not liable to be impeded by being immersed in it. On the whole, it is generally thought better to apply the water at about 30° from the top of the wheel. In such high-breast or nearly overshot wheels, the water is let on to the buckets over the top of the sluice, which is made to open by lowering, and shut by lifting. In this way, however small may be the quantity of water, it is always applied at the highest possible level, which is of importance when it is its weight multiplied by the height of descent, not its impulse, that yields the effective power. The structure of the overshot and breast wheel is nearly the same as that of the under

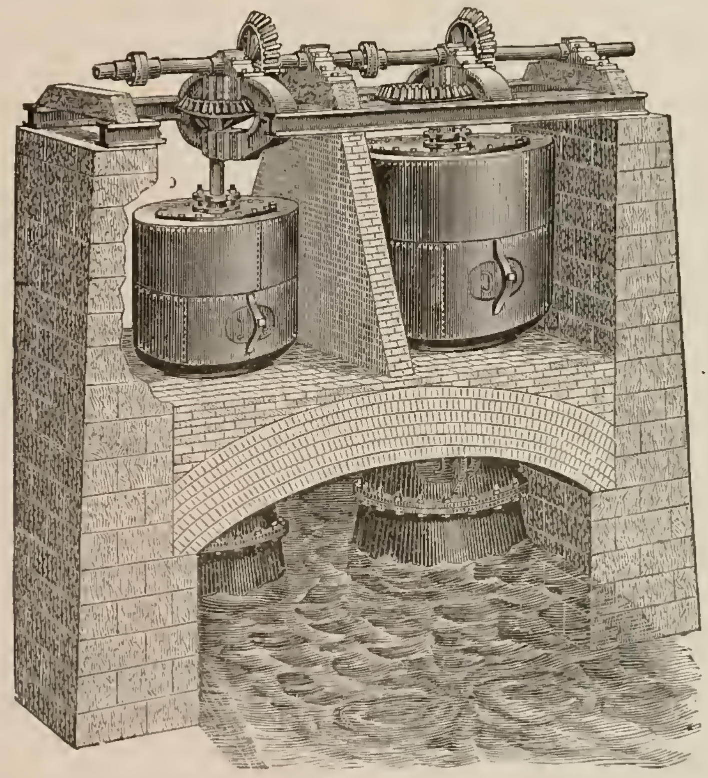


Fig. 2.

of the wheel; and they have, instead of the straight floats, curved or kneed buckets, according as they may be made of iron-plate or of wood, and of such a shape as to retain the water down to the lowest possible point. There are generally in good wheels ventilating openings in the sole for the escape of air. The overshot wheel has this disadvantage that, as the water has little or no power until considerably past the top center, the wheel is burdened with a useless weight of water. Fig. 1 shows the Risdon turbine, 20 inches diameter, in comparison with an overshot wheel having a diameter of 20 feet. The direct overshot wheel has the water run, without changing its direction, right over the top, which arrangement has this advantage, that as the top of the wheel moves in the same direction as the stream, it gets the benefit of the whole initial velocity and impulse of the water; but, on the other hand, the bottom of the wheel, if at all immersed in water, which it generally is to some shot, except in the substitution of curved or angular buckets, for straight floats; but, even in the undershot wheel the floats are sometimes made with a slight curvature.

In any description of wheel, the motion may be taken off the axle by torsion, which necessarily requires rigidity in the arms; or it may be taken directly off the periphery, when the power is applied to a pinion working into segments, either external or internal, attached to the shrouding. In this arrangement there is no torsion of the axle, or transverse strain on the arms, and therefore the latter are more often made of round, wrought-iron rods, with a slight axle. This wheel is much lighter than with the massive axle and the strong wooden or cast-iron arms, and is called a *suspension* or *spider-wheel*. The velocity of the periphery of an undershot wheel is usually from 500 to 600 feet a minute, and that of a bucket-wheel, overshot or breast, from 300 to 450 feet. It is seldom that the whole height of a fall can be advantageously made use of; for, if the wheel be placed so low as to get the benefit of the whole height of the fall in low states of the water, very often it is liable in floods, to have the lower rim immersed, and to be obstructed or stopped by back-water.

In the proper turbine the water passes either, first, vertically down through the wheel between fixed screw blades, which give it a spiral motion, and then strikes similar blades attached to a movable spindle, but placed in the opposite direction, so that the impact of the water communicates a rotatory motion to the blades and spindle, or second, a modification of the foregoing is to pass the water from the center horizontally outward through fixed curved blades, so as to give it a rotatory or tangential motion, and thereby cause it to act on the blades of the wheel which revolves outside. In the reactionary wheel, which is in principle almost identical with the Whitelaw and Stirret's wheel, the water is admitted at the center of the wheel from below, passes to the circumference between curved blades of the wheel, and escapes by tangential orifices at the circumference, there being valves made to open more or less, according to the quantity of water and to the power required. Although only a few horizontal wheels have been described, their name is legion, and it would require a volume to mention them all, or to describe their respective merits. The reciprocatory hydraulic engine, works exactly on the same principle as the ordinary non-condensing steam-engine. The water, under considerable pressure, is admitted at one end of a cylinder, the exit valve at that end being simultaneously closed, while it is shut off from the other end, and the exit valve there opened; and so the alternating action of the valves and of the piston goes on continuously. To work smoothly and effectively, the piston ought to be of large diameter, in proportion to the length of stroke, and to go slowly; otherwise the quick jerking is apt to shake and to injure the engine; and generally it is better to have two cylinders and pistons working together, as that enables them to work more equally, and to turn the crank without the use of a fly-wheel. Both the turbine and the reciprocatory engine have the advantage of being able to take the use of a fall much greater in height than the diameter of the largest wheel that can be made; but for all ordinary falls, a good breast or overshot wheel, or even an undershot, is, on the whole, generally considered better.

Fig. 2 shows the Risdon turbine on a horoizontal shaft located at some distance above tail-water, the whole effect due the head being obtained by using an air-tight tube for a draft-tube, and immersing the lower end of it in standing tail-water. This mode of setting the wheel admits of placing a pully directly on the water-wheel shaft, and communicating the power, by means of a belt, directly to the line-shaft. This saves in the first cost of gears, as well as in that cost which the maintenance of gears afterwards occasions, dispenses with the loss of power caused by using gears, and does not require so strong an arrangement of shafts, bearings, and foundations as would be required when using gears. The loss of effect caused by turning water from a horizontal direction, as it is discharged by wheels thus located, to a vertical direction into the tail-race, is much less than the friction caused by cog-gearing, and the friction of the shafts in their bearings where they are forced aside by gears. In a word, turbines thus arranged are less expensive in the end, less trouble to keep in order, are of simpler construction, save noise and jar, and leave more of the power of the water to apply to work. It is a well known fact that no turbine will give the same percentage of power of the water used, when discharging half the water of its full capacity. This is familiarly known as loss of percentage of the part-gate. This loss is greatly avoided by using two or more of these turbines on one shaft; then, as the volume of the steam diminishes, or the work to be done lessens, a gate on one wheel can be partly or wholly closed, so as to use what water there is at full-gate, or nearly so. In this way the geatest possible power is obtained from it. See *Hydraulic Power* and *Turbine*.

WATKINS ELECTRIC CHRONOGRAPH.—The screens in this instrument are on the same principle as Bashforth's, but the method of registration of the breaks in the current owing to the passage of the shot through the screens is different. This is accomplished by means of a *spark* from the induced current of a Ruhmkorff coil. The instrument is so arranged that the time taken by the shot to pass the various screens is accurately recorded, and by means of a calculating scale the velocity may be at once ascertained for any distance between screens. See *Chronograph*.

WATKINS RANGE FINDER.—This instrument is double reflecting, on the principle of the ordinary sextant, but is so constructed that the near object is seen by reflection and the distant one by direct vision, thus rendering it easier and quicker to use, more particularly in hazy weather. There are two patterns in the Service, differing only in size and weight; that for Artillery being 10 inches long, $3\frac{3}{4}$ inches wide, and $1\frac{3}{4}$ inches deep—weighing with its case about 5 pounds. That for the Infantry, $5\frac{3}{4}$ inches long, $2\frac{1}{4}$ inches wide, and $1\frac{1}{4}$ inches deep—weighing about $1\frac{1}{4}$ pounds.

This instrument consists of a brass rectangular box, carried, when not in use, in a leather case slung over the shoulder like an ordinary field-glass. When in use half of the cover is thrown back, thus exposing the right hand of the instrument. In the cover is carried a key for adjusting; and in the artillery pattern a small telescope for use in taking long ranges. There are two eye-holes, fitted in the larger pattern with movable slides, so that the instrument can be used with or without the telescope.

The fittings supplied for use with the instrument are: (*a.*) A wire cord, 18 feet long, in a leather case. (*b.*) A steel tape, in case, for occasionally testing the cord. (*c.*) Three steel pickets, fitted with leather disks to render them conspicuous. These are carried in leather buckets. (*d.*) For mounted men two knee-halters. Two men are generally employed as range-finders, though, if necessary, the service can be performed by one only. No. 1 carries the instrument slung over his shoulder like a field-glass, one picket (when mounted strapped to the saddle on the off side), steel tape in case, and knee-halter (if mounted). No. 2 carries wire cord in case, two pickets (when mounted strapped to the saddle on the off side), and knee-halter.

The instrument has three separate operations to perform—first, to establish a right angle, then to get the length of the base-line, and finally, after returning to the initial point, to get the range. The length of time necessary to get an observation varies with the conditions of the ground, and the accuracy of the observation will of course depend upon the skill and care of the observer as well as the conditions of the atmosphere. The advantages of this instrument are that it is light, portable, easily worked, and can be tested and adjusted in a few moments by any person of ordinary intelligence. It indicates the range directly without calculation; no vernier is used—the only graduation being the simple scales of the length of base and ranges in yards. It is cheap as compared with other range-finders, the cost being about $35.

One man can take an observation, but for convenience and rapidity two men are preferred. The accuracy of the instrument for all ordinary attillery distances, say up to 3,000 yards, is very satisfactory. It has the drawback, however, of necessitating the use of a right angle, but this disadvantage is greatly reduced by the facility of working with different lengths of bases, the ease with which the base can be changed, and the fact that the instrument itself is used as an optical square, thus doing away with the

The instrument was tested at Sandy Hook, June 19 and August 22, 1879, with the following results :

	Actual.	By instrument.	Error.	Base-line.	Time.	Remarks.
	Yards.	*Yards.*	*Yards.*	*Yards.*		
1	900	910	+ 10	$97\frac{3}{4}$	Not taken.	Times marked with * taken as fast as possible; in others, length of base-line walked.
2	1,000	1,025	+ 25	100	*4′ 20″	Actual time occupied in running over a base-line of 110 yards and returning, 1′ 10″.
3	1,200	1,185	— 15	$123\frac{1}{2}$	*3′ 40″	
4	1,300	1,330	+ 30	$123\frac{3}{4}$	*3′ 15″	
5	1,600	1,600	None.	$123\frac{5}{8}$	*0′ 0″	
6	1,700	1,740	+ 40	$118\frac{3}{8}$	Not taken.	
7	1,500	1,450	— 50	117	”	
8	1,400	1,345	— 55	$112\frac{1}{2}$	“	
9	1,300	1,285	— 15	115	“	
10	1,100	1,100	None.	128	“	
1	800	772	— 28	$60\frac{1}{2}$	Not taken.	
2	900	968	— 32	$73\frac{1}{2}$	“	
3	1,000	984	— 16	$67\frac{1}{2}$	4′ 20″	
4	1,100	1,059	— 41	63	*3′ 43″	
5	1,300	1,289	— 11	115	5′ 13″	
6	1,400	1,362	— 38	$106\frac{3}{4}$	6′ 33″	
7	1,500	1,472	— 28	115	*3′ 40″	
8	1,700	1,679	— 21	$108\frac{1}{2}$	*3′ 13″	

necessity of a separate instrument. It is believed that the conditions of the ground and atmosphere for taking accurate observations could not have been much more unfavorable than on the days when the ranges at Sandy Hook were taken. See *Russell Prism Range-finder.*

WAVE ACTION.—In gunnery, the name applied to abnormally high pressures which are found to occur in a gun when very large charges are used: they appear to be local, and do not give increased velocity to the shot.

WAVE-MOTION.—Wave is the name given to a *state of disturbance* propagated from one set of particles of a medium to the adjoining set, and so on; sometimes with, sometimes without, a small permanent displacement of the particles. But the essential characteristic is, that energy, not matter, is on the whole transferred. The theory of wave-motion is of the utmost importance in physical science; since, besides the tide-wave, waves in the sea, in ponds, or in canals, undulations in a stretched cord, or in a solid, we know that sounds in air are propagated as waves, and that even light is a form of wave-motion. The general investigation of the form and rate of propagation of waves demands the application of the highest resources of mathemathics; and the theory of even such comparatively simple cases as the wind-waves in deep water (the Atlantic roll, for instance) though easily enough treated to a first, and even to a second and third approximation, has not yet been thoroughly worked out, as fluid friction has not been taken account of. In this article, however, we will merely *state* some of the more important conclusions which mathematical analysis has established in the more difficult of these inquiries, comparing them with the observations of Scott Russell and others; while we give at full length the very simple investigation of the motion of a wave along a stretched cord and of the propagation of a particular kind of sound-wave. To find the rate at which an undulation runs along a stretched cord, as for instance, when a harp-string is sharply struck or plucked near one end, a very simple investigation suffices. Suppose a uniform cord to be stretched with a given tension in a smooth tube of any form whatever, we may easily show that there is a velocity with which the cord must be drawn through the tube in order *to cease to press on it at any point*, that is, to move independently of the tube altogether. For the pressure on the tube is due to the tension of the cord; and is relieved by the so-called centrifugal force (see *Central Forces*) when the cord is in motion. If T be the tension of the cord, r the radius of curvature of the tube at any point, the pressure on the tube per unit of length is $\frac{T}{r}$. If m be the mass of unit length of the cord, v its velocity, the centrifugal force is $\frac{mv^2}{r}$. These are equal in magnitude, and so destroy each other, if $T = mv^2$. Hence, if the cord be pulled through the tube with the velocity thus determined, there will be no more pressure on the tube, and *it may therefore be dispensed with*. If we suppose the tube to have a form such as that in the figure, where the extreme portions are in

Fig. 1.

one straight line, the cord will appear to be drawn with velocity v, along this, the curved part being occupied by each portion of the cord in succession; presenting something like the appearance of a row of sheep in Indian file, jumping over a hedge. To a spectator moving in the direction of the arrow with velocity v, the straight parts of the cord will appear to be at rest, while an undulation of *any* definite form and size whatever runs along it with velocity v, in the opposite direction. This is a very singular case, and illustrates in a very clear manner the possibility of the propagation of a *solitary* wave.

Thus we have proved that the velocity with which an undulation runs along such a cord is the square root of T divided by m.

If l be the length of the cord in feet, w its whole weight, W the appended weight by which it is stretched, g=32.2 ft., the measure of the earth's gravity, this becomes

$$\left(\frac{W}{w} lg.\right)$$

This formula is found to agree almost exactly with the results of experiment. We can easily see why it should be to some small extent incorrect, because we have supposed the cord to be inextensible, and perfectly flexible, which it cannot be; and we have neglected the effects of extraneous forces, such as gravity, the resistance of the air, etc. Let us next consider the motion of air in a cylindrical tube, in the particular case in which the leg of a vibrating tuning-fork is applied at one end. This is a simple case of the propagation of sound-waves. We shall treat it by a synthetical process, somewhat like that given by Newton. As we have already seen (see *Pendulum*), a simple vibration such as that of a pendulum or tuning fork is the resolved part, in a definite line, of the uniform motion of a point in the circumference of a circle. What we have now to explain is, that such a motion of all the particles of air in the pipe, the *phase* of the vibration (or the position of the particle in its path at any instant) depending on its distance from the end of the tube, is consistent with mechanical principles. When this is done, it will be easy for us to trace, in this particular example, the process by which the wave is propagated from one layer of the fluid to the next. We must now consider (a little more closely than in *Pendulum* or *Sound*) the nature of the simple vibration of each particle of the air. Suppose P to move, with uniform velocity V, in the circle APB, and let PQ be drawn perpendicular to the fixed diameter, OA, then the acceleration of P's motion is $\frac{V^2}{OA}$ in the direction PO.

Hence in the motion of Q, which is a simple vibration, we have, by the rule for resolving velocities and accelerations,

$$\text{Velocity of } Q = \frac{PQ}{OA}V \text{ in the direction } QO;$$

$$\text{Acceleration of } Q = \frac{OQ}{OA}\,\frac{V^2}{OA} \text{ in the direction } QO.$$

Next consider two particles of air near one another in the axis of the tube, or the masses of air in two contiguous cross-sections of the tube. If the phase of vibration were the same for both they would be *equally* displaced from their original positions, and the air between them would be neither compressed nor dilated. Hence, that a wave may pass, the phases must be different. Let, then, Q (Fig. 2) rep-

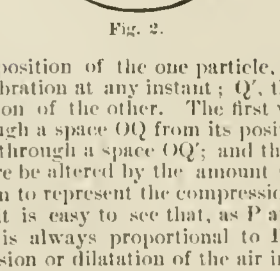


Fig. 2.

resent the position of the one particle, or layer, in its line of vibration at any instant; Q', the simultaneous position of the other. The first will be displaced through a space OQ from its position of rest; the second, through a space OQ'; and their distance will therefore be altered by the amount QQ', which may be taken to represent the compression or dilatation. But it is easy to see that, as P and P' move round, QQ' is always proportional to PQ. Hence the compression or dilatation of the air in any cross-section of the tube is proportional to the velocity with which it is moving. Hence the difference of pressures before and behind any such section is proportional to the difference of velocities—*i. e.*, to the acceleration of the motion while the section passes over a space equal to its own thickness. And this is consistent with mechanical principles, for the *mass* of air in the section is constant, while the difference of pressures before and behind produces the acceleration, and should therefore be proportional to it. The particles of air in cross-sections of the tube therefore vibrate, each in the same period as does the tuning-fork, but the phase is *later* for each section in proportion to is distance from the fork. Where the phase is one or more whole vibrations later than that of the fork, the motion is exactly the same as that of the fork, and *simultaneous* with it. At all other points, it is the same as that of the fork, but not simultaneous. Thus the greatest displacement of the fork is immediately shared by the layer next it, later by the next layer, and so on. Thus, a *wave* of displacement travels along the tube from one section to the next, while each particle merely oscillates backward and forward through (in general) a very small space about its position of rest. The reader who has followed the little geometrical investigation above will have no difficulty in proving for himself that the velocity with which the wave travels is proportional to

$$\left(\frac{p}{d}\right)^{\frac{1}{2}}$$

where p is the pressure, and d the density of the air. The easiest mode of doing this is to express, in terms of these and other quantities, the equation given us by the laws of motion.

Mass × Acceleration = Difference of pressures,

and to assume that Hooke's law holds, even during the *sudden* compression of air. This, we know, is now the case; so that a correction has to be applied to the above expression; depending on the heat developed by sudden compression or lost in sudden rarefaction, by each of which the elastic force of the air is *increased*. But this has been already discussed in *Sound*. The above formula shows us, however, thot the velocity of sound is not affected by the pressure of the air—*i. e.*, the height of the barometer—since, in still air, p is *proportional* to d. The velocity does depend on the temperature, being, in fact, proportional (*ceteris paribus*) to the square root of the temperature measured from absolute zero. We see also from the formula that the velocity is inversely as the square root of the density of the gas—the pressure being the same. Thus a sound-wave travels about four times faster in hydrogen than in air. Also we see that, within the limits of approximation we have used, the velocity does not depend upon the intensity, pitch, or quality of the sound. The investigations which seem to lead to slight modifications of this conclusion are too recondite to be introduced here. We can only mention, also, the beautiful investigations of Stokes connected with the extinction of a sound-wave as it proceeds, partly by fluid friction, partly by radiation. And we may conclude by stating that the result of a completely general investigation of the velocity of a sound-wave gives, to a first approximation, the result we have deduced from the study of a simple particular case. For further information on this subject the reader is referred to the recent work, *Elements of Wave-motion*, by Prof. Peter S. Michie, West Point.

WAVER.—To hesitate before the enemy under a withering fire; to be undecided whether to go on or retreat. This feeling may be brought about from panic seizing the troops, or from loose formation, causing the order of the march to be desultory. It occurs, sometimes, from the officer in command hesitating as to his future movements.

WAX.—An organic product of considerable importance; it is obtained from different sources, the chief of which is the beehive, where it is used by the bees in the formation of their cells. The characteristic properties of good wax are its roughness when chewed, its non-adherence to the teeth, and its fragrant honey-like smell. The substances generally used to adulterate wax are rosin, tallow and earth. The latter may be detected by melting the wax, when the earth will subside to the bottom as it cools, and may be removed by a knife. Tallow may be inferred when wax breaks smooth, and adheres to the teeth when chewed, also by the absence of the honey-like smell. Rosin may be detected by putting small pieces of wax in spirits of wine; the rosin will be dissolved, leaving the wax uninjured. When the wax has served its purpose in the domestic economy of the hive, it is collected for manufacturing purposes, and goes through a certain refining process before it is taken to the market. Bees-wax is now largely used as an ingredient in lubricating cartridges, and undergoes the following examination before it is employed for this purpose:—Press a small fragment of wax repeatedly between the first finger and thumb, so as to spread it down the latter. The wax should curl away from the thumb as the finger descends. If it clings tightly to the thumb, and becomes very soft and smeary, the adulteration with some description of fat is indicated. This test, though very crude, is sufficiently good to serve for the detection of any considerable adulteration of this kind. A piece of *blue litmus paper* pressed upon a piece of the wax (with a knife or rod but not with the finger), which is thus heated gently on a metal service, until it begins to melt at the edges, should exhibit no change of color to red. Several fragments of wax are placed in a wide test tube and gradually heated (the tube being moved in and out of the flame) until perfectly melted. The wax in this state should be quite clear and transparent, and free from mechanical impurities. The heat should be applied to the wax until the portion of the tube containing it can no longer be touched by the finger (the temperature being about 220° Fahr.). If it has then exhibited no signs of frothing, it is free from water. If much of the latter be present, the wax will begin to froth even before it is completely melted, and as the heat is raised, a crackling noise will be noticed. Water may be expelled from wax by maintaining the latter at a temperature of 210° Fahr. until frothing ceases.

WAY OF THE ROUNDS.—In fortification, a space left for the passage of the rounds between the rampart and the wall of a fortified town.

WAY-PLANK.—An oak plank 15 feet long, 12 inches wide, and 3 inches thick. Each end is beveled for a distance of six inches, the bevel on one end being on the side opposite the bevel of the other end. These planks are used chiefly for forming temporary tramways for rollers, or for the wheels of carriages bearing heavy weights.

WAYWODE. — A word of Slavonian derivation, meaning "War Leader," applied to Military Commanders in Poland, where each Province, or *Arrière Ban*, had its *Waywode* or Woyevoda, in Russia, until abolished by Peter the Great; and in Moldavia and Wallachia, where it was supplanted by the Greek *Despota*, and finally by its Slavonian equivalent, *Hospodar*. Sometimes written *Waiwode*.

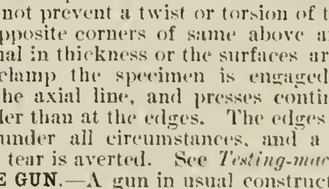
WEAPONS.—Instruments of offensive or defensive combat. Under this head is embraced small-arms of all descriptions and the machines of war for overthrowing, destroying, and burning the defenses of an enemy. The ancient machines of war were of three kinds; the first for projecting arrows, darts, stones, javelins, and fire-arrows; the second for battering and breaching walls, etc.; and the third for covering the troops thus engaged. The numerous weapons of war, ancient and modern, are described under appropriate headings throughout this Work.

WEB.—1. A material used in a saddle. It is made of coarse canvas 9 inches × 3 inches, nailed across the two side bars. Its use is to prevent the seat of the saddle from being pushed upward by the peg on on which it hangs. Web made of pure hemp is used for girths, man-harness, and for cartridge cartouches. 2. A name frequently given to the basket-work of a gabion.

WEDGE.—One of the mechanical powers, and in principle a modification of the inclined plane. The power is applied by pressure, or more generally by percussion to the back, thus forcing the edge forward. The wedge is employed for such purposes as the splitting of wood, the fastening firmly of the handle of an axe, the raising of a ship in a dry dock, etc. The investigation on statical principles of the mechanical advantage of wedge is extremely unsatisfactory, the power which is scarcely ever a "pressure," being always assumed to be one, and the enormous friction on the sides of the wedge being generally neglected; the theoretical result thus arrived at is that the pressure applied at the back : the resistance or weight : ½ width of back of wedge : length of side. In the application of the wedge to the splitting of wood in the direction of the fibers, the split generally extends some distance in advance of the edge of the wedge, and the action of the latter is then a combination of the action of the wedge with that of the lever; in fact, this compound action is found more or less in all applications of the wedge as a cutting or splitting weapon, and tends further to complicate the statical investigation of its mechanical properties. The best and simplest illustrations of the single wedge are axes, nails, plugs, planes, chisels, needles, and all sharp-pointed instruments. See *Mechanical Powers*.

WEDGE BREECH-LOADER.—This method of closing the breech has been considerably employed in the experimental Armstrong ordnance. It is called the *side* or *wedge breech-loader*, and may be generally described as a cross-piece or sliding-block inserted in a horizontal mortise which intersects the bore at right angles. This block is fitted with a sliding hammer, and has on its face, which forms the bottom of the bore, a thin iron or tin cup to stop the gas. The sliding-block is similar to that of the Cavalli gun. This apparatus prevents the necessity of lifting out a heavy vent-piece.

WEDGE CLAMP.—A device used in testing-machines for securing a perfectly central pull or stress on the flat specimens to be tested, without the possibility of any twist or tearing from the edges or sides. The drawing shows the latest invention in this line. The face of the clamp which grips the specimen is slightly raised through its center longitudinally its entire or partial length. Wedges with curved backs, and



wedges with the ball and socket joints, are made to accommodate specimens of uneven thickness, but they will not prevent a twist or torsion of the specimens if opposite corners of same above and below are unequal in thickness or the surfaces are harder. In this clamp the specimen is engaged at once through the axial line, and presses continuously a little harder than at the edges. The edges are then relieved under all circumstances, and a side pull causing a tear is averted. See *Testing-machines*.

WEDGE GUN.—A gun in usual construction similar to B. L. R. guns of the English Service, and rifled on the same principle, so as to fire a lead-coated shot; but the method of closing the breech is different from that of the screw and vent-piece gun. In the wedge and stopper gun a slot passes through the breech from side to side, and the parts which close the bore are therefore inserted or withdrawn at the side of the piece, instead of at the top; by this arrangement the gun may be loaded more rapidly, and with much less labor, and the detachment is much less exposed than with the screw and vent-piece gun. The wedge guns of Sir W. Armstrong's manufacture

(40-pr and 64-pr.) were introduced into the service in consequence of the objection urged against his breech-screw guns.

WEIGHING-MACHINE.—There are few of our military readers, and, in fact, few professionals generally, who are not familiar with the remarkable work performed by the Watertown testing-machine. That after recording hundreds of thousands of pounds it will show the strain which breaks a horse-hair, or, when testing the hundreds of thousands of pounds, read to a fraction of its load as small as that of an analytical balance, are facts which have caused the greatest wonderment and curiosity in regard to the remarkable mechanism by which these results have been accomplished. It is evident to those who are familiar with the apparatus and the way it has been developed that a revolution in machinery for weighing is at hand. Abandoning as utterly useless the knife edge, Mr. Emery struck out upon what is an entirely new line. From the weight to the recording index he undertook the problem of transferring the pressure by itself, and practically without motion. He undertook to do this without introducing back-lash or the wear of pivots or knife-edges. The importance of this we can the better understand when we refer to the work of some of the best analytical balances of the country. One of these, exhibited at the Centennial, with one pound in each scale, will turn with $\frac{1}{500000}$ of its load. The finest assay scales by the same maker with one gram in the pan will turn with $\frac{1}{10}$ milligram, or $\frac{1}{10000}$ of the load. Such a scale, on account of the great amount nine weighings required more than a day for their accomplishment, on account of the great length of time necessary for balancing the scale with such a load.

Scales of this sort may be said to be excessively impatient, if we may be permitted the term, of overweight, or a weight which exceeds that for which it was intended by the makers, and are always injured by any excess of this weight, becoming sluggish when it is placed in the pan and having their knife edges ruined. In fact, the ordinary load soon destroys, by wear and crushing, the sharpness of

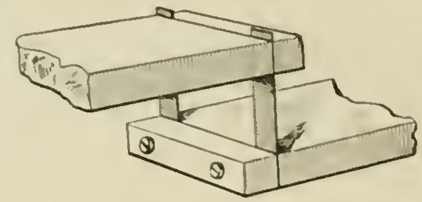


Fig. 2.

the knife edge, and the scales deteriorate sensibly and rapidly by ordinary use. They are also sensitive to dirt and to rusting. If one of these delicate scales be overloaded the knife edges lose their shape and are crushed into forms approaching circles. Not only, then, are edges crushed and worn into the rounded forms but the fulcrum distances are by this

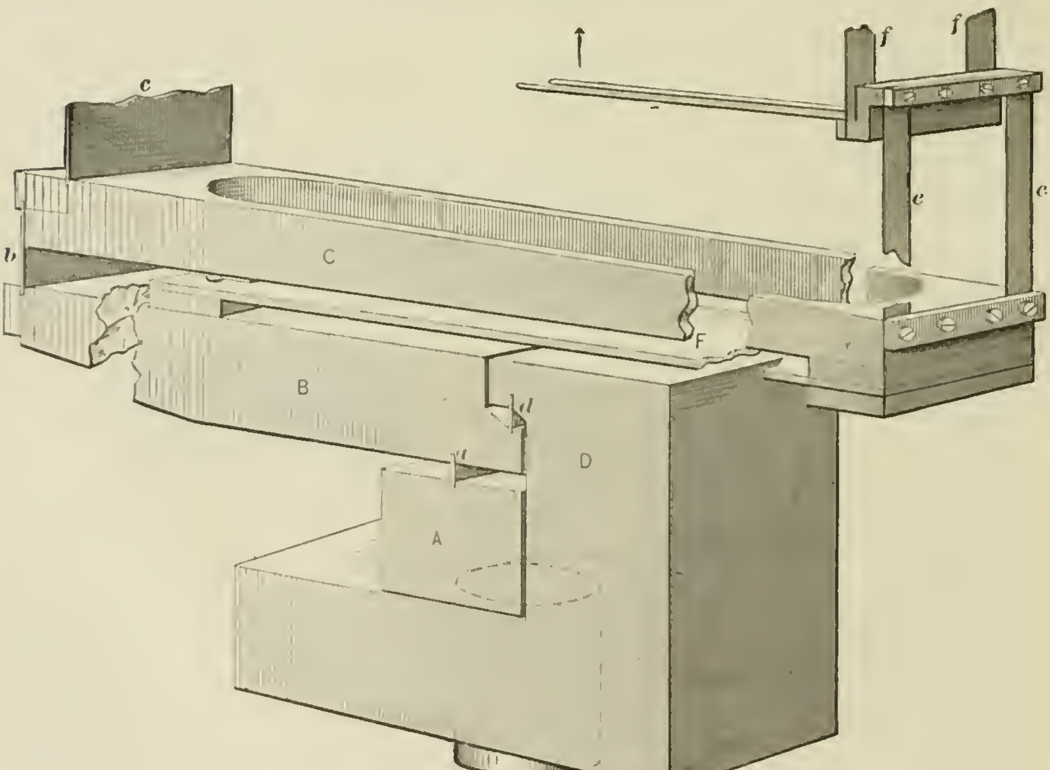


Fig. 1

of motion and the fact that a considerable mass must be put into motion by an exceedingly small force, is excessively slow in coming to rest. On one occasion a gentleman used a whole day in weigbing a single pound seven times. The maximum difference between the greatest and the least weight obtained was $\frac{1}{150000}$ part of the load. When on the same scale the attempt was made to weigh two pounds, means changed, and consequently the accuracy of the scale is lost. The fine scales for weighing silk are intended to take 1 pound and are sensitive to $\frac{1}{7000}$ part of the load—that is with 1 pound in the pan—and they will indicate 1 grain. Disbelieving the manufacturer's statement that 5 pounds would ruin this scale, a certain party bought one, and after testing it well within its capacity attempted to weigh

5 pounds with it. After this weight had been put on he found that although the scale still moved with

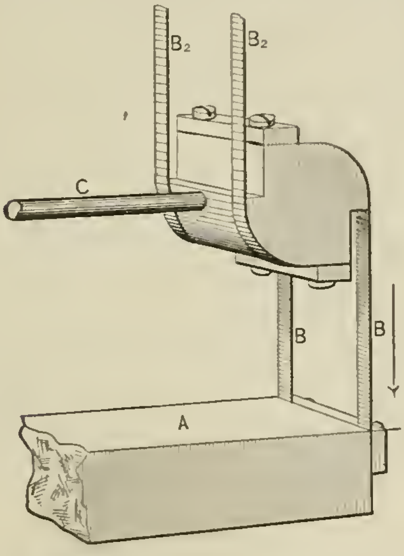


Fig. 3.

a single grain, yet it would not weigh a pound twice alike to within a single grain. In other words, the over-loading had not only destroyed its sensitiveness, but had ruined it for accuracy by changing the fulcrum distances.

In contrast with this we take the scale beam of the testing-machine at the Watertown Arsenal, which was used before the machine was finished as an ordinary beam-scale by the prolongation of its weight-beam. When rigged as a balance, 100 pounds was put in the pan and weighed seven times, and the greatest difference between the maximum and minimum weights obtained was one part in 1,750,000. A 200-pound standard was afterwards weighed nine times in succession. Here the greatest difference between the maximum and minimum weighings was one part in 2,350,000. The sensitiveness of the scale when thus used with the 200-pound load, stated according to the ordinary method, was equivalent to the scale turning with $\frac{1}{14000000}$ part of its load. In other words, a scale-beam with its fulcrum capable of sustaining without injury a load of 4,000 pounds has been made more sensitive than the finest analytical balance yet made in this or any other country. Indeed, the same beam, if we understand Mr. Emery's statement correctly, might be used for analytical work with a far greater perfection than is attainable with the ordinary balances of their range of accuracy.

To understand how such accuracy is possible, we must first get an idea of the nature of the fulcrums used and the levers employed in Mr. Emery's scales, gauges and dynamometers. The second step will be the means used for transmitting enormous loads on heavy scales or the strains of large testing-machines

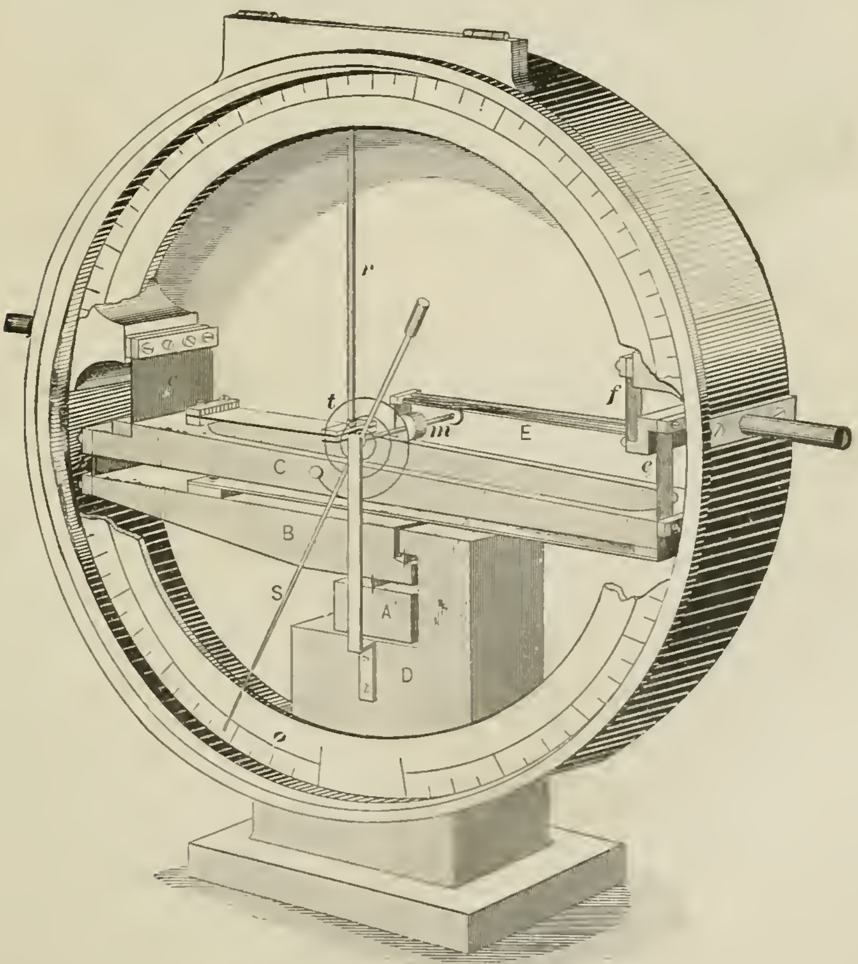


Fig. 4.

to the weighing apparatus. Lastly will follow a description of the methods of balancing the beams and reading the loads. Figs. 1, 2 and 3 illustrate the arrangement of these fulcrums and levers as applied to a pressure-gauge or weighing-dynamometer. They consist of thin, flat pieces of steel of suitable widths and lengths, forced into grooves or held between columns. In Fig. 1, *a*, *d*, *b*, *c* represent these fulcrums made of flat pieces of steel, and *e* and *f* show similar fulcrums where two flat strips of steel take the place of a wide one. The method of connection and the variations of the bearing are shown in Figs. 2 and 3, which are enlarged details of certain parts of special scales or gauges. In the case of the gauge or weighing-dynamometer, A (Fig. 1) shows the pressure column, consisting of a cylinder widening into the rectangular head A, in which is planed a groove to receive the first fulcrum *a*, into which it is pressed, and which is also pressed into similar grooves at its upper end in the first lever B. A fixed fulcrum, *d*, is pressed at its lower end into the lever B, and its upper end into a groove in the fulcrum block D. The third fulcrum *b* is shown clamped at

of the ordinary knife edges. Here the beam B receives its load from the pressure column A through the fulcrums *b* and *c*. These are connected together by the block *c*, for the purpose of introducing, or allowing for a certain amount of lateral motion around the center of motion in the fulcrum *b*. The beam is prevented from yielding bodily to the stress by the fulcrum *d*, held in the fulcrum block D. As its outward end moves up or down, motion is transmitted to the indicator rod G by means of two suspension fulcrums E and F. Their action on the point of support of the indicator rod G is similar to what is shown in Fig. 3, which is, however, from another piece of apparatus, and this construction is intended to permit a large range of motion. We may here point out a decided difference in the two constructions. In Fig. 5 the bending of the fulcrums *e* and *f* is directly as the angular motion of the indicator rod G, while in Fig. 3 the bending of the fulcrums B and B_2 is constant, no matter what the angular motion of the indicator rod C may be. This construction is often employed by Mr. Emery where it is necessary to hang one beam from another, and where it is de-

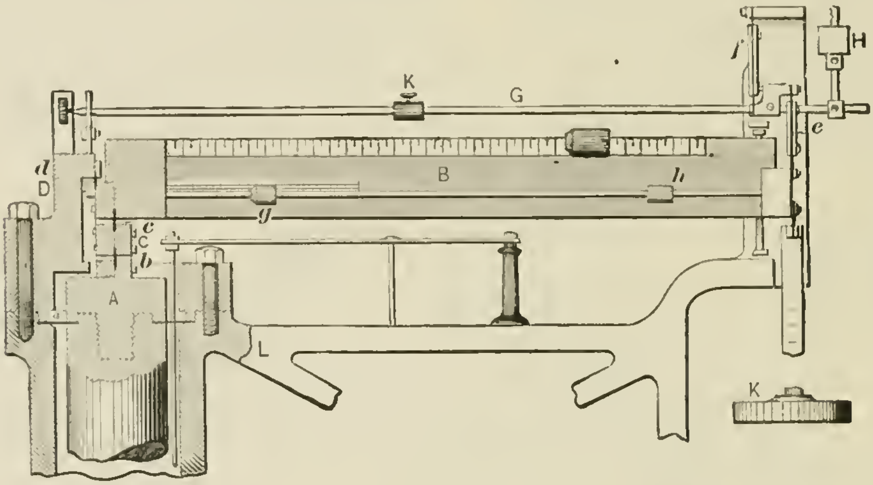


Fig. 5.

the outer end by a clamping-plate, and its upper end is pressed into the lever C, or into a block attached to the lever C. The same block clamps the fourth fulcrum *c* to its lever C. The fulcrums *d* and *c* are both fixed, which causes the lever B to move upward at its upper outer end, as shown by the arrow, and the lever C to move downward at the same time. The strain on the first four fulcrums *a*, *d*, *b*, *c*, is compression, while that on the fulcrum *e* and *f* is tension.

These fulcrums are all of tempered plate steel, and are often gold-plated, to prevent rusting. In the illustration shown, the pressure on the block A may amount to 4,000 or 5,000 pounds, and the thickness of the first and second fulcrums is from .04 to .05 inch, and the third and fourth fulcrums *b* and *c*, .02 inch. The width of these is 4 inches, and the exposure or portion left free between the different levers is about .2 inch for *a* and *d*, and .8 inch for *b* and 2 inches for *c*, the loads on the latter being reduced to about 400 pounds through the lever B. Fig. 1 is an enlarged view of the pressure-gauge shown in Fig. 4. This hydraulic gauge is used for measuring loads of 7,500 pounds to the square inch. Surprising as it seems at first sight, the motion of these levers, though firmly connected in this way and transmitting strain without the possibility of back-lash, is practically frictionless.

A further application of this form of fulcrum is shown in Fig. 5, where the heavy lines *b*, *c* and *d* represent pieces which, as we have said, take the place

sirable to obtain a great angular motion. Fig. 2 illustrates the method of clamping suspension fulcrums similar to E and F in Fig. 5. It must be observed, however, that in Fig. 5, the fulcrums being very long and delicate, it is found desirable to protect the central portions, and this is done by a pair of clamping plates. From the end of the beam B a poise rod and weight plate K are hung by a pair of thin plates, which illustrate another application of this kind of fulcrum, giving all the lateral motion and flexibility which is needed, and preserving the exact fulcrum distance without wear or friction. The thickness of metal used for supporting the beams is very slight, and it would surprise most engineers to know that a piece of metal one-twentieth of an inch thick, and 5 or 6 inches long, and perhaps 2 inches "exposure," or portion not in, but between, the groove, will carry thousands of pounds without suspicion of buckling or springing. For those bearings or primary fulcrums which are to take the heaviest pressures in the large gauge, the strips of metal are of the finest spring steel, one-twentieth of an inch in thickness and 4 inches in width, and are pressed into their grooves with a load of 18,000 pounds, though in use they would receive 4,000 or 5,000 pounds only. The greater portion of this metal is, as the reader will see from the different drawings, firmly fixed in slots cut in the beams. When tensile strain is to come upon these fulcrums of course a much thinner spring and a longer one is possible, and, with the construction shown in Fig. 3, the angular motion can then be made as great as may be desired, and with the other construction it can usually be made as great as is necessary. In many constructions the thickness of these fulcrums for compression is reduced to as little as $\frac{1}{3000}$ inch, and for tension to as little as $\frac{15}{10000}$ inch. By increasing the width, the amount of strength obtained can be raised indefinitely, and any load whatever supported.

Fig. 1 shows the system of levers adopted for the pressure-gauge in Fig. 4, where the motion between the pressure column A and the point of the indicator S is multiplied more than 60,000 times, so that a movement of the column of less than $\frac{1}{1000}$ inch will give the 60 inches reading at the point of the needle where the arc is graduated and divided into a thousand parts, each graduation being made by actual test. This, we think, is the greatest multiplication by levers in so small a space of which we have any knowledge. The graduation of the dial by actual test, eliminates several sources of error which would theoretically be found in employing the usual methods for graduation. The method of operation of these levers and fulcrums may be understood by reference to Fig. 1, where the pressure communicated to the fulcrum block A is transmitted by the fulcrum to the lever B; about one-tenth of this is transferred to the outer end of the beam and to the fulcrum B. This in turn is communicated to the lever C, which at its outer end transmits in a downward direction to the resisting spring F about one-thirtieth of the load which it receives. The spring F uses up by bending the entire force transmitted to it. The motion through the fulcrums *e e* and *f f* is then transmitted through the rods E (see Fig. 4) to the indicator-rod S, and thus indicates the entire amount of bending which has taken place when the bending of the spring has brought it into equilibrium. Briefly stated, the method of measuring the load, in large platform scales is to transmit a portion of the downward pressure of the load to the weighing mechanism. The load may be supposed to be supported on a series of diaphragms, which, through a system of pipes, by a hydraulic pressure transmit a portion of this pressure to other similar diaphragms, where the resultant pressure is measured by suitable apparatus. In other words, the principle of the hydraulic press is introduced into the weighing apparatus as a transmitting mechanism, but the construction is such as to make the apparatus frictionless.

Fig. 6 shows what is called a hydraulic support, and is one of the members which primarily receive the load on a large platform scale. It consists of a base, A, in which is a circular chamber, usually $\frac{15}{1000}$ inch in depth, which is filled with a liquid on which sits the pressure column B contained in the protecting case C, to which it is secured against vertical motion at the top by the diaphragm D, and at the bottom by the diaphragm E, the latter being the pressure diaphragm, which prevents the liquid from flowing out of its chamber when pressed by the load put upon the pressure support. The diaphragm D not only centers and retains the upper end of the column B in the support, but seals the chamber around it from dirt, etc., this chamber being merely filled with air. A bell-shaped cap, F, receives the load from the platform and protects the diaphragm D from injury. It transmits the load from the platform to the pressure colum B through the rubber block G, which does not act like a spring, as it is confined by the ring H, but serves to transmit the load to the column B, and at the same time permit lateral movement and tipping of the cap F caused by any bending of the platform. The liquid contained in the chamber I communicates through the pipe K, usually $\frac{5}{100}$ or $\frac{5}{100}$ inch in diameter, to a small sealed pressure chamber within the weighing mechanism.

This diaphragm is of large size, held firmly between surfaces, and has a total motion in, for example, a 50-ton testing-machine, of one four hundred thousandth inch. For one pound the change or motion is one forty millionth inch. The whole range of the first diaphragm is one millionth inch. The indicating arm, equivalent to B, in Fig. 5, moves one hundredth inch for each pound, and has a total motion in that particular case above and below zero amounting to one and six-tenths inches. The main diaphragm, in moving, displaces a column of water, which acts upon another or secondary diaphragm receiving only a small fraction of the pressure upon the primary one. In this way very intense strains are, by the simple difference in the size of the diaphragms, reduced to come easily within the range of the scale beams to manage. In track scales and other scales where large platforms have to be supported there are usually a number of primary diaphragms, which are connected and transmit pressure to a series of smaller ones, which in turn act as a unit on the real secondary diaphragm which actuates the beam. The possibility, then, of reducing the weight to be measured at one or two steps to an amount which can easily be handled is an immense advantage, and the fact that this reduction, instead of being made by means of beams, is accomplished by a fluid in small pipes, is a very great advantage. Practically, it seems that there would be no difficulty in placing the platform 5, 10, or 50,000 yards away from the beam.

The diaphragm used here may be essentially a flat metallic bag of circular form. The circular grooves are formed in the plate and in the diaphragm itself, or, rather, we should say the two diaphragms, and are very essential features. The plate takes the weight

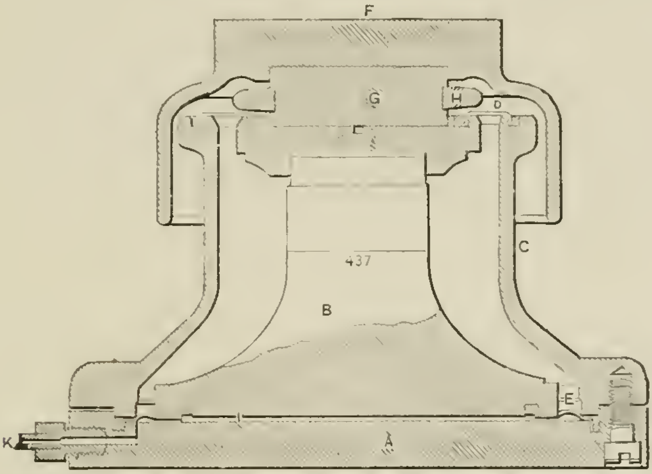


Fig. 6.

which is resisted by the liquid inclosed between the diaphragms. There is a tendency to force it through the connection 221, shown in Fig. 7, this tendency to displacement varying with the load. In order to hold this plate in place and prevent it from having any side motion, and consequent friction, a thin annular diaphragm connects it with the ring. This diaphragm 33 is shown on a large scale in Fig. 7; 34, 34 are the rings of solder which hold it in place. Any pressure which is brought to bear upon the plate 32 will, of course, be transmitted to the fluid inclosed beneath it, and this pressure will at once be transmitted through the connecting-pipes. By using a diaphragm of a smaller diameter, the pressure may

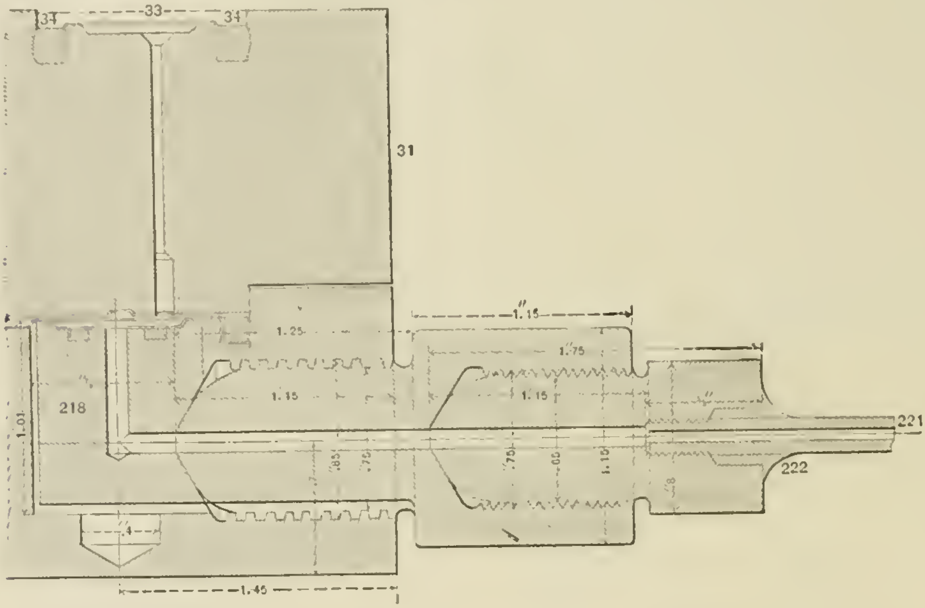


Fig. 7.

be reduced to practically any desired extent. Though there may be 100,000 pounds on the large diaphragm, it is not necessary to have on the receiving diaphragm a load any larger than can be conveniently handled. The amount of reduction is, of course, determined by the ratio of the area of the primary and secondary diaphragms. If, as in the case illustrated, the first diaphragm has a diameter of 13 inches, the area will be, say, 132 square inches, and if the receiving or secondary diaphragm be 4 inches in diameter, the pressure will be reduced approximately to one-tenth of the original amount; hence, by choosing proper ratio of areas, the pressure to be dealt with is entirely within control. The importance of this point can hardly be overestimated.

In track scales and other scales where large platforms have to be supported there are usually a number of the primary diaphragms, which are connected and transmit pressure to a series of smaller ones, which, in turn act as a unit on the real secondary diaphragm which actuates the beam. Fig 7 shows the details of the diaphragm and connections. The actual pressure to be reduced by the screw-threads is merely nominal, and the tight joints are attainable with very small wrenches and merely nominal pressure. See *Emery Testing-machine*, *Rodman Testing-machine*, and *Testing-machines*.

WEIGHT OF PROJECTILES.—As to what constitutes the correct weight of a rifle-projectile of given caliber, there exists great diversity of opinion. The principal nations seem, however, to have settled upon the most suitable weights for all moderate calibers, and Mr. Vavasseur has suggested the following formula for determining the weight of all rifle-projectiles:

$$\frac{(\text{Diam.})^3}{3} = \text{Weight.}$$

This corresponds quite closely to the standards adopted throughout the world up to a caliber of ten inches.

Capt. Butler, of the United States Army Ordnance, proposes as a standard the formula $(\text{Radius})^3 \times 2.80$, and suggests that under no circumstances should a projectile exceed in weight three times the cube of its radius.

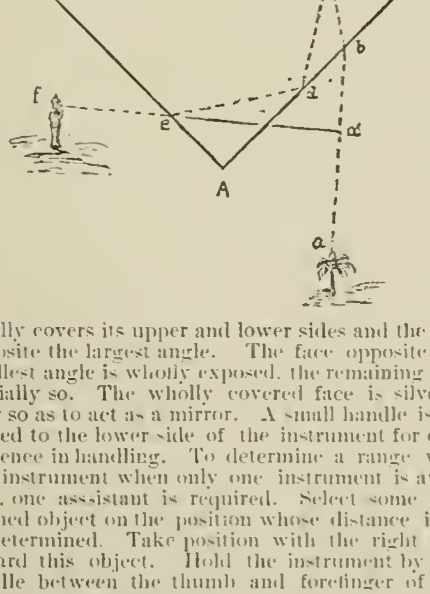
In the employment of very large cast-iron projectiles, there is a risk of crushing or breaking up the projectile in the bore of the gun. The action of the discharge upon each square inch of the base of a large projectile, is the same as upon each similar superficial unit in a small projectile, while the column of metal superimposed upon each of such units is very much longer. From its own inertia cast-iron cannot upset, as wrought-iron will do; but it can crush or break under sudden shocks, and thus prove disastrous to the gun. The greatest care should be taken to secure the best quality of iron and to prevent hidden defects in the casting. See *Projectiles* and *Solid Shot*.

WELDING.—That operation by which pieces of iron or steel, or steel and iron, are heated nearly to a state of fusion, and appearing to be covered with a strong glaze, or varnish, are brought together, and united by repeated blows of the hammer, or under pressure, and the union not to be perceived. The heat required for welding iron varies in some degree with the purity of the iron. When it is required to thicken any part of a bar of iron without welding, it is done by the operation called "*upsetting*." This consists in giving it the welding heat at the part to be thickened, and, while one end rests upon the anvil, hammering at the other till the required size is produced. When the bar is large, if it be lifted and jumped upon the anvil, its own weight will supply the required force for upsetting. When it is required to weld two bars of iron together, the ends are first *upset*, or made thicker.

Each end is then beveled off to a thin edge, called *scarfing;* the two ends are then placed in the fire, and raised to a welding heat, or nearly to a state of fusion; care is required that both arrive at the proper heat at the same time. The bars may in part be prevented from wasting by taking care to supply them at the heated part with powdered glass or sand just before they arrive at the welding-heat. The sand or other material melts on the surface of the iron, and serves to form a flux, or fluid glass, which protects the iron from the impurities of the fuel, and defends it from the air, at the same time uniting with and removing the oxide which may have been formed on the heated scarfs. When the bars have obtained the welding-heat they are removed from the fire with the utmost despatch, and struck across the anvil to remove as far as possible all scales and dirt which would hinder their uniting; they are then placed in contact at the heated part and hammered, the superfluous cinder is squeezed out as the clear parts are brought together, and the hammering continued until no visible seam or fissure remains.

In welding large pieces the process is more difficult. Several minutes must sometimes elapse before the parts can be brought together; meanwhile thick scales are forming on the exposed heated surfaces. The rapidity with which iron at a welding-heat becomes oxidized is strikingly illustrated in the operation of "patting" the Armstrong tubes after they are welded end to end. The scales that form on the inside of the tube are jarred off at every stroke of the hammer upon the outside, thus exposing fresh surfaces to oxidation. At the end of the process the scales form a pile in the tube several inches in depth. See *Iron*.

WELDON RANGE-FINDER.—This is perhaps the simplest of all the instruments yet devised for determining ranges. It is essentially a pocket instrument, has no adjustments, and is scarcely susceptible of injury. If it be correct when new it will continue so. Every new instrument, therefore, should be carefully tested before being put to practical use. The Weldon range-finder consists of a small glass prism, the largest angle of which is 88° 34′ 03″, and the smallest just half this amount. The third angle must of course be 180° minus the sum of these two. This prism is well protected by a metal frame which

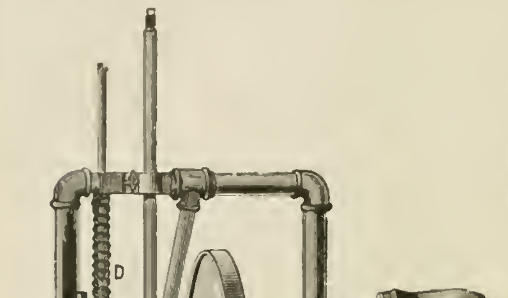


wholly covers its upper and lower sides and the face opposite the largest angle. The face opposite the smallest angle is wholly exposed, the remaining face partially so. The wholly covered face is silvered over so as to act as a mirror. A small handle is attached to the lower side of the instrument for convenience in handling. To determine a range with this instrument when only one instrument is available, one assistant is required. Select some well defined object on the position whose distance is to be determined. Take position with the right side toward this object. Hold the instrument by the handle between the thumb and forefinger of the right hand. Raise it up to the right eye, the wholly covered face of the prism resting against the right side of the nose, the sharp angle of the instrument towards the eye, the largest angle of the prism toward the object. An image of the object will be seen through the instrument in the line of sight as the observer faces. Direct the assistant—who is provided with a suitable stake or pin—upon this line, and cause him to plant his stake, so that it, as seen *over* the instrument, and the image of the object, as seen *through* it, will be in coincidence. Plant a similar stake in the angle of the observer's feet as he then stands. This determines the direction of the base. Pass now beyond the assistant's stake. Turn the left side toward the object. Hold the instrument in the right hand, the handle uppermost and between the first and second fingers, the thumb on its lower side, the sharp angle of the instrument toward the eye, the thumb nail against the right side of the nose. An image of the object will be seen through the instrument on the line of sight. Advance or retire on the line of the stakes already planted, until the image comes on that line. Plant a third stake in the angle of the feet as the observer then stands. Remove the assistant's stake. Measure the distance between the two remaining stakes, and multiply by twenty for the distance from either to the object.

With two instruments and two observers, some time would be gained, especially in determining long ranges. No assistant would be then required. The second observer, holding his instrument as prescribed for the second position in the last case, is directed on the line of the base by the first observer. He then advances or retires along that line, until a point is gained at which the image of the object, as seen *through* the instrument, and the right eye of his associate as seen *over* it, appear in coincidence. If the point be accurately chosen, similar conditions will prevail at the station of the first observer. Each then plants a stake in the angle of his feet, and the base is determined, from which the range is obtained as before. Mathematically, the instrument is very simple, being based upon the fact that the secant of 88° 34′ 03″ is forty times the radius. The instrument is so constructed, that it deflects the image of the object, through that angle, and this, being done at two points on the same line, is equivalent to laying down an isosceles triangle, the angles at the base of which are each 88° 34′ 03″, and the object, the apex of the triangle.

Optically, the instrument is also simple. The ray from the object, *a*, in the drawing, enters the prism at *b*, and is reflected towards the normal through a certain angle. It then impinges on the silvered face of the prism at *c*, is reflected to *d*, and again reflected by that unsilvered surface to *e*; where, emerging from the prism it is again reflected—this time away from the normal through an angle equal to its reflection on entering the prism. It thus enters the eye of the observer in the direction of *e f*, which makes, with its original direction *a b*, an angle of 80° 31′ 03″ or twice the angle of the reflecting surfaces. See *Nolan Range-finder*, *Pratt Range-finder*, *Russell Prism Range-finder*, *Telemeter* and *Watkins Range-finder*.

WELL-BORING.—It is believed that the Chinese have been long acquainted with the methods of deep boring. Deep wells have been in use for centuries in Austria, especially in the neighbourhood of Vienna, where they are very abundant. No knowledge existed as to their source, and consequently the boring was engaged in and conducted in a rude and empirical manner. An excavation was made till a bed of clay was reached; on this a perforated mill-stone was laid, and through the whole the clay was bored until water rose. As soon as geology took the position of a science, and the theory of Artesian wells was propounded, the engineer was able, after the geological survey of a district, to discover whether a supply of water could there be obtained in this way. Already, districts formerly dry and arid have received a plentiful supply of water by means of such wells, and many more applications have yet to be made: it seems likely that ere long Africa's deserts may thus be converted into fertile plains. In an official report of the Algerian Government for 1856-57, it is stated that Artesian borings had been executed in the Sa-

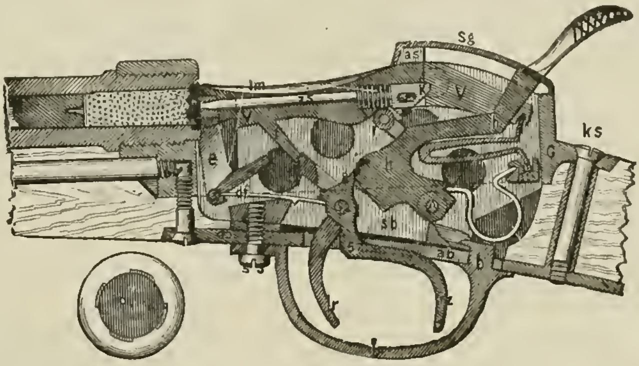


hara of the province of Constantine with remarkable success. The first attempt, after a few weeks' labor, produced a constant stream, forming a perfect river, and yielding 4,010 quarts of water per minute, at a temperature of 78° F. There are now upwards of 75 such borings in the Sahara, yielding an aggregate of 600,000 gallons per hour. The result is proving beneficial not only to the country materially, but also to the character and habits of its nomadic Arab inhabitants. Several tribes have already settled down around these wells, and thus forming the centers of settlements, have constructed villages, planted date-palms, and entirely renounced their previous wandering existence.

Deep boring well machinery is now constructed with a view to transporation, and may readily accompany an army in desert countries. For use in remote, wild or mountainous countries, where it is very difficult and expensive to use steam or horse power, machines are made to be operated by man power alone, 4 to 8 men being able to supply all the power, 4 man power only being required for the first 150 feet, and 6 or 8 man power after a depth of 300 feet or more is reached. Where it is required to transport or carry machines great distances, on the backs of mules, or on shoulders of men, over mountains, or through narrow mountain passes, the machines are made in sections, the heaviest piece weighing less than 200 pounds, all carefully fitted and marked, so they can be taken apart and put together easily. The drawing shows the Pierce portable hand rock or gravel boring-machine, which is well adapted for military usage. It embodies a novel and practical method of operating rock drills, enabling the same to be driven rapidly, and with greater facility than is possible by the usual method of churning by hand or striking with sledge-hammers. Simple in construction, durable, and not liable to get out of order, it is easily moved about by laying it down and rolling it on its wheel, like a wheel-barrow. Its small size, extreme cheapness and simplicity recommend it. As the disk is rotated, the lifting arm is carried upwards by the roller in slot, and as the arm on being raised clamps the drill rod by friction, it carries the latter with it, and as the arm passes over the center of the disk, it turns the drill rod one fifth of a revolution. When the arm is carried over the center, the arm is released and the drill and arm fall together. As the arm falls on the leather cushion below, the drill rod is released, and thus makes a full blow on the rock. An iron ball of 30 to 60 pounds is sometimes screwed to the top of the drill rod, to cause a more effective blow. E is an emery wheel attachment on which to sharpen the drills. With this machine one man can do the work of three. See *Artesian Wells* and *Tube-well*.

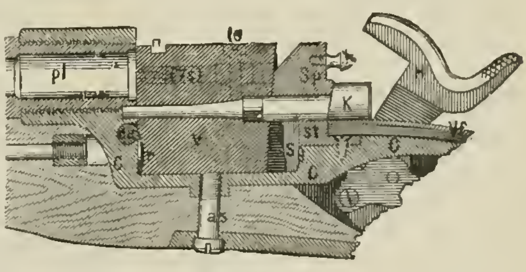
WERDER RIFLE.—The breech-loading system of small-arms adopted in 1869 for the Bavarian Army is the invention of J. L. Werder, of Nuremburg, and is known as the Werder system. It belongs to the class of falling breech-blocks of which the Peabody may be considered the exponent in this country. It differs, however, from this and most other guns of this class, as the breech-block is opened and closed by the hammer, instead of the lever-guard, giving, as claimed, greater safety and ease of manipulation, especially when the soldier loads lying on the ground. The breech and lock mechanism of the Werder gun are contained in a box, the sides of which are two plates which furnish the bearings and pivots of the several parts. This box, with its contents of parts is inserted in the vertical cut of the receiver, the front end of which is screwed to the barrel and the rear end is screwed to the stock by the tang screw, (*k s*,) as is shown in the drawing. The guard-plate, *a b*, closes the bottom of the receiver, but has the necessary openings for the two triggers. The pivot-pins are riveted to the right side-plate, *s h*. The left plate has holes for these pivots, and also a projecting flange *s g*, which forms a cover for the rear portion of the receiver-cut. The breech-block is shown in V. Its forward part is bored out for the firing-pin and the spiral retracting spring. The firing-pin is held in place by a pin, which works in a horizontal slot to give the necessary play. The extractor *e* has two arms; the long arm is forked, and each fork has a claw to seize hold of the rim of the cartridge-head. The forward part of the breech-block is cut away on the under side for the purpose of striking when it falls against the short arm of the extractor, thereby forcing the long arm, with the cartridge-shell, to the rear. The sear-spring, *d f*, serves the double purpose of a sear-spring and a spring for returning the extractor and breech-block to their proper positions for inserting the cartridge. It is supported by a bolster, about two-thirds of its length from the extractor.

The hammer is shown in *h*, and occupies a central position between the side-plates. It is composed of the following-named parts, viz: The comb or thumb-piece which projects from the right side of the breech system, the horizontal branch which passes under the curved cover, *s g*, the part of the body which strikes against the head of the firing-pin *k*, and the full and half-cock notches for the nose of the sear. The mainspring which gives the blow to the hammer is of horseshoe form; the end of one branch rests in a notch in the bolster. The locking-brace is composed of three arms, viz, the brace proper, which supports the breech-lock, the finger-piece, and the rear locking-arm, which is forced upward by a projection on the hammer to insure locking at the moment of full-cock. The locking brace is cut away to receive the sear and trigger, and both pieces work on the same pivot. Attached to the hammer are two arms, one on each side, and between these points is a friction roller. The object of this arm is to press the breech-block up to the position of covering the chamber when the piece is cocked, and that of the roller is to diminish the friction in passing over the curved portion of the block; it also assists in retracting the firing-pin, which it does by pressing against the projection on the under side of the pin at *n*. A V-shaped spring causes the forward portion of the



breech-block to strike with force enough against the short arm of the ejector, *e*, to throw the shell clear of the gun. The upper surface of the breech-block has a groove, *l m*, to facilitate the insertion of the cartridge into the chamber. The projection, *a s*, forms a rest for the hammer when let down to its lowest point. The body of the firing-pin is cut away on its sides, so that its cross section is a hexagon, thus diminishing the bearing-surface against the block, and rendering the pin less liable to be obstructed by dirt or rust. To open the breech-block for loading press on the finger-piece; by so doing the support of the block is removed and it falls under the pressure of a spring, and in falling strikes the ejector, as before stated, and throws out the empty shell. To close the breech, push back the hammer to full cock, when the block is pressed upward by the arm, *h r*. A projection, acting on the curved arm, forces the point of the brace under the projection, and insures the locking of the breech-lock when the piece is fired. It will thus be seen that but one motion is required to open and one to close the breech and cock the piece ready for firing. If the arm is not to be fired at once, the hammer should be lowered to the half-cock notch to prevent accidental discharge. Both carbine and pistol have the Werder breech-loading system. They are accompanied by wiping rods; the carbine-rod is jointed to fold up after the manner of the handle of a parasol; and the pistol-rod is a single piece. The rifle-grooves are four in number, (see drawing); their depth is 0''.0075, and twist is one turn in 22 inches. The diameter of the bore is 0''.435; the length of the barrel, including chamber, but exclusive of breech-frame, is 35''.0; the weight of the arm without bayonet 9.75 pounds. The cartridge belongs to the reprimed class known as "Berdan's." The powder charge weighs 66 grains, and it is of the kind known as musket-powder. The bullet weighs 340 grains, and has three cannelures for lubricant, and a deep, narrow cavity in the center of the base. The cartridge for the carbine and pistol are similar in all respects to that for the rifle, except the charge of powder, which is reduced to correspond to the weights of the carbine and pistol. The bullet is the same for the three arms. See *Small-arms*.

WERNDL GUN.—The new system of breech-loading small-arms, adopted into the Austrian Service in place of the alteration of Wänzl, is the invention of Joseph Werndl, a gun manufacturer of Styria, and is applied to muskets, carbines, and pistols. The breech-block in this system vibrates around an axis parallel to and below the axis of the bore prolonged to the rear of the chamber. The principal parts are shown in the drawing; C, is the receiver screwed to the barrel; the chamber and a portion of the rifling are shown at *p l*; V, is the breech-block, which vibrates around a spindle; *z s*, is the firing-pin; H, is the hammer; *l s*, the firing-pin screw; *d a*, the cartridge-shell extractor; *n*, is the extractor-groove; *s p*, is the striking-plate; *s t*, is the spindle-bed with its fastening-screw and its wedge-shaped head; *v f*, is the spindle-spring, which presses on K, the wedge-shaped head of the spindle. The receiver is screwed to the stock by the forward guard-screw, *a s*, and two rear guard-screws, which screw into the tang of the receiver or bed for the spindle. The extractor-shaft is embedded in the front surface of the well of the receiver below the chamber. The point of one arm is notched

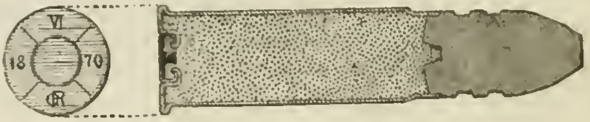


to fit under the flange of the cartridge head, while the point of the other arm projects into the groove *n* of the breech-block V. When this point comes against the end of the groove in turning the breech-block, the cartridge-shell is thrown out. Of course the groove is arranged so that the extractor does not commence to move until the breech-block uncovers the cartridge-head.

The rear end of the breech-block has the form of a screw surface, the height or pitch of which is 5 millimeters, or about 0.2 inch. The front surface of the striking-plate corresponds to the screw at the rear end of breech-block. The reason for this form is that the breech-block shall press firmly against the cartridge-head when closed, and shall be free to move the moment it begins to open. The striking-plate is slipped into its groove in the receiver and held in place by a small screw. The rear of the striking-plate has a projection over the spindle, partly for the purpose of giving a better bearing on the spindle and partly for the reason that the lug *h* forms a stop for the breech-block when closed. A portion has a screw surface corresponding to the end of the breech-block and to the wedge-shaped head of the spindle which is in contact with it. The spindle, K is the axis around which the breech-block vibrates. The head of this spindle is wedge-shaped in cross section, and lies with one of its flat surfaces on a spring when the block is open or closed. The portion next to the head is cylindrical. Next to this it is square, that it may turn with the breech block, and in front of the square portion it is cylindrical conical.

The firing pin is pressed back by a spiral spring near its point, and kept in place by the screw, *l s*, which passes through a notch in the pin. The head of the pin has a slot for adjusting its position with a screw-driver. The lock is of the ordinary back-action pattern, and the hammer is raised to the half or full cock whenever the breech-block is opened, which is done by turning the thumb-piece to the right, and closed by turning it back again to the left. The screw surfaces on the block, striking-plate, and spindle-head, act to force the block against the end of the barrel when closed, and at the same time press the extractor into its recess in the forward part of the receiver. When the breech-block is thrown open a groove in it, is brought opposite to the opening of the barrel for the insertion of the cartridge in the chamber. The action of the spring on the wedge-shaped spindle-head is very important, inasmuch as it keeps the breech-block in place when open and closed, and accelerates the ejection of the cartridge-shell. In the new model gun lately adopted this exterior flat spring was replaced by a spiral spring entirely inclosed and covered up in the receiver. The barrel of the musket is made of good cast-steel. Its length is 33.14 inches, including the chamber, which is 2.07 inches. Its weight is 3.83 pounds. The rifle grooves are six in number, and their depth is 0.007 inch. The lands are 0.07 inch wide, and the grooves 0.15 inch. The twist is one turn in 28.5 inches. The total length of this arm, including its saber-bayonet, is about 73.0 inches, while its weight including the bayonet, is about 11.5 pounds. Without the bayonet the length is about 50.5 and the weight 9.85 pounds. The barrel, bands, and sight are browned. The remaining parts are of a case-hardened gray color. The sight is of the Enfield pattern, and is graduated up to 1,060 meters.

The cartridge adopted for the Werndl arms is a solid-headed shell, drawn out from sheet brass, composed of 93 parts of copper and 7 of zinc. Its form is shown in the drawing. It has an outside center-



fire primer, which is so arranged that there is no escape of gas from the charge. The charge is 63.0 grains of musket-powder. The bullet is made of soft lead, 1.18 inches long, and weighs 313.0 grains. It has a small expansion cavity in its base, two cannelures, and a rabbet for the bullet to fit into the mouth of the cartridge-shell. The bullet is lubricated by dipping the point as far as the shell into a melted composition of 7 parts of tallow and 1 of bees-wax. Attempts have been made in Austria to use compressed powder for arms of small caliber, and it is understood that this form of powder is still employed in the cartridges for the 2,000 Remington trial guns in the hands of the Austrian troops. The difficulties met with in Austria in making compressed-powder cartridges on a large scale, are to regulate the compression to suit the varying densities of service-powder, the mechanical difficulties to be overcome, and the danger from accidents. Therefore the results obtained in firing such cartridges are inferior to those of grain-powder in the loose state. A breech-loading carbine and breech-loading pistol, both on the Werndl breech-loading plan, constitute portions of the small-arm system of Austria. The cartridges of these arms are similar to those of the rifle, except the charge of powder.

The Austrian army revolver may be briefly described as follows, viz: Total weight, 2.0 pounds; total length, 12.0 inches; length of barrel, 7.2 inches; length of cylinder, 1.9 inches; diameter of bore, or caliber, 0.433 inch; number of grooves, 6; width of grooves double that of the lands; twist, one turn in 16 inches. The cartridge-shell and bullet are the same as those employed for the Werndl rifle and carbine, the powder-charge is 20 grains less than that for the carbine, and the vacant space between the powder and bullet is filled with a wad. The initial velocity is 524 feet. With the exception of the locks, which are made at the imperial arsenal in Vienna, the Werndl rifles for the Austrian Government are made by Mr. Werndl at his private armory in Styria. See *Small-arms.*

WERTHMULLER SYSTEM OF FORTIFICATION.—In this system the enceinte has fausse-braie; and in rear, the buildings are disposed for resistance. The long ravelins are flanked by the enceinte; and their flanks are intended to give a reverse fire in the dead angle of the tenailles.

WESTCOTT COMBINATION CHUCK.—A variety of chuck much used in arsenals, and adapted for work

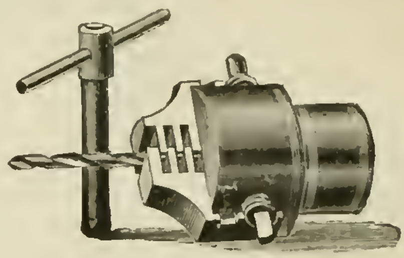
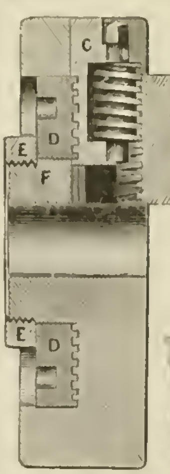


Fig. 1.

on all round, oval, oblong or eccentric shapes. The drawings show the device, in sections, also its mode of action. The features of this chuck consist in not only making the jaws reversible, by which arrangement the small-sized chucks can be used with facility in holding screws, pipes and drills, but also in making them act independently of each other if required, as well as to act concentrically and simul-



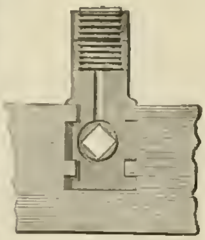


Fig. 2. Fig 3.

taneously. This chuck is therefore enabled to seize

WEST INDIA ISLANDS
SCALE OF MILES
0 50 100 200 300
Railroads
UNITED STATES
FLORIDA
GULF OF MEXICO
ATLANTIC OCEAN
BAHAMA ISLANDS
CARIBBEAN SEA
CENTRAL AMERICA
SOUTH AMERICA
VENEZUELA
MOSQUITO
CUBA
HAITI
SAN DOMINGO
JAMAICA
PANAMA
GREATER ANTILLES
LEEWARD ISLANDS
WINDWARD ISLANDS
VIRGIN ISLANDS
Gulf Stream
Florida Str.
Old Bahama Channel
Windward Passage
Mona Passage
Nicolas Chan.
Providence Chan.
Tampa B.
Charlotte Har.
C.Romano
C.Sable
C.Canaveral
C.S.Blas
Apalachee B.
Key West
FLORIDA REEF
TORTUGAS
TROPIC OF CANCER
HAVANA
C.S.Antonio
C.Catoche
C.Corrientes
PINOS ID.
COZUMEL
Cienfuegos
GT.BAHAMA
GT.ABACO
LIT.ABACO
ANDROS
ELEUTHERA
BERRY IS.
Nassau
INAGUA
TURKS IDS.
SILVER BK.
BAJO DE NAVIDAD
C.Isabella
C.Vieux Francais
C.Samana
Samana B.
San Domingo
San Juan
PUERTO RICO
C.Rojo
MONA
SAONA
BEATA
ALTA VELA
TORTUGA
LIT.CAYMAN
CAYMAN BRAC
George T.
GD.CAYMAN
MISTERIOSA BK.
VICIOSAS
SWAN IDS.
PEDRO BK.
PORTLAND RK.
Morant Pt.
Kingston
N.Negril Pt.
S.Negril Pt.
SERRANILLA
BAJO NUEVO
EL COMBOT
LA VELA
C.Gracias a Dios
MOSQUITO CAY
QUITA SUENO
SERRANA CAIS
OLD PROVIDENCE
ST.ANDREW
Pearl Cay Pt.
Bluefields
L.Nicaragua
S.Juan del Norte
G. of Nicoya
L.Chiriqui
Chagres
C.S.Blas
G.of Darien
Cartagena
Magdalena R.
G.of Maracaybo
L.Maracaybo
Maracaybo
Pt.Gallinas
ORUBA
CURACAO
BUEN AYRE
LOS ROQUES
ORCHILLA
BLANQUILLA
TORTUGA
MARGARITA
Caracas
Barcelona
Cumana
TESTIGOS
TOBAGO
Scarborough
TRINIDAD
P. of Spain
Paria G.
C.Galeota
Mths. of the Orinoco
GRENADA
S.George T.
GRENADINES
CARRIACOU
S.VINCENT
Kingstown
BARBADOES
Bridge T.
S.LUCIA
Pt.Castries
MARTINIQUE
Ft.Royal
DOMINICA
Roseau
GUADELOUPE
Basse terre
LES SAINTES
MARIE GALANTE
DESIRADE
Pt.a Pitre
MONTSERRAT
ANTIGUA
S.John
BARBUDA
NEVIS
S.CHRISTOPHER
S.EUSTATIUS
SABA
S.BARTHOLOMEW
S.MARTIN
ANGUILLA
SOMBRERO
ANEGADA
VIRGIN GORDA
S.CRUZ
Christiansted
AVES
Longitude West from Greenwich
85 80 75 70 65 60
25 20 15 10

and hold firmly round, oval, oblong or eccentric shapes, as well as to hold work in an eccentric position.

Figure 2. is a vertical section showing the manner in which the ring *D*, engages in the box *C*; also showing the position of the screw *B*. Fig. 3. is a section of the chuck showing the end of the screw and box, *C*; also the strong and durable manner in which all the parts are secured to the body of the chuck. All screws and the boxes carrying the jaws are made of the best cast-steel, the jaws, wrenches and scroll ring of the best hammered iron, made especially for this work. The jaws and all wearing parts are thoroughly case-hardened.

Fig. 1. shows a self-centering drill chuck, very compact and having no projection to throw it out of balance or to catch in the sleeves of the workmen. The jaws do not extend outside of the body of the chuck when opened to their fullest extent. See *Chuck*.

WESTINGHOUSE ARMY ENGINE.—This renowned automatic engine, so extensively used for military purposes in Europe and the United States, is the result of a most rigid system of construction which involves the best appliances in the way of special tools and processes. All parts are built strictly to gauge, within an allowance of one five-hundredth or one thousandth of an inch, according to size. This necessarily leads to complete *interchangeability of parts*, and extends to every detail of the engine. The details of construction will be best understood by a reference to Fig. 1. The cylinders, *A A*, are cast in one piece with the valve-chamber, *B*, and are bolted to the top of the bed or crank case, *C*. The cylinder heads, *a*, *a*, cover the upper ends of the cylinders only, the lower ends being uncovered and opening directly into the chamber of the crank case. The pistons, *D*, *D*, are of the "trunk" form, double walled at the top to prevent condensation, open at the bottom, and carrying the hardened steel wrist pins, *b*, *b*. They are packed with four rings. The connecting rods, *F*, *F*, are hollow, with ribs, and are subject to compression only; the cranks, *G*, *G*, balanced by the bolts, *x*, *x*, the crank pin, *P*, and the crank shaft, *H*, *H*, are all of steel, and may be removed by taking off the crank case head, *c*. The steel of which the cranks are made is cast under pressure and is a true steel; its quality is shown by the fact, that it may be drawn out and tempered for a lathe tool. The crank shaft bearings are in the form of removable shells, *d*, *d*, lined with Babbitt metal which is expanded into place under a hydraulic pressure of 15 tons per square inch of surface. A chamber is formed in the flange of the shell, *d*, inclosed by the cover *d'*. In this chamber, and revolving with the shaft, is the wiper, *W*, which takes up the oil as it works past the bearings and returns it through the tube, *e*, into the crank case, *C*. This renders all other lubrication unnecessary and keeps the engine clean. A syphon overflow, with a funnel head, *n*, prevents any accumulation of water from rising above the level of the pipe, *e*, and at the same time prevents the escape of oil. This

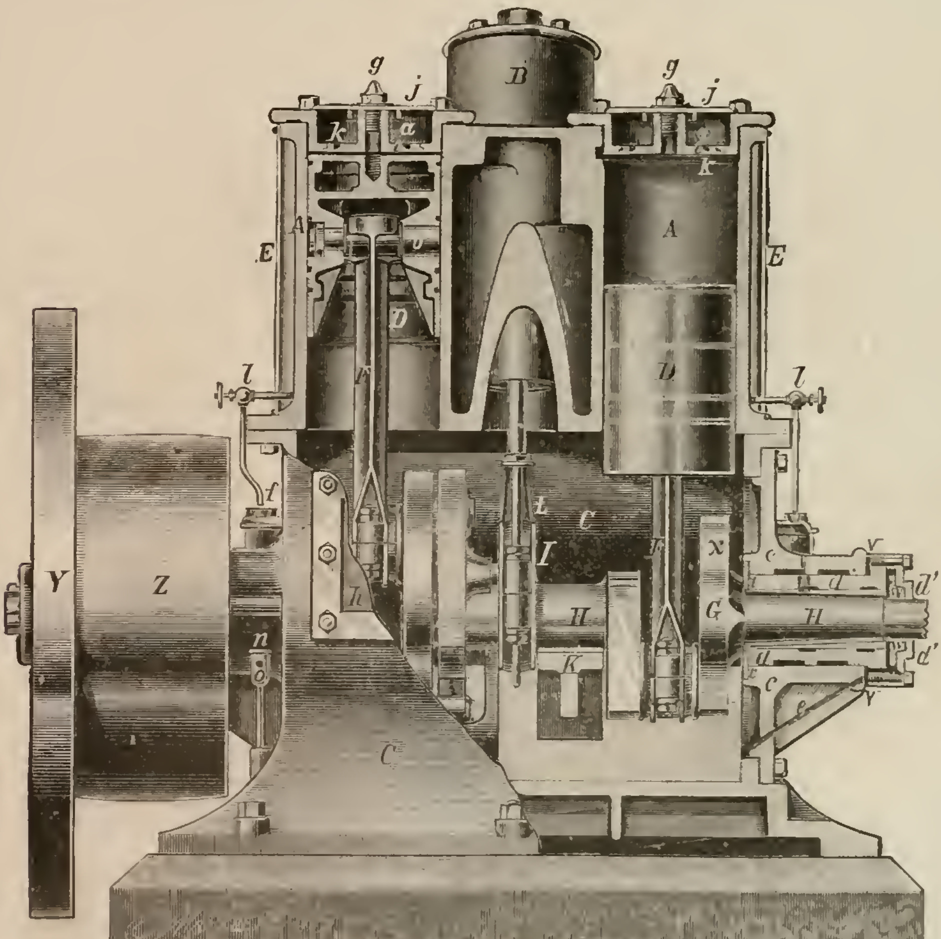


Fig. 1.

overflow may be piped off at the hole, *o*, in the funnel head,as convenient. Collar washers,*t*,*t*,of bronze, form the end bearings of the cranks. Lead washers, *r*, prevent the taper sleeves from being taken up so as to cause binding. A center bearing, *K*, bridges the crank case,and receives the thrusts of the pistons. The bonnet,*h*,is removed to give access to the cranks. The valve, V, is of the piston variety, of improved construction. Water is supplied to the crank case through a pipe,and the level indicated in the funnel head of the overflow pipe. The water cannot rise too high, but care should be taken that it never falls so low as to be out of sight in the funnel head.

Oil for the lubrication of all the internal parts *may* be added through the pipe, R, but it is preferable to maintain a constant feed into the oil cups, *f*,*f*,on the main bearings, whereby their proper lubrication is first assured, and the oil afterwards returned into the case by the wipers, for the benefit of the crank pin and all the other bearings. No other oiling than through these cups is required. The front portion of the jacket conceals the oil reservoir, which fills the entire space between the cylinders, and delivers to the oil cups by concealed pipes and cocks. The reservoir once filled,will last a long time,'and the entire lubrication of the engine, (except the valves and cylinders which are lubricated from the steam pipe in the usual way), is thus introduced from one point. The cocks, should be kept open to allow a *constant* but slow drip of oil into the cup. The band-wheel is a combination pulley, *Z*, and fly-wheel, Y, cast together,so that the pulley overhangs the main bearing,throwing the line of belt strain well towards the center of the bearing,and taking the spring off from the shaft. The automatic governor is located on the shaft, between the cranks,and actuates the valve direct without rock-shafts or other mechanism. By means of governor weights the eccentric is thrown to its position of greatest eccentricity, giving a maximum travel to the valve, corresponding to a cut-off of about ⅝ stroke. The parts of the governor remain in this position till the engine is within a few revolutions of its full speed. The centrifugal force of the weights then over-balances the tension of the springs,and the weights move outward, reducing the travel of the eccentric and valve, and consequently shortening the point of cut-off. This engine is peculiarly adapted as follows:

To Electric Lighting of all kinds. Belting is direct from the fly-wheel of the engine to the dynamo, and the expense of counter-shafting, together with the one or both ends of the engine shaft, the outer ends being carried in pillow-block, as seen in Fig. 2. These shafts carry the driving pulleys, and the cost is much less than that of counter-shafting, besides saving very considerably in power. Still another plan, convenient in many situations, is to couple a pair of smaller engines, cranks quartering, to each end of a shaft of required length, which carries the driving pulleys as seen in Fig. 3. There are advantages, however, in favor of independent engines. In addition to the "Standard" engines, for this purpose a specialty of engines is made and connected directly to the dynamo-electro machines, the armature serving as the fly-wheel. Where space is an object, this system is of great value.

To Circular Saw Mills.—In large merchant mills, one of two systems may be adopted. First we couple a single engine to the jack-shaft at say 300 revolutions, belting direct from pulleys on the shaft to the circular, the gang, and to the shaft driving the trimmers, edgers, etc. The high first motion enables us to dispense entirely with heavy and costly counter-shafting and bearings, enormous pulleys, and wide belts. The speeds being not over two to one, the belts are nearly parallel, avoiding tightness. Second, we subdivide the power, driving the circular by a single engine, belted: the gang by another, which may be belted or coupled direct, and the small machinery of the mill by a third. This plan does away with shafting and pulleys almost entirely, and the first cost of the several engines is no greater than that of a single engine of equal power. *But one engineer is required.* Either plan results in a saving of thousands of dollars in the first cost of shafting, pulleys and belts, and other thousands in their subsequent maintenance, and avoids a heavy loss of power from friction.

To Rolling Mills, from their compact shape and solid build, their protection from dust, and the convenience of connecting direct to high-speed roll-trains, cold saws, etc.; thus saving heavy belts, pulleys, counters, and power.

