HANDBOOK OF TRAVEL

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PREPARED BY

THE
HARVARD TRAVELLERS CLUB

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PREFACE.

This volume has been prepared by the Harvard Travellers Club in furtherance of its avowed purpose to promote intelligent travel and exploration. While the chief value of the book may lie in its hints from men of pioneer experience to those less expert, nevertheless the Club hopes that it will appeal as well to the general traveller, not alone on account of its useful information to those contemplating serious work, but also on account of its suggestions for the gathering of objects and facts that shall make the casual pleasure trip of permanent and real value.

The several chapters fall mainly under the heads of Camping and Camp Equipment, Methods of Transport, Mapping and Route Surveying, Medicine, and Records and Observations of Travel. The various articles have been specially prepared by members of the Club, each of whom, from his knowledge and experience, seemed particularly fitted to treat the subject assigned him from an expert as well as a practical standpoint. As originally undertaken, the allotment of the subjects was chiefly done by a committee of the Club, with Professor William M. Davis as Chief Editor. Some of the manuscript had the benefit of critical revision by members of this Committee and its Editor, in consultation with the several authors. The final coördination of the various chapters and their preparation for press has latterly devolved upon the undersigned.

Glover M. Allen,
Editor.

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CAMP AND TRAVEL IN THE NORTH-COUNTRY.

BY WILLIAM B. CABOT.

Shelter.

For sustained travel of the sort here concerned some kind of tent shelter is indispensable. In fine weather this may not be used, or at need may be used as a blanket, while in side operations some chances may be taken on rain where brush shelter or other partial means are available; but man is one of the shelter-requiring creatures, and some sort of tent is his usual resource when taking seriously to the open. A turned-up canoe makes a sufficient shelter for a night or day of rain; a properly done evergreen or other thatched lodge, in absence of too much wind, is better yet; a shelter of splits or bark, again, is better even than of cloth — it does not catch fire nor flap; but when all is said, the traveller's necessary shelter, to meet all conditions, must be taken along, and the cloth tent, in most parts of the world, it can only be.

The wedge tent, the cone, and the lean-to are the types, and the wedge can be put up as a lean-to also. A low wall, in locations not too exposed, is a good addition, the side spaces of the wedge being waste places of cold and drip; while the larger floor space required for the wedge is often farther to seek and harder to drain. Most permanent dwellers under cloth use the wall. For these, warmth is nearly the main thing, and a tent with low spaces running off along the ground is almost unwarmable. The wall may be of light stuff; in winter a double wall of the very lightest is used for hunting tents, and turns cold remarkably. Something stouter is needed for strong wind. A low wall does not have to be staked, being as well off merely turned under ten or twelve inches, and weighted with green sticks. This applies rather to the round-end tents; flat-ended ones do at times have to have stakes at the bottom.

The rectangular tent, excellent as a bedroom, is not in all ways the best. It is the military shape, in suitable sizes sleeping the greatest number of men of a length, but its shape is not especially suited to incidental purposes. At first sight the shape seems all economy. But ordinarily some baggage has to come inside and there is no obvious place for it to go. Here come in the rounded forms; the luggage goes into the segments, leaving a squared space for sleeping. All the space is used, either for storage or bed; all the tent that has head room to stand in is left to the party — and head room in small tents is altogether a boon.

Rounded tents do best against wind, rain, and cold, but not always where blowing snow is concerned. In some regions it is found that the wind backing off from a flat-ended tent keeps it fairly clear of drift where a rounder tent would bury. Reasonably, somewhat the same result would follow in the case of drifting sand.

For comfort there is nothing to compare with the many-poled tepee, the Indian lodge, with its central fire, but such tents in travelling sizes catch fire. The chemist who arrives at a fireproofing for thin cloth, that at the same time will not dissolve away in rains, will have done more for the small-shelter question than almost anyone before him.

In two- or three-man sizes the cone tent is a little too round for convenience; only one person can stand and do much at a time, and there is too much eave space, though the shape comes in well for open and windy country. The advantages of wedge and cone are well combined in the Hudson's Bay tent, a low-wall tent six or seven feet on the ridge, but with something near a half cone added to each end. This gives virtually an ellipse on the ground, a good shape. Whatever tent is used, it should have room to stand up in somewhere. A tent argues weather, and one should not have to go out to dress or stretch joints. The weathering out a cold northeast storm in camp is trying enough at best, and the doing it in a damp cloth burrow, impenetrable by fire, is unnecessarily punishing.

An 8 by 9- or 10-foot space is enough for three persons, perhaps four. The simple wedge, as already noted, converts well to a shelter tent, for use in cold times with an open fire. For this the cloth should be white; if black, worse yet; if at the same time thin, the heat of the fire passes through it and is lost. One is burnt in front and cold behind. The triangular ends of the shelter may be light; balloon silk is good here, but catches fire too readily.[1]

For unquestioned tightness and wear 10-ounce, double-filled duck, paraffined, is standard. It is too heavy for some service, and good results may be had with balloon silk at a third or quarter the weight and bulk. With this a fly is required in driving rains, at least on the windy side, the whole, in a closed tent for three or four, at about eight pounds. Where a little more weight and bulk can be dealt with, good drilling has its points; it takes water- and fire-proofing [2] much better than the silk, stands scratching and cutting better, and costs less.