To Grain Elevators. A small engine may be geared direct to each "leg," and drive the blowers, steam-shovels, leg hoists, conveyers, etc., each by its own engine, reversing when necessary. While the saving in the first cost is many thousands of dollars, the most important consideration is that of maintenance and running expenses, in which marked advantages appear in favor of the system of independent power. Superintendents will appreciate the desirability of

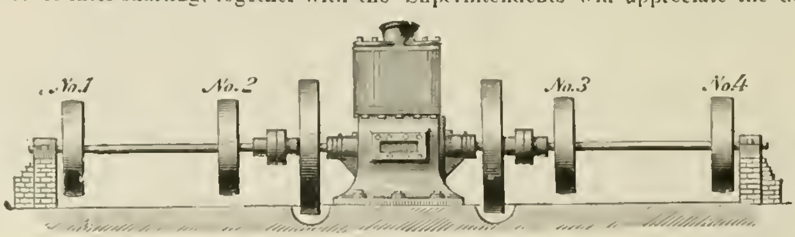


Fig. 2.

room and power required to operate it, is entirely avoided. It is usually preferable to drive each dynamo, or at most, two dynamos, from a single engine. By this means each circuit is made independent of all the rest, and may be shut down or started without interfering with the others, and the consumption of steam is kept closely proportional to the number of lights actually burning, which is by no means the case when a single large engine is part of the time running only a few lights. The first cost of the power is usually materially less by this system, and for beautiful steadiness of the lights it probably has no equal. This is especially noticeable with incandescent lamps. Should it be preferable to drive three or more dynamos from a single large engine, shafts of proper length are coupled direct to running each leg at the speed best adapted to the condition of the grain at that moment in transit. Nor does any temporary accident, such as "choking," etc., compel the shutting down of the whole elevator. But one engineer is required for all the engines. When preferred, it is easy to drive from several large engines set over the bins, and belting to the shafts. Being self-contained, the engine is particularly adapted to this service.

To Wire Mills, on an improved plan of connecting a small engine direct to each bench with one gearing. This saves the enormous cost of heavy shafts and bevel gears, and the dead loss of power required to run them, allows the blocks to be run at their most efficient speed, and admits of indefinite extension by adding an engine with each bench. The engines take up little room, and are handled by the nearest workman.

To Planing Mills, etc., using high-speed machinery. The line shaft is run at from 300 to 400 revolutions, and saves largely in weight of shaft and size of pulleys. Divided power is of advantage in many cases.

To Fan-blowers, which may be driven direct or by belts without counter-shafts. The dust-proof qualities of the engine are especially valuable in foundries and similar situations.

To Rotary or Centrifugal Pumps, by a direct connection or otherwise for fire-service, drainage, irrigation, etc. Whenever a variable speed is required, the engine is fitted with a variable cut-off, adjustable by hand.

To Direct Connection to shafting of all kinds. In many mills it is desirable to drive each line shaft by a separate engine. In that case only one engineer is required for any number of engines, and their compact form will enable them to be set on a wall-pier or similar foundation.

To Mining, in a very especial manner on account of their compact form and light weight per horse-power, reducing cost of transportation, their entire protection from grit or dust, and their extreme simplicity and freedom from repairs in regions remote from machine-shops. A set of duplicate parts for repairs can be carried in stock at small cost.

To Deficient Water Power, as a relay engine. In many such cases steam power is only required for a few weeks in the year. Low first cost then becomes a matter of serious consideration, as also a degree of simplicity which will admit of any ordinary helper as a temporary engineer, without the necessity of keeping a first-class man under pay. Where the engine is liable to stand idle for some months, the fact that all the parts are inclosed from dust and submerged in oil renders slushing or other preservative care unnecessary.

To Portable Power, where pumps, electric lights, etc., must be mounted on a truck.

WESTLEY RICHARDS RIFLE.—A breech-loading small-arm having a fixed chamber closed by a movable breech-block, which rotates about a horizontal axis at 90° to the axis of the barrel, and lying above the axis of the barrel and in rear, being moved from below. In its general features this arm resembles the Martini, having, however, the lever separate from and pivoted in front of the guard, and by its movement in opening, cocking the true hammer lying concealed beneath the block, and impelled by a flat mainspring placed below the barrel. The blow of the hammer is directly delivered upon the cartridge, a groove for its movement being cut in the under side of the breech-block. The usual extractor in guns of this class is employed.

WEST POINT ARMY MESS.—A Mess established at West Point in 1841, and now having about 275 living members. It is the right of any commissioned officer of the Army of the United States, and of no other person, to become a member of this Mess.

Every officer on joining the Mess is required within four months thereafter, to pay, as an initiation fee, one fifth of the monthly pay of a Second Lieutenant (not mounted) prior to five years service, increased by one-half of any amount by which his monthly pay at the date of his joining may exceed the aforesaid minimum monthly pay of a Second Lieutenant. In case of officers temporarily on duty, such as members of Courts-Martial, Boards, etc., not forming part of the Military Academy, this fee is not considered as due until the officer shall have been stationed at the Post for a period of six months. Any member of the Mess whose pay is increased, must pay one-half of the amount of the increase for one month, provided such increase continues for a period of six months.

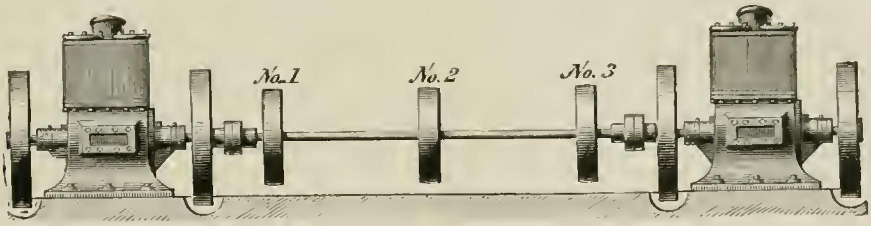


Fig. 3.

This amount is due from the date of his change of pay. A married officer on joining the Mess, must pay one-half the entrance fee above mentioned, and there is due from him one-half of the amount as due from an unmarried officer, when receiving an increase of pay.

The officers of the Mess are a President, a Treasurer, a Caterer, a Senior Council of Administration and a Junior Council of Administration. The senior officer present is *ex-officio* President of the Mess. The Treasurer is elected by ballot for a period of six months, or when a vacancy occurs, and by a majority of the members present at the Post. The Caterer is elected for a period of three months, or when a vacancy occurs. He is taken from among the resident members, and is elected by a majority of them. The Junior Council consists of the three senior resident members, exclusive of the President; and when one of these is required as Treasurer or Caterer, his place is filled by the next in rank. The Senior Council of Administration consists of the members of the Junior Council and two non-resident members of the Mess. The Junior Council is named quarterly by the President and the additional members required to constitute the Senior Council are elected semi-annually by ballot, by a majority of the members present at the Post. In case of the non-existence of a Junior Council, the duties herein assigned to the Senior Council are performed by the two non-resident members of the same.

All orders, rumors and conversations relating to, or in any manner affecting the Military Academy, or Post of West Point, and also those relating to the ordinary detail of the Post, are not touched upon or discussed at the Mess Table before the removal of the cloth. The dinner costume of the Mess, on all occasions when the Mess as a body gives an entertainment, is the full uniform prescribed in the General Regulations for the Army, with the exception of the sword, sword-belt and cap; on all other occasions it is the undress uniform as prescribed by the same Regulations. Any officer of the Army, who is a member of the Mess, and who resigns his commission in the Army, shall, nevertheless, continue as a member of the Mess, and he is entitled to all the privileges thereof. Upon the motion of any member of the Mess, a majority consenting thereto, the Mess may impeach any member, and by a vote of four-fifths of the members stationed at the Post, may dismiss him.

Pursuant to action recently taken, the West Point Army Mess is now a body corporate, endowed by law with all the rights and liabilities of an individual.

WEST POINT FOUNDRY.—The West Point foundry was established under the special patronage of the Government in 1817. In 1819 an agreement was made with the Ordnance Bureau to receive all the old unserviceable cannon, carronades, shot, stools, etc., at the Navy Yard, Brooklyn, N. Y., and to return kentledge therefor; to pay $25 per ton for old iron, and deliver the kentledge at $55 per ton. On July 11, 1820, the first contract was made and signed by Gouverneur Kemble, President of the West Point Foundry Association, for 32 42-pounders, long guns at $125 per ton, to be delivered in New York in twelve months; December 1st, the same year, the following guns were ordered by the Ordnance Board: 24 42-pound carronades at $185 each; 32 42-pound cannon at $125 per ton; 36 32-pound cannon at $125 per ton; 4,500 42-pound round shot at five cents per pound; 3,500 32-pound round shot at 5 cents per pound; 1,200 42-pound stools at five and one-half cents per pound; 610 32-pound stools at five and one-half cents per pound; 14,400 42-pound grape shot at eight cents per pound; 7,680 32-pound grape shot at eight cents per pound; 300 32-pound double head at six cents per pound.

From the establishment of the West Point foundry until the commencement of the Rebellion this establishment was engaged in the manufacture of cast-iron, smooth-bore Dahlgren and Rodman guns, which were at that date as efficient as any ordnance then manufactured in the world. At the commencement of the civil war immediate demands were made by the Government upon the West Point foundry, and its whole force was devoted to the production of rifled cannon on the Parrott system, a peculiarity of which consists in the band or reinforce of wrought iron made by coiling a bar of iron upon a mandrel, and the welding of this coil into the breech of a cylinder which is afterwards bored and turned and shrunk upon the breech of the gun; the manner of attaching the band to the gun is another peculiarity, as is also the mode of rifling and the expanding projectiles used in this system. In 1860 were first manufactured the 10-pound Parrott guns, and in the following year 20 and 30-pounders, the Parrott projectile, and also the 100-pounders; still later were made the 200 and 300-pounders: of this special system of ordnance were manufactured of the various sizes about three thousand, and one million six hundred thousand projectiles. Since the close of the war the West Point foundry has received orders for supplying ordnance from Spain, Peru, Chili, and Venezuela, and have also *converted* for the U. S. Government a considerable number of ten-inch Rodman guns into eight-inch rifles, and eleven-inch Dahlgren guns into eight-inch rifles, for use in the army and navy. The original Rodman and Dahlgren guns are of cast-iron, and the conversion consists in the inserting of a coiled wrought-iron tube inside the old gun. The system adopted by the United States after careful experiments is a combination of the cast-iron shell with the wrought-iron tube, a gun being thereby produced which, it is believed, will stand as heavy charges and repeated firing as the built-up wrought-iron guns lined with steel, manufactured at Woolwich by the British Government, and at Elswick by Sir William Armstrong, or even as the forged steel ordnance made by Fred Krupp in Germany. These guns can be produced at much less cost than the European ordnance, more particularly for the reason that the largest portion is composed of cast-iron, a much cheaper material than either steel or good wrought-iron.

When reporting on the converted guns, the Chief of Ordnance, in 1876, said: "It must now be conceded that the strength and value of conversions by using coiled wrought-iron lining tubes for 8-inch rifles have been proved and established. The success which has attended these experiments at Sandy Hook in the effort to utilize our smooth-bore cast-iron guns by converting them into rifles of great power and efficiency is a source of great satisfaction, and this uniform success justifies us in the conclusion that equally satisfactory results will follow our trials with the higher nature of 10-inch and 12-inch rifles which are now in course of preparation. If our anticipations are realized in the success of these larger calibers, the Department will have developed a system of heavy ordnance at small expense which will compose an armament for our forts fully able to cope with foreign guns of equal caliber. Such a system will bring the manufacture entirely within the capacity of our private foundries, using our own raw material and with no dependence on foreign establishments." Again, in 1878, the Chief of Ordnance remarks that "the 12¼-inch rifle completed and mounted at Sandy Hook had been fired only twenty-four rounds with charges varying from 60 to 120 pounds powder, and shot weighing 600 to 700 pounds. The report shows that with 115 pounds powder and shot weighing 700 pounds, it gave a velocity of 1,485 feet with pressure of 33,500 pounds to the square inch; a very satisfactory result—comparing favorably with results obtained in other countries with guns of the same caliber. To the length of bore and the excellent character of our powder and projectiles may be attributed its superiority, if any, over others. While unable to make an exact comparison between this gun and those used abroad as to capacity for work because of differences in charges of powder and weights of projectiles, the following favorable indications may be noted: The English 38-ton gun with 85 pounds powder and 600 pounds shot has given 450 foot-tons *less* energy than ours; Krupp's, with 88 pounds powder and 664 pounds shot has given 1,254 foot-tons *less* than ours. The Italian with 110 pounds powder and 770 pounds shot has only given about 400 foot-tons *more* than ours. Our gun uses only eighty pounds powder and 600 pounds shot. With 110 pounds powder and 700 pounds projectile our American rifle yields 9,551 foot-tons, an energy about as great as is given by any gun known using the same charge, and superior to the Krupp and Italian using *heavier* charges." The performance of these guns, however, is sufficiently satisfactory to demonstrate that they would be very effective against the powerful iron-clads of Europe, and their success has led to the adoption of the system by the Government of the United States, and it is quite evident that with new guns built upon this system and adopting the latest European improvements, there can be no question but that equally good results could be obtained. The experiments made in Europe during the past twenty years have been at a vast expense, and we can take advantage of all the results arrived at, and, adopting such improvements as seem advisable, omit the errors that have been committed, with no outlay for experiments beyond the cost of the firing of trial guns as required by the U. S. Government when a new model or caliber is introduced.

The West Point iron-foundry is supplied very fully with all the necessary appurtenances for manufacturing heavy ordnance of all descriptions, including wrought-iron tubes up to eighteen-inch bore, also muzzle-loading and breech-loading rifled cannon of all calibers, and which are in every respect fully up to the standard of quality required by the Ordnance Department of the Army and Navy. They also have facilities for the manufacture of expanding projectiles of all the new patterns, together with shells and battery shot with chilled ends. There seems no question but that the use of muzzle-loading rifled-guns will be discontinued, and that they will be superseded by breech-loaders, of which the advantages are now admitted and the difficulties of construction have been overcome, thus securing through the new system adopted by the United States greater initial velocity, heavier projectiles and guns of much greater strength, sufficiently powerful to destroy any iron-clad which can cross the Atlantic. [NORTON'S BREECH-LOADING SMALL-ARMS, HEAVY ORDNANCE, AND OTHER MUNITIONS OF WAR.] See *Foundry* and *South Boston Foundry*.

WETTEREN POWDER.—The royal powder-mills at Wetteren are situated on the Scheldt, near Ghent, and occupy over 27 acres, surrounded by a wide, deep ditch, which may be filled with water from the Scheldt, at high tide, and drained at low tide by means of a canal and flood-gates constructed for this purpose. It employs 250 workmen. The charcoal is prepared from the berry-bearing alder, a kind of buckthorn which grows in damp forests, the wood of which is ackowledged to be the best of all for the manufacture of gunpowder. The process of preparing the charcoal is peculiar, and is said to produce coal of the best quality. The distillation is effected by means of superheated steam. The wood is placed in a wrought-iron cylinder, the end of which is tightly closed and securely held by clamp-screws. Steam is carried in a thick wrought-iron pipe from a boiler to the fire-place of the boiler, where, making several turns in contact with the flames, its temperature is raised to 500° F. or 570° F. It is then introduced by means of a stop-cock into the cylinder which contains the wood to be carbonized. The hot steam quickly penetrates the pores of the wood, dissolves and drives out the sap, pyroligneous acid and tar, which are formed at this high temperature. These are permitted to escape as desired by means of a stop-cock and pipe, which conducts the gases and vapors into the flue of the chimney, or by another pipe into a condenser, from which the gases are conducted into the fire-place and are burned, to assist keeping up the fire under the boiler, and thereby economize fuel. The quality of the charcoal, whether that of the red or the more thoroughly-burned black coal, will depend upon the less or greater time the wood is subjected to the action of the steam in the cylinder, and its temperature. The operation can be stopped at any moment by closing the cock which lets on the steam. The charcoal is taken out and put quickly into copper coolers, where it is kept till it has entirely cooled off. The proportion of ingredients used is 73.775 saltpeter, 12.020 sulphur, 14.205 charcoal. The saltpeter, with a proportion of charcoal, is pulverized in wrought-iron barrels containing an equal weight of bronze balls, and making 24 revolutions-per minute. The sulphur has likewise a portion of charcoal added to it, and is pulverized in the same way. These two compositions are then put together in the proper proportions, and are mixed in leather barrels with an equal weight of bronze balls. After running in the barrels for one hour, the materials are transferred to the wheel-mill, where they are still further incorporated, each charge of 55 pounds being for two hours under stone wheels weighing from 22,000 to 26,000 pounds the pair, and making from 5 to 6 revolutions per minute. See *Gunpowder*.

WHEEL.—All artillery carriage wheels are similarly constructed; they differ, however, in the size and strength of certain parts, depending on the size of the carriage to which they are attached. The principal parts are the *nave*, the *nave-bands*, the *nave-box*, the *spokes*, the *felloes*, and the *tire*.

The nave constitutes the central portion of the wheel, and distributes the pressure of the axle-arm to the spokes. It is generally made of a single piece of wood, and strengthened by four iron bands called the nave-bands. It is also pierced with a conical hole for the axle-arm: and to diminish wear and friction, it is lined with a box of brass or cast-iron, called the nave-box. The spokes serve to transmit the pressure of the load to the rim of the wheel. In all artillery carriages there are *seven* felloes and *fourteen* spokes. The felloes are the wooden segment which form the rim, and are joined together at their ends by wooden pins, or *dowels*. The tire is a strong band of iron, shrunk tightly around the felloes, to hold them together, and protect the rim from wearing away by contact with the ground.

The spokes are fastened to the nave and felloes by means of mortises and tenons, and in a direction oblique to the axis of the nave. Thus situated, they constitute the elements of a conical surface which is called the *dish*—the principal object of which is to give stiffness to the wheel, and enable it to offer greater resistance to the lateral vibrations of the load in passing over uneven ground. The *height* of the dish will therefore depend on the nature of the ground; and in artillery carriages, which are required to pass over a great variety of ground, it is about two inches. The dish gives *elasticity* to the wheel, and increases its durability: it permits the axle-tree to be made shorter, and therefore stronger; it relieves the linch-pin of a certain amount of pressure, which it transfers to the shoulder-washer—the wheel is, therefore, less liable to come off in travelling; for a given length of axle-tree, it allows a greater width of carriage-body; and finally, it throws the mud clear of the carriage. The stiffness of a carriage-wheel may be increased by placing every alternate mortice in the nave nearer the shoulder of the axle-tree: this gives one half of the spokes a greater dish than the other half. This plan, however, does not answer for artillery carriages.

The object of a carriage-wheel is to diminish the resistance opposed to draught, by transferring the friction from the ground to the axle-arm. When a carriage is at rest, the lowest element of the axle-arm is supported on the bottom of the nave-box. To set the carriage in motion, the friction along the elements of contact, arising from the weight of the carriage must be overcome, and the axle-arm must rise in the nave-box as though it were moving up an inclined plane tangent to the surface of the box. When this is done, the resultant of the weight of the loaded axle-arm and force of traction causes the wheel to revolve around the point of contact with the ground, and the continuance of this condition sustains motion. Let P be the weight resting on the element of contact: p the weight of the wheel: X the force necessary to produce motion; r the radius of the box; and f the co-efficient of friction between the arm and the box. When the wheel is well greased, this co-efficient is about 0.180. To determine the force acting parallel to the ground which will move the wheel, we have the resultant of P and X, equal to $\sqrt{P^2+X^2}$, and the friction arising from it, equal to $f\sqrt{P^2+X^2}$. The pressure on the ground is $P+p$; and if the wheel slips, the friction on the ground will be $F(P+p)$, F being the co-efficient of friction. The points of these resistances, being at the distances r and R from the center of rotation, respectively, they will counteract each other when

$$rf\sqrt{P^2+X^2}=FR(P+p).$$

If the wheel turns, there is no slipping on the ground, and

$$fr\sqrt{P^2+X^2}<FR(P+p),$$

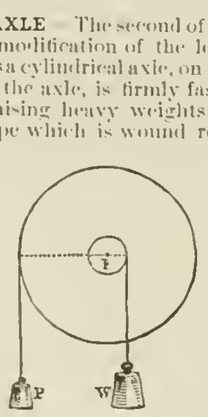
from which it results that

$$X=fr\frac{\sqrt{P^2+X^2}}{R}=\frac{frP}{\sqrt{R^2-f^2r^2}}$$

So long as the wheel turns, the draught is not affected by the friction on the ground, since the value of X is independent of F: but if F becomes so small that $fr\sqrt{P^2+X^2}$ becomes equal to or greater than $FR(P+p)$, the wheel will no longer turn, but slide as the runner of a sled. This occurs on ice, or when the wheels are locked; in which case the draught is proportional to the friction on the ground. From the expression for the value of X we see *that the resistance which a wheel offers to motion increases with the radius of the axle-arm, and decreases as the radius of the wheel increases*. When the radii are nearly equal, the wheel becomes a roller—a machine much used in modifying the friction of fortress carriages.

In the theoretical expression of the force necessary to move a wheel, rolling-friction has been omitted, as it is very small when the wheel is inelastic, and the ground is very hard. The experiments of Coulomb show that this kind of friction does not increase the draught of an artillery carriage more than 2¼ pounds. When the wheel penetrates the ground, it will experience the same resistance as though it were moving upon an inclined plane whose inclination increases with the depth of penetration: and Edgeworth found, in experiments with two-horse carriages, that the force necessary to move a wheel is six times greater than the theoretical force. This difference arises from the compressibility of the soil,and the flexibility of the wheel. On railroads, where the wheels and track are made of iron, the actual and the theoretical draught are very nearly the same; and on the best roads it is about *five* times more than on a railroad. The depth of the *rut*, or track, made by a wheel,may be reduced by making the felloes broader: this increase will also cause a wheel to pass more easily over rough ground. Rumford found by experiment that a 7-inch felloe required *one-tenth* more tractile force than one of 12 inches breadth, on a pavement, *one-twelfth* on a hard road,and *one-seventh* on a sandy road. The saving of tractile force arising from increasing the diameter of a carriage-wheel, is limited by the height of the horse, for if the center of the nave be higher than his shoulders—the point at which the traces are attached—the line of traction will be inclined downward, and if he be moving up hill,or on level ground, the vertical component of the tractile force will increase the friction of the wheel, and diminish the hold of the horse upon the ground. If he be moving down hill, the same cause diminishes the friction of the wheels, and consequently increases the difficulty of holding back. Large wheels surmount ordinary obstacles more easily than small ones, and penetrate less into yielding ground. The wheels of gun-carriages should be as light as possible, to prevent the axle-tree from being bent in the first instant of the recoil, before their inertia is overcome. To make it practicable to replace broken wheels in the field, there should be as few kinds as possible for each service. In the field-service there are two sizes, called Nos. 1 and 2; and in the siege service but one. The No. 2 wheel is stronger than No. 1, and is used on the heaviest carriages. Both wheels, however, have the same height (58 inches) and the same size of nave-box, that they may be interchanged if necessary. The siege wheel is 60 inches in diameter. See *Archibald Wheel*.

WHEEL AND AXLE.—The second of the mechanical powers, and a modification of the lever. Its most primitive form is a cylindrical axle, on which a wheel, concentric with the axle, is firmly fastened. When employed for raising heavy weights, the weight is attached to a rope which is wound round the axle.



and the power is applied either to a rope wound round the axle, or to a handle fixed at right angles to the wheel's rim (in the latter case, the wheel may be dispensed with, unless it is useful as a conservator of momentum, and an ordinary winch substituted). The wheel and axle is neither more nor less than a lever, whose extremities are not points as in the normal form, but the circumferences of circles. Accordingly the power and weight are not attached to particular points in these circumferences, but to cords wound round them, and thus the imaginary simple lever (formed by joining the points where the cords become tangents to the circles), is preserved unaltered in position and magnitude. The conditions of equilibrium are, that P (the power) × the radius of the wheel = W (the weight) × the radius of the axle, or, since the circumferences of circles are proportional to their radii, that P : W :: circumference of axle : circumference of wheel. When there is no wheel, but only a winch, the circumference described by the power in one revolution is substituted for the circumference of the wheel. The *capstan* and *windlass* are simple and common examples of this mechanical power, and combinations of toothed-wheels, or of wheels from one to another of which motion is communicated by an endless band, are compound illustrations of the same.

WHEEL CASES.—In pyrotechny wheel-cases are made and driven like sun-cases. They are used for giving a rotary motion to pieces mounted on an axis, and to produce at the same time a very brilliant fire. They are attached to the end of the spoke of the wheel which they are to turn by means of iron wire or strong twine, and they are inclined to the spoke from 20° to 30° to give a larger circle of fire. See *Fireworks*.

WHEELED HARQUEBUSE.—A form of harquebuse invented in 1515 at Nuremberg. It has a wheel-lock (made of ten separate pieces) and is fired by means of *marcasite*.

WHEELERS.—The shaft horses of a gun-carriage. The term is also applied to the mechanics of a battery engaged in setting up the wheels of the gun-carriages.

WHEEL GUARD PLATE.—An iron plate on each side of the stock of a field or siege gun-carriage to prevent its being chafed by the wheels when turning.

WHEELING.—A *wheel* is a circular movement, by which the front of the squad, set of fours, company, etc., is placed at right angles to its original position, or changed ninety degrees. An *about* is a circular movement, by which the front of the squad, set of fours, company, etc., is placed facing to the rear, or changed one hundred and eighty degrees. Wheelings are of two varieties; on *fixed* and on *movable* pivots.

Wheeling on a fixed pivot.

Being at a halt, the Instructor places a well-instructed man on the marching flank and commands: 1. *In circle, right* (or *left*) *wheel*. 2. MARCH. At the command *march*, the men, except the pivotman, step off with the left foot, turning at the same time the head a little to the left, the eyes fixed on the line of the eyes of the men to their left; the pivot-man marks time strictly in his place, gradually turning his body, to conform to the movement of the marching flank; the man who conducts this flank takes steps of twenty-eight inches, and from the first step, advances the left shoulder a little, casts his eyes along the rank, and feels lightly the elbow of the next man toward the pivot, but never pushes him. The other men touch with the elbow toward the pivot, resist pressure from the opposite side, conform to the movement of the marching flank, and shorten their steps according to their distance from it. After wheeling around the circle several times, the Instructor commands: 1. *Squad*, 2. HALT. At the command *halt*, the rank halts, and no man stirs. The Instructor, going to the flank opposite the pivot, places the two outer men in the direction he wishes to place the squad, leaving just sufficient space between them and the pivot to contain the other men, the pivot conforming to this direction. He then commands: 1. *Left*, 2. DRESS, 3. FRONT. Being at a halt, to wheel the squad, the Instructor commands: 1. *Right* (or *left*) *wheel*, 2 MARCH, 3. *Squad*, 4 HALT, 5. *Left* or (*right*) 6. DRESS, 7. FRONT. At the second command, the squad wheels to the right as just explained; at the fourth command, given when the squad is nearly at right angles to its original position, it halts, and at the sixth command, given immediately after, dresses up to the perpendicular. To wheel the squad and move forward, the Instructor commands: 1. *Right* or (*left wheel*), 2. MARCH, 3. *Forward*, 4. MARCH, 5. *Guide* (*right* or *left*). The command *forward* is given in time to add *march* the instant the wheel is completed: at which all the men take the step of twenty-eight inches, and turn their heads square to the front. To execute an *about*, the Instructor commands: 1. *Right* (or *left*) *about*, 2. MARCH, 3. *Squad*, 4. HALT, 5. (*left* or *right*), 6. DRESS, 7. FRONT; or 3. *Forward*, 4. MARCH, 5. *Guide* (*right* or *left*). The command *halt* is given when the marching flank has nearly completed the half circle; or, if the squad moves forward, the command *march* is given the instant the about is completed.

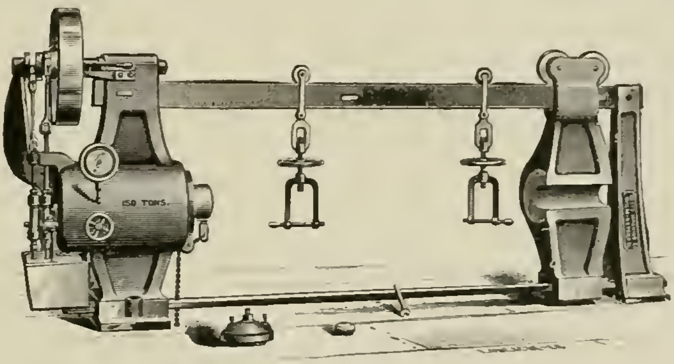
Wheeling on a movable pivot.

Being in march, to change direction, the Instructor commands: 1. *Right* (or *left*) *wheel*, 2. MARCH, 3. *Forward*, 4. MARCH. The first command is given when the squad is three yards from the wheeling-point. At the command *march*, the wheel is executed as on a fixed pivot, except that the pivot-man, instead of turning in his place, takes steps of nine inches, and thus gains ground forward in describing a small curve, so as to clear the wheeling-point. The command *forward* is given in time to add *march* the instant the wheel is completed; at which all the men retake the step of twenty-eight inches, and turn their heads square to the front. In wheeling in double time, the man on the pivot takes steps of eleven inches. The radius of the circle described by the pivot-man increases with the size of the squad, and is equal to nearly one-half of the front of the squad or subdivision. During the wheel, the guide, without indication, is on the marching flank; upon the completion of the wheel, the guide, if not already there, is announced on the same flank as before the movement.

WHEEL-LOCK.—An improvement on the matchlock. It was invented in Nuremberg about 1517, was used at the siege of Parma in 1521, and was carried to England in 1530. It consisted of a steel wheel rasped at the edge, which protruded into a priming pan; a strong spring; and a cock into which was fixed a piece of pyrites (sulphuret of iron). The wheel fitted on the square end of an axle or a spindle, to which the spring was connected by a chain swivel, and the cock was so fitted that it could be moved backwards or forwards at pleasure, a strong spring being connected with it to keep it firm in its position. When it was required to discharge the gun, the lock was wound up by means of a key or spanner which fitted on the axle or spindle, and the cock was let down to the priming pan, the pyrites resting on the wheel. On pressing the trigger, the wheel was released and put in motion, when sparks were emitted which set fire to the powder in the pan. The wheel-lock frequently missed fire, as the pyrites, which is of a friable nature, broke in the pan, and impeded the free action of the wheel, hence the match was usually retained to be ready for use when required.

WHEEL-PLATE.—A flat, horizontal metallic ring, affixed to the body of a carriage. Its under surface rests on the upper surface of the *sweep-plate*. These two plates have their centers in the axis of the *main-pin*; so that at whatever horizontal angle the fore-carriage is inclined to the direction of the wagon, the *sweep-plate* and the *wheel-plate* will still remain in contact.

WHEEL-PRESS.—A hydrostatic press for forcing wheels on their axles and removing them. The axle is suspended from the hooks, and one end passed through the groove in the slotted post, which resists the thrust of the ram, and is held at any desired position by a key or otherwise. The ram is usually operated by a double-acting pump or two single-acting pumps, and may be worked up to a pressure of 5,000 pounds per square inch. The drawing shows such a machine having a capacity to admit 42-inch wheels, with a maximum power of 150 tons. The cylinder is lined with copper, and the ram is operated by two single-acting pumps, with steel valves and seats, giving a continuous motion; it is arranged with pressure-gauge and safety valve to prevent overloading, and is furnished with formers for the ram and pump-packing. Traverse elevating screws and slings for carrying wheels and axles swing on rollers upon the top rail. The weight of this size machine is 8,000 pounds.



WHEEL-WORK.—The arrangement for conveying motion from one axis to another, by means of toothed-wheels, is familiar to every one; it has been in use since the days of Archimedes, and was in use, probably, for many centuries before; but it is only in modern times that the action of such wheels has been critically examined and understood. To a superficial observer, the action appears to be extremely simple; a tooth of the driver pushes against a tooth of the driven wheel, thereby causing that wheel to turn round; and, since by this turning the teeth must become disengaged, it is requisite that, before one tooth let go, a second tooth of the driver be ready to take hold of another tooth of the driven wheel. For this purpose, it is enough that the distances between the teeth on the two wheels be alike: in other words, that the diameters be proportioned to the number of the teeth. When two unequal wheels act upon each other, the smaller one turns faster than the larger. Thus, if a wheel with 60 teeth work into one of 20, the latter will turn 3 times as quickly as the former; and it is on this principle that the trains of clock-work are arranged. For example, the *great-wheel* of a common house-clock may have 180 teeth, and may drive a smaller wheel, or *pinion* as it is called, of 15 leaves, and in this case, if the great-wheel turn once in 12 hours, the pinion must turn once in every hour; the axis of this pinion carries the minute-hand. On the same axis the *hour-wheel* is fixed which may have, say, 96 teeth, and may drive a pinion of 12 leaves. This pinion, then, must turn 8 times per hour, or once in 7½ minutes. On the same axis with this last-mentioned pinion there is fixed the *third wheel*, having, perhaps, 75 teeth, and this drives a pinion of 10 leaves, which, turning 7½ times as fast, must make one turn per minute. On the axis of this last pinion the *escape-wheel* is fixed. This escape wheel has 30 teeth, each tooth acting twice upon the pendulum, thus making 60 beats per minute. In such a case as this, there is no difficulty in arranging the numbers of the teeth, and these may be varied in many ways, provided the proper proportions be kept. But in other cases, a considerable amount of skill, and often a great deal of labor, is required for the discovery of the proper numbers. Thus, if it be wished to indicate the moon's age on the dial of a clock, we must have an index turning once in the time between new moon and new moon. This time, which astronomers call a *lunation*, averages 29 days, 12 hours, 44 minutes, and nearly three seconds (2.853), and it is by no means an easy matter to find out what number of teeth will produce this motion. The mouth-wheel would need to turn rather more than 59 times as slowly as the great-wheel of the clock, and if the mean lunation had been 29½ days, without the odd 44 minutes, the thing could have been managed by making a pinion of 8 teeth lead a wheel of 59 teeth, on the axis of which another pinion, say of 10 teeth is fixed; and made to work a wheel of 50 teeth. But then such an arrangement would go wrong nearly three-quarters of an hour every month, and in three years would indicate new moon a day too early. In order to obtain a better train, we may compute the number of days in 2, 3, 4, 5 lunations until we get nearly a number of half-days. Now, 16 lunations consist of 472 days, 11 hours, 45 minutes, or almost 945 turns of the great-wheel. This proportion can be obtained by causing a pinion having 12 teeth to lead a wheel of 81 teeth, and another pinion also of 12 teeth to lead a wheel of 105 teeth. This arrangement gives an error of one quarter of an hour in 16 months, or hardly an hour in 5 years. If still greater precision be required, we must carry the multiples further; 33 lunations make 974 days, 12 hours, 13½ minutes, or 1,949 turns of the great-wheel of the clock; but then this number 1,949 has no divisor, and it is quite impracticable to make a wheel of 1,949 teeth; so that we must continue our multiples in search of a better train. In this way, when great exactitude is desired, we often encounter an unexpected amount of labor. For reducing this labor, the method of continued fractions is employed, and the toil is further lessened by the use of tables of divisors. Such calculations have to be made for the construction of orreries, by which the times of the revolutions of the planets are shown: and engineers have to make them, as when a screw of a particular pitch has to be cut. If, for instance, we have to cut a screw of 200 turns to the French meter on a lathe having a leading screw of 4 turns to the English inch, the axis of the lathe must make 50 turns while the screw makes 39 and a fraction, since the meter is 39.37079 inches. By applying the method of continued fractions, we discover that, for 2,225 turns of the lathe-spindle there must be 1,752 turns of the screw; and as these numbers can be reduced into products—viz., 2,225 into 5×5×89, and 1,752 into 2×2×2×3×73, we can easily get trains to produce the required effect. From these illustrations, it is apparent that the computation of the trains of wheel-work is intimately connected with the doctrine of prime and composite numbers.

The general sizes of the wheels and the number of the teeth having been fixed on, the next business is to consider the shape which those teeth ought to have. Now, for the smooth and proper action of machinery, it is essential that the uniform motion of one of the wheels be accompanied by a motion also equable of the other wheel. Two curves have been known to give this quality of equable motion—viz., the epicycloid, formed by rolling one circle upon another, and the involute of the circle traced by the end of a thread, which is being wound upon a cylinder, or unwound from it. But the general character of all curves which possess this property has been only lately examined. If it were proposed to construct two wheels which shall have their centers at the points A and B (Fig. 1), and the one of which

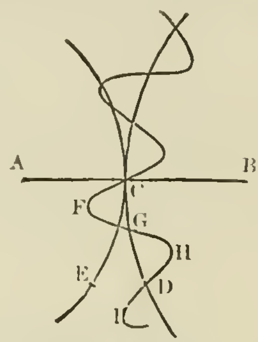


Fig. 1.

may make 5 turns while the other makes 3, we should divide the distance AB into 8 parts, and assign 5 of these for AC, the radius of the one wheel, the remaining three parts for the radius BC of the other wheel. Wheels made of these sizes, and rolling upon each other, would turn equably, and if the circumference be divided into five and three parts respectively, the points of division would come opposite to each other as the wheels turned. The circumferences of these circles are called the *pitch-lines*, and the portions of them included between two teeth is called the *distance of the teeth*; the distance, or arc CD, on the one wheel must be equal to the distance CE on the other wheel, in order that the motion may bring the two points D and E together. For a reason that will appear in the sequel, we cannot use wheels with so few as 3 or 5 teeth, and therefore we subdivide the distances CD and CE into some number of parts, say four, and obtain wheels of 20 and 12 teeth. Since the tooth of the one wheel must necessarily come between two teeth on the other, the distance between the teeth must be halved, the one half being given for tooth, and the other half for space. Having then divided off the pitch-line of the wheel B, as in Fig. 1, CD being the distance of the teeth, CG the half distance, let us sketch any contour, CFGHD, for the shape of a tooth, and let us examine what should be the characters of this outline. In the first place, the form of this outline must be repeated for each tooth: and in the second place, the line should be symmetric from the top, F, of the one, to the top, I, of the next tooth, in order that the wheel may be reversible face for face. These obvious conditions having been attended to, let us now cut, in thin sheet brass or in other convenient material, a disk having this outline, and let us pin its center at the point B. Having prepared a blank disk on which the outline of A is to be traced, let us slip it under the edge of the previous one, and pin its center at the point A. If, now, B and A being held fast, we trace the outline of B upon A, we move each of them slightly but in the proper proportion forward, and make a new trace upon A, and so continue as far as needed, we shall obtain a multitude of curve lines marked upon A. The line which envelopes and touches all these curves is, obviously, the proper outline for the wheel A; and thus it appears, that whatever outline, within reasonable limits, may have been assumed for the teeth of B, it is always possible by a geometrical operation, to discover the proper corresponding form for the teeth of A. These forms may be called *conjugate* to each other, inasmuch as, that if the disk A were now cut out and used as B has been, the identic form of B would be reproduced. We may obtain a whole series of wheels, A′, A″, A‴, etc., from the same original B; and from A, as an original, we may obtain another series, B′, B″, B‴, etc., having various numbers of teeth. And it has been shown that any wheel of the series A will work accurately along with any one of the series B. So far well; but then the wheel A of 20 teeth may not be like the wheel B of the same number of teeth. It becomes, therefore, an important desideratum to choose the form of the teeth of B in such a manner that its conjugate of the same number of teeth may have the same identical form; by such an arrangement we shall obtain a series of wheels, any one of which will work with any other. If the number of the teeth of B be augmented indefinitely, the outline of the pitch-line will then become nearly straight; and so drawing through C (Fig. 2)

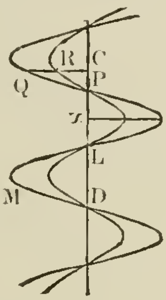


Fig. 2.

a straight line to touch the pitch-line of A, we shall have the pitch-line of the straight rack, as it is called, which could be worked by any wheel of the series A. The reverse of this rack would work with any one of the series B, and therefore, if the series A and B be identic with each other, the rack must be its own reverse. Thus we obtain a very important general result—viz., that if we mark off along a straight line distances, CD equal to the desired interval between the teeth, and then draw any line CKLMD, consisting of 4 equal parts, CK, KL, LM, MD, symmetrically arranged, all the wheels obtained from this as the original, will work into each other; and moreover the forms thus obtained answer for internal as well as external teeth.

Being then at liberty to choose any line whatever, subject to the above conditions of symmetry, for the figure of the straight rack, we may inquire whether it may not be arranged so as to bring about other desiderata. this line, it may be noted, is not necessarily curved; it may be either composed of straight lines, or partly of straight and partly of curved lines. The general appearance of this wavy line recalls that curve known as the curve of sines, which, indeed is, the simplest known curve, consisting of equal and symmetric undulations, and unlimited in extent. By changing the ordinates in any ratio, say in the ratio PQ to PR, the waves of the curve may be made shallower or deeper; and on studying the effects of such a change, we discover some new and very important laws concerning the contacts of the teeth of wheels. Beginning with the curves of sines *proper*, in which the greatest ordinate, SK, is equal to to the radius of a circle of which CD is the length of the circumference, it is found that wheels traced from it can only touch each other at *one* point; of course such wheels cannot work, because the solitary contact is now on the back and now on the front of the tooth. In this case the contour of the tooth crosses the pitch line at an angle of 45°. On deepening the teeth, still keeping to same kind of curve, it is found that the wheels begin to touch at more points than one; and when they are made so deep that the contour crosses the pitch line at an angle of 65°, there are always three contacts, neither more or less. If the teeth be still further deepened, the contacts become more numerous; they appear and disappear in pairs, so that with an inclination of, say, 68°, there would be sometimes three, and sometimes five contacts. When it becomes 70° 17′, there are always five; and with an inclination of 73° 11′, there are always seven points in contact at once. Of these points of contact, some are on the sides of the teeth, and others are near the top and bottom; the latter, on account of the obliquity of their action, are of no use in driving; they may be called supplementary, and their number is always one less than the number of useful or working contacts. In the system of seven contacts, four are useful, two of them being forward, and two backward, so that two teeth are always in action at once; an arrangement by which a gradual improvement in the equality of the teeth is secured by their wearing. When two properly formed wheels are put in motion, the points of contact move also, and describe a peculiarly shaped line, the nature of which depends on the character of the primary form adopted for the tooth of the straight rack. Conversely, if this path of the points of contact be first assumed, and the law of motion in it be observed, the form of the tooth of any wheel may be thence obtained: and this leads us to the most convenient way of making the delineation. In Fig 3,

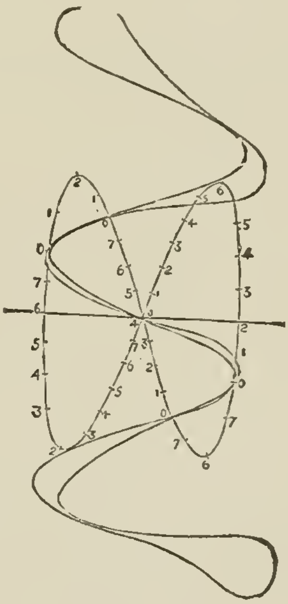


Fig 3.

the form of the straight rack and the corresponding shape of the teeth of a wheel of 20 are shown in contact, the depth of the tooth being such as to give five contacts, which in the drawing are at the five points marked 0. If we suppose the rack to be slid upward, carrying the wheel along with it, the points of contact will change; and when the motion has been one-eighth part of the interval between two teeth, these points will occupy the positions marked 1. When a motion of another eighth is made, the two upper contacts on the left hand merge into one, and are about to disappear; at the same instant, two new contacts begin at the lower point, marked 2; and thus the motion continues in the order of the numbers marked along the peculiarly shaped path of the points of contact. Those contacts which occur along the crossing lines of the curve are working contacts; those which happen along the external arcs, are supplementary. When the form of this path, and the positions of the the successive points in it have been obtained by calculation, the outline of any wheel is easily traced geometrically.

In well-constructed machinery there should never be fewer than seven contacts in the system, since of these only four are working; and therefore only two teeth are fully engaged; and it is necessary that two teeth be engaged at once, in order that the wearing may tend to remove any unavoidable inequalities of workmanship. When we attempt to delineate the forms of wheels with few teeth by help of any of these orbits, we find that the contours overlap each other; in such cases the following tooth of the conjugate wheel effaces, as it were, the trace belonging to the preceding tooth; and the contacts, though still holding good of the geometrical curves, become mechanically impossible. Thus it is that there are limits below which we cannot go in the numbers of the teeth. If the overlapping occur at the shoulder of the tooth some of the useful contacts are wanting; but when the replication is only at the point of the tooth, the want of the supplementary contact, occasions no inconvenience. An examination of the different cases shows that, with seven contacts, the smallest numbers which can be used on the three systems just mentioned are 19, 17, and 11, so that the system of epicycloidal teeth has, in this respect, a very marked advantage over the others. Clock pinions, then should not have fewer than eleven leaves, to insure good results.

Among the many purposes to which wheel-work is applied, it sometimes happens that an unequable motion is wanted. Thus, in the construction of an orrery, it is desirable that while one index turns uniformly to show the time, another may turn so as to show the unequal motion of the sun in the ecliptic.

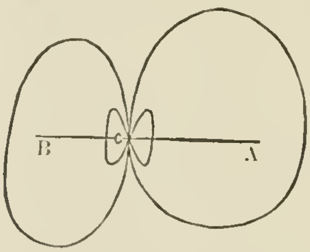


Fig. 4.

In that case the variations of the velocity are small, and it is enough to divide the teeth unequally, as the slight inequality can hardly effect the working of the apparatus. But when the changes of velocity are considerable, the matter must be more carefully looked into. If we suppose the pitch-lines of two wheels to be uneven, and to roll upon each other without regard to the positions of their centers, the forms of teeth to be arranged upon those pitch-lines may be traced out almost in the manner already explained for round wheels. The pitch-line must be divided into equal distances, and the disk must receive a half-sliding, half-turning motion, so that the pitch-line may pass through the point C (Fig. 4) always perpendicularly to the line AB, which is the line of centers for round wheels. The combination of this motion with the proper motion of the points of contact gives true forms for the teeth. Thus, the form of the tooth can be obtained when that of the pitch-line is known. Now, when two disks, turning on fixed centers, touch each other at any point out of the straight line joining these centers, there is a slipping of the one surface over the other; and therefore, in order that the pitch-lines may roll together, they must be so shaped that the point of contact may lie in the line of centers. It can be shown that, for any assumed contour of the wheel A, another contour having its center at B, and rolling upon A, is possible. But, except in one or two special cases, the working out of the problem has not been accomplished. It will be enough here to mention the single case of elliptic wheels. The action of these is founded on the well-known property of the ellipse, that the sum of the distances of any point in it from the two foci is constant, and that the curve makes equal angles with these two lines. Hence two equal ellipses turning on their foci, when their centers are at a distance equal to the major axis of the ellipse, will roll upon each other; and teeth formed upon these as pitch-lines will work perfectly. When the ellipses have their major and minor axes in the proportion of 5 to 4, the focus is at one-fifth part of the major axis from one end; and therefore one focus, at one part of the revolution, moves four times as fast—at another part, four times as slowly as the other focus. This is evident, and does not need any mathematical proof or illustration.

Sometimes one of the wheels has to be quite at rest during part of the motion of the other wheel.

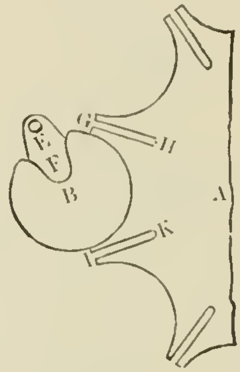


Fig. 5.

This is accomplished by causing some part of the wheel that is to be stationary, to bear upon a part of the circumference of the moving-wheel which is concentric with its axis. This is exemplified in the arrangement for counting wheels shown in Fig. 5. The object of this apparatus is to count and record the revolutions of the wheel B. As this wheel turns round, a pin E attached to it enters into the slit GH, and thus carries the wheel A round as long as the pin remains in the slit, that is, until the slit GH be brought into the position IK. As soon as E leaves the slit at I, there would be no further connection between the two wheels, and A could be moved any how, altogether independently of B. In order to prevent this, the disk B is made nearly five-sixths entire, and parts of A are scooped out between the slits so as to receive and to fit B. By this means A is prevented from being turned either backward or forward until the pin E again comes into one of the slits. When this happens, the projecting part at G finds room in the recess F. If there be seven slits, GH, round the wheel A, and if B turn once in twenty-four hours, an index attached to A would show the days of the week; and the index might be made to be stationary all day, the change being effected during the night. Another example of this kind of interrupted motion is seen in the ordinary dead-beat clock escapement, in which the detaining surface of the pallet is concentric with the axis of the crutch.

When the axes are to be inclined to each other, *beveled* wheels are used. Just as common wheels may be regarded as fluted cylinders, beveled wheels may be described as fluted cones having a common apex. The principles which regulate the formation of the teeth of these are the same as for plane wheels, but the application of these principles is considerably more intricate. Since both the teeth and the spaces between them are tapered, it is impossible to notch out the intervals by means of a revolving cutter. Attempts have been made to construct machinery for planing the teeth by means of a cutter moving in a line toward the apex of the cone, but the complexity of the apparatus, and the slowness of the process, have prevented its introduction; and thus the accurate formation of beveled wheels has still to be accomplished by hand.

WHINYARD.—A sword or hanger, so called by Butler in his Hudibras.

WHIP.—1. A small single tackle; a *whip upon whip* consists of two movable blocks, one of which is applied to and acts upon the running end of the fall of the other. 2. In artillery exercise, to whip a rope is to tie a piece of twine round the end to prevent the strands being laid open.

WHIPPING.—Corporal punishment by whipping, public as well as private, was formerly often awarded by the criminal law of England for minor offenses, such as petty larceny, and was not unfrequently superadded to some other punishment, such as imprisonment or the pillory. In early times, and by the usage of the Star-chamber, whipping could not be competently inflicted on a gentleman. In Scotland sentence of whipping was also frequent, the terms of the sentence sometimes requiring it to be repeated at intervals and in different parts of the Kingdom. In the last century the Scottish Burgh Magistrates were in the habit of awarding sentence of whipping on summary convictions for police offenses, such as broils, street outrages, and the keeping of disorderly houses; but in modern practice the competency of inflicting this sentence at common law without the intervention of a jury has been made matter of doubt. Whipping used not long since to be an occasional addition to the sentence of the justiciary court on persons convicted of aggravated assaults. See *Flogging*.

WHIRLING-MACHINE.—When firing projectiles at very low velocities, the ballistic pendulum was not found to be satisfactory, as rebound occurred, and thus the impact was not that of inelastic bodies. With the electrical instruments at present employed, difficulties are also experienced at low velocities, as wires and currents cannot readily be broken by the projectile in flight, and thus records cannot be obtained. The *whirling-machine* designed by Robins, however, offers a means of finding the resistance of the air to bodies moving at low velocities. It consists of a cylinder, and a cone, carrying a long, feather-edged arm, to the end of which is attached the body, to which the resistance of the air is to be found. A light wire braces this arm to prevent bending. The whole is caused to revolve round a vertical by means of a silk thread wound round the cylinder, and passing over a pulley with a weight (W) at the end of it. When set in motion, the velocity is found to become uniform in a very short time; the period of performing several revolutions is then noted, and hence the time of one revolution is found. The body at the end of the arm is then replaced by an equal flat weight of lead, which is put edgeways and exposes very little surface to the air in the direction of its motion.

By trial and error it is found that a smaller weight (w) will now give the same uniform rotation to the system as before. Hence, the difference of weight (W w) in the two instances must be due to the resistance of the air on the surface of the body, and the true amount (R) of it is obtained by proportion. R : W w :: a : l, in which a is the radius of the cylinder, and l is the distance of the center of the body from the axis of rotation.

The velocity of the body is known from the dimensions of the machine, and from the time to perform one revolution.

WHITEBOY.—The name of an illegal Association of the Peasantry in Ireland, which for a long series of years was the fruitful source of agrarian outrage, sometimes of a very revolting and sanguinary character. The Association had its origin in the early years of the reign of George III.; and first took an organized form in the County of Tipperary, where it appeared in the shape of a united resistance to an attempt on the part of certain proprietors to inclose and appropriate lands up to that time common. The movement at the beginning was confined to throwing down the newly erected fences, and destroying the inclosure, from which circumstance the rioters were in the first instance called "Levelers;" but their views soon extended further, and they addressed themselves to the redress, first, of the oppressive exactions of tithes, and afterward of various other grievances, especially those connected with the tenure of land. The name of Whiteboys was given to them in consequence of their wearing white shirts in their nightly expeditions. Many acts of cruelty and outrage having been committed, a special Commission was issued in 1762 for the trial of the offenders; but the repression was only partial and temporary, and Whiteboyism reappeared more than once in the Southern Province. In 1787 a new Association, the members of which called themselves the "Right-boys," appeared in the same district, and was made the subject of discussion in the Irish Parliament. The conflicts of the northern Orangemen and Ribbonmen for a time drew attention away from the minor discontents of the South; but the same spirit of secret combination has continued among the peasantry down to the present day. The Shanavests, Caravats, Rockites, Terry Alts, and the other more obscure and more local denominations, must be regarded as embodiments of the very same discontent, which has long held its ground among the poor classes in Ireland, and which, although undoubtedly exaggerated and imbittered by the recollections of hereditary wrong inseparable from the condition of a conquered people, are held, even by politicians of very moderate views, to have much justification in the social condition of the people, and in certain striking anomalies of the legislature in reference to Ireland. The ground of discontent furnished by the endowment and establishment of the Church of a small minority of the population, has now ceased to exist.

WHITE CAST-IRON.—Since in white cast-iron a considerable proportion of iron is in intimate combination with carbon, this variety would be expected to present the characters of the compound of carbon with iron, described above. Accordingly the white cast-iron is very brittle and extremely hard, so that a file will scarcely touch it: whereas gray iron is much softer, and admits of being filed and turned. White cast-iron is softened at a lower temperature than gray, but becomes less perfectly fluid; in cooling, it passes through the pasty or semi-fluid state, and contracts considerably on solidification. It *scintillates*, or throws off sparks, as it runs from the furnace to a much greater extent than gray iron. Its average specific gravity is 7.5. White iron usually, but by no means invariably, contains less total carbon than gray iron. Its qualities generally are the reverse of those of gray iron, and it is therefore unsuitable for ordnance purposes.

There are two distinct kinds of white iron. *First*, That obtained from ores containing a large proportion of *manganese* crystallizing in large plates: this variety, called *spiegeleisen*, is highly prized for making steel. And *Second*, that resulting from a heavy mineral burden of the furnace, or from a general derangement of its working. See *Cast-iron*.

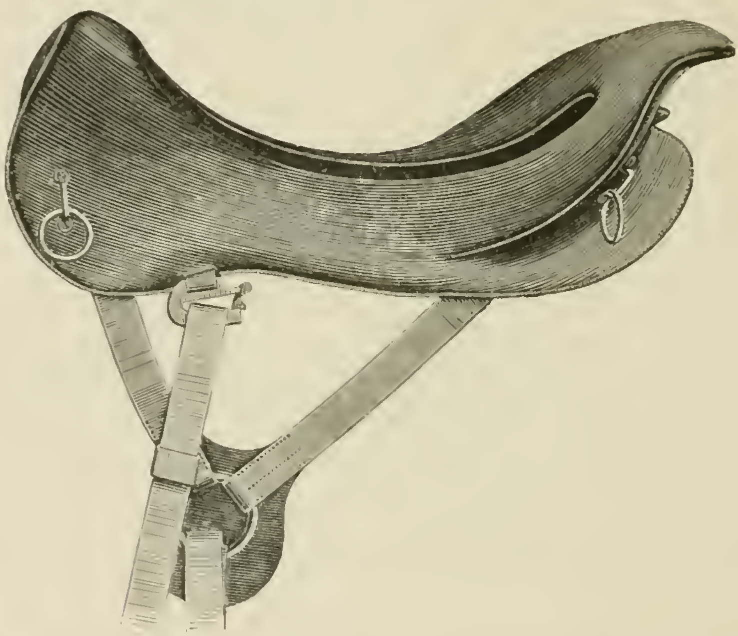
WHITE GUNPOWDER.—A mixture that was at one time employed in blasting, but is now scarcely ever employed in consequence of the danger attending its preparation, and the facility with which it explodes by friction. Its ingredients are chlorate of potash, the dried ferrocyanide of potassium, and sugar. See *Gunpowder*.

WHITE SERGEANT.—A term of ridicule in the British Service, applied to those ladies who, taking advantage of the weakness of their husbands, neglect their domestic concerns to interfere in military matters.

WHITING.—An impure carbonate of lime, usually prepared by grinding, and then washing, chalk, so as to separate the coarser particles from the finer ones, which are collected in masses and dried. To make the whiting used by soldiers for accouterments, it is necessary to boil many handfuls of bran enveloped in linen. Dissolve afterward pipe-clay in this water. Whiten with it when cold. When the buff leather is greasy and does not receive the whiting, scrape it, and apply to it a solution of pipe-clay and Spanish whiting.

Another recipe, calculated for one hundred men, is the following: Pipe-clay, 3½ lbs.; Spanish whiting, 8 ounces; white lead, 4 ounces; glue, 1½ ounces; starch, 6 ounces; white soap, 5 ounces. Put the pipe-clay and Spanish whiting in about five gallons of water; wash them and leave them to soak for six hours; 2d, throw out the first water, and replace it by 5½ gallons of pure water; add the white lead, glue, and white soap. Cook them together, taking care to stir constantly the composition. At the moment that the foam shows itself on the surface, withdraw the vessel from the fire without suffering the composition to boil; put then the starch in the whiting, and mix all well together.

WHITMAN SADDLE.—The favorite American saddle, invented by Colonel R. E. Whitman, U.S.Army. The saddle has a round, smooth-cut, back pommel, as low as can be made and escape contact with the highest withers. This pommel is secured by iron plates, upper and lower, riveted to each other; narrow in the interior, so as not to slip forward, and exterior so narrow as not to uncomfortably spread the rider at the thighs. The seat is long and flat, and invites the rider to *sit down*, instead of forcing him to stand in his stirrups. The effect of the saddle is to correct the bad habit of riding the upright or forked seat, and to throw the weight of the rider where it should be, as near the middle of the back as possible.



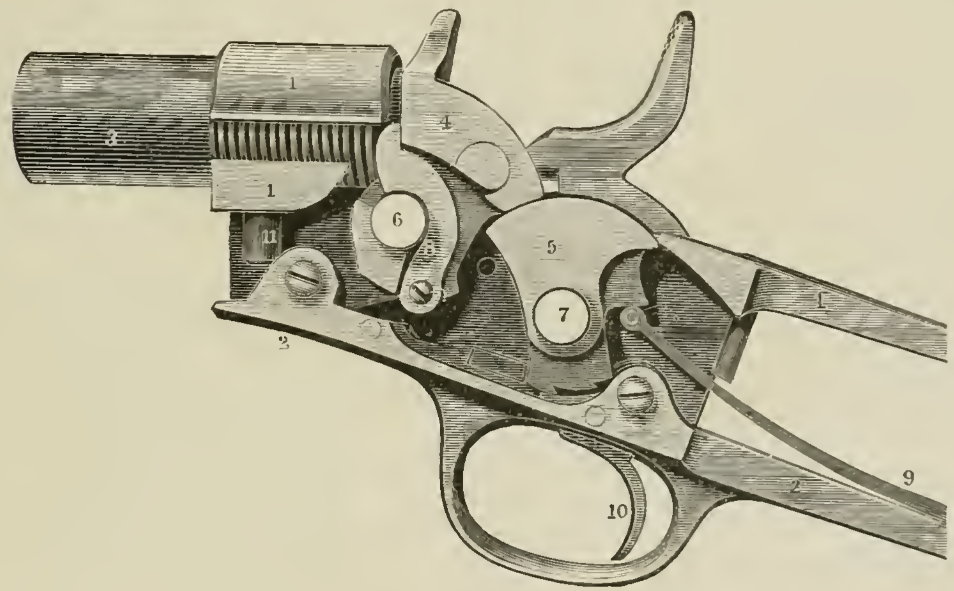
The most noticeable feature of this saddle is the perfect adjustment of the *bearing surface*. This is as long as possible, and so fitted to the average back as to evenly distribute the weight over its whole length. These saddles are intended for the Mexican *cincha* straps, and are held in place, front and rear alike and do not twist on the horse's back. There are no buckles to break or pull out. A long, narrow strap is attached to the ring which joins the rigging straps of the saddle; the girth is made short and strong, with a D-ring in each end. The fastening is simple. Put the end of the strap through the girth ring, point toward you. Put it up over itself through the upper ring, and again through the lower; then pull up and toward you until the girth is tight; then place the strap that along the folds, holding them in place with the left hand; pass the end of strap under the left side of upper ring and pull tight through forward toward the horse's head; fold that over toward the tail; then put it up under the right side of ring, pull tight, and pull end down under loop thus formed.

The stirrups are so hung that when the rider has assumed an easy, natural seat, they will fall exactly opposite the feet. The stirrups have rubber mats at the bottoms, a great convenience and comfort to the rider, as the slight amount of elasticity prevents shock, while the adhesive property of the rubber holds the foot in place without effort. See *Saddle*.

WHITNEY RIFLE.—At the special request of President Jefferson, when Secretary of State in Washington's administration, Mr. Eli Whitney undertook the manufacture of muskets for the United States, taking as a model the French Charville flint-lock, that being the most improved arm in use in Europe. In presenting his views to Mr. Jefferson in reference to the feasibility of making all arms interchangeable, Mr. Whitney met with most violent opposition, both English and French ordnance officers ridiculing the idea as an impossibility, and claiming that each arm would be a model and would cost at least one hundred dollars. Supported by Government, Mr. Whitney prosecuted his labors, and established an armory where the most perfect uniformity of parts was secured to the great satisfaction of his friend, Mr. Jefferson. The Springfield Armory was established in the year 1800, and the system invented by Mr. Whitney was put in force there, and has been in all Government works ever since. The English War Department was forced to adopt the same system, and put it to practical use in 1855 by importing a large amount of American machinery. Since that date other European Governments have adopted the same general system, which is made specially necessary in the proper manufacture of breech-loading small arms. The admirable series of inventions used in this system of Mr. Whitney's, remains now the same as when first invented, no practical change taking place in eighty years, notwithstanding the inventive genius which has been at work during that period of time. No patents have ever been taken out for the Whitney inventions, but they have been freely given to the public, and have saved the United States Government large sums of money by lessening the cost and

perfecting the manufacture and repairs of fire-arms.
The Whitneyville Armory, property of the Whitney Arms Co., is now one of the largest in the United States. It is located near New Haven, in the State of Connecticut, and has a capacity for employing over 500 men, being supplied with all the modern improvements in machinery, and now under the control of the son and grandson of the founder, who have added many valuable improvements. The specially novel systems of arms introduced by the Whitney Arms Company, are known as the *Phœnix* and *Kennedy* systems of repeating-rifles, and are manufactured in all the various styles for both military and sporting service.

The final and perfect development of this system is seen in the *Whitney improved* rifle, which is similar to the Kennedy in general outline. The drawing shows the action. 1. receiver, 2. guards 3. barrel, 4. breech-block, 5, hammer, 6. breech-block pin. 7. hammer-pin. 8. extractor, 9. main-spring, 10. trigger, 11. ram-rod stud. In this rifle the shells are



automatically ejected from the chamber and there is an arrangement on the breech-block by which the firing-pin is positively withdrawn whenever the breech is opened. No spring is used in connection with the firing-pin, except for rim-fire cartridges, and this advantage can not be too highly appreciated. Numerous accidents have occurred with other rifles of note, owing to the rusting of the firing-pin and consequent sticking, so that the spiral spring did not withdraw it, and thus causing the explosion of the cartridge on the breech-block being closed with force. This rifle does not employ the Government 45-inch cartridge, in as much as experience shows that it is not a suitable cartridge for a magazine-gun with its form of magazine. A cartridge to be safe, must have the bullet made flat on the end so that it will not press against the primer of the cartridge in front of the magazine.

The rifle is made in various styles, by the most approved machinery and skillful workmen.

The musket weighs about 9 lbs. The barrel is 30 inch. It carries when loaded, 17 cartridges.

The carbine weighs about 7¼ lbs The barrel is 20 inch. It carries when loaded, 12 cartridges.

The sporting-rifle weighs 9 to 10 lbs. The barrel is 24 inch. It carries when loaded, 15 cartridges. See *Kennedy Rifle* and *Phœnix Rifle*.

WHITTEMORE RIFLE.—A breech-loading small-arm having a fixed chamber closed by a movable breech-block, which rotates about a horizontal axis at 90° to the axis of the barrel, lying below the axis of the barrel and in front, being moved from above by a thumb-piece. The arm is opened and cocked by drawing back a locking-piece, hinged to the hammer, and pressed against the frame by a spring lying between it and the hammer. It is closed and fired by drawing the trigger, the mainspring being placed beneath the barrel. The piece is locked by the engaging of the locking-piece, with a corresponding abutment on the frame, into which it is pressed by the locking-piece spring, just before the cartridge is struck by the hammer when the piece is fired.

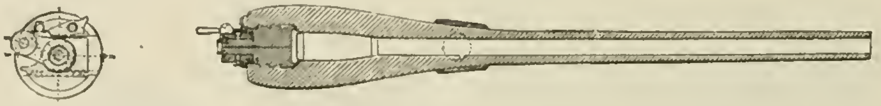
Extraction is accomplished by a hooked lever pivoted on the hammer, and moving bodily with it in the first instant of opening, and ejection is effected by striking the lower end of another similar lever pivoted to the side of the frame, by the end of the locking-piece, when the opening is nearly compleed. A flap hinged to the top of the barrel may be interposed between the head of the cartridge and the hammer, so that the piece may be carried safely when loaded; the upper portion of this flap is formed into a sight base.

WHITWORTH BREECH-STOPPER.—This apparatus was adopted by Mr. Whitworth in his early guns. A cap, revolving in a ring hinged to the gun, is screwed over the end of the bore. The largest gun made in this way was an 80-pounder, which was disabled after a short experimental service.

WHITWORTH GUNS.—Sir Joseph Whitworth & Co., in presenting for exhibition in Paris, in 1878, the products of their Works in Manchester, made the following general remarks regarding their steel, to wit: The Whitworth fluid-pressed steel, from which the following objects are made, is submitted to great pressure whilst in the fluid state. By this means perfect soundness and homogeneity, even in the largest masses, are obtained; it is afterwards forged to the required shape by hydraulic pressure. The distinguishing characteristics of the Whitworth fluid-pressed steel are soundness, strength, and ductility. It is made of various tempers to suit all purposes, and is specially suited for purposes where it is exposed to sudden and violent strains.

It is only the intention to allude here to Whitworth's guns and his idea of gun construction, leaving the question of his mode of production of steel for consideration under the heading of steel and other material for gun building. The firm stated in 1878 that: The Whitworth system of breech-loading has been very severely tested with most satisfactory results. Two guns, viz, a 7-inch, firing projectiles weighing 150 pounds, and a 9-pounder, have been tried by the English Government with very satisfactory results. The ease with which the breech arrangement worked throughout the experiments was very remarkable. The Brazilian Government have adopted the Whitworth ordnance, in consequence of the satisfactory results they had had with it during the Paraguayan war. Many of the guns fired from 4,000 to 5,000 rounds without being damaged.

The following description of his 9-pounder breech-loading gun, which embodies the general features of his plan, and the accompanying drawing, will serve to set forth the points peculiar to the system. The breech-closing arrangement of the gun consists of a breech-block sliding horizontally in grooves inclined at an angle to the rear face of the gun, the block being moved by means of a tappet handle which revolves a pinion-gearing into a rack on the gun; the block is held in its place, when closed, by a catch. The rifling is polygonal, being a hexagon with rounded corners. The powder-chamber is enlarged in diameter in order to burn an increased charge. There is also a slightly enlarged shot-chamber, to ensure ease in loading. The powder-charge is contained in an ordinary serge-bag, no metallic case being employed. All escape of gas is prevented by an elastic steel ring in the rear of the gun, and a disc in the face of the breeck-block, which are pressed tightly together when the block is closed. This ring and disc are movable and can be readily replaced. Owing to the simple form of the rifling, the projectiles for all the Whitworth guns are molded by self-acting machinery, and fired as they are cast without being planed. By this means there is a saving in first cost, and, as there is no soft metal required to give rotation, the projectiles, when recovered after practice, can be fired several times. This gun has withstood the severest tests—among others, those in which elongated projectiles of lead of 10 pounds and 3 pounds of powder were used.

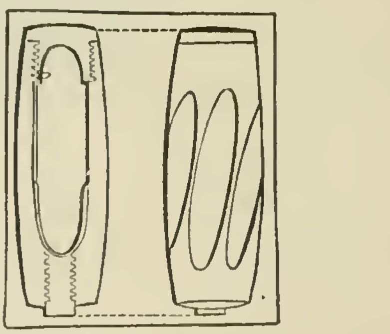


The mode of closing the breech has all the simplicity of the Krupp, and the fermeture can be manipulated with such ease and rapidity as to lead to the belief that, for field-service especially, it would prove superior to both the interrupted screw and the sliding-block systems.

The views of the Manchester Works are that steel and steel alone should be used for the construction of large guns; field-guns forged solid, and afterwards bored and rifled, the trunnion-hoop being screwed on, and that for larger guns the barrels should be forged hollow, the strength and weight being obtained by adding hoops according to the size of the gun. Alluding to some experiments made at the Manchester Works, it is stated: The tubes are of fluid-compressed steel, and have been subjected to explosions of gunpowder. The large tube, 26 inches long, 7.83 diameter, with 2.56 bore, being that of a 9-pounder field-gun. It has had 48 explosions with 1¼ pounds of powder. The strain on the metal is about six times greater when the ends are closed than when a gun is fired in the ordinary way. The force of the explosion being so great, a small permanent alteration took place at the first explosion, and the expansion of the bore has been going on every time it has been fired, and now amounts to nearly 0.2 of an inch. The tub was never expected to stand such a number of explosions. Seventy-two pounds of powder have now been fired in it. A cast-iron tube of the same dimensions burst at the first explosion with 3 ounces of powder.

No comparisions are made between this steel and and other well-known varieties; but attention is invited to the fact that a cast-iron cylinder of the same dimensions burst at the first round, with only one-eighth of the charge employed with the compressed steel. The tenacity of the cast iron is not stated, but as the metal Sir Joseph Withworth says was known to be of good quality, it is fair to presume that it was of the ordinary grade of English cast-iron for guns, the tensile strength of which is given by English authorities as ranging from 20,000 to 31,000 pounds per square inch. The great enlargement (0.2 inch) resulting from the repeated firings of the steel cylinder is worthy of note, as showing the capacity in toughness and ductility of steel produced by the Manchester processes. See *Ordnance*.

WHITWORTH PROJECTILE.—This projectile is first turned so as to make the cross sections circles, and the sides tapering toward both ends. The middle-portion is then carefully planed off to fit the bore of the gun. The drawing represents a Whitworth blind shell for firing against armor-plates. It is made of tempered steel, and each end is closed with a screw. To prevent the heat of impact from acting

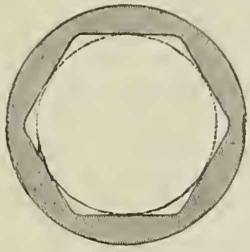


too soon on the bursting charge, it is surrounded by one or more thicknesses of flannel. A 7-inch shell of this kind has been found to have sufficient strength and stiffness to penetrate five inches of wrought-iron before bursting. The fuse usually employed for igniting the bursting-charge is dispensed with, as the heat generated by the impact of the shell is sufficient to ignite the bursting-charge. To prevent the heat generated by impact from acting prematurely, and to regulate the time of ignition, the bursting-charge is covered with a proper thickness of flannel, or other material which is a non-conductor of heat. See *Projectiles* and *Steel Projectiles*.

WHITWORTH SYSTEM OF RIFLING.—The Whitworth gun has a hexagonal spiral bore, the corners of which are rounded off. The form of the bore is not, however, strictly hexagonal.

The interior of each gun is first bored out cylindrically, and when the rifling is completed, a small portion of the original cylindrical bore is retained along the center of each of the sides of the hexagonal bore, and the other parts of each side recede or incline outwards towards the rounded angles; hence the diameter of the hexagonal bore is greatest at the rounded angles. This description will be readily understood by reference to the drawing.

The reasons for thus modifying the general form of the rifling are, to facilitate loading, and thus allow of a reduction of windage, and also to insure, if possible, the bearing of the sides of the projectile on



the surfaces instead of on mere lines, as would be the tendency with a plain hexagonal bore having windage.

A hexagonal bolt revolved on its axis within a slightly larger hexagonal orifice would not bear upon its sides, but only upon its six corners. The points of contact would be mere lines.

The peculiarities of this system are the polygonal rifling and comparatively small bore. It has great range and penetration, but has never been adopted for heavy guns by any nation except Brazil. The polygon has twenty-four surfaces with six grooves, each .4 inch deep.

Though the long iron bearing diffuses the strain over a large surface, and enables a rapid twist with a large rotation to be given, yet the bearing is really on a mere line in each groove, and is much nearer the axis of the projectile than in systems with projecting flanges, and the leverage for rotating is therefore much less. In muzzle-loading guns of this system it is difficult to thoroughly sponge the bore. A patent lubricating cartridge in a metallic case is used with the breech-loaders. See *System of Rifling.*

WHIZ.—To make a humming or hissing sound like an arrow or a ball flying through the air.

WHO COMES THERE?—A form of military challenge. During certain prescribed night hours all parties approaching a sentinel are challenged with "*Who Comes There?*" and are halted or advanced according to circumstances. See *Challenge.*

WHOOP.—A shout or loud noise which soldiers make in charging. It is a natural though a barbarous habit, and has been preserved in civilized armies from a prevailing custom among savages, particularly the wild Indians of America.

WICKET.—A small door in the gate of a fortified place, affording a free passage to and fro, without opening the great gate.

WIENER POWDER.—Colonel Wiener, of the Russian artillery, caused to be patented in this country, early in 1874, a new process of making gunpowder, which it is claimed is superior to that made in the ordinary way, while the process itself is much simpler, safer, more expeditious, and cheaper. The peculiarity of the process consists in its entire exclusion of water, and the substitution of heat, in forming the press-cake. The materials are pulverized and incorporated in barrels with bronze balls, and thence transferred to the press for forming the cake, the press being so arranged that the composition may be brought in the operation to a temperature of 240° F., the melting point of sulphur. The cake thus obtained is broken into grains in the usual way. The powder made by this process is almost entirely free from dust; it absorbs not more than one-half as much moisture from like exposures; its force is greater, and its action more uniform. The saving that will be effected will be, as is readily seen, considerable—estimated to be about 40 per cent.—when it is borne in mind that the operation of incorporating the material under the wheels, a slow and expensive one, and that of drying the powder, are entirely done away with.

As it is well known that the variable quantity of water used in the fabrication of gunpowder is the cause of variations in the strength of the product, and that gunpowder made of charcoal which has been permitted before being used to absorb moisture, is unfit for such purpose, it would seem to be in accordance with reason to expect that a powder made by a process which eliminates these causes of variation would be both stronger and more uniform than that made by the old way. The claim put forward by Colonel Wiener, that his powder is much stronger than ordinary gunpowder, appears to be borne out by the report of Colonel Struve, the engineer in charge of the construction of the permanent Liteiny bridge across the Neva at St. Petersburg. He states that in driving piles by means of a gunpowder pile-driver of Shaw's plan, the gunpowder charges prepared from Colonel Wiener's powder gave favorable results compared with the government powder made of the same materials, being almost twice as effective. It has been stated that the Russian government will change the machinery of its mills, to adapt them to the making of powder on this system. See *Gunpowder.*

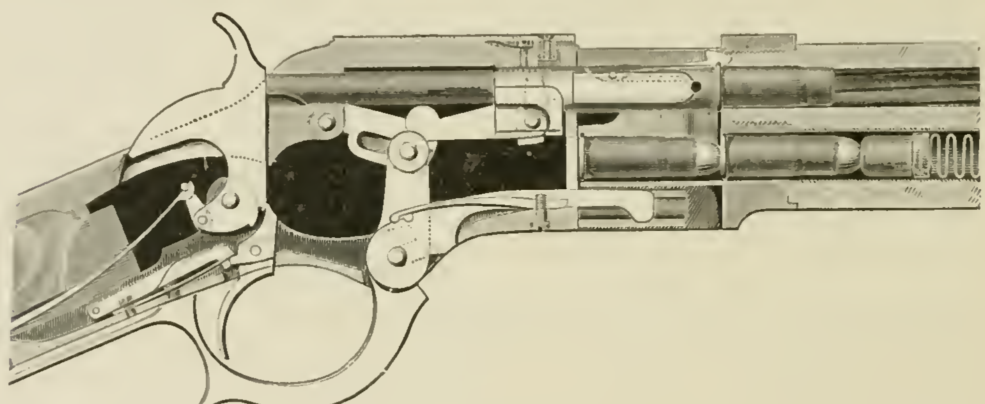
WIGWAM.—An Indian cabin or hut. The wigwam, or Indian house, of a circular or an oval shape, is made of bark or mats laid over a framework of branches of trees stuck in the ground in such a manner as to converge at the top, where is a central aperture for the escape of smoke from the fire beneath. The better sort has also a lining of mats. For entrance and egress, two low openings are left on opposite sides, one or the other of which is closed with bark or mats, according to the direction of the wind.

WILKINSON PROJECTILE.—This projectile is a cylindro-conoidal pellet indented with three deep furrows, a construction favorable to compression longitudinally; and, therefore, expansion laterally.

WILL.—A testament of any individual, giving instructions as to the disposal of his or her property or effects. Soldiers making their wills while in hospital, should, when practicable, get the Medical Officer to witness their signature, and he is to affix a declaration to such will, stating whether the parties were in a fit state of mind at the time to execute the same. See *Nuncupative Wills.*

WIMBLETON TARGET.—The target used upon the range of the National Rifle Association of Great Britain at Wimbleton. The target works in a somewhat similar manner to the sashes of a window, the upper sash representing the target, and the lower sash a second target covered with wire, and only used for the purpose of signaling. The target differs from the principle of a window, in as much as when the target is pulled down the second target goes up simultaneously. The framework of the target is made of iron, one inch thick by two inches deep (the front edge sharpened), and is covered with paper canvas. Signal-disks are suspended from the netting over the face of the second target, and are used to mark the approximate positions of hits. A separate disk is used to show riochets, outers, inners, or bull's-eyes. The secondary target is below the ground, and the apparatus for working is sheltered by a parapet and a trench, and is protected from fire. When the target is hit, a *spotting-disk* is placed on the corresponding point of the second or lower target and it is raised to view. As soon as it is observed from the firing-stand, the second target is lowered, and the next shot is fired.

WINCHESTER RIFLE.—The system and operation of this rifle is easily understood by the following description and sectional drawing. The magazine is charged while the system is closed, in the position shown in the drawing, by pressing down the spring-cover, with the point of the cartridge, and inserting the latter through the opening thus made. This last is closed by the spring-cover as soon as the cartridge is inserted. The operation is repeated until the magazine is filled When it is desired to load, the finger-lever is thrown forward, and then returned. This motion throws out the shell or cartridge in the chamber, transfers a cartridge from the magazine to the chamber, cocks the hammer, and leaves the arm ready to fire by pulling the trigger. This motion may be executed while the gun is at the hip, or at the shoulder without taking the eye from the sights, thus enabling the firer to discharge two or more shots without removing the gun from the shoulder or losing sight of the object which it is desired to hit. The arm appears in several models. That of 1866, remains, in the mechanism for loading and firing, precisely the same as the Henry: the improvements in this model consist in an entire change in the magazine and the arrangement for filling it. By these changes the gun is made stronger, yet lighter; the magazine is closed and strongly protected; it is more simple in operation, requiring fewer motions in the one case, and fewer pieces in the other, than did the HENRY. This gun uses a rim-fire metallic cartridge $\frac{44}{100}$ caliber, with 28 grains of powder and 200 grains of lead. The receiver or lock-frame and butt-plate are of gun metal, the other parts, except the stock, of steel and wrought-iron of the best quality, no malleable iron being used. Up to the limit of range that is possible with the small amount of powder and ball used, it to-day remains unexcelled as a weapon or hunting-piece, and contrary to the expectation of the manufacturers since the introduction of more powerful arms, it is still in active demand. Notwithstanding the success of the Model 1866, of which over 150,000 are now in use, the demand for a more powerful arm resulted in the production of a new Model in 1873.



The first and most important improvement consists in adapting it to the use of a longer, and a center-fire cartridge, holding a charge of 40 grains of powder instead of 28, as in the model of 1866, retaining the same caliber $\frac{44}{100}$ and the same weight of ball, viz.: 200 grains. The effect of this change is to increase the initial velocity of the arm from about 1,125 to 1,325 feet per second, reducing or flattening the trajectory and increasing the power and accuracy of the arm, and giving it a penetration of about four inches, in pine board, at 1,000 yards.

A second improvement in the sporting-arm is the addition of a set, or hair-trigger. This differs from the ordinary hair-trigger, in that it can be used precisely as if this trigger was not on the gun, if, as in hunting, it is not wanted. For fine shooting, as in target practice, it is made available thus: After setting the hammer at full-cock, the trigger should be pressed forward slightly, and it is thus set. If it is found too delicate, or not delicate enough, it can be adjusted to suit the wishes, by turning a set screw in or out. This screw will be found by the side of the trigger. A third improvement consists in a sliding lid, which covers the opening in which the carrier-block moves up and down. This lid, by the action of the finger-lever, opens automatically when the gun is loaded, and should always remain open until closed by hand after firing. The object of this lid is to keep dirt and snow out of the lock. A fourth improvement consists in the substitution of iron, in place of gun metal or brass, in the manufacture of the lock-frame, butt-plate, and other parts, thus increasing the strength of the arm and reducing its weight. The gun metal is, however, retained in the carrier-block and the lid in the butt-plate, opening into the receptacle for the cleaning-rod; the object being to avoid the liability to rust, so as to impede the movement of these parts, which would exist if made of iron. A fifth improvement consists in a device which absolutely prevents accidental or premature explosions. In most breech-loading firearms, the firing-pin after the explosion of a cartridge, depends upon a spiral spring to be thrown back even with the face of the breech-closing bolt. If this spring is very strong, so as to insure its operation, it tends to break the force of the blow of the hammer; but if not strong enough for the purpose, it soon gets so foul as not to work, and the firing-pin then projects, and if the breech is closed with a quick motion the cartridge is exploded prematurely. To obviate this, no spring is used, but the firing-pin is carried back by a positive motion retractor, and avoids all danger from the cause above mentioned. This model is furnished either 32, 38, or 44 caliber cartridges as may be desired. The success attending the model of 1873, and the constant calls from many sources, and particularly from the regions in which the grizzly bear and other large game are found, as well as from the Plains where the absence of cover and the shyness of the game require the hunter to make his shots at long range, made it desirable to build a still more powerful gun, in 1876. Retaining all the essential mechanical elements of the former model, and adding such improvements as seemed possible, the result has been a gun carrying a central-fire cartridge, capable of reloading, caliber $\frac{45}{100}$ with 75 grains of powder and 350 grains of lead, being nearly double the charge used in Model 1873, about the same as that adopted by the U. S. Government, and giving an initial velocity of 1,450 feet. See *Express Rifle*.

WINDAGE.—Windage is the space left between the bore of a piece and its projectile, and is measured by the difference of their diameters. The objects of windage are to facilitate loading, and to diminish the danger of bursting the piece: it is rendered necessary by the mechanical impossibility of making every projectile of the proper size and shape, by the unyielding nature of the material of which large projectiles are made, by the foulness which collects in the bore after each discharge, and by the use of hot and strapped shot. The *true windage*, which is the difference between the true diameters of the bore and projectile, increases slightly with the size of the bore, and is greater for solid shot, which are sometimes fired hot, than for hollow projectiles, which are never heated. The ordinary windage of smooth-bored cannon, used in the United States' service, is about $\frac{1}{40}$ of the diameter of the bore, and the loss of force arising from the escape of gas through this windage, amounts to a very considerable portion of the entire charge. The amount of loss in any case depends on :—

1. The degree of windage; 2. The caliber of the gun; 3. The length of the bore; 4. The kind of powder; 5. The charge of powder; 6. The weight, or density of the ball. It is probable that the influence which some of these causes exert on the force of the charge is very slight; and that to determine the exact influence of each of the others would be a very difficult if not an impracticable problem. The most important question is, to determine what allowance must be made for a given difference of ordinary windage.

The pressure, or force, exerted by a charge of powder on different balls at the same point of the bore of a piece, will be proportioned to the surfaces, or squares of the diameters. If the weight of the balls be the same, the pressure will be proportional to the square of the velocity communicated to the balls in a given time. We, therefore, have the proportion—$D^2 : d^2 :: V^2 : v^2$ and $D^2 : d'^2 :: V^2 : v'^2$, or $D : d :: V : v$ and $D : d' :: V : v'$. From these last two proportions we have $D : D-d :: V : V-v$, $D : D-d' :: V : V-v'$, or $D-d : D-d' :: V-v : V-v'$ in which D, d, and d' represent the diameters of three balls, and V, v, v' their initial velocities, respectively. If D equal the diameter of the bore $D-d$ is the windage of the ball whose diameter is d, and $D-d'$ is the windage of the ball whose diameter is d'. If we multiply the extremes and means of the last proportion, and divide the resulting equation by $V(D-d)$ we shall have the expression

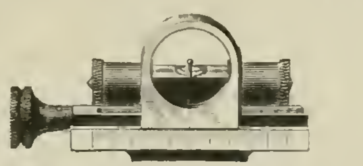
$$\frac{V-v'}{V}=(D-d')\frac{V-v}{V(D-d)}$$

By making $m=\frac{V-v}{V(D-d)}$, the equation becomes $V-v'=V\times m(D-d')$. This equation expresses the relation between a certain windage, $D-d'$ and the loss of velocity due to that windage, or $V-v'$.

In a series of experiments made by Major Mordecai, with the ballistic and gun-pendulums, it was found that m was constant for all values of $D-d'$ that would be likely to arise in service. From this it follows that $V-v'$ is proportional to $D-d'$; or, in other words, that the loss of velocity by windage is proportional to the windage. When the charge of powder is varied, it was found that the absolute loss of velocity by a given increase of windage, was very nearly the same for all the charges used. It follows from this that the proportional loss is less for the higher charges. Both the absolute and relative loss of velocity by a given difference of windage (say one-tenth of an inch) increase as the caliber of the piece decreases. From the foregoing, it may be stated, that the loss of velocity by a given windage, is directly as the windage, and inversely as the diameter of the bore, very nearly.

WIND CONTUSIONS.—Military Surgeons so often meet with cases in which serious internal mischief (as for instance, the rupture of the liver, concussion of the brain, or even a comminuted fracture of a bone) has been inflicted, without any external marks of violence to indicate its having resulted from the stroke of a cannon-ball, that they were led to the conclusion that solid objects projected with great velocity through the air might inflict such injuries indirectly by aerial percussion; the hurt being inflicted either directly by the force with which the air is driven against the part, or indirectly by the rush of air to re-fill the momentary vacuum created by the rapid passage of the ball. So many observations have, however, been made of cannon-balls passing close to the body (even shaving part of the head, tearing away portions of uniform, or carrying off the external ear or the end of the nose, without further mischief) that this hypothesis is totally untenable, and is now generally rejected. The true explanation of the cases formerly attributed to the windage of cannon-balls appears to rest, according to recent views, "in the peculiar direction, the degree of obliquity with which the missile impinges on the elastic skin, together with the situation of the structures injured beneath the surface, relatively to the weight and momentum of the ball on one side, and hard-resisting substances on the other.

WIND-GAUGE.—An attachment to the sight (either front or rear) of a fire-arm by which an allowance for the wind on the projectile can be made in aiming. Though usually called *wind-gauge*, it is also used to counteract *drift* or any other deviation which can be anticipated. The wind-gauge is usually attached to the front-sight, but some of the more recent military arms have it attached to the rear-sight. In the present U. S. service rifle, the sight-piece is moved by hand, and has graduations to guide the marksman. The front-sight, upon most long-range rifles, is made to traverse from right to left by a screw, and has a scale marked with divisions so as to permit an exact allowance to be made for wind. To prevent any loss in elevation from tipping the rifle, a small level is placed in front of the fore-sight, so that, when the rear-sight is perpendicular, the bubble is directly under the fore-sight. In aiming on ground which is not level it is almost impossible to keep the sights plumb without it. The deviating effect of wind depends on its force, and its direction with regard to the plane of fire; generally speaking,



large and heavy projectiles, moving with high velocities, are deviated less than those of contrary character. It is difficult to calculate the effect of the wind in any particular case: in making allowance for it, therefore, the marksman should be guided by experience and judgment. For the same projectile, velocity, and wind, the deviation varies very nearly as the square of the range. When it is stated that Major Fulton has been seen, in practice at 1,000 yards, to alter his wind-gauge twelve feet between two consecutive shots, and make a bull's-eye both times, the advantage they afford to those skilled in their use will be recognized, as well as the amount of judgment and perception required to use them properly. The wind-gauge is frequently attached to breech-sights of cannon in Europe. In this country the Parrott gun is similarly equipped.

WIND INSTRUMENTS.—Musical instruments of which the sounds are produced by the agitation of an inclosed column of air. They are generally classified into *wood instruments* and *brass instruments* (both of which are played by the breath). The name wood instruments is applied to musical instruments constructed either of wood or of ivory, of which the principal are the flute, piccolo, clarionet, flageolet, basset-horn, oboe, and bassoon. They are generally characterized by a soft, smooth, aerial tone, resembling the human voice. By the use of holes and keys, considerable compass is given to them; they are capable of producing only one sound at a time, but with considerable command of piano and forte. Of brass instruments the chief are the horn, trumpet, trombone, cornet-a-piston, euphonium, bombardon, and ophicleide. They are generally more powerful, and their quality more piercing than wood instruments; the ophicleide, however, approaching more than the rest to wood instruments in capabilities and tone. In a full band there are generally two flutes, two oboes, two clarionets, two or four horns, and two bassoons, frequently with the addition of two basset horns, one or two piccolos, and one or two ophicleides or trombones. Each part, except when there is an unusually large number of bow-instruments, is single. See *Band*.

WINDLACE.—Formerly an apparatus for bending the bow of an arblast or cross-gun.

WINDLASS. That modification of the wheel and axle which is employed in raising weights. Its simplest form is that of an axle supported by pivots on two strong upright pieces, and pierced near one end with four or six square holes, into which handles known as *handspikes* are inserted. In other forms, a winch at each end is employed for the handspikes. If the weight is to be lifted a considerable distance, the length of the rope which attaches it to the axle largely increases the weight, and thus aids the power when descending and counteracts it when ascending. This difficulty is partially got over by employing a double rope, one end of which ascends while the other descends; but this modification, though partially effective for the end in view, lends aid to the power when aid is least, and hinders it when aid is most, required. A more efficacious plan is to form the axle not cylindrical, but of a barrel-shape, like two truncated cones, placed base to base, and to fasten two ropes, one to each end, so that when coiled up round the barrel they approach the middle; in this case when one rope is fully uncoiled, and winding-up commences, the gross weight, which is then at its maximum, acts at the minimum leverage of the end, and as the progress in winding up diminishes the weight, its leverage so increases that the momentum is preserved uniform. On the other hand, the empty bucket, when commencing its descent, acts at its greatest leverage, and as the unwinding of the rope adds to the weight, its leverage becomes smaller, so that the momentum of the descending weight always remains the same; and thus the strain on the power is preserved uniform. The ratio of the weight to the power it is sometimes found necessary to increase greatly; but with the ordinary windlass this could only be effected by similarly increasing the ratio between the leverage of the handle, and the radius of the axle—an object attained by a great increase of the former, rendering the machine too cumbrous, or by greatly diminishing the latter, and so weakening it. The desired result is attained, however, in a manner not liable to these objections, by the use of the *differential axle*, an axle of which one-half is of greater diameter than the other, and the single rope, after being coiled round the whole axle from end to end, is fastened at each end of the axle, and the weight is hung by a pulley, which is supported in a bulge in the center of the rope. As the portion of the rope on one half of the axle is unwound, that on the other half is wound up; but since the rates of winding and unwinding are different, the bulge of the rope increases when the rope is wound *on* the smaller end of the axle, and decreases when it is wound *off* the smaller end. The more nearly equal the two radii of the axle are, the greater is the weight which can be raised by the power—the ratio between the two being

$$\frac{W}{P} = \frac{\text{radius of circle described by power}}{\text{difference of radii of the portions of the axle}};$$

so that if the radius of the power is 18 inches, and the radii of the axle 5 and 4 inches, the power balances a weight = 18 times itself; while the strength of the axle requires to be only equal to that of one of the ordinary kind, in which the power can only balance a weight = $4\frac{1}{2}$ times itself. The same principle is applied to the screw. For a very accurate estimate of the mechanical advantage of the windlass, the thickness of the rope must be taken into account, by adding half of its diameter to the radius of the axle.

WINDLASS CROSS-BOW.—A form of cross-bow anciently used by the infantry. It was much heavier than the cross-bow of the cavalry, and the string was stretched by means of a windlass, or windlace. It was generally called *cranequin* cross-bow.

WINDSOR CASTLE. Among the fortified places of England in days gone by, Windsor Castle held a conspicuous place. Before the time of William the Conqueror, Old Windsor, about two miles distant from the site of the present Castle, was not a fortress, but a palace for the Anglo-Saxon monarchies. The present Castle is stated to have been built by William I., and to have been regularly fortified by him. It appears, however, that the history of the existing Castle begins in the reign of Henry III. Historians have dealt with the various associations of the spot. Her Majesty makes it, at different times, her residence.

WING.—An ornament worn on the shoulder; a small imitation epaulette or shoulder-knot. The term *wing* is sometimes used to denote the branch of a crown-work, etc.

WINGED.—In Heraldry, represented with wings, or having wings, of a different color from the body.

WING HELMET. A Polish casque, with winglets, of the seventeenth century, worn by the troops under Sobieski, who were called *winged cavalry*.

WING OFFICER. -An officer of the Indian Army attached to a wing of a native infantry regiment. On the re-organization of the above Army, after the Indian mutiny (1857-58), native regiments were divided into two wings, to each of which a wing officer was appointed, either a Field-officer or a Captain.

WINGS. The two flanks or extremes of any portion of an army or any body of troops on the right and the left of the center.

WING TRAVERSES.—The parallels are covered by their parapets from all fire of the besieged; but the boyaux, from receiving a direction toward the besieged works, may be exposed either to a very oblique slant fire in their front; to an enfilading and a slant reverse fire; or to a fire on both flanks and in front. From the first, they are usually secured, by running them out so far beyond the point from which the most dangerous slant fire may come, that a projectile, thrown from this point, striking the top of the parapet of the boyaux, will not plunge low enough to hit a man standing at the reverse of the trench and in the line of direction of the fire. This position is attained, in practice, on a site sensibly horizontal, by giving the line of the trench such a direction, that, prolonged, it would pass 30 or 40 yards outside of the most dangerous point. On ground inclining downward toward the dangerous point the direction given should be the further out as the exposed ground is the steeper; but, on ground rising toward the dangerous point, the direction may be laid nearer in toward the dangerous point than on sensibly level ground, so as, in some cases, to be run directly upon this point, with full security from its fire. In practical field operations, the selection of the proper direction in each case will depend upon the experience of the engineer conducting the approach, and his *coup d'œil* for the lay of the ground.

Where the approach is exposed to an enfilading and a slant reverse fire, and does not admit of a change of direction to avoid these, resort is had to the erection of traverses across the line of trench to cover from an enfilading view, and to short portions of trench, termed *wing traverses*, run back from the approach in a direction perpendicular to it, the parapets of which intercept the slant fire.

To effect this the trench is carried forward by means of the half-double sap. So soon as the head of the sap has been advanced the length of twelve gabions beyond No.4,a short end of sap is commenced in a direction perpendicular to that of the trench,and run out until it intercepts the line of fire upon the point of departure of the trench, which should be at most at the distance of twelve gabions in the rear. When this end of sap is completed, the provisional parapet of the trench in its rear can be taken down, and the trench enlarged to its proper width. In this way the trench is successively pushed forward and enlarged, until a position has been reached where it becomes necessary to place a traverse to cover the trench from both enfilading and reverse views. These traverses are made by changing the direction of the trench perpendicular to that of the original line, and continuing in this new direction, by the full sap, the requisite length of the traverse; the original direction is then resumed,and continued,by the half-double sap, a sufficient distance to leave room for the width of the traverse and a trench of double sap; a rectangular return is then made, by the double sap, back to the line of gabions of the original trench,and the original direction is taken up and carried forward by the half-double sap.

The traverses are usually seven gabions, or about 14 feet in width. Their length will depend on the position of the dangerous point, but they are seldom made over 30 feet in length. Their distance apart will also depend on the command of the dangerous point. The portion of trench between any two traverses must be perfectly covered by the advanced traverse. As a practical rule the traverses are not placed farther than 25 or 30 yards apart. See *Traverse*.

WINTER-QUARTERS.—When winter puts an end to the active operations of an army in the field, the troops are, as a rule, put into quarters to recruit and to rest from the fatigues of the campaign. These quarters are so located that the army can keep possession of the points already gained, and that the troops occupying them can be near the new field of operations when the season admits of the re-opening of the campaign. *Winter quarters*, in order to admit of the easy supply of the troops, are more widely distributed than camps, and are analogous to the occupied points of a " defensive line". They should be, if possible, so arranged as to be perfectly secure, from all attempts to carry them, and so as to admit of an easy and quick concentration of the troops upon the key-point of the line, if at any time they are threatened by the enemy. See *Cantonments* and *Field-service*.

WIRE.—The facility with which any metal can be drawn into wire depends upon its ductility. Most metals have this property; but some, like bismuth and antimony, are so brittle that they can be drawn out with difficulty, and wire made from such metals is useless, from want of tenacity.

Metals largely used for making wire, such as iron, brass,and copper, are drawn by essentially the same process. We may take iron as an example. It is prepared by cutting up flat rolled plates into square rods of a given thickness. This is done by means of a pair of slitting rollers; one of these has grooves, equal to the breadth of the rods wanted, fitting into corresponding grooves in the other, which cut up the metal like scissors. The rods are cleaned of scales of oxide, either by mechanical rubbing, or by chemical treatment with dilute sulphuric acid. If the rod is thick, it has its square edge taken off by rollers. It is then drawn into wire by forcing it through the hole of a *draw-plate*. This is an oblong piece of hard steel pierced with conical holes gradually diminishing in diameter,and having the smallest ends of these tapering holes carefully prepared to the required size. Sometimes cubical shaped dies, each with a single trumpet-shaped hole, are used. Motion is given to the drawing-block or cylinder by means of beveled wheels connected with a shaft.

The workman commences by making a point on the rod, so as to allow it to pass through the hole, and be grasped by a pair of pincers attached to a chain, which draws it out till the length is sufficient

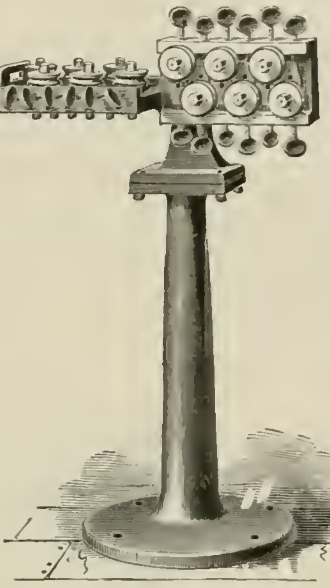


Fig. 1.

to pass round the cylinder. This much is done by hand, and then the cylinder, being put in gear, is made to revolve and pull the wire through the draw-plate—coiling it round itself as the drawing proceeds. After being once drawn, it is again passed through a smaller hole, and so the process is repeated till it

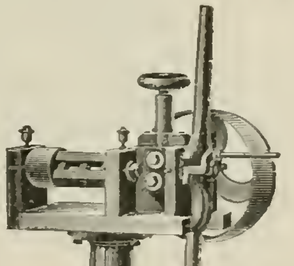


Fig. 2.

has been reduced to the required size. Fine wire may require from 20 to 30 drawings. The cylinder revolves slowly with a thick wire, and the speed is increased as the size diminishes. After being passed a few times through the draw-plate the metal becomes brittle, and requires to be annealed. Sometimes, a lubricating substance—as wax, grease, or soap—is employed during the drawing, especially for fine wires. For some very accurate purposes, such as chronometer springs, and for gold and silver lace, the wire is drawn through jeweled holes, that is, holes perforated in rubies and other hard gems. A silver wire 170 m. long, and about $\frac{1}{300}$ of an inch in diameter, has been drawn through a hole in a ruby, and found, by a micrometer, to be of exactly the same size at the end as at the beginning; whereas the drawing of a length of 16 m. of brass wire through a steel draw-plate necessitates a readjustment of the hole. Platinum wire can be drawn as thin as one three-thousandth of an inch in diameter by first encasing it in silver, drawing down the compound wire, and then dissolving off the silver with nitric acid. By the same process gold wire can be obtained only one five-thousandth of an inch in diameter. It has been shown by Babbage, as an illustration of how greatly labor increases the value of a raw material, that one pound of iron, which costs twopence, will yield 50,000 wire pendulum springs or watches, each weighing about one-seventh of a grain and selling at the retail price of twopence.

After drawing, the wire is in spiral coils and for most purposes in the arsenal, requires to be straightened before being used. Figure 1, represents a very simple machine for this purpose. The machine has any number of rolls desired. For small wire, twelve-roll machines are generally preferable; but for sizes from $\frac{3}{16}$ to $\frac{5}{8}$ inches in diameter (the latter being the largest for which this kind of straightener is recommended), eight rolls are commonly sufficient. Figure 2, shows a hand wire cutting-machine, employed to cut the wire in short lengths accurately, or in long lengths that are to be cut up again. It is very compact, simple and easily operated. The feed rolls and straightener are run by power communicated from one countershaft. The cutting-off is done by a hand-lever, and pieces can be cut at the rate of 100 or more per minute, varying, of course, according to the size of the wire, the length of the pieces, and the dexterity of the operator. This machine is made in three sizes for $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{3}{8}$ inch wire, each being capable of cutting smaller sizes, though the $\frac{3}{8}$ machine being necessarily heavy, is not recommended for a continued use on anything smaller than $\frac{3}{16}$. The $\frac{1}{8}$ inch size is suitable for small wire up to $\frac{1}{8}$ inch only, and the $\frac{1}{4}$ size may be used for $\frac{1}{4}$ and all the smaller sizes. A combined hand and power wire straightening and cutting-machine, such as is employed in making priming wires and cutting the larger sizes of wire in long pieces is shown in Figure 3. This machine is not designed for work requiring great accuracy in length; for all such the automatic wire cutting-machine, provided with a slide feed is more especially adapted. Its operation is as follows: The wire is drawn through a straightener by a suitable gripping device mounted on a slide, which is movable back and forth by a pitman connected with the rotating disc on the left side. The length of wire to be cut is regulated by the throw of the pitman, which is adjusted by means of a screw in the slot of the disc. The wire thus drawn forward is held in place by the first of the two levers shown on the right, while the second, which is provided with a suitable cutter, cuts it off; these two levers are operated by cams on the main shaft. This machine is adapted for both fine and coarse wire, and can be arranged to cut a great variety of lengths. A device may also be attached to the cutting lever, for flattening, nicking or bending one end of the wire as it is cut off, if desired. Various other wire-working machines, used in the armory and arsenal have been designed and perfected by Messrs. John Adt and Son, United States. Wire, although mostly cylindrical in form, is drawn of many different sections, such as oval, half-round, flat, triangular, molded, and the grooved pinion-wire from which the small toothed pinions for clocks and watches are cut. Copper wire of different forms is used to form various patterns. The following numbers (given by Dr. Tomlinson) of the weights, omitting fractions of a pound, which were sustained by wires 0.787 of a line in diameter, show the comparative tenacity of

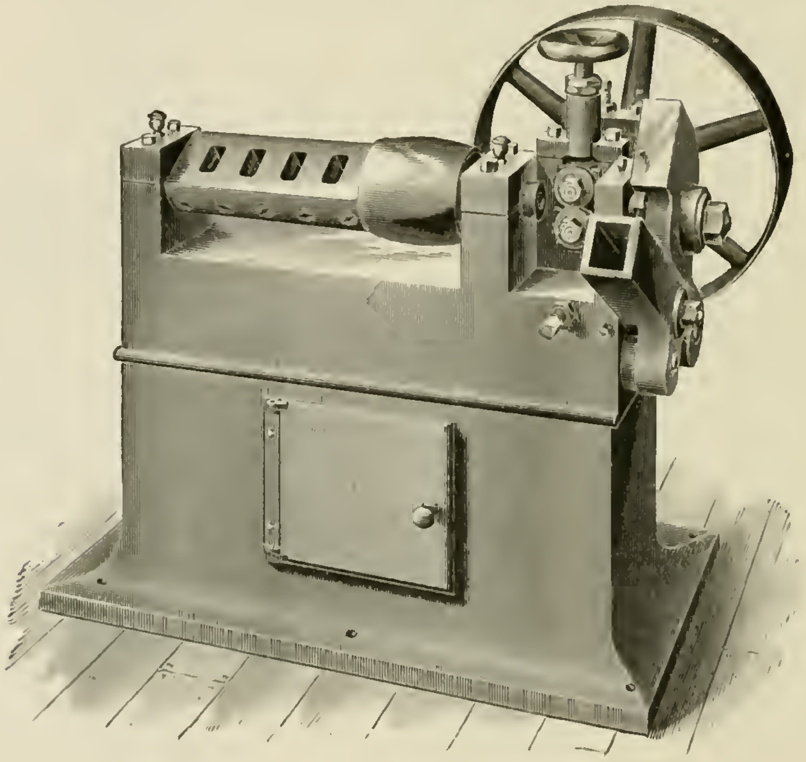


Fig. 3.

a few of the metals: Iron, 549 lbs.; copper, 302 lbs.; platinum, 274 lbs.: silver, 187 lbs.: gold, 151 lbs.: zinc, 110 lbs.: tin, 35 lbs.; lead, 28 lbs. It may be remarked here that some kinds of brass wire have been noticed to become extremely brittle in the course of time, especially if subjected to vibration, and even to break when used to support objects, without any assignable cause.

WIRE CARTRIDGE.—A cartridge used for fowling in which the charge of shot has wire ligaments.

WIRE GAUGE.—The want of uniformity in common wire gauges is well-known; even if they all agreed with published tables of sizes, there would still exist serious objections to their use, as the variations between different numbers is so irregular. The annexed tables give the dimensions of each size bers. A perusal of these tables should satisfy us that we have a sufficient variety to choose from, and ample refinement, when we get down to one-millionth of an inch, which is the final figure in some cases. In many cases the difference between two numbers falls as low as two one-thousandths of an inch, in others it is only one one-thousandth, etc. It may be possible to make one gauge to any of these standards, which shall be so accurate as to defy the detection of an error, and with the same care it may be possible to make a thousand such gauges, but every mechanic, and every person accustomed to making accurate measurements of the best work, knows that it is simply impossible to obtain absolute accuracy in such pieces of work, when produced in large quantities. It is impossible commercially, on

Number of Wire gauge.	American, or Brown & Sharpe.	Birmingham or Stubs.	Washburn & Moen Mfg. Co. Worcester Mass.	Trenton Iron Co. Trenton, N. J.	G. W. Prentiss, Holyoke Mass.	Old English, from Brass Mfrs.' List.	Number of Wire gauge.
000000	....	....	.46	....	....	....	000000
00000	....	....	.43	.45	....	....	00000
0000	.46	.454	.393	.4	....	....	0000
000	.40964	.425	.362	.36	.3586	....	000
00	.3648	.38	.331	.33	.3282	....	00
0	.32495	.34	.307	.305	.2994	....	0
1	.2893	.3	.283	.285	.2777	....	1
2	.25763	.284	.263	.265	.2591	....	2
3	.22942	.259	.244	.245	.2401	....	3
4	.20431	.238	.225	.225	.223	....	4
5	.18194	.22	.207	.205	.2047	....	5
6	.16202	.203	.192	.19	.1885	....	6
7	.14428	.18	.177	.175	.1758	....	7
8	.12849	.165	.162	.16	.1605	....	8
9	.11443	.148	.148	.145	.1471	....	9
10	.10189	.134	.135	.13	.1351	....	10
11	.090742	.12	.12	.1175	.1205	....	11
12	.080808	.109	.105	.105	.1065	....	12
13	.071961	.095	.092	.0925	.0928	....	13
14	.064084	.083	.08	.08	.0816	.083	14
15	.057068	.072	.072	.07	.0726	.072	15
16	.05082	.065	.063	.061	.0627	.065	16
17	.045257	.058	.054	.0525	.0546	.058	17
18	.040303	.049	.047	.045	.0478	.049	18
19	.03539	.042	.041	.036	.0411	.04	19
20	.031961	.035	.035	.034	.0351	.035	20
21	.028462	.032	.032	.03	.0321	.0315	21
22	.025347	.028	.028	.027	.029	.0295	22
23	.022571	.025	.025	.024	.0261	.027	23
24	.0201	.022	.023	.0215	.0231	.025	24
25	.0179	.02	.02	.019	.0212	.023	25
26	.01564	.018	.018	.018	.0194	.0205	26
27	.014195	.016	.017	.017	.0182	.01875	27
28	.012641	.014	.016	.016	.017	.0165	28
29	.011257	.013	.015	.015	.0163	.0155	29
30	.010025	.012	.014	.014	.0156	.01375	30
31	.008928	.01	.0135	.013	.0146	.01225	31
32	.00795	.009	.013	.012	.0136	.01125	32
33	.00708	.008	.011	.011	.013	.01025	33
34	.006304	.007	.01	.01	.0118	.0095	34
35	.005614	.005	.0095	.009	.0109	.009	35
36	.005	.004	.009	.008	.01	.0075	36
37	.004453	....	.0085	.00725	.0095	.0065	37
38	.003965	....	.008	.0065	.009	.00575	38
39	.003531	....	.0075	.00575	.0083	.005	39
40	.003144	....	.007	.005	.0078	.0045	40

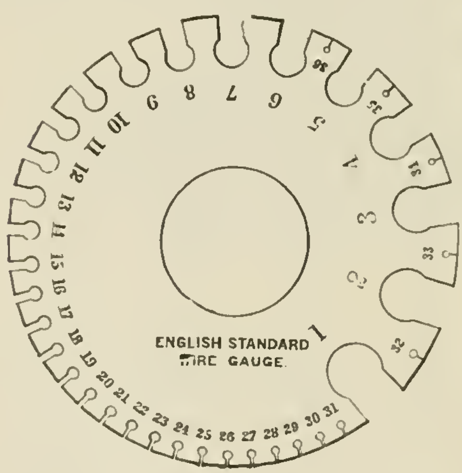
of the gauges in ordinary use, and show the necessity of the adoption of a common standard by which the confusion now existing may be avoided.

Refering to the foregoing tables, we would call attention to some of the absurdities and anomalies of the present system of gauges, denoted by the numbers account of the cost, and that settles the question. Every one knows of the wonderful accuracy of the Whitworth gauges, and also their enormous price, which makes them almost unsalable. In regard to ordinary wire gauges, they are notoriously inaccurate because they cannot be made accurate and be at all salable. Another trouble is with the wearing of the gauges, for which there is no remedy. In regard to the terms "light," "easy," etc., we have, for instance, the differences between the Nos. 27 and 28, in the three systems, as follows:—

.00225, .002, .001551,

or two hundred and twenty-five one-hundred-thousandths, two one-thousandths, and fifteen hundred and fifty-four millionths. How is it possible for the

roller to know just how many millionths of an inch another man, whom he never saw, means when he says No. 28 "full," or No. 27 "easy"? and how is he to guess how many thousandths of an inch the other man's gauge is wrong in its make, or how many hundredths it has worn in years of steady use? This is no fancy sketch; the above are nearly every-day difficulties in this age, when every mechanic knows



just what he wants and will have nothing else, and yet has no better way of telling his wants, than to say I want such a gauge "tight," when probably his gauge differs from every other gauge that was ever made. There is a very easy and simple way out of this whole snarl, and that is to abandon fixed gauges and numbers altogether. The micrometer sheet-metal gauges, made by the Brown & Sharpe Manufacturing Co., of Providence, R. I., cost less than a common gauge, or no more. They measure thousandths of an inch very accurately, and even a quarter of a thousandth may be neatly measured. They are very simple, so that any boy of ordinary intelligence can be taught to use one in a very few minutes. They have very easy arrangements for re-adjustment, when worn; and even when worn considerably, they can be used accurately, without adjustment, by making allowance for the error in reading at the zero line.

WIRE GUNS. The most prominent recent developments at the Elswick Works are the experiments with and the production of the wire or "ribboned" guns. The successful test of a 6-inch gun of this type has led to the fabrication of 10.236-inch and 13-inch calibers, respectively, the former having only a weight of 21 tons, and the latter a weight of 44 tons, thus securing a gun of much greater power than the 12-inch 43-ton gun of the ordinary Armstrong type. The general features of the wire system are the building up from a steel tube, about one-half a caliber thick, a gun about a caliber in thickness of walls, by wrapping around a tube ribboned wire, or rather wire of a rectangular cross-section—under varying tension for different distances from the axis of the bore, the ribbons being applied longitudinally as well as circumferentially, the wire being covered with hoops of steel or wrought-iron of varying lengths, yet comparatively short, adding a protection to the wire, finish to the gun, and so locked in with the body underneath as to give increased longitudinal strength. The details of building up these guns, taking the 10.236-inch, shown in the drawing, as a type, are as follows: The steel tube constituting the body of the gun, after being turned to the proper dimensions, is next provided with the different pieces affording shoulders, between which the forward sections of wire are wound or laid on. These rings being shrunk on, and having serrations corresponding to the ones on the tube, an intervening thin copper band, by its compression under shrinkage, locks them to the tube. The rear band is also similarly attached to the tube. The tube, being then made ready for the reception of the wire, is properly centered in the coiling lathe, and the different sections between the shoulders of the ring, except the rear section, have the ribband steel applied, both circumferentially and under different tensions and longitudinally. The trunnion ring is next shrunk on over the wire and part of the adjacent rings. The winding and laying on of the rear section of ribband completes the wiring of the gun at the breech, twenty layers being placed around the body, and four layers lengthwise of the bore. The different sections of wrought-iron hoops to complete the structure are laid on in succession and in turn, and the piece completed as far as the building up is concerned. The weights of the different parts, as approximately calculated, are as follows:—

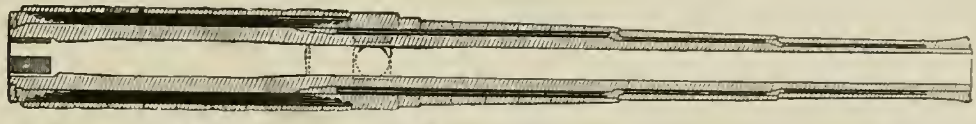
	Tons.
Tube (steel, Whitworth's fluid-compressed)......	7.28
Steel ribband..	5.93
Wrought-iron parts..................................	7.79
Total..	21.00

The 13-inch 44-ton gun of this type is somewhat different in the details of its construction. The gun is designed without trunnions. Four square-cut rings on the under section of the hoop, corresponding to the trunnion band, are seated in a block grooved for their reception, and attached to the carriage. All steel and wire are used in rear up to this equivalent of the trunnion hoop, the exterior portion for this band, however, being made of wrought-iron sections. Another feature is that a steel jacket is shrunk over the inner-tube, enveloping it to a distance a little beyond the chamber, and is believed to be serrated on its interior, and united longitudinally to the inner tube with corresponding serrations by melted phosphor-bronze or thin copper tube. No longitudinal wires are used. In general subdivision of parts, it otherwise resembles its prototype, the 10.236-inch. This gun is expected to reach the enormous muzzle energy of 27,500 foot-tons, or, say, 622 foot-tons per ton of metal of weight of gun. The United States projected breech-loading gun of 55 tons could only realize, say, 20,000 foot-tons muzzle energy, or, say, 350 foot-tons per ton of metal of the weight of the gun. The recent firings with one of the 10.236-inch guns are tabulated below :—

Number of rounds.	Weight of charge.	Weight of shot.	Velocity.	Pressure.	Energy per ton of metal in gun.	Energy.
	Lbs	Lbs	Feet.	Lbs.		
15..................	300	400	2,238	....	......	....
15..................	300	500	2,150	67,000	760	16,000

The date of firing was recent, and the pressure and foot-tons of energy attained at the muzzle, also foot-tons of energy per ton of weight of the gun, are the figures furnished by Captain Noble of the Elswick Works.

The 43-ton breech-loading gun, ordinary Armstrong



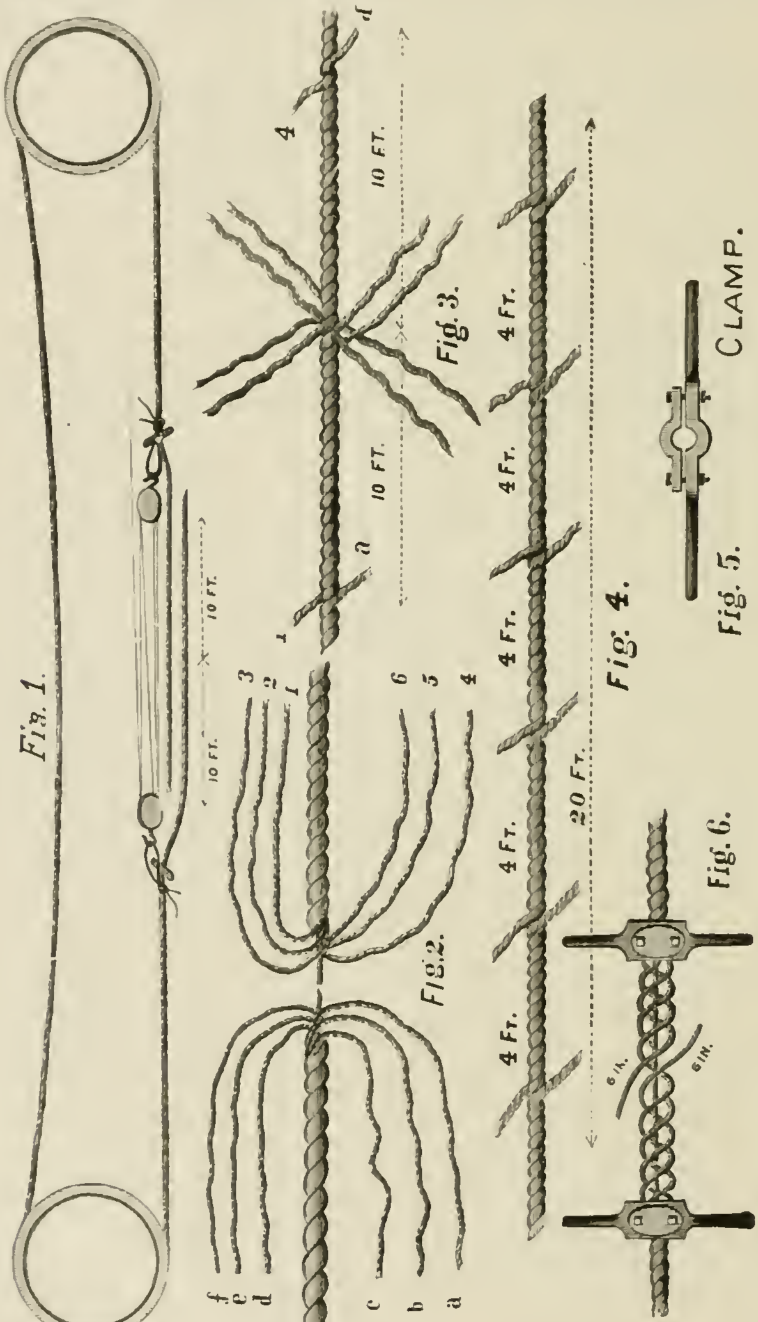
type, has a service charge of 330 pounds, with a 700-pound projectile, and a resulting muzzle velocity of 1,845 feet, and hence yielding, say, a muzzle energy of about 16,500 foot-tons. A wire gun of 21 tons gives about the same power, but, being impressed upon a smaller area of surface, its penetrating power is greater. It would be inferred from these figures that even constructions wholly of steel, otherwise than those using wire, are not trusted—by constructors who have had experience in both—to attain anything like the power expected from the use of the latter

The incalculable advantages which arise in built-up systems, in contradistinction to plans involving the use of huge homogeneous masses (like cast-iron), of a subdivision into parts comparatively light in weight, and hence readily produced and easily handled, are carried out in the highest degree in the system under consideration. The subdivision admits of opportunities for accurate inspection, the attainment of a minute and thorough knowledge of the physical properties of the metals employed in the building up of our structures, and enables us to apply more thoroughly the sound and well-established modern theories of gun construction. The germ of these theories is to be found in the developments of General Rodman in his experiments, which, independent of the very inferior metals at his command, enabled him to point out the great general principles which should underlie all sound constructions—the principles of initial tension and varying elasticities. If we take the 10.236-inch Armstrong wire gun as an illustration, we will find that the heaviest part to be handled—the internal tube—only weighs about 7.28 tons. The wire is, of course of no moment as to the weight to be handled, and the superimposed frettes are none of them so heavy as to require especial consideration of the question of ease in handling. Other natures of higher power will, as seen in the 13-inch (the heaviest weight employed in it not exceeding 12 tons), likewise confirming the advantages of the introduction of the subdivision of parts found in the system.

The simplicity of the plant required is apparent, especially when we consider that the steel interests of the country should, if not now, yet in the near future, produce the tubes, wire, frettes, etc., and that the assembling and finish can be done in any well-appointed machine-shop, well provided with the necessary lathes for the turning, boring, and winding of the wire: also rifling-machines and other and simpler tools for finishing and fitting minor parts. This last feature, arising from the construction leads us to point out that, without interference with the private manufacturing interests of the United States, some of our present arsenals—such as Frankford and Springfield—have ample facilities for the production of *experimental* guns on the plan under consideration, and upon the above condition of supply of parts even of the highest calibers required for armament. Heretofore this has been impracticable, as the expensive, cumbersome, and large plant in huge pits and furnaces and heavy cranes and lathes necessary to produce huge homogeneous masses, has not been at our command. The system now under discussion, however, dispenses in a great measure with all these, and brings the construction within the scope of ordinary appliances and ordinary machinery, and would, in the event of a decision to try it, lead—if the trials were successful—to a bringing into play our present resources for experimental constructions, to afford models and experience for fabrication by the contractors to be intrusted with the work of construction. The benefit to be secured by enabling us to provide standards for fabrication is evidently incalculable: but, of course; this obvious advantage can only be urged in the cases where it can be attained in connection with the most advanced and best construction to which it must always, of course, remain *subordinate*.

The time required for the construction of these guns in quantity, must necessarily be less than for the less subdivided types, provided the facilities for the production of the different parts are fully developed and available: and this important element is one not to be overlooked in studying out the problem of the best and most readily available rifled ordnance to supplant our present smoth-bore guns. No very accurate data are, as yet, at hand as to comparative cost of this system with the ordinary built-up steel ones: but it is not seen that any very wide differences in favor of the solid jackets over built-up wire sections can possibly exist. It is stated that a 100-ton Armstrong gun (ordinary type) costs about $80,000; and an 80-ton Woolwich gun about $50,000: and that a 100-ton wire gun, after the plan of Longridge, would only cost $40,000. It is hardly probable, however, that wire guns can be produced at so much less price than the built-up steel or steel and wrought-iron models: but even if they cannot be made for less than, say $625 per ton—the Woolwich figures—a comparatively inexpensive gun would be the result. Sixty-ton 12-inch cast-iron guns lined with steel tubes and fretted externally would, it is fully believed, even made in quantities, exceed in the cost per gun those of *equal power* made with wire. It is doubtful, from the present prices (here) for the former guns, if such ordnance could be produced for less than $50,000 apiece, or say, over $800 per ton, and under the most favorable circumstance of prices for labor and material.

In closing these remarks on steel ribband guns in England, attention is invited to the change in details of construction in the latest model—the 13-inch. The most important departure in the construction from its prototype, 10.236-inch, is the introduction of an auxiliary steel jacket shrunk over the inner tube, and in all probability united to it by serrated surfaces, between which copper sheets or phosphor-bronze finds place, and undoubtedly introduced to secure an additional longitudinal strength. This diminishes the quantity of wire, but gives additional longitudinal strength. A deficiency in this respect seems to be a source of anxiety, influenced probably from the failure of the gun on board of the "Duilio." An ample provision for it, it would seem, is intended in this last structure to be made, sacrificing to a limited extent, however, the presumed advantage of wire over solid rings or frettes. This, it is deemed, can be readily afforded, as there seems to be no misgivings as to the tangential strength of the system being all, and more than all, that would be demanded in proof or service.



The inherent weakness in regard to the longitudinal stress in the system leads us further to remark that it becomes a matter of the very first importance, in considering plans based upon it, to scrutinize closely the features which are designed to provide for this strain. The Armstrong, the Schultz, and probably others which may be presented to the Government, all will undoubtedly meet the requirements in providing against tangential rupture; but it will be a matter for close study to select for test, if wire should be deemed worthy of trial, those which promise best in securing a system, if not relatively as strong longitudinally as tangentially, yet so far providing for the former stress as to place beyond a shadow of doubt (as far as human judgment can provide) their capacity for endurance in this respect. The tendency in built-up constructions, under violent vibrations, brought into existence by discharge and aggravated by repeated firings with heavy charges, to separate piece from piece, and the effects arising from the tendency of the parts to leave each other by the different inertias of their different masses, both combine to render the problem in this gun construction one of peculiar difficulty, and demanding the closest calculations and deep and prolonged study. The very *jars* may in an indifferent construction be sufficient, if not to part the gun, at least to render it unsafe for the repeated discharges contemplated for actual service. See *Ordnance* and *Schultz Wire Gun*.

WIRE ROPES.—A hemp rope, 6 inches in circumference, and weighing 9 lbs. per fathom; an iron-wire rope $2\frac{3}{8}$ inches in circumference, and weighing 5 lbs. per fathom; and a steel-wire rope $1\frac{7}{8}$ inch diameter and weighing 3 lbs. per fathom, are all of equal strength—the breaking strain of each being 10 tons. The distance to which wire rope transmissions can be applied ranges from 50 or 60 feet up to *miles*. As a magnificent example of long transmission, we would mention that of Schaffhausen, in Switzerland, at the Falls of the Rhine Here 800-horse power is carried diagonally across the Rhine, and extended for a distance of two miles, and distributed among fifty different manufactories, situated in every imaginable position, and embracing all the varied arrangements of changing directions. Wire rope transmission comes into use at the point where a belt or line of shafting becomes too long to be used profitably, and in point of economy it is much cheaper than its equivalent in either shafting or belting. Power can, by this method, be transmitted in any desired direction, up or down hill, across rivers, around buildings or obstructions of any kind, and thus make available many sources of power which are now useless. The ropes hang free in air, and require no protection from the weather, except an occasional coat of warm coal tar, which can be applied to the rope by pouring from a can into the groove of the wheel while running; or raw linseed oil can be swabbed on the rope to keep it from rusting, and thereby preserve it. The splices for running ropes are all of the kind known as the long-splice, and should be put in 20 feet long. The size of the rope is not increased or diminished, nor the strength of the rope perceptibly weakened by this splice, and after it has run for a day or two the locality of the splice cannot be discovered except by the most careful examination. We insert a diagram of splices, which fully illustrates the manner of splicing in all its stages, from beginning to end, and by a little study of these diagrams, and carefully following the directions, any man of ordinary genius can make a successful splice on the first trial. In most cases the ropes can be applied endless, and in such cases the ropes can be forwarded spliced ready to go on. In cases where the endless rope cannot be put on, the rope has to be put around the sheaves, hove taut by pulley-blocks, and the slice made. See Figure 1, page 644. Wire rope is susceptible of the most perfect splice: a smoother and better splice can be put in a *wire rope* than in any other kind of rope, for the simple reason that it is made with a view to this purpose. It has just the desired number of strands, namely, six, and a hemp core which provides a place for fastening the ends. It is a plain, simple process, and but the work of an hour for any one to learn. The only tools required are a hammer and sharp cold chisel for cutting off ends of strands; a steel point for opening strands; two clamps for untwisting rope; a pocket knife for cutting the hemp cord; a wooden mallet and block.

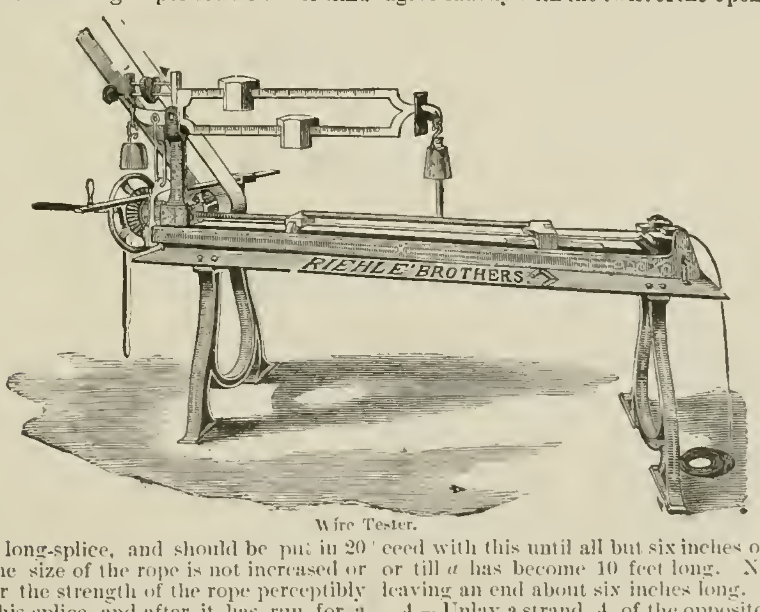
1.—Put the rope around the sheaves, and heave it *tight* with a good block and fall. See Fig. 1. The blocks should be hitched far enough apart so as to give room between to make a 20 foot splice. A small clamp may be used to prevent the lashing from slipping on the rope where the blocks are hitched. See Fig. 1. Next, see that the ropes overlap about 20 feet; about 10 feet each way from the center, as shown by the dotted lines in Fig. 1. Next, mark this center on both ropes with a piece of chalk, or by tying on a small string. Now proceed to put in the splice, with the blocks remaining taut when it is necessary, but the better way is to remove the blocks, throw off the ropes from the sheaves, let it hang loose on the shafts, and proceed with the splice on the ground or floor, or scaffold, as the case may be.

2.—Unlay the strands of both ends of the rope for a distance of 10 feet each, or to the center mark as shown in Fig. 2. Next, cut off the hemp cores close up, as shown in Fig. 2, and bring the bunches of strands together so that hte opposite strands will interlock regularly with each other. See Fig. 3.

3.—Unlay any strand, *a*, and follow up with strand 1 of the other end, laying it tightly in open groove made by unwinding *a*: make twist of the strand agree exactly with the twist of the open groove. Proceed with this until all but six inches of 1 are laid in. or till *a* has become 10 feet long. Next, cut off *a*, leaving an end about six inches long.

4.—Unlay a strand, 4, of the opposite end, and follow with strand *d*, laying it into the open the groove as before, and treating this precisely as in the first case, see Fig. 3. Next, pursue the same course with *b* and 2, stopping four feet short of the first set. Next, with 5 and *e*, stopping as before; then with *c* and 3; and lastly with 6 and *f*. The strands are now all laid in with the ends of each four feet apart, as shown in Fig. 4.

5.—The ends must now be secured without enlarging tne diameter of the rope. Take two rope clamps,



Wire Tester.

see Fig. 5, and fasten them to the rope as shown in Fig. 6; twist them in opposite directions, thus opening the lay of the rope, see Fig. 6. Next, with a knife cut out the hemp core about 6 inches on each side; see dotted lines, Fig. 6. Now straighten the end, and slip them into the place occupied by the core; then twist the clamps back, closing up the rope, taking out any slight inequality with a wooden mallet. Next, shift the clamps, and repeat the operation at the other five places, and the splice is made.

If the rope becomes slack, in time, and runs too loose, a piece can be cut out and the rope tightened up. This will require a piece of rope about 40 feet long and two splices, one splice to put on the piece of rope, and the other splice to join the two ends together. See *Transmission of Power for Military Purposes.*

WIRE TESTER. A machine for ascertaining the strength of wires of different sizes. The drawing, on page 645, shows an improved machine of this class, with the following:

DIMENSIONS.	ft. in.	ADAPTATION.	in. ft.
Extreme height	4 9.	Tensile specimens	5 to 5
Extreme length	9 8.	¼ in. diameter to 0.	
Extreme width	3 2.	Motion of screw	12 in.
Weight...1,000 lbs.		Capacity...10,000 lbs.	

The machine tests with great rapidity, and is provided with a vernier at each end, for long or short specimens, for indicating the stretch of specimens to 1-1000th of an inch. It is operated by steam or hand-power, and is compact, accurate, and complete. An improved grip secures the specimen firmly, and does not require the wire to be cut off from the coil. See *Testing-machines.*

WIRE-TWIST.—A kind of gun-barrel made of a ribbon of iron and steel, coiled around a mandrel and welded. The ribbon is made by welding together laminæ of iron and steel, or two qualities of iron, and drawing the same between rollers into a ribbon. See *Twist-barrels.*

WITNESS.—One who testifies in a cause, or gives evidence before a judicial tribunal. After a witness has been sworn, the first question should be as to his own name and rank, and the second so framed as to elicit an answer embracing the recognition of the prisoner on trial, including rank, battery, (company or troop), regiment, etc. The third in such form that the answer may show that the witness has been so placed as to have knowledge of the circumstances set forth in the pleadings. The fourth and subsequent interrogatories to be framed so as to elicit all the facts material to the matter at issue. Care should be taken in the direct examination to prove, as nearly as possible, the averments of time and place laid down in the specifications. Leading questions, or such as from their construction plainly suggest to the witness the desired answer, are not admissable in an examination-in-chief, but this does not apply to questions which are merely introductory. In the trial of a case, the Court should usually defer questioning a witness until after his examination by the Judge Advocate and the prisoner has been completed. Such questions should be for the purpose of clearing doubts in the minds of the members, or of reconciling discrepancies, and be relevant to the issue. The *cross-examination* should be confined to testimony elicited in the examination-in-chief, and not run into a general defense involving new matter. When facts are to be elicited from witnesses for the prosecution, advantageous to the prisoner, such witnesses can be recalled by the defense for that purpose. The witnesses then *pro tanto* become new witnesses for the defense. *Re-examination* is only for the purpose of explaining any facts that may come out in the cross-examination, and should, as a general rule, be confined to this. Witnesses may be recalled by the Court at any stage in the proceedings for such examination as may be deemed necessary, in which case both parties must be present. After a witness has given his evidence in full, it should be read over to him that he may see whether it has been recorded as he gave it, and that he may make corrections, if necessary, and the fact should be duly noted in the record. Every witness has a right to explain the evidence he has given; and if doubt arises after his examination is closed, the Court may call upon him for such explanation. *Burden of proof* lies on the party maintaining the affirmative of any proposition. There are two tests for ascertaining on which side the burden of proof lies. (1.) It lies on the party who would be unsuccessful if no evidence were given on either side. (2.) It lies on the party who would fail if the particular allegation in the specifications, for example, were struck out. In every case, the *onus probandi* lies on the person who desires to support his case by a particular fact which lies *peculiarly within his knowledge*, or of which he is reasonably cognizant. To illustrate: In a trial for "desertion" the Government asserts the affirmative of the *general* issue that the soldier *did* desert, and, therefore, it must prove the unlawful absence and other attendant circumstances, concurrent acts, and statements of the prisoner, as showing the *intention* to desert or *not return*, in order to constitute the offense. Should the prisoner admit the absence and set up in defense an unfounded arrest by civil authority while on furlough, an affirmative *special* issue would be raised by him, and upon him would devolve the *onus* of proving the fact. In order to ascertain as to the competency of a *witness*, the opposite party, whether Judge Advocate or prisoner, is entitled, on request, to examine him upon the subject before he is examined in chief. This is termed an examination on the *voire dire*; but if the incompetency appear at any period during the trial, the Court will give the opposite party the benefit of it by ruling, on motion, not to consider the testimony of the witness.

His competency, when thus impeached on the *voire dire*, may, however, be restored by cross-examination by the party calling him, or by introducing other evidence thereto. In the same manner, when a prisoner objects to being tried by a *member* of the Court for cause stated, he may examine the member on his *voire dire*, with a right then to the Judge Advocate to establish competency, subject to mature decision of Court as to whether he ought to serve. All this must become matter of record. The following oath should be used on the *voire dire*: "*You do solemnly swear that you will true answers make to such questions as may be here put to you, touching your competency to serve as a witness (or member) in this cause, (or touching the challenge exhibited against you.) So help you God.*" It sometimes happens that a witness may be adverse to the party calling him; in which case the Court may allow, or request, the direct examination to take the character of a cross-examination.

After a witness has been examined in chief, his direct examination being closed, his credit may be impeached—

(1.) By disproving the statements of the witness.

(2.) By introducing evidence affecting his reputation for truth and veracity.

Under the second head the examination must be confined to his "general reputation." The impeaching witness should be asked if he knows the *general reputation* of the witness to be impeached, among his neighbors. If he answers in the affirmative, he is asked, "Is it good or bad?" If he answer, "It is bad," he is then asked, "From what you know of his general reputation, would you believe him under oath?" In answer to such evidence, the other party may cross-examine the impeaching witness as to the persons he has heard speak of the impeached witness; and may also impeach the impeaching witnesses, and support the reputation of his own witness by fresh evidence. A witness may also be impeached by proving that he has made statements out of Court contrary to his evidence in Court, but in such case his attention must be first particularly directed on cross-examination to that part of his evidence. He may be also asked by the opposite party whether he has been charged with or convicted of any particular offense. No proof of the commission of crimes, of which he has never been been convicted, can be offered. A witness is only allowed to state facts of which he has a personal knowledge, yet he may refresh his memory by reference to memoranda made at the time when the facts occurred: but if he has no recollection of the facts, except that he finds them in such memoranda, then his evidence is inadmissible. When a witness speaks from memoranda, the opposite party is to be allowed an opportunity of examining them. See *Courts-Martial*.

WOBBLING.—The unsteady motion of an elongated projectile through the air, caused probably by uneven resistance, due to a certain variable motion in the axis of the projectile. This unsteadiness may be caused either by insufficient rotation being communicated in the bore of the gun, or by the subsequent action of the air, the pressure of which causes an instability of rotation, and thus an irregularity in the amount of surface which the projectile presents to the air.

WOHLGEMUTH GUN.—A breech-loading small-arm, having a fixed chamber closed by a movable barrel, which rotates about an axis at 90° to the axis of the barrel, and horizontal and beneath the barrel. These arms are on the general plan of the Lefaucheux system, are essentially alike, and use pin-fire cartridges. One of the barrels is provided with a rifled lining, which, being removed, shows a smooth-bore barrel of larger caliber for the use of cartridges containing buck-shot.

WOJWODA.—An old Slavonic word (composed of *woi*, warrior, and *wodit*, to lead), means, literally, Army-leader or General, and was from early times used by most Slavonic nations in this sense. Afterward, it became the title of the elective Princes before hereditary Monarchies were formed. Thus, at one time the Princes of Walachia and Moldavia were called Wojwodes; from the Greek Emperors, with whom they had been in intimate alliance from the year 1439, these Princes next received the title of Despots, a title they afterward exchanged for that of Hospodar. The name was also given to the elective Princes of Transylvania, whether dependent or independent. The same title of Wojwoda was applied to the elective Chiefs of the Polish Government before the beginning of the Piast Dynasty. Later, the name denoted office and dignity; and was given in the former Kingdom of Poland to the Governors in the districts, or Wojwodschafts, into which the Kingdom was divided. They had at first only a military authority; afterward, however, both the civil and military were united in one person, so that Wojwoda and Palatine were one and the same. The name of Wojwodschaft was preserved in Russian Poland till recent times; now the Polish Wojwodschafts are named uniformly with the other Russian "Governments." From 1849 till 1860 the Banat and part of the military frontier constituted a separate Austrian Crownland, called "The Servian Woiwodina and Temeser Banat."

WOODBRIDGE GUN.—This gun consists of a thin steel barrel, strengthened by wire wound on its exterior surface, barrel and wire being subsequently consolidated into one mass by a brazing solder melted into the interstices. Square wire is wound upon a steel core somewhat larger than the intended bore of the gun, a sufficient number of wire being wound at once, side by side, to produce the required obliquity of the turns. The successive layers have opposite twist, their number being, of course, sufficient to give the desired exterior diameter to the gun. When thus wound the whole mass is inclosed in a tight case, to protect it from oxidation, and is heated therein to a temperature somewhat above that required for the fusion of the metal to be used for consolidating it. The soldering metal is then run in, filling all the interstices of the mass. When properly cooled the gun is bored and finished from the mass in much the same way as if it were a common casting. As the quality of the steel wire is a matter vital to the principle of the Woodbridge gun, great care has been devoted to its preparation, and very stringent conditions have been exacted from its producers, not only in respect to the quality of the steel, but the subsequent drawing and annealing. The principal dimensions of the finished gun are as follows: Whole length, 174 inches; whole length of bore, 155 inches; greatest diameter, 36 inches; diameter of trunnions, 11.75 inches; weight of gun, 30,300 pounds; preponderance at breech or seat of elevating-arc, 100 pounds. See *Gun-construction*, and *Ordnance*.

WOODEN FUSE.—This fuse, used with the mortar shells, consists of a conical plug of wood, of the proper size for the fuse-hole of the shell with which it is to be fired. The axis of this plug is bored out cylindrically, from the large, down to within a short distance of the small end, which is left solid. At the large end a cup is hollowed out, and the outside of the plug is divided into inches and parts, generally tenths, commencing at the bottom of the cup. The cylindrical space is filled with composition, pounded hard, and as regularly as possible, and the cup filled with mealed powder moistened with whiskey or alcohol. The rate of burning is determined by experiment, and marked on a waterproof cap, which is tied over the cup. Knowing the time any shell is to occupy in its flight, the fuse is cut off with a saw at the proper division, and firmly set in the fuse-hole with a fuse-set and mallet. Say the fuse burns 5″ to the inch. If a shell be 10″ in reaching the mark two inches of fuse will burst it as it strikes. If it takes 8″ to reach the mark, $1\frac{6}{10}$ inch should be cut off, etc. The disadvantage of this fuse is its irregularity, it being very difficult to pound the composition so that equal lengths will burn in equal times.

No.	Nitre.	Sulphur.	Mealed Powder.	Time of burning 1 inch.	Remarks.
1	2	1	3	3.8 sec.	For Siege Mortars.
2	2	1	2¼	5 "	For Sea-Coast Mortars.
3			1	2.2 "	For 8-in. Howitzers.

The shell may either burst too soon, and a great part of its effect be lost; or it may burst after burying itself in the ground; or it may burst after passing the proper point. This irregularity of burning is common to all fuses where the composition is driven in successive layers in a column which burns in the same direction. In the table above is given the ordinary composition of these fuses. See *Fuse* and *Mortar-fuse*.

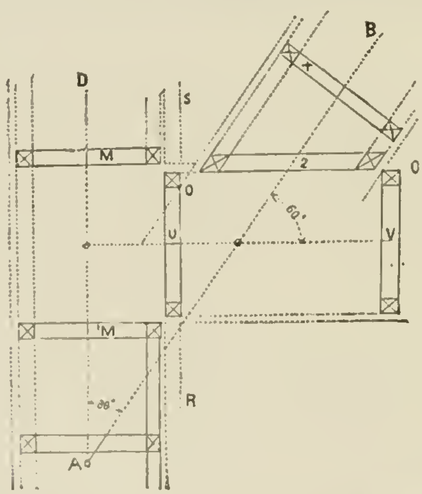
WOODEN GALLERY.—All temporary galleries are made of frame-work covered in by plank, and are prepared but a short period before they are required for use. The frames of temporary galleries consist of four pieces: two uprights termed *stanchions*, and two horizontal pieces; the one at top termed a *cap sill*, and the bottom piece a *ground sill*. The plank or boards which cover in the frames are termed *sheeting*. The top sheeting of the frames usually consists of boards from 3 ft. 6 in. to 4 ft. in length, from 7 to 12 in. in width, and from 1 to 1½ in. thick. The side sheeting may have the same length and breadth, but need not be thicker than from ¾ to 1 inch. To set the frames up and retain them in their places, slips of plank termed *battens* are used, which are 2½ in. in width and 1 in. thick. The frames may be either of well-seasoned oak or pine; the latter is preferable, as lightest. The parts of each frame receive the dimensions in the annexed table.

GALLERIES.	GROUND SILLS.	STANCHIONS.	CAP SILLS.
Great gallery...............	$6 \times 4\frac{1}{2}$	6×6	7×6
Common gallery..........	5×4	5×5	6×5
Half gallery................	$4\frac{1}{2} \times 3\frac{1}{2}$	$4\frac{1}{2} \times 4\frac{1}{2}$	$5 \times 4\frac{1}{2}$
Branches.....................	$3\frac{1}{2} \times 3$	$3\frac{1}{2} \times 3\frac{1}{2}$	$4\frac{1}{2} \times 3\frac{1}{2}$
Small branches............	3×3	3×3	4×3

A gallery which leads from another is termed a *return gallery;* and *it* is called either an *oblique* or *rectangular return*, according to whether the projections of the axes of the two galleries make a right or an acute angle with each other. The gallery from which the return is made is termed the *gallery of departure.* When the floor of the return rises or falls from that of the departure, the return gallery is termed *ascending* or *descending.*

To make a working sketch of a combination of galleries, the projections of the axes are first laid out, their points of intersection marked; and the distances and reference between all the points written. The half width of each gallery in the clear being next set off on each side of its axis, lines are drawn parallel to it, then parallel and exterior to these, at the thickness of the gallery frame from them, two others; and finally two more to make the exterior line of the sheeting. In the drawing, the line A D is the axis of the gallery of departure, and A B that of the return. The frames, M and 'M, bound the entrances or *landings* to the returns.

In oblique returns, where the angle between the axes of the two galleries is 45° or greater, the return is run directly from the main gallery. The first frame



of the return being an oblique one, having its stanchions and sills cut with a suitable obliquity, so that, when the frame is placed alongside of the main gallery, the outside of its stanchions will be parallel to the axis of the return.

When the angle between the axes is less than 45°, it would give too wide a landing in the gallery of departure to run the return directly from it. A short rectangular return must first be made to serve as a landing to the oblique return. To determine the position of the rectangular return, so that it shall be the shortest practicable, set off the lines of the gallery of departure and of the oblique return in the usual manner, draw a line R S parallel to the axis A D, and at the thickness of the gallery frame of the rectangular return from the exterior line of the sheeting; the point O, where this line cuts the exterior line of the sheeting of the oblique return, will be the position of the interior edge of the stanchion of the gallery frame U, of the rectangular return; having next drawn the lines of this return, the position of the other frame, V, will be at the point O, where the outside line of the stanchions of the rectangular cuts the outside line of the sheeting of the oblique return. The landing frames, M and 'M, of the gallery of departure are placed just far enough apart to leave room for the insertion of the sheeting of the rectangular return.

From an examination of the above, it will be seen that the object to be accomplished is so to place the two frames of the gallery of departure, which bound the entrance to the return, that the stanchions of these frames shall not be in the way of the miner, when pushing forward the side sheeting; or, in other words, if the return were a box that could be pushed forward, like a drawer, in the direction of its axis, the stanchions in question should not hinder this movement.

Several other problems of a similar character may present themselves in returns, and in changes of direction in galleries, which it will be unnecessary to treat here, as the illustration above given will readily suggest the methods to be adopted for their solution.

Having set off all the lines on the working sketch, and marked the positions of the different frames, etc., at the junction of the galleries, their forms, dimensions, and also their exact positions with respect to any fixed point can be accurately determined from the scale of the sketch, and be written upon it for reference in conducting the work. See *Gallery.*

WOODEN SHELLS.—In pyrotechny, shells made of light wood or paper, and filled with ornaments of different kinds. They are thrown nearly vertically from a mortar, and when at their highest point explode and throw out their ornaments, set on fire by the bursting charge. To make the shell, turn in a lathe, from well-seasoned poplar or pine, two hemispheres of the size and thickness required, leaving a rabbet to unite the two. Cover the shell thus formed with lens-shaped pieces of No. 2 paper, pasted on smoothly, two or three thicknesses; or form the shell on a ball, the size of the cavity of the shell, by pasting on it strips of paper of lens-shape until it is .2 inch thick. Cut the shell into two equal parts, and take out the core; place the two halves together, and continue to paste on pieces of paper, permitting them to dry perfectly, until the shell is of the required thickness. This mode requires much time, as the shells dry slowly, and each successive layer must be thoroughly dry before other pieces are pasted on. Introduce the stars, serpents, etc., through the fuse-hole, and then the bursting-charge; cover the fuse where it comes in contact with the shell with glue, and drive it into place. To insure the fuse taking fire, tie around the shell two pieces of quick-match, crossing over the fuse. Cover the fuse with several strips of paper, pasted to the shell at their ends. These are removed before the shell is fired. Stars for these shells are made as usual. Those made of composition which burn with difficulty must have a hole in their axes, like those used for Roman candles.

The dimensions and weights of paper or poplar shells are given on page 649. See *Fireworks.*

WOODS. Woods are of great importance in concealing the movement of troops from the enemy; but in very dry weather the dust arising from columns on the march often enables the enemy to detect the presence of troops, and even sometimes assists him to make a rough guess at their strength. As regards the part woods play in fighting, it may be accepted as a general rule that a large wood intersected with numerous good roads is advantageous when situated in rear of a position, but dangerous when close in front of it, or on the flanks. In the first case, a retreat, if necessary, is favored by the woods, and the retreating troops on entering it are soon screened from the fire of their pursuers." Wellington formed

	Thickness of—		Weight of				Weight of charge.				Ornaments.							
											Weight of				Number of—			
Caliber.	Sides.	Bottom.	Empty.		Loaded.		In mortar.	In shell.	Diam. of fuse-hole.	Time of fuse.	Stars.	Gold rain.	Rain of fire.	Serpents.	Stars.	Gold rain.	Streamers.	Serpents.
In.	*In.*	*In.*	*Lbs.*	*ozs.*	*Lbs*	*ozs.*	*Oz.*	*Oz.*	*In.*	*Sec.*	*Oz.*	*Gr.*		*Gr.*				
5 8	0.5	0.62	10	5	2	10	3.5	0.5	1.4	3	0.5	40	....	210	60	170	32	14
8	0.5	0.62	1	10	7	8	5	0.5	1.4	3	0.5	40	....	210	40	600	40	60
10	0.75	0.1	3	25	11	14	5	1	1.4	3	0.5	40	....	210	270	950	230*	130
15	1.25	1.5	44	14	35		12	1	1.4	3	0.5	40	....	210	900	3,400	760	460

his lines at Waterloo well in advance of the forest of Soignies, thus obtaining good cover for his troops in case of defeat. The wood could easily be traversed by infantry, for several good roads led through it from the rear of his position. "On the other hand, woods placed close in front, or on the flanks of a position, screen the advance of the enemy, afford facilities for sudden attacks, or at least enable an enemy to deploy to attack more or less under cover. "Fighting in large woods should, if possible, be avoided, for as there can be little or no supervision on the part of the officers, troops soon get out of hand, and even under the most favorable circumstances, the scattering and mixing together of corps is always to be feared.

The method of dealing with woods, villages, etc., may be best examined by referring to first principles. To troops acting on the defensive it is of importance to see without being seen, and to be so placed as to be able to use their weapons with freedom.

Troops acting on the offensive must seek to overwhelm their enemies with fire, and by advancing in individual order, seek to draw off the fire from the main bodies in rear. Now it is apparent that if both parties are in a wood, neither party will benefit, the shelter afforded by the trees being common to both sides. Consequently, if a wood is to be used for defensive purposes, the *defenders must hold the outskirts of the wood* in that portion nearest the enemy, and must seek to prevent the attackers penetrating into it; if they once gain the wood, unless further arrangements are made for internal defense, the cover afforded by the trees become common to both sides.

Long range weapons lose much of their value in a wood, consequently the object of the defenders should be as long as possible to deny the edge of the wood to the attackers, and keep them under fire. Once the latter get into the wood the fighting is on even terms physically, morally it is all in favor of the attackers, who have gained the wood. Woods, as a rule, check, impede, and render the movements of cavalry and artillery difficult and dangerous, they further disorder infantry; but they at all times afford a useful position and protection to the latter arm. Upon the offensive zone of a field of battle, woods, if of great extent, are injurious to the army taking the offensive, breaking up its formation, and producing crowding and disorder. Woods of small size, however, aid the offensive considerably, helping to mask bodies of troops, and concealing the positions of reserves. They are especially of value if they are of such a nature as will admit of the cavalry being concealed behind them, which can be brought out at an opportune moment to act on the flanks of an attack.

Woods properly held on the defensive zone are of great value, enabling the front of the army holding them to be extended. A wood of very great extent cannot be so treated, because its perimeter, which must be held, becomes too extensive, and the force acting on the defensive would become too much disseminated. In such cases the position taken up should be in rear of the wood, and sufficiently near to crush the heads of the hostile columns as they attempt to debouch. The battle of Hohenlinden affords an example of this; Moreau met the Austrian columns as they debouched from the forest of Ebersburg, and sent Richepanse to attack their flank through the woods from Ebersburg. The Austrians, unable to see in the woods what was going on, on their flank, were broken in two, and the moment Moreau saw the wavering in his front produced by the attack on their rear, he assailed and drove them back.

The difficulty of defending a wood of any extent is that the troops are apt to lose in a short time all tactical connection, and escape out of the control of their officers. The difficulty in attacking a wood is that the attackers are in entire ignorance of what the wood contains, how the defenders are disposed, and that the defenders are sheltered from fire, and can shoot down the attackers with all the more ease, because they themselves suffer but little. It is only by bearing clearly in mind the object in view that any definite ideas can be worked out. To defend a wood by troops, efforts should be made to increase the power of the breech-loader on the defensive by opposing obstacles to the enemy, and covering the defenders from fire, rendering them as secure as possible, and thus enabling them to pour in a well-directed fire on the attackers. These are the principles of all defenses, but in addition, in a wood, it is requisite to take special precautions that the troops actually firing, and on the outskirts of the wood, know where their supports are, and that effective measures be taken to communicate between the skirmishing line, the supports, and the main body.

Before putting any wood in a state of defense, it should be carefully examined, and the following points should be chietly kept in view during the examination: *a.* The size of the wood, its length and breadth. *b.* The nature of the wood, whether open or thick. *c.* The nature of the edge of the wood, whether marked or indefinite, whether belts of underwood and straggling trees intervene eenbetw the main wood and the open ground; whether there are any outlying clumps, or belts of trees, their size, and at what distance from the main road. *d.* Whether there are many roads or paths in the wood, whether there are houses, clearings or open spaces in the wood itself, whether there are streams or wet places in the wood, and whether the ground is broken or smooth. *e.* The nature of the position in rear of and on the flanks of the wood.

In putting a wood in a state of defense, the first thing to be attended to are the salients, and any small detached clumps of trees within five hundred or six hundred yards should be either cut down or occupied, such small clumps are peculiarly dangerous, as affording *point d'appui* for an attack. Trees round the salient portions should be cut so as to form a rough abatis. A little thought is requisite in felling these trees, some trees will be better if felled with their heads out, some better if felled parallel to the front; some trees aid the defense and should be left standing. Generally, large trees should not be cut, they afford cover for two or three men, and take time and experienced woodmen to cut. It is far better to begin operations upon all the salients at once, and make them thoroughly strong, than to attempt surrounding the whole wood with a belt of abatis. Although trees afford good shelter from the front, it is desirable not to neglect making shallow rifle-pits, which will protect the men on the flanks, while the trees afford cover in front. All cover should, as far as possible, be removed from the front of the position occupied for six to seven hundred yards. This is a very difficult operation, and one, although most desirable, that can rarely be performed. When a wood has an undefined edge, with brushwood, undergrowth, and tongues of trees running into the open ground, it becomes a very difficult question to decide how much shall be defended, how much given up to the enemy. From one hundred to two hundred yards of abatis will usually be ample in each place, and the space between, which may be four hundred to five hundred yards, will afford openings through which an offensive attack may be made.

In all cases every nerve should be strained to prevent the enemy getting into the wood, as he will see the abatis in front of the salients, and as such salients are usually on spurs, it is likely that he may seek to turn them and penetrate by the flanks; to check this, each flank of the abatis should have a return behind it, prolonged into the wood, and should not terminate abruptly; if the enemy then penetrates he will be taken in flank as he tries to advance, and the flank of the defenders of the salients will be covered.

Great care should be taken in using artillery in a wood, if the wood is in front of a line of battle, and can be flanked from the main line, few guns should be put into it; if it form a portion of the main line, and guns must be placed in the wood, they should never be placed on the roads leading out of the wood, where they offer marks to an enemy, but at slight distances to the right or left of the roads in places specially prepared; they should be placed at considerable distances apart, as the splinters from trees do much damage; and, if possible, each gun should have two or more places from which it can fire, previously prepared for, sufficiently near to allow it being moved by hand from place to place. Troops are really safer in a wood than in a village or in houses, the masonry knocked about by artillery fire is more dangerous than the splinters from trees, which often stop splinters of shells; and above all, the retreat is far more secure.

Roads should never be blocked in the wood or at its entrance; unless for special reasons, it is better to break them up at a farm-yard, a village, or some place seven hundred or eight hundred yards to the front, and form a small post there to cover the barricade. It is always desirable to prepare for disaster, although never desirable to parade that preparation. Consequently, although the edge of the wood is the place where the great struggle should take place, a second line should be provided somewhere within the wood; this may be at a clearing or barren spot, which often exists in a wood, or behind a watercourse or river; in every case it is desirable to make some line of abatis *parallel* to the line of retreat; such an abatis held firmly, acts as a flank attack on the enemy, and may prevent him from extending, when once he has penetrated the wood.

Woods in civilized countries are usually cut up by roads, sometimes these are main roads, sometimes mere tracks used to haul timber out; in a word it is very easy for troops to lose themselves, and it is very advisable that marks should be made on the trees to denote the direction in which different places are to be found. The principal roads may be marked by a Staff-officer with an axe and a paint-pot; but it is requisite that each Battalion Commander should also mark the way from the skirmishers to the supports, and from the supports to the main body. A simple blow made on the tree with an axe will do this, and a few men should be left to pass orders back; and it is desirable that the skirmishers should know that the supports are close behind them, for, of course, in a wood they cannot be seen. In many woods there is a spot where all the roads converge; at such points there is often a farm, a house, a small village, such a position should be put in a state of defense, and a strong reserve put there, which should embrace a few cavalry.

Sometimes in a wood, when the edge has been lost, a skillful use of a reserve will turn the attackers out. When troops have found their way in, there will always be some eager spirits who will push on, and others who won't like to hold back; the main body may be disconnected, the second line not yet up, and consequently, the hold on the woods a weak one. The front on which the attackers have entered will in all probability be a narrow one, and a rapid advance, especially on their flanks, will often restore the fight. True, everywhere, in a wood especially, reserves properly held in hand and brought up steadily, will usually turn the day. And this does not refer alone to either an army corps reserve or a divisional reserve, but to brigade, battalion, and even company reserves. In a wood the supports may be weaker than in the case of an attacking force; because the skirmishing or firing line will suffer less, and the true function of the support being to fill up the gaps in the skirmishers' line, it will not be so much needed; hence, the skirmishing line may be longer or occupy more ground, and as there is less likelihood of the skirmishers being taken in flank, than there is if the ground be open, the supports may be distributed in smaller bodies along the rear, while at the same time they may be brought much nearer to the front; this is all the more requisite, as, to support effectually, the officer commanding the supports must be in front to watch the effect of the fire, and on a long line in a wood he cannot see what is going on, consequently the supports must be sufficiently near at hand for their officers to act on their own responsibility. All the Commander of the supports can do is to try and find the most dangerous place, that where the enemy seems most disposed to direct the attack, and post himself there. The Commander of the main body cannot watch the fight from the rear, but must do so from the front, and he has therefore to remain in front and send back orders to the main body, which consequently must not be too far off. Cavalry should be posted on the flanks and in rear of the wood, if an opportunity offers, and they can circle out suddenly, they may produce a great effect. If a small body of cavalry can be concealed in the wood itself and pushed rapidly out, from the fact of cavalry not being expected, it may affect much, but this must be determined by the nature of the wood. If the wood be in front of a position, arrangements should be made to bring a heavy fire to bear on it, and a line of retreat for the defenders should be pointed out to the commanding officer, so that fire may be opened the moment the wood is abandoned, without interfering with the retiring troops. Whenever troops who have once attacked get into cover after heavy loss, there is some difficulty in inducing them to come out again, more especially if met by heavy fire on the other side when they try it.

The attack of a wood is one of the most difficult and dangerous operations in war. One of the great difficulties is to know how the wood is held, where the guns and infantry are, and which are the weak points. The reconnaisance of wood prior to its attack should embrace not only the ground in front and on the flanks, but information as to inside the wood should be sought from country people and from maps. The position of the defenders can be best found out by some false attacks, which may induce the enemy to show his position. It is better to make two or three distinct though simultaneous attacks on a wood than to trust to one: the reason of this is, that the defenders, from the difficulty of intercommunication offered by the trees, have their supports and reserves less under control than would be the case in open ground, a fact which the soldier very soon realizes; and the demand for supports sent back from the front, if not promptly responded to, tends to demoralize men who cannot be properly supervised by their officers. The attackers in the open have the benefit not only of intercommunication, but of being completely under the supervision of their officers. Consequently several attacks, if made at the same moment, will produce emulation among the men, while at the same time it will have the effect of disconcerting the defenders.

It is desirable to bear in mind that the attack of troops armed with a breech-loader, and holding an open position, is a dangerous and difficult operation, but when troops armed with a breech-loader are covered by trees, shelter-trenches, walls, etc., the attack becomes far more dangerous, because of the effective fire of the troops acting on the offensive is seriously interfered with, the defenders' fire becomes at the same time all the more accurate and deadly because they suffer but little from the attackers' bullets; consequently the attack on troops occupying a wood or village, or an intrenchment, requires a longer preparation and a greater quantity of artillery fire than if the defenders had no cover. But although it is better to make several attacks, these attacks should not be separate and disconnected, but should work together, one or more being directed on the flanks, while one or more assail the front. The exact nature of the attack can only be determined by the nature of the ground and the amount of cover in front of the wood.

In the attack on a wood, as in all other attacks, as many guns as possible should be got into position, and should be divided into as many divisions as there are attacks; if possible, these guns should be so placed as to fire on all the points selected for forcing an entrance. It is not likely that there will be many guns in the wood, and hence the artillery may push up to some one thousand four hundred or one thousand five hundred yards: a very rapid fire should be begun on the wood, those guns that can support all the attacks firing for a short time in support of each in succession, the actual attack being made by the infantry. Under fire of the artillery an attempt should be made to penetrate into the wood, through the breach effected by the fire; once the edge of the wood is gained no great advance should be made until a sufficiently strong body of men is in hand, and then a careful steady advance should be made with the flanks well supported, as, if the enemy have not been demoralized by the artillery, they will seek to attack and drive out the intruders by operating on their flanks.

There is one special danger in all wood-fighting, viz., the risk of the general line of attack or defense getting dislocated. Constant attention must be given by officers to this point, and the men should be urged to keep a connection with those on their right and left; should the line get dislocated, the enemy, finding no fire coming from one place, will push in, and by thus dividing it and acting on the flank, compel the retreat, perhaps the flight, of the whole line.

The most remarkable instance of wood fighting that has occurred of recent years was undoubtedly that at the wood of Maslowed at Königgratz. The Austrians made little or no effort to hold the edge of the wood, but fell back and allowed the Prussians to get into the interior and take possession of a great part of the outskirts on their (the Austrian) side, but not of the whole, because of the great extent of wood, and the fierce struggle raging in parts of the interior. The Prussians got the whole of a division into the woods, and although they were repeatedly driven back, their line divided and cut in two by large Austrian forces, yet they never could be driven out. This was due to the very skillful way in which the Prussian officers make flank attacks on the Austrians with small bodies of men. The companies had all become mingled together as the fight swayed backwards and forwards in the dense wood. No unity of guidance was possible on ground where hills and woods shut out all view of the surrounding country, and all that the Commanders of the different detachments could do was to lead their men by their own personal example. In all parts the officers rallied round them whatever men were in their neighborhood, no matter to what regiment they belonged. See *Strategy*.

WOOD TANGENT-SCALE.—This scale is graduated up to 8° for all natures. A brass staple is fixed on behind the scale, into which the head of the brass tangent-scale, when elevated, fits. It is graduated in yards as well as degrees, and is marked for the nature of the gun for which intended. See *Tangent-scale*.

WOOLDING.—A knot for tightening a rope. It is used to secure a load on a carriage, so firmly that it may travel without loosening. A stick, called the *woolder*, is used in the operation of tightening the knot.

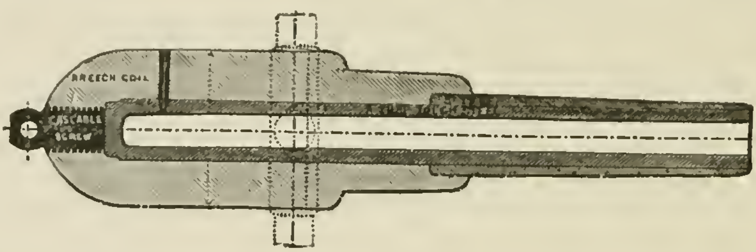
WOOLWICH GUN.—This comprehensive term is applied to all the guns manufactured in England since 1866. It might be expanded into wrought iron muzzle-loading guns, built on Sir William Armstrong's principle, modified by Mr. Fraser, improved by Mr. Anderson's method of hooking the coils, with solid-ended steel tubes toughened in oil, rifled on the French system, modified as recommended by the Ordnance Select Committee, for projectiles studded according to Major Palliser's plan. The gun consists of an A tube, a B tube, a breech-coil, and a cascabel:

(1.) *The A tube*, or inner barrel, is made from a solid forged cylinder of cast-steel, which is supplied to the Royal Gun Factory by Messrs. Firth, of Sheffield. Casting is necessary, not only for the purpose of obtaining a sufficiently large block of steel, but also of making the block homogeneous and uniform in density. Forging imparts to it the properties of great solidity and density. A piece is cut from the block at the breech-end, and divided into small pieces, which are tested for tensile strength and elasticity in the natural state, and also to ascertain at what temperature the block can be immersed in oil to the best advantage. A steel block, which stands all the tests, is rough-turned, in which operation a lip is formed on the muzzle to facilitate lifting the tube into or out of the furnace or oil-bath. It is then bored roughly from the solid. The tube thus formed is heated from four to six hours to the approved temperature in a vertical furnace, and then plunged into an adjacent bath of oil, in which it is allowed to cool and soak, generally twelve hours. It must then be turned and bored to make it straight inside and outside, and to remove any flaws. It is then subjected to the water-test of 8,000 pounds per square inch, and, if no flaw is detected, the barrel is considered safe, and remains in this condition until the B tube is ready to be shrunk over it.

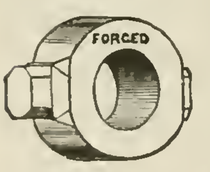
(2.) *The B tube* is composed of two single and slightly taper coils united together. The two coils, being made and welded in the usual manner, are faced and reciprocally recessed to the depth of about one inch, and then united together endways by expanding the recess of a coil by heat, and allowing it to shrink around the shoulder of the other. This holds the two coils together enough to allow the tube thus formed to be placed upright in a furnace: when it arrives at welding-heat, it is removed to a steam-hammer, and receives on its end six or seven blows, which weld the joint completely. The tube is next rough-turned, in which process a rim is left near the muzzle for convenience in lifting, and then rough and fine bored. The interior of the B tube having been brought to the required smoothness for contact with the steel barrel, it is gauged every twelve inches down the bore, and at the shoulder.

To the measurement the calculated amount of shrinkage is added, and the exterior of the A tube is turned so that it shall be exactly larger than the interior of the B tube by the full required amount of shrinkage.

(3.) *The breech-coil* is composed of a *triple coil*, a *double coil*, and a *trunnion-ring*. The triple coil is made of three bars, all of the same section, but differing, of course, in length; the middle one is coiled in a reverse direction so as to break joints. To weld the folds, it is raised to welding-heat in a furnace, and hammered on end; then a mandrel is forced down inside from either end, and it is hammered on the outside, being heated before each operation. When cold, the ends are faced, and the outer coil is turned down at the muzzle-end to form a shoulder for the reception of the trunnion-ring. The double coil is made of two bars of the same section as those of the triple coil, but of different lengths. It is made in the same manner as the triple coil, and it has a shoulder formed at its lower end, so that it may overlap the trunnion-ring. The trunnion-ring represented in the



drawing, like all wrought-iron trunnion-rings, is built up on the end of a porter-bar. All these parts, triple coil, double coil, and trunnion-ring, being thus prepared, the trunnion-ring is heated to redness and dropped on the shoulder of the triple coil, which is placed upright on its breech-end for this purpose; while the trunnion-ring is still hot, the double coil is dropped down on the front of the triple coil through the upper portion of the trunnion-ring, which thus forms a band over the joint, and while cooling grips the two coils sufficiently to admit of the whole mass being placed bodily in the furnace, where it is raised to welding-heat. It is then placed on its breech-end under a heavy hammer; six or seven blows suffice to amalgamate all the parts; but to make the weld more perfect in the interior, a cast-iron mandrel is forced down the bore to within 20 inches of the breech. The mass is then reversed, and the mandrel driven out again. It is then turned and bored. The front of the double coil is recessed to a distance of nine inches, and deep enough to overlap the B tube. Finally the thread is cut for the cascabel.



(4.) *The cascabel* is made of the best scrap-iron. It is first forged into a single cylinder, then turned, and a bevel thread cut on it. A hole which is afterward, enlarged to a loop is drilled through the end. One round of the thread is turned off at the end of the cascabel, so that there may be an annular space there which in connection with the channel now cut along the cascabel and across the threads $\frac{1}{8}$ inch in depth, forms the gas-escape which comes out at the right side of the loop. This will give notice, in case the steel tube should split.

The A tube and the B tube, being prepared as described, are shrunk together in the following manner: the B tube is placed over a grating, and heated for about two hours by a wood-fire, for which the tube itself forms the flue, until it is sufficiently expanded to drop easily over the muzzle-end of the A tube, which is placed upright in a pit ready to receive it. The B tube is then raised, the ashes brushed from its interior, and it is dropped over the steel barrel. During the process of shrinking, a stream of cold water is poured into the steel barrel by means of a pipe and syphon, to keep it as cool as possible. A ring of gas is placed at the muzzle-end of the B tube to prevent its cooling prematurely, and jets of cold water play on the other end, and are gradually raised to the muzzle for the purpose of cooling the whole tube consecutively from the breech-end, which it is desirable should grip first. The method of cooling the tube prevents it from being drawn out into a state of longitudinal tension. The A and B tubes, shrunk up, are placed in a lathe, and while one cutter fine-turns the B tube to its proper shape, another cutter fine-turns the breech-end of the A tube according to the plan of the breech-coil. The half-formed gun, composed of the A and B tubes, is placed on its muzzle in the shrinking-pit; and the breech-coil is heated and shrunk on in the same manner as the B tube; it is, however, being nearly of the same thickness throughout, allowed to cool naturally, and cold water is forced up into the bore of the gun by a jet round which the muzzle rests. The cascabel is next screwed in, which operation requires great care, as the front of it must bear evenly against the steel barrel. After it is screwed in, it is splined to prevent it from turning.

The above method of construction is now applied to the 7-inch and 8-inch guns, as shown in the drawing. It has been modified for the 9-inch guns and upwards, by using a slightly thinner steel tube and two double coils on the breech instead of one triple coil. The higher natures have an intermediate B coil in addition, and the 12-inch 35-ton gun has a button instead of a cascabel hole.

The process of building up the 80-ton gun is similar in most respects, except that it has a 2 B coil between the 1 B coil and the B tube. Over the rear end of the A tube is shrunk a powerful coil called the breech-piece, which is made of a single bar 12 inches thick. The C coil is a double coil, and carries the trunnions. In shrinking on the coils, the compression of the C coil is so great as to cause a contraction of .023 inches in the bore.

The vent enters at a point two-fifths the length of the service-cartridge from the end. The vents are lined with copper, specially hardened and bored vertically in the 7-inch, 8-inch, and 9-inch guns; but in the 10-inch and 12-inch guns they are bored at an angle of 45° with the vertical, and on the right side of a broadside gun, but on the most convenient side in a turret-gun. In the 80-ton gun, the vent is axial. See *Armstrong Guns*, *Fraser Gun*, and *Ordnance*.

WOOLWICH INFANT.—The name given to the M. L. R. 35-ton and 38-ton guns, which form a part of the armament of the English Service, more especially for the Navy. Experiments with the 35-ton gun, of 12 inch caliber, as tabulated by Captain Noble, R.A., and showing the capabilities of this gun with the service charge of powder (100 pounds of pebble powder), and a 700-pound shot are herewith given. With the ordinary backing of hard wood; added to the thickness of the iron target, at 200 yards range,

TABLE OF DIMENSIONS, RIFLING, CHARGES, PROJECTILES, ETC., OF WOOLWICH M. L. R. GUNS.

Caliber and Weight.	Length.			Rifling.		Grooves.			Charge.	Projectiles.		Piercing Power in Iron		Range.			Remarks.
	Gun.	Bore.	Rifling.	System.	Spiral.	Number.	Depth.	Width.	Service.	Shot.	Shell loaded.	At 500 yards.	At 1,000 yards.	Distance.	Elevation.	Time.	
	ft. in.	ins.			Increasing		Inches.	Inches.	R. L. G.			ins.	ins				
16" 80 Ton	26 9	288		Woolwich					370 lbs		1,700	27.5	26.				Powder-chamber 18" diam.
12".5 38 Ton	18 9½	198	170 5	"	0 to 1 in 25	9	.2	1.5	130		843	18.7	17.7	5,000	9°.25	13".29	
12" 35 Ton	15 11⅜	165 5	135	"	"	9	.2	1.5	85		607.9	15.4	14.6	4,800	9°.1	12".76	
12" 25 Ton	14 3½	145	127	"	1 in 100 to 1 in 50	9	.2	1.5	55	Cored 596	600	13.9	13.1	4,800	10°.25	13".34	2 Breech-coils.
10" 18 Ton	14 2½	145 5	118	"	1 in 100 to 1 in 40	7	.2	1.5	44	400	398.12	12.7	12.0	4,800	10°.33	14".18	
9" 10 Ton	12 3	125	104	"	0 to 1 in 45	6	.18	1.5	43	Solid 254	248.2	10.4	9.6	4,800	10°.39	14".36	
8" 9 Ton	11 4½	118	99 5	"	0 to 1 in 40	4	.18	1.5	20	180	179.4	9.8	9.5		10°.53	14".50	1 Breech-coil.
7" 6½ Ton	10 6	111	93 5	"	Uniform. 1 in 35	3	.18	1.5	14	115	156.2	7.7	7.1	4,800	9°.51	13".83	1 Breech-coil.
7" 90 cwt	10 4½	111	95 5	"	"	3	.18	1.5	14	Case 69	156.2						2 Breech-coils.
64 pdr. of 64 cwt	9 3½	95 5	90 5	Plain.	1 in 40	3	.11 & .08	.6 & .4	10	50.8½	64			4,000	12°.	16".61	1 Breech-coil.
64 pdr. of 71 cwt	9 0	103 27	96 27	"	"	3	.115	.6	8	50.8½	64			4,000	12°.	16".61	Converted from 8-in. 65 cwt.
3" 8 cwt	5 8½	63 5	59 8	Modified French.	1 in 30	3	.11	.8	1.12oz.	9.13⅓	9.1			3,500	11°.27	13".45	Breech-coil, no B-tubes.
3" 6 cwt	4 10	53	49 3	"	"	3	.11	.8	1.8	9.13½	9.1			2,600	8°.52	9".65	Breech-coil, no B tubes.
3" 200 lbs	3 00	32 15	29 15	French.	1 in 20	3	.1	.6	.12	6.4	7.6½			4,000	24°.24	20".40	All tough steel.

the projectile can be sent through 15 inches of iron; at 500 yards, through 14 inches (the thickness of the *Devastation's* turret); at 1,700 yards, through 12 inches; at 2,600 yards, through 11 inches; at 4,000 yards, through 9 inches; and at 4,500 yards, through 8 inches. Thus, at a range of over 3 miles, a shell ¾ ton in weight can be made to pierce the sides of some of the heaviest iron-clads in the Navy. The dimensions of the gun are as follows:

Length	15 feet 11¾ inches.		
	Tons.	cwt.	qr.
Average weight of gun	34	15	0
Preponderance	0	1	1
	Inches.		
Length of bore	162.5		
Length of rifling	135		
Caliber	12		
Rifling (Woolwich) No. of grooves	9		

Twist increasing from 0 at breech to 1 turn in 30 calibers at muzzle.

The guns of this caliber hitherto made are specially for sea service, and are intended for turrets. The vent enters the bore at 12 inches from the bottom of the chamber, forming an angle of 45° with the vertical plane passing through the axis of the piece. The 38-ton gun is built on the same principle as the one just described; its caliber is 12½ inches; charge about 130 lbs. of either pebble powder or a powder made specially for a gun of this size; weight of shot, 800 lbs.; initial velocity, about 1,400 feet per second. An 81-ton gun has lately been manufactured and subjected to proof; its dimensions are as follows:—

Length	27 feet.
Length of bore	24 "
Caliber	15 inches.
Diameter of chamber	16 "

The early tests with this gun were with charges increasing from 170 lbs. to over 300 lbs. The weight of the shot used during these trials varied from 1,254 lbs. to 1,466 lbs. The gun is now being bored throughout to 16 inches. The energy of the gun was ascertained to be fully 24,000 foot-tons, and the velocity of the shot was over 1,500 feet per second. It is capable of penetrating a 24-inch iron plate.