A rope, unless with exceptional anchorage, does not make as good a ridge as a pole. The suspension method of hanging a ridge to a pole above with ties permits the use of a crooked or bent pole, enables a smooth, shapely tent, and obviates any question of ridgepole drip. Uprights, with almost any tent, can be replaced by pairs of poles crossed at the ridge, of course outside the tent. The arrangement is easier on cloth and pegs than the usual one, reduces flapping, and gets the ordinary front upright out of the doorway.

When out without a cloth, more is to be done with evergreen or other boughs than is generally supposed. If a low-branched tree is available it is an easy matter. Long, well feathered branches, cut of course from other trees than the shelter one, are best for the thatching, and if their

[1] Waterproofing process: Dissolve finely divided paraffin in benzine or turpentine, keeping away from fire; apply to stretched cloth with a brush.

[2] Waterproofing process, also retards fire and mildew: Dissolve ½ pound each of sugar of lead and alum separately in rain water, three or four gallons each part; let settle, pour off clear solutions and mix together; soak tent a few hours, rinse, stretch, dry.

unleaved stems are left on will be the better to work with. A conical thatch is carried up and in toward the trunk, stems toward the apex, the long-cut ones shoved among the growing branches doing the main part in holding all in place. A little climbing may be necessary, for tightness depends on steepness of pitch, and this makes the difference between a miserable drip, as bad in the end as open rain, and a practically perfect shed-off. If the branches of the camp-tree slope downward, a night's rain can be provided against rather shortly. If they slope up, more has to be done and there may be some drip. In default of a good camp-tree any lean-to can be thatched to shed rain if run up high and steep.

The Axe.

A first word about axes may fairly be one of caution. The lucky escapes of a wilderness party are rather more likely to take the form of close misses from a glance or foul on an overhanging limb than from more picturesque dangers. Such misses or worse are sure to happen in the usual expedition. In its passive state, also, the axe is an enemy, lying in wait for man and material; nor will the legend "Safety first," however stamped on all minds, quite certainly cope with it. The careful old hand is hardly immune, nor the professional chopper; the lumber camps rarely fail of a man or two, foot or leg swathed, in his bunk, or sitting on the edge of it. The axe is a much-used tool, and of its many strokes some will go wrong. Almost as certainly it will manage to leave its mark on person or fellow article of outfit when not in use.

The partial preventive is a sheath, any sort of a sheath so that it be not large or unhandy. Two bits of firm leather with four or five copper rivets through will do, with a light strap and buckle to hold it on. A soldered brass sheath with a slip for the strap is better; a sheet aluminum one perhaps the last word. A sheath will not always be used when it should be, but in carrying an axe with other things, and when scuffing about the outfit with unmailed extremities, the sheath is the reasonable man's friend, and the habit of it one to be cultivated. A bare axe, above all, should never, especially over night, be left where it can be brought up against by any of the party; nearly as well a cocked gun.

Perhaps no article of outfit, unless the snowshoe, betrays the level of experience and craftsmanship of a party as does its axe; the size of it, shape, handle, hang, above all, its condition. In timber countries at least, it must have the indefinable we know as style. Here men of the woods rarely let themselves down.

A good four- or five-pound axe is a great luxury where serious chopping is to be done, sometimes indeed a sheer necessity. Yet almost as fast work can be done with a 2¼-pound blade (Fig. 2) for an hour or two at a time. It is harder work. A keen, thin edge, not too wide, is required

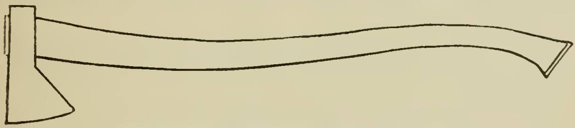

Fig. 1. One-Pound Hudson's Bay Axe

for this, calling for high-quality steel. Such an axe, to cut heavy night wood, say a frozen yellow birch or maple 14 inches through, and a dry spruce the same size, both to be felled and logged up after sundown, must be hung to a hair.

This lies chiefly with the handle. Almost any handle will do for a heavy axe, but a light one, not to hit everywhere and often glance when put to the pace, is another matter. The handle must be slim enough in the bend not to jar the hands on hard or frozen wood, yet strong enough not to break, a delicate requirement. A handle of round section will cripple the hands through the thickest mitten, yet if too flat will buckle in bringing out a stuck blade. Woodsmen's handles are usually a little flatter than those of the shops. In general the straighter a handle is the flatter it needs to be to keep it from twisting in the hands. Fine balance rests with the swell or throw, six or seven inches from the blade. When the handle at this point is laid flat on one hand, the end lightly held with the other, the head should either lie level or turn slightly, edge up; if it turns down the tool will swing as awkwardly as a pick, and glance with malignity. The longer the bit and the lighter the poll, the more throw is required.

In the snowshoe North, light axes are not thus hung for the full swing, which would be a risky method in deep, light snow, particularly as regards cutting the large snowshoes; nor is the full blow necessary. For the northern timber is not large and does not harden much when frozen; a moderate blow counts. The swing is short, but the blows follow fast; it is surprising how quickly a man will beaver his way through a log. For this a flat, deep handle suits, slender near the butt if anywhere, with little throw and a down balance. The depth of handle along the middle gives a most effective grip in the one-hand hatcheting

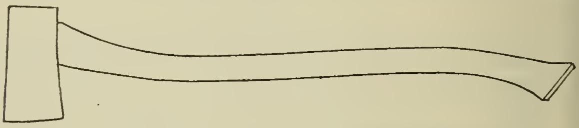

Fig. 2. Two and One-Half Pound Axe for Night Wood

that is everywhere such a large part of campmaking. The full-swing axe, owing to its meager grip, does rather poorly as a one-hand hatchet, and in fact for far-north camping either in summer or winter is somewhat too specialized a tool. An opposite pattern, the Hudson's Bay shape (Fig. 1), with its long edge, small poll, and even its down hang, is nearly as good an axe-hatchet for the region as any. In this land of small trees, however, almost anything will do.

Young hickory makes a good handle, extra white oak a fair one. Hornbeam seems to chatter the hands least — this a point where light axes and very hard wood are concerned. Hornbeam works exceptionally soft when green, yet it is almost like bone when dry. Maine handles are mostly maple, far-north ones no better than yellow or white birch.

Woodsmen do not favor short handles, though for a traveller a pocket axe is handy in the lighter camp work and a good auxiliary; at any rate is easily better, outside the Tropics, than a heavy knife. But at least one handle in a travel outfit should have length; it gives power, and saves getting down to chop. The mere reach of it is a great convenience. A one-pound Hudson's Bay steel may well have a 26-inch handle. On snowshoes the good of a long handle is clear; those the Indian women use, in particular, look half as long again as a common store helve. In wedging a handle fast, soft wood is used, such as cedar, and the ends of the eye need to be filled tight as well as the sides. A loose head is annoying, if not dangerous. For final assurance it is worth while to drive an iron wedge into the wooden one after it is in and cut off.

The artist eye takes to a little straighter lines in a handle, near the end, than are commonly seen; also to a steel put on with some draw, *i. e.*, hooking toward the handle a little, like a pick. The average man mounts his axe square with the helve, or even, like some noses, looking away from its work, but it hurts the sensitive.

The rule of having steel soft enough to sharpen with a file when one is to be long away from a grindstone is probably to be relaxed in these days of carborundum whetstones, and the harder the edge, of course up to brittleness, the better. Slightly rounded corners break less easily than square ones. An axe on which much depends ought to be tried out for temper and soundness before starting on knotty stuff. The lighter Peavey axes, from Bangor, have always been quite right in model and quality. For greater timber of the oak type the six- or eight-pound double bit, long handled, is effective in strong professional hands, but however good for down chopping, no ordinary person can stand to with it in felling. Its perfectly neutral hang is against it. The Maine axe at its best, generally in shape a modified wedge, has feel, is responsive; it shares quality here with some of the higher instruments of skill.

Fire.

Of the four or five primal needs in travel, fire is perhaps the one that wilderness means are least likely to supply at need. Shelter, food, clothes, can be taken chances with — there are ways; but means of fire may be far to seek. The outfit burnt, sunk, lost, one must be sure of fire. Aside from accidents, the story of the last match, at some trying time and away from a base, is a recurring one.

There are two suitable matches, sulphur and wax, the latter desirable only in best quality. The small, English sulphur match in blocks is compact and beyond doubt. The wax one, in its best estate, is a more developed agency: it burns longer, with more flame; is not as likely to blow out. Although held a bad starter, flashing and blowing out before the wax catches, a touch of preparation makes it better in this than any wood match. All needed is to catch a thread or two at the cut end with the thumb nail, strip it down to the other end, and wind it loosely around the friction head. The fuzzy ball that results flames strong, and in any ordinary wind ensures firing the stem.

Slightly damp matches are helped by running through the hair, but damp scratching surfaces are not so easily dealt with. As a matter of fact it is not a surface that is wanted but an edge. The salt-water fisherman simply shakes the water from his sheath knife and lights his match upon it. The match is held end-on against the edge and drawn down it. A very short knife, even a pocket knife, will answer.

With all the field devices offered now, it is curious that a tolerable match-box has never appeared. Those to be had are all small, round — an evil shape — and with screw tops or other nuisances to make them tight. A 12-gauge brass shell shoved into a 10-gauge is used, but the arrangement sticks, is not light and, like all the others, holds little. Invention seems to have passed by the match-box, perhaps not realizing the importance of the small thing, and that a box needs shape and capacity as well as tightness, besides being a non-fumbler.