WORD.—In time of peace, a signal notified in the orders of the day, in virtue of a knowledge of which a sentry will allow the utterer to pass. In the field the Officer Commanding fixes daily upon a *word* and *countersign* (for which any arbitrary terms are taken) and communicates them to the sentries on guard, and to such other persons only as he may choose to permit to pass through the lines. Any person then approaching a sentry without knowing the *word* has a fair chance of being shot; if he knows not the *countersign*, the sentry will take him into custody, and deliver him to the Officer of the Guard. Care has to be taken that the word should not suggest the countersign. Any arbitrary combination is therefore usually adopted.

WOORDIE MAJOR.—A native Adjutant of an Indian irregular cavalry regiment.

WORK.—To do work is to overcome resistance. If we try to lift a ton-weight, however we may fatigue ourselves, we cannot move it, and therefore we do no work. But we can lift with ease a hundred-weight, and then we do more work in proportion as we raise it higher. In lifting coals from a pit, the work done is evidently in proportion to the depth of the pit, and to the weight of the coals raised. This and numberless other instances are too well known to need further description. We may therefore at once define the *work done by a force as the product of the force into the space through which it moves its points of application in its own direction*, and it is usually measured by engineers and others who do not require absolute accuracy, in *foot-pounds*, the work required to raise a pound one foot high. If the motion of the point of application be in the *opposite* direction to that of the force, the work is done against the force. If the motion be perpendicular to the direction of the force, no work is done by or against the force. Thus, the work spent in projecting a curling stone, in opening a massive gate, or in turning a large fly-wheel or grindstone, has nothing whatever to do with the force of gravity—the body moved, in all these cases, is, as a whole, neither raised nor lowered as regards its distance above the earth's surface. If the direction of the force be oblique to the direction in which the point of application moves, we must resolve the force, by the law of the parallelogram of forces, into two components, one *in* the direction of motion, the other perpendicular to it. The former is the working component; the latter, as we have just seen, does no work. A good illustration of this is found in the case of raising stones from a quarry by carting them up a series of inclined planes, as contrasted with hauling them up vertically. The work done in either case is measured by the product of the weight of the stones, and the height through which they have been raised; and thus, for the same load of stones, it will be the same whichever process is adopted. This is evident from the property of the inclined plane—viz., that the force required to support a body resting on the plane (which is the force that has to be overcome when we haul it up the plane, is to the weight of the body as the *height* of the plane), to its *length*. Hence, this force, multiplied into the length of the plane, gives the same product as the whole weight into the height of the plane; and these are the two quantities of work we are comparing.

When work is done upon a body, there is always an increase of velocity unless other forces act on the body, so that it does an equal amount of work against them. Thus, if we push a movable body, such as a cart, along a road, the velocity gradually increases, and would increase indefinitely were there no friction and no resistance of the air (forces against which all work has to be done), and could we move fast enough to remain continually pushing it, however great its velocity may become. If, on the other hand, by means of a rope and pulley, we raise a stone, if once started, it will ascend uniformly, so long as we pull with a force just equal to its weight, because, then, as much work is done on the stone by the hand as it does against gravity. If we pull with a force greater than its weight, we do more work on the stone than it does against gravity, and the upward velocity increases; if with a force less than the weight, the stone has to do more work against gravity than is done on it by the rope, and its velocity upward becomes less. The measure of the excess of work done on a body over that which it does against resistance is *the increase of the product of half the mass into the square of the velocity*—i.e., of what was formerly called the *vis viva* of the body, what is now called its *actual*, or preferably, its *kinetic energy*. See *Force*. Hence, as it is evident that if a body, or system, be acted on by a set of forces which are in equilibrium, it will have no tendency to lose or to acquire velocity, its kinetic energy will remain unchanged, and therefore *as much work must be done upon it by some of the applied forces, as it does against the rest, in any displacement so slight as not to change the circumstances of the particular arrangement*. That is, when forces are in equilibrium on a body, if the body be slightly displaced, the sum of the products of each force by the effective component of the displacement of the point of application is zero the product being positive when the force does work, negative when work is done against it. This is the celebrated principle of *virtual velocities*, the term virtual velocity having been, very inconveniently, applied to what we have called above the effective component of the displacement of its point of application of a force. It was often employed as the basis of the whole of statics, and very curious attempts have been made to give proofs of it (independent of the laws of composition of forces), especially by Lagrange. But the principle of work, or energy, of which that of virtual velocities is a mere particular case, and which is at once applicable to the whole range of dynamical science, is distinctly enunciated by Newton in a scholium to his third law of motion. His words are memorable, and they should be universally known—*Si æstimetur agentis actio ex ejus vi et velocitate conjunctim; et similiter resistentis reactio æstimetur, conjunctim ex ejus partium singularum velocitatibus et viribus resistendi ab earum attritione, cohæsione, pondere, et acceleratione oriundis; erunt actio et reactio, in omni instrumentorum usu, sibi invicem semper æquales.* Newton has defined what he means by the velocity of an agent—viz., the component of the velocity of its point of application which is in the direction of the agent. He has also shown what is the measure of resistance arising from acceleration, so that, merely using modern terms instead of those employed by Newton, but in nowise altering the scope of the above remarkable passage, we have the following version of it: *Work done upon any system of bodies* (literally, *the parts of any machine*) *has its equivalent in work done against friction, molecular forces, or gravity, if there be no acceleration; but if there be acceleration, part of the work is expended in overcoming the resistance to acceleration, and the additional kinetic energy developed is equivalent to the work so spent.*

When work is expended in overcoming the resistance to acceleration, i.e., the *inertia* of a body, we have its equivalent in additional kinetic energy. When it is expended against gravity, as in raising a weight or bending a spring, we have it stored up in a dormant form as *potential energy*. When it is expended in overcoming friction, there appears at first sight to be no equivalent—but the comparatively recent researches of Joule and others have satisfactorily accounted for its diappearance by proving its quantitative transformation into heat, sometimes into other forms of molecular energy. But to pursue this point would lead us again to questions already treated at some length in the article *Force*. There is one remark, however, which it is important to make. In compressing a gas, in the receiver of an air-gun, for instance, we can never recover as useful effect all the work expended. The reason is that a gas is *heated* by compression, so that part of the work spent is converted into this heat, conducted through the metal, and by the principle of *dissipation of energy* lost, at least in part, to man. Had we a gas which could not be heated by compression (take the imperfect analogy of a space filled with fine spiral springs), we should recover, by allowing it to expand, all the work expended in the compression.

The table below, due to Poncelet, gives at least approximate notions of the horse-power employed, and the whole work done, in a working day, by men and animals variously applying their exertions.

One other remark remains to be made. It will be noticed that Newton speaks of the action of an agent as the product of the agent and the component *velocity* of its point of application. This is what we now call *rate of doing work*, or *horse-power*. Watt estimated a horse-power at 33,000 foot-pounds per minute, or 550 foot-pounds per second. This is probably too high; but it is constantly employed in engineering calculations. A curious quantity, sometimes employed as regards steam-engines, especially those employed for pumping mines, is the *duty*, which is measured by the number of foot-pounds of work done by a hundred-weight of coals supplied to the furnace. A similar mode of comparison is now applied to steam-engines for agricultural purposes, etc. The quantity of work which can be got out of any machine, human, animal, or other, depends in many cases on the rate at which it is done, or the horse-power actually exerted. An average man can easily work at the rate of a horse-power for a few minutes at a time: but if he were to work at no other rate he would do very little work in a day. Various singular investigations have been made, both theoretically and experimentally, as to the most profitable rate of doing work, and their results are highly interest-

Description of Work.	Weight raised.	Velocity per Second.	Unit of work per second.	Length of Working Day.	Total work in a Day.
	Lbs.	Feet.	Lbs. × ft.	Hours.	Lbs. × ft.
A man mounting an easy staircase, or an incline without a load, his work consisting simply in moving the weight of his own body	143	0.5	71.5	8	2,059,200
A man raising weights by means of a cord and pulley, which renders necessary the return of the cord without a load	39.6	0.66 say 0.67	26.53	6	573,048
A man raising weights by his hands	44	0.56	24.64	6	532,224
A man crrrying a weight on his back up an easy incline, and returning without a load	143	0.13	18.59	6	401,544
A man raising materials by a wheel-barrow, on an incline of 1 in 12, returning unloaded	132	0.065	8.58	10	308,880
A man throwing earth by a spade a height of 5 ft. 4 in.	5.94	0.66 say 0.67	3.98	10	143,280
A man working a pin-wheel or a drum—					
1st, at the level of the axle	132	0.5	66	8	1,900,800
2nd, at bottom of wheel	26⅖	2.34	61.8	8	1,779,840
A man walking and pushing, or drawing horizontally, in a continuous manner	26.4	2	52.8	8	1,520,640
A workman acting upon a winch	17.6	2.5	44	8	1,267,200
A workman pushing and pulling alternately in a vertical direction	13.2	2.5	29	10	1,044,000
A horse harnessed to a carriage, going at a walking pace	154	3	462	10	16,632,000
A horse harnessed to a carriage going at a trot	96.8	7.22	699	4.5	11,323,800
A horse in a mill, at a walking pace	99.0	3	297	8	8,553,600
" at a trot	66.0	6.56	433	4.5	7,014,600
An ox in a mill, at a walking pace	132	2	264	8	7,603,200
Mule " "	66	3	198	8	5,702,400
Donkey " "	30.8	2.67	82.24	8	2,368,512

ing. But to discuss them properly would require more space than we can afford.

WORK DONE BY CHARGE.—The amount of work capable of being done on a projectile by the charge of powder in a gun, depends principally upon the ratio of the cubic space occupied by the charge to the cubic capacity of the bore of the gun. This is modified in practice: (1.) By the nature of the powder; (2.) By the method of ignition, and the position of the vent; (3.) By the amount of air-space allowed; (4.) By the weight of the projectile, and the frictional and other resistances to its motion; (5.) By the quantity of heat absorbed by the gun. Such results as would be required ordinarily in practice are embraced in the following table:

Volumes of expansion.	Work in foot-tons, per lb. of powder burned.	Volumes of expansion.	Work in foot-tons, per lb. of powder burned.
5.0	83.53	7.6	97.96
5.1	84.25	7.7	98.39
5.2	84.95	7.8	98.81
5.3	85.64	7.9	99.23
5.4	86.31	8.0	99.64
5.5	86.96	8.1	100.04
5.6	87.60	8.2	100.44
5.7	88.22	8.3	100.84
5.8	88.83	8.4	101.23
5.9	89.43	8.5	101.62
6.0	90.02	8.6	102.00
6.1	90.59	8.7	102.38
6.2	91.14	8.8	102.75
6.3	91.69	8.9	103.12
6.4	92.23	9.0	103.48
6.5	92.76	9.1	103.84
6.6	93.28	9.2	104.19
6.7	93.78	9.3	104.54
6.8	94.28	9.4	104.89
6.9	94.77	9.5	105.23
7.0	95.25	9.6	105.57
7.1	95.72	9.7	105.90
7.2	96.18	9.8	106.23
7.3	96.63	9.9	106.55
7.4	97.08	10.0	106.87
7.5	97.52		

By the foregoing table, the maximum work that can possibly be obtained in any gun by a given charge of powder may be calculated. A pound of powder is taken to occupy a space of 27.7 cubic inches. The number of volumes of expansion in a gun is obtained by dividing the cubic capacity of the bore by the charge. Comparing the "work" so obtained with that calculated from actual practice with any cannon, there is found a deficiency in the energy realized in practice. This is due to the *modifications* already mentioned. The greater the weight of the projectile, the more rapid the explosion of the powder, and the less the proportionate amount of heat absorbed by the gun; the more nearly will the maximum theoretical effect of the powder be realized. The percentage of this effect actually realized is called the *factor of effect*. The value of this factor for every gun constructed can be determined, and in designing new pieces the factor for such piece as approaches nearest to the new one will have to be used in calculating the power of the proposed cannon. The velocity of a projectile at any point of the bore depends on its weight, and upon the work done on it up to *that point*. Using the formula—

$$\frac{wv^2}{2g} = W,$$

in which w is the weight of the projectile and v its velocity at any point of the bore, we have,

$$v = \left(\frac{2g}{w} W\right)^{\frac{1}{2}}$$

It is then only necessary to take from the table the value of W for any given expansion, multiply it by the "factor of effect" for the particular gun, charge, etc., and substitute the proper values in the above equation. From this formula it will be seen that the velocity of a projectile at any point of the bore varies *directly* as the square root of work done upon it up to that instant, and *inversely* as the square root of its weight. See *Energy* and *Gunpowder*.

WORKING PARTY.—A body of soldiers told off, by command, to perform a certain work of labor foreign to their ordinary duties. A small extra pay, called "working-pay," is allowed in the English Army averaging 4d. a day.

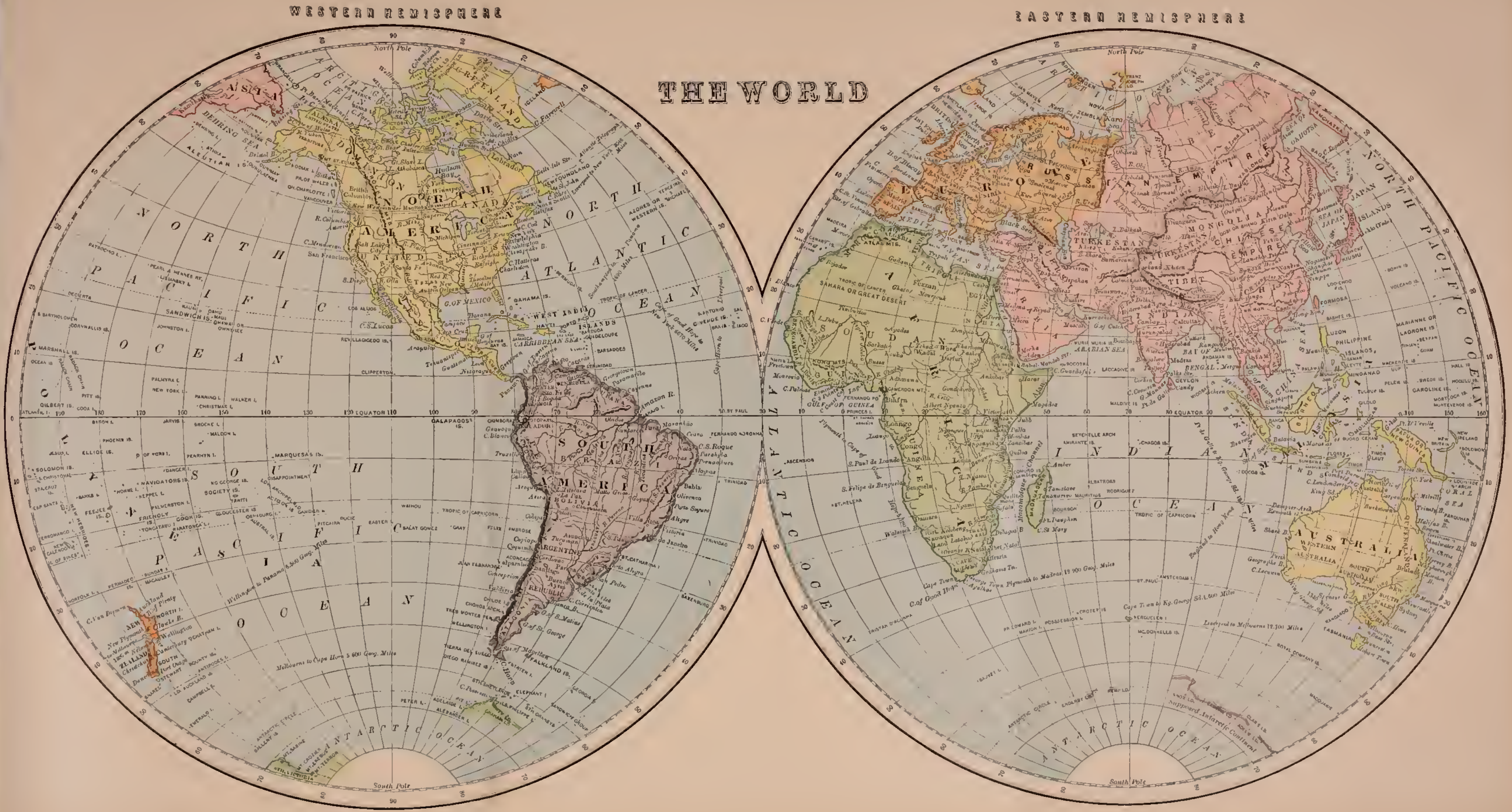
WORKING POWER.—A foot-soldier travels in one minute, in common time, 90 steps = 70 yards. In quick time, 100 steps = 86 yards. In double quick, 140 steps = 109 yards. He occupies in the ranks a front of 20 inches and a depth of 13 inches, without the knapsack; the interval between the ranks is 13 in.; 5 men can stand in a space of 1 square yard. Average weight of men, 150 lbs. each. A man travels, without a load, on level ground, during 8½ hours a day, at the rate of 3.7 miles an hour, or 31¼ miles a day. He can carry 111 lbs. 11 miles a day. A porter, going short distances and returning unloaded, carries 135 lbs. 7 miles a day. He can carry in a wheel-barrow 150 lbs. 10 miles a day. And also the maximum power of a strong man, exerted for 2½ minutes, may be stated at 18,000 lbs. raised 1 foot in a minute. A man of ordinary strength exerts a force of 30 lbs. for 10 hours a day with a velocity of 2½ feet in a second = 4,500 lbs. raised 1 foot in a minute = *one-fifth* the work of a horse. Daily allowance of water for a man 1 gallon, for all purposes.

WORKING-SPOKE.—The lower spoke of the wheel, or the one nearest approaching the vertical. This spoke bears the burden and sustains the shocks almost exclusively, and should be vertical whenever a gun is discharged from the carriage.

WORKS. — The fortifications about the body of a place. This word is also used to signify the approaches of the besiegers, and the several lines, trenches, etc., made round a place, an army, or the like, for its security. Works are either *permanent* or *field*: the latter are enclosed or open, according as a parapet does or does not entirely surround the site occupied. Redoubts and forts are called enclosed, redans and lunettes, open works. See *Fortification*.

WORSHIP.—The act of paying divine honor to the Supreme Being. The Articles of War enjoin on all officers and soldiers the necessity of attending at divine service, according to the persuasion of each. Without just impediment, no officer or soldier can absent himself from the place appointed for the assembling of the Corps to which he belongs, or, when there, behaving himself in an indecent or irreverent manner, without rendering himself liable to be tried by a Court-Martial. It is earnestly recommended, in the Articles of War, to all officers and soldiers diligently to attend divine service, and all officers who behave indecently or irreverently at any place of divine worship, if Commissioned Officers, are brought before a General Court-Martial there to be publicly and severely reprimanded by the President; if Non-commissioned Officers or soldiers, every person so offending, for his first offence, forfeits one-sixth of a dollar, to be deducted out of his next pay; for the second offence, he not only forfeits a like sum, but is confined 24 hours; and for every like offence, suffers

WESTERN HEMISPHER


WESTERN HEMISPHERE
EASTERN HEMISPHERE
THE WORLD
North Pole
South Pole
NORTH AMERICA
SOUTH AMERICA
NORTH PACIFIC OCEAN
SOUTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
ATLANTIC OCEAN
INDIAN OCEAN
ANTARCTIC OCEAN
ARCTIC OCEAN
GREENLAND
ALASKA
CANADA
UNITED STATES
G. OF MEXICO
WEST INDIA ISLANDS
CARRIBBEAN SEA
BOLIVIA
ARGENTINE REPUBLIC
FALKLAND IS.
EUROPE
RUSSIAN EMPIRE
AFRICA
SAHARA OR GREAT DESERT
SOUDAN
MONGOLIA
CHINESE EMPIRE
TURKESTAN
TIBET
INDIA
ARABIAN SEA
BAY OF BENGAL
JAPAN
PHILIPPINE ISLANDS
AUSTRALIA
WESTERN AUSTRALIA
SOUTH AUSTRALIA
QUEENSLAND
NEW SOUTH WALES
TASMANIA
NEW ZEALAND
MADAGASCAR
CEYLON
EQUATOR
TROPIC OF CANCER
TROPIC OF CAPRICORN
ANTARCTIC CIRCLE
Supposed Antarctic Continent

and pays in like manner: which money,so forfeited, is applied by the Captain or Senior Officer of the troop or company to the use of the sick soldiers of the company or troop to which the offender belongs.

WORM.—1. An implement employed to take out the charge of a fire-arm. 2. A short revolving screw the threads of which drive the *worm-wheel*, by glaring into its teeth or cogs. The worm and worm-wheel plan is generally employed with gun-carriages, as the violent blow,on firing,tend to break the teeth of the elevating gear.

WORM-WHEEL.—A wheel, employed in elevating gears,having teeth formed to fit into the spiral spaces of a screw called a *worm*, so that the wheel may be turned by the screw. This has the advantage of not requiring to be clamped,as the worm cannot be moved by the tendency of the gun to move the worm-wheel (from reasons connected with the angle of friction of the surfaces of the teeth in contact). This,however, leads to the disadvantage that something is likely to break when the blow is considerable. The friction cone remedies this defect by enabling the gun to twist the cone around inside the *worm-wheel* (when it gives a severe blow on firing), as the two are only caused to revolve together by friction,which is regulated by the nut. This friction is, however, quite sufficient to keep the breech of the gun from running down in laying. The giving way of the gear on firing is not found to impair the accuracy.

WORRELL RIFLE. — A breech-loading small-arm having a fixed chamber. It has a perforated block revolving in a mortised frame about an axis at right angles to its length. When closed the hole in the block lies in the prolongation of the bore.

WOUNDED.—All the individuals belonging to an army who may have been maimed, or otherwise hurt in action. See *Ambulance* and *Hospital*.

WOUNDS.—Besides the wounds caused by gunshots, a soldier in the field is liable to a great variety of others, which might be classified according to the nature of the article or weapon with which they are inflicted, as incised, punctured, lacerated and contused. *Incised* wounds, such as are made by a sword or knife, should be carefully cleansed, all extraneous substances removed, the edges brought together, adhesive plaster applied, and the muscles near by relaxed. *Punctured* wounds, such as are made by bayonets, pointed rocks, etc., very often excite inflammation in their vicinity, cause formation of matter under the fascia and frequently result in hemorrhage. The wounded part should be kept at rest, all sub-cutaneous oozing of the blood prevented, and an exit made for the discharge. If suppuration sets in, an incision should be made at once in order to let out the pus. Probing in search of extraneous matter is very hurtful. *Lacerated* wounds, such as are inflicted by blunt and obtuse bodies, are invariably attended with severe pain, are slow in healing, and are very liable to gangrene. They should be thoroughly cleansed, all foreign bodies removed and the flaps of torn skin replaced as far as possible. A good poultice and disinfectant should be applied to the wound. *Contused* wounds, such as are produced by any blows without breaking the skin, should be attended to without delay, the parts restored to the normal state by a few days of rest, and some stimulating liniment applied. For a contusion of the head apply cold water,administer cathartics, make the diet light, take no stimulants, and remain quiet.

For scalp wounds, cleanse the exposed surfaces and replace the torn scalp—the parts will generally heal: if abcesses form they should be evacuated by timely incisions.

In the treatment of wounds the diet should be carefully attended to. In cases like a wounded lung it is necessary to reduce the patient to nearly a state of starvation.

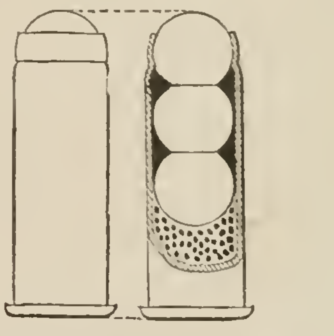
The most excruciating pains from shots are readily relieved by the hypodermic injection of a solution of morphia. Ice, if procurable, will subdue inflammatory symptoms. No description of spirits should be poured upon a bleeding wound, as it only serves to irritate and influence it. A wounded man is always thirsty; give him cold water, but never spirits. See *Gun-shot Wounds*, and *Surgery*.

WREATH.—In Heraldry,a wreath is a twisted garland of silk of different colors, otherwise called a torce, on which it has, since the 14th century, been usual to place the crest. The side-view of a wreath thus drawn exhibits six divisions, which are generally tinctured with the livery colors—that is, the principal metal and color of the shield. Every crest is now understood to be placed upon a wreath,except when it is expressly stated to issue out of a chapeau or coronet. A wreath,when represented alone,shows its circular form. A Moor's head is sometimes encircled with a heraldic wreath. A wreath is always understood to be the twisted garland of silk above explained,unless otherwise specified; but wreaths of laurel, oak, ivy, etc., sometimes occur, and savages used as supporters are often wreathed about the head and middle with laurel. Ordinaries are occasionally *wreathed*,otherwise called *tortillé*, in which case they are represented as if composed of two colors,twisted as in the heraldic wreath; as in the coat of Carmichael, argent, a fess wreathed azure and gules.

WRENCH.—An instrument used for screwing or unscrewing iron work. The *general service knock-up* wrench consists of two claws and a bar, the upper one formed in one piece with the bar and the lower one sliding; the latter is fixed at any required distance from the upper by means of a suitable iron wedge.

WRIGHT FUSE.—A modification of the Bormann fuse, which extends the time of burning to twelve seconds, and gives excellent results. See *Bormann Fuse*.

WRIGHT MULTIBALL CARTRIDGE.—A buckshot cartridge proposed by E. M. Wright, United States Army, for the present service revolvers when altered. This cartridge, as shown in the drawing, has a case similar to the service cartridge, excepting in its length, being 1".61, and in its being bottled forward to pass the choke in the chamber. The mean of the charge of powder obtained from the cartridges is 25



grains. There are three bullets, each weighing 110 grains,and having a diameter of ".428. The two extreme balls are segments of spheres, with one base, the radius of which is one-eighth of an inch; the middle ball is a segment of a sphere, the radii of whose bases are each one eighth of an inch. The powder is closely compressed, so as to occupy but ".42 of the case. The capabilities of this cartridge will be best understood by a reference to the comparative tables, on pages 658 and 659.

The efficiency of the cartridge turns upon two considerations: first, accuracy; second, effective energy. In point of accuracy, when used either against a single file or a front or body of men,under the usual service conditions, viz., without rest, and fired by pointing, not sighting, the multiball cartridge is a little superior to the service up to 25 yards; between that and 50 yards, nearly twice that of the service

VELOCITY.

Bullet.	Weight of powder.	Weight of bullets.	Initial velocities.	Remaining velocities. 50 yards.	75 yards.	100 yards.	25 yards.
	Grains.	Grains.	Feet.	Feet.	Feet.	Feet.	Feet.
Service	28	230	725	695	681	667	709
Multiball	25	330	690	591.5	554	517.5	637

ENERGIES.

Bullet.	Weight of powder.	Weight of bullet.	25 yards.	50 yards.	75 yards.	100 yards.
	Grains.	Grains	Foot-pounds.	Foot-pounds.	Foot-pounds.	Foot-pounds.
Service	28	230	256.8	246.7	236.9	227.3
Multiball	25	110	99.1	85.5	75	61.5

PENETRATION (White-pine butts.)

Multiball Bullets.	25 yards.	50 yards.	75 yards.	100 yards.
	Inches.	Inches.	Inches.	Inches.
1	2.06	1.9	1.42	.99
2	1.6	1.6	1.26	.74
3	1.3	1.25	1.04	.44
Mean of 3 balls	1.65	1.58	1.24	.72

ACCURACY (Muzzle-rest.).

Cartridges.	No. of bullets.	25 yards. Mean absolute deviation.	No. of hits.	50 yards. Mean absolute deviation.	No. of hits.	75 yards. Mean absolute deviation.	No. of hits.	100 yards. Mean absolute deviation.	No. of hits.
		Inches.		Inches.		Inches.		Inches.	
Service	10	3.39	10	5.67	10	10.12	10	13.76	10
Multiball	3	4.09	30	10.45	30	20.66	25	28.53	18

against a front of men, and nearly equal to the service against a single file. Between 50 and 100 yards it approaches nearly three times that of the service-cartridge against a front of men. The experiments lead to the conclusion of a probable and marked superiority (on account of the greater number of balls) of the multiball cartridge over the service, to include the range of 50 yards. See *Buck-shot Cartridge*, and *Multiball Cartridge*.

WROUGHT-IRON.—If we remove carbon from cast-iron, so that the amount becomes less than two per cent., we obtain either *steel* or wrought-iron according to the amount removed, the subsequent treatment of the metal, or to both combined. Wrought-iron approaches to, theoretically, pure iron, and, according to the old nomenclature, is iron containing from 0.1 per cent, to 0.3 per cent. of carbon, though we shall find that certain characteristic steels now made have no larger proportion of this element. Wrought-iron is obtained by removing the carbon from cast-iron by puddling or otherwise, and then working it up by hammering or rolling into a useful or marketable form, whence the term wrought or piled is applied to this particular kind of iron. If the cast-iron is very impure, some of the impurities will be retained by the wrought-iron, and will affect it seriously if present in any quantity. Thus a small proportion of phosphorus, 0.25 per cent., will make a bar of wrought-iron "cold short" or brittle when cold, while a little sulphur present makes wrought-iron "red short" or brittle when heated.

While this more or less pure metal obtained from

ACCURACY (Fired on horseback at a gallop.)

Cartridge.	From 100 to 60 yards.			From 60 to 25 yards.			From 40 to 10 yards.		
	No. of trial.	Shots fired.	Hits.	No. of trial.	Shots fired.	Hits.	No. of trial.	Shots fired.	Hits.
Service	1st	6	1	1st	6	2	1st	6	3
	2d	6	1	2d	6	3	2d	6	2
	....	....	....	3d	6	2	3d	6	4
	....	....	....	4th	6	3	....	....	....
Total	2	12	2	4	24	10	3	18	9
Multiball	1st	6*	5	1st	6	11	1st	6	7
	2d	6	2	2d	6	9	2d	6	3
	....	....	....	3d	6	5	3d	6	6
	....	....	....	4th	6	3	....	....	....
	2	12	7	4	24	28	3	18	16

ACCURACY (Fired on foot at a run).

Cartridge.	From 100 to 65 yards.		From 75 to 45 yards.		From 50 to 25 yards.		From 35 to 17 yards.	
	No. of Shots.	Hits.	No. of Shots.	Hits.	No. of Shots.	Hits.	No. of Shots.	Hits.
Service	6	2	6	2	6	5	6	6
Multiball	6	11	6	7	6	10	6	16

cast-iron by removal of the carbon, through puddling or otherwise, is worked under the hammer or rolls, it is drawn out and so given a fibrous structure, the fibers running lengthwise in the direction in which it is drawn. The fiber runs along the length, in fact, as the fiber runs in the branch of a tree. This structural arrangement of the material can be readily demonstrated by subjecting a piece cut off a bar of wrought-iron to the action of acid, when certain portions of the mass are eaten away, and the fibers stand out clearly, presenting the appearance of a bundle of fine wires. This fibrous quality of bar-iron renders it much stronger in one direction than in the other, for—just as in the case of wood—it requires about twice the force to break a piece of wrought-iron across its fiber that it does to tear it asunder along the fibers. In the latter case the fibers need only be separated, not broken, and the cohesion which binds them together is not much greater than that of the crystals which compose good cast-iron. Unfortunately the process of working up good wrought-iron into proper condition for use does not remove all the foreign matter, such as minute portions of slag, etc., which have been entangled amongst the particles and fibers, so that owing to its mode of treatment a mass of wrought-iron is never thoroughly homogeneous, and if laid open always exhibits flaws of some description, whence it is difficult to obtain a uniform and smooth surface of wrought-iron perfectly free from defects.

Wrought-iron may be said to be practically infusible in any ordinary furnace, but it has the property of welding (which cast-iron has not); that is, if two clean surfaces of wrought-iron heated to a white heat (about 3,000°) be brought into contact and pressed together, either by rolling or hammering, they will unite so perfectly that the mass when broken will part as readily at any other place as at the point of union; this is a most valuable property, and is largely taken advantage of in the construction of our service ordnance. Wrought-iron is very malleable and ductile, and is also of great tensile strength, although its tenacity is much below that of most natures of steel. The tenacity is about 25 tons per square inch for good average wrought-iron. The elastic limit of wrought-iron is not very high; about 12 tons per square inch; but after that limit is exceeded much work must be done in permanently stretching this very ductile metal before the limit of fracture is reached, giving us a large margin of safety.

Forged or wrought-iron, like cast-iron, varies greatly in quality according to purity and treatment in its manufacture. It may be divided generally into four different kinds:

First. Iron which is tough and malleable at all temperatures. This is the best and most useful, as it may be bent in any direction without breaking, both when it is hot and when it is cold. It may be known generally by the equable surface of the forged bar, which is free from cross fissures, or cracks, in the edges, and by a clear white small grain, or rather fibrous texture. The best and toughest iron is that which has the best welding properties, and which bears the highest heat without injury, and which has most fibrous texture, and is of a clear grayish color.

Second. The next best iron is that which has a texture consisting of clear whitish small grains intermixed with fibers. It is tough and malleable at all temperatures, bears a moderately high degree of heat without any injury, and has good welding properties.

Third. Another kind of iron is tough when heated, but brittle when it is cold, so brittle that it will sometimes break with a single blow of the hammer, or by a sudden jerk, which makes it unfit for several kinds of work where life and property are dependent upon it; but for some kinds of work that are to be exposed to the weather it is very useful, as it will resist the action of the atmosphere better than the other kinds. It may generally be distinguished by a texture consisting of large shining plates, without any fibers, and is called *cold-short iron.*

Fourth.—Hot-short, or *red-short, iron.* This is extremely brittle when hot, and malleable when cold. It will not bear bending without breaking, or piercing without splitting, and it is never used for superior kinds of work. But owing to its being much cheaper than the superior kinds, and being very tough and ductile in its cold state, for many purposes it is a very useful iron. On the surface and edges of the bars of this kind of iron, cracks or fissures may be seen, and its internal appearance is earthy, dull and dark.

The following observations on ores and furnaces will be instructive and interesting in this connection:

The production of spiegeleisen a variety of white iron very highly prized for making steel, is facilitated by the prevalence of a high temperature in the region of the hearth, the use of hotter blast being found to increase the quantity of manganese reduced. The metal produced under favorable conditions contain 8 per cent. of manganese, which is reduced to 4 per cent. when the temperature of the blast is allowed to fall to 100°. The slag must be as nearly as possible neutral, *i.e.*, having the oxygen of the bases equal in amount to that of the silica; but as silicates of lime and alumina of this form are extremely refractory, the requisite fusibility is attained by the partial substitution of other bases, such as magnesia, but more particularly protoxide of manganese. Silicate of protoxide of manganese, requiring a very high temperature for its reduction by carbon, does not exercise a decarburising influence on molten cast iron to the same extent as the corresponding silicate of protoxide of iron. Owing to their basic character, the slags have a tendency to corrode the sandstone hearth of the furnace very rapidly. This is counteracted to a certain extent, by the use of water-blocks surrounding the exterior of the hearth at several different levels. The amount of manganese reduced also depends upon the state of oxidation in which it exists in the ores, being greatest when spathic ore is used, and least when supplied in the form of manganesiferous hematite. Formerly the spiegeleisen of Musen was produced by the treatement of the Stahlberg spathic ore without flux; but since the introduction of limestone into the charge, the metal is much richer in manganese.

The furnaces used in Sweden are in many respects similar to the Blauofen of Styria, the fore-hearth being small and narrow. Their dimensions are usually small and narrow. Their dimensions are usually small, varying from about 600 to 2,300 cubic feet. The largest at Sandviken, near Gefle, is 52 feet high, 9½ feet wide at the boshes, and 6 feet at the throat, with six twyers, four of which are used at one time; the other two are in the tymp, South Wales fashion. The slags and metal are drawn on opposite sides of the hearth, an arrangement similar to that of the furnace at Säfvenäs, so that the iron may be run directly into the Bessemer converters. The clay and quartz lining of the hearth is from 6 to 8 inches thick; it consists of from 4 to 6 parts of quartz, mixed with 1 of fire-clay.

The Swedish ores vary considerably in character. The best are those known as self fluxing,—*i. e.*, containing earthy materials in the proper proportions to form a fusible bisilicate slag without further addition. The ores of Dannemora, Langbanshytta, and Langshytta are of this character: they contain from about 50 to 59 per cent. of iron. At the last-named furnaces, the charge, with the addition of from 3 to 5 per cent. of limestone, or blast-furnace slag, contains at times as much as 60½ per cent. of iron. As a general rule: the more quartzose hematites and micaceous ores are mixed with calcareous magnetites, and fluxed with dolomitic limestone, the average percentage of the charges being from 35 to 52 per cent. The maximum amount of flux, 25 per cent. of limestone, is used in smelting the siliceous hematite of Nora; and at Taberg, where the ore is a serpentine impregnated with magnetite, and the charge contains only 20 per cent. of iron.

The temperature of the blast does not exceed 200°, the pressure varying from 10 to 15 lines of mercury, or at most 20, in the new furnaces. The gases for heating the blast are drawn through an opening in the side of the furnace, about 12 or 14 feet below the throat; the stoves are of the horizontal, serpentine, or Wasseraltingen pattern, with pipes of circular section; the coil rarely containing more than three or four turns. Cold blast is only used at Finspong, in the manufactory of gun-foundry iron; even the Dannemora furnaces are now worked with blast heated to 80° or 100°. The average weekly production of the Swedish furnaces ranges from 700 to 1,400 centners (24 centners = 1 ton). In excess of these yields are of those of Langshytta, 1,800 ctr. At Taberg, on the other hand, the amount is as slow as 600 ctr. The furnaces are, as a rule, only kept in blast during the winter months, in 1864 the average was 150 days, when the ores and fuel can be easily brought to the works by means of sledges. At the mouth of the Lapland rivers, some of the furnaces are in connection with saw-mills, the blast-engine boilers being fed with the waste slabs and sawdust; the ores and fluxes, in such cases, being brought from the south in the summer time by sailing vessels. The consumption of charcoal varies with the nature of the ore, the average for the whole country from 16 to 17 cwt. per ton of white or mottled forged pig, and about one-third more, or from 21 to 22 cwt. per ton, of the grey metal, suitable for foundry or Bessemer steel purposes. At Langshytta, the consumption is as low as 13½ to 14 cwt., making a white and mottled iron. The poor ores of Taberg require as much as 50 or 60 cwt., per ton.

The charcoal furnaces of Lake Superior are noticeable for their large productions. At Greenwood furnace, near Marquette, two classes of iron ore are smelted—namely, brown hematite, containing an average 40 per cent., and slaty red hematite, or specular schist, with 60 per cent.; the former, although poorer, is preferred, as being more easily reducible than the harder slaty ore. The two qualities are mixed to yield 55 per cent. of pig iron. The furnace is 40 feet high, 11 feet diameter at the boshes and 4 feet at the throat; the cases are collected in a narrow ring flue, enclosed by an iron cylinder, remaining open. The blast, at a temperature of 330° and pressure of 1½ to 2 lbs. per square inch, is introduced through the twyers of 3½ inches in diameter on opposite sides of the hearth. A variegated crystaline limestone is used as flux, to the amount of about 10 per cent. of the weight of the ore. The fuel is hard wood, principally maple charcoal, the consumption being at the rate of 125 bushels, weighing from 16 to 20 lbs. each, or about 25 cwt. per ton of pig iron. The ores are not roasted, but all the materials are reduced to the size of ordinary road metal by a Blake's rock breaker previous to charging. The daily produce in July, 1865, before the furnace had arrived at its full make, was from 16 to 18 tons, mostly small-grained, dark grey pig iron, suited for Bessemer steel-making and foundry work, especially chill castings, such as railway wheels. At Wyandotte Iron Works, near Detroit, in a furnace of similar dimensions, the consumption of light-wood coals is 140 bushels of 14 lbs. weight per ton. The charges are 500 lbs. of red slaty ore, 40 lbs. of limestone and

40 lbs. of forge cinders: yield 65 per cent. The large amount of fuel required by these furnaces has already made a very decided impression on the surrounding timber. The average yield per acre of the best timber land on Lake Superior is, often 50 to 60 cords of 128 cubic feet measurement, or about 2,700 bushels: a quantity only sufficient to make about 20 tons of pig iron. So that the daily supply of one single furnace necessitates the clearing of an acre of forest; or, supposing it to be put down in the center of a uniformly-wooded district, and to make sixteen tons daily, two years working would be sufficient to clear a circle of a mile in diameter. It is evident, therefore, that even in a densely-wooded country a permanent supply of fuel cannot be looked for except where the works are placed within reach of rivers or navigable waters.

In South Staffordshire the make is chiefly grey pig iron for forge purposes, which is afterwards converted into bars, plats, and other small varieties of merchant iron. The ores employed are partly "native mine," *i. e.* clay ironstones from the coal measures, and partly the brown and red hematites from North Staffordshire, Lancashire, an other parts. Forge cinders are extensively used in the production of common hot blast metal, but the best mine pigs are still made with cold blast and coke. According to Jones the annual consumption of this district is as follows:—

	Tons.
Native mine (clay ironstones of the measure)	948,500
Brown hematite, "hydrate," or Froghall calcareous brown hematite	368,000
Red hematite, Ulverstone	50,000
Northamptonshire brown iron ores	200,000
Northamptonshire argillaceous carbonate and blackband	180,000
Forge and mill cinders	150,000
	1,896,500

The coals of South Staffordshire are of a non-caking class, yielding only a very slightly coherent coke, from the absence of binding qualities: therefore the slack cannot be coked alone. Of the two principal seams used for iron-making, the thick yields 54 per cent. by weight of coke, with 0.31 of sulphur and 4.18 of ash: the lower, or heathen coal, contains 0.51 of sulphur and 4.58 of ash. Generally the fuel is used partly raw and partly coked. The pressure of blast varies between 2½ to 3 lbs. per square inch, and the temperature from 300° to 330°, except in the small number of cold blast furnaces. The flux used is principally Silurian limestone from Dudley and Wenlock Edge, and carboniferous limestone from North Staffordshire and Derbyshire. The average consumption of coal per ton of metal made is for hot blast furnaces from 55 to 60 cwt., and for cold blast from 60 to 70 cwt., or rather the corresponding equivalent in coke, besides 2 cwt., of small for calcining, and 15 to 22 cwt. used in the hot blast stoves and steam boilers, very few furnaces in this district being provided with gas-saving apparatus.

In Belgium the ores smelted are chiefly red and brown hematite. The former, a mixture of specular and micaceous ore, is known as *violet mine;* the latter, or *yellow mine*, is mostly ochreous and earthy requiring to be fully subjected to the processes of crushing and dressing before it is fit for treatment in the furnace. A variety of spathic ore, containing a considerable proportion of carbonate of zinc, found at Angleur, near Liege, has a reputation of making an extremely strong iron. A large proportion of the brown hematite is obtained from the oolitic formations in Luxemburg. 1864 the number of furnaces in blast and the total production were as follows:

46 coke furnaces produced . . 444,430 tons.
6 charcoal furnaces produced . 5,545 "

corresponding to a weekly make of 186 tons per furnace on coke, and 18 tons on charcoal; the latter figure is probably too low for the period of actual working, as these furnaces are rarely in blast continuously for the whole year.

The anthracite furnaces of Pennsylvania are remarkable for the very high pressure (from 6½ to 7½ lbs. per square inch) of blast employed. The ores are similar to the *rock mine* of Sweden—*i. e.*, massive magnetite and hematite, yielding from about 50 to 60 per cent. of iron. The following are the charges and produce of two different furnaces:

	Lehigh.	Lackawanna.
Ore	42¼ cwt	38½ cwt. (52 per cent.)
Limestone	29¼ "	14½ "
Coal	39½ "	33 "

Weekly make 248 tons (⅓ No. 1, ⅔ No. 2) 268 tons (all No. 3).

In the State of Indiana, the specular and red hematite ores from Lake Superior, Iron Mountain, and Pilot Knob, in Missouri, are smelted with the so-called *block coal.* This is a free-burning, non-caking splint coal, which is highly esteemed for iron-smelting purposes, and is used in the raw state. The furnaces are all of moderate size, from 50 to 60 feet in height, from 12 to 16 across the boshes, and 5 to 6 feet in width of hearth.

At Brazil, (near Indianapolis), the furnace charges as follows: 1,545 lbs. mixed ores (hematite, magnetite, scrap, and mill cinder); 475 lbs. limestone; 1,800 lbs. coal. The yield is about 68 per cent., the furnace being tapped three times in the twenty-four hours. The blast is heated by the waste gases to a temperature of 370° to 450°, and is delivered under a pressure of from three to four pounds to the square inch, through seven twyers, each 3½ inches in diameter.

The estimated make of pig iron in the United States from 445 furnaces in blast, in 1881, was as follows, classified according to the fuel employed:—

	Tons.
Anthracite	1,548,627
Coal and Coke	2,025,236
Charcoal	570,391
	4,144,254

At Newark, in New Jersey, speigeleisen is made from the residues obtained in the treatment of the mixed zinc and iron ores of Franklin, in the same State. The ore is an intimate mixture of franklinite and red zinc ore, with a massive green variety of willemite or silicate of zinc; it occurs in crystalline limestone, forming an irregular bed, which in places is 52 feet thick, the different minerals being very intimately mixed. A mixture of finely-crushed ore, with lime and anthracite, is heated in an oven-shaped calciner, having a cast-iron bed, perforated with numerous narrow slits, through which air is blown by a fan in sufficient quantity to burn the coal and oxidise the zinc vapor as it forms. The oxide of zinc produced in this process passes through a long series of condensing tubes and cooling chambers, the current being kept up by exhausting fans, until it is sufficiently cooled to be collected in bags made of cotton cloth. The residue remaining in the furnace after the removal of the zinc is a black cindery mass, containing the whole of the iron and manganese of the franklinite and the silica of the willemite, besides some undecomposed zinc oxide; it is estimated to contain 25 per cent. of iron, and 4 per cent. of zinc, and is smelted for spiegeleisen. The furnaces employed are very small, being only 20 feet high, and 7 feet across the boshes.

At *Von Fridau's* and *Von Ficher's furnaces, Vordern*, the ores are well adapted for the production of spiegeleisen, though they contain less manganese than those of a similar kind smelted in Siegen: but owing to the price of fuel, it is not always made. The slags usually contain a considerable quantity of protoxide of manganese (from 10 to 21 per cent.), and often nearly as much protoxide of iron, owing to the small amount of lime employed in fluxing. In some instances, a certain quantity of ankerite (carbonate of lime, magnesia, and protoxide of iron) is added to every fourth or fifth charge.

In the Siegen district the ores smelted are principally spathic and brown hematite, with a considerable quantity of manganese, together with red schistose hematite, partly raised in the neighborhood, and partly brought from Nassau. The products are white and grey pig metal and spiegeleisen, all of which are employed in steel-making; the first (*weissstrahlig* or *rohstahleisen*) in the open fire or puddling furnace, and the others in the Bessemer process. Formerly the furnaces were small, and chiefly worked with charcoal, but in those of newer construction the use of coke and hot blast is found to be attended with great regularity in the composition and quantity of the products. The following examples give the working details of two of the largest and most improved furnaces:—

Heinrichshütte. The ordinary charge contains, by measure:—

⅝ roasted spathic ores . .	7 cwt.
⅜ brown hematite . . .	4 "
25 to 30 per cent. limestone .	3 "

The fuel is coke from the Ruhr coal-field, containing from 9 to 10 per cent. of ash. Each charge weighs 14 cwt., and contains from 41 to 48 per cent., corresponding to a burden of 36 cwt. of ore and flux per ton of metal. The daily number of charges is from 38 to 40.

The blast is supplied through three twyers, that at the back being $2\frac{1}{2}$, and those at the sides $2\frac{3}{8}$ inches diameter. The pressure is $3\frac{1}{8}$ lbs. per square inch, and the temperature from 270° to 300°. About 26 tons of a white lamellar metal (*rohstahleisen*), suitable for conversion into steel, and sheet and wire iron, are produced daily, with a consumption of from 20 to 22 cwt. of coke per ton.

In order to obtain greater regularity in the distribution of the blast, the large number of twyers may be replaced by a single mouth-piece, with a long, narrow, rectangular aperture, which delivers the air in a thin stream uniformly along the entire length of the hearth. This system of twyer, together with the elliptical form of hearth, has been adopted in the construction of cupolas for smelting slags in the Lake Superior copper works. In the original furnaces of this class in the Ural, the breadth of the hearth at the twyers is 3 feet, at the throat 7 feet, height 30 feet, cubic capacity 1,950 feet, and the daily production, when working on rich magnetic ore (67 per cent.), with charcoal and cold blast, about 30 tons of grey pig-iron.

The mode of charging has an important influence upon the working of blast furnaces; this becomes evident when we consider that, in order to obtain regularity of action, the descending materials ought to be heated uniformly by the upward current of hot gases. This, however, is by no means the case, owing to the essential differences in the character of the two motions, the gases following the sides of the furnace close to the wall, the flow at the center being almost imperceptible. Thus, in an open-topped furnace, a wooden pole may be plunged into the center of the charge to a depth of 2 or 3 yards, without being carbonised, while the materials adjoining the wall, at the same level, are at a red heat. The descent of the charges, however, takes place under precisely opposite conditions, the velocity being greater at the center than at the sides, where the fragments are retarded by friction against the wall. It therefore appears that the central portion of the column of materials is likely to be imperfectly heated in its passage downward, and to arrive in the region of fusion in an unprepared state.

When the charges are of ore and fuel, deposited uniformly in the throat of the furnace in parallel layers, the increased velocity of descent at the center causes the middle of an upper layer to overtake the sides of that preceding it, so that at a certain depth below the mouth the contents of the furnace are more or less completely mixed. But for this circumstance, it would be impossible to maintain a uniform heat in the hearth, which would become alternately hot and cold, according to whether fuel or burden happened to be in front of the twyers.

In large furnaces, where it is necessary to drop the charges from a certain height into the throat, the distribution of the materials becomes complicated by the nature of the upper surface of the column in the shaft, which may be either a cone raised in the center, an inverted or conical funnel depressed in the middle, or a combination of both, such as a conical ring, according to the method of charging employed. The charges, therefore, instead of being deposited in parallel layers, have to accommodate themselves to the inclined surface of the preceding one. See *Iron*.

WUMMERA.—An Australian bow-instrument for propelling darts. In consists of a flat and straight piece of wood, 3 feet in length, having at its extremity a tube of bone, or a piece of tough skin into which the end of the dart is placed. The *wummera*, thus charged with the dart, is grasped in the right hand, and the dart itself is held and its direction determined by the thumb and forefinger of the left hand. Before the weapon is thrown a vibrating movement is imparted to it, under the impression that thus the aim may be taken with greater precision. When the dart is discharged, the *wummera*, or throw stick, remains in the warrior's hand.

WURST.—A kind of carriage used by the French, in 1791, with the view of improving the mobility of field-batteries. It was a two-wheeled ammunition-cart, resembling in a general way an Irish jaunting-car; the gunners sitting in two rows facing outwards, with the ammunition between them. Besides the danger incurred in bringing these cars under fire, they had another objection, that of constantly upsetting on the slightest inequality of ground or obstacle coming in the way. Car-carriages were adopted in the English artillery in 1803, but after a few years were discarded. Their use led to the introduction of a better sort of ammunition-carriage, the want of such being felt by the officers of the artillery. The ammunition-carriage thus introduced was on 4 wheels, and similar to our present ammunition-wagon.

Wyvern.

WYVERN.—A fictitious monster of the Middle Ages, frequently occuring in Heraldry. It resembles a dragon, but has only two legs and feet, which are like those of the eagle. See *Dragon* and *Griffin*.

X

XANTHICA.—A military festival observed by the Macedonians in the month called Xanthicus (our April), instituted about 392 B. C.

XYBELE.—An ancient machine of war, described by Heron, Philon and Vitruvius. It was a variety of the catapult.

Y

YAGER.—One belonging to a body of light infantry armed with rifles. Written also *Jager.*

YANKEE—YANKEE DOODLE.—Yankee, the popular name for the New Englander in America, and in Great Britain often applied indiscriminately to the whole population of the United States, was in its origin the corruption of the word English as pronounced by the Indians (Yenghies, Yanghies, Yankees). It seems to have been first applied about 1775 by the British soldiers as a term of reproach to the New Englanders, who themselves afterward adopted it. Since the War of Secession the Southern population apply it to the Northern people generally.

The air known as *Yankee Doodle* was originally *Nankee Doodle*,and is as old as the time of Cromwell, to whom, under that name, the doggrel words belonging to it seem to have had a reference which was known in New England before the Revolution; and one account of its appropriation in America; as a national air, is that after the battle of Lexington, the brigade under Lord Percy marched out of Boston, playing it in derisive allusion to the then popular nickname of the New Englanders; and that afterward the New Englanders, saying that the British troops had been made to dance to *Yankee Doodle*, adopted the air as they had adopted the nickname. The citizens of the United States do not now recognize *Yankee Doodle* but *Hail, Columbia*, as their national air.

YATAGHAN.—A Turkish poniard having a Damascus blade, straight or crooked. It has a double edge and sharp point, with a ridge in the middle of its whole length; the handle and scabbard are generally highly ornamented and costly.

YEOMANRY.—A volunteer force of cavalry in Great Britain, numbering in 1878, 14,830 of all ranks, and costing the country annually about £80,000. It was formed during the wars of the French Revolution, and then comprised infantry as well as cavalry; but the whole of the infantry corps,and many of the cavalry, were disbanded after the Peace of 1814. The organization of the corps is by Counties, under the Lords-Lieutenant. The men provide their own horses and uniform; in consideration of which they receive annually a clothing and contingent allowance of £2 a man, are exempt from taxation in respect to the horses employed on yeomanry duty,and draw during the annual training 2s. a day for forage, besides a subsistence allowance of 7s. a day. If called out for permanent duty, they receive cavalry pay, with forage allowance. The Yeomanry are available in aid of the civil power; and in time of invasion, or apprehended invasion, the Sovereign may employ them for service in any part of Great Britain, under the provisions of the Mutiny Act and Articles of War.

YEOMEN OF THE GUARD.—A veteran company, consisting of 100 old soldiers of stately presence,employed on grand occasions, in conjunction with the Gentlemen-at-Arms, as the body-guard of the Sovereign. These Yeomen were constituted a corps in 1485 by King Henry VII., and they still wear the costume of that period. Armed with partisans, and in the quaint uniform, the men present a curious sight in the 19th century. The officers of the corps are a Captain (ordinarily a Peer), a Lieutenant, and an Ensign. There is also a "Clerk of the Cheque and Adjutant." All these appointments are held by old officers,and are considered as important prizes. The whole charge is borne by the Sovereign's civil list. The head-quarters of the corps is at the Tower of London,where the men are known as *Beef-eaters.*

YESAWUL.—In India, a state messenger; a servant of parade,who carries a gold or a silver staff; an Aide-de-Camp.

Y-LEVEL.—Of the different varieties of the leveling instrument, that termed the Y-level has been almost universally preferred by American engineers, on account of the facility of its adjustment and superior accuracy. The telescope has at each end a ring of bell-metal, turned very truly and both of exactly the same diameter; by these it revolves in the wyes, or can be at pleasure clamped in any position when the clips of the wyes are brought down upon the rings, by pushing in the tapering-pins. It also has a rack and pinion movement to both object-glass and eye-piece, another adjustment for centering the eye-piece, and still another used for insuring the accurate projection of the object-glass, in a straight line. Both these are completely concealed from observation and disturbance by thin rings which screw over them. The telescope has also a shade over the object-glass, so made that, while it may be readily moved on its slide over the glass,it cannot be dropped off and lost. A small compass, without sights and with 2½-inch needle, is sometimes attached to the telescopes of the larger leveling instruments,and used to obtain the bearing of lines when desired.

The necessity for the adjustment insuring the accurate projection of the object-glass slide, which adjustment is peculiar to the instruments constructed by Messrs. Gurley, United States, will appear, when we state, that it is almost impossible to make a telescope tube perfectly straight on its interior surface. Such being the case,it is evident that the object-glass slide which is fitted to this surface, and moves in it, must partake of its irregularity,so that the glass and the line of collimation depending upon it,though adjusted in one position of the slide,will be thrown out when the slide is moved to a different point.

To prove this, let some level be selected which is constucted in the usual manner,and the line of collimation adjustment upon an object taken as near as the range of the slide will allow; then let another be selected,as far distant as may be clearly seen; upon this revolve the wires, and they will almost invariably be found out of adjustment, sometimes to an amount fatal to any confidence in the accuracy of the instrument. The arrangement adopted to correct this imperfection, and which so perfectly accomplishes its purpose, is quite novel.

There are two bearings of the object-glass slide, one being in the narrow bell-metal ring,which slightly contracts the diameter of the main tube,the other in the small adjustable ring, which is also of bell-metal, and suspended by four screws in the middle of the telescope. Advantage is here taken of the fact, that the rays of light are converged by the object glass, so that none are obstructed by the contraction of the slide,except those which diverge,and which ought always to be intercepted, and absorbed in the blackened surface of the interior of the slide. Now, in such a telescope, the perfection of movement of the slide, depends entirely upon its exterior surfaces, at the points of the two bearings. These surfaces are easily and accurately turned concentric, and parallel with each other, and being fitted to the rings, it only remains necessary to adjust the position of the smaller ring, so that its center will coincide with that of the optical axis of the object-glass. When this has been done, no further correction will be necessary,unless the telescope should be seriously injured.

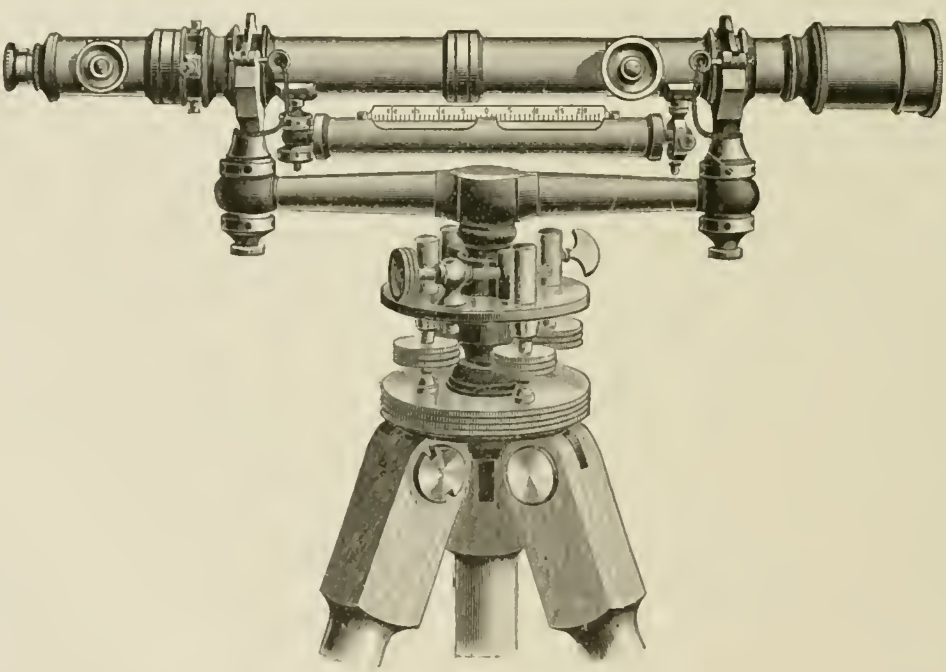
In the best instruments, the level telescopes are usually furnished with the ordinary rack and pinion movement to both object and eye tubes. The advantages of an eye-piece pinion are, that the eye-piece can be shifted without danger of disturbing the telescope, and that the wires are more certainly brought into distinct view, so as to avoid effectually any error of observation, arising from what is termed the instrumental parallax. The object-slide pinion is usually placed on the side both of transit telescopes, and of those of the level. The pinion of the eye-tube is always placed on the side of the telescope.

The level or ground bubble tube is attached to the under side of the telescope, and furnished at the different ends with the usual movements, in both horizontal and vertical directions. The aperture of the tube, through which the glass vial appears, is about five and one-fourth inches long, being crossed at the center by a small rib or a bridge, which greatly strengthens the tube. The level scale which extends over the whole length, is graduated into tenths of an inch, and figured at every fifth division, counting from zero at the center of the bridge; the scale is set close to the glass. The level vial is made of thick glass tube, selected so as to have an even bore from end to end, and finely ground on its upper interior surface, that the run of the air-bubble may be uniform throughout its whole range. The sensitiveness of a ground level, is determined best by an instrument called a level-tester, having at one end two Y's to hold the tube, and at the other a micrometer-wheel divided into hundredths, and attached to the top of a fine-threaded screw which raises the end of the tester very gradually. The number of divisions passed over on the perimeter of the wheel, in carrying the bubble over a tenth of the scale, is the index of the delicacy of the level. In the tester generally used, a movement of the wheel ten divisions to one of the scale, indicates the degree of delicacy generally preferred for railroad engineering. For canal work practice, a more sensitive bubble is often desired, as, for instance, one of seven or eight divisions of the wheel, to one of the scale.

The wyes are made large and strong, of the best bell-metal, and each have two nuts, both being adjustable with the ordinary steel pin. The clips are brought down on the rings of the telescope-tube by the Y pins, which are made tapering, so as to clamp the rings very firmly. The clip of one of the wyes has a little pin projecting from it, which entering a recess filled in the edge of the ring, ensures the vertical position of the level and cross-wire.

The level-bar is made round, and of the best bell-metal, and is shaped so as to possess the greatest strength in the parts most subject to sudden strains. Connected with the level-bar is the head of the tripod-socket.

The tripod-socket is compound; the interior spindle, upon which the whole instrument is supported, is made of steel, and is nicely ground, so as to turn evenly and firmly in the hollow cylinder of bell-metal; this again has an exterior surface fitted and ground to the main socket of the tripod-head. The bronze cylinder is held down upon the spindle by a washer and screw, the head of the last having a hole in its center, through which the string of the plumb-bob is passed. The upper part of the instrument, with the socket, may thus be detached from the tripod-head; and this also, as in the case of all fine instruments, can be unscrewed from the legs, so that both may be conveniently packed in the box. A little under the upper parallel plate of the tripod-head, and in the main socket, is a screw which can be moved into a corresponding groove, turned on the outside of the hollow cylinder, and thus made to hold the instrument in the tripod when it is carried upon the shoulders. It will be seen from the drawing that the arrangement just described allows long sockets, and yet brings the whole instrument down as closely as possible to the tripod-head, both objects of great importance in the construction of any instrument.



The leveling head has the same plates and leveling-screws as that described in the account of the Engineers' Transit; the tangent-screw, however, is commonly single. The 20-inch Y level, complete and mounted on its tripod, is shown in the drawing. Its adjustments should be carefully made before using.

To Adjust the Object-slide.—The maker selects an object as distant as may be distinctly observed, and upon it adjusts the line of collimation, in the manner hereafter described, making the center of the wires to revolve without passing either above or below the point or line assumed. In this position, the slide will be drawn in nearly as far as the telescope-tube will allow. He then, with the pinion-head, moves out the slide until an object, distant about ten or fifteen feet, is brought clearly into view; again revolving the telescope in the Y's he observes whether the wires will reverse upon this second object. Should this happen to be the case, he will assume that, as the line of collimation is in adjustment for these two distances, it will be so for all intermediate ones, since the bearings of the slide are supposed to be true, and their planes parallel with each other. If, however, as is most probable, either or both of the wires should fail to reverse upon the second point, he must then, by estimation, remove half the error by the screws placed at right angles to the hair sought to be corrected, remembering, at the same time, that on account of the inverting property of the eye-piece, he must move the slide in the direction which apparently increases the error. When both wires have thus been treated in succession, the line of collimation is adjusted on the near object, and the telescope again brought upon the most distant point; here the tube is again revolved, the reversion of the wires upon the object once more tested, and the correction, if necessary, made in precisely the same manner. He proceeds thus, until the wires will reverse upon both the objects in succession; the line of collimation will then be in adjustment at these and all intermediate points, and by his bringing the screw-heads, in the course of the operation, to a firm bearing upon the washers beneath them, the adjustable ring will be fastened so as for many years to need no further adjustment. When this has been completed, the thin brass ferule is screwed over the outside ring, concealing the screw-heads, and avoiding the danger of their disturbance by an inexperienced operator. In effecting this adjustment, it is always best to bring the wires well into the center of the field of view, by moving the little screws, formed for working in the ring which embraces the eye-piece tube. Should the engineer desire to make the adjustment of the object-slide, it will be necessary to remove the bubble-tube, in order that the small screw immediately above its scale may be operated upon with the screw-driver.

The adjustment we have now given is preparatory to those which follow, and are common to all leveling instruments of recent construction, and are all that the engineer will have to do with. What is still necessary then is: 1. To adjust the line of collimation, or in other words, to bring both wires into the optical axis, so that their point of intersection will remain on any given point, during an entire revolution of the telescope. 2. To bring the level-bubble parallel with the bearings of the Y-rings, and with the longitudinal axis of the telescope. 3. To adjust the wyes, or, in other words, to bring the bubble into a position at right angles to the vertical axis of the instrument.

To adjust the Line of Collimation, set the tripod very firmly, remove the Y-pins from the clips, so as to allow the telescope to turn freely, clamp the instrument to the tripod-head, and, by the levelling and tangent-screws, bring either of the wires upon a clearly marked edge of some object, distant from 100 to 500 feet. Then with the hand carefully turn the telescope half way around, so that the same wire is compared with the object assumed. Should it be found above or below, bring it half-way back by moving the capstan-head screws at right angles to it, remembering always the inverting property of the eye-piece; now bring the wire again upon the object, and repeat the first operation until it will reverse correctly. Proceed in the same manner with the other wire until the adjustment is completed. Shoud both wires be much out, it will be well to bring them nearly correct before either is entirely adjusted. When this is effected, unscrew the covering of the eye-piece centering screws, and move each pair in order with a small screw-driver, until the wires are brought into the centre of the field of view. The inverting property of eye-piece does not affect this operation, and the screws are moved direct. To test the correctness of the centering, revolve the telescope, and observe whether it appears to shift the position of an object. Should any movement be perceived, the centering is not perfectly effected. It may here be repeated, that in all telescopes the position and adjustment of the line of collimation depends upon that of the object-glass; and, therefore, that the movement of the eye-piece does not affect the adjustment of the wires in any respect. When the centering has been once effected, it remains permanent, the cover being screwed on again to conceal and protect it from derangement, at the hands of the curious or inexperienced operator.

To adjust the Level-bubble.—Clamp the instrument over either pair of leveling-screws, and then bring the bubble into the center of the tube. Now turn the telescope in the wyes, so as to bring the level-tube on either side of the center of the bar. Should the bubble run to the end, it would show that the vertical plane, passing through the center of the bubble, was not parallel to that drawn through the axis of the telescope rings. To correct the error, bring the bubble entirely back, with the capstan-head screws, which are set in either side of the level-holder, placed usually at the object end of the tube. Again bring the level tube over the center of the bar, and the bubble to the center, turn the level to either side, and, if necessary, repeat the correction until the bubble will keep its position, when the tube is turned half an inch or more, to either side of the center of the bar. The necessity for this operation arises from the fact, that when the telescope is reversed end for end in the wyes in the other and principal adjustment of the bubble, we are not certain of placing the level-tube in the same vertical plane; and therefore it would be almost impossible to effect the adjustment without some lateral correction. Having now, in great measure, removed the preparatory difficulties, we proceed to make the level-tube parallel with the bearings of the Y-rings. To do this, bring the bubble into the center with the leveling-screws, and then, without jarring the instrument, take the telescope out of the wyes and reverse it end for end. Should the bubble run to either end, lower that end, or what is equivalent, raise the other by turning the small adjusting nuts, on one end of the level, until by estimation half the correction is made; again bring the bubble into the center and repeat the whole operation, until the revision can be made without causing any change in the bubble. It would be well to test the lateral adjustment, and to make such correction as may be necessary in that, before the horizontal adjustment is entirely completed.

To adjust the Wyes. Having effected the previous adjustments, it remains now to carefully describe that of the wyes, or, more precisely, the one which brings the level into position at right angles to the vertical axis, so that the bubble will remain in the center during an entire revolution of the instrument. To do this, bring the level-tube directly over the center of the bar, and clamp the telescope firmly in the wyes, placing it as before, over two of the leveling-screws, unclamp the socket, level the bubble, and turn the instrument half-way around, so that the level-bar may occupy the same position with respect to the leveling-screws beneath. Should the bubble run to either end, bring it half-way back by the Y-nuts on either end of the bar; now move the telescope well over the other set of leveling-screws, bring the bubble again into the center, and proceed precisely as above described, changing to each pair of screws, successively, until the adjustment is very nearly perfected, when it may be completed over a single pair. The object of this approximate adjustment, is to bring the upper parallel plate of the tripod-head into a position as nearly horizontal as is possible, in order that no essential error may arise, in case the level, when reversed, is not brought precisely to its former situation. When the level has been thus completely adjusted, if the instrument is properly made, and the sockets well fitted to each other and the tripod-head, the bubble will reverse over each pair of screws in any position. Should the engineer be unable to make it perform correctly, he should examine the outside socket carefully to see that it sets securely in the main socket, and to notice that the clamp does not bear upon the ring which it encircles. When these are correct, and the error is still manifested, it will, probably, be in the imperfection of the interior spindle. After all the adjustments of the level have been effected, and the bubble remains in the center, in any position of the socket, the engineer should turn the telescope in the wyes until the pin on the clip of the wye will enter the little recess in the ring to which it is fitted, and by which is ensured the vertical position of the spirit-level and the cross-wire. When the pin is in its place the vertical-wire may be applied to the edge of a building, and in case it should not be parallel with it two of the cross-wire screws that are at right angles to each other may be loosened, and by the screws outside, the cross-wire ring turned until the wire is vertical; the line of collimation must then be corrected again,and the adjustments of the level will be complete.

When using the instrument, the legs must be set firmly into the ground,and neither the hands nor person of the operator be allowed to touch them; the bubble should then be brought over each pair of leveling-screws successively, and leveled in each position, any correction being made in the adjustments that may appear necessary.

Care should be taken to bring the wires precisely in focus,and the object distinctly in view,so that all errors of parallax may be avoided.

This error is seen when the eye of an observer is moved to either side of the center of the eye-piece of a telescope, in which the foci of the object and eye-glasses are not brought precisely upon the cross-wires and object; in such a case the wires will appear to move over the surface, and the observation will be liable to inaccuracy.

In all instances the wires and object should be brought into view so perfectly, that the cross-wires will appear to be fastened to the surface,and will remain in that position however variously the eye is moved.

In running levels it is best wherever possible, that equal fore and back sights should be taken, so as to avoid any error arising from the curvature of the earth.

If the socket of the instrument becomes so firmly set in the tripod-head as to be difficult of removal in the ordinary way,the engineer should place the palm of his hand under the wye-nuts at each end of the bar,and give a sudden upward schock to the bar,taking care also to hold his hands so as to grasp it the moment it is free. See *Engineer's Transit*, *Hand-level*, *Leveling*, and *Leveling-rods*.

YOKE-HOOP.—A hoop used to secure the axletree of a carriage at each end of the bed.

YOUNGSTERS. A familiar term to signify the junior officers of a troop or company.

Z

ZAGAIE.—A long dart or lance in use among some African tribes, particularly the Moors,while fighting on horseback. It is armed with a sharp stone and thrown like a javelin. The savages of New Holland are still armed with it.

ZAIM.—High caste among the Turks, who are bound to maintain a proportion of militia according to their revenue, viz., one horseman for every 5000 aspers.

ZALINSKI INTRENCHING-TOOL. The Rice trowel-bayonet and the various intrenching knife-bayonets are useful tools for the soldier, but there is an objection to them all, in as much as the soldier is liable to use the tool for intrenching while it is attached to the gun, and very likely bend the gun-barrel and ruin the arm. As a weapon any one of these tools is quite as efficient as the triangular bayonet, which is carried on modern arms rather for ornament than use, except in doing guard duty. Either the spade or the knife is a convenient addenda to the soldier's kit, provided the soldier is allowed to employ it for some other purpose than absorbing his spare time and muscle in the polishing thereof. The ramrod-bayonet invented by Lieutenant E. L. Zalinski, U. S. Army, serves all the purposes of the regulation bayonet for both show and guard duty. It is simply the wiping rod enlarged for a foot or so of its length, and fixed in its thimbles so that it can be projected at the enlarged and pointed end for a foot or more, and then held in the partly drawn position by a spring catch. The saving in weight by the substitution of this bayonet for the triangular bayonet is nearly a pound, and the soldier gets rid of the bayonet-scabbard, which latter was apparently originally devised for the express purpose of tripping awkward recruits. This intrenching-tool is of simple construction. It is a short stout blade, somewhat resembling a trowel, but having a pivoted handle which may be turned down against the blade and the whole device secured in a shallow mortise in the stock of the gun. As the tool cannot be used while on the stock, there is no danger of injury to the arm by the attachment of this tool. The Springfield rifle with Zalinski's ramrod-bayonet and intrenching-tool attached,weighs less than the same arm with the regulation triangular bayonet. Buskett, of St. Louis, provides a trowel or scoop attachment to the stock of a gun which is opened to form an extension of the stock, and is used as an intrenching-tool in that position. See *Intrenching-tool*.

ZALINSKI SIGHT.—An improved telescopic sight invented by Lieutenant E. L. Zalinski,United States Army. The artillerist is aware that the attainment of a given *long* range is most difficult and uncertain. With the present appliances of powder, projectiles, and ordinary sights,the chances of striking a target, such as is presented by a war-vessel in motion, at distances of two or more miles are comparatively small. But the uncertainties of range due to the powder and projectiles are gradually being reduced in extent; we may reasonably hope that in time they will be measurably eliminated. Assuming that these *are* eliminated,the gun must be accurately *laid*,both as to direction and elevation, to obtain the desired results. The advantages gained by the use of telescopic sights for artillery in long-range firing, have been indicated by personal experiences at the Artillery School and the published experiences in France and England. A telescopic sight will necessarily be more delicate than an open sight, and requires more careful handling. The expense is also much greater: but the attainable range of modern ordnance has outstripped the sighting ability of the naked eye. Its cost has also been enormously increased both as to guns and carriages and the ammunition used. The better results obtainable by the use of an improved sight will therefore more than compensate for the additional care of manipulation and its first cost. Indeed, the cost of the telescopic sight will be less than a single round of the heavier guns, and is but a very small atom as compared to the cost of a field-piece, its equipment, and the maintenance of its personnel. The very great gain of relative efficiency, as shown by Colonel De Cossigny and Captain Scott, should settle any doubt as to the advisability of adopting telescopic sights. Should a sight become disabled, the gun will be thrown back to its normal status, using the open sight, with which it will be provided for the closer and more rapid firing. The firing, using the telescopic sight, will be at the longer ranges and may be sufficiently deliberate to permit a moderate amount of care in manipulation.

In designing his sight Lieutenant Zalinski endeavored to overcome the sources of error, difficulties of manipulation, defects of omission, and insufficiencies of the telescopic sights formerly used. Without specifying where they occur, they all may be comprehended as follows: 1st. Errors in elevation due to varying refraction. This applies equally to open sights, where the elevation is to be given by the line of sight. 2d. Necessary smallness of the graduated arcs for deflections and elevation; hence arise both difficulty to read corectly and to subdivide accurately to very small portions of a degree. 3d. Ease with which the line of collimation of the telescope may be thrown out of adjustment with reference to the zero of graduation without becoming apparent, except by the results obtained. 4th. Difficulty of replacing the telescope in exactly the same position upon the gun; danger, when replacing or withdrawing the telescope, of affecting the adjustment. 5th. Defective or entire absence of adjustment when the axis of the gun-trunnions are out of the horizontal. 6th. Necessity of transforming for each range, the degrees and minutes of deflection into yards or feet. 7th. Insufficient deflection adjustment for long ranges and high winds. 8th. The graduation for elevation being upon the side of the instrument, necessitating a marked, and sometimes inconvenient change from the sighting position in order to read it. The 2d and 3d causes are incidental to the usual mode of mounting telescopes for transits and similar goniometers by means of trunnions attached near the center of the length of the tube. This presents the two-fold disadvantage of a necessarily small radius of graduated arc, and a very considerable leverage upon the telescopic trunnions. There is, consequently, danger of displacement of the line of collimation with reference to the *mounting*. This latter, in an artillery sight, determines its relation to the axis of the bore. Hence a slight displacement may cause a considerable error in the telescopic line of sight.

Three features of the Zalinski design are believed to be new, viz: 1st. Mounting the telescope by a ball-and-socket joint, so that the center of motion is coincident with the optical center of the object-glass, and making this essentially fixed in all positions of the telescope: by this arrangement is obtained also the maximum available radius of graduation as well as great stability. 2d. The use of a level, on a telescopic *sight*, by means of which the errors of refraction may be eliminated. 3d. The peculiar graduation of an arc, in connection with the dividing plate, by means of which a vernier is obtained for a scale of *unequal* parts. Those who have had experience in devising new instruments will readily understand that the mechanical details can only be perfected gradually from experience obtained by practical use. This description of the telescopic sight is made in advance of its actual construction. See *Sight*.

ZAYM.—In the East Indies, a Feudal Chief, or Military Tenant.

ZEMINDAR.—The name given to the Governors of districts or large towns in India, under the Mogul Rule. Many of the Zemindars occupied in India a position almost similar to the Dukes and Counts of Western Europe in the Middle Ages; they received from their superiors, the Nabobs or Provincial Governors, fiefs of more or less extent, for which they paid a certain due annually, being then exempted from all imposts whatsoever. The dues paid by the Zemindars were, of course, exacted, with additions, from the ryots or cultivators, and constituted a large part of the imperial revenue. Under the British Government the same system of tax collection is continued in Bengal, the Zemindars in that Presidency being looked upon as the hereditary Lords or Proprietors of their respective districts. The Zemindars of the Coromandel district were formerly called *Polyghars*. Under the Zemindars were the *Havildars*, or heads of villages, whose duty it was to collect their share of the tax imposed by the Zemindar, and as, like their Chief, they took care to collect an additional proportion for themselves, the most atrocious oppression was commonly practiced: the "Nabob" plundering his "Zemindars," the "Zemindar" in turn plundering his "Havildars," while the "Havildar" more than reimbursed himself at the expense of the Hindu villagers.

ZENITH.—A word, like *nadir*, borrowed from the Arabic. The name is given to that point of the heavens which is directly overhead, *i.e.* in line with the spectator's position and the center of the earth. It is thus the upper pole of the spectator's horizon, like the nadir is the under pole. The word would seem to be connected with the Arabic *san*, which means a "point."

ZENITH-INSTRUMENT.—A geodetical instrument, invented by Captain Talcott, United States Engineer, for measuring the difference of the zenith of two stars, as a means of determining the latitude. Two stars are selected which pass the meridian about the same time and at about equal distances from the zenith, but on opposite sides of it. It has adjustments in altitude and azimuth, has a graduated vertical semi-circle and a level, and a micrometer for measuring the distances between the stars. A rather convenient form of zenith-instrument is used in the United States Coast and Geodetical Survey and the United States Corps of Engineers. The telescope swings on a horizontal axis, which is fastened to a vertical axis, and can therefore be moved into any position. It is especially adapted for the determination of differences of zenith distances. The horizontal circle is provided with two stops, in order to bring the telescope into the meridian. The telescope carries a circle with the latitude level, and is provided with a micrometer eye-piece. The instrument is made in various sizes. See *Altitude and Azimuth Instrument*.

ZERO.—A term in thermometry applied to certain points of temperature. The Centigrade zero is the temperature of melted ice. Fahrenheit puts his zero at the point indicated by his thermometer in a mixture of mixed snow and salt, supposing such point to be absolute zero. The Centigrade thermometer zero is the temperature of water formed by ice at the exact moment of its fusion. See *Thermometer*.

ZIGZAGS. In fortification, trenches pushed forward during a siege towards the place besieged. The trenches are constructed in a zigzag direction, so that, when prolonged, they shall fall clearly without all the defensive works, that they may not be enfiladed. See *Approaches*.

ZINC.—This metal, in commerce frequently called "spelter," was first mentioned by Paracelsus, in the fifteenth century, under the name of *zinetum*. It does not occur in the native state, but is obtained from its ores, which are chiefly the sulphuret and carbonate of zinc. It has long been imported into

India from China. The name *tutenague*, by which Chinese zinc was known in commerce, is evidently derived from the Tamil word *tutanagum*, and it was at one time called Indian tin. The ores of zinc were, no doubt, employed by the ancients in making brass. Zinc (Zn = 32) is found in the state of an oxide, but principally as a sulphuret (*blende*) and a carbonate (*calamine*). From both ores it is converted into an oxide by the process of roasting, and then reduced to metallic form by the aid of carbonaceous matter, when it may either be fused or sublimed. Until purified by a second distillation, it contains as impurities small portions of other metals, as iron, copper, arsenic, etc. In the corrugation of iron, zinc is the metal used. It was also used, not very long since, as an alloy, in the manufacture of shot studs for the smaller natures of projectiles.

ZINCOGRAPHY.—Essentially the same art as lithography, zinc-plates being substituted for those of stone. One form of the art is described under the name of Anastatic printing. A style of it, called paneiconography, brought forward by Gillot of Paris, for the purpose of producing, by lithographic, autographic, or typographic proof, any drawing with crayon or stump, or engravings from wood or copper, is thus described: A plate of zinc finely polished is prepared, and if an original drawing is to be copied, it is done by the artist in lithographic crayon on this plate: autographic writing done with the crayon, lithographs, and fresh proofs of wood or of copperplate engravings, must be transferred in the usual way to the surface of the plate; and while still wet, an ink-roller is passed over, so as to give a deeper impression. Rosin very finely powdered is then sifted over, which adheres to the wet ink, and becomes consolidated, so that the superfluous powder is easily brushed off from the parts not covered with ink. The plate is next placed with its face upward in a shallow trough containing dilute sulphuric or hydrochloric acid sufficient to slightly cover it: the trough is then gently rocked, so as to make the acid flow backward and forward over the plate, and if this be continued for some time—an hour or upward—all the parts of the plate not covered with the ink and rosin are etched deep enough to be used as a relief-plate for printing from. In impressions where there are large insterspaces, it is usual to saw them out; and in some cases, where it is found that the relief is not sufficiently high, the raised parts are re-inked, and again covered with the rosin, and submitted a second time to the action of the acid.

ZIYAMUT.—In the East Indies,a fief bestowed for military services.

ZIZARME.—A sort of pike or lance much used in ancient times.

ZOARQUE.—A soldier who had charge of an elephant among the Ancients.

ZOBO.—A hybrid between the yak and the common ox of India. It is not very unlike the English ox. It is common in the western parts of the Himalaya, and is valued as a beast of burden, as well as for its milk and its flesh.

ZONE ENERGY.—This is a mode of expression in artillery, whereby the relative power of different guns as armor-piercers is estimated,viz.,by the number of foot-tons per inch of the shot's circumference. At the muzzle of each gun, this power is a *maximum*, but owing to the resistance of the air it gradually diminishes during the shot's flight.

ZONE OF DEFENSE.—A term used in fortification, signifying the belt of ground in front of the general contour of the works within effective range of the artillery on the ramparts. Should the zone of defense be wooded and inhabited, one of the first duties of the defenders would be to clear it of all trees,houses, etc., in one word,of everything that may impede the fire of the guns or be made use of by the enemy as a place of concealment.

ZONE OF FIRE.—A term synonymous with range or trajectory; the dangerous zone is that space of ground which is rendered so to troops in the field by the projectiles having their full effect upon them. It differs in small-arms, and depends in guns on the initial velocity and the angle of elevation. The French call *Zone Morte* the space of ground where the projectile has lost its strength, and is spent. See *Dangerous Space*.

ZONE OF OPERATIONS.—The strip of territory which contains the lines of operations, or lines on which an army advances, between the base and the ulterior object. See *Strategy*.

ZOUAVES.—A body of troops in the French Army, which derives its name from a tribe of Kabyles inhabiting the mountains of Jurjura, in the Algerian province of Constantine. Long previous to the invasion of Algiers by the French, these Kabyles had been employed as hired mercenaries in the service of the Rulers of Tripoli, Tunis, and Algiers; and after the conquest of the last-named country in 1830, the French, in the hope of establishing a friendly feeling between the natives and their conquerors, took the late Dey's mercenaries into their Service,giving them a new organization. Accordingly General Clausel created, in 1830, two battalions of zouaves, in which each company consisted of French and Kabyles in certain proportions, officers, subalterns, and soldiers being selected from either race; the zouaves, though retaining their Moorish dress, were armed and disciplined after the European fashion; and the battalions were recruited by voluntary enlistment. As it was soon found, however, that the system of commingling the two races did not effect the object intended, the French and Kabyles were formed into separate companies; and in 1837 they were divided into three battalions, and put under the command of a Colonel. Their first Colonel was Lamoricière,who mainly effected their reorganization, and under whom, as well as his successor, Cavaignac, they distinguished themselves in many a bloody conflict with the Arabs of the South. Gradually, however, the native element was eliminated, and since 1840 they may be considered as French troops in a Moorish dress. In 1852 to 1855 their numbers were greatly augmented, and they now amount to upwards of 10,000 men, divided into four regiments of four battalions each. They are recruited from the veterans of the ordinary infantry regiments who are distinguished for their very fine physique and tried courage.

When the French and the African elements of the original zouave battalions were separated, the Africans were constituted into a separate body, under the name of Algerian Tirailleurs, a force still recruited in Algiers to form a part (three regiments) of the regular French Army. They are better known as *Turcos*.

ZUCCHETTO.—A burgonet skull-cap in iron, with a movable nose-piece and plated neck-guard.

ZUMBOORUKS.—Diminutive swivel-artillery, carried on the backs of camels.

ZUNDNADELGEWEHR.—A celebrated Prussian needle-gun. This gun is a representative of the *slide system* of breech-loading construction. Its great disadvantages are leakage at the breech, difficulty of opening and charging when a little foul, no half-cock and accidental discharges, due to a mere prick of the needle even without concussion.

END OF VOL. III.

ILLUSTRATIONS.

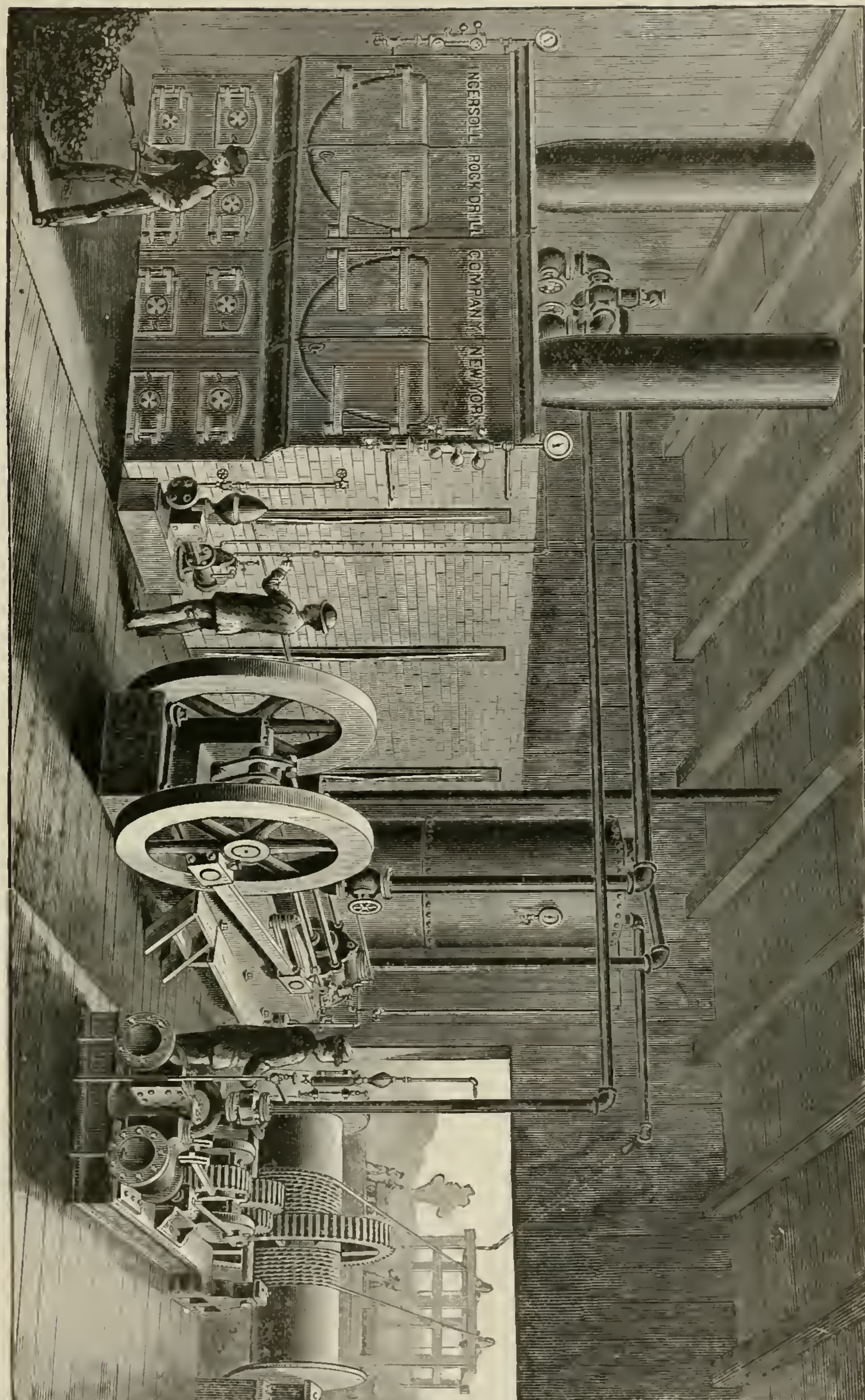
OF

GENERAL AND SPECIAL SUBJECTS

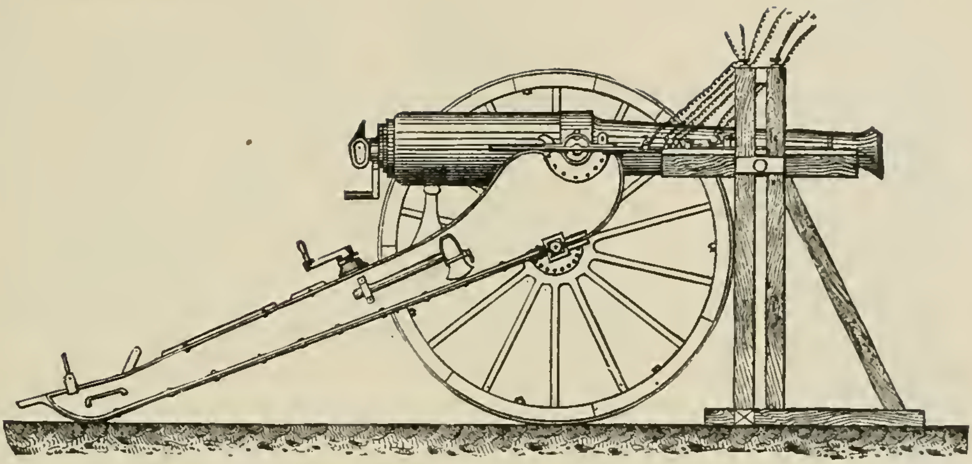
TREATED IN

FARROW'S

MILITARY ENCYCLOPEDIA.