The F. S. H. box (Fig. 3), made by Mr. Francis S. Hubbard for his own trips, is really a good one. It can be made in any size and shape and is quick in use, no matter how wet or numb the hands. Properly it should have a snug-fitting, dressed-leather case and thong guard. The stopper, not shown in the drawing, may be either rubber or common cork.

A screw-top can does for the general match supply.

There is something in dividing this about, and here common tin tobacco boxes will answer, those opening at the top, say 3 by 4 by ¾ inches in size; the tin is thin, and a slip of wood may be run down the middle of the can to stay the sides from collapsing. A piece of surgical or electrical tape around a joint makes it tight. A short piece of candle to light the actual fire with, as related elsewhere, is a great match-saver, besides being a good possession otherwise.

A flint-and-steel cigar lighter is a trifle worth taking

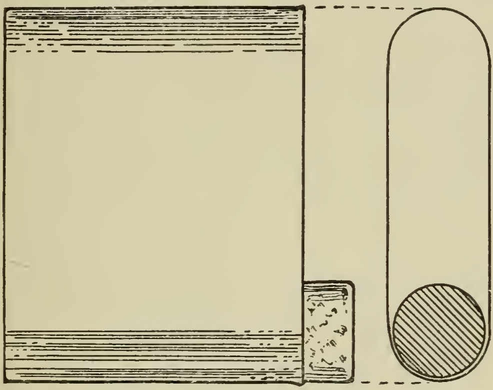

Fig. 3. The F. S. H. Match-Box

for an auxiliary. In its absence a file or knife-back on flint or pyrites makes a spark, while tree fungus or charred cotton rag does as tinder. A rag rubbed with damp black powder and fired lightly from a gun brings easy fire. If reduced to this, one needs to know the use of the firehorn, for at such times fire may be easier carried than made.

The bow-drill method is at least interesting. A ¾-inch strip from a barrel stave does for a bow, a stout leather shoestring for the cord. The spindle may be 18 by ¾ or ⅞ inches. A notch ½ inch in front and ¾ of an inch deep is made in the side of the block, like the space between two teeth of a saw laid flat, and the point of the drill is put exactly at the apex, down pressure being applied by a small greased or soaped cup dented into a knotty block. Porous, light-grained fir is the best wood for both block and spindle; red cedar does fairly when not too dense (see Boy Scouts' Book). Scraped white pine or its sawdust is perfectly good tinder for the large coal made by the bow-drill. The struck spark takes something better. According to Galton it is better to use agate than flint. For the beginner in woodcraft a little preliminary schooling in sparks, friction coals, and punks can be more than a diversion.

For a simple cooking-fire no more is needed than a couple of small logs or three stones a few inches apart with light stuff between, and more often than not the fire is almost a chance pile, with a slanting kettle stick.

For a quick roar and heat a square cobbing up of small, split wood does well. The layers are started on a pair of round bearing-sticks and cobbed up with about inch spaces. In the Northwest, heavy timber is so cobbed up for a night fire, supper being handily cooked by a small fire built on top of the square pile. Meanwhile the fire works down through the latter and is in good order for the night.

Nothing is more unworkmanlike than a larger fire than is needed, with its unapproachableness and the bad cooking it causes. The best warm-weather fire for slight cooking is made between stones, with sticks and bits so small and few as to have to be added to every few minutes; such a fire is almost smokeless, and is hardly perceptible in sunshine, while with the thinnest sheet-pan nothing is burnt. Few white men, and they professionals, live to this method. There are not many slips in the cooking of those who do.

An all-night fire should have a good back. Three or four green logs laid up against two stakes are the usual thing, the lower log fully a foot through. Two six-inch ones are placed for firedogs with dry and green logs laid on to complete. In a still night a two-o'clock replenishing will carry through until daylight, at an expenditure for the night of two quite tall trees.

In winter, green hardwood, such as the birches and even maple, burn well by themselves when once started, but in summer are mostly too sappy. Small fires of course take dry wood. A very good build of small fire, especially to suit one kettle boiling and meat spit-roasting about the sides, is the Indian fire, butts laid on each other and sticks sloping radially all ways. This fire has draught, and countenances two or three persons pleasantly warm at one time, neither burnt nor, ordinarily, smoke-harried.

The Asian cross fire is mentioned by Dr. Roland B. Dixon. It is particularly for windy, bare countries. Two trenches are dug, each four feet long, crossing each other at right angles, and the fire is placed at the intersection. The arrangement especially suits fires of dung and other scant material.

A fair night can be knocked out of unpromising one-blanket and bad-fuel conditions by clearing the ground and firing the whole bed space with any sort of picked-up wood for three or four hours before turning in. The warm ground, raked of coals and boughed over, helps out a frosty night remarkably. Fine picked evergreen over one will somewhat take the place of a blanket if the ground is so warmed.

Carefulness about fire is one of the cardinal virtues. If on organic ground, the whole fire site must be drenched before leaving, excepting after long rain. Old stumps sometimes smoulder for days, the burrowing fire following out the roots and then blazing up. Carelessness here is a grave, even criminal fault.

Blankets.

Good blankets are easily had now. The army blanket, the moderate-sized California ones, Hudson's Bay blankets, and mackinaws are all they should be. A pair, or even a single heavy one, is enough for most times of year. A luxurious reserve is a common down quilt, at 3½ pounds, rolling very small and standing for portable warmth beyond almost anything else available; a 12-pound pair of blankets counts less. With a light woolen sheet over to turn sparks it can be used by itself to about frost point.

The woolen blanket, however, is the standby, taking no harm when wet and meeting all kinds of wear. It is nearly as warm wet as dry. The old soldier's practice of wetting his blanket in the brook and wringing it out, to keep out wind, is perhaps going far, but there are worse things than a wrung blanket.

There is something in the matter of dye. Natural wool, as well as cotton, is better than colored. The choice is between "sheep's gray," the color of black-sheep's wool when scoured, and white. The same holds with stockings and all; it is well to be wary of dye. Northern Indians, notwithstanding their half tropical *penchant* for color, buy white blankets. These come to a gray tan color from the moss, punkwood, and smoke, but are still good blankets. One reason for their keeping their quality, and more important than their being undyed, is that they are not allowed to stay damp and get musty, for such people of the open are a needed model to most occasional campers in often hanging out their blankets to the sun and air, a most decent practice. Some campers who are altogether fastidious in their town life seem to lose their bearings when out and doing for themselves, letting everything get musty, throwing refuse anywhere, using chance and various places for sink and latrine. In warm weather their fate, there if not here, rests considerably with the fly.

The down quilt needs particularly its chance at the sun and fire, puffing up almost consciously when unrolled and held before a blaze. Not that water will touch the down unless rubbed in. A quilt can be left out over night in the rain without harm, but should not be slept in or rolled up until the cover is dry. At that it is not as delicate a thing as it looks; its chief fault is its unventilating quality, its want of transpiration.

Blankets are undoubtedly warmer when sewed up to form a bag than when open. In the matter of plan and dimensions personal fancy seems to count more than with most other kit. For the bare-ground season perhaps as effective a bag as any is made by simply turning half the blanket over on the other half and sewing coarsely the bottom and two thirds or three quarters up on one side. Or for lightness the bottom may be narrowed to 22 inches, but the upper third of the bag should be full width, say, when laid flat, four to six inches less than the chest measure of the sleeper. The bag should be at least as long as the sleeper, in winter four or five inches longer. Eskimo bags are shorter and have a flap at the top, but these are for salt-water sledging primarily, and out of the question for present purposes. A special bag kit for lowest temperatures is described in the section on deep-snow walking.

Almost every writer on camping mentions the rubber ground-cloth as a matter of course. In soggy country it may be necessary, but ordinarily the weight and also the smell of it are worth considering. Woods people use bark, birch and other, even in small pieces, dead pieces at that, or they put a layer of broad-leaf browse next the ground. Mostly they do well enough, and really well enough, with the natural man's-nest of dry grass, dry leaves, or evergreen. The wet that shows on the under side of rubber in the morning, making the camper feel as if he had escaped rather a bath, is commonly mere condensation on the cold, thick rubber; on gossamer rubber it would rarely be seen, more than condensation on an empty glass. In fact, a piece of yard-wide gossamer seven feet long is a very serviceable cloth, and weighs next to nothing. The pinholes that appear in course of time do not hurt it for its purpose, or for covering ordinary goods in the rain, and it will be used more for rain and wave-slop than for anything else. But the best for all that comes is an oilskin jacket; it is good over, under, or on. Backed by a set of waterproof dunnage bags it is perhaps the conspicuous luxury of a kit.

A pillow bag means much to some, and cannot be grudged; others prefer a spare undershirt or sweater, stuffed the same way — the natural man likes soft woolen surfaces next his face, and the cotton pillow bag is apt to be scratchy when filled with woods materials. The best filling is spare woolens. The ticking mattress, as urged by Kephart, is hardly for sustained travel, and the wholly desirable built bunk is of course only for the settled.

Clothes.

In the matter of clothes a certain difference may be made between the working traveller who accepts the routine service of the life, and the one who does not, perhaps beyond lending a hand as may be, but relies chiefly on the craftsmanship and strength of paid people. The latter course, it may be said, is often the successful one, looking only to the purpose of an expedition, the definite objective. Most ventures that are more than outings command some trained service, compared with which that of persons not bred to it is rather ineffective and may count little; there is even such a thing on the part of inexperience as merely messing in. On the other hand, the relation of staff and line in a party of size is a natural one, often the most effective one, and as often satisfactory to all concerned. With many who go out, however, the life is at least part of the objective; with younger travellers it is apt to be a main part; indeed, their objective is as often as not the experience.