AIR-COMPRESSOR.—Plant Employed at the Croton Aqueduct, New York.



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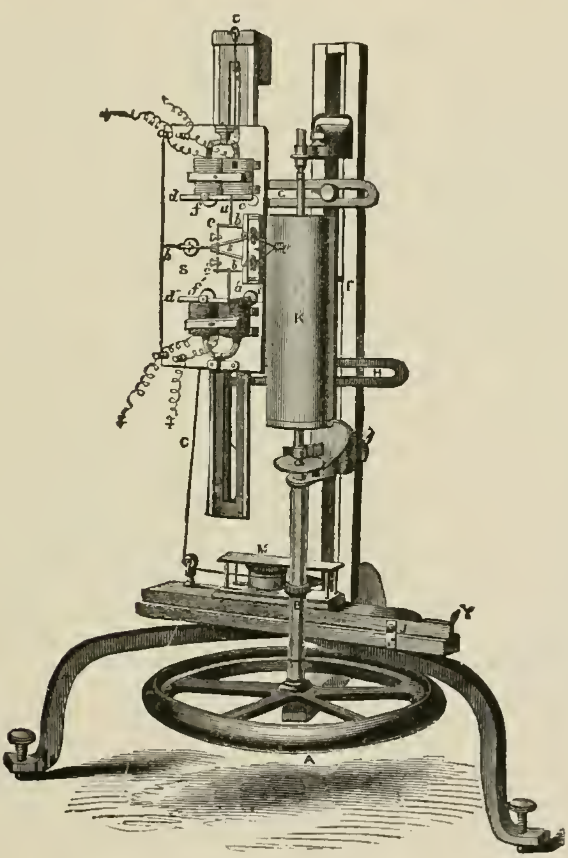

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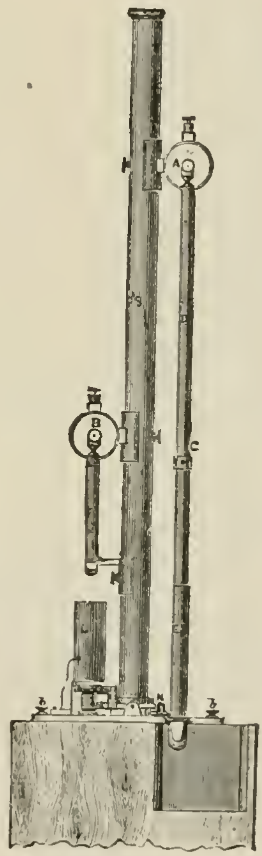

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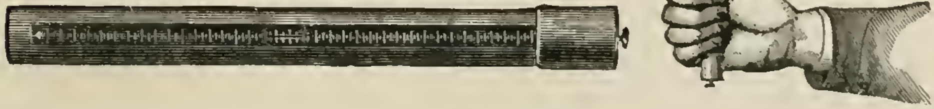

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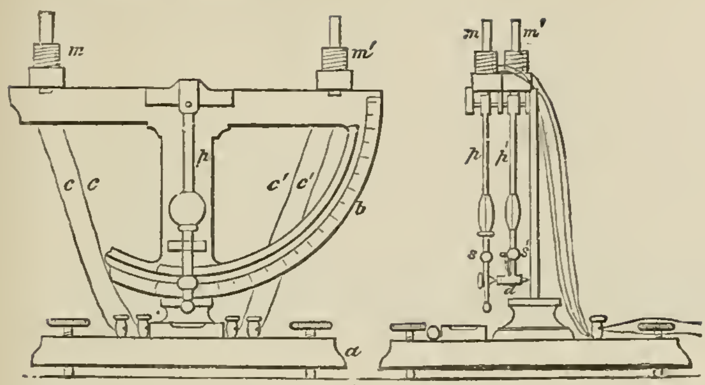
BALLISTICS.—1. Velocimeter.—Marine Artillery Service. 2. Bashforth Chronograph. 3. Le Boulengé Chronograph. 4, Telemeter.



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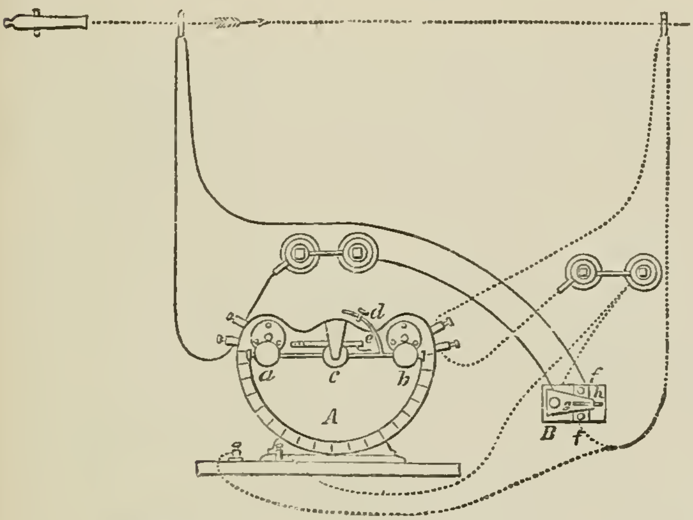

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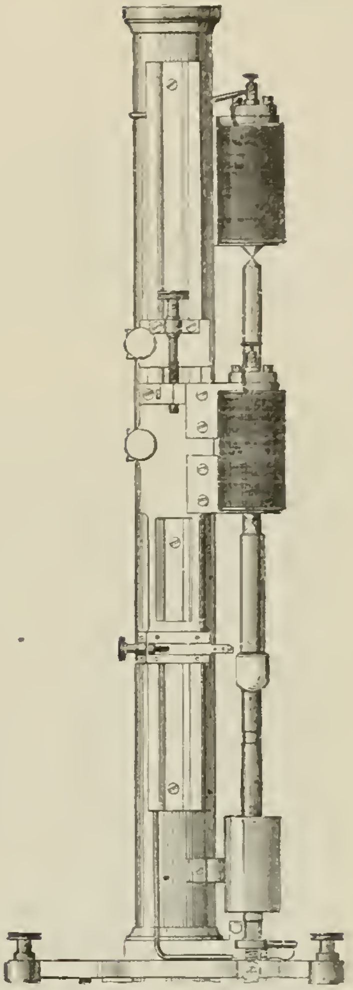

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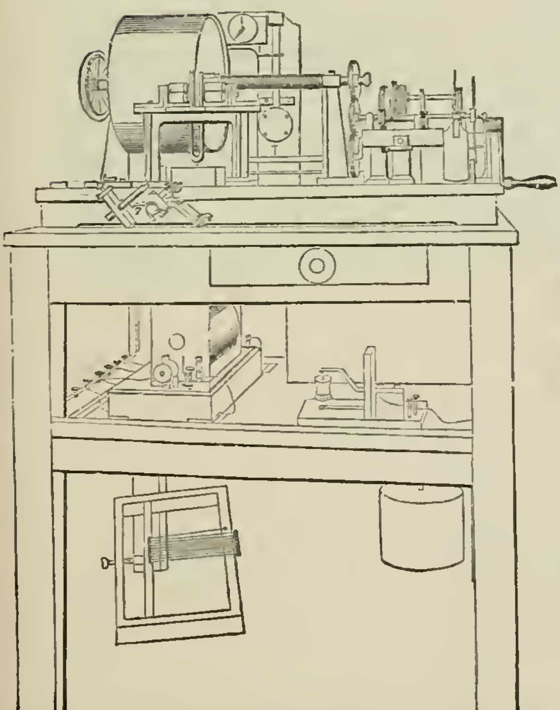

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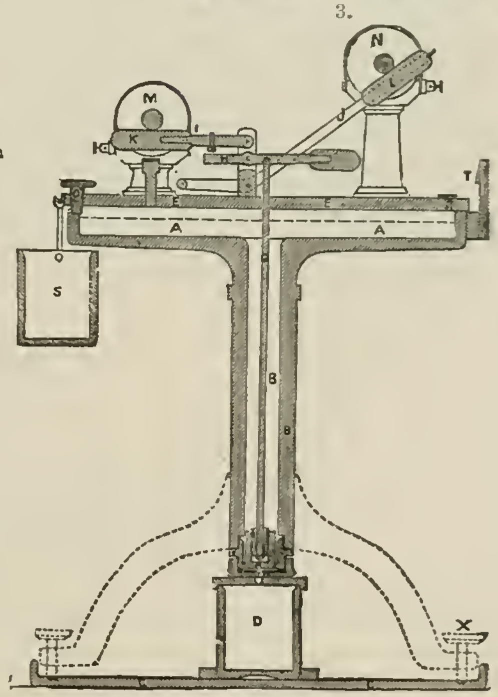

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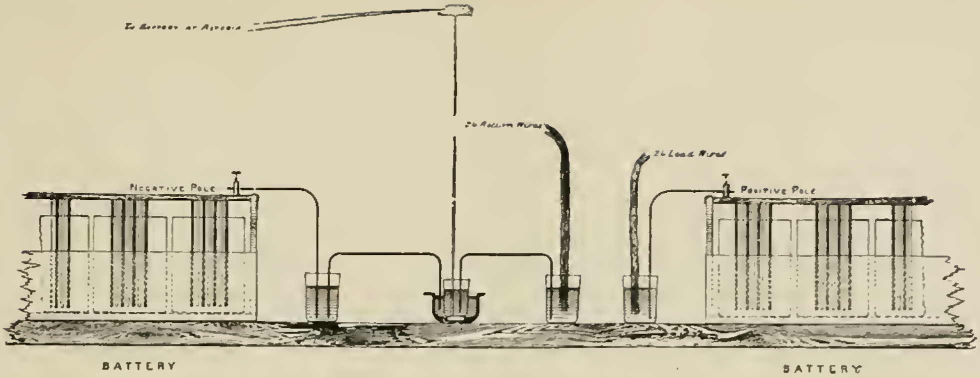
BALLISTICS.—1, Benton Thread Velocimeter. 2. Navez-Leurs Chronoscope. 3. Breger Chronograph. 4. Schultz Chronoscope. 5. Electric Clepsydra.



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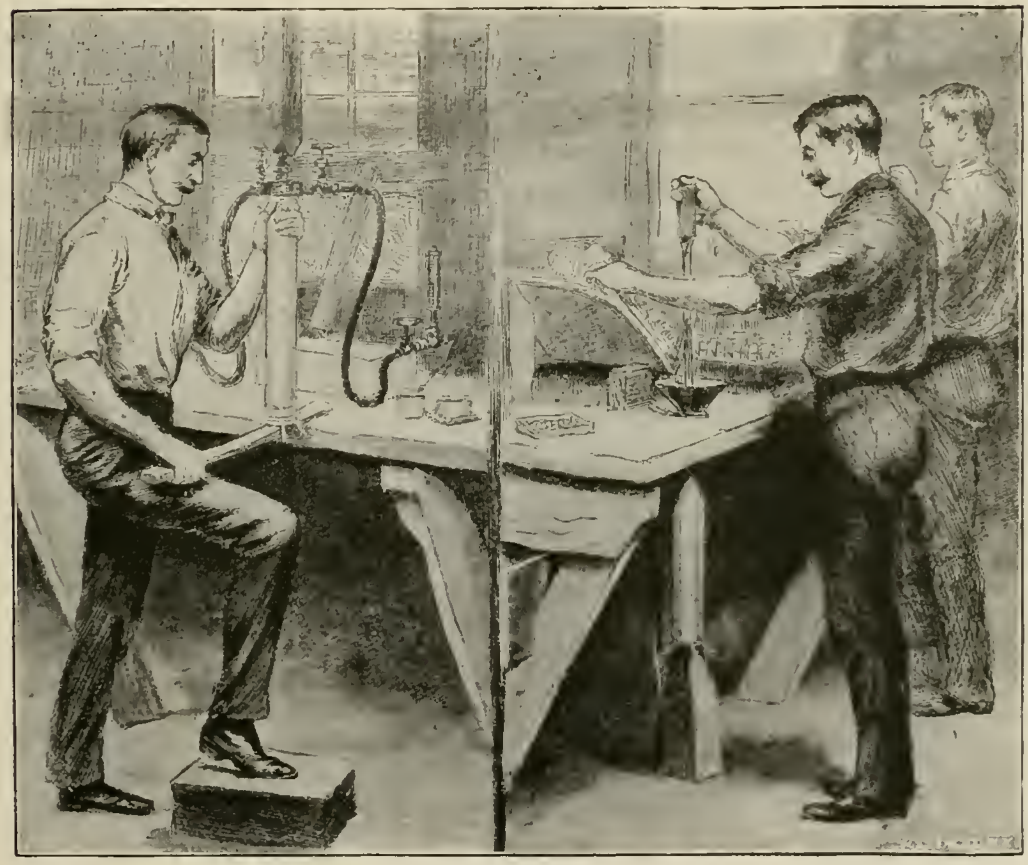

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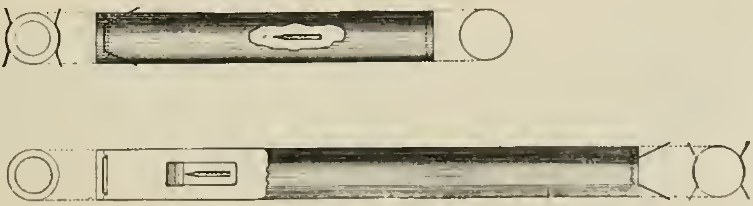

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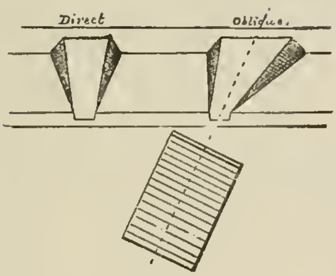
BLASTING.—1. Arrangement of Batteries and Circuit-closer. 2. Soldering Cartridges. 3. Wires for Preventing the Slipping of Cartridges from the Drill holes.



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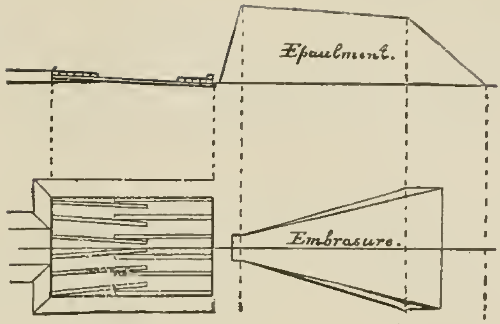

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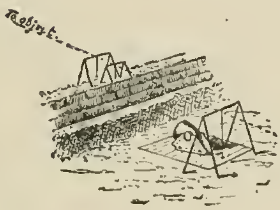

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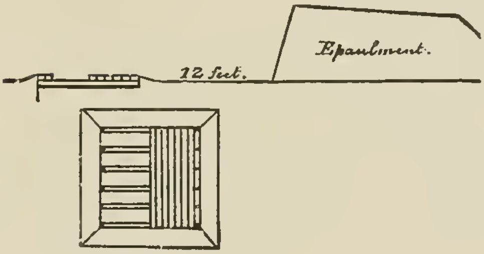

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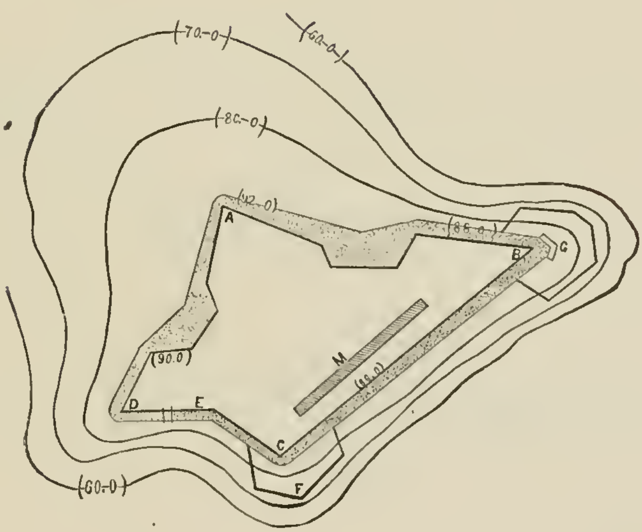

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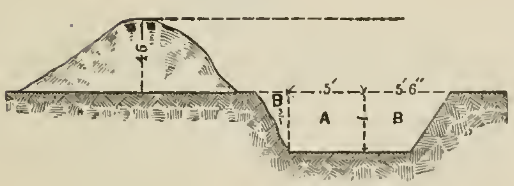

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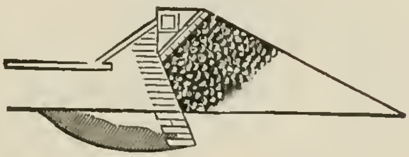

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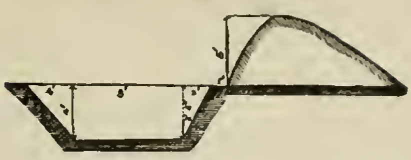
FORTIFICATION.—1, Oblique Embrasure. 2, Rail Platform. 3, Mortar-pointing. 4, Siege-mortar Platform. 5, Plan of Exterior Defenses of a Fort. 6, Profile of an Approach. 7, Stone-fougasse.



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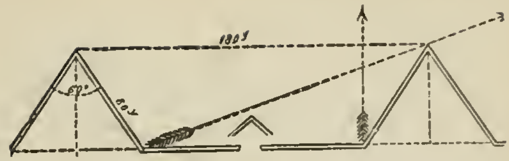

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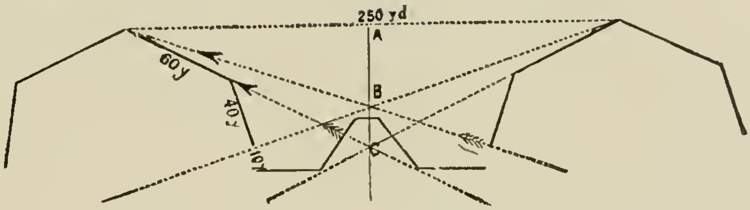

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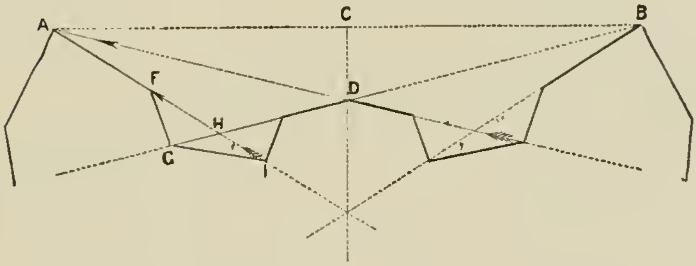

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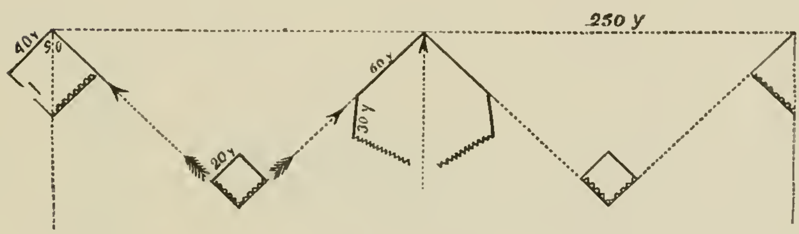

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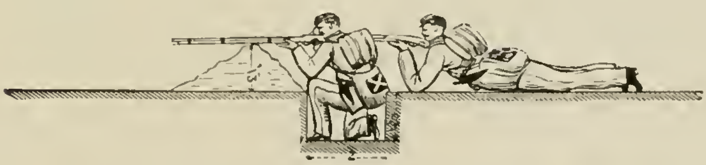

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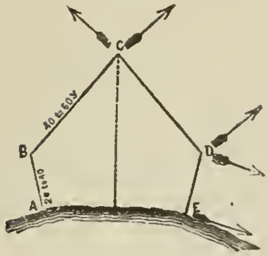
FORTIFICATION.—1, Profile of Approach by Single Trench. 2, Redan Line. 3, Rogniat Line. 4, Bastioned Line. 5, Line with Intervals of Lunettes or Square Redoubts flanked by Retired Redans. 6, Section of Trench—Skirmisher firing, kneeling and lying down. 7, Section of Hedge Defense, with Trench in Rear. 8, Section of Parapet behind the Hedge, Ditch in Front.



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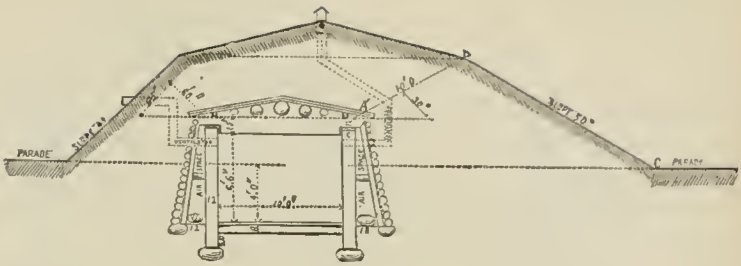

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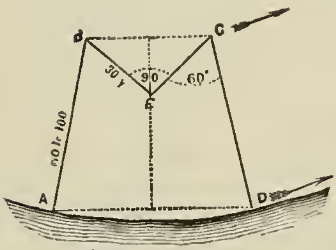

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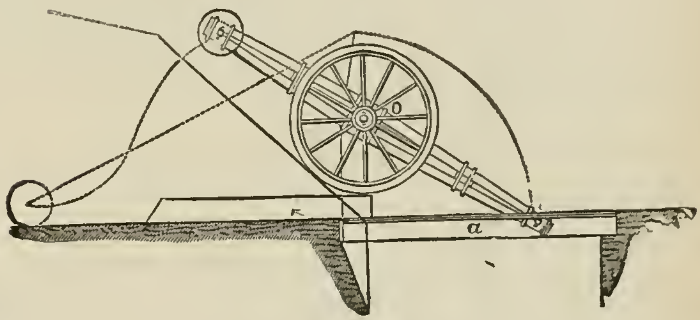

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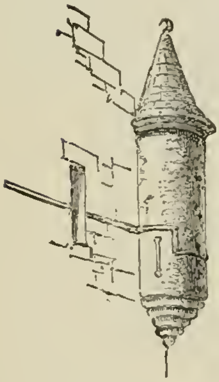

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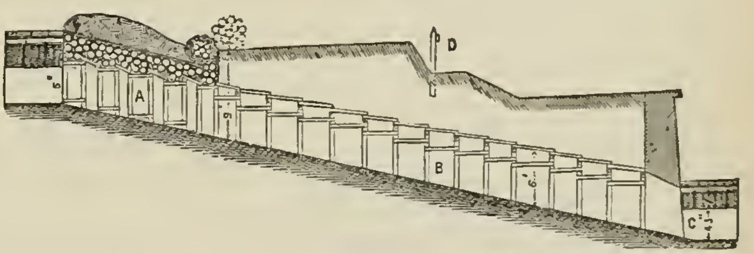

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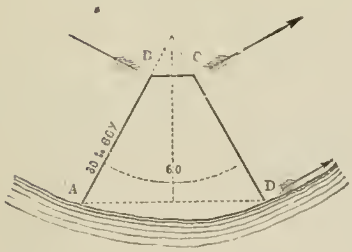

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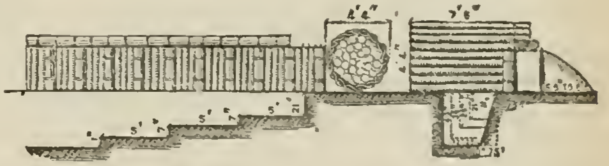

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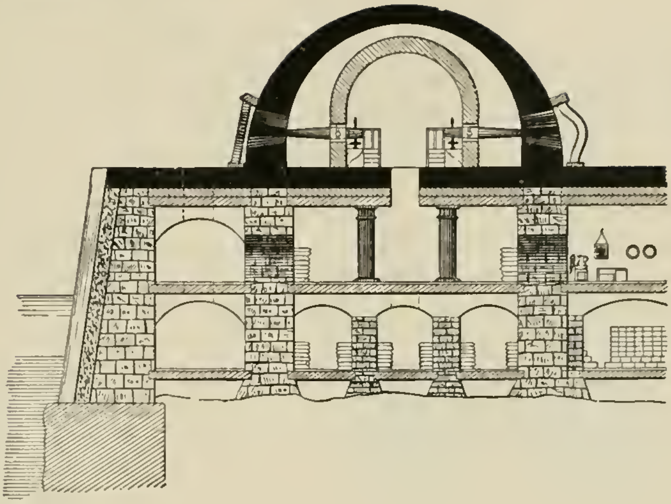
FORTIFICATION.—1. Swallow-tail. 2. Cross Section of a Bomb-proof Magazine. 3. Priest-cap. 4. Bèrgere Draw-bridge. 5. Partizan. 6. Blinded and Gallery Descent into the Covered-way. 7. Redan. 8. Full Sap.



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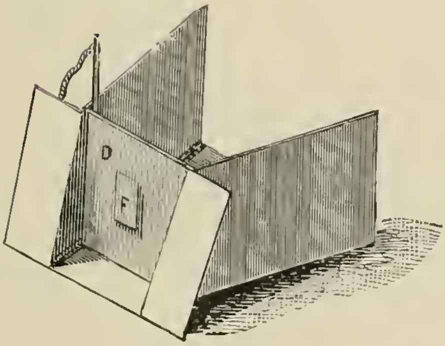

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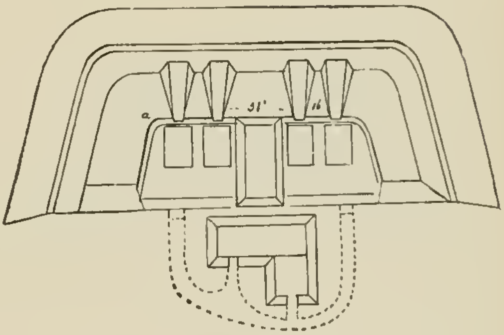

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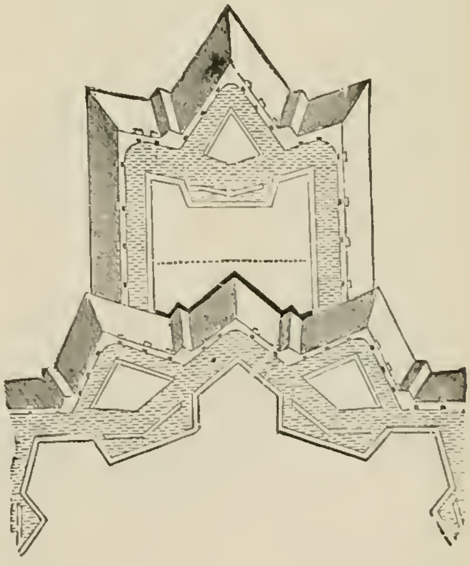

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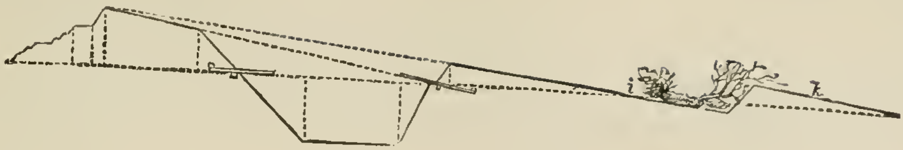
FORTIFICATION.—1. McLean Fortress. 2. Section of Powder Magazine. 3. Wrought-iron Casing, for Embrasure. 4. Battery for four Siege-pieces. 5. Countermining Operations at Siege of Sebastopol. 6. Horn work, Covering a Bastion.



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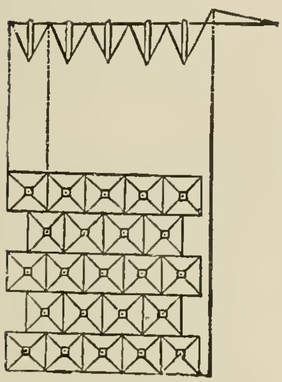

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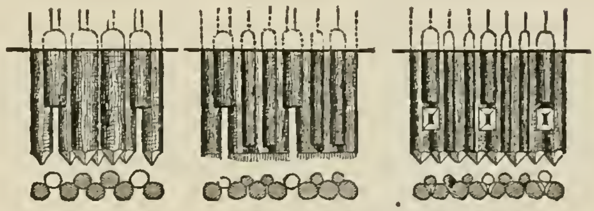

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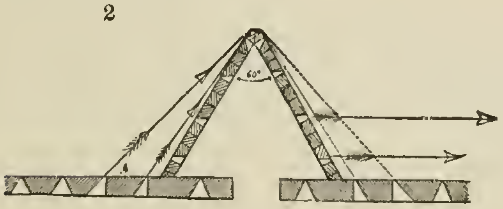

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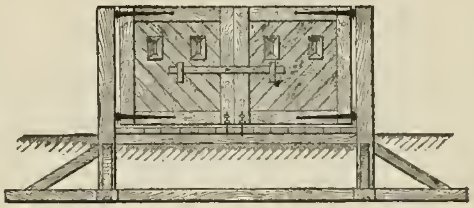

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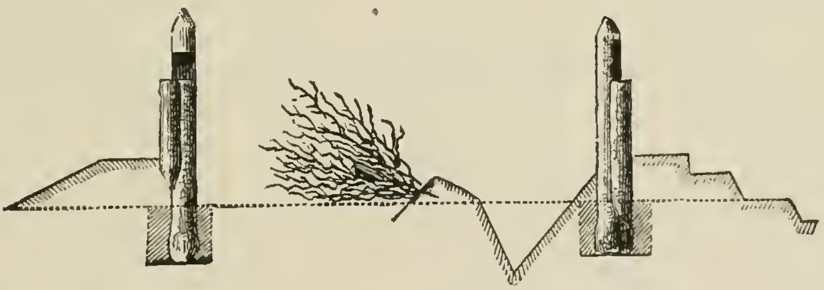

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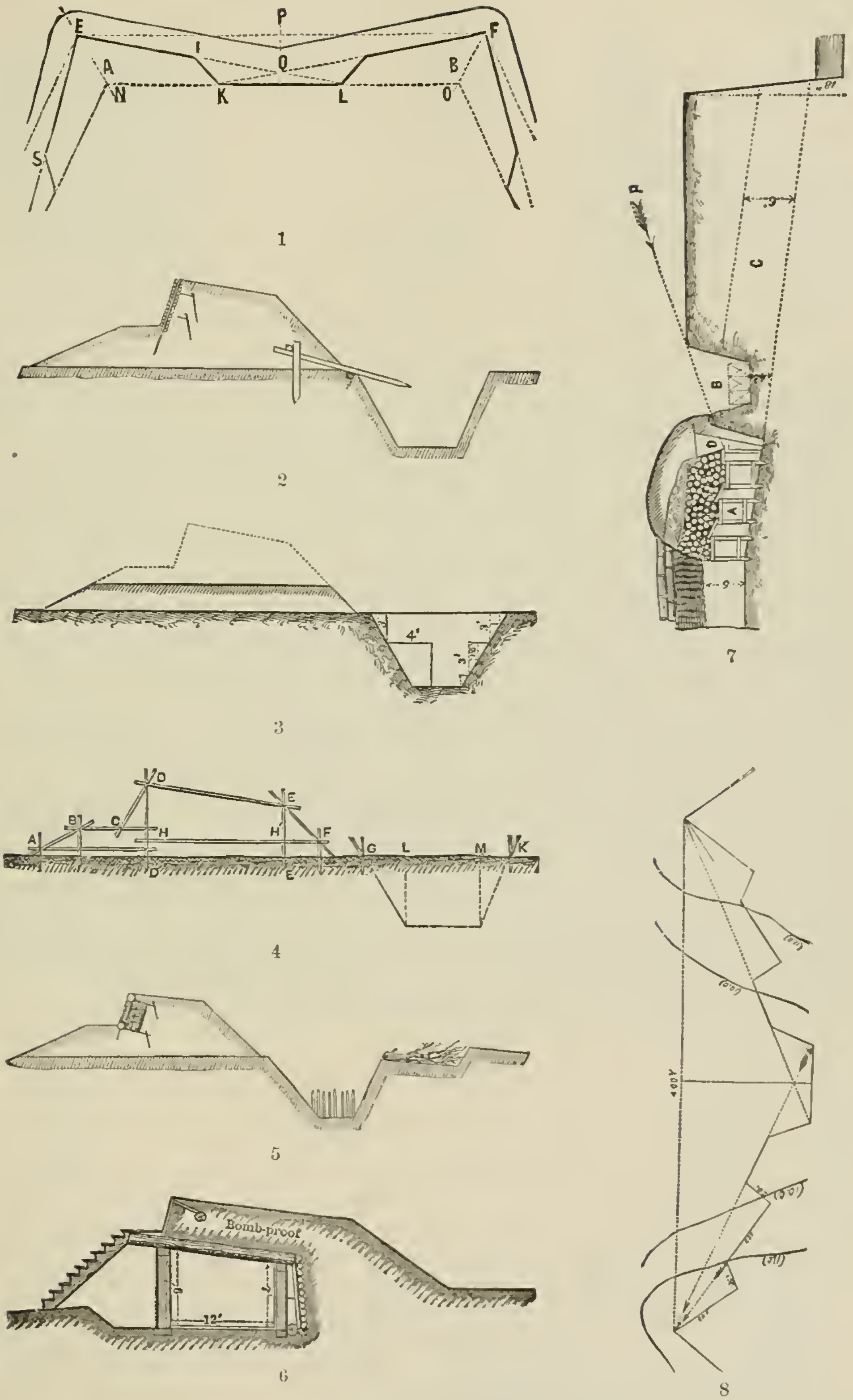
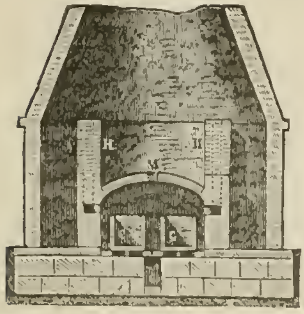
FORTIFICATION.—1, Abatis. 2, Trous-de-Loup. 3, Stockade strengthened by second row of timbers, and loop-holed. 4, Tambour. 5, Barrier. 6, Stockade, with obstacles. 7, Slashing. 8, Section and Elevation of Stockade of Gorge.



FORTIFICATION.—1, Bastion. 2, Hurdle Revetment. 3, Section of Parapet. 4, Profiling. 5, Profile of Gabion and Fascine Work. 6, Bomb-proof Shelter. 7, Blindage Descent into the Covered-way. 8, Irregular Site.



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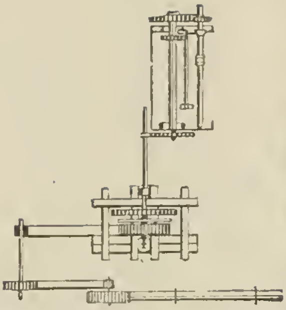

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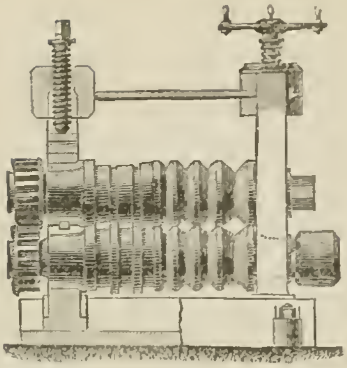

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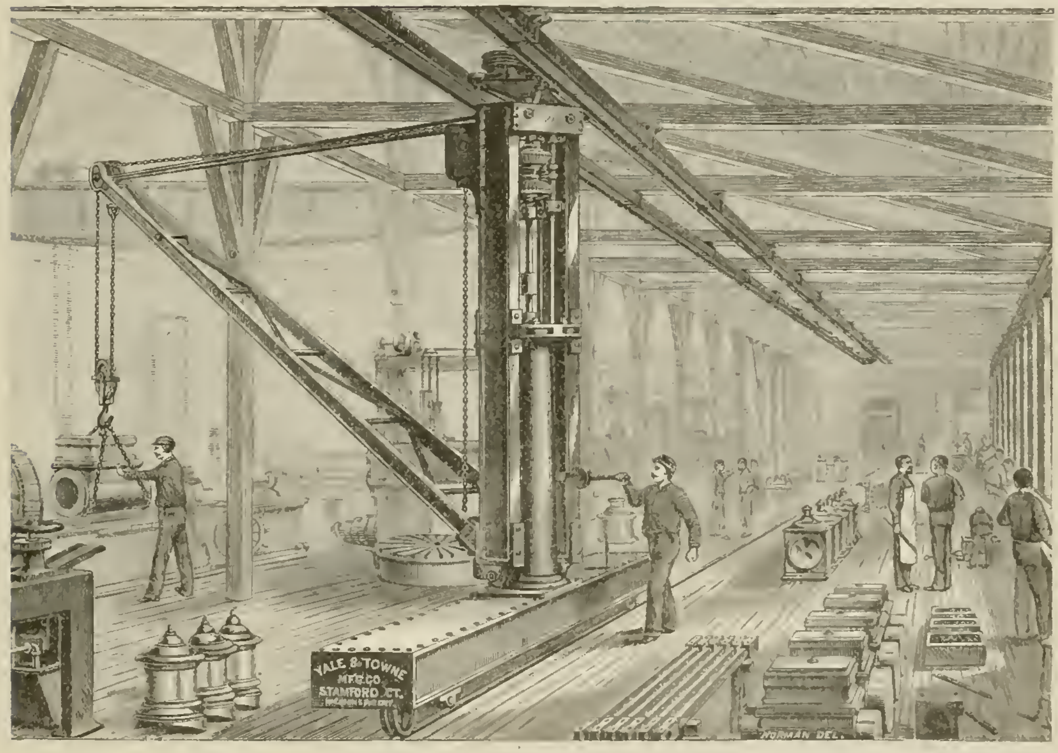

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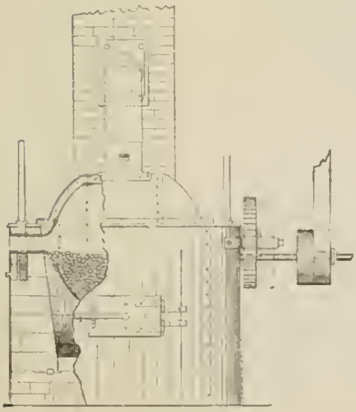

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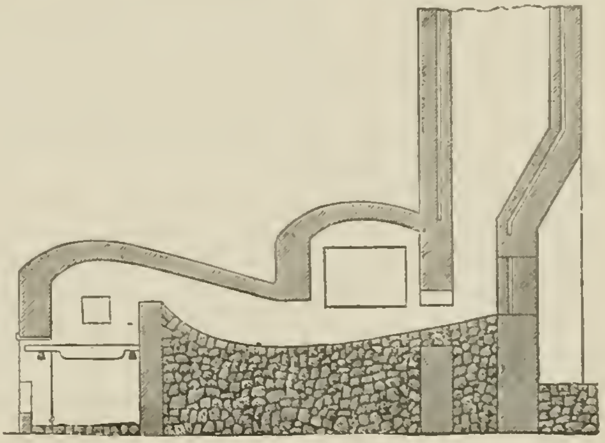

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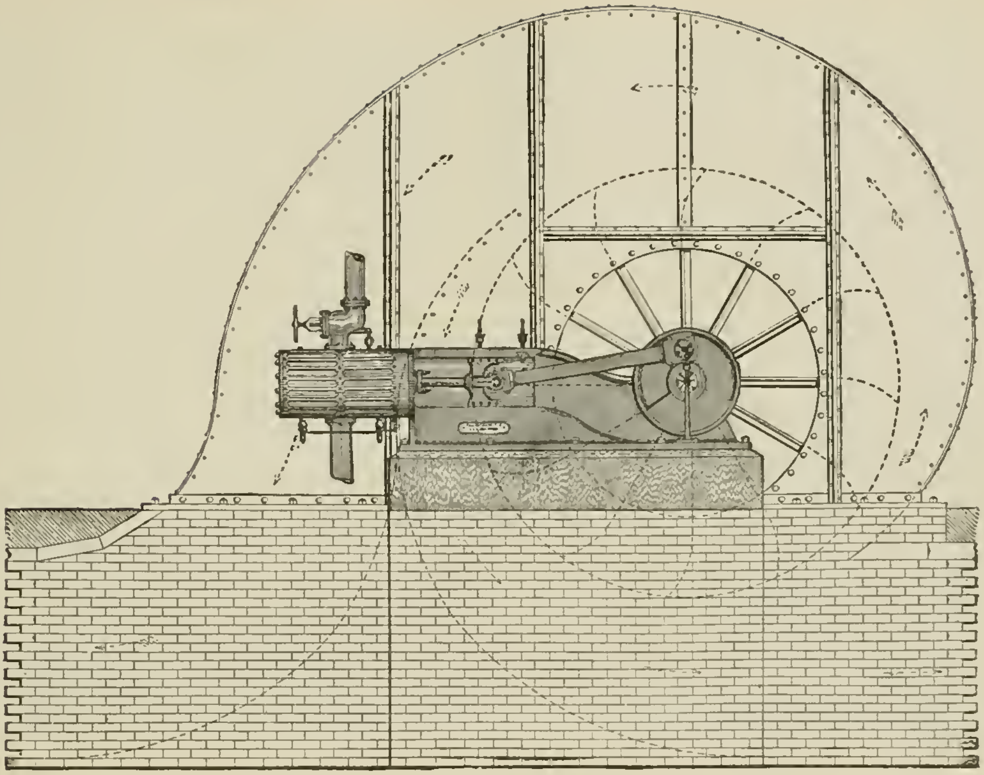
FOUNDRY.—1, Converting-furnace. 2, Coiling Apparatus for Coiled Tubes. 3, Rolling-mill. 4, Power Crane for General Foundry Work. 5, Annealing Furnace. 6, Reverberatory Air-furnace.



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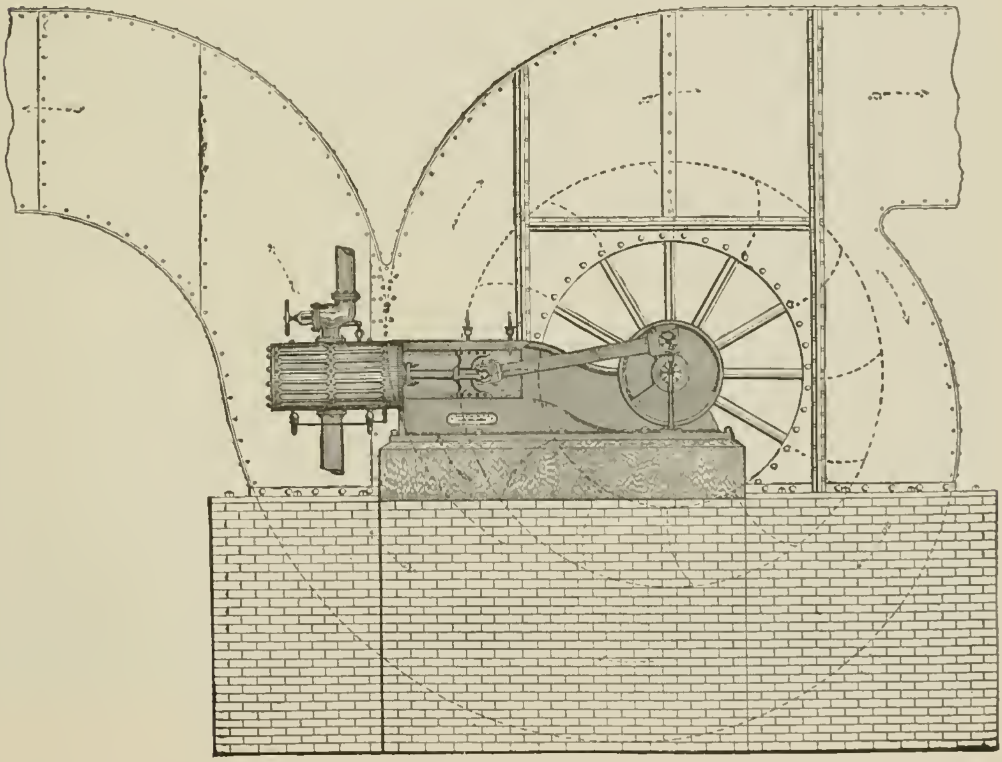

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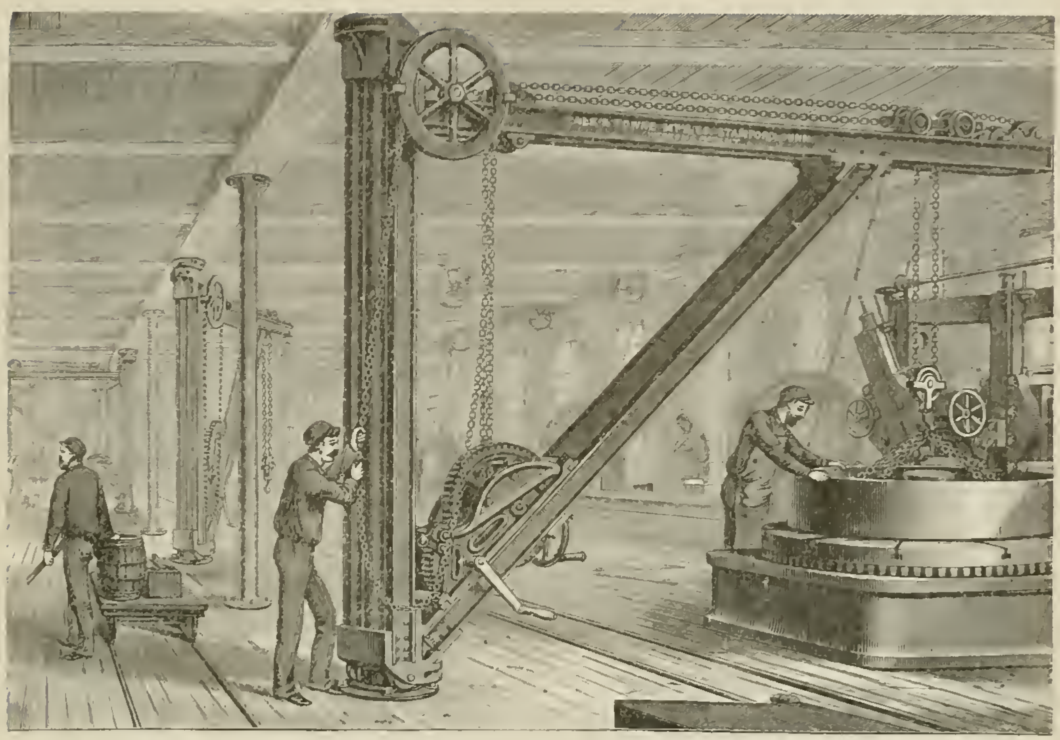
FOUNDRY.—1, Blower. 2, Exhausting Fanner.



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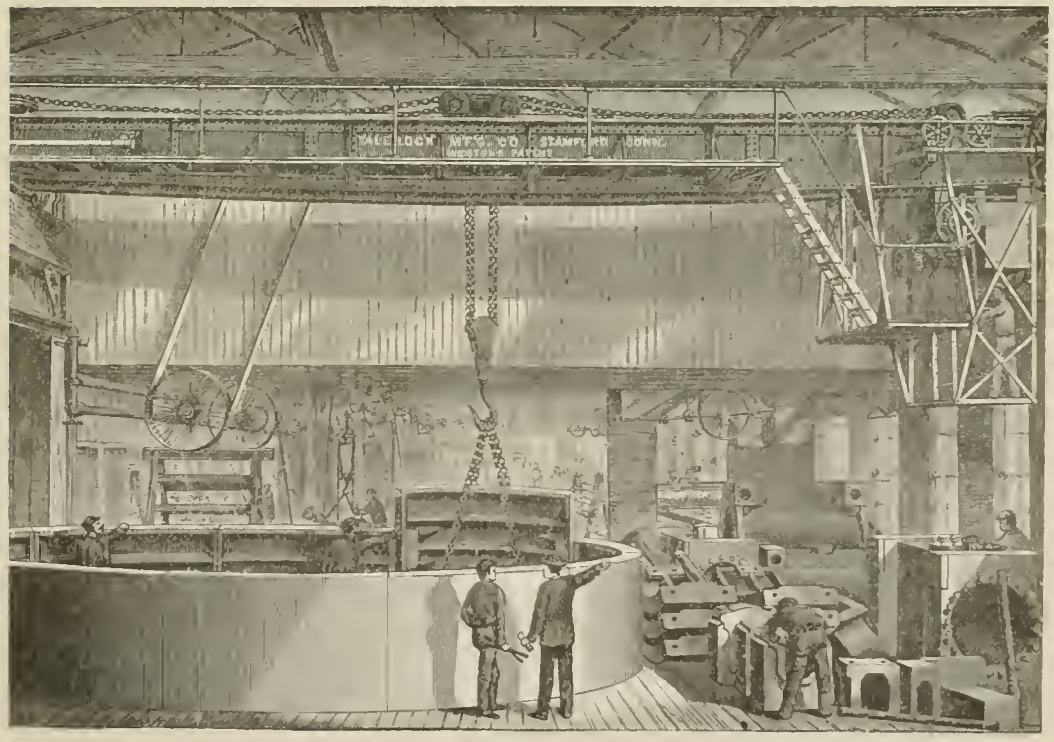

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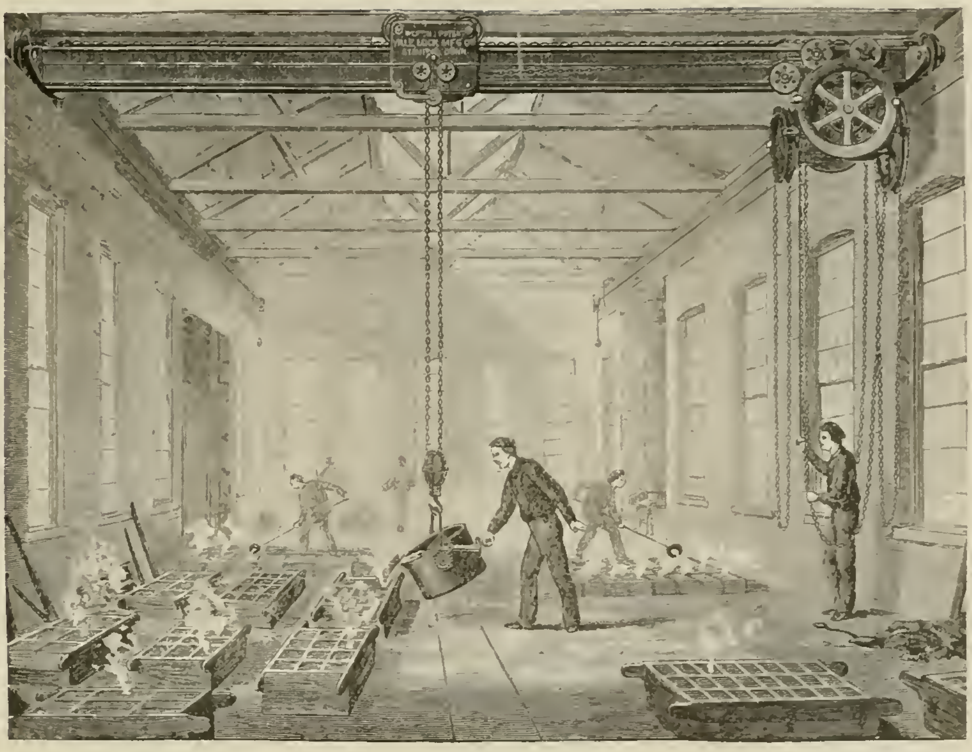
FOUNDRY. 1, Column-crane. 2, Foundry-crane for very Heavy Work.



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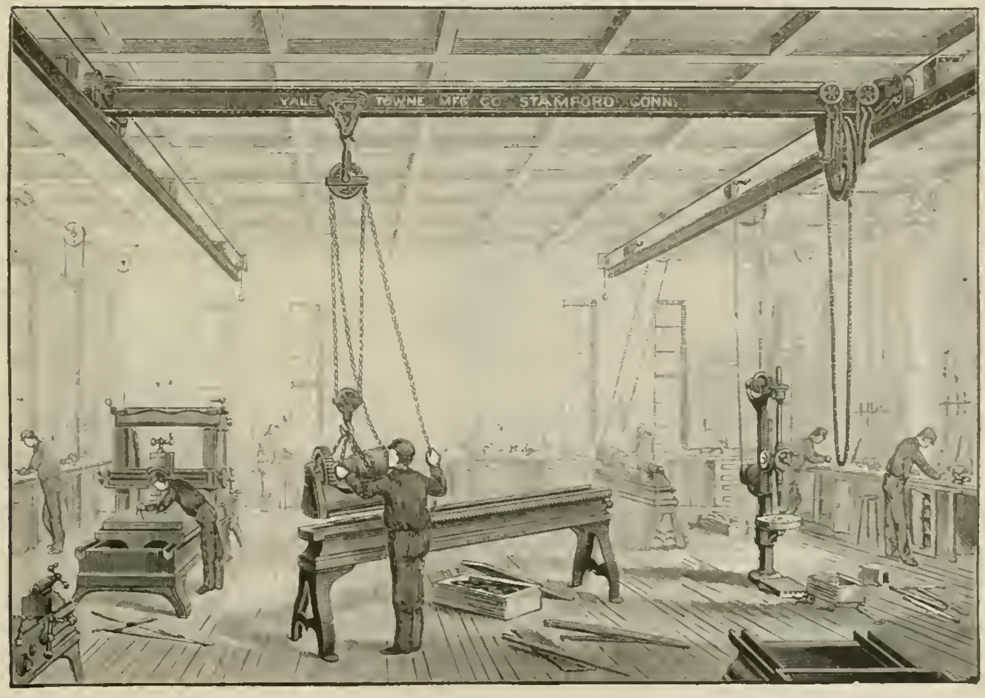

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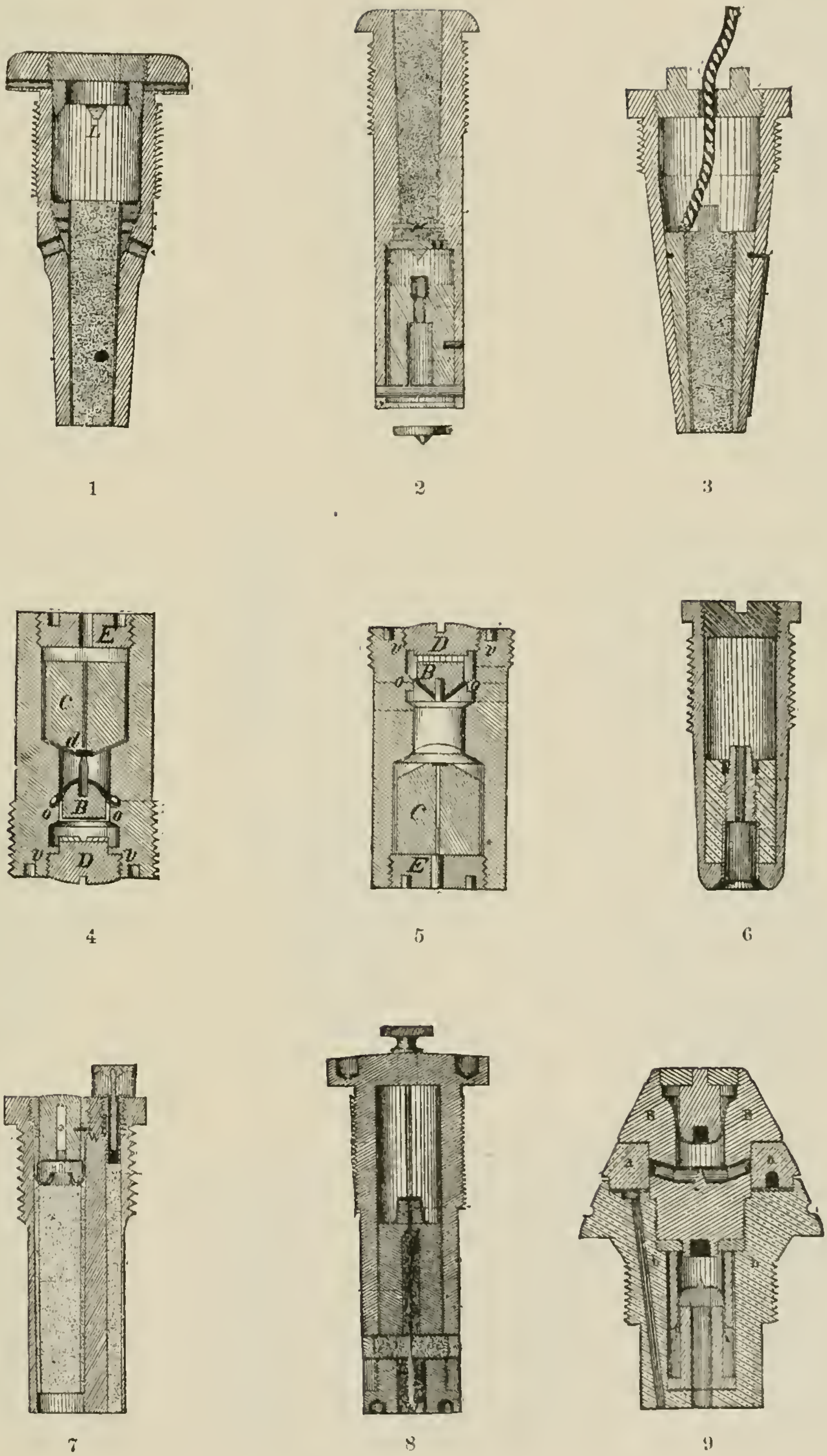
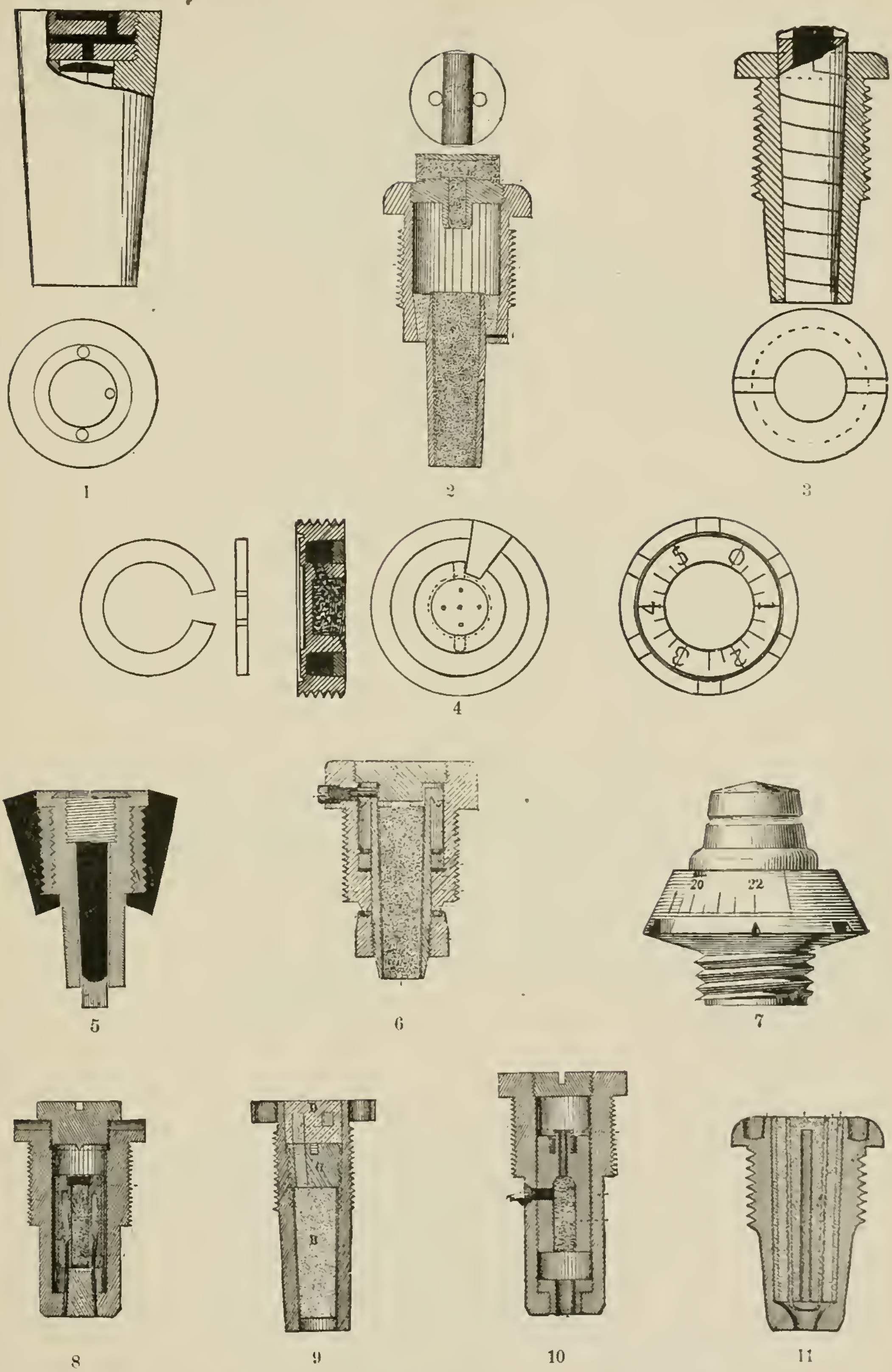
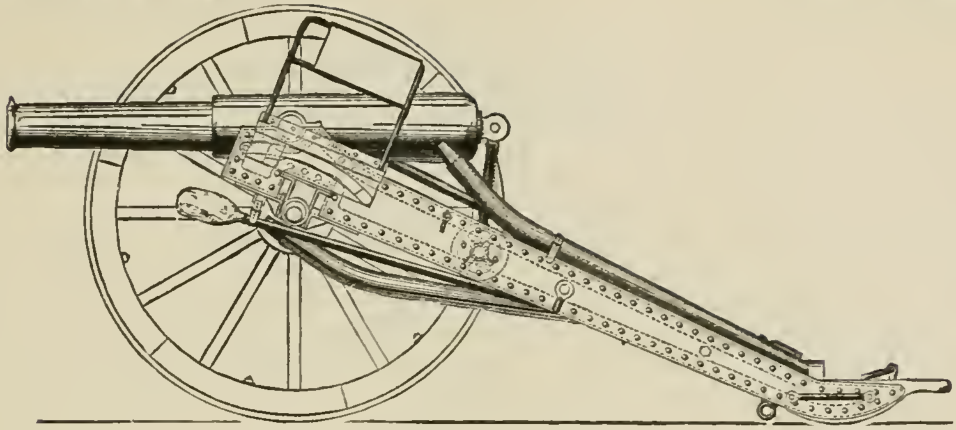
FOUNDRY.—1 Hand Traveling-crane. 2, Walking-crane.



FUSES.—1, Ware Combination-fuse. 2, Gill Combination fuse. 3, O'Reilly Combination-fuse. 4-5, Plumacher Percussion-fuse. 6, Absterdam Percussion-fuse. 7, Thompson Combination-fuse. 8, Eggo Percussion-fuse. 9 Ruben and Fornerod Combination-fuse.



FUSES.—1, Fuse-plug. 2, Gill Combination-fuse. 3, Time-fuse. 4, Bormann Fuse. 5, Boucning. 6, Ware Combination-fuse. 7, German Time fuse. 8, Hotchkiss Percussion-fuse. 9, McIntyre Fuse. 10, Schenkle Percussion-fuse. 11, Treadwell Combination-fuse.



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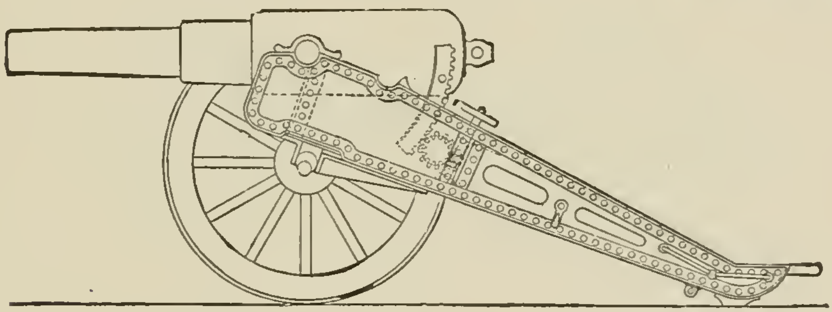

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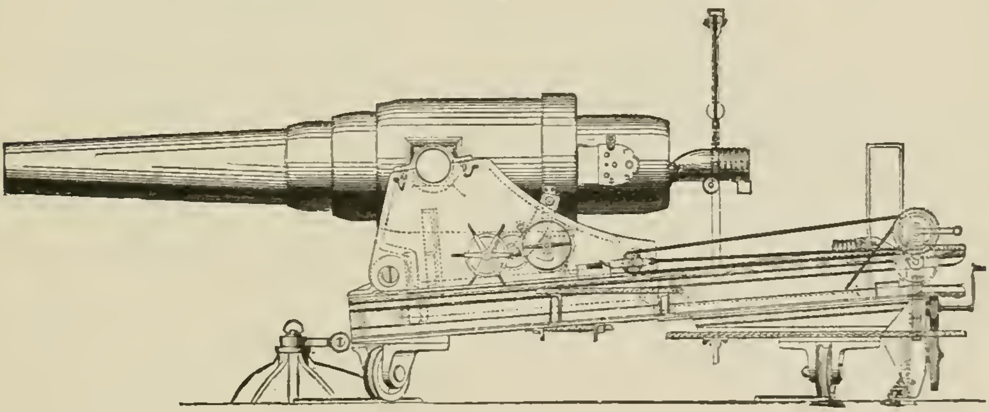

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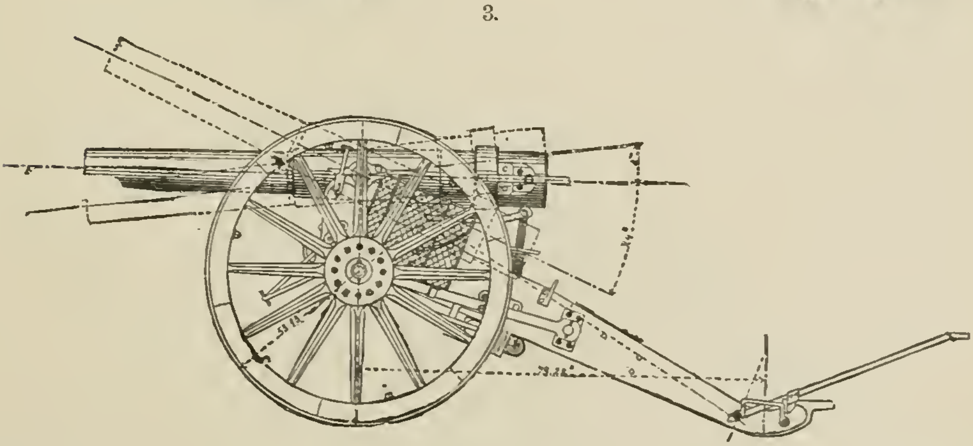
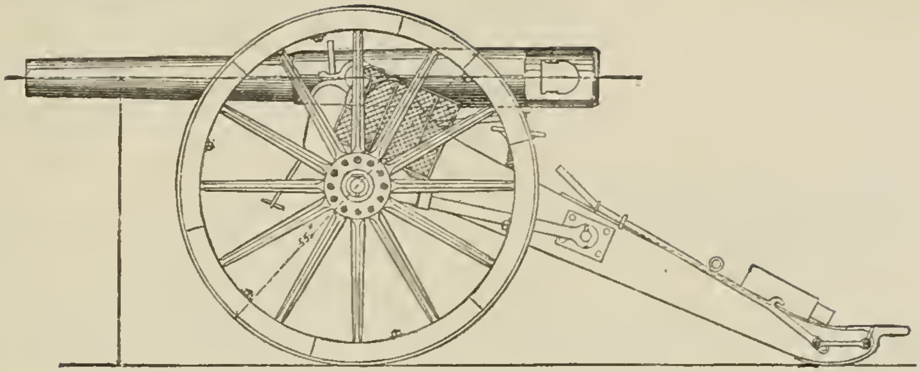


4.

GUN CARRIAGES.—1. English Gun-carriage, with Whitworth Elevating Apparatus. 2. English Siege-carriage. 3, Krupp Sea-coast Carriage. 4. Austrian 3.42-inch Gun-carriage.



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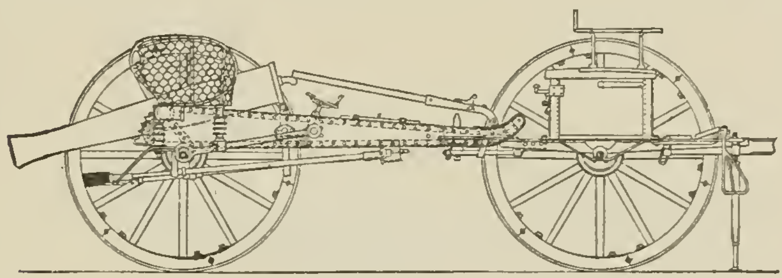

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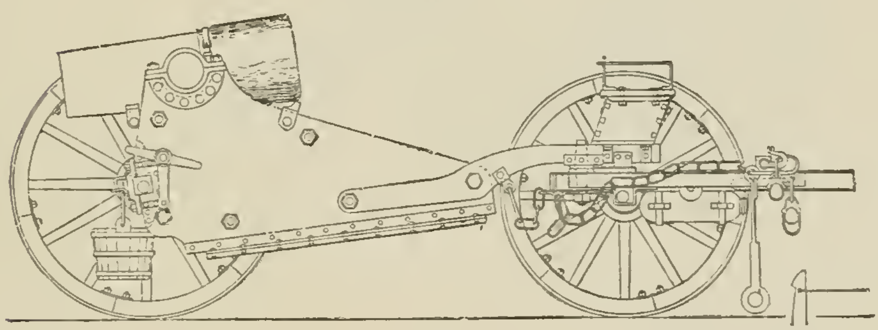

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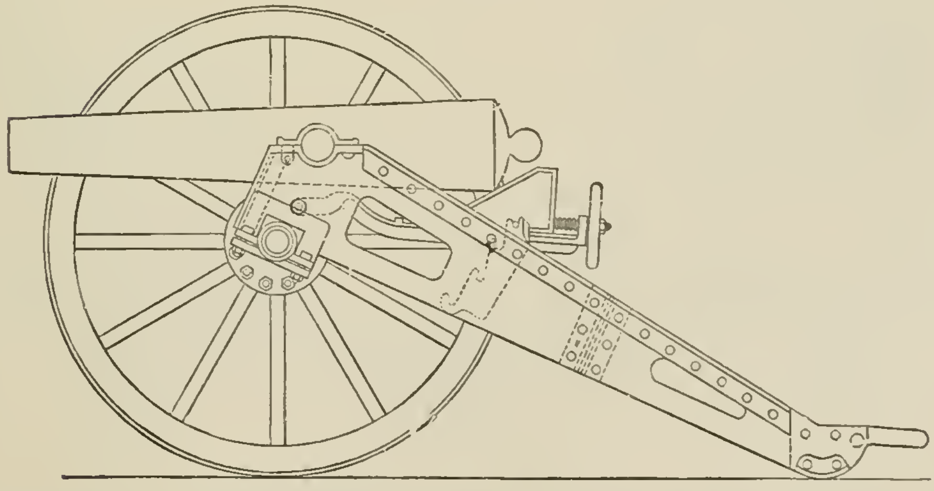
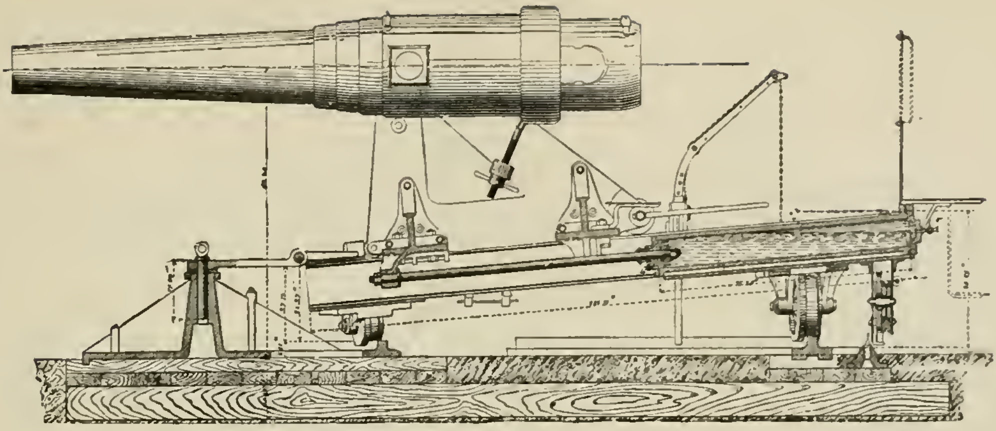


4.

GUN-CARRIAGES.—1, Krupp Field-carriage. New Model. 2, Sweedish Carriage. 3, Russian Mortar Carriage. 4, Mountain Carriage for the Light 12-pounder.



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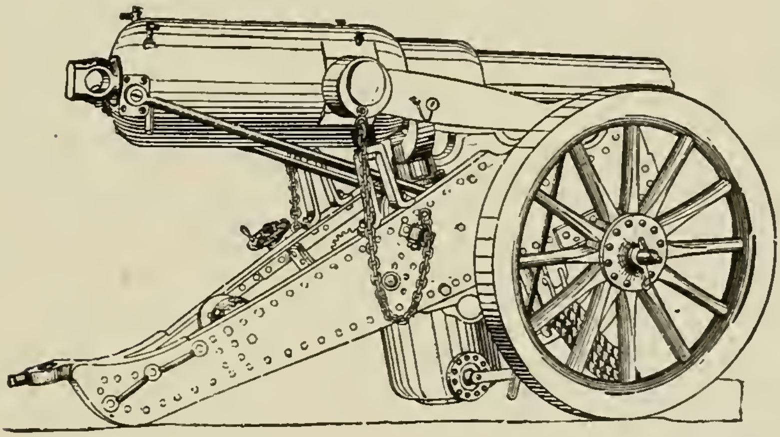

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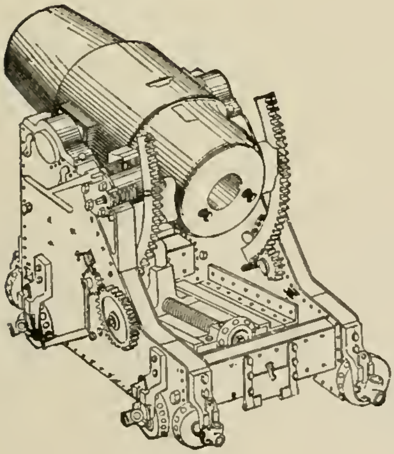

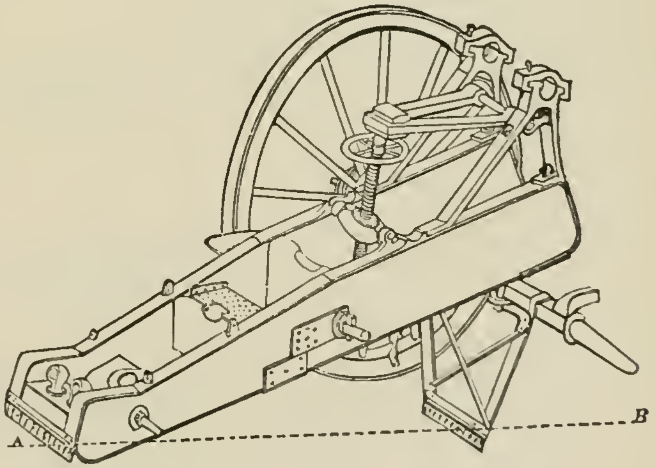

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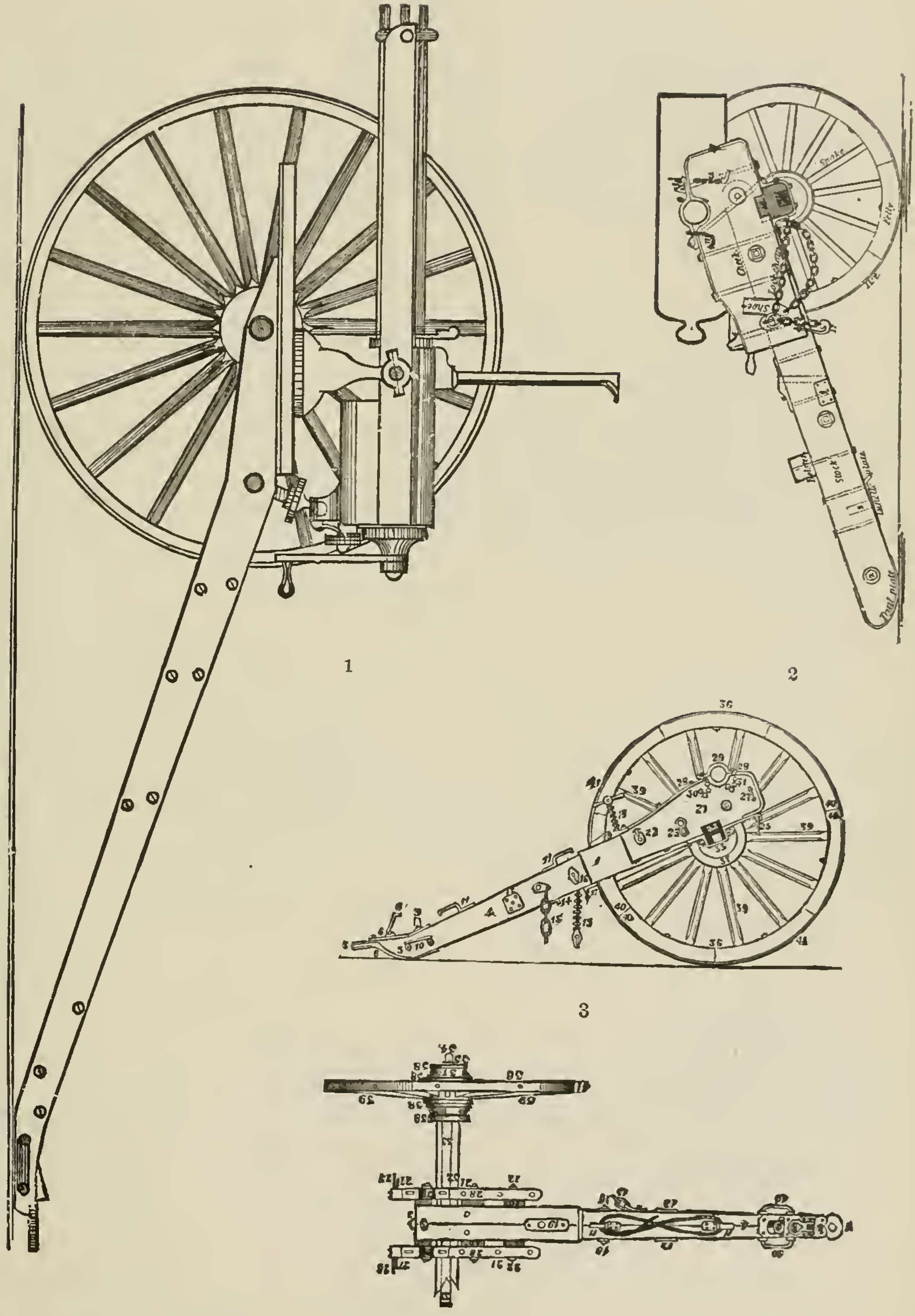
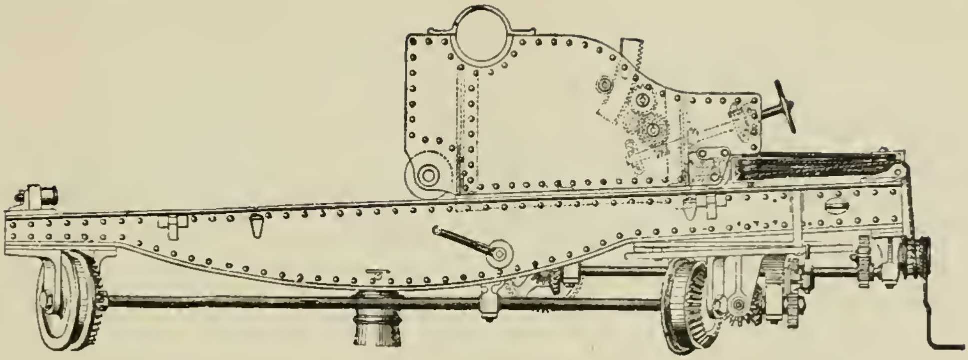
GUN-CARRIAGES.—1, Gruson Sea-coast Carriage. 2, Moncrieff Depression Carriage. 3, Austrian Mortar Carriage. 4, Indirect Pointing Apparatus.



1 2 3 4

GUN-CARRIAGES.—1, Carriage for the Lowell Battery-gun. 2, Siege-howitzer Carriage. 3–4, United States Field Gun-carriage.



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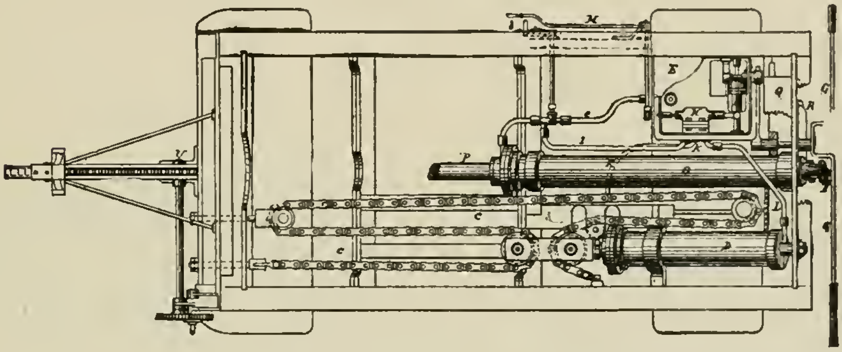

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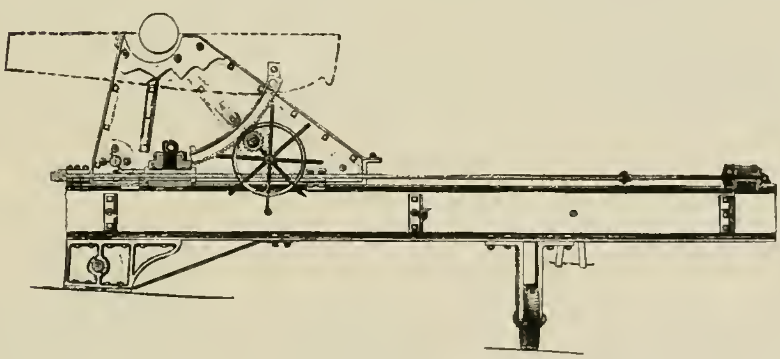

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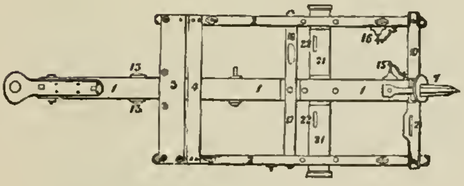

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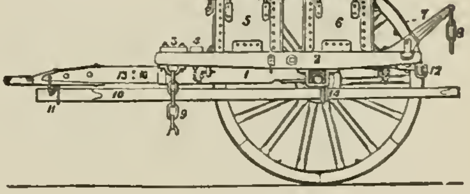
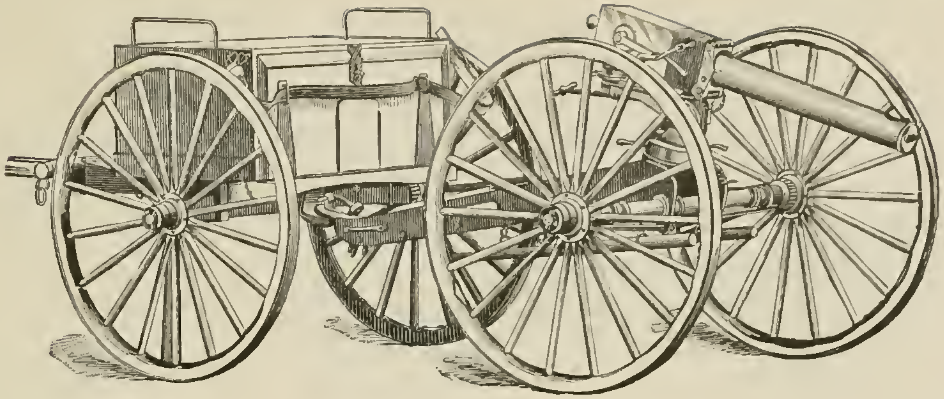


5

GUN-CARRIAGES.—1. English Sea-coast and Garrison Carriage. 2. 35-ton Hydraulic Gun-carriage. 3. United States Sea-coast Carriage. 4—5. Caisson, U. S. Pattern.