The non-working members of a party need clothes for protection rather than wear: a duck suit, tan or dull grass, will do; perhaps khaki, though it soon looks shabby. A duck shooting-coat, with its many pockets, is most handy. It should be large enough for a jersey underneath, besides a waistcoat, this with a back of thin wool. Thin, tight-wove wool is better than cotton for pockets and linings also. The less-active member does well to have his jersey with a button front, but pockets in it are doubtful; they gather trash and snow, catch on everything, and are slow to dry. Underclothes are wool, weight to conditions; thin ones can be doubled; stockings thick, not fine wool. If the non-working one's skin dislikes wool, he may use very thin smooth cotton underwear under it; probably this is better next the skin for anyone, being above all absorbent.

Strong, moderate-weight shoes are the safe thing for walking, moccasins at a fancy; in any case beef moccasins for the canoe. Shoes may of course be heavy and lace high, but better not; light feet, almost everywhere, get about best. Moderate soft iron hobs are useful where there is much rock, and they save on gravel. A few at the toe double the life of a shoe on steep slopes; without them a good shoe may be actually cut off an inch, sole and upper, in a few days where gravel is angular. Shoes should have large lace holes or hooks and a strong shank; for uppers nothing is better than horsehide. For cool, damp country and for walking in slush, the shoe pack or soled moccasin has a better build than the usual shoe.

A felt hat is preferred, wide for horse country, unless a sun helmet is used, but a close-brim, good-quality felt for woods. For general hunting cotton clothes are too noisy. They should be wool to the leggins, if these are used; flannel shirt, dull-colored, very large to allow of shrinkage. Buckskin has great wear and sheds rain, but would be better for long trips if more washable. A narrow belt may be worn for the knife, though this can go on a thong between two suspender buttons. Cheap drilling gloves are indispensable, partly for mosquitoes. They dry better than leather, wash and ventilate; are better than leather in all usual work. Leather tends to yield to woven materials in outfits.

Wet leather burns readily. Some one person in a party is likely to be almost an enemy here, a boot-burner, perhaps the very person who is most friendly in taking care of the others' things. The most susceptible footwear is oil-tanned moccasins; they will hardly bear the sun. A bad enemy of all moccasins, and even shoes, is the mosquito smudge. There may be a dozen going on at once, and as they smoulder down they are stepped on unnoticed. Altogether it is a lucky trip that brings all its shoes through.

About salt water at least, oilskin trousers are worth while, but oilskin is like tin in cold weather; then rubber comes in, but this stiffens too in serious cold. Pilots, looking to their common case of numb fingers, break out the springs from snaphooks on rubber coats and use the hooks without them.

At the start, clothing outside and in, unless for the hat, should be practically new. Things that kept in use would have lasted long, deteriorate when laid by, woolens always; the fibers seem to let go each other, besides actually weakening. Leather, given time enough, is worse; old book bindings tell the story. Cotton oiled with linseed rots; rubber hardens. The sewing of shoes that have been much in water is the worst of all; after a season laid away the thread may give out in a few days. Almost everything one wears or uses seems to do best if kept reasonably going until its time is done.

The service member of a party, the worker, needs a firmer jersey than the less-active one, and without buttons. A button front catches on everything possible, at all tasks; is a crab-maker in rowing, a puller of the axe handle, an invitation to sticks and stubs. The coat, if any, may be a light, easy sack; trousers, best woolen, strong riding twills or the like. They must be loose above the knees, must squat well; the riding-breeches cut is the idea. This keeping the knees and thighs free is really important; one has only to see a party of bare-thighed natives in action to appreciate the point. They complain that they cannot walk well in trousers.

For leggins the Hudson's Bay Company strouds are a good material in any but very thorny countries; canvas is too noisy, leather nearly as bad. The white woodsman merely pulls his stocking legs up over his trousers, with no more thought of wearing leggins than a breechcloth.

The question of having a visor or brim on the working hat depends. In thick places the brim hat gets jerked from the head by branches, a sorry attention to a belated one making time; if he is carrying much he is sure to be annoyed. Without making too much of the subject, there is something to be said for the close visor cap. For one thing it does not have to be as unpleasantly tight in a wind as a hat does, and there is no flapping in a blow, but comparative peace. It goes through brush well, is the least visible shape in hunting. The cap is of course not an umbrella, but in a following rain the visor can be turned back to take care of the neck. As a matter of fact this position of visor is rather customary when the head is slanted forward in packing, to clear the view, while the all-round brim has to be dealt with at some trouble. Altogether the cap has points; it may be taken as the woodsman's fighting clip.

Wool clothes in general should be of good-sized fiber, stockings and things to the weather of really coarse. Fine wool under the feet pulps and mats, does not stand up, and behaves none too well anywhere. A thin white-foot cotton sock (dyed cotton wears the skin) gives a better surface against the foot than any wool.