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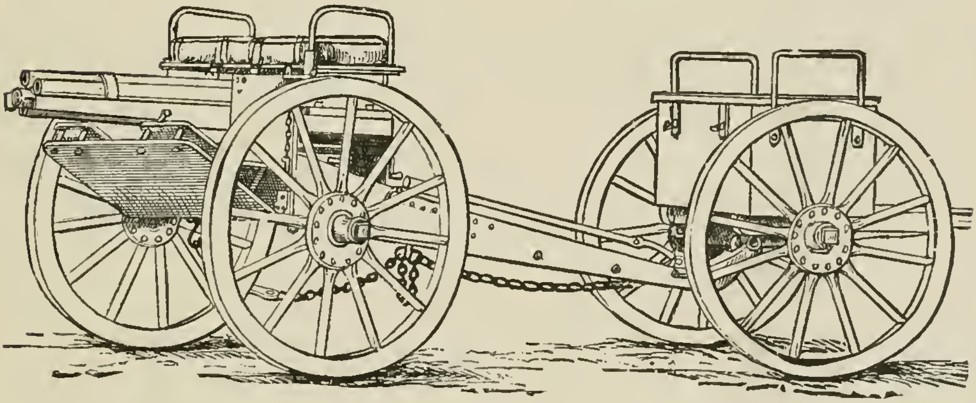

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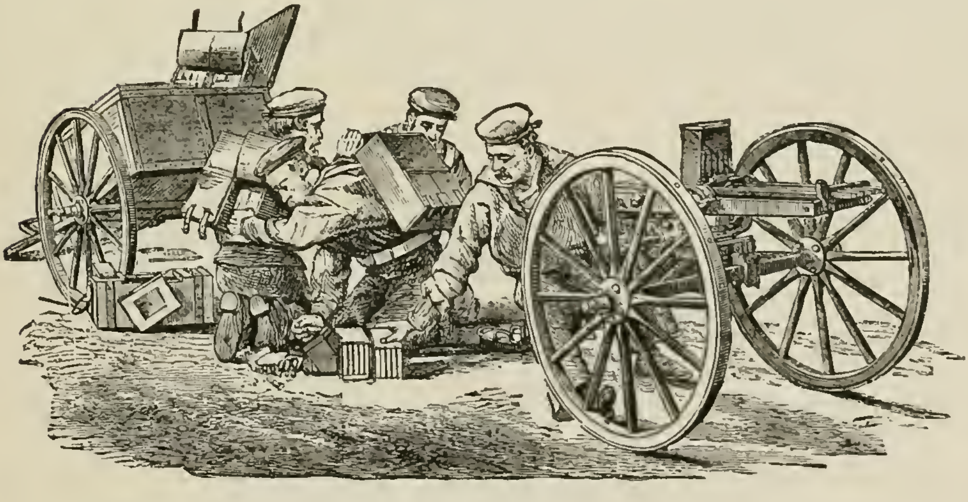

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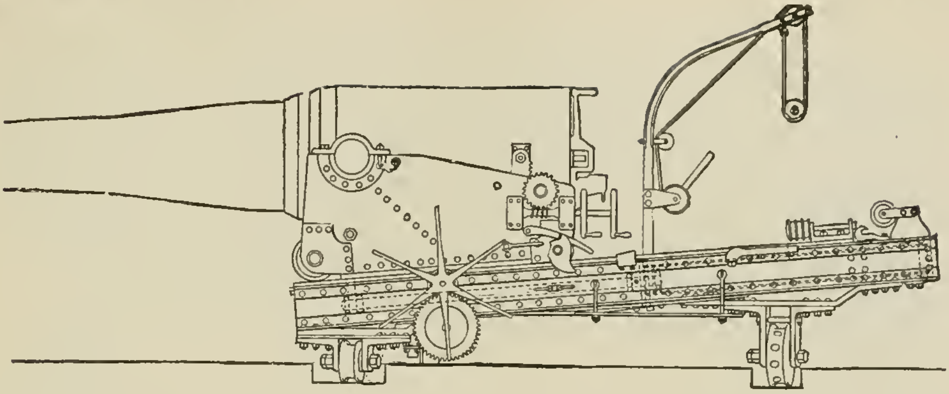
GUN-CARRIAGES.—1, Gardner Gun-carriage and Limber. 2, Gun-carriage and Limber, Revolving-cannon. 3, Nordenfelt Machine-gun Mounted on Limber. Infantry Service



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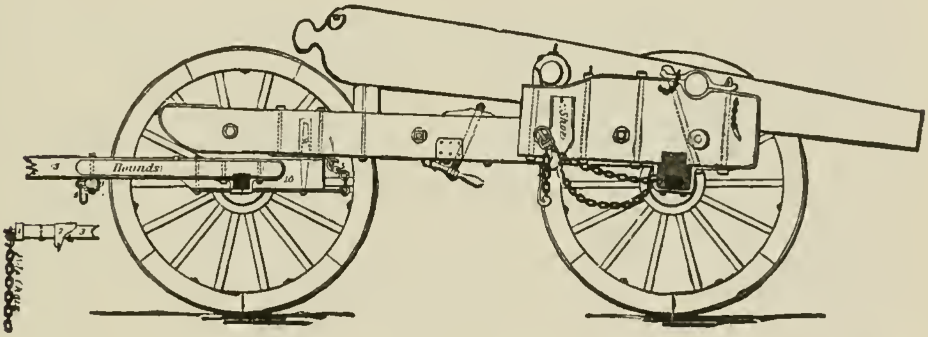

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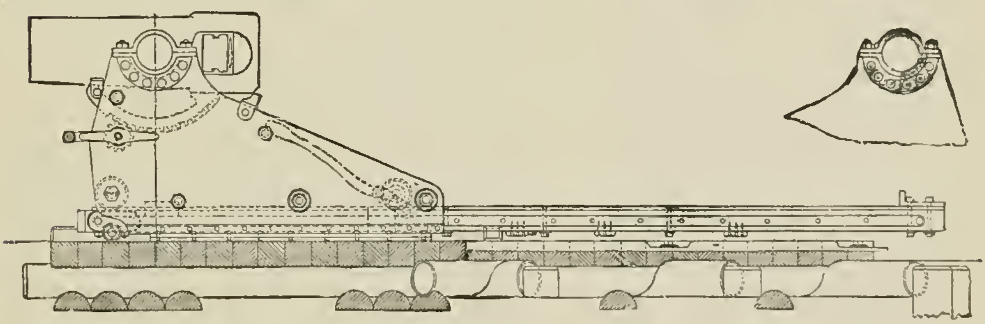

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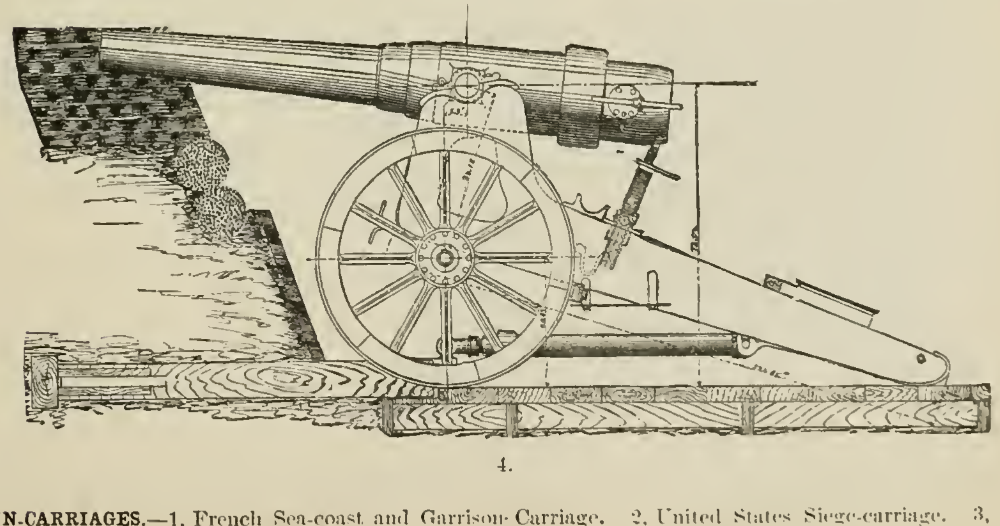
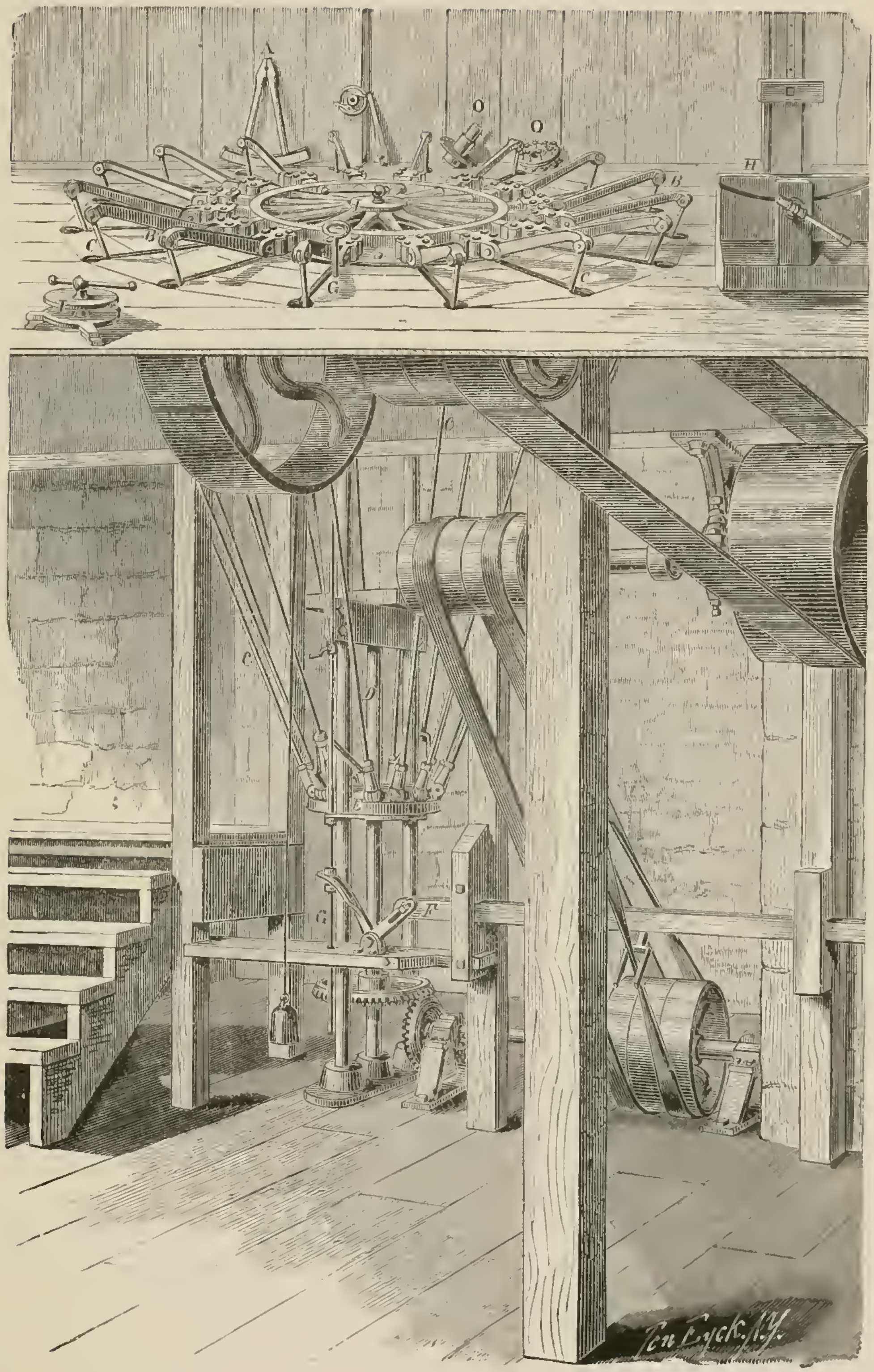
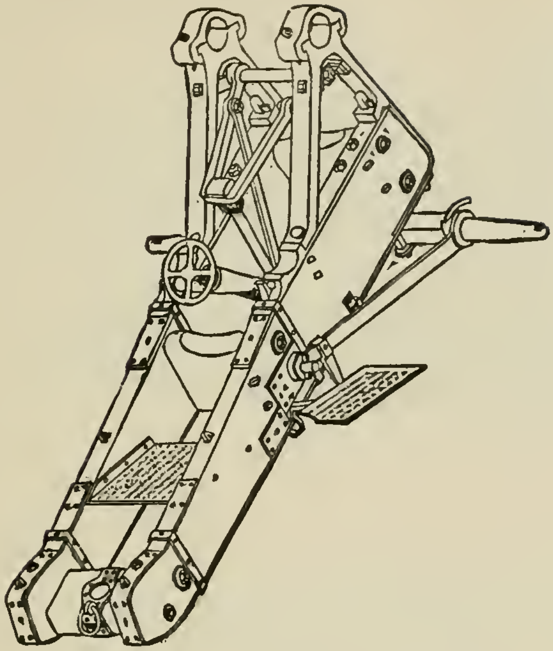


4.

GUN-CARRIAGES.—1, French Sea-coast and Garrison-Carriage. 2, United States Siege-carriage. 3, Prussian 6-inch Mortar-carriage. 4, Prussian 15-Centimeter Carriage.



GUN CARRIAGES.—Manufacture of Wheels for Gun and Traveling-carriages.



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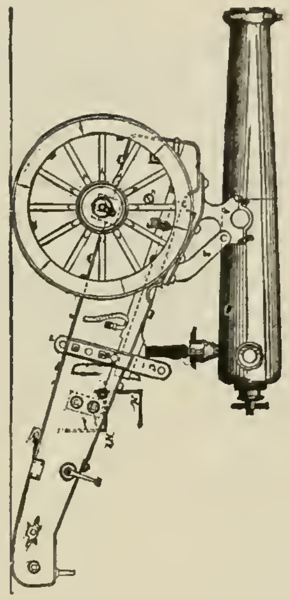

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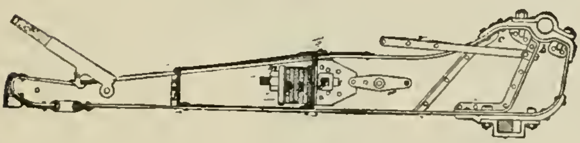

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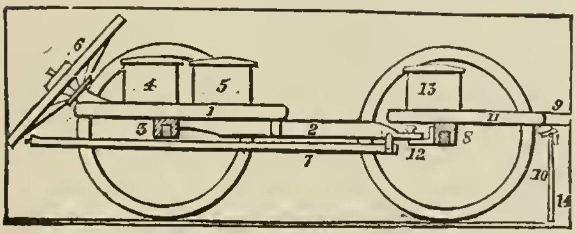

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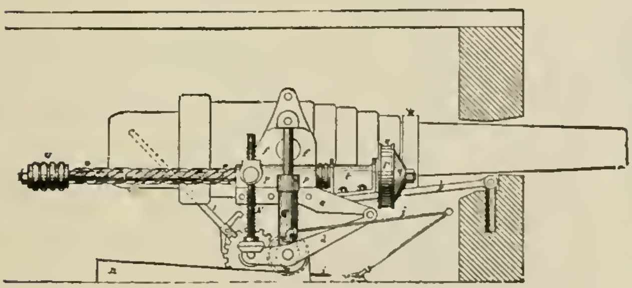

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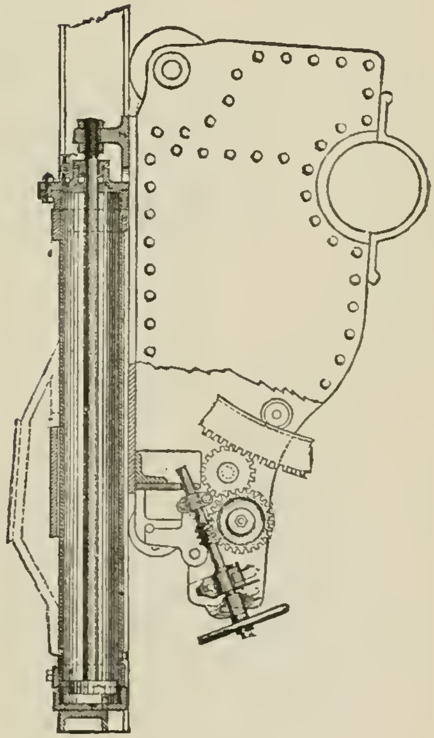
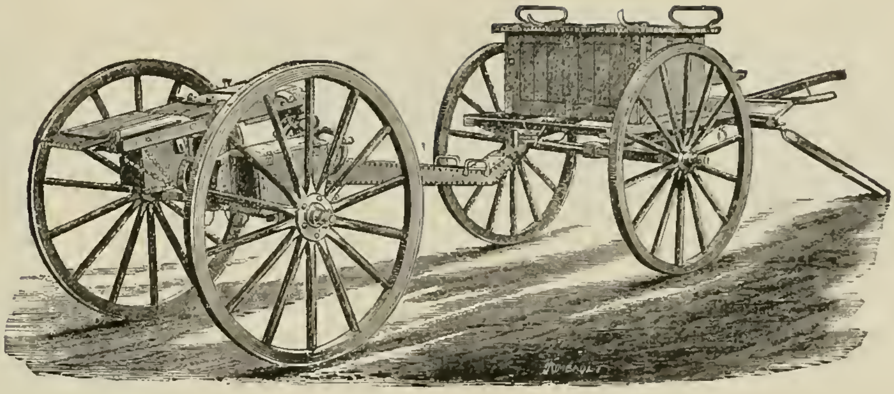


6

GUN-CARRIAGES.—1, Prussian Siege-carriage. 2, Austrian Siege-carriage. 3, Englehardt Gun-carriage. 4, Artillery Caisson. 5, Turret-carriage. 6, Hydraulic Buffer.



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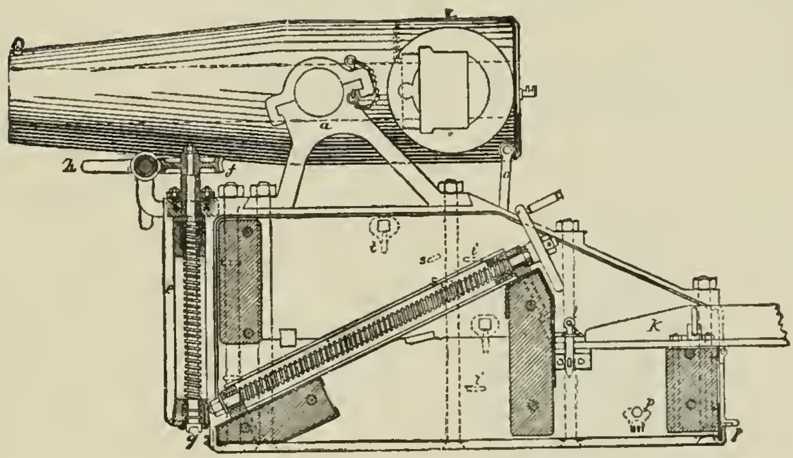

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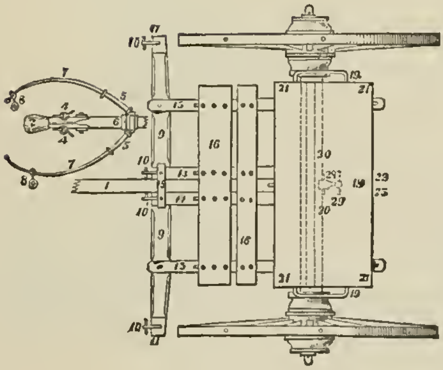

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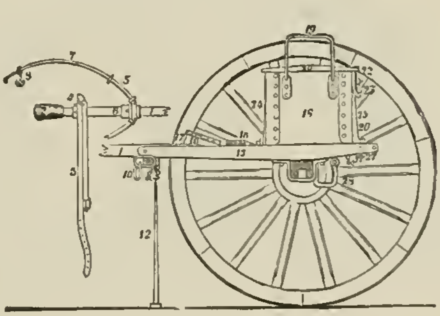
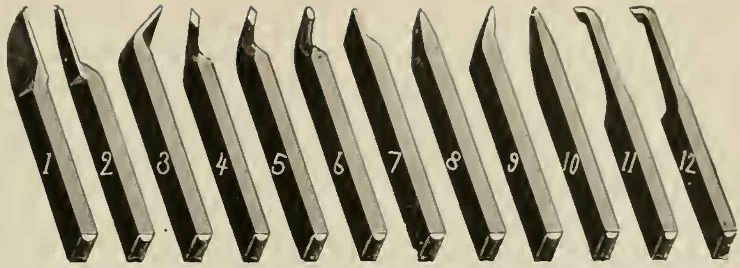


4

GUN-CARRIAGES.—1, Light Carriage for Machine-gun—Capacity 4000 Rounds of Ammunition. 2. German Mortar Carriage. 3-4. Limber. Plan and Section. U. S. Pattern.



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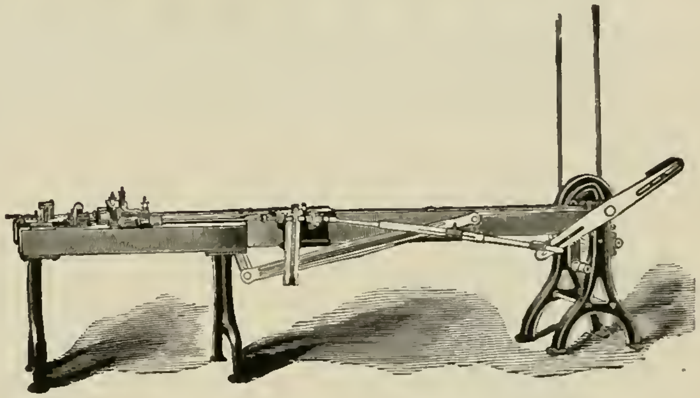

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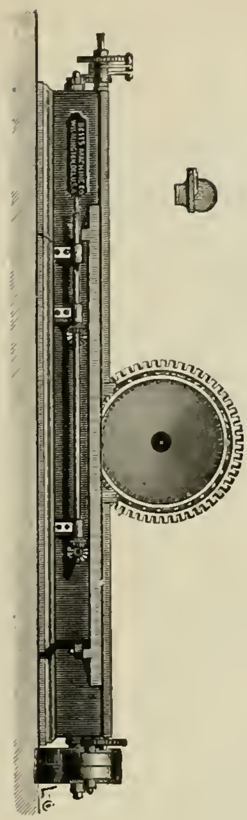

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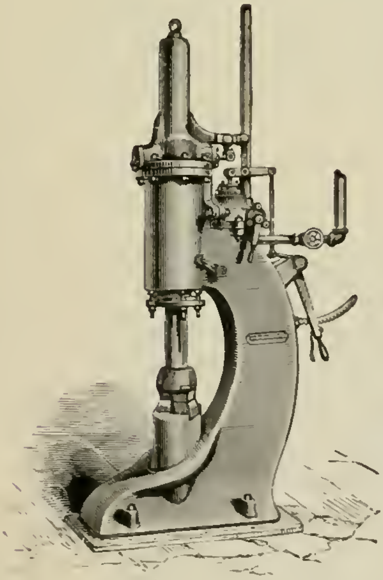

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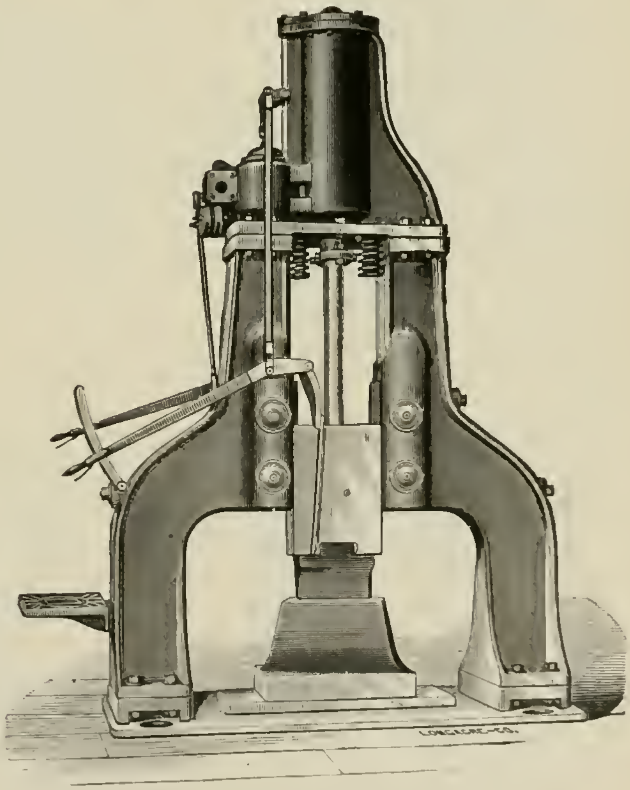
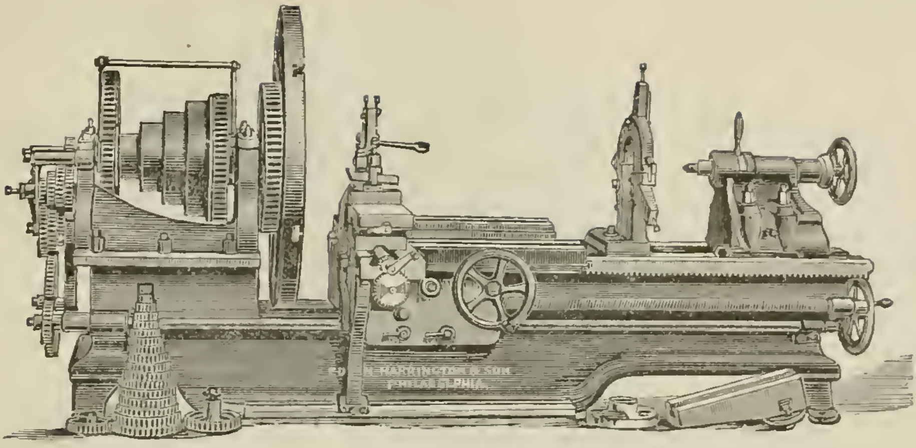


5

GUN-CONSTRUCTION.—1, Lathe Tools. 2, Rotary Planing-machine. 3, Rifling-machine. 4, Single Upright Steam-hammer. 5, Double Frame Steam-hammer.—*Gun-machinery.*



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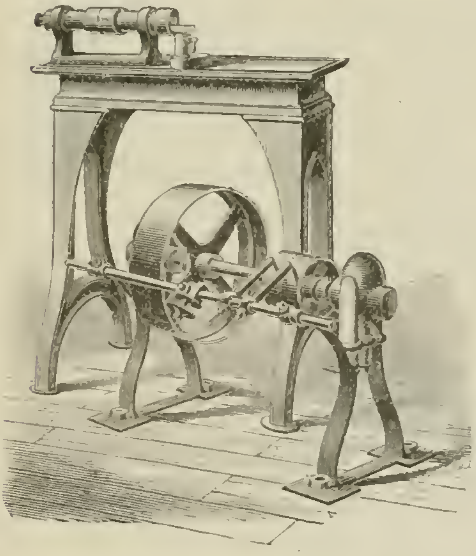

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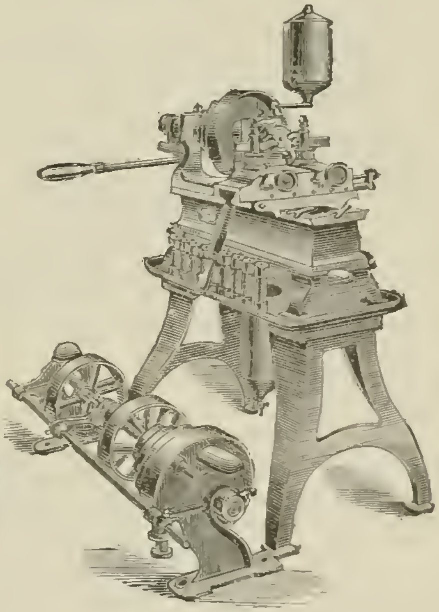

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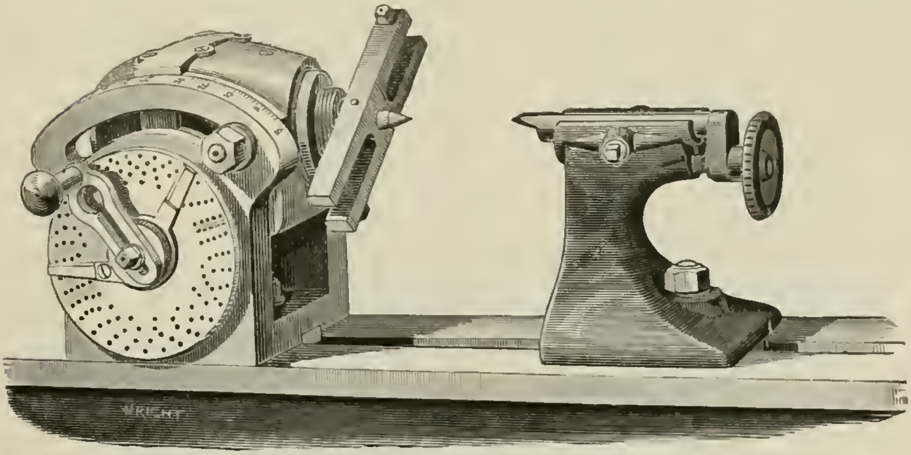
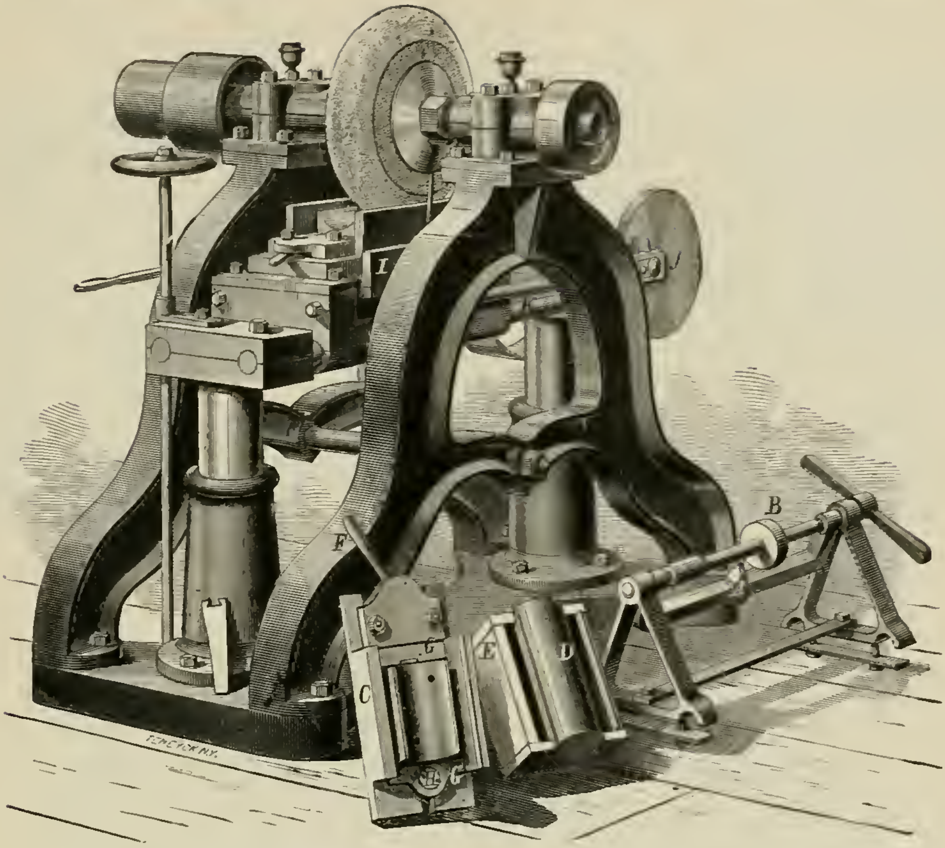


4.

GUN-CONSTRUCTION.—1, Boring and Section Lathe. 2, Screw Polishing Machine. 3, Screw-making Machine. 4, Dividing Head and Tail Stock.—*Gun-machinery.*



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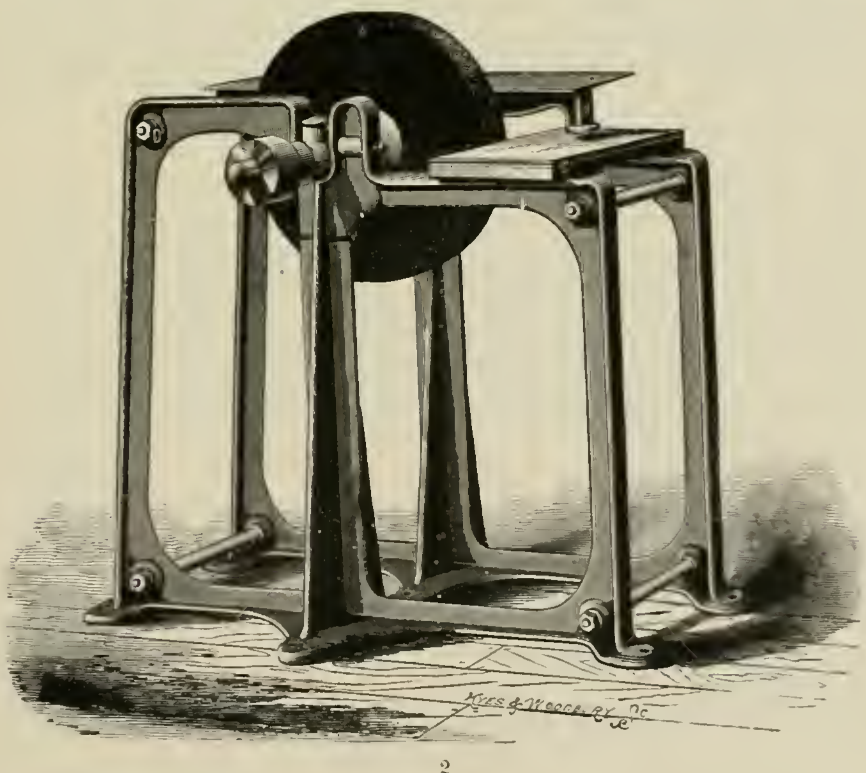
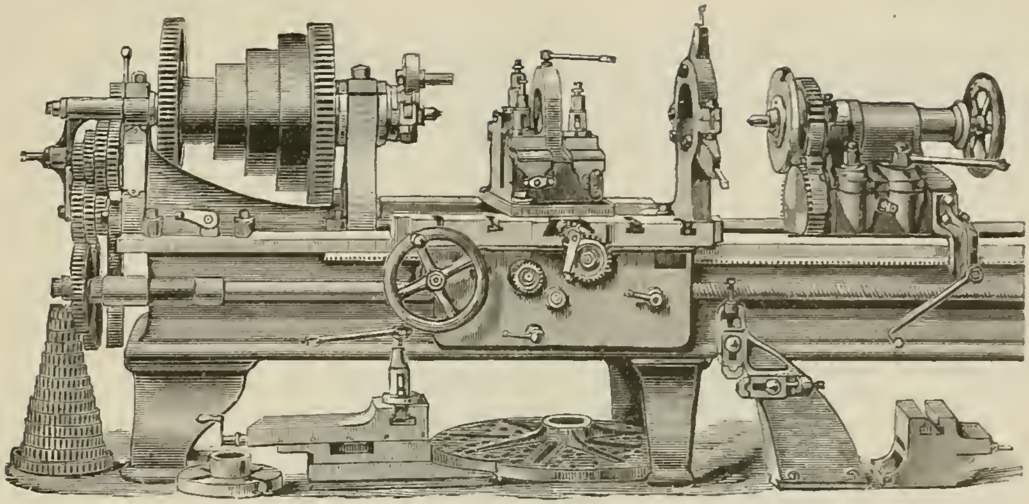


2

GUN-CONSTRUCTION.—1. Brass-fitting Machine. 2. Emery-grinder. *Gun-machinery.*



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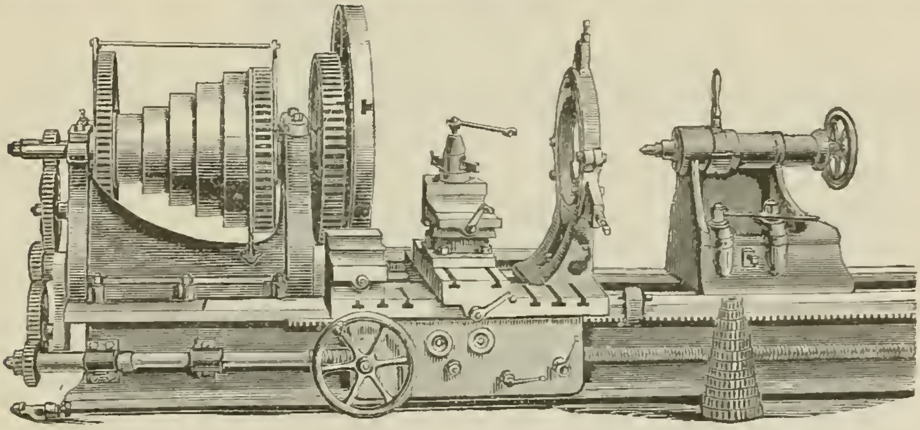

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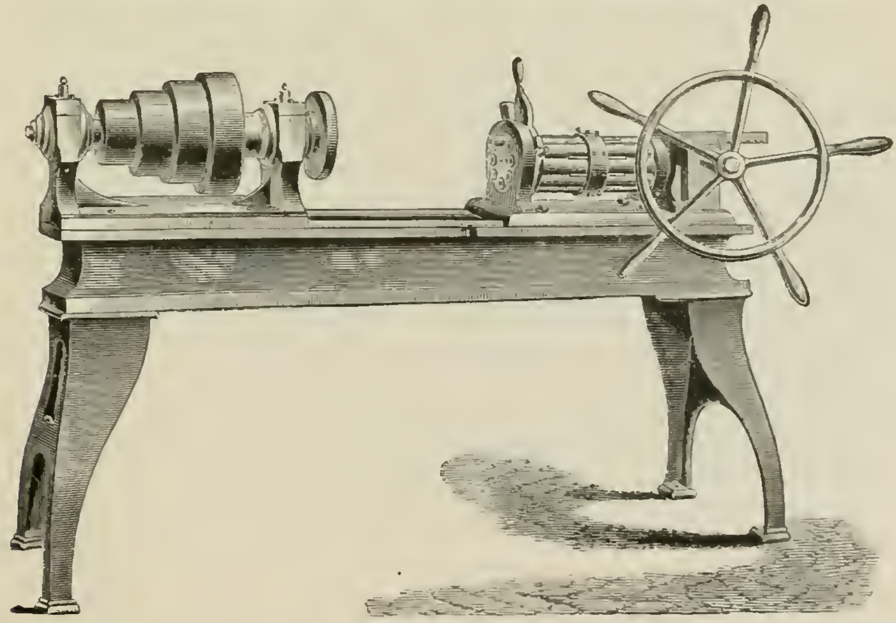
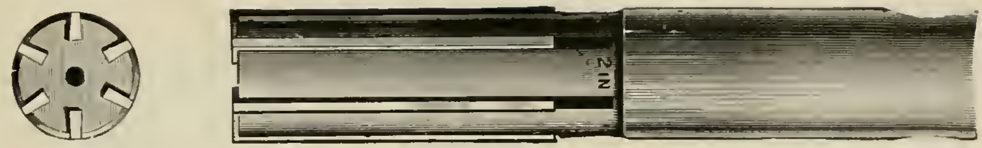
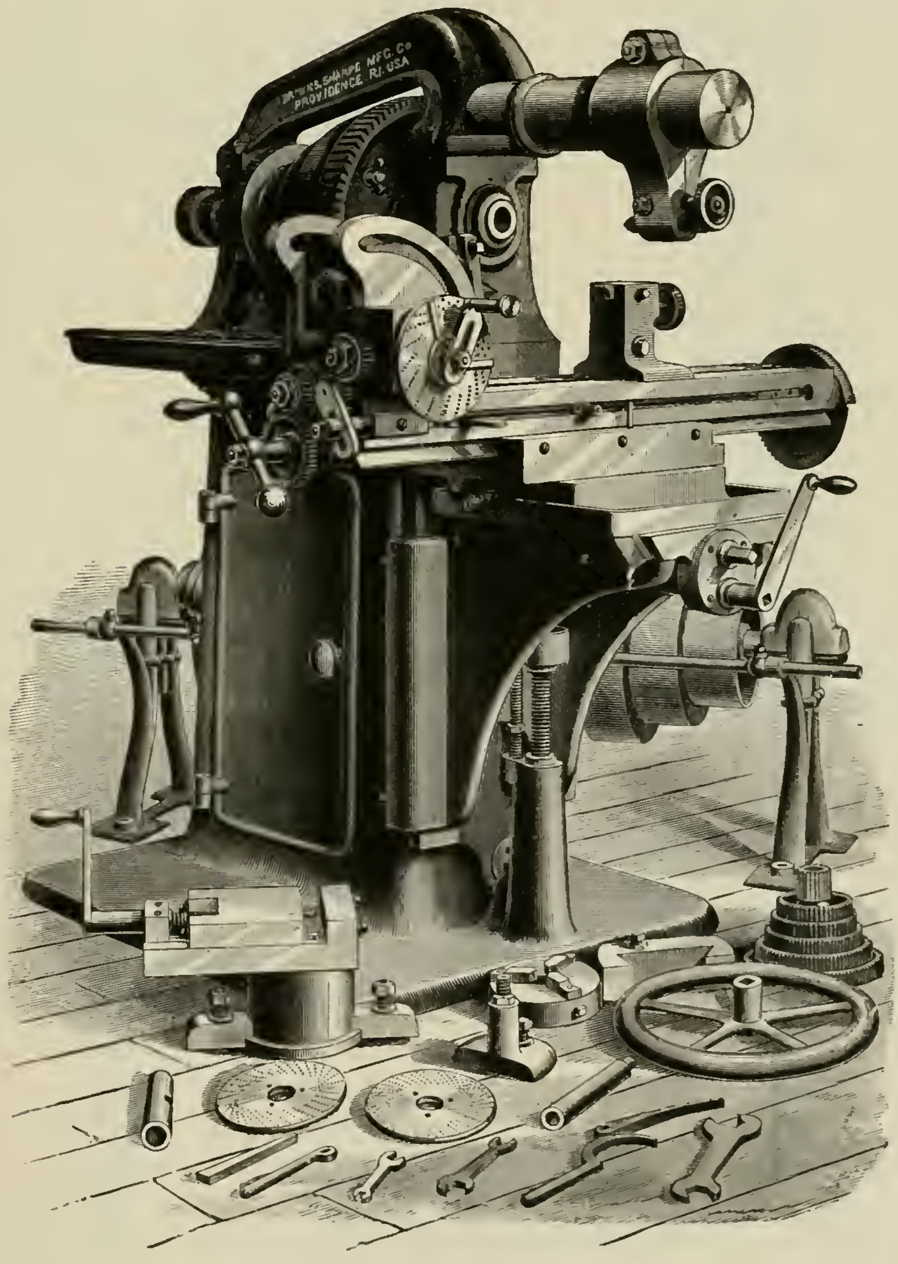


3

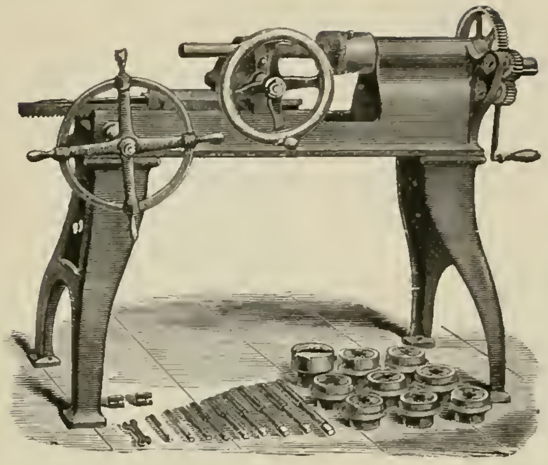
GUN-CONSTRUCTION.—1, Shafting-lathe for Turning Long Pieces. 2, Power-lathe for Heavy Ordnance. 3, Chucking-machine.—*Gun-machinery.*





2

GUN-CONSTRUCTION.—1. Reamer. 2. Universal Milling-machine.—*Gun-machinery.*



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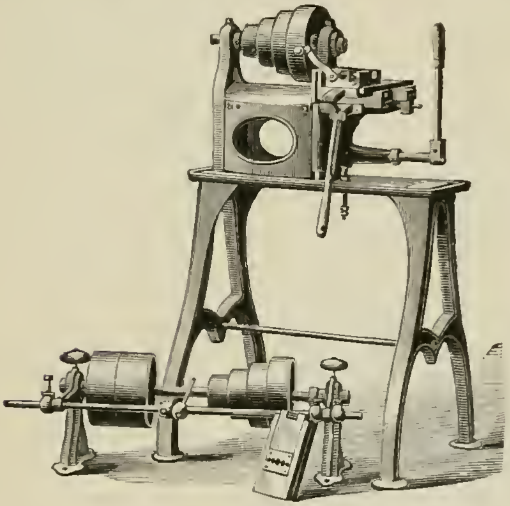

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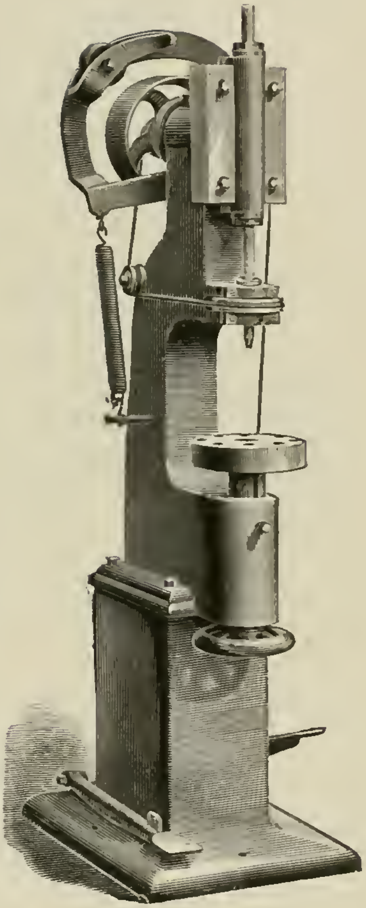

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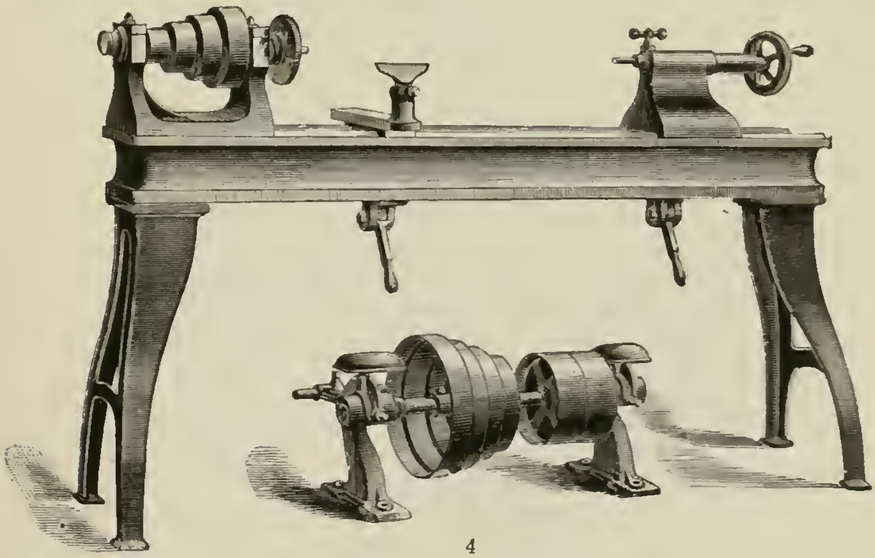
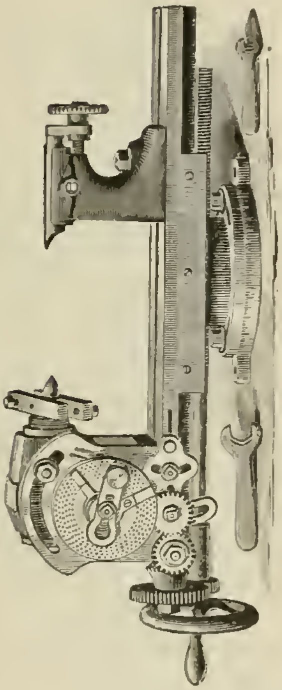


4

GUN-CONSTRUCTION.—1, Hand Bolt-cutter. 2, Combined Milling-machine and Screw-head Slotter. 3, Light Riveting-machine. 4, Light Lathe for Small-arms, etc.—*Gun-Machinery.*



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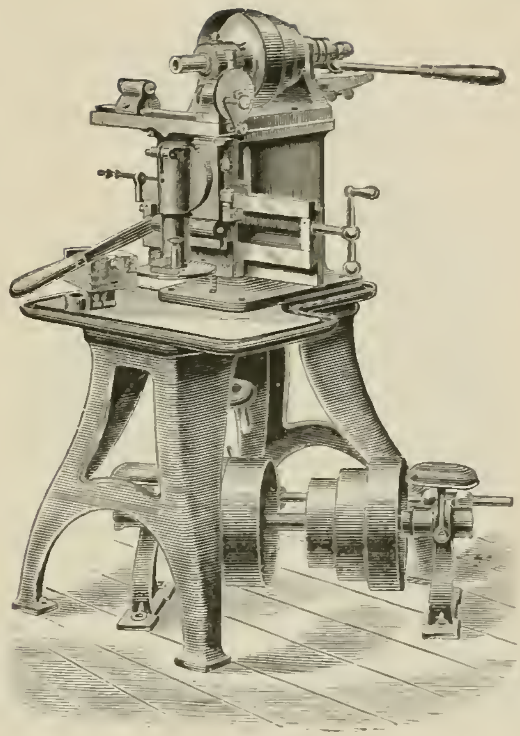

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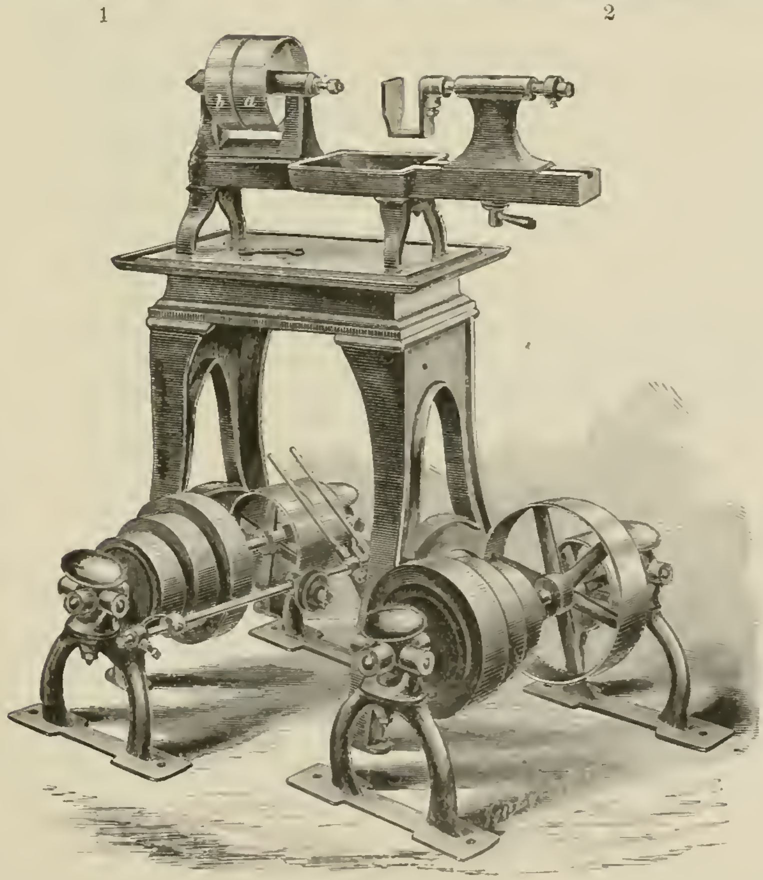

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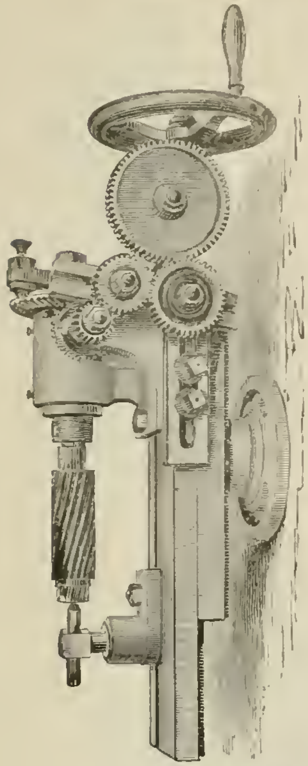
GUN-CONSTRUCTION.—1. Spiral Attachment for use with the Milling-machine. 2. Index Milling-machine. 3. Tapping-machine.—*Gun-machinery.*



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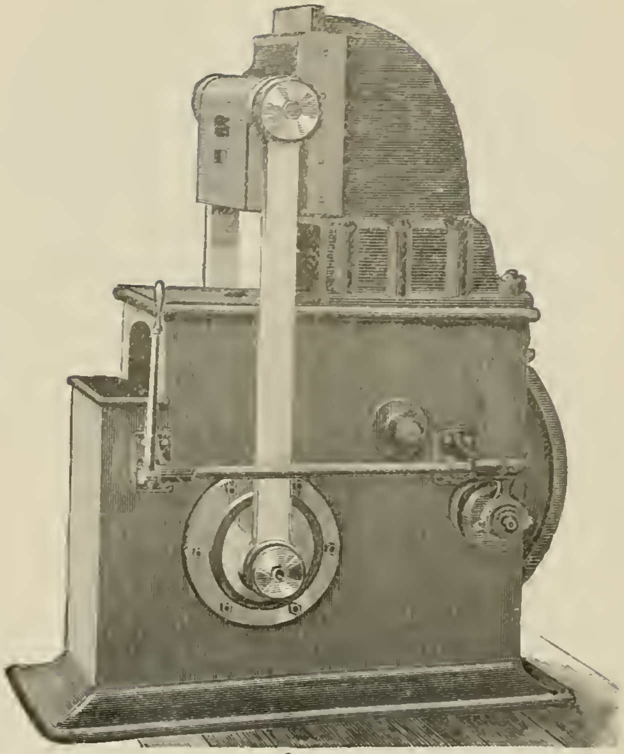

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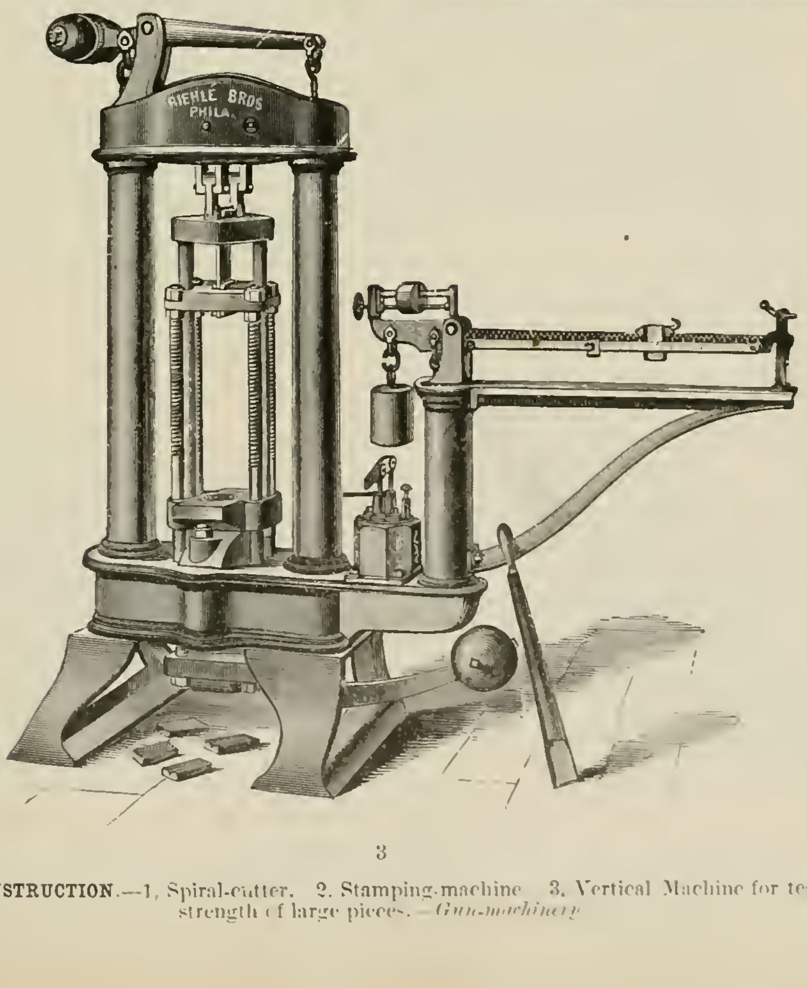

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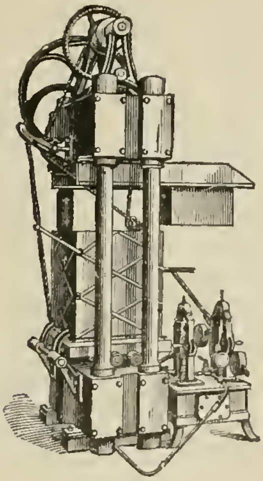
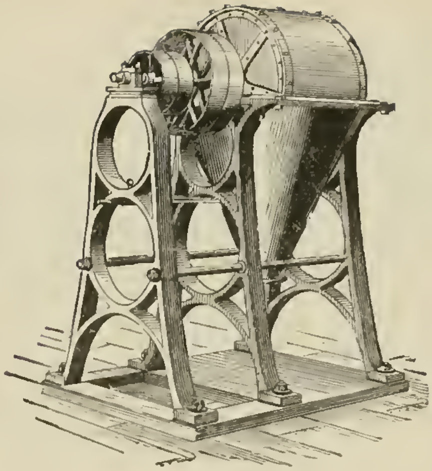
GUN-CONSTRUCTION.—1, Spiral-cutter. 2. Stamping-machine 3. Vertical Machine for testing strength of large pieces.—*Gun-machinery*





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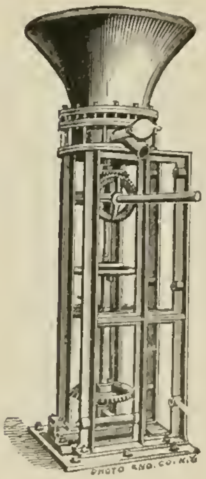

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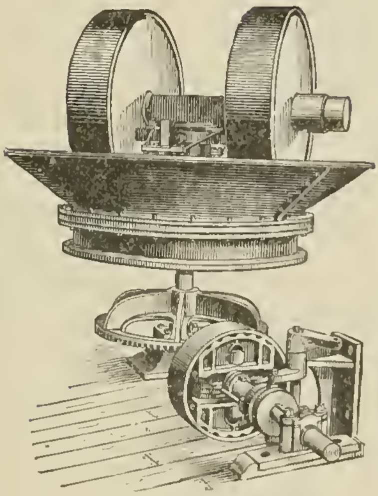

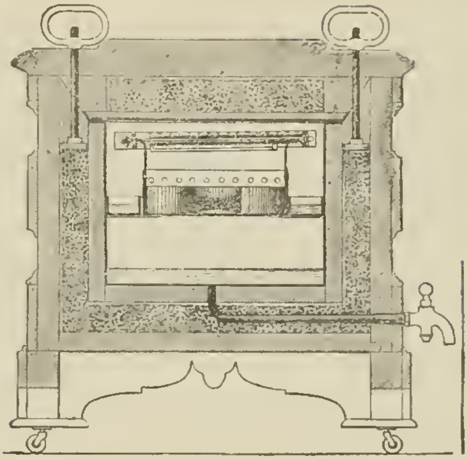

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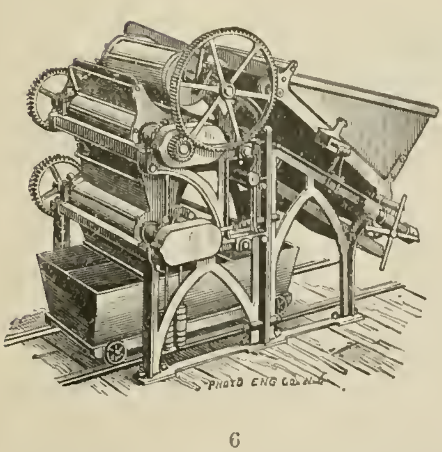

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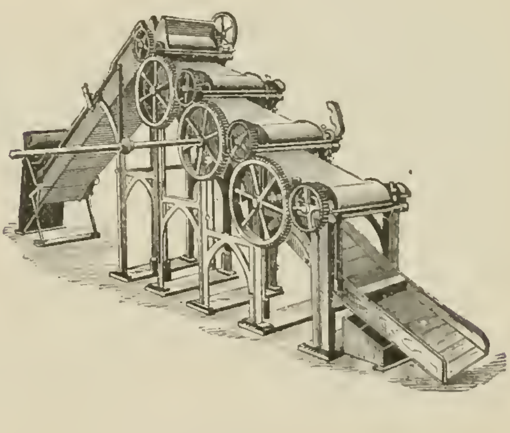

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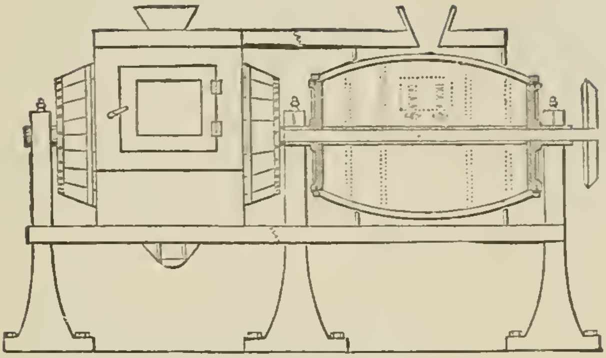
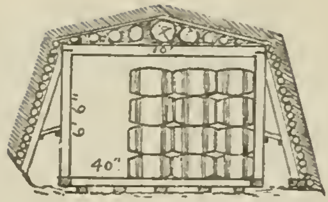
GUNPOWDER.—1, Powder Press. 2, Mixing Machine. 3, Charcoal Grinder. 4, Incorporating Mill. 5, Hygroscope. 6, Breaking-down Machine. 7, Granulating Machine.





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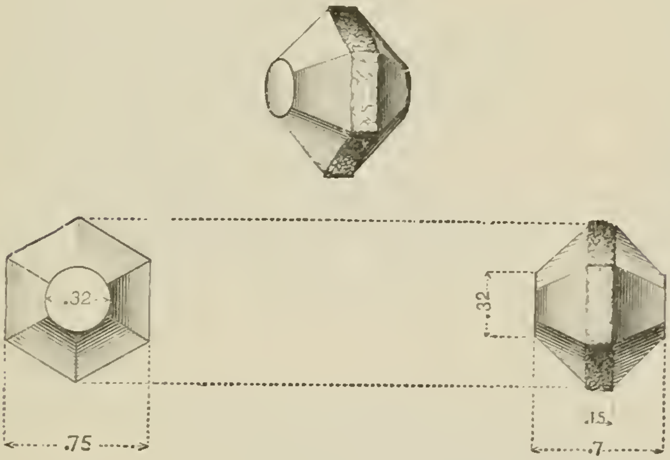

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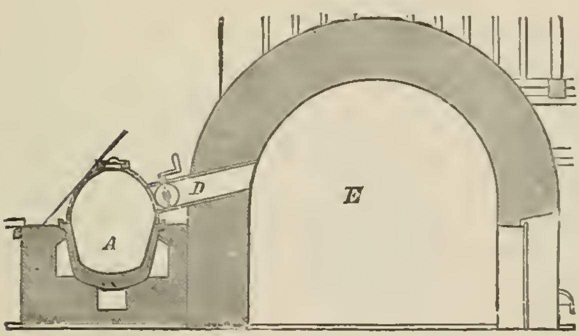

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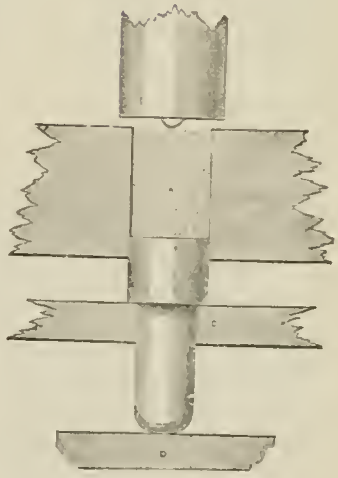
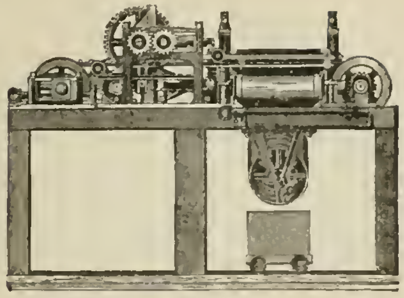


7

GUNPOWDER.—1. Glazing Apparatus. 2. Storage of Gunpowder in Magazine. 3. Sphero-hexagonal Powder. 4. Hexagonal Powder. 5. Densimeter. 6. Sulphur Refining Apparatus. 7. Special Powder Machine.



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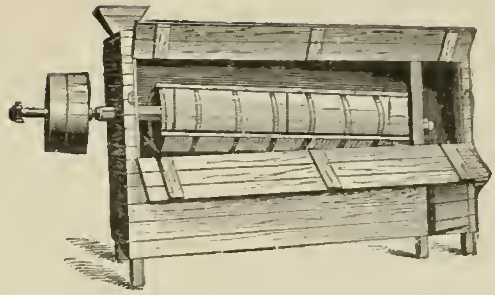

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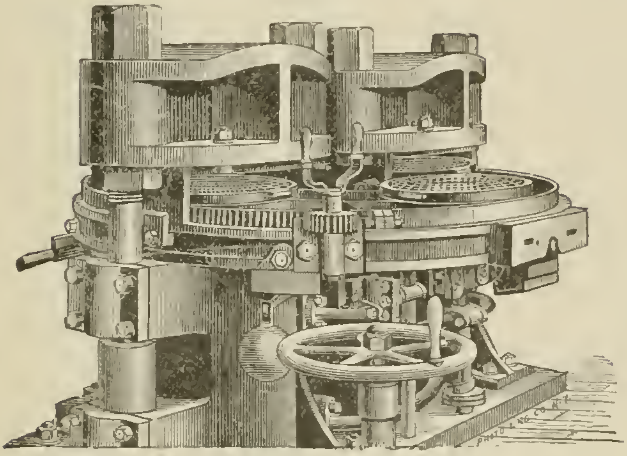

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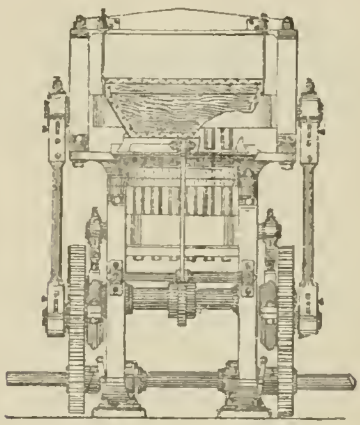

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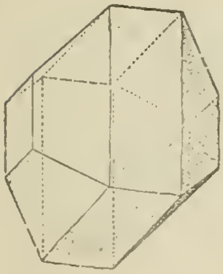

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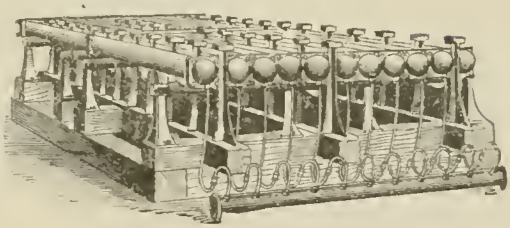

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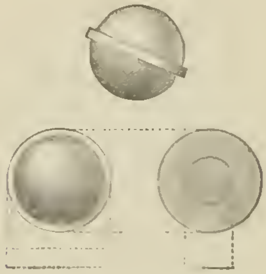

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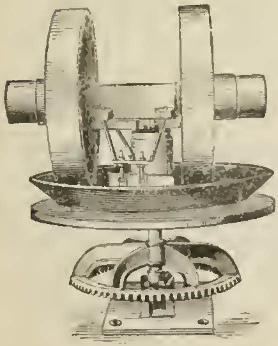

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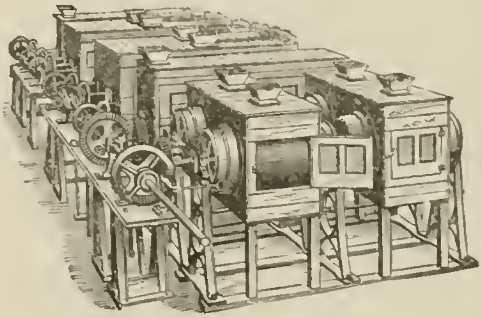

10

GUNPOWDER.—1, Pebble Powder Machine. 2, Sifting-reel. 3, Pellet Powder Machine. 4, Prismatic Powder Machine. 5, Schaghticoke Powder. 6, Drying-stove. 7, Compensating Powder. 8, Saltpeter Apparatus. 9 Cubical Powder. 10, Dusting-reels.

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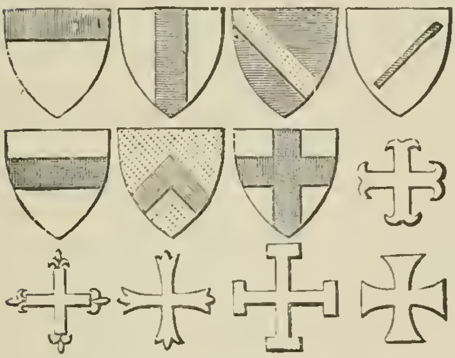

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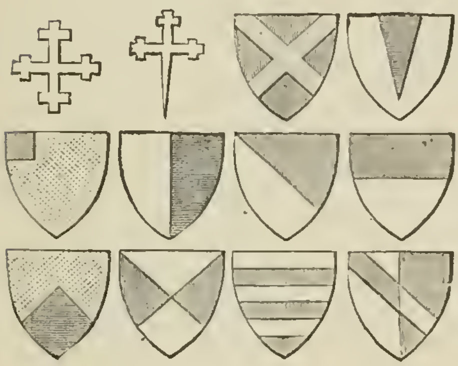

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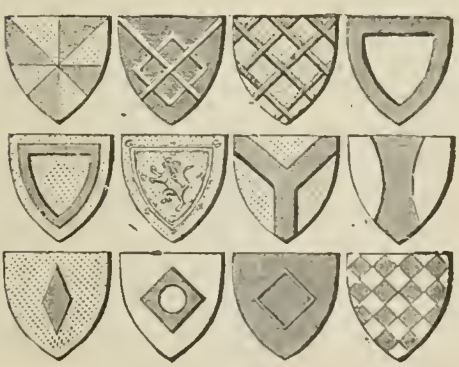

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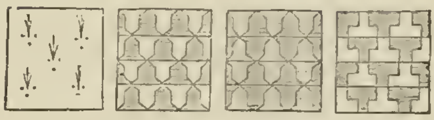

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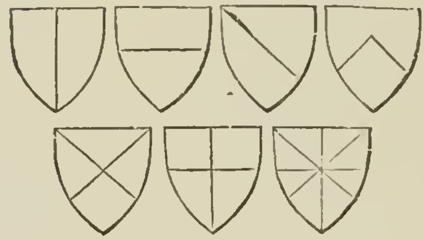

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HERALDRY.—1, Colors in Heraldry. 2-3-4, Figures in Heraldry. 5-6, Cadency—First House and Second House. 7, Furs in Heraldry. 8, Partition Lines in Heraldry. 9, Lion in Heraldry. 10, Trefoil in Heraldry. 11, Same in Architecture.

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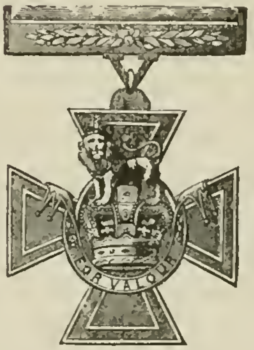

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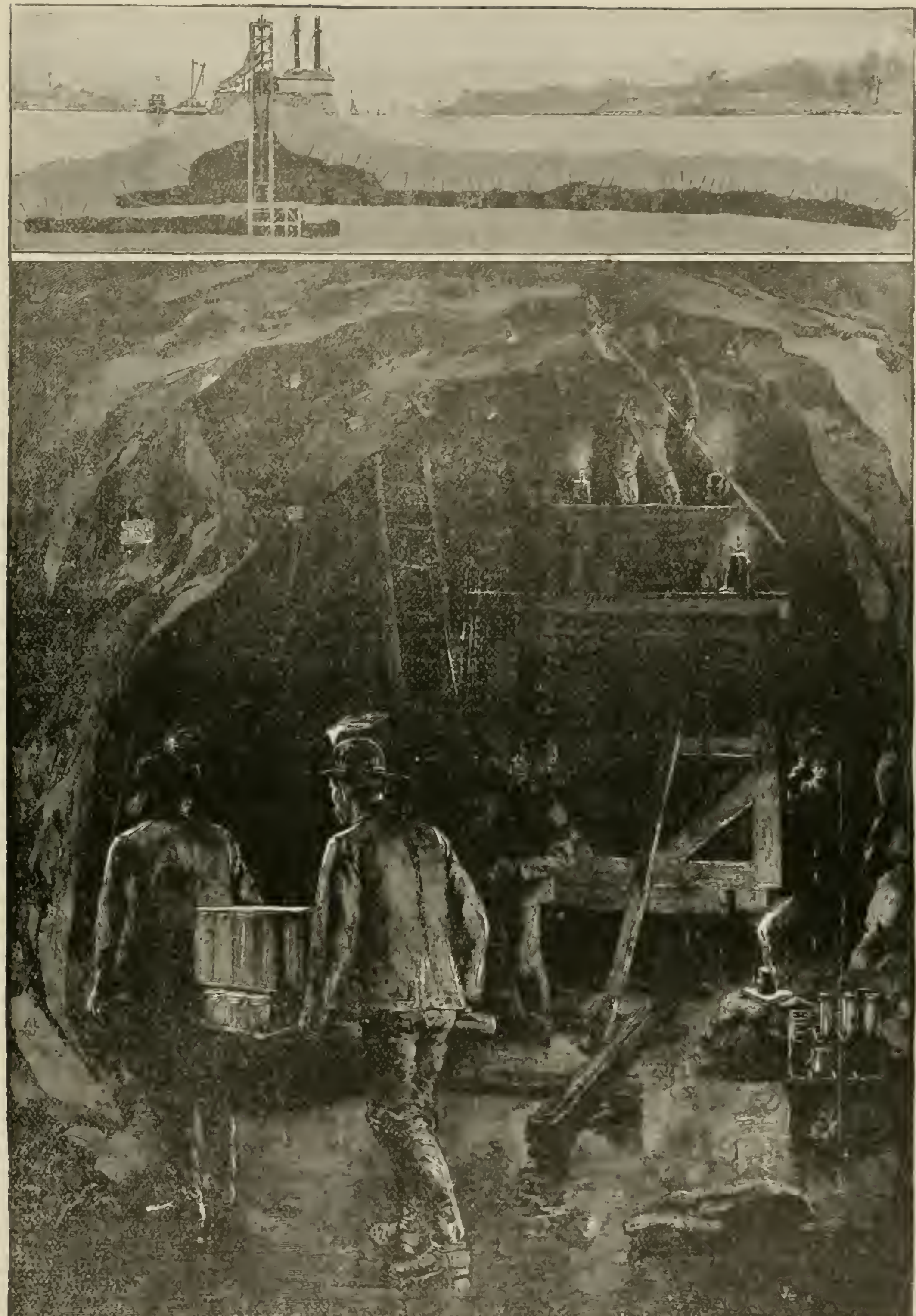
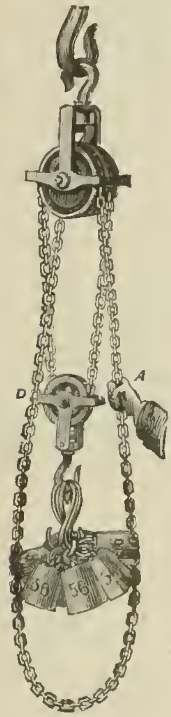
HERALDRY.—1, Order of Alcantara. 2, Star of the Portuguese Order of Christ. 3, Star of the Order of the Annunciation 4, Badge of Order of Avis. 5, Royal Arms of Scotland, previous to the Union. 6, Victoria Cross. 7, Star of India. 8, Order of Isabella the Catholic. 9, Star of the Order of the Black Eagle. 10, Star of the Order of the Thistle. 11, Hatchment of Husband.



HIGH EXPLOSIVES.—Flood Rock. Interior view of Tunnel, showing the location of holes and method of loading them with the explosive contained in thin copper cases. After the holes are filled with Rackarock within a few inches of their mouths, a short case of Dynamite is inserted and left projecting to assist in producing explosion by "sympathy."



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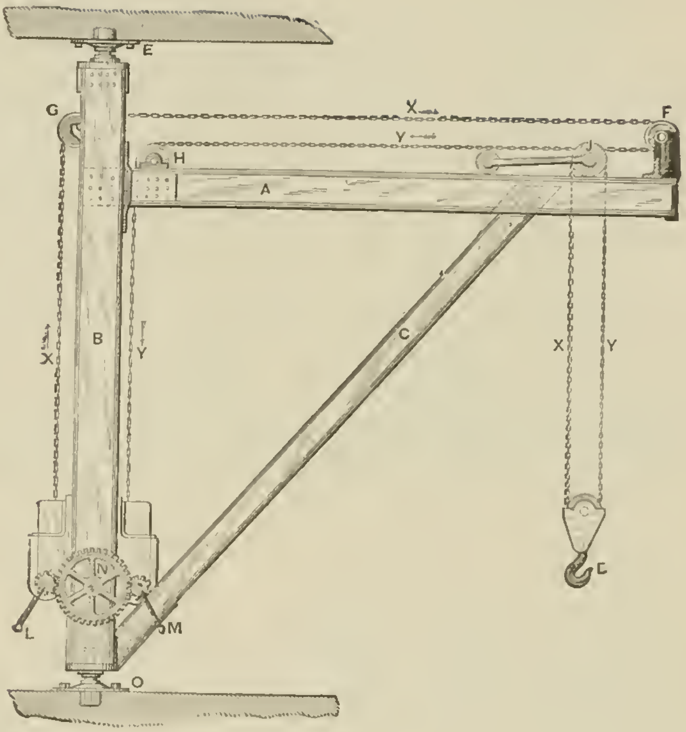

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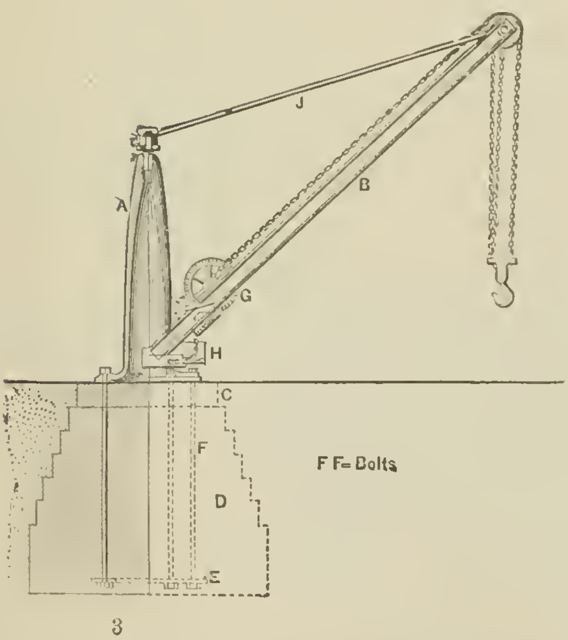

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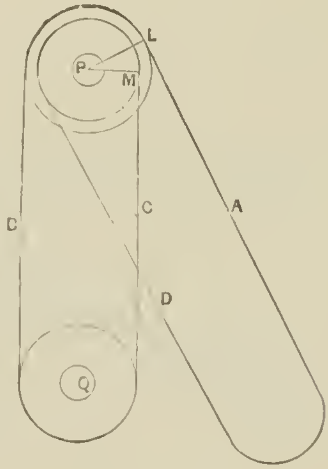
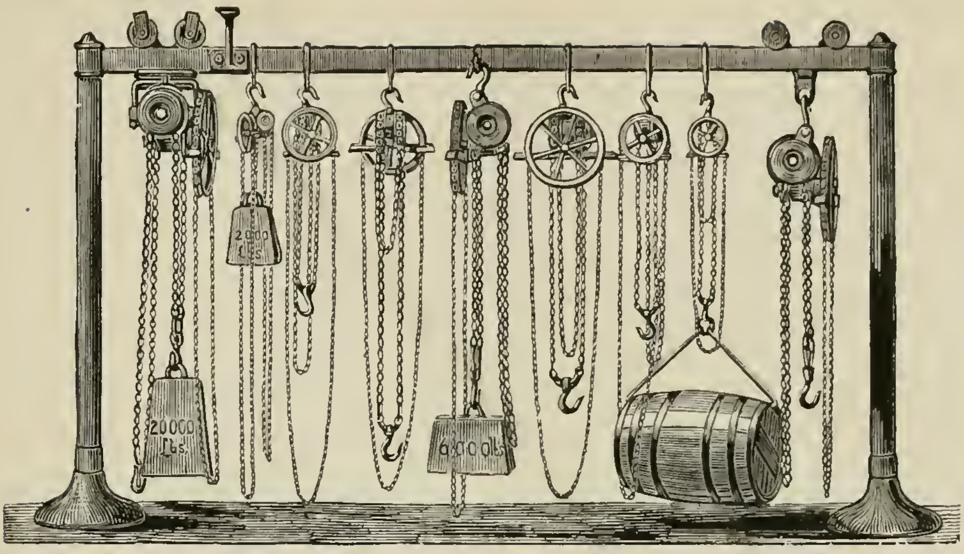


4

HOISTING APPARATUS.—1 4. Differential Pulley-block. 2. Jib-crane with Combined Hoisting and Traversing-gear. 3. Pillar-crane.



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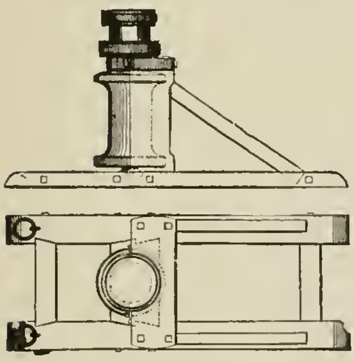

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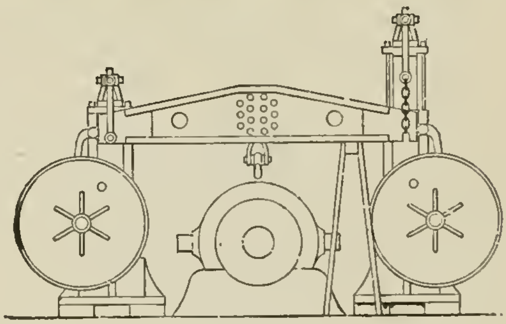

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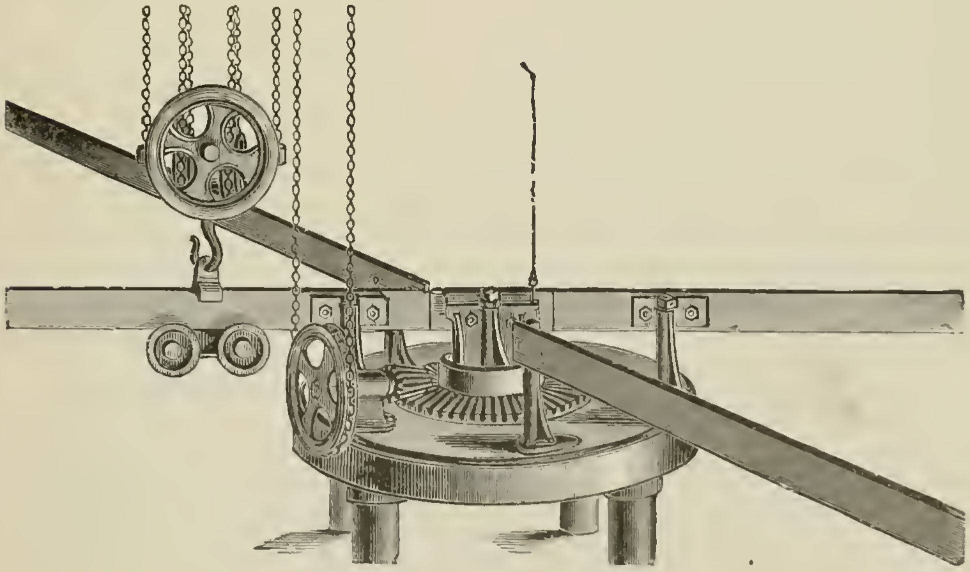
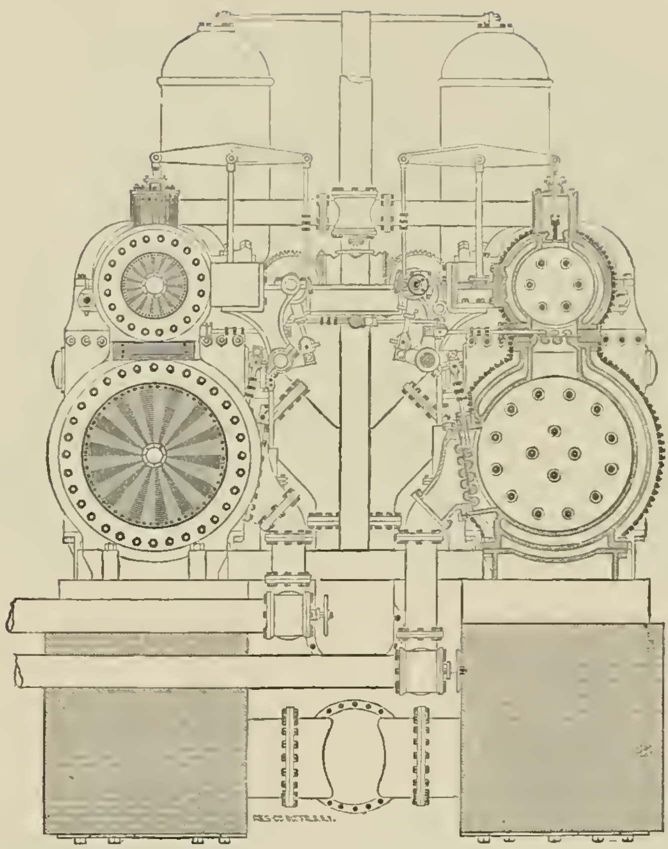


4

HOISTING APPARATUS.—1. Tackles. 2. Capstan. U. S. Service Pattern. 3. Prussian Gun-lift. 4. Turn-table for an Overhead Track.



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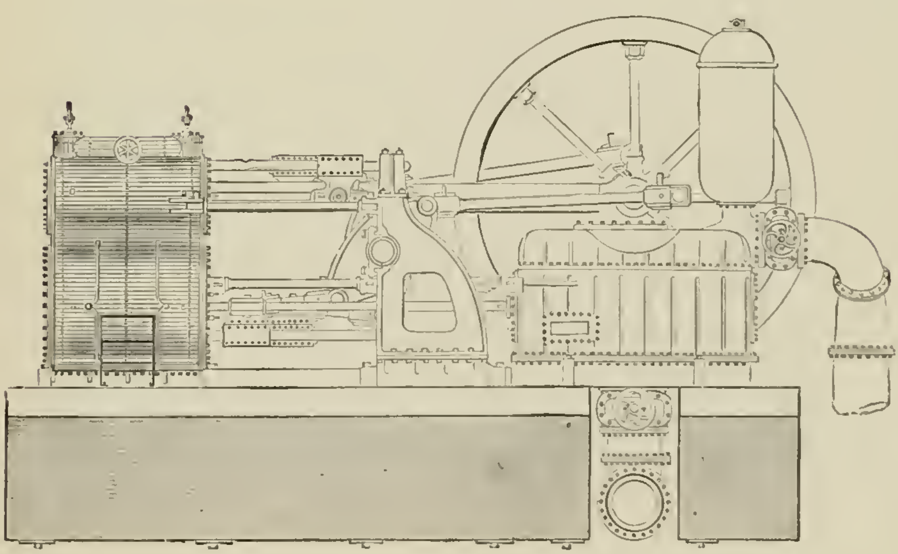
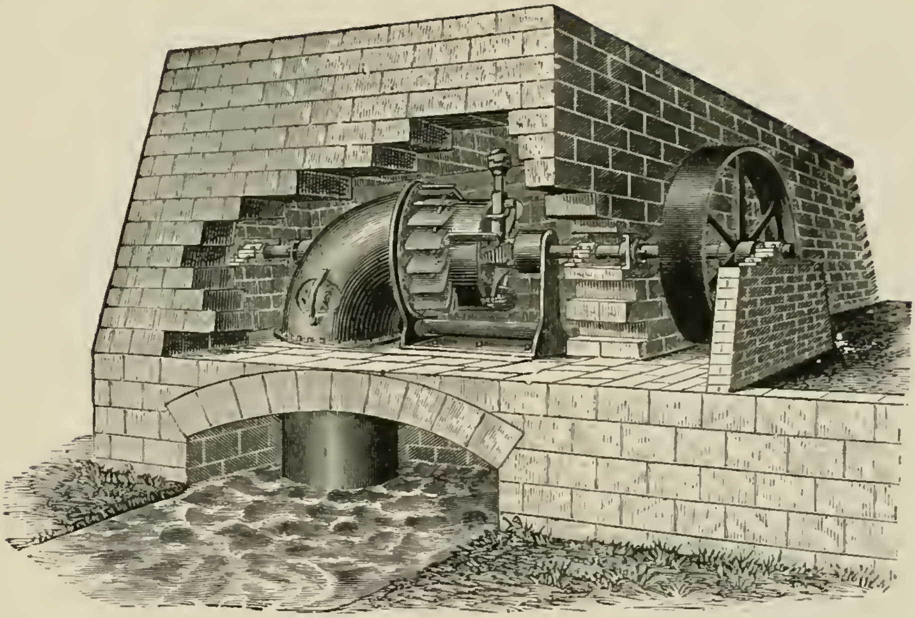


2.

HYDRAULIC POWER.—1-2. Horizontal Compound Condensing-engine, designed by Mr. H. F. Gaskill.