In general it is doubtful trying to have one article of outfit serve many functions; the combination arrangement, like the Jack of trades, is likely to do nothing very well. A wind jacket can be water-tight too, but it is better to use a soft sweater under it when needed than to line it up heavily for warmth. So with a shoe, it cannot have the comfort that goes with ventilation and at the same time be water-tight.

It is true that some conditions do demand tightness, and in early still hunting, when wet hollows and ground slush are at their worst, the lumberman's rubber is quite the thing; still it is better to put the period through in oil-tan moccasins, sure to leak somewhat, than to bring in rubber toward an all-round foot combination.

Particularly in cold weather, there is a good deal in subdivision of clothes, this in order to keep them from getting damp with perspiration before stopping or coming out on a wind-swept lake or mountain top. If one has not been over-clothed and is dry, all goes well; the slipping on of a sweater or wind frock does all that could be asked. If one is damp it may be hard to keep from freezing. We civilized ones do not get effective ventilation as our clothes are made. Eskimo do; they travel, turn maybe to fishing, sitting back to a cold wind, and at a pinch sleep on the snow in the same clothes at lower temperatures than are well to mention. Their clothes are better than ours but they ventilate also. The good sewing that is done on native clothing is part of their merit. In hunting countries sinew is used for thread, and it outlasts the main material. Dental floss has some of its qualities, is at any rate good for sewing on buttons; the writer's experience with it is, however, a limited one. In sewing leather one is practically limited to the old shoemaker's waxed thread. For canvas common carpet thread is not the worst. Common spool thread is poor stuff. A few copper rivets should be taken along — these at least will not rust nor wear.

The belt knife is fairly a part of the clothes, at any rate is to be put on and off with them. Its temper may be rather soft. The cheap kitchen blade is practically as good as any, thin, five or six inches long, broadest near the end. It is not of much use for cutting wood; a good double-blade pocket knife is carried for this. A smallish tool knife also, with gimlet, awl, reamer, and perhaps a saw, is a good thing in the kit, and comes in well if the pocket knife is lost. For skinning, either knife will do, though the larger one is better for cutting up the caribou and moose size of game. If a hard belt knife is preferred let it not be thick or daggerish. The little Dall DeWeese knife is handy, sufficient, and unwarlike in appearance. A belt knife, whatever sort it be, should go into the sheath nearly to the end of the handle.

The belt knife should be always and faithfully worn, and always in the same place, say on the left side under the waistcoat pocket. It is least in the way there and can be reached by either hand. By having it habitually in the same place the hand goes to it automatically whenever an impulse comes to cut. Then, if a rope is to be cut under water in a capsize, or if in any situation quick knifing is to be done, one hand or the other is likely to save the day. A knife in a wet pocket is far away. Aside from emergencies the outside knife is vastly convenient, sometimes to the point of inconvenience — the pocket-knife members of the party are continually coming for it rather than get out and open something of their own.

Pocket knives, whatever of larger ones, should be white-handled. Pencils also should be white or bright colored, and so with small things generally that are subject to being dropped or left about. They should catch the eye, whether in the kit, or laid down temporarily, or lost, or half hidden about a camp site when one is taking a last look before leaving. The difference between dark and light things when dropped overboard is that between a live fish, hard to see at all, and a belly-up one that shows far away. There is nothing quite like white for small articles.

Woodsmanship.

The beginning of woodcraft is finding one's way, the keeping from being seriously lost. The sense of direction, on which this much depends, varies with different persons; some are almost without it and must use a guide. Few can feel easy in difficult forested country alone unless after much experience, and to pass days and nights alone without concern they must have begun, almost all, before they were out of their teens. It is as with using the axe, the tool of the woods; the belated learner rarely comes to full ease with it; by his queer cuts he is known, almost always, to the end.

There is no such thing for the free traveller as not, in an incidental way, getting lost. In difficult strange places all woods people lose themselves, guides, Indians, and all. In level country of sameness no one can go straight in a fog. The hopeless thing of all is straight-down snow, especially after the trees become loaded. In his book on the North Shore, Comeau tells of being out with a competent Indian at such a time. On being unable to identify a lake in the falling snow they simply camped to wait for bearings. In the morning when it had cleared the lake turned out to be perfectly familiar to the Indian. Their camping to wait was altogether the right thing.

The trouble comes with losing one's head and "taking to flight." The curious tendency to walk in a circle, usually if not always to the right, is well known. Comeau relates that a lost man whom he followed, walked around and around in his own track until it was hard. Finally exhausted, he sat down, back to a tree, without attempting to make a fire and without opening his package of food; there he was found frozen. While unusually tragic in its ending the case was true to type. The unfortunate walker had set out to go some miles on an ill-marked trail against the advice of more experienced persons, signs looking toward snow. He had been over the trail four times, however, and felt safe. Losing the trail in falling snow and becoming confused, the impulse to flight took possession.