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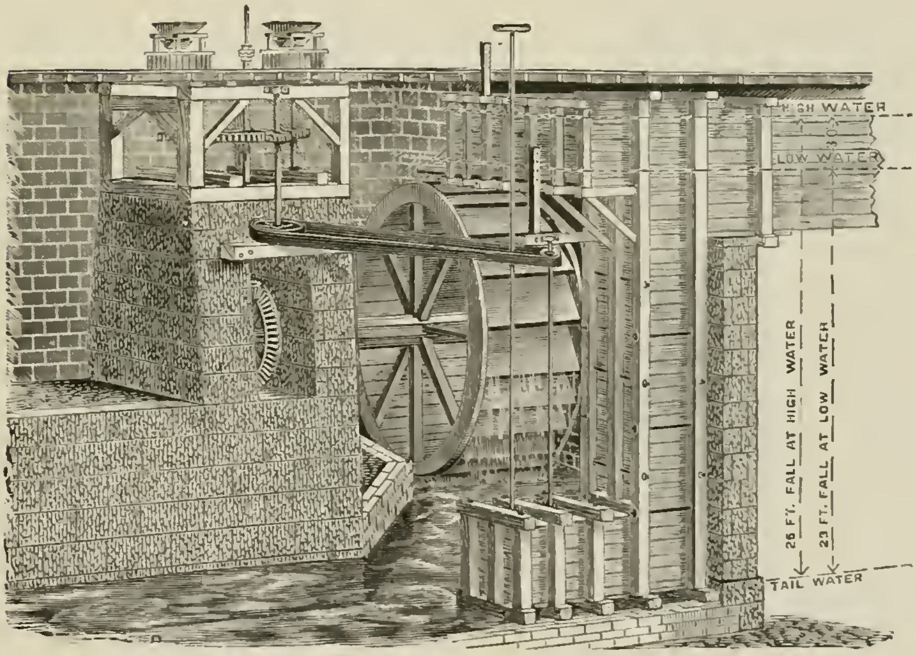
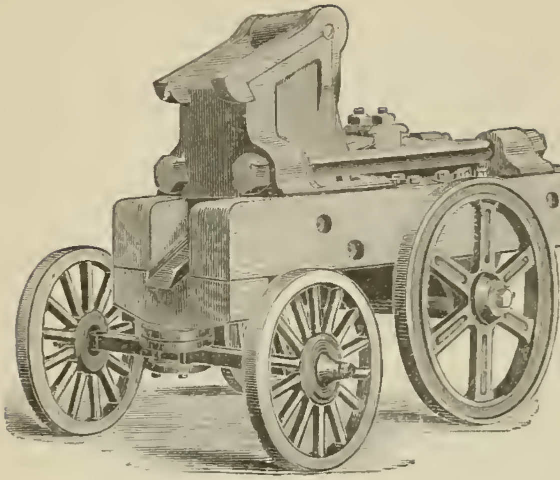


2

HYDRAULIC POWER.—1. Arrangement for a Large Turbine with a Horizontal Axis. 2. Arrangement of Turbine for maximum useful effect, shown in comparison with an Overshot Wheel.



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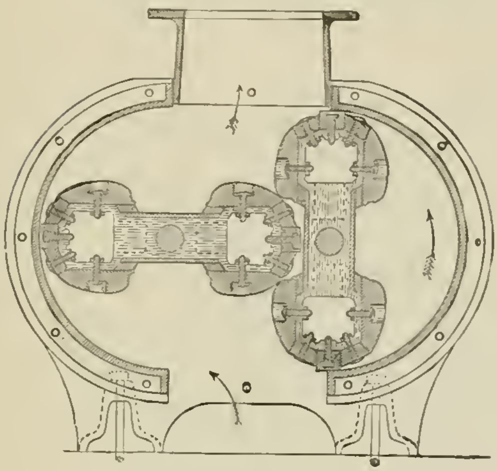

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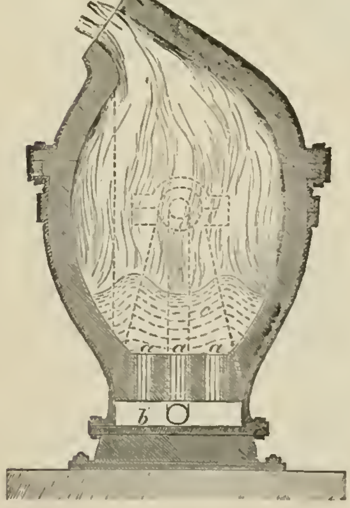

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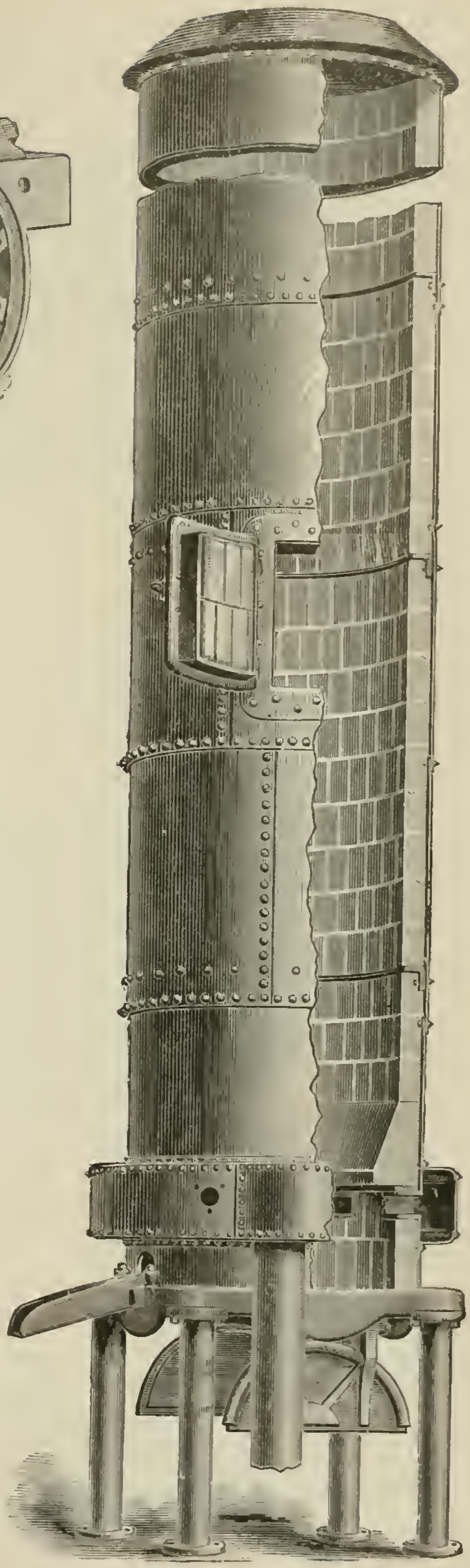
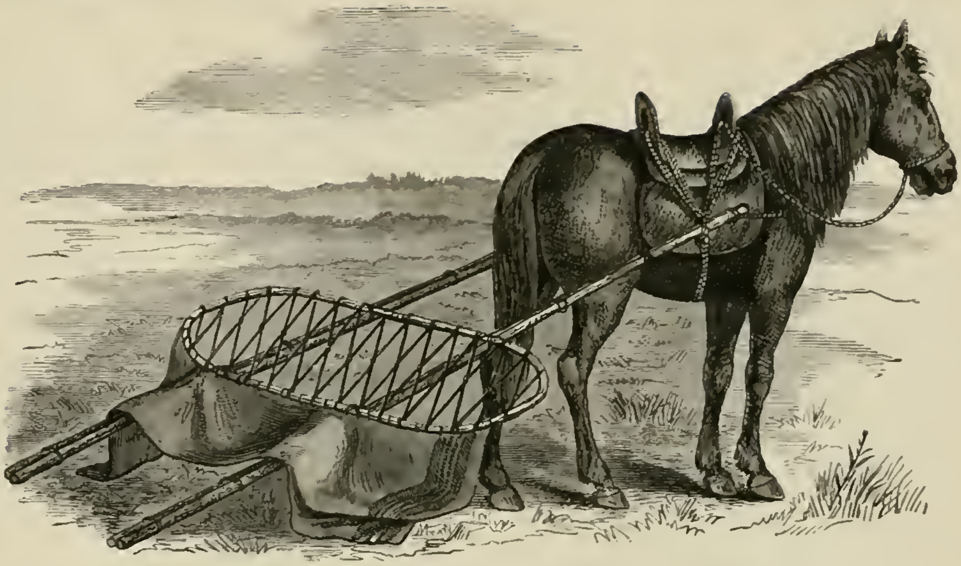


4.

IRON.—1. Ore Crusher. 2. Rotary Blower. 3, Converter, on Trunnions. 4. Cupola.



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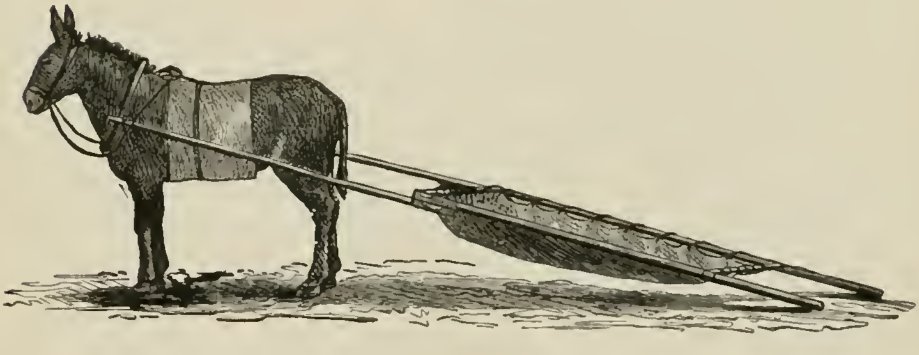
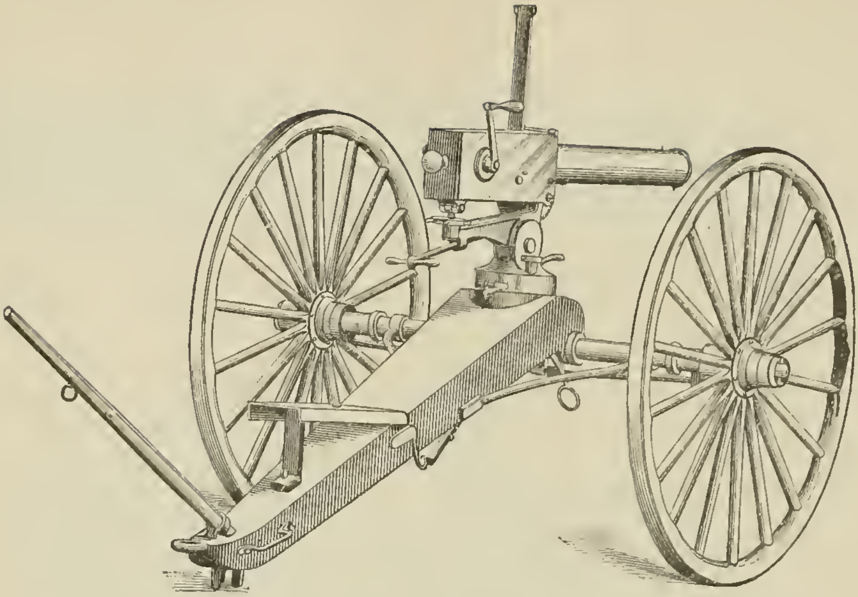


3.

LITTERS.—1. Indian Travée. 2. Marcy Two-horse Litter. 3. Greenleaf Combination Horse and Hand Litter.



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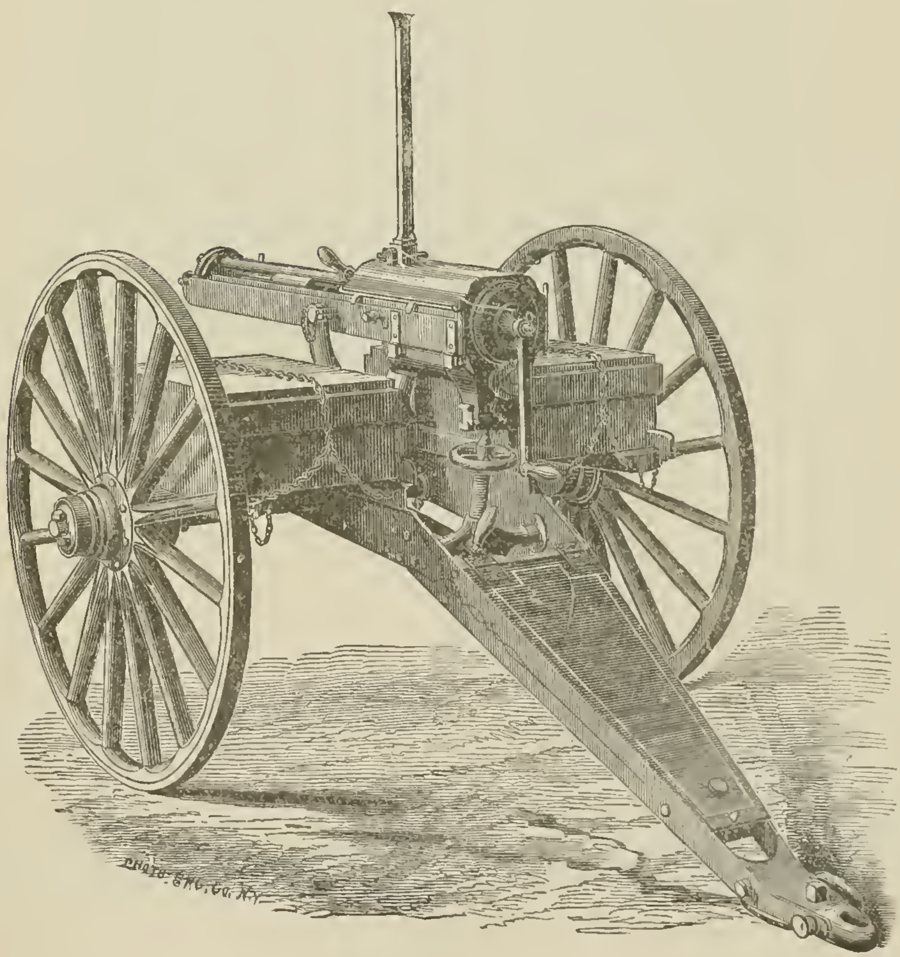
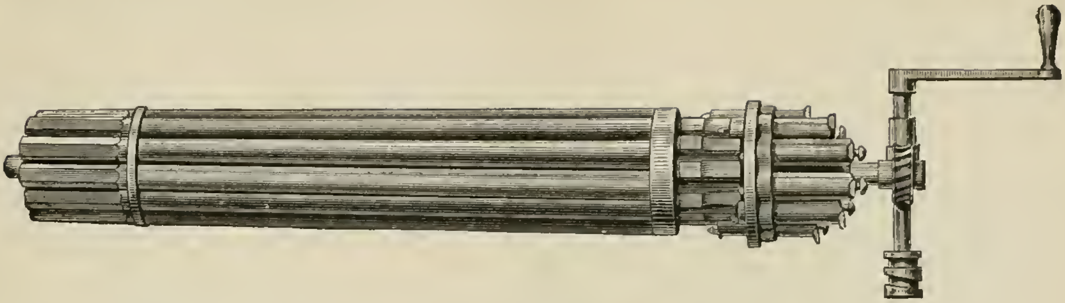


2.

MACHINE GUNS.—1, Gardner Machine-gun Mounted on Carriage. 2. Lowell Battery-gun.



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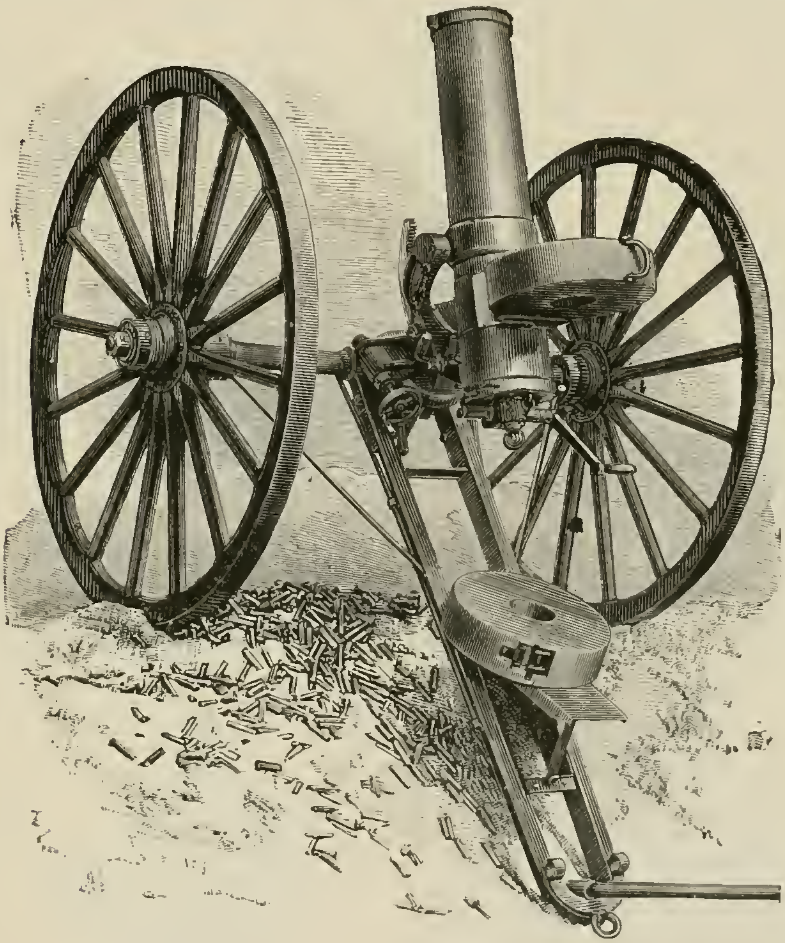

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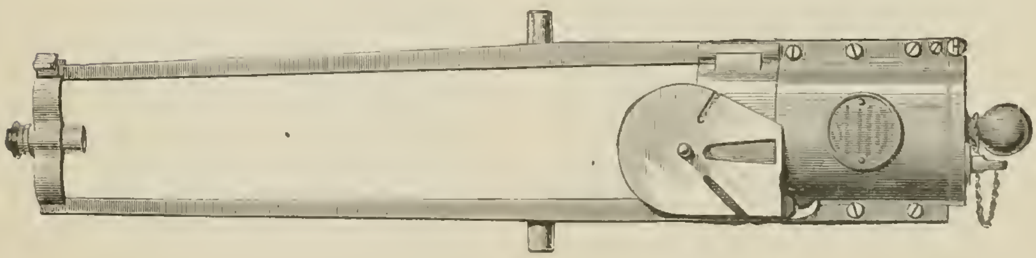
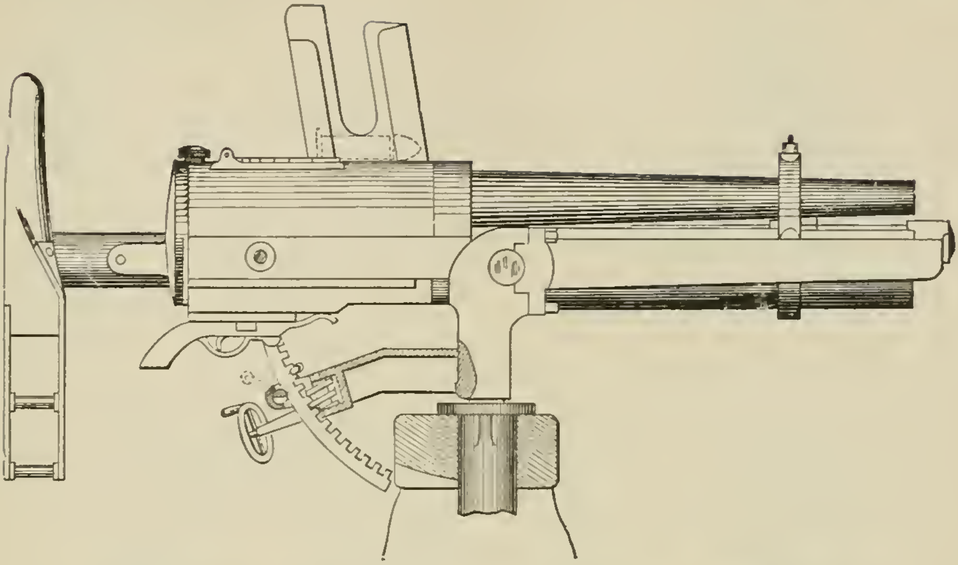


3.

MACHINE-GUNS.—1, Barrels, grouped around the Shaft. 2, Improved Gatling Gun and Feed-magazine. 3, The Casing.



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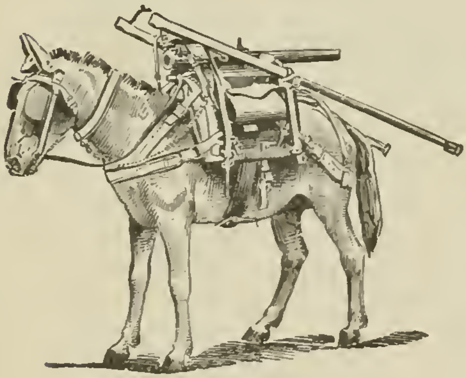

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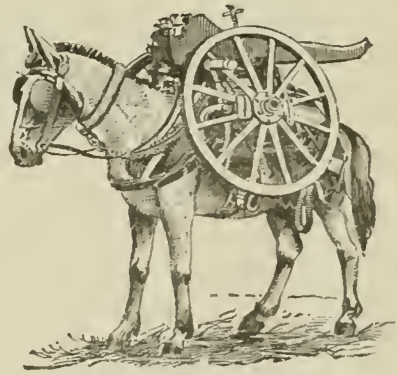

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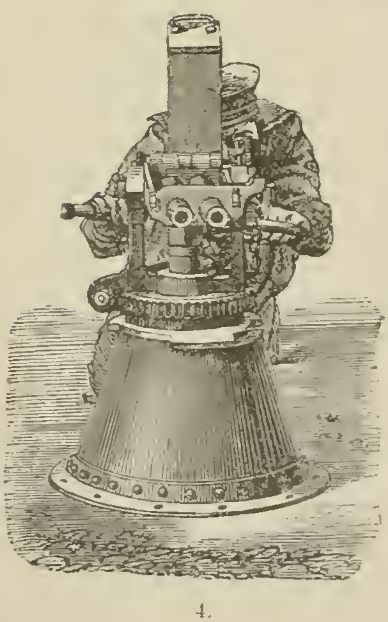

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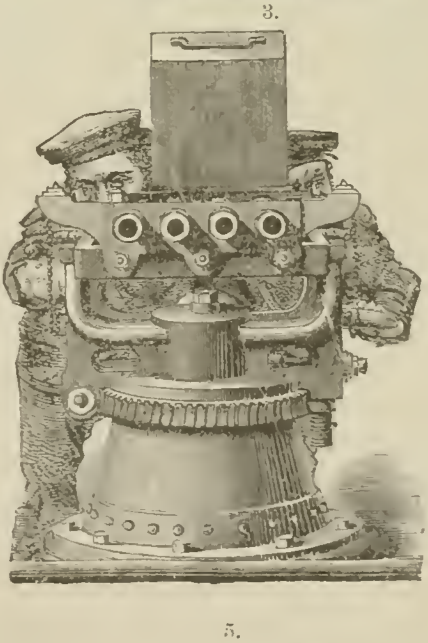
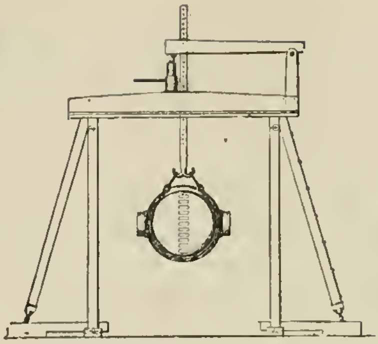


5.

MACHINE GUNS.—1, Hotchkiss Revolving-cannon, with Shoulder-piece. 2–3, Hotchkiss Revolving cannon and Carriage Packed for Transportation. 4, Nordenfelt Double-barrel Gun. 5, Nordenfelt Four-barrel Gun.

1



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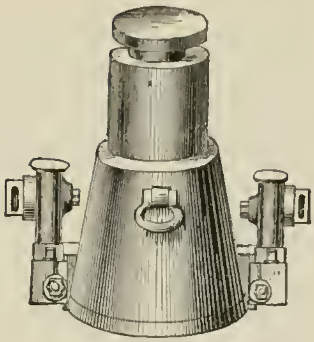

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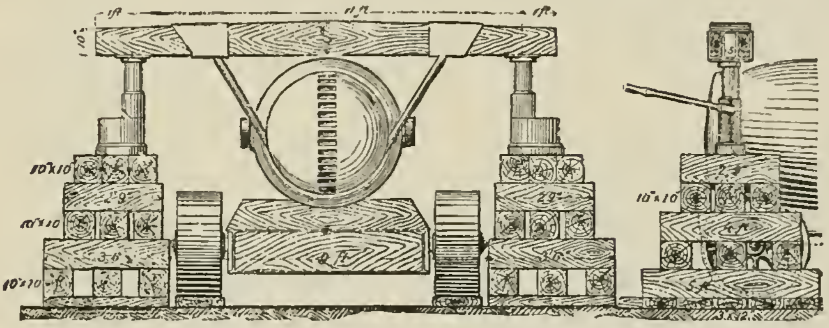

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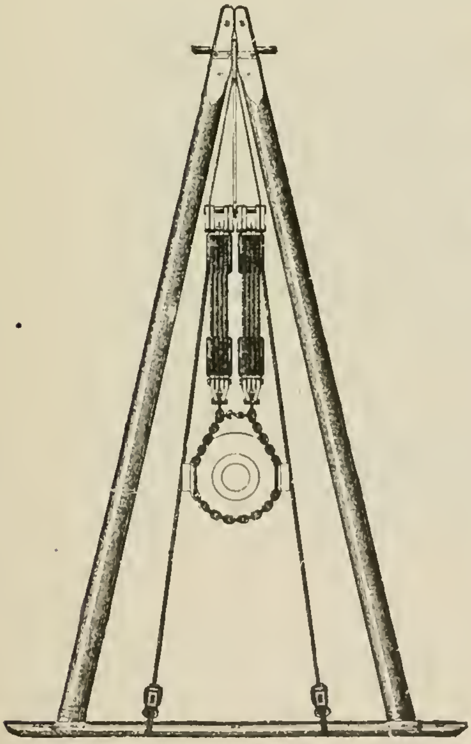

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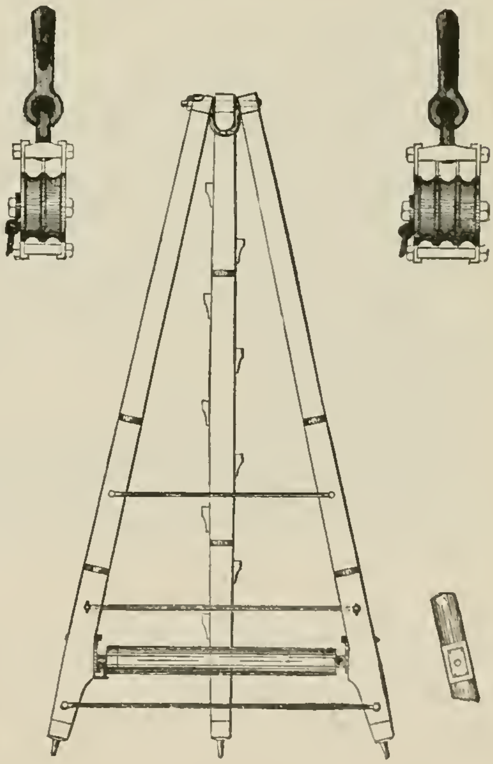
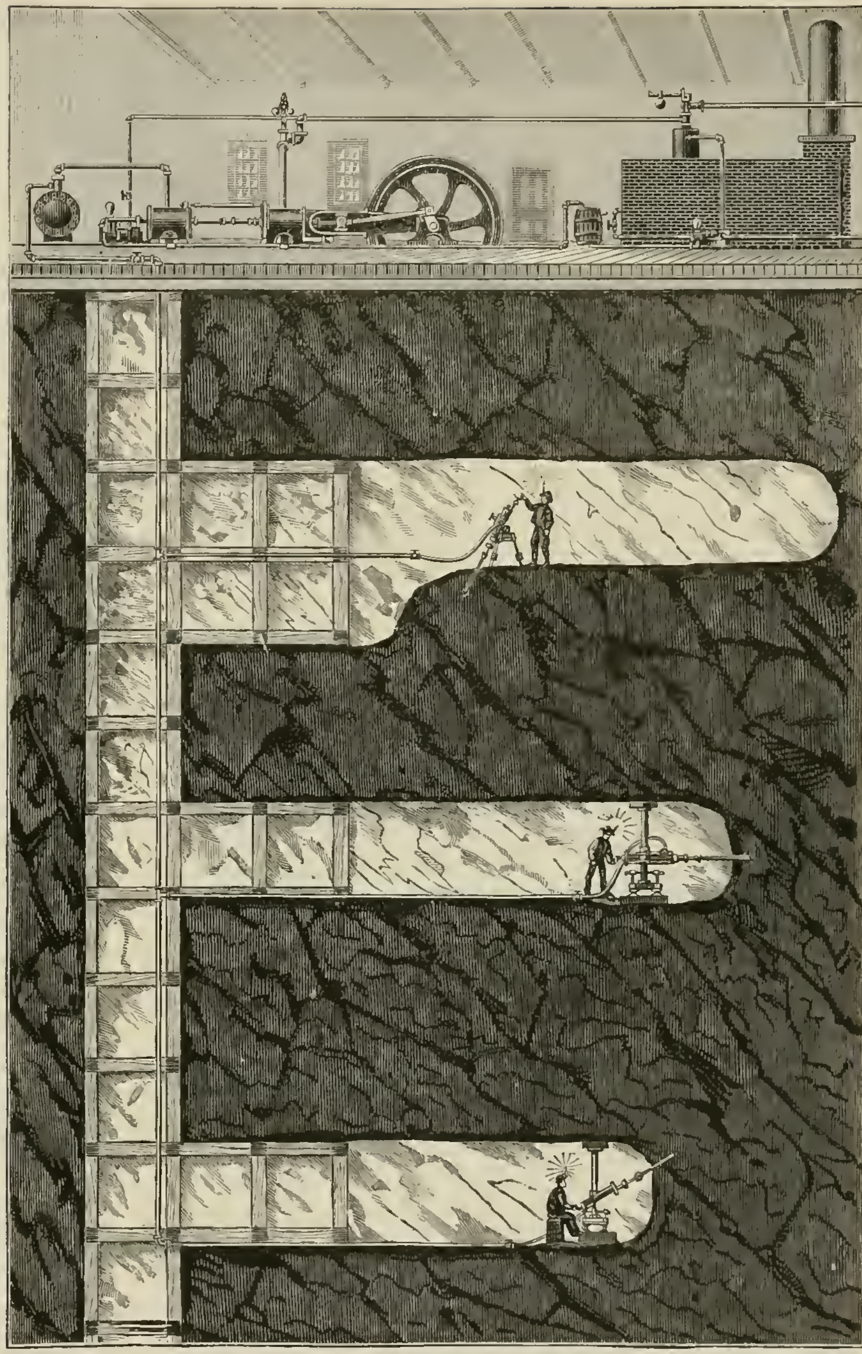
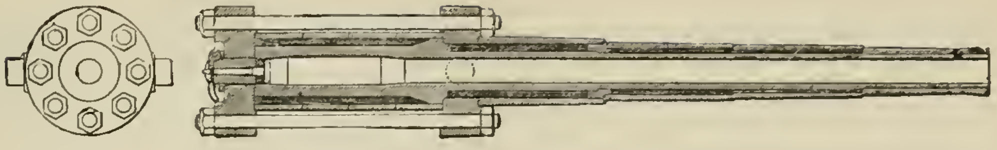


6

MECHANICAL MANEUVERS. -1, Hydraulic Jack. 2, Gun-lift, U. S. Army. 3, Double Pump-jack. 4, Mounting Canon—using Blocks. 5, Shears. 6, Gin.



MINES.—General arrangement of Compressed Air Machinery Plant in a Mine.



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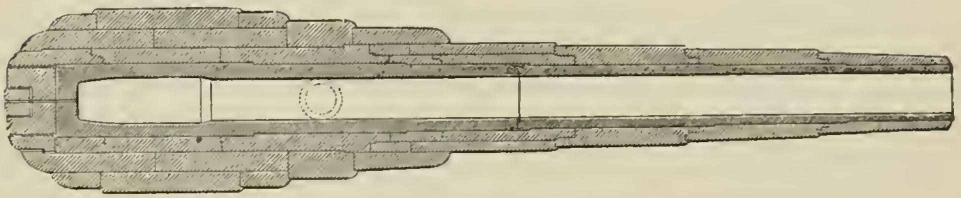

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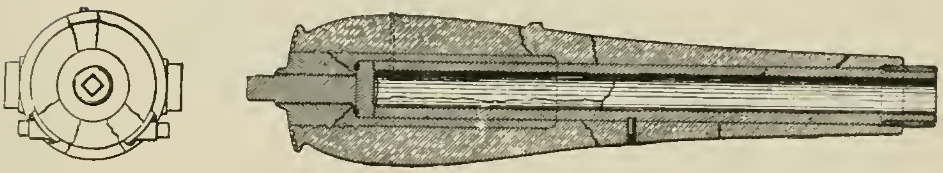

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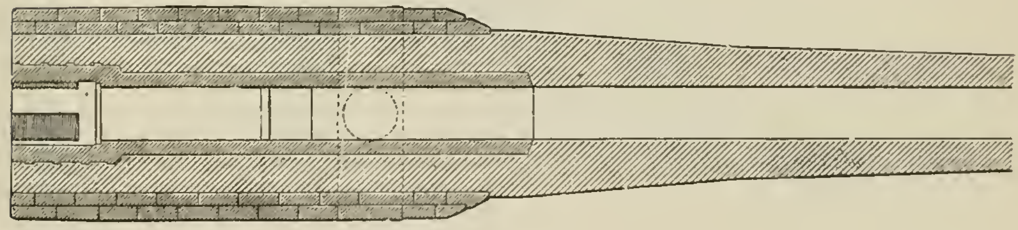

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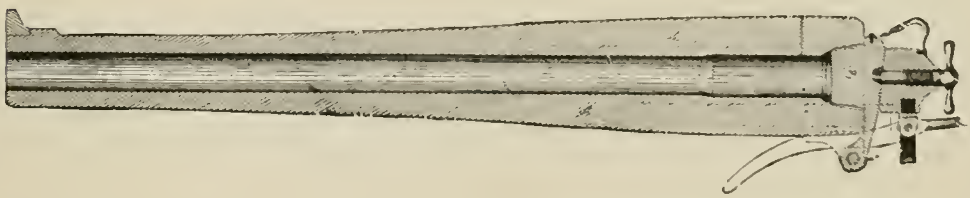

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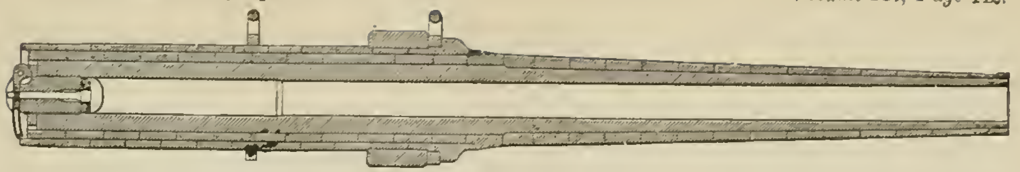
ORDNANCE.—1, Schultz Wire Gun. 2, Breech-loading Wire Gun. 3, Armstrong Gun. 4, Eight-inch Converted Rifle. 5, Steel Tube Gun—42 ^{m}. 6, Moffatt Gun.



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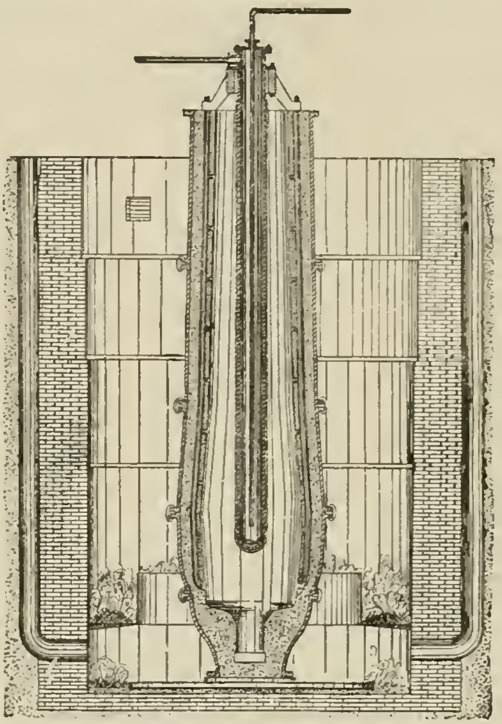

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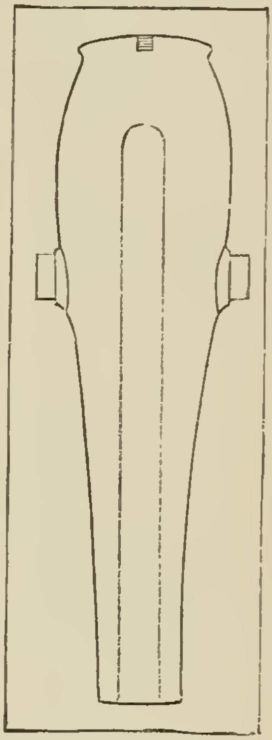

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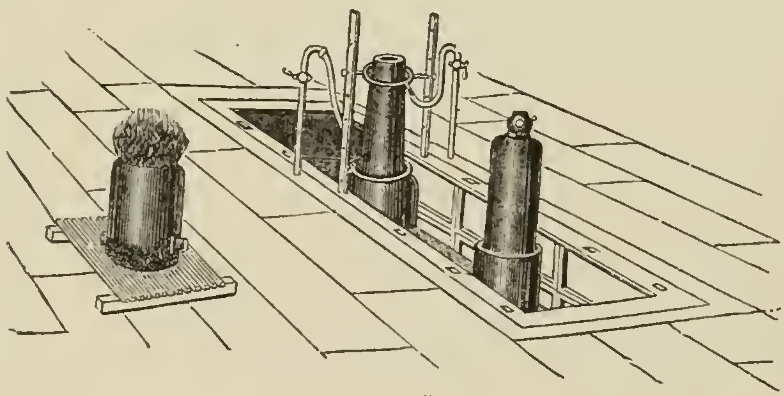

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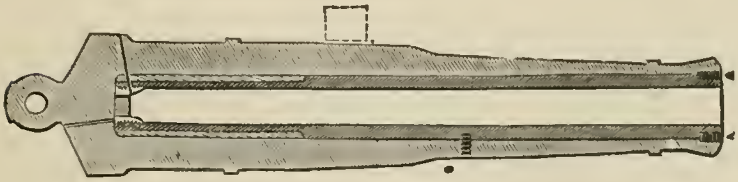

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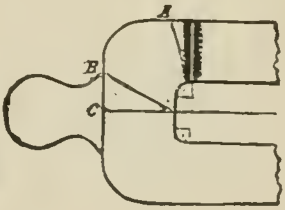
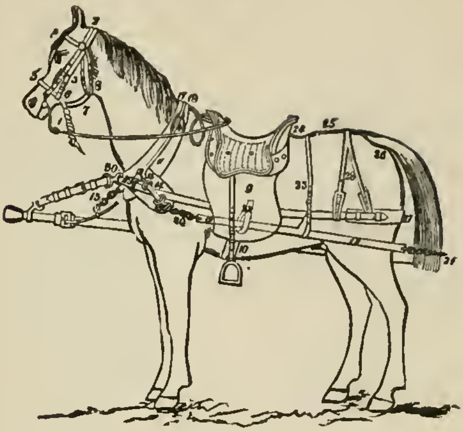


7

ORDNANCE.—1, French heavy gun, Modèle de Bange, 24cm. 2, Molding Cannon. 3, Columbiad. 4, Wire Gun. 5, Shrinking Coils. 6, Palliser Gun. 7, Section of Breech, showing the location of Vents.



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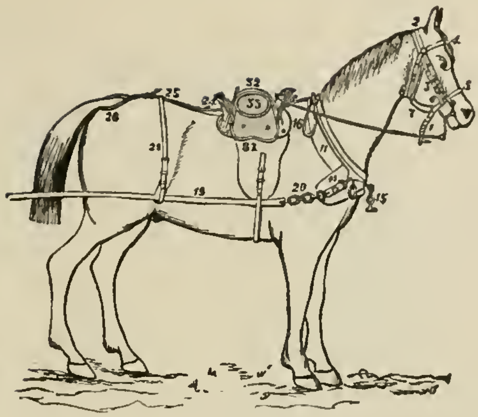

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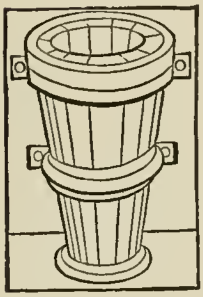

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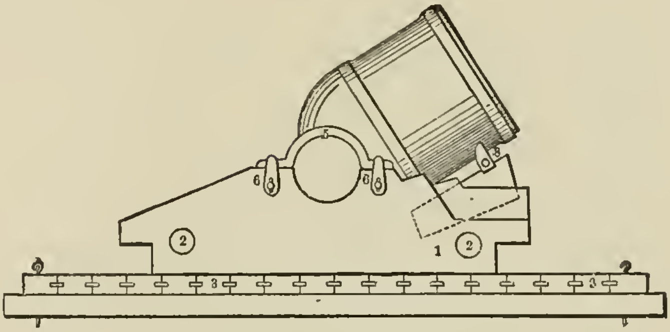

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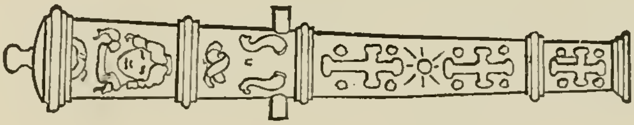

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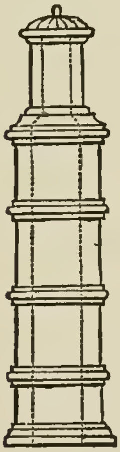

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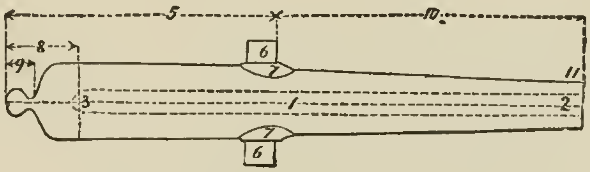

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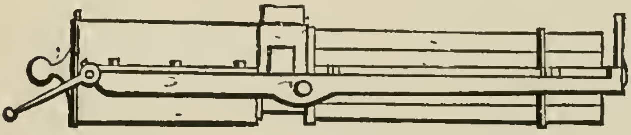

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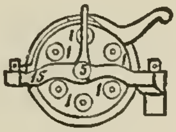
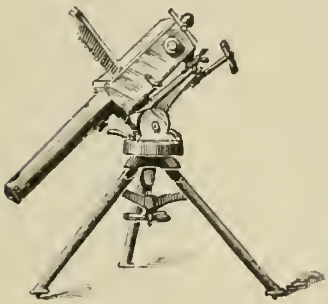


9

ORDNANCE.—1-2, Harness for Artillery Service. For Nomenclature, see Volume II. Page 15. 3, Bombard. 4. Mortar, mounted on carriage. 5, Culverin, "Queen Anne's Pocket-piece." 6, Perriere. 7, Light Field-rifle, 3-inch. 8-9, One-inch Mitrailleur.



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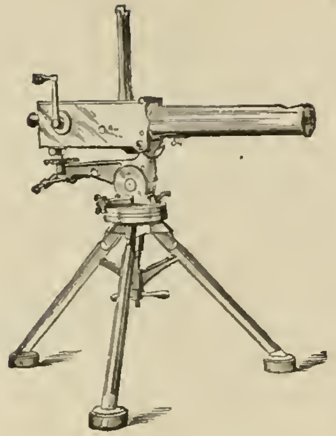

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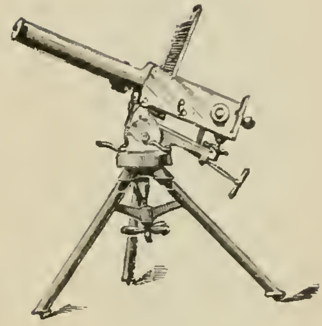

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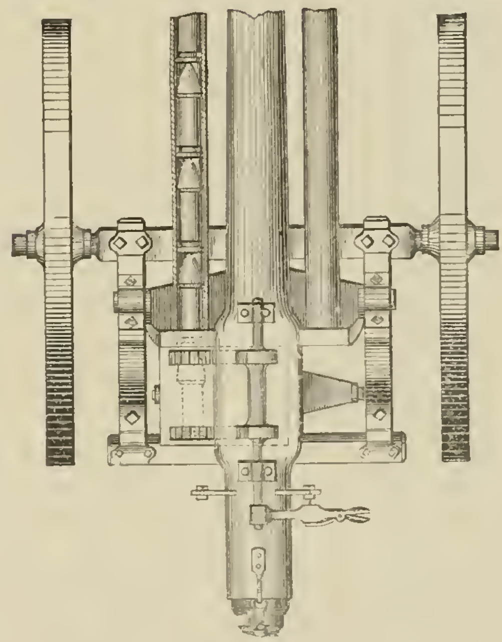

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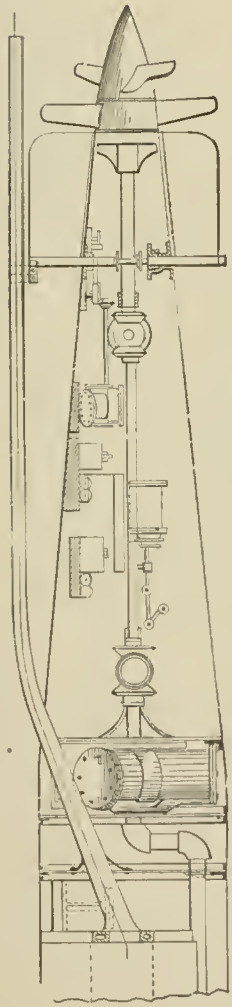

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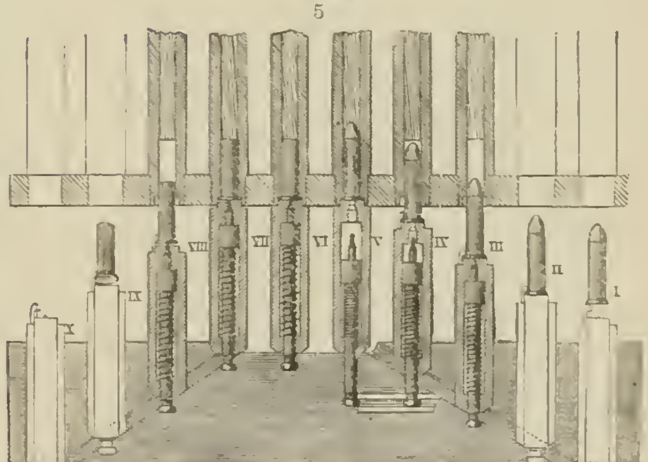
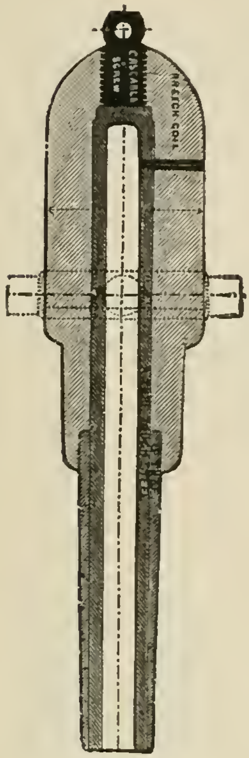


6

ORDNANCE. 1, 2, 3, Improved Tripod for Machine-guns. 4, Lay Torpedo. 5, McLean Machine-gun. 6, Cam-ring of Gatling Gun.



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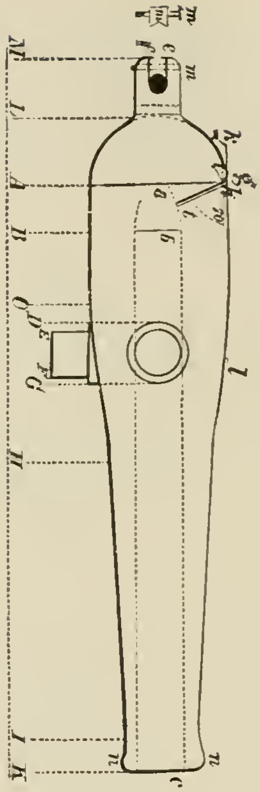

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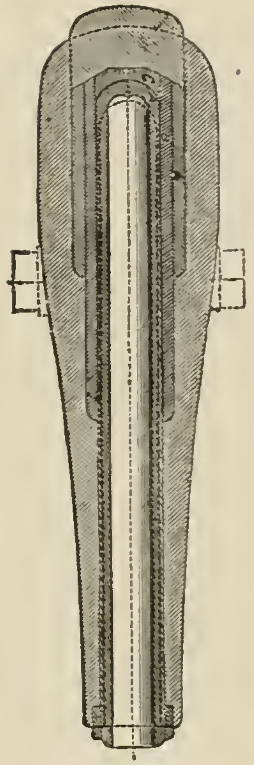

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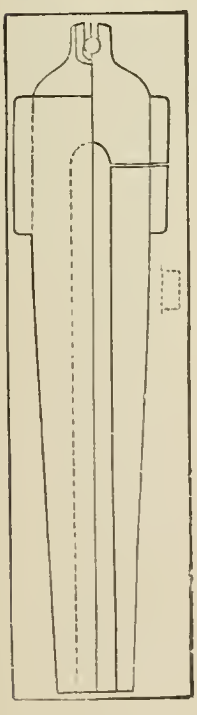

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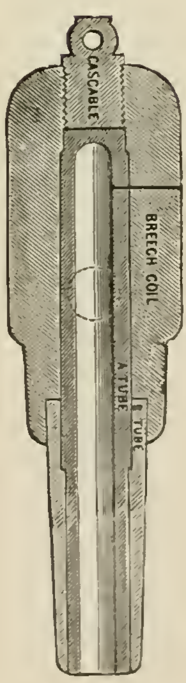

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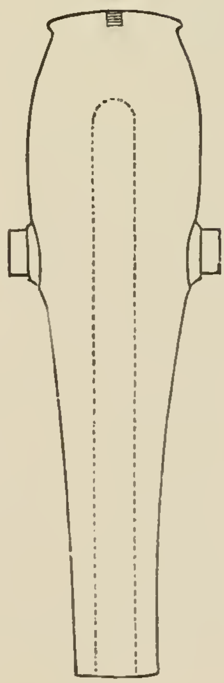

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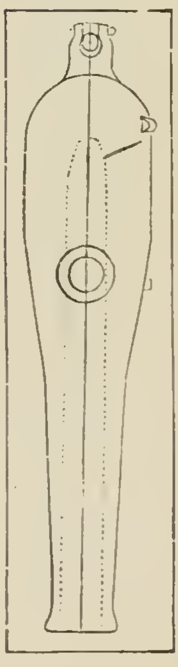
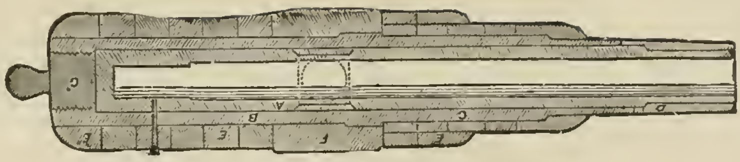


7

ORDNANCE.—1. Woolwich Gun. 2. Cannon—sectional view. 3. Parsons Gun. 4. Parrott Gun. 5, Fraser 9-inch Gun. 6. Rodman Columbiad. 7. Dahlgren Gun.



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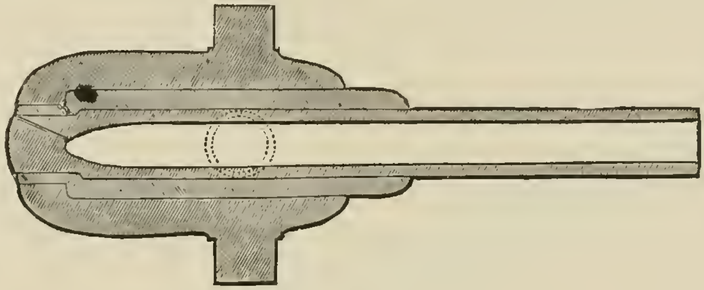

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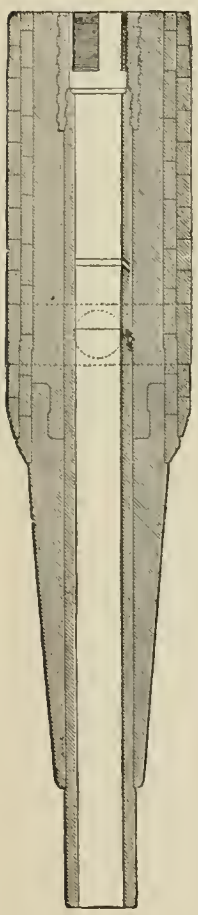
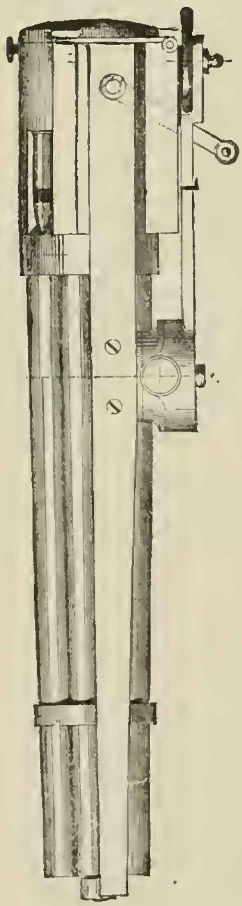
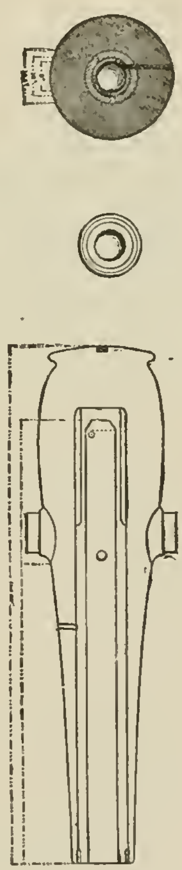
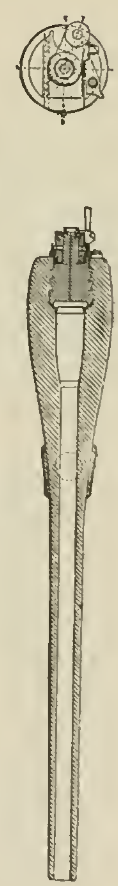


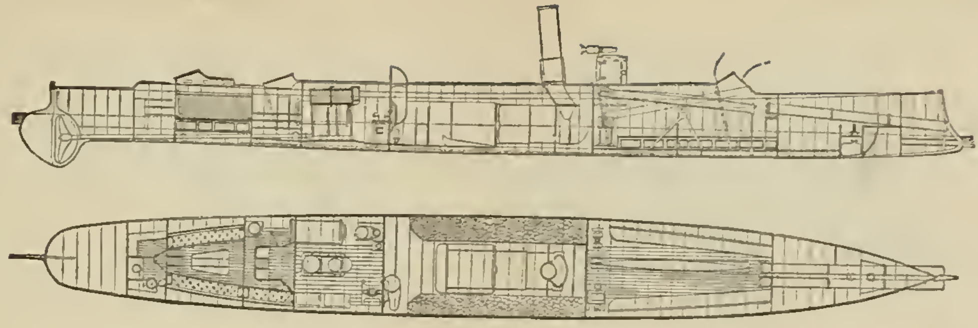






5 6 8

ORDNANCE.—1, Napoleon Gun. 2, Built up Gun. 3, Blakely Gun. 4, Light Field-gun. 5, Improved Steel Gun—*Tubage.* 6, Hotchkiss Revolving-cannon—Barrels and Casing. 7, Eight-inch Rifle, U. S. Pattern. 8, Whitworth Gun.



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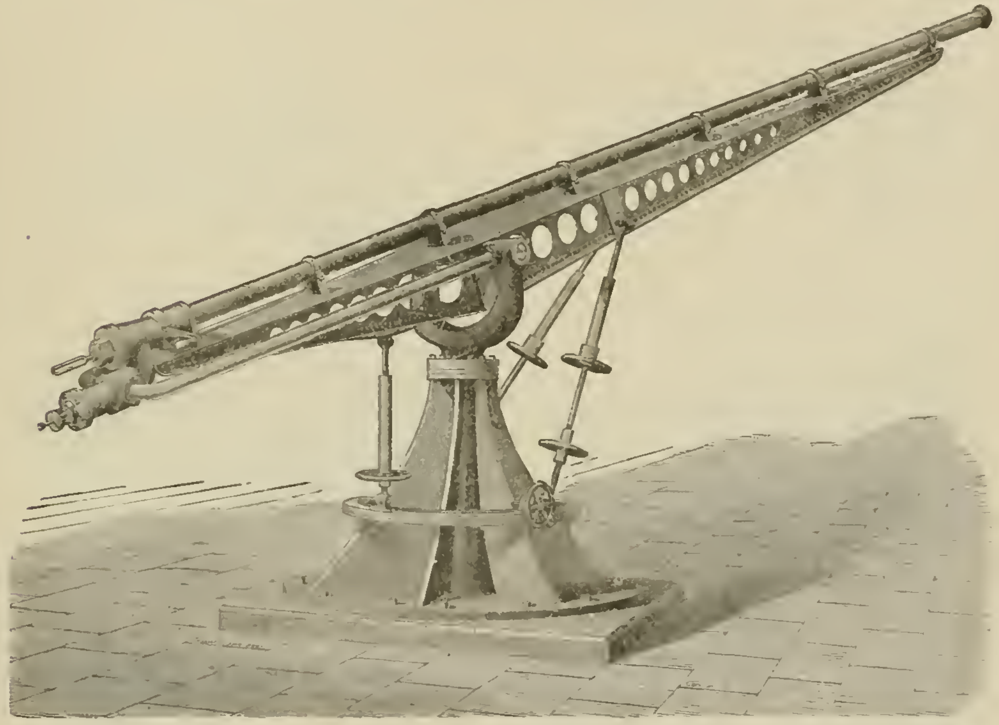

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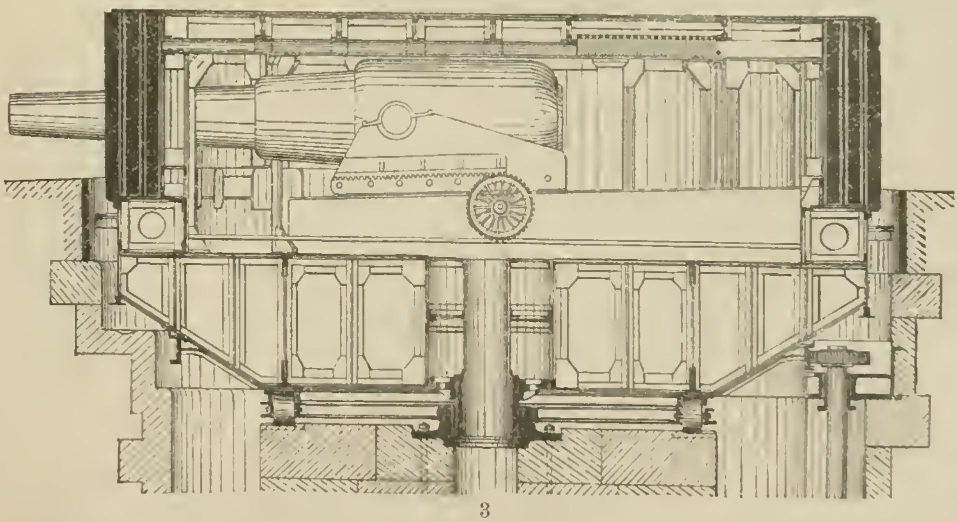
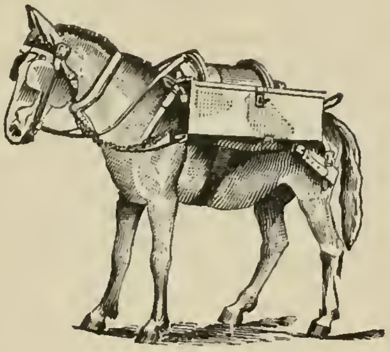


3

ORDNANCE.—1. Torpedo Boat—Built for the Danish Government. 2. Dynamite-gun. 3. Armored Defense—Turret for two 80-ton Guns.



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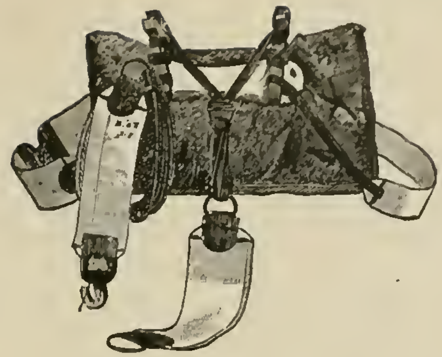

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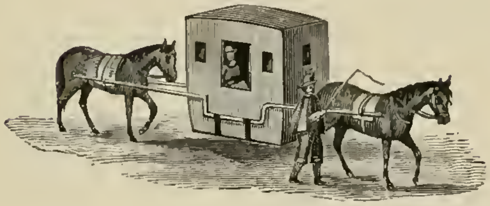

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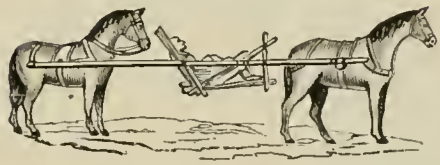

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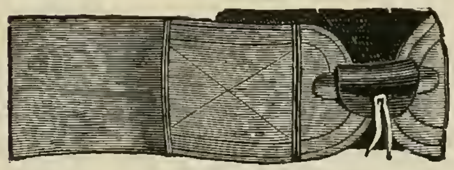

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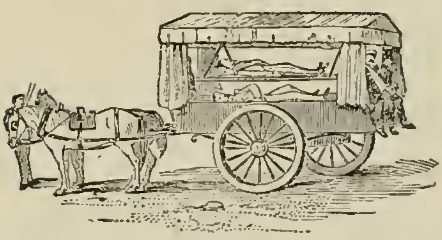

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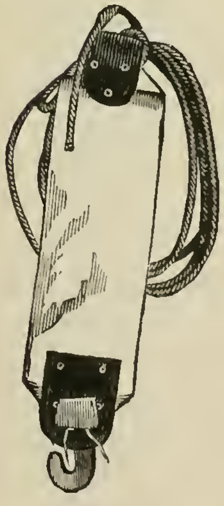

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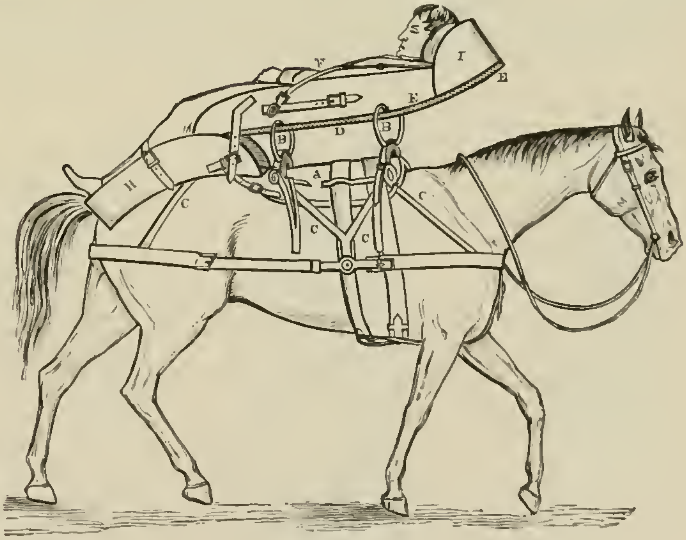
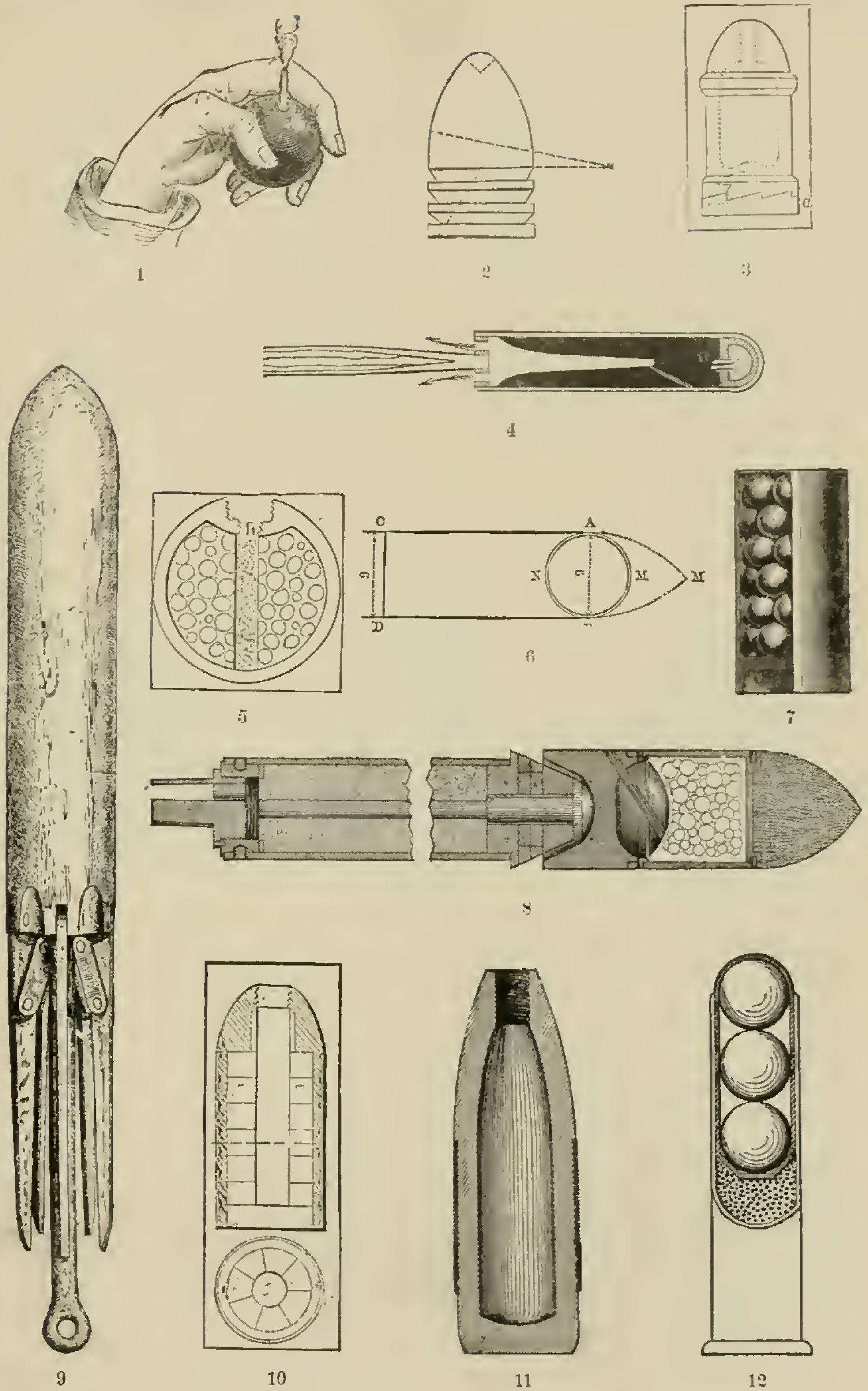
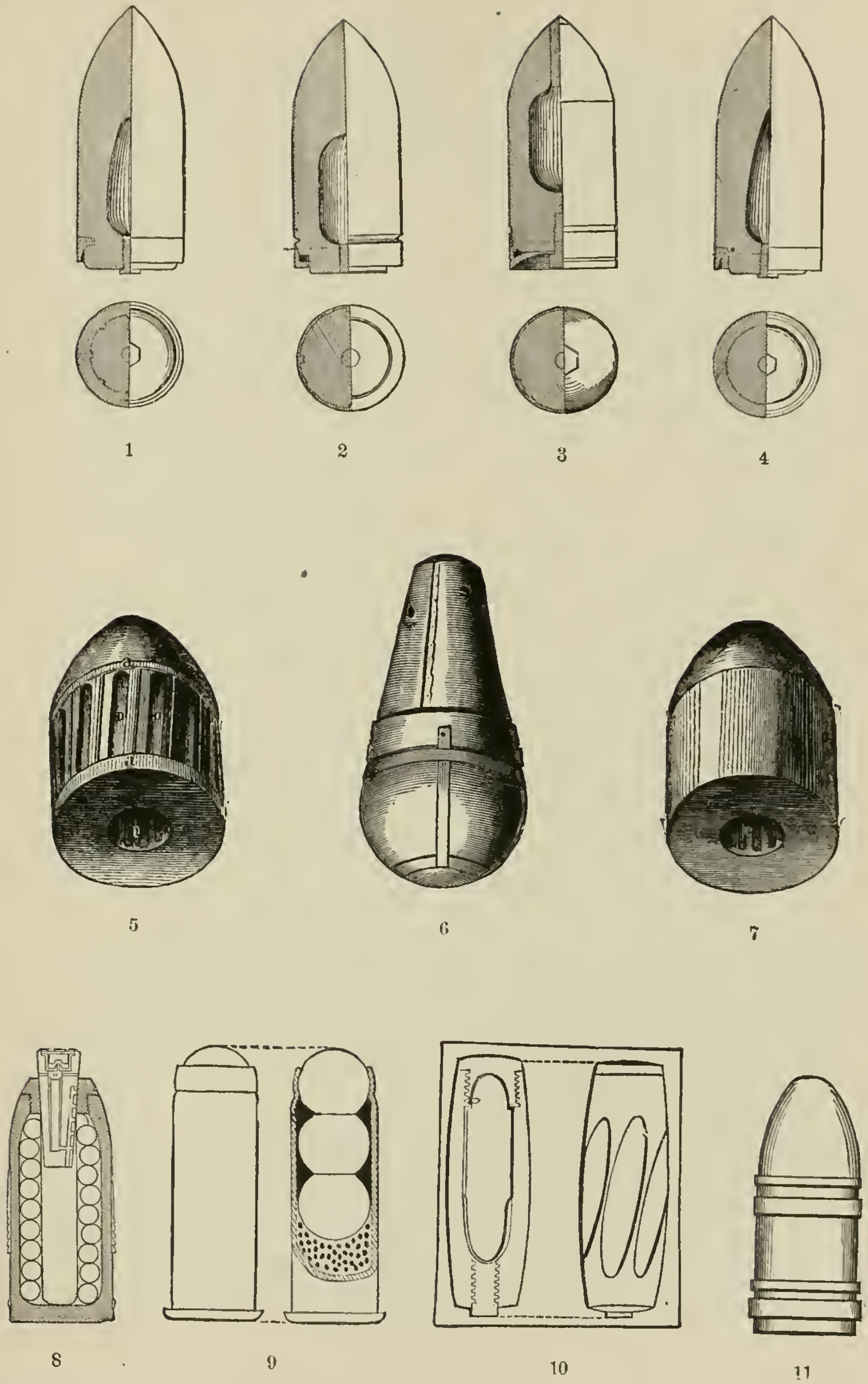


8

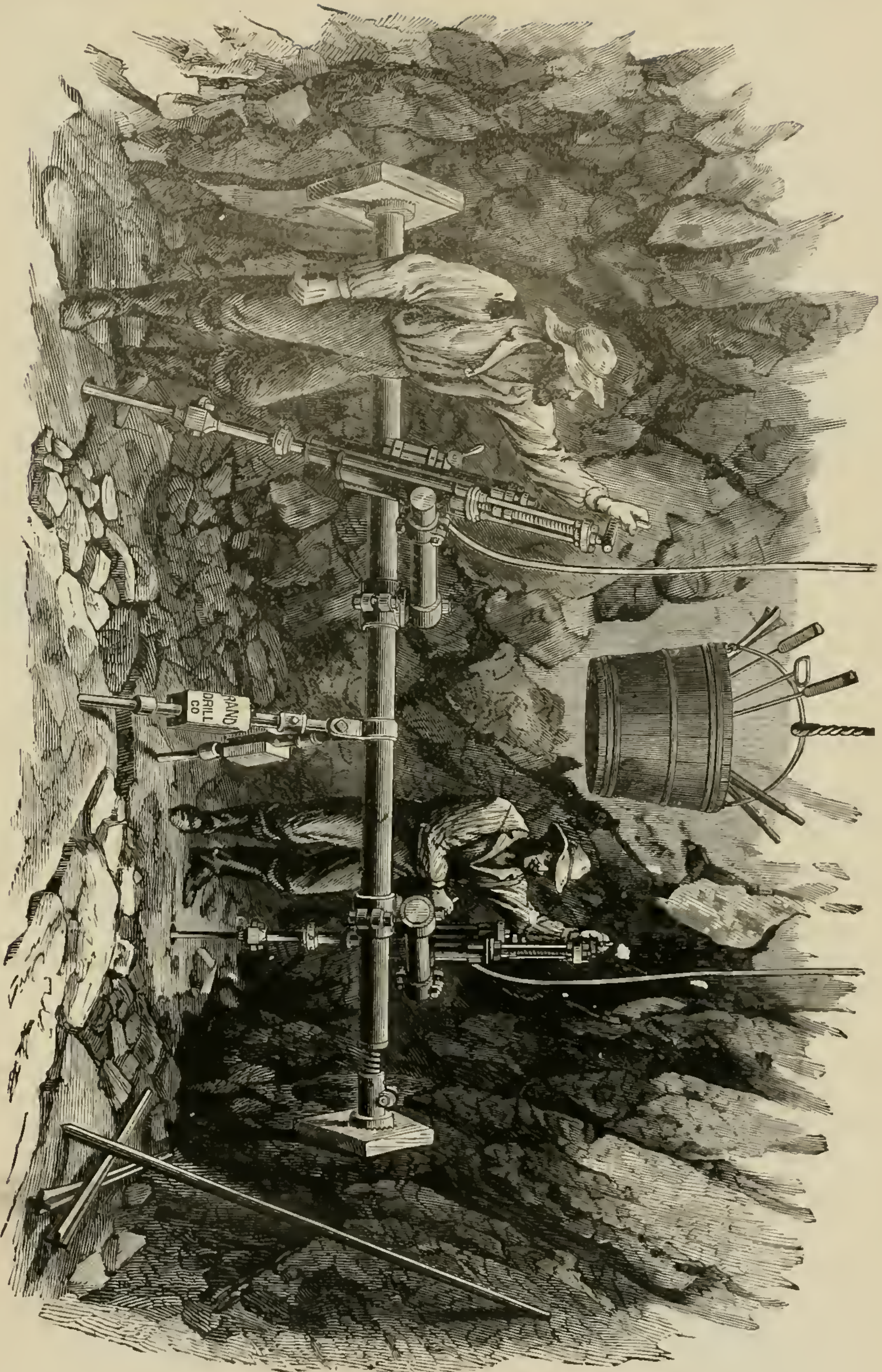
PACKING.—1, Packing-gear for Machine-guns or Mountain Artillery. 2, Cross-tree Pack-saddle. 3, Palanquin. 4, Two-horse Litter. 5, Crouper. 6, Guthrie Ambulance Cart. 7, Lash-rope and Cinch. 8, Thistle Litter, and Packing-gear.



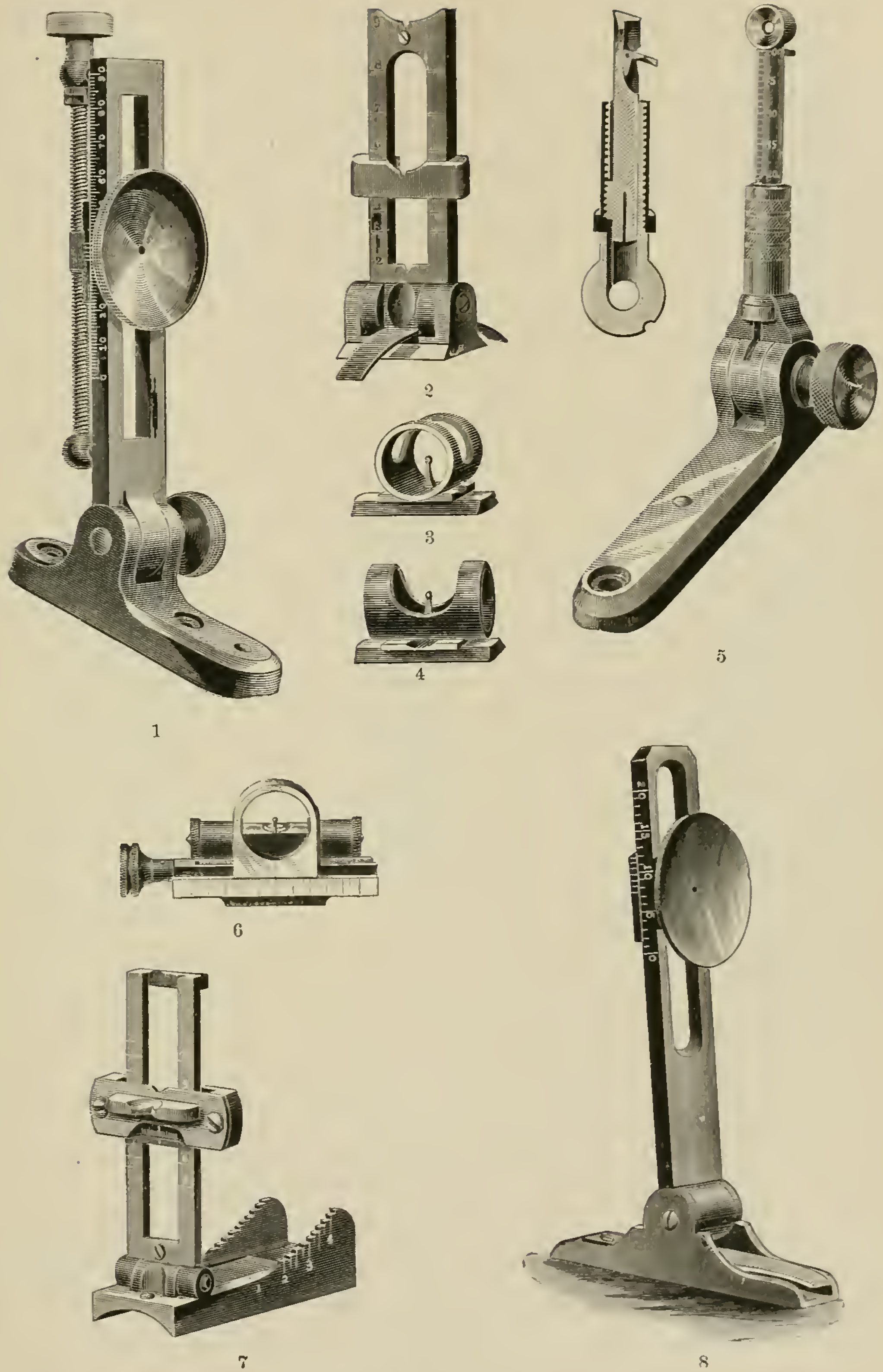
PROJECTILES.—1, Hand-grenade. 2. Oblong Bullet. 3. Confederate Projectile. 4. Signal-rocket. 5. Spherical Case-shot. 6, Elongated Projectile. 7. Rifle-canister. 8. MacDonald's Hale Rocket. 9, Lyle-Emery Grapple-shot. 10. Armstrong Projectile. 11, Hotchkiss Shell. 12. Multiball Cartridge.



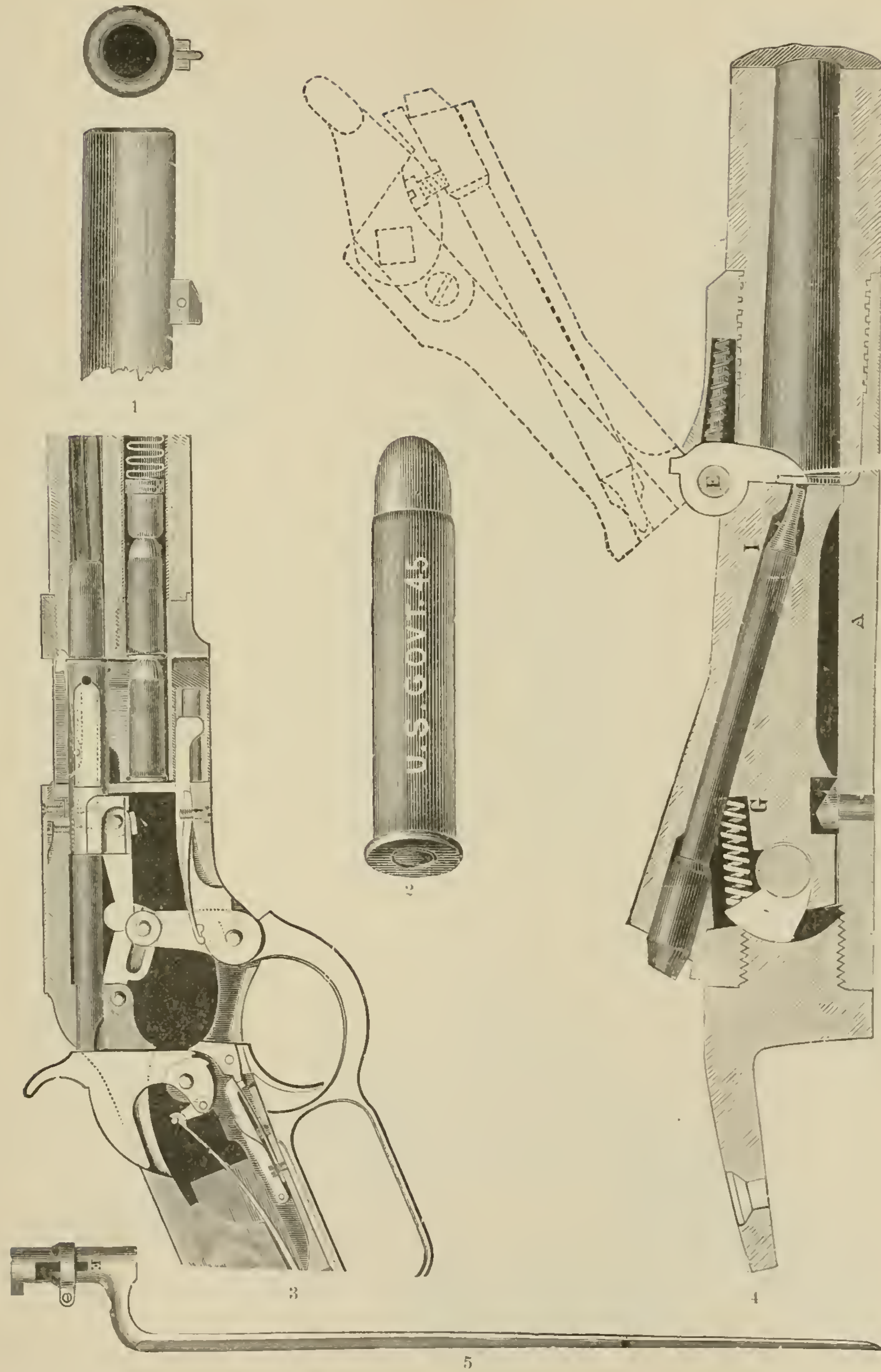
PROJECTILES.—1, Parrott Projectile. 2, Dana Projectile. 3, Arrick Projectile. 4, Butler Projectile. 5–7, James Projectile—before and after Application of the Packing. 6, Stand of Ammunition. 8, Rifle-shrapnel. 9, Wright Multiball Cartridge. 10, Whitworth Projectile. 11, Coated Projectile.



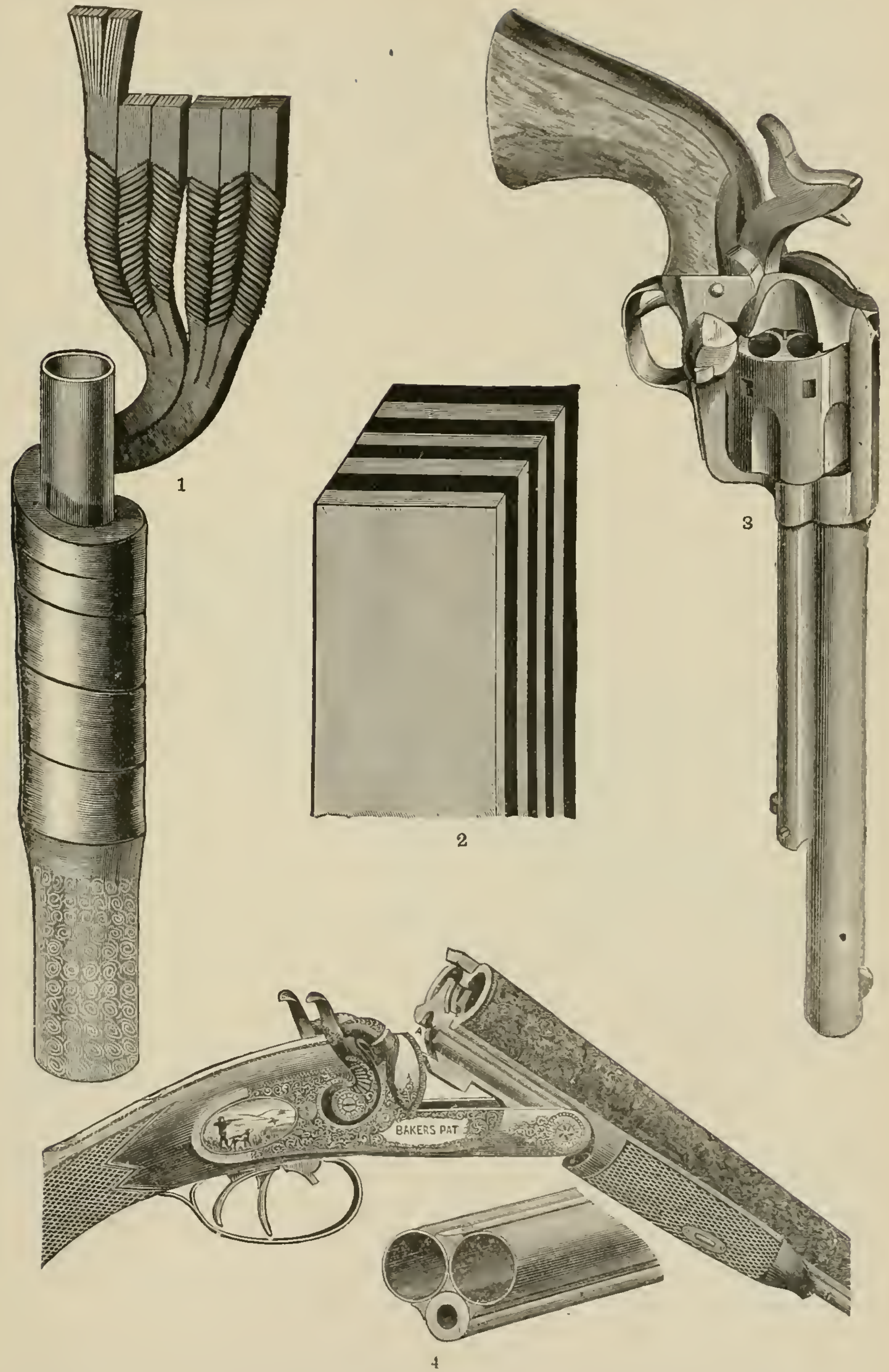
ROCK DRILL.—Shaft-sinking by means of Rock Drills Mounted on a Duplex Swivel-jointed Bar.



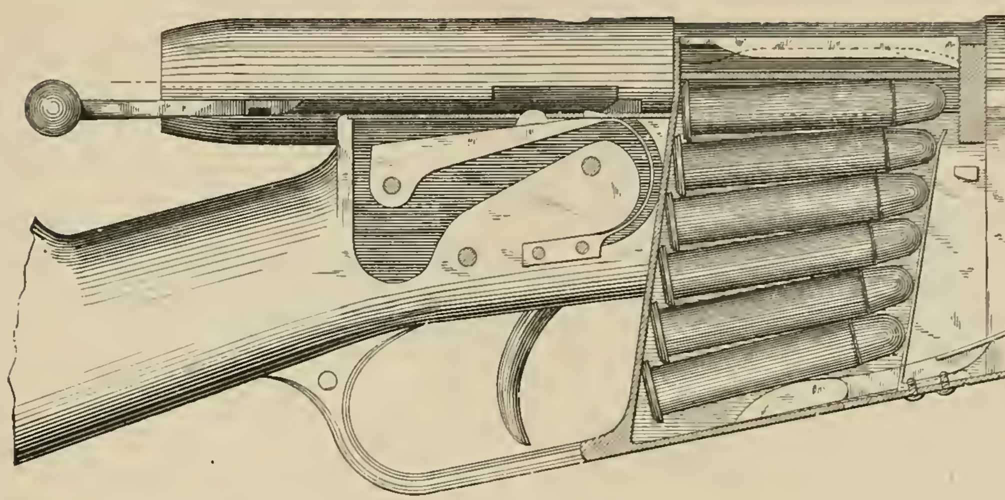
SIGHTS—1. Vernier and Peep Sight. 2, Musket Rear Sight 3. Reversible Sight, Closed. 4. Reversible Sight, Open. 5, Lyman Sight. 6, Front Sight and Wind-gauge. 7, Graduated Back Sight. 8. Peep Sight.



SMALL ARMS.—1, Front Sight, Springfield Rifle. 2, U. S. Cartridge, Caliber .45. 3, Winchester Rifle. 4, Springfield Rifle. 5, Triangular Bayonet, for Springfield Rifle.



SMALL ARMS.—1, Manufacture of Gun-barrels. 2, The Piling. 3, Colt Revolver. 4, Baker Gun, Rifle and Shot Combined.



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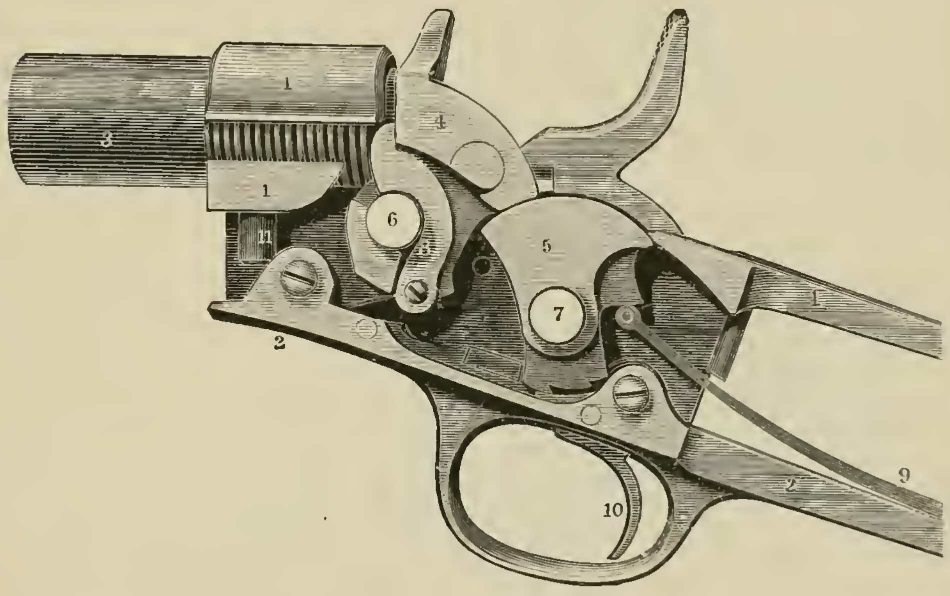

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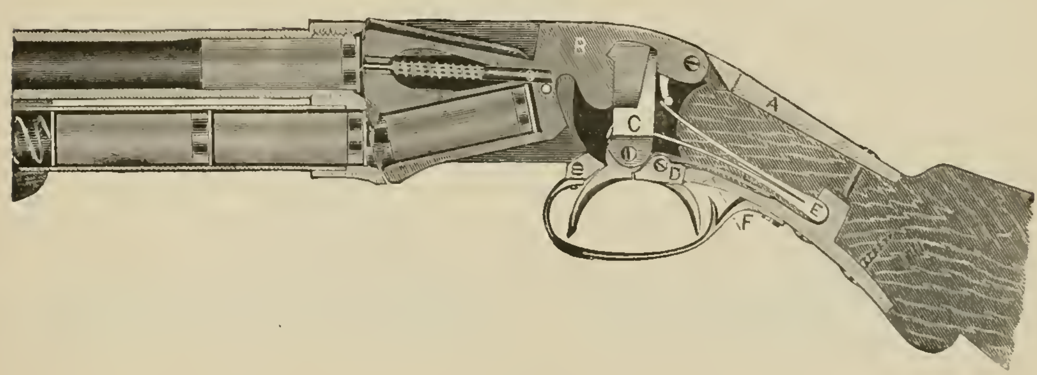

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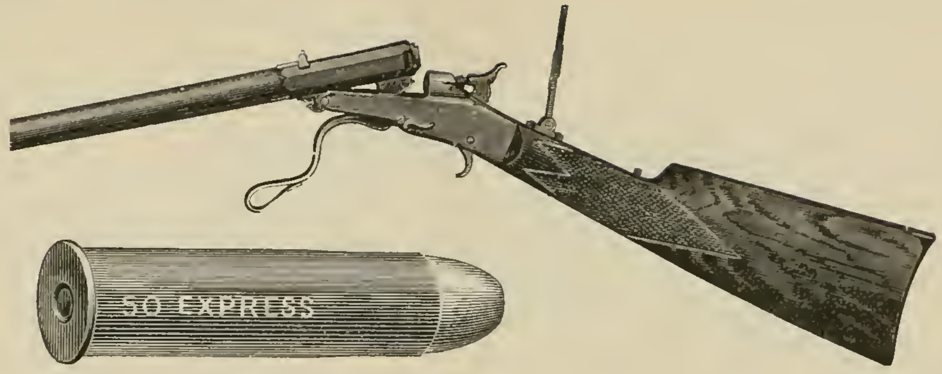
SMALL ARMS.—1, Russell Magazine-gun. 2, Whitney Rifle. 3, Spencer-Roper Gun.



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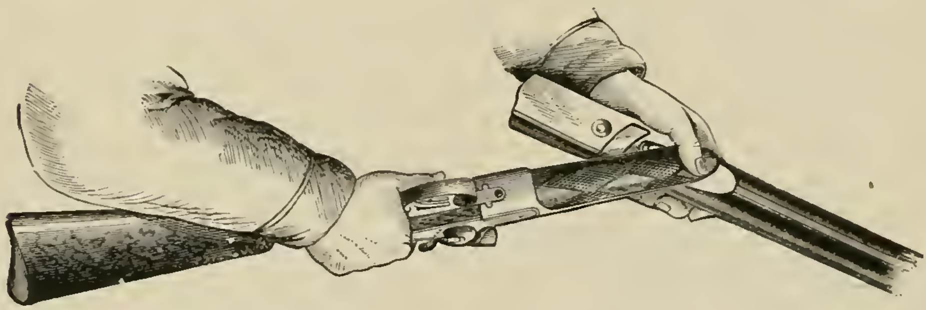

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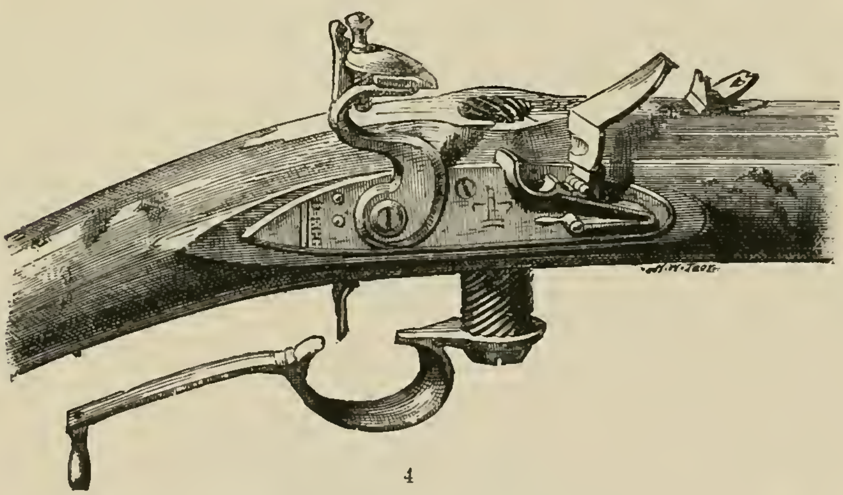

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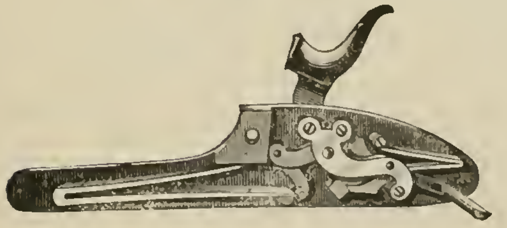

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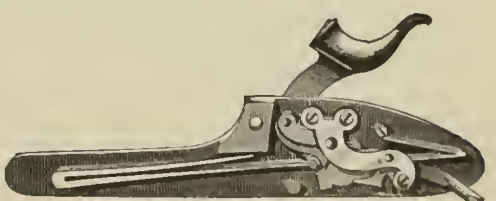

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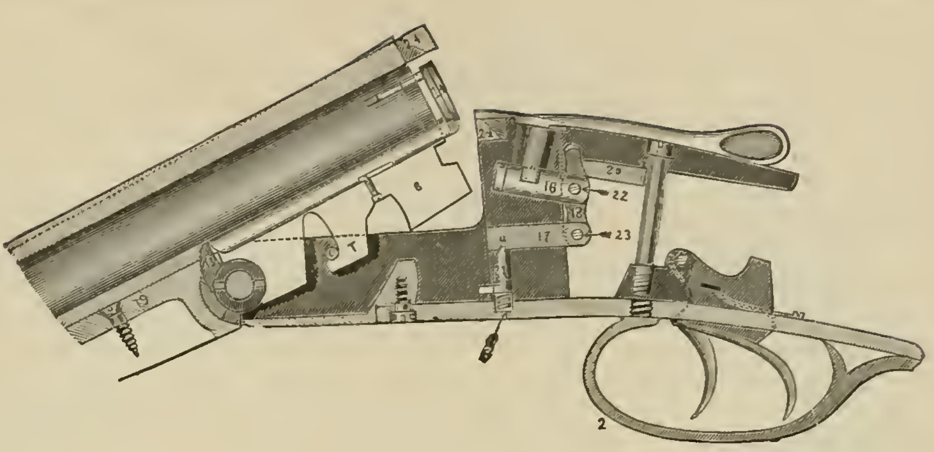
SMALL-ARMS.—Express Rifle Cartridge. 2, Maynard Rifle. 3, Fox Action. 4, Ferguson Rifle. 5-6, Gun-lock, half and full-cock.



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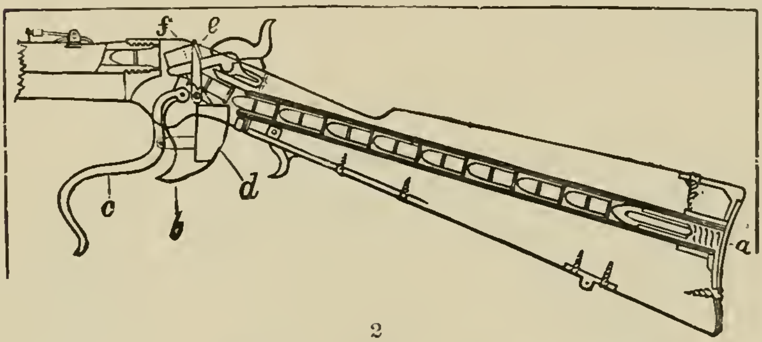

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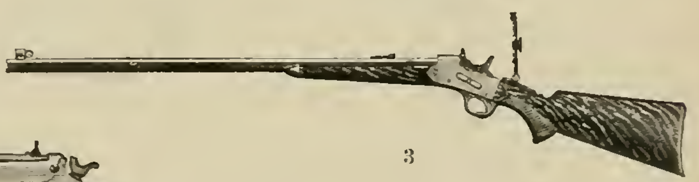

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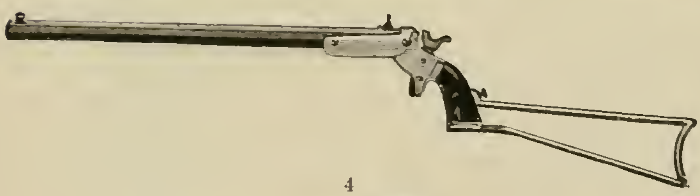

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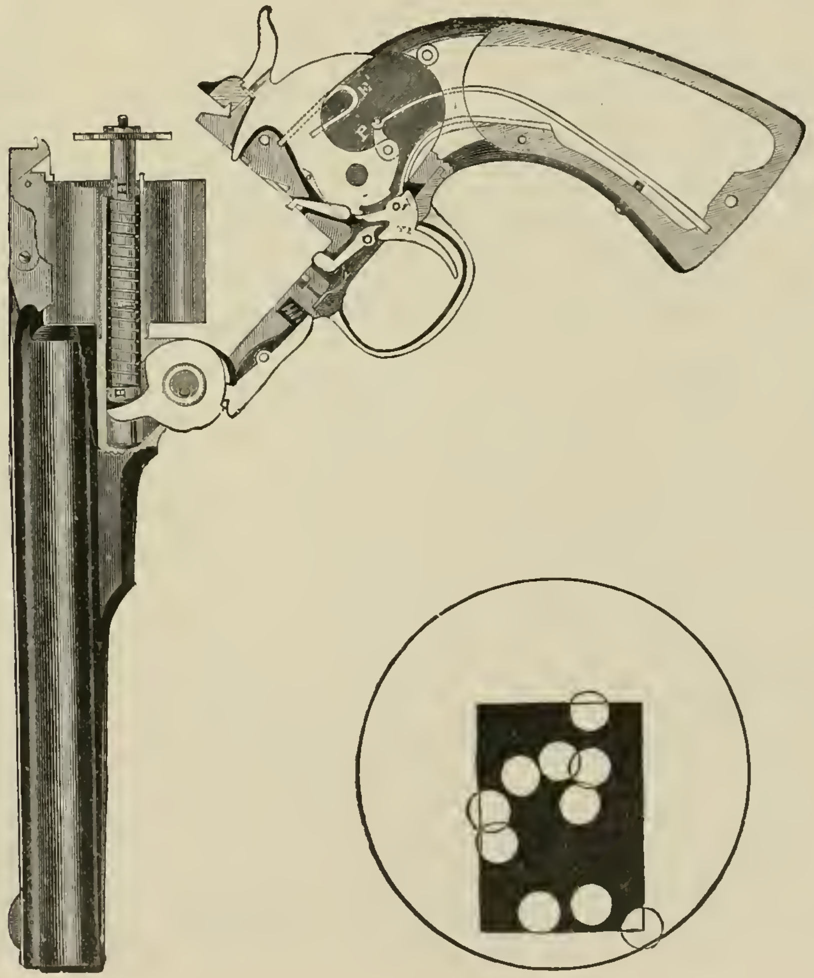
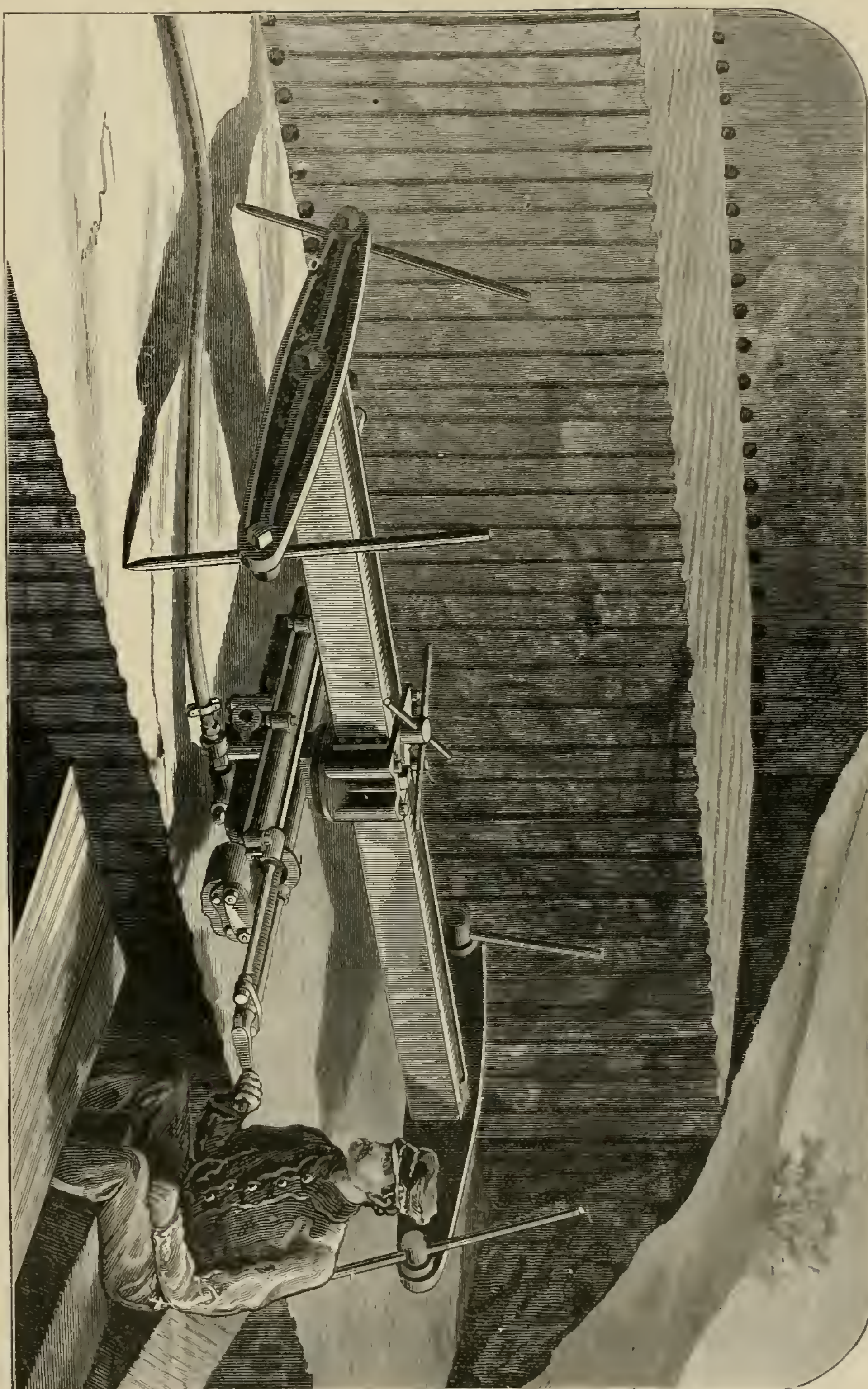
SMALL-ARMS.—1. Parker Gun. Section Showing Breech-action. 2. Spencer Rifle. 3. Pistol-grip. 4, Pistol Carbine. 5. Hammerless Gun.

1

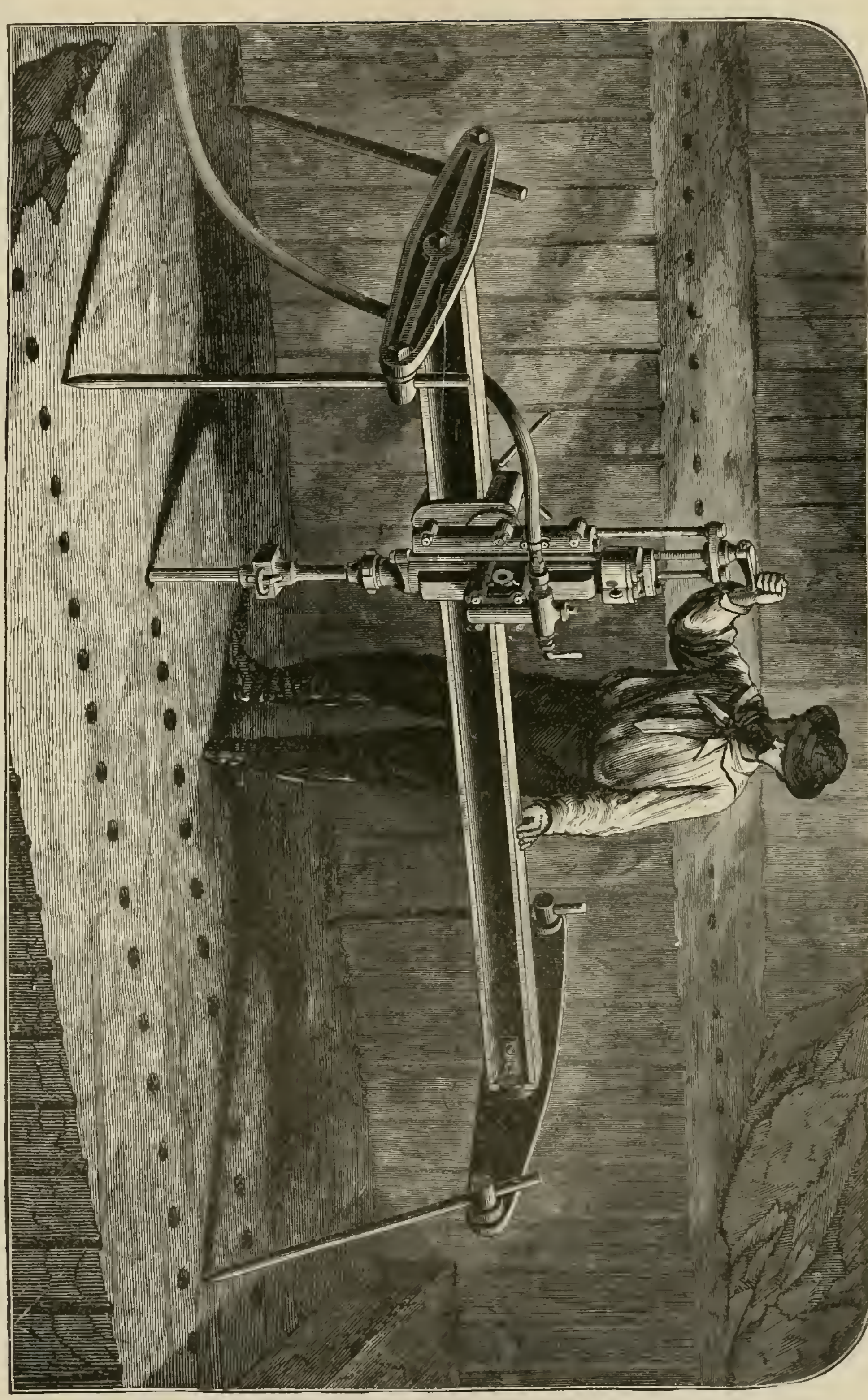


2 3

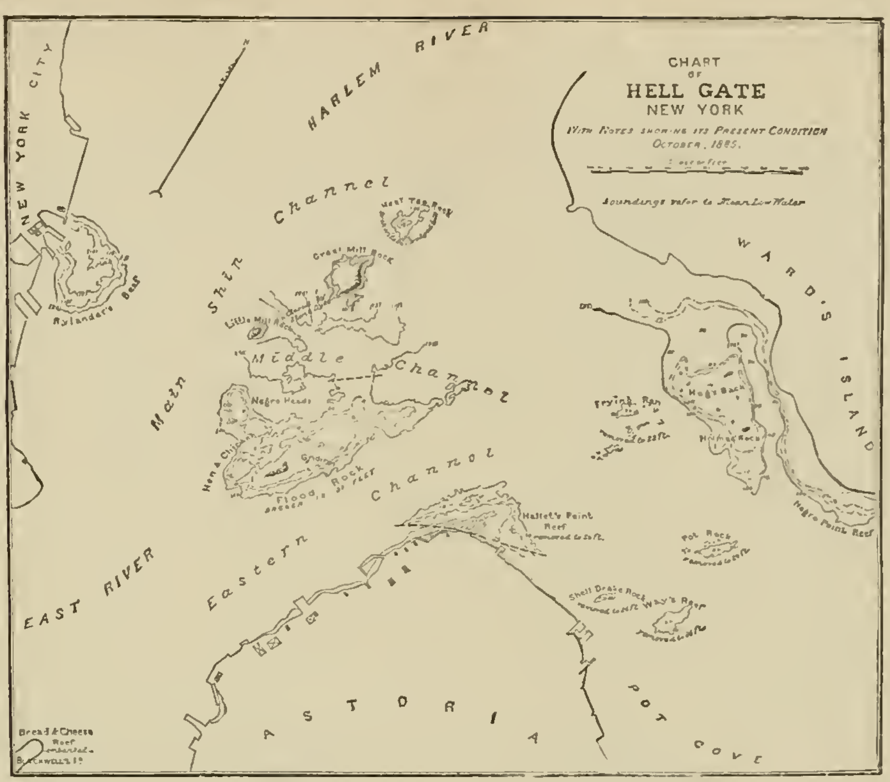
SMALL–ARMS.—1. Smith and Wesson Revolver. 2. Schofield-Smith and Wesson Revolver. 3. Target at Close Range.



STONE-CUTTING.—Quarry Bar in position for drilling Horizontal Holes.



STONE-CUTTING.—Quarry Bar in position for drilling Vertical Holes.



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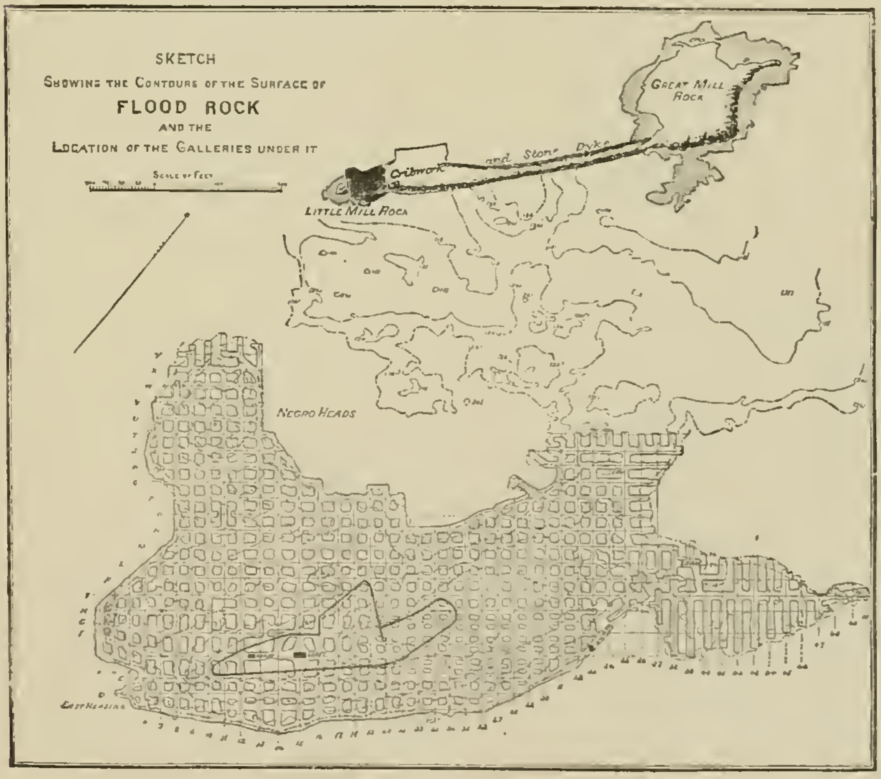
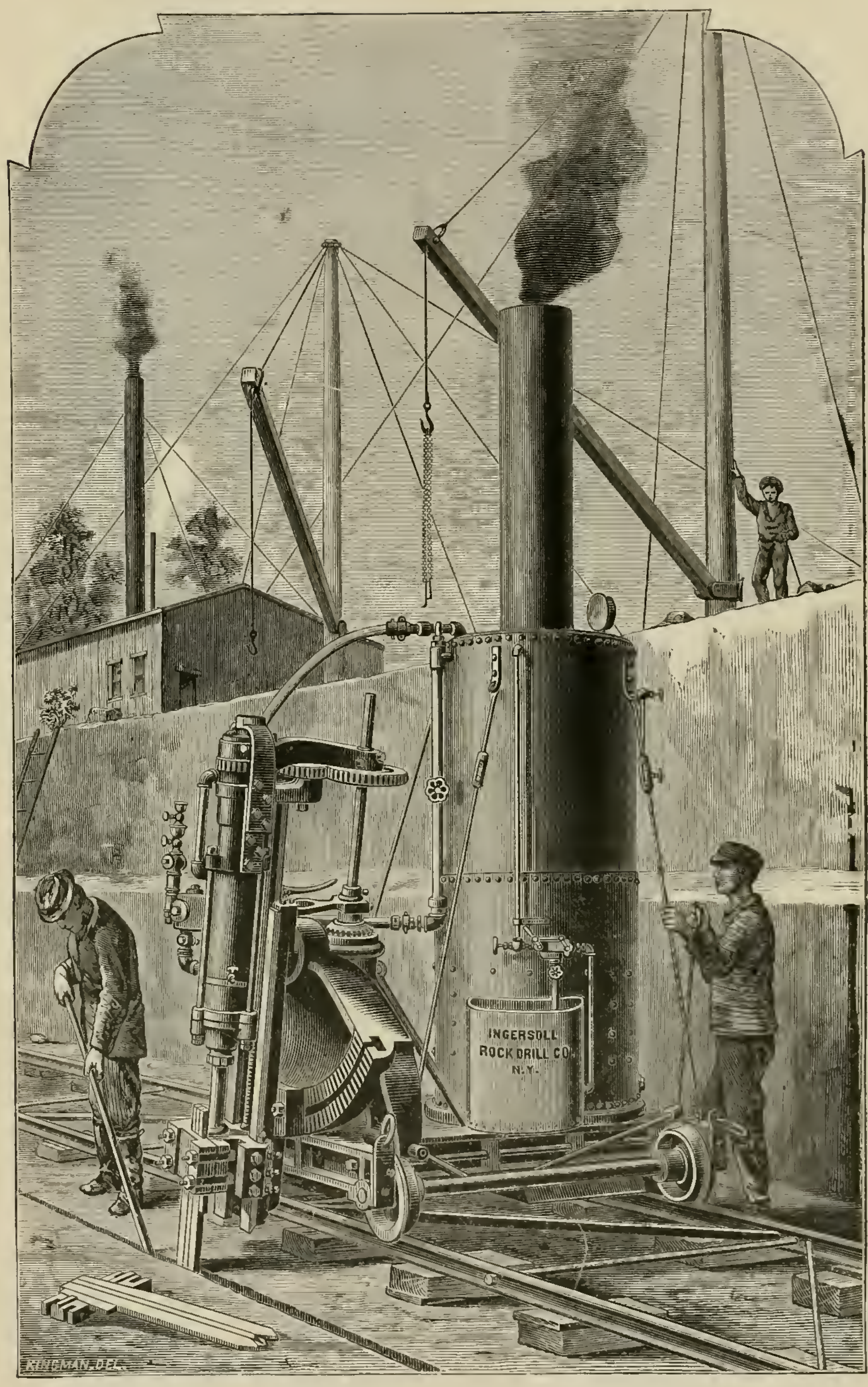
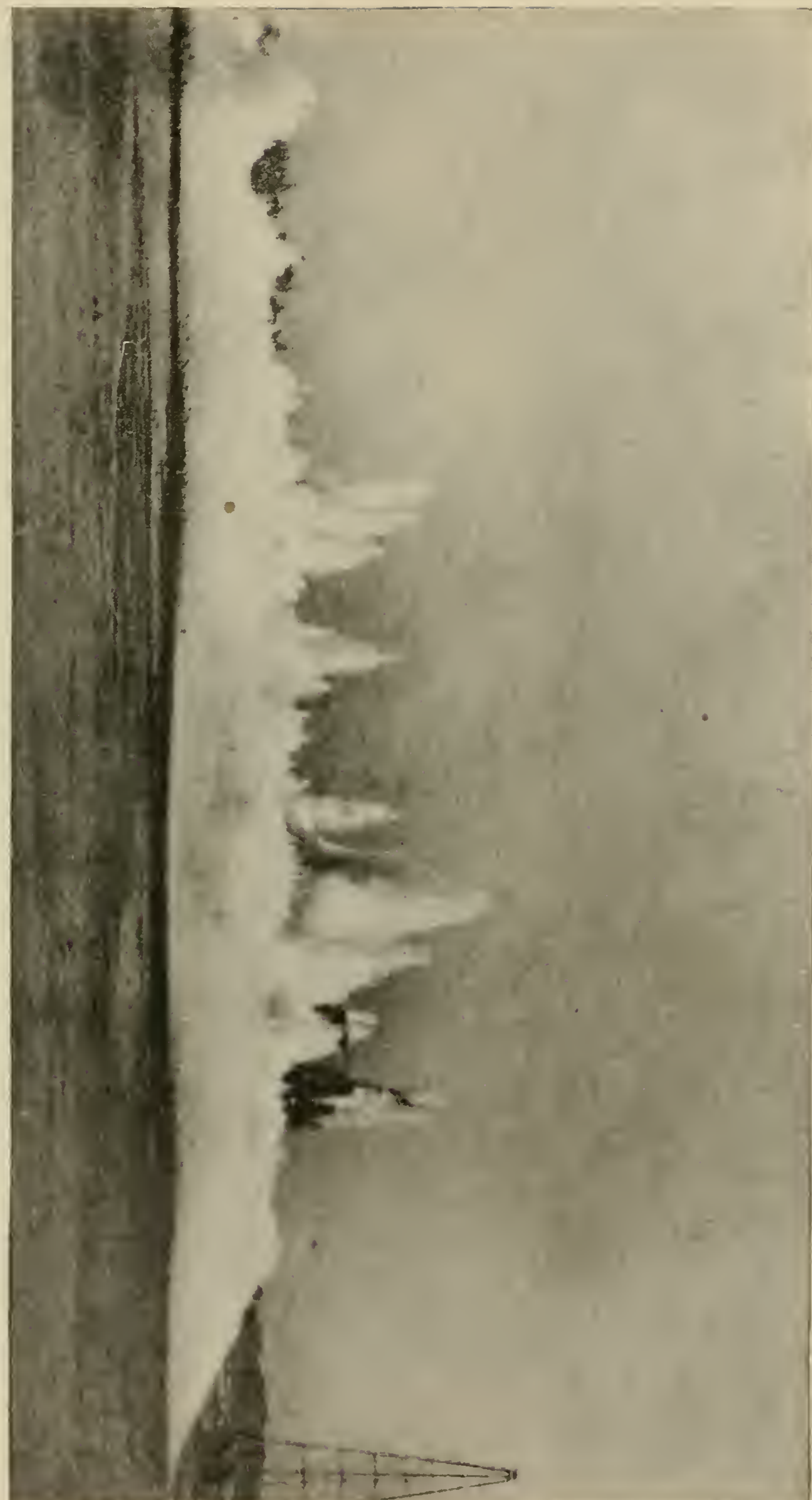


2

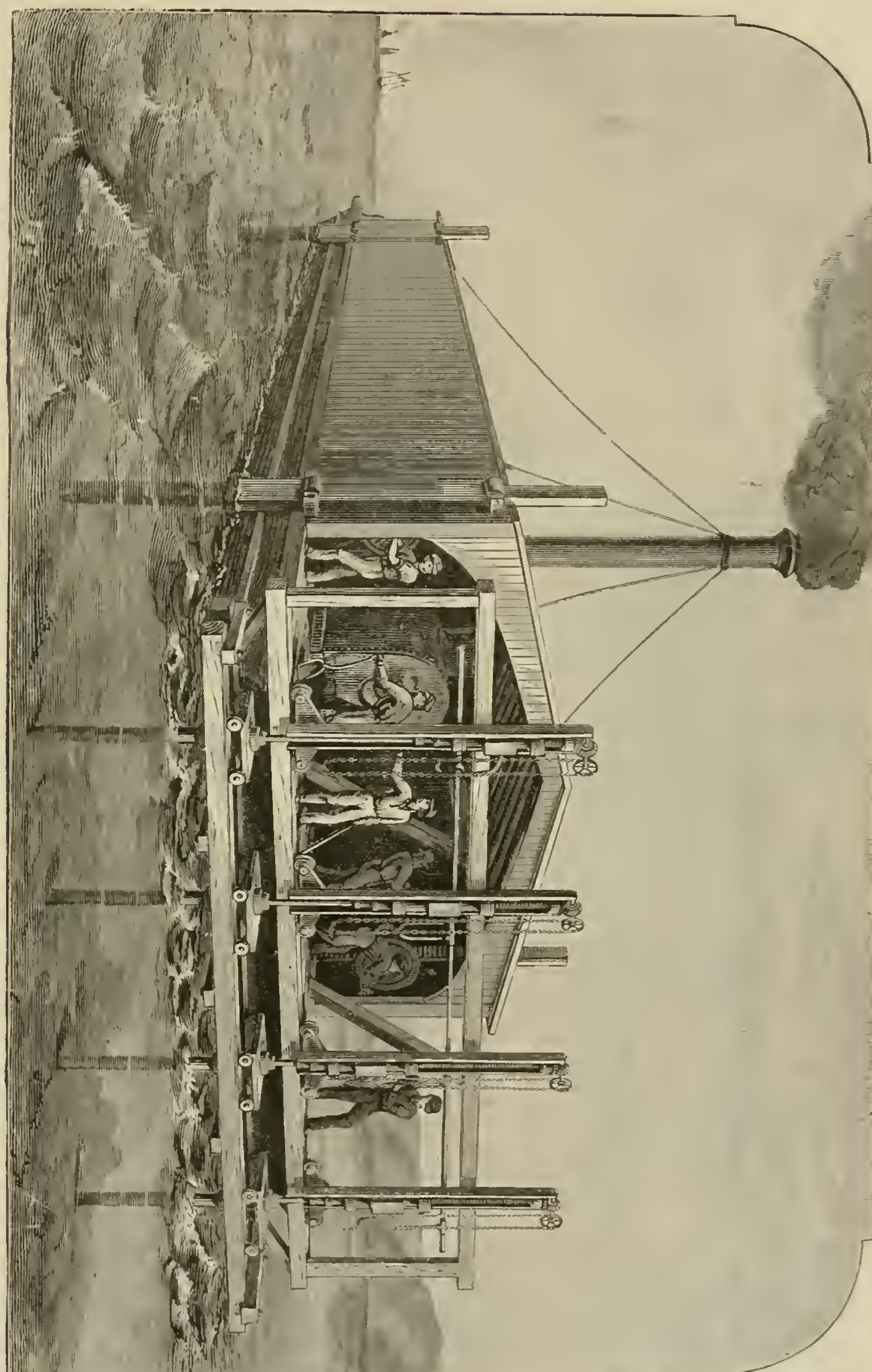
SUBMARINE BLASTING.—1. Chart of Hell Gate, New York. 2. Location of Galleries under Flood Rock, New York.



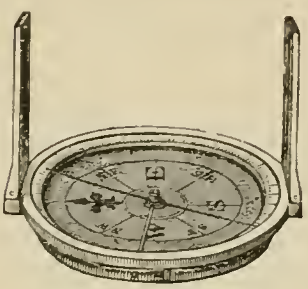
STONE CUTTING.—Stone Channeler, Arranged for Cutting long, narrow channels in rock for the purpose of freeing the sides of large blocks of Stone.



SUBMARINE-BLASTING.—Flood Rock Explosion, October 10th, 1885. From a Photograph taken soon after the Water commenced to Rise. Location of Camera about 1,300 feet South-west of Explosion. Explosive used 240,000 pounds of Rackarock. Area of Explosion 9⅓ Acres.



SUBMARINE DRILLING. Drill Scow as used at Hell Gate for Submarine-drilling.



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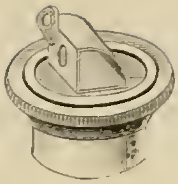

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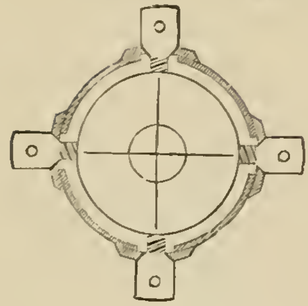

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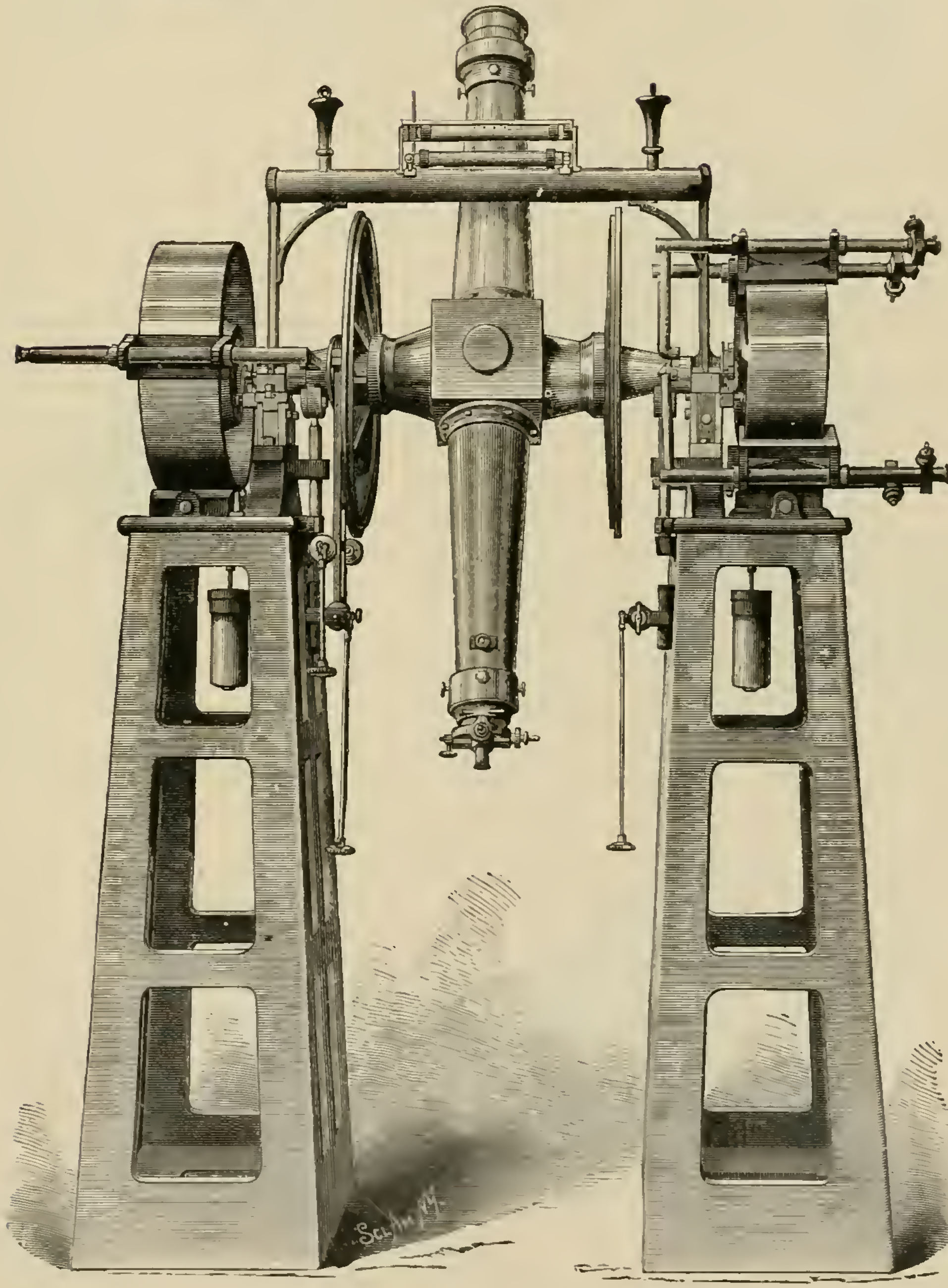
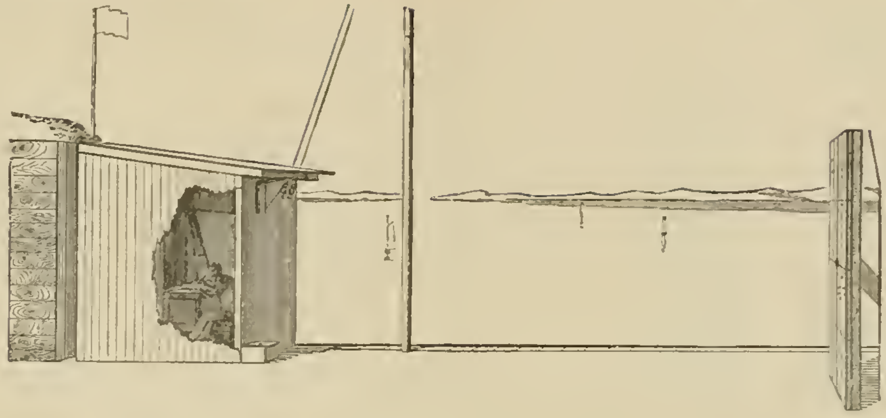


4.

SURVEYING.—1. Plain Compass. 2. Eye-piece. 3. Cross-wires of Telescope. 4. Transit Instrument.



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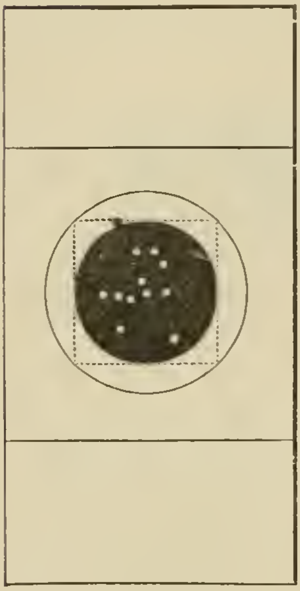

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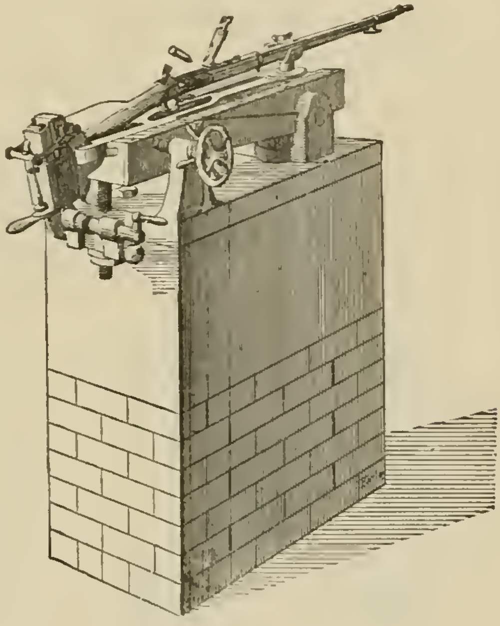

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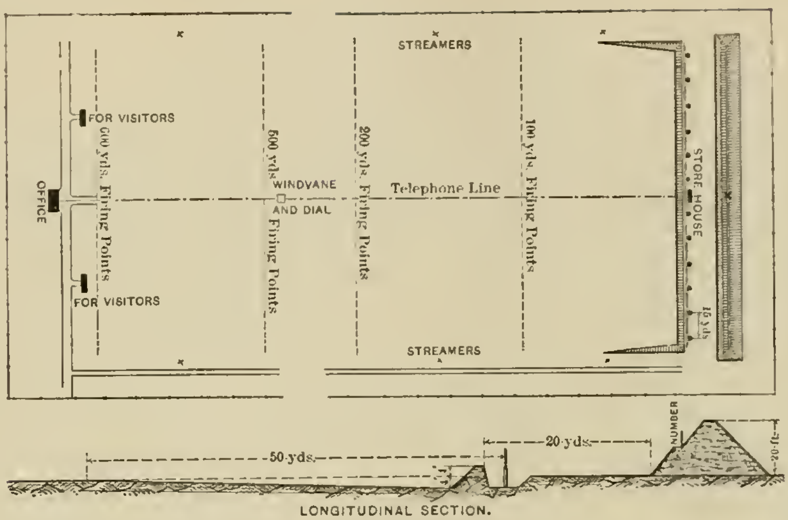
4

TARGET PRACTICE. -1. Range Fixtures. Arrangements for recording Shots, etc. 2. Long Range Target. 3. Improved Gun Rest and Sighting Stand. 4. Back Position for Long Range Firing.



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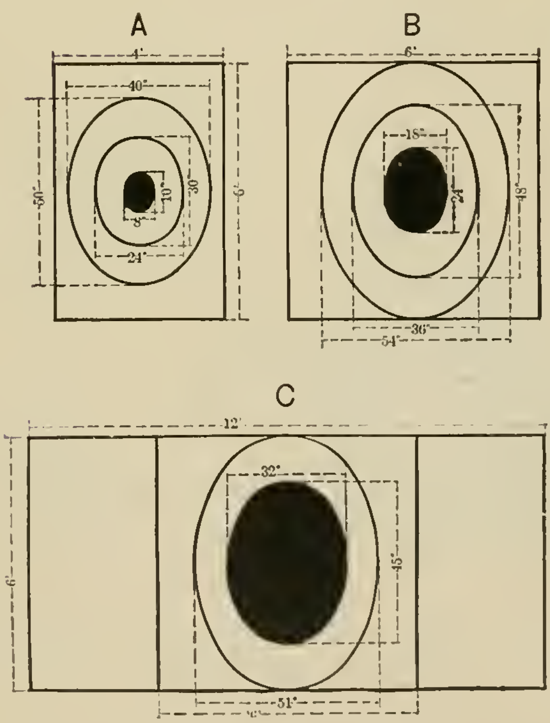

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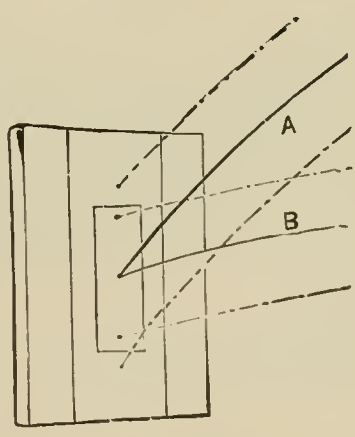
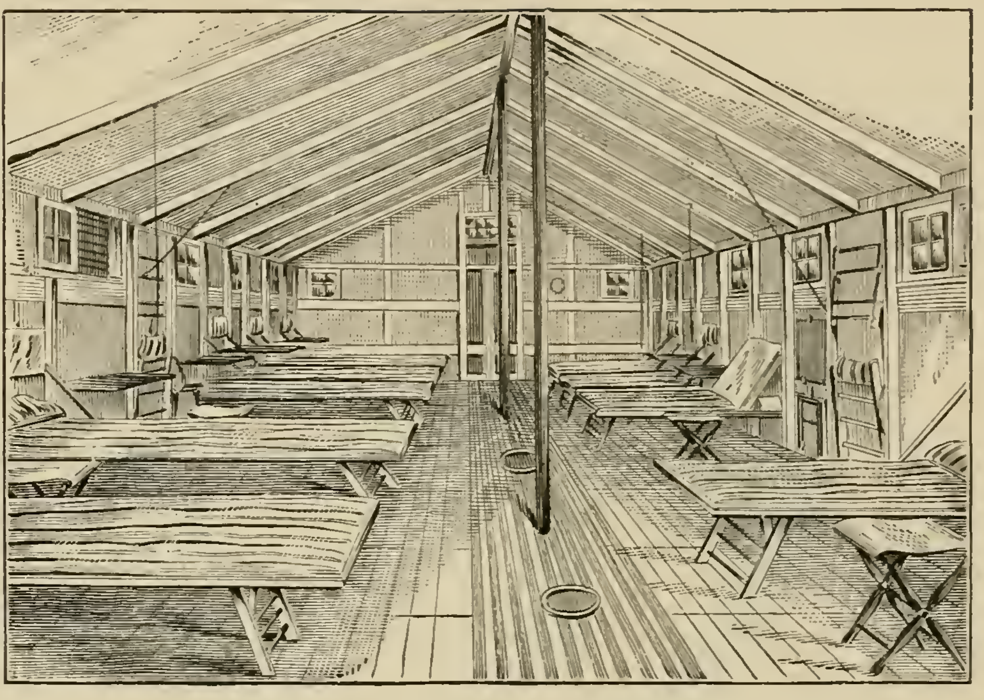


5.

TARGET PRACTICE.– 1, Range, Plan and Section. **2,** Front-sight Discs. 3, Target for Volley and File Firing. 4, Regulation Targets Classes A, B, and C. 5, Circular Target. 6, Descending Branch of Trajectory and Effect of Shots.



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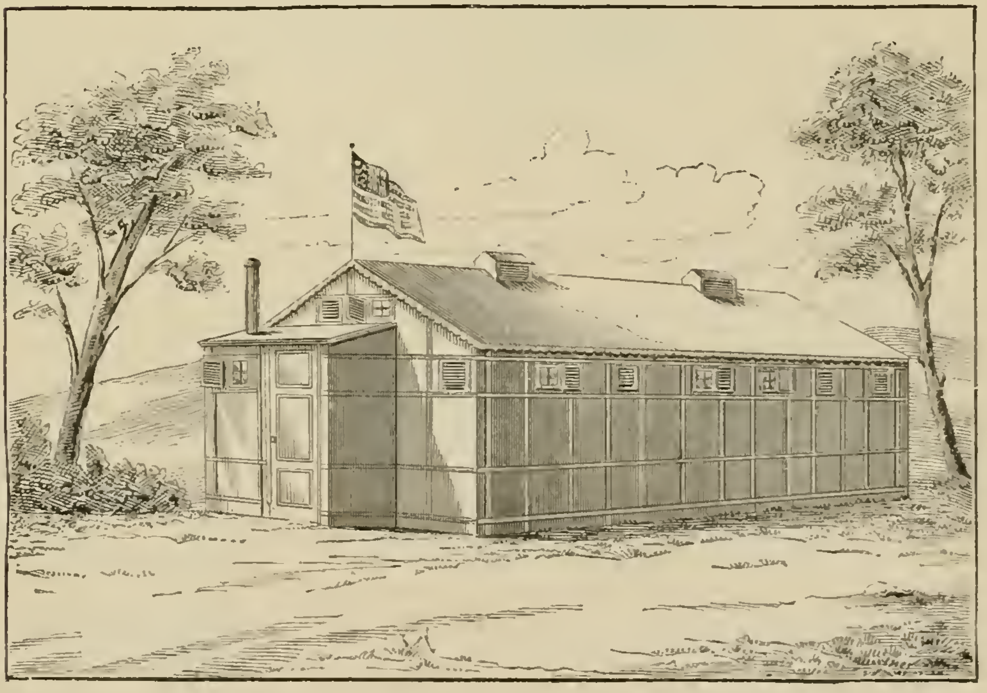

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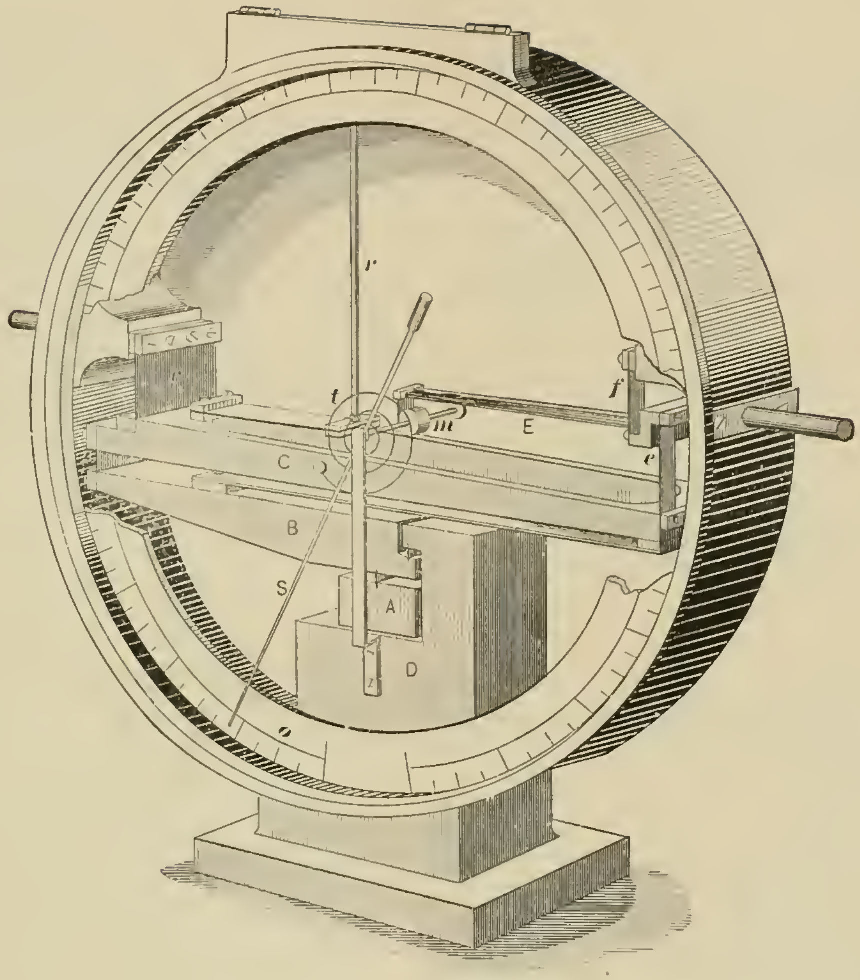
TENT.—1, Ducker Hospital Tent and Barrack—Inside View. 2, Exterior View



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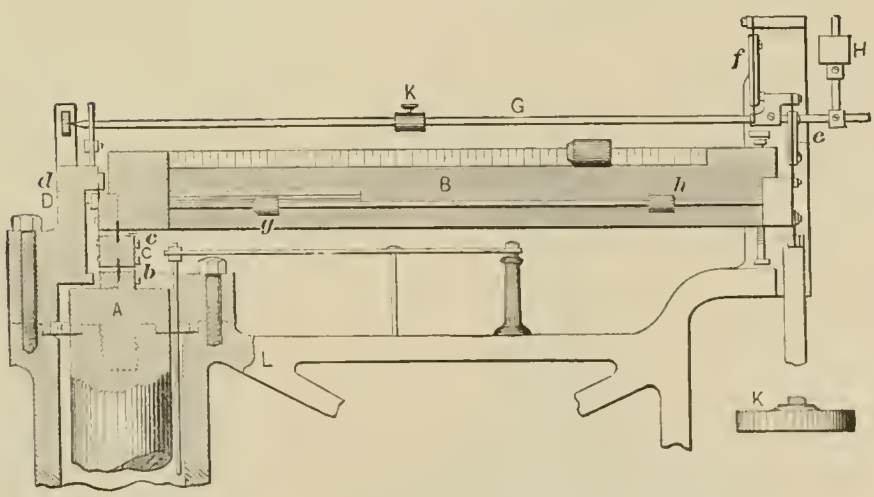
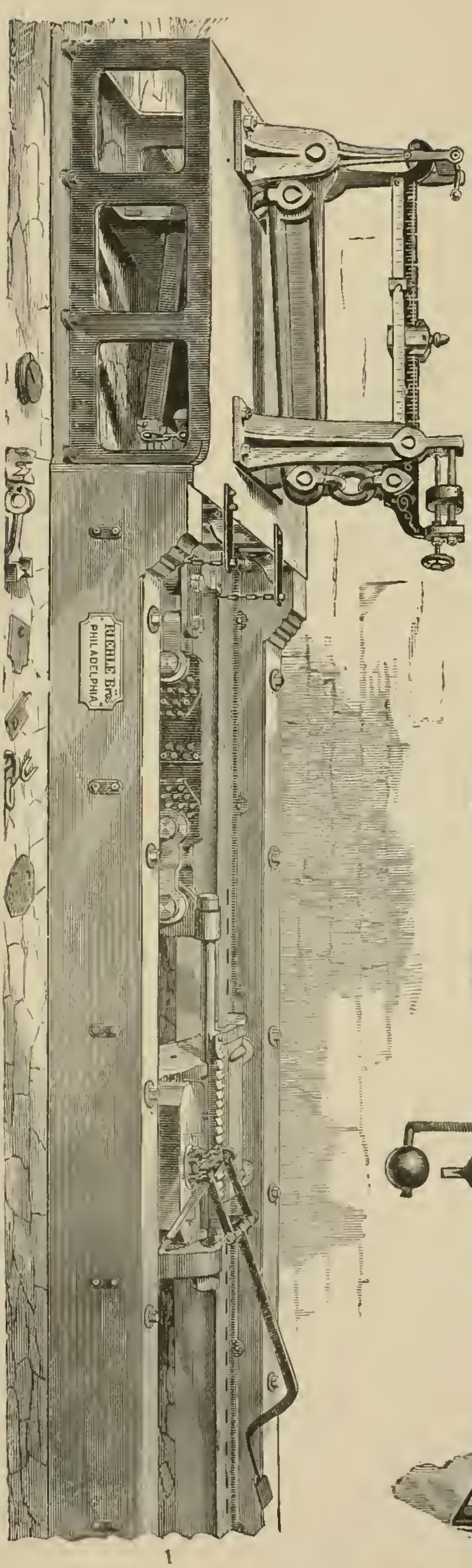


2

TESTING MACHINES.—1, Pressure gauge. 2, Arrangement and Application of Fulcrums.



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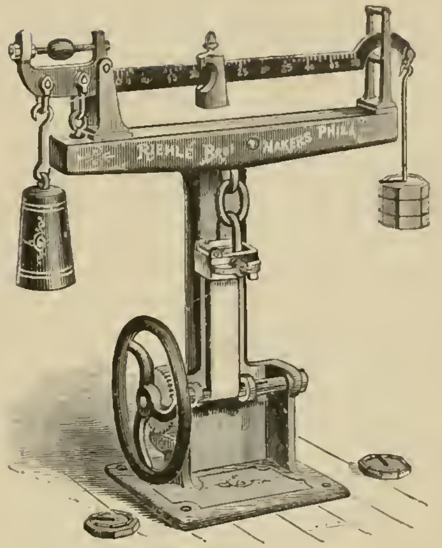

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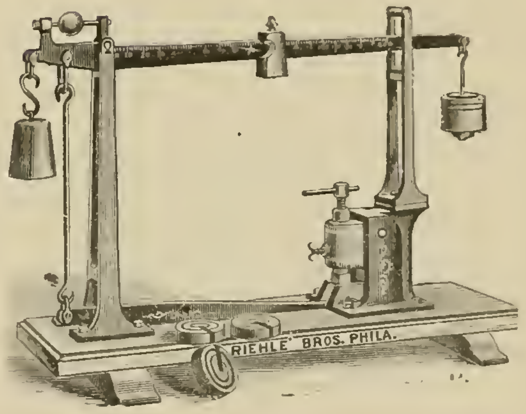

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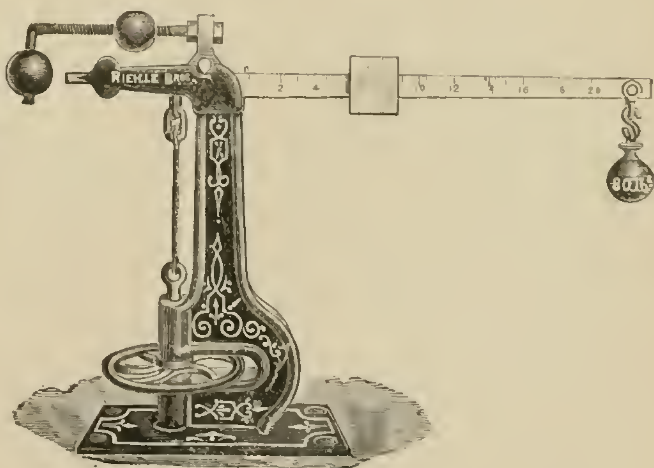

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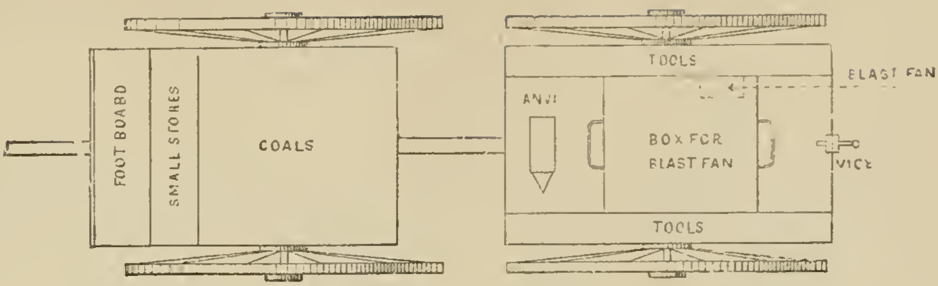
TESTING-MACHINES.—1, Horizontal Testing-machine. 2, Cement-tester. 3, Cloth-tester. 4, Twine-tester.



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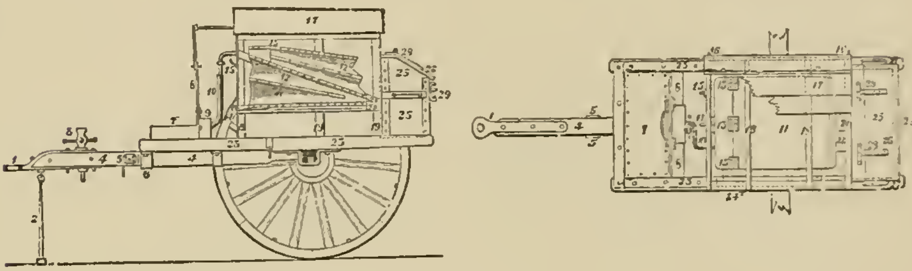

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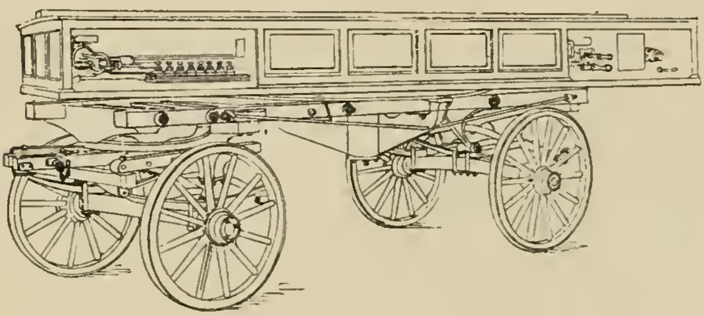

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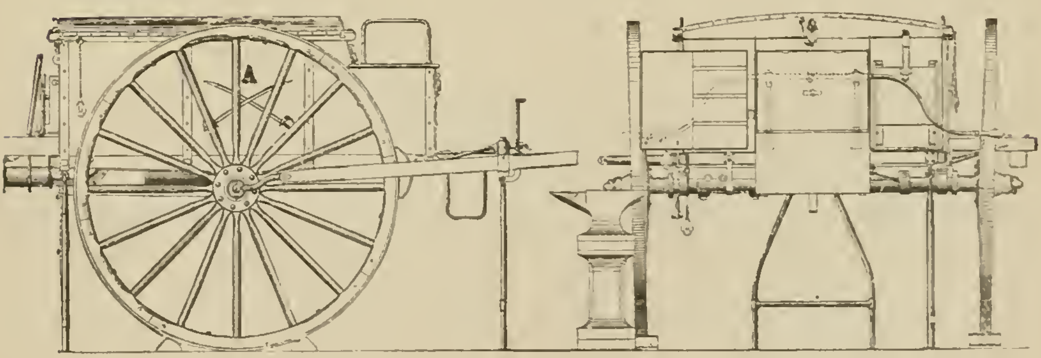
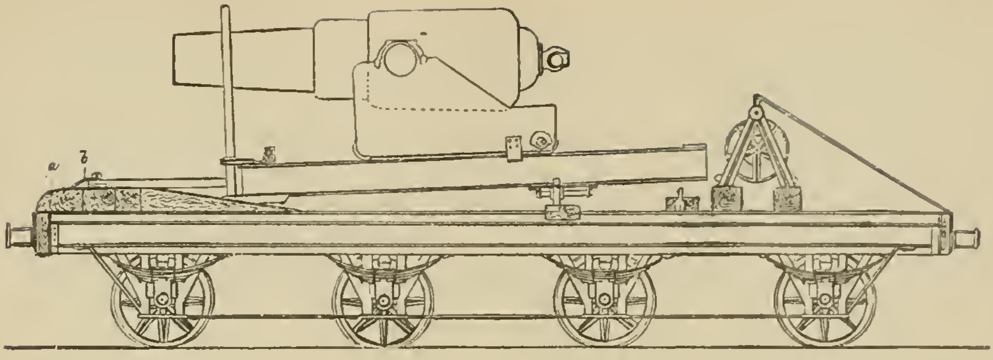


4

TRAVELING CARRIAGES.—1, Swedish Field-forge. 2. Traveling-forge, U. S. Pattern 3, Berdan Telemeter Wagon, No. 6. 4, Laidley Cavalry-forge.



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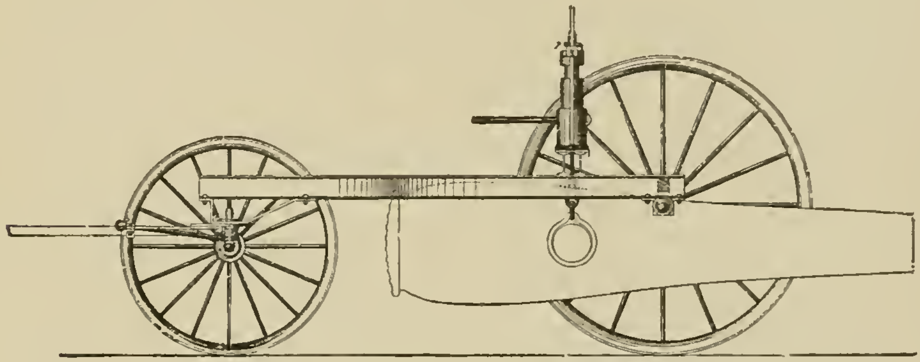

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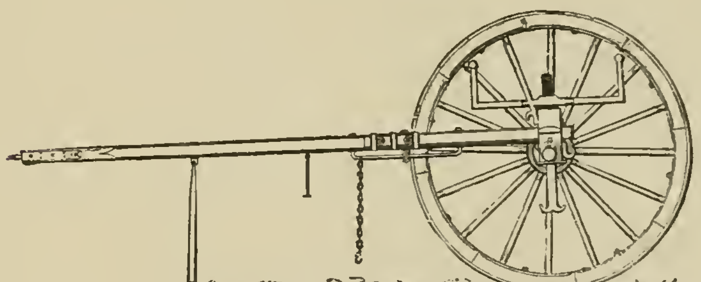

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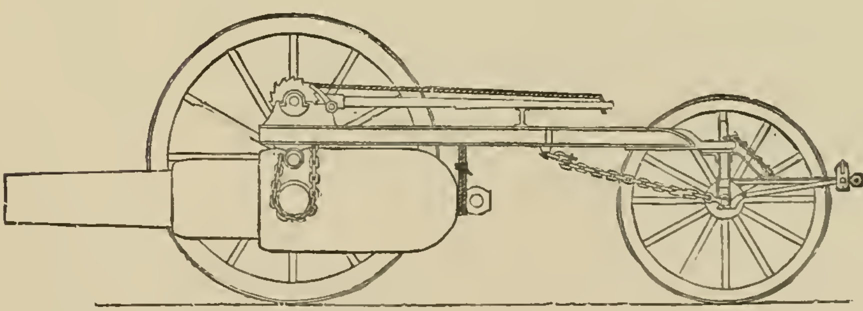
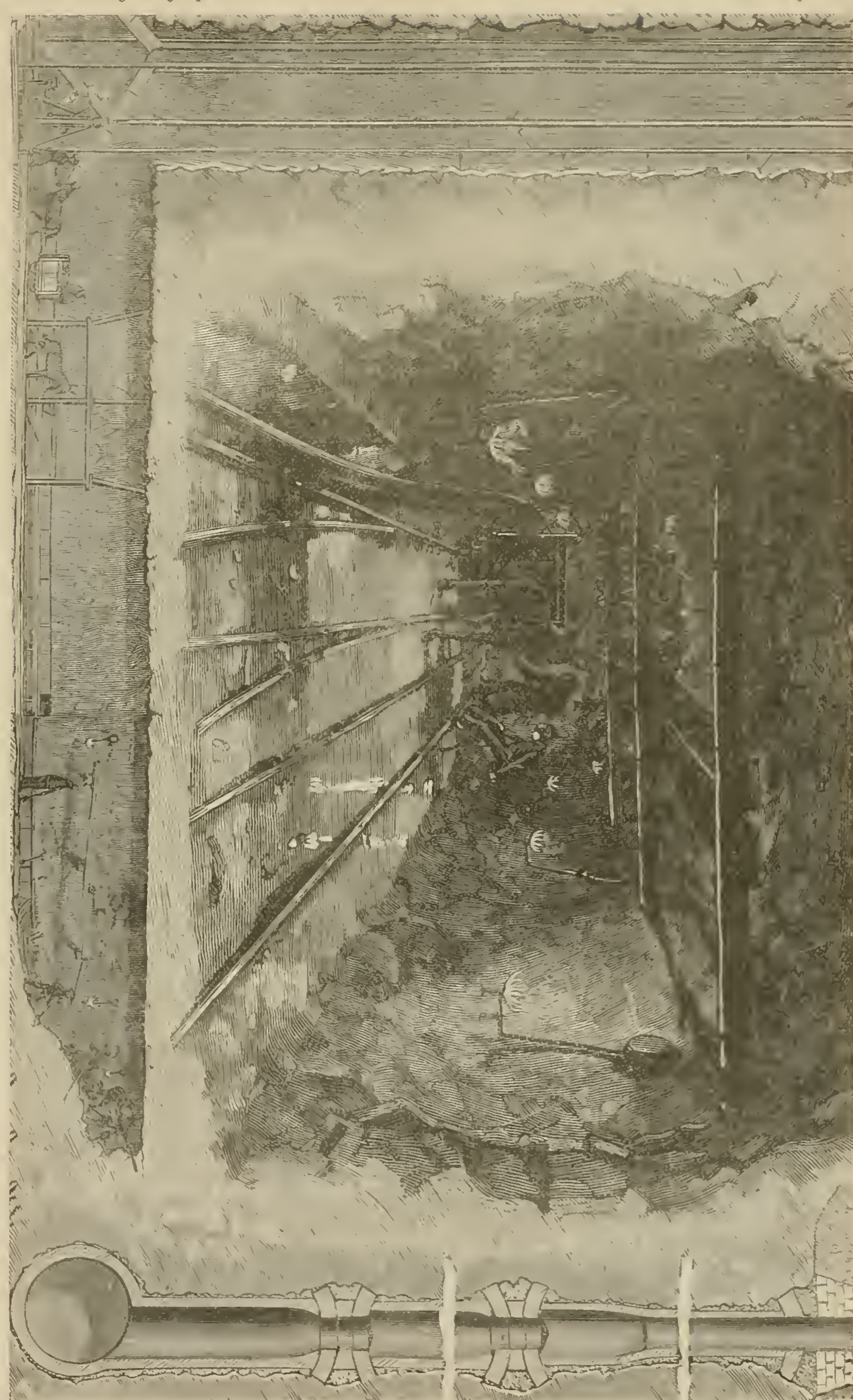
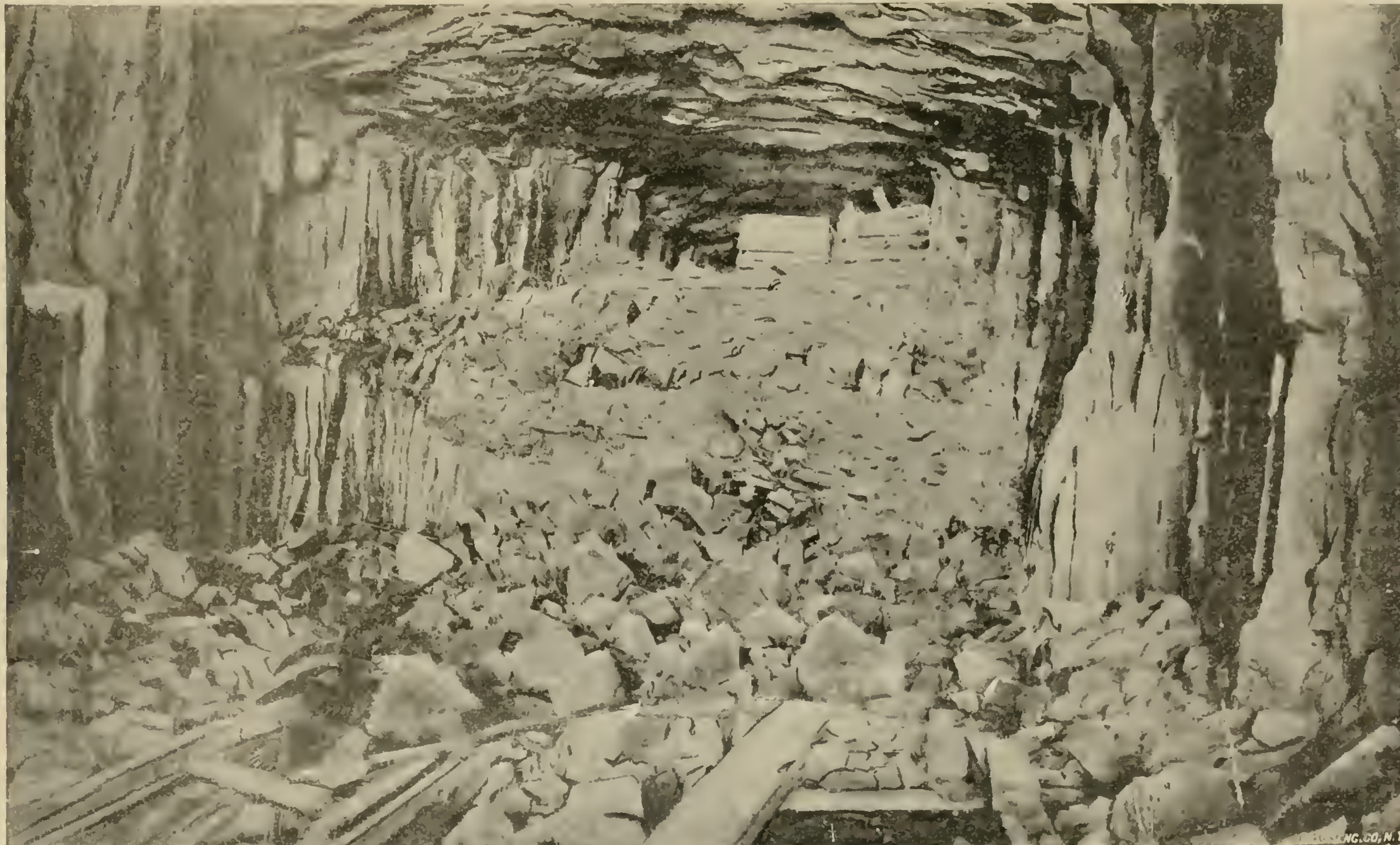


4.

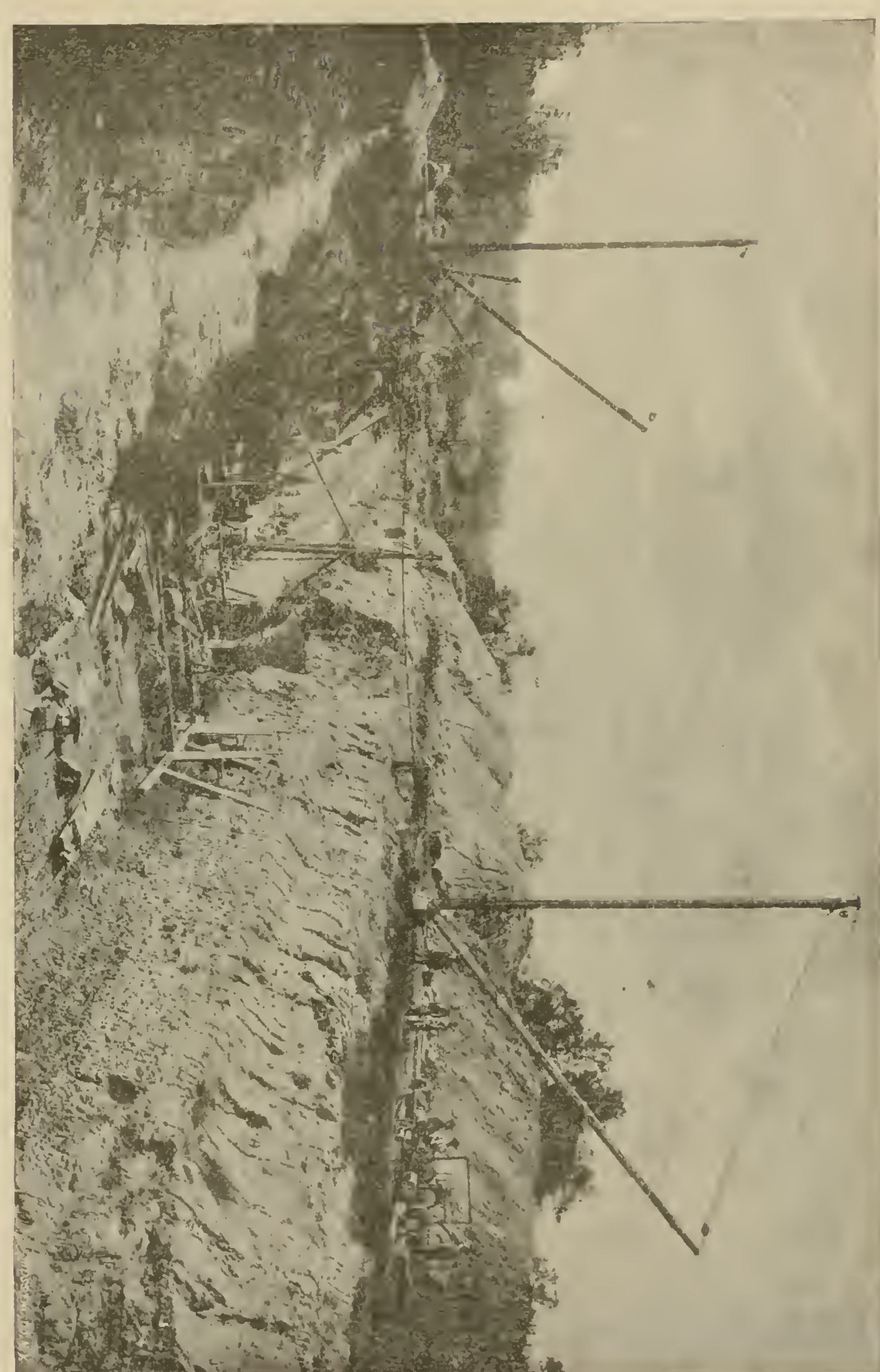
TRAVELING-CARRIAGES.—1. Iron-clad Train. 2. Sling-wagon. U. S. Pattern. 3. Improvised Sling-cart. 4. English Iron Sling-cart.



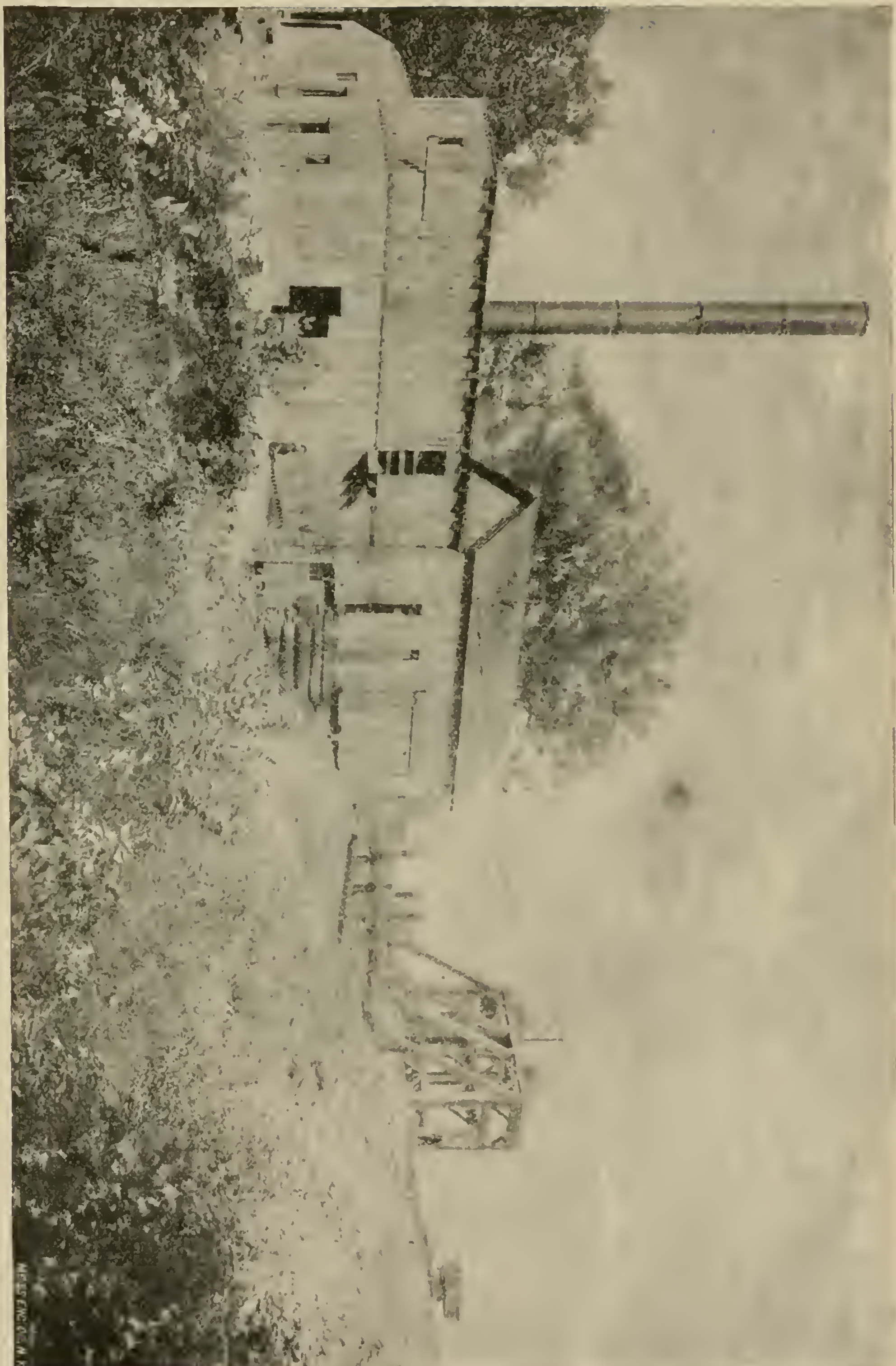
TUNNELING.—Interior View of Tunnel. Work at the New Croton Aqueduct. North Heading at Shaft No. 11.



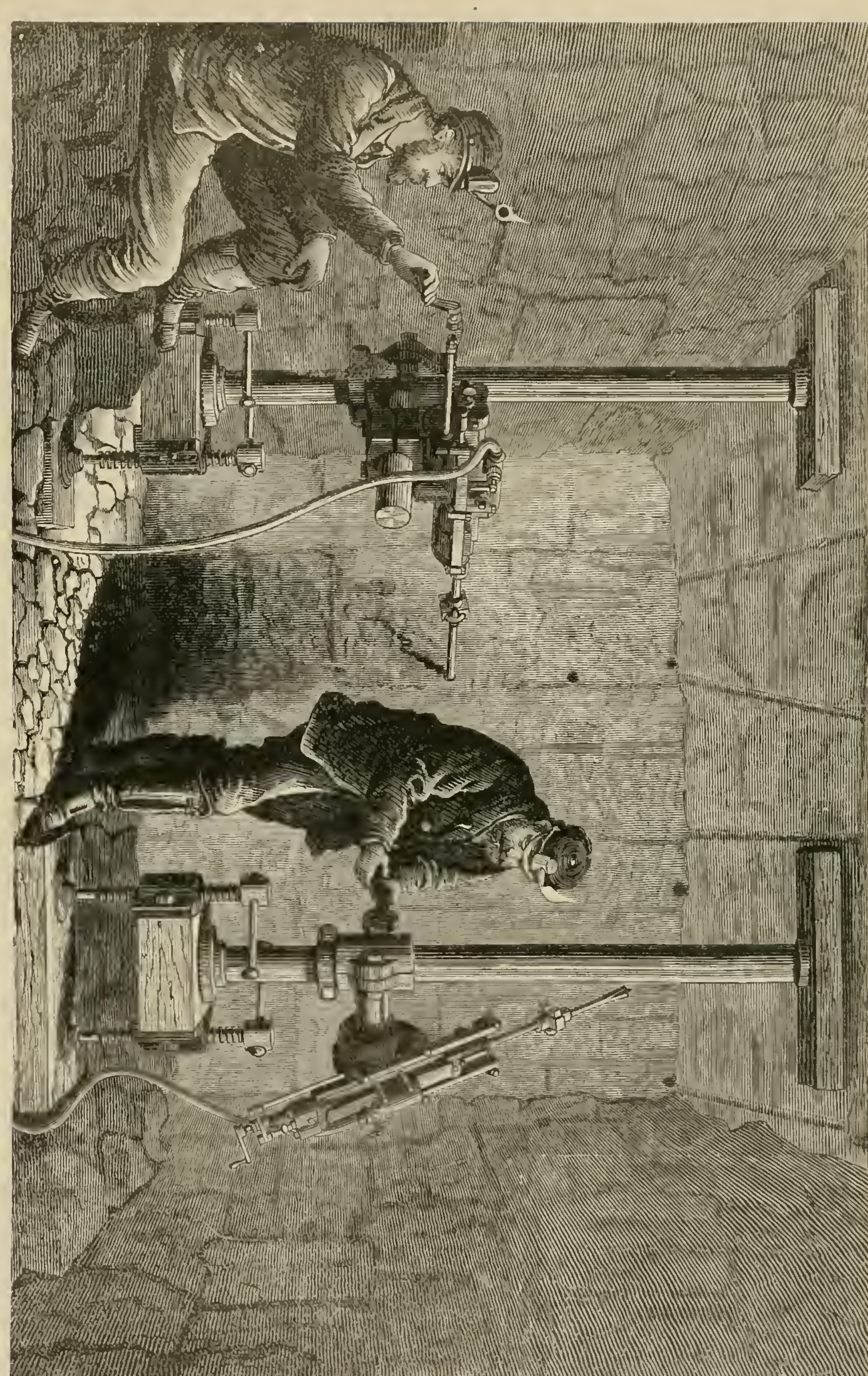
TUNNELING. Interior of Haverstraw Tunnel during Construction. Location of Camera 280 feet from the Mouth of the Tunnel. The broken rock is shown as it appeared, immediately after a blast with Rackarock, on the Bench or Bottom.



TUNNELING.—Open Cut at South Yonkers, N. Y., in the line of the New Aqueduct for the City of New York.



TUNNELING.—Shaft 21 at Kings' Bridge, N.Y., in the line of the New Aqueduct for the City of New York. Sunk with the Rand Shaft-bar and Drills.



TUNNELING.—Rock Drills Mounted on Tunnel or Drifting Columns.