At such times the mind becomes incapable almost at once, somewhat so even with men rather used to the woods. A member of a trapping party operating on difficult headwaters known to the writer wandered off his marked line and was gone some three days, but in mild fall weather. While he was not so shaken before being found as to be past describing afterward some of the country he had been over, he stuck to it that among other incidentals he found a brook that ran up-hill. He put chips in it and tried it and knew.

These are type cases. An instance of doing the right thing rather than the other occurred awhile after the discomfiture of the trapper mentioned and in the same range of ground, the *personae* being no less than two young women, at that wholly new to the woods. They were following a marked line an hour behind the men of the party and walked off the end of a false set of marks that took off imperceptibly and gradually swung away and gave out, a misleading trap for anyone. They had been told to look out for the place, but once off the spots there were makings of a very unpleasant matter. For once the right thing was done. One of them sat firmly down while the other explored within hearing, and in time they worked out the situation. They kept their heads.

In any wild country, bearings must always be kept of main features, such as lakes, streams, and changes of ground generally, these more for position, and of sun; wind and movement of clouds for direction. Clouds will not change their course without marked change of appearance. In darkness or thick weather shots fired for an echo sometimes do much for one. Branches of trees on ridges usually point southeast if away from large water. Moss on trees, difference in the sides of rocks, and such matters of exposure have to be studied in the field. When trees have fairly equal exposure around they are not hard to go by in daylight, old trees especially. The trouble with tree signs is that in the times of storm and twilight when one needs them most they are hard to see. Local signs of the sort are many, but though plain enough to the old hand, are hardly communicable by description. The old woodsman scarcely remembers them definitely and may not have much to say about them when asked, but they come to him when he is out.

The dependence of the occasional traveller is apt to be mainly the compass, hardly to be done without in mapping, and in view of its other services cherished almost as his matches. Quickness of needle and handiness are the points to choose for; and a flat needle is quicker than a bar, a small box, say 1¾ inches across, handier than a large one. A short needle, too, is quicker than a long one; in fact, for most purposes a snappy little watch-charm affair, so that it swings free, does surprisingly well. Whatever sort is used, a good place for it is a lower waistcoat pocket, with a shoestring or thong for guard.

A self-opening lid is convenient, but the spring is apt to give out and it is then harder to open than a common one. The detachable lid also has its infirmity; it is apt to get lost and leave the glass unprotected, though this is not as likely to be broken in use as in knocking about among other articles when off the person. The usual hinged lid need not be a bother, as in times of frequent use the compass can be shoved into the pocket open and be as ready as an open-faced one.

It is a good plan in buying a compass to lay out several and compare them carefully for balance and quick, certain swing. The best one will be worth a great deal more than some other, and a poor one is a miserable thing. Most compass trouble comes from crumbling of the pivot point, and this is a delicate thing to sharpen. The cause, usually, is not keeping the stop on when the compass is not in use.

Believing the compass is like keeping one's wits, in other words not taking to flight when lost — a hard thing to do sometimes, and not alone for the inexperienced. Before depending upon the compass in difficult country one ought to acquire a little the compass habit. Iron and steel that are near deflect the needle and have to be looked out for. A bunch of keys or a knife will do this. Ships have been lost because the sailor at the binnacle wore a sheath knife. When taking direction it is well to hold the box well away from the clothes, looking out also for gun or axe. People of the woods are inclined to look rather lightly upon the compass habit; are given to saying they do not need one, or regard it as only an emergency means. The traveller at large feels otherwise; to him the needle is indispensable, and at times in constant use.

Yet no one really likes the hesitating compass; the instantaneous eye is beyond all made devices where it will serve, landmarks are what we go by when we can. The reckoning we keep of these becomes in time almost subconscious, but whether or no, some sense of position must be carried along as we move. To wander, without direction, beyond known landmarks will not do. In uncertain places a day-long feeling of thankfulness goes to the long stream or range or high mountain that one can always, so to say, keep one's hand on. When a route is to be retraced, conscientious looking back at turns and outlook places is to be enjoined, the sure memorizing of features of note as they will be seen in coming back. The tax on memory may be lightened by marking a tree, perhaps placing a chip in the cut pointing the way; or by throwing down a branch or laying up a stone—anything, so that it is plain to see, perhaps when forgotten and out of mind. Indians so mark controlling points: in open ground by a stone laid on a boulder, beside water by a tree marked where the trail takes off. To a stranger going over a route they give a bark map, their field marks adding certainty. In marking a route the possibility of having to send an unacquainted person over it or having to go oneself in time of storm or bad light has sometimes to be considered.

In forest there is little for it but the spotted line, the blazed trail. The spots should go more than through the bark, face as the line goes, and be visible one from another. Snow may have to be considered, and the spots need to be high. Crooked places are marked plainer than straight ones, branching places likewise. The barring a false lead or wrong fork by a sapling laid across may be a saving thing in some twilight return. One's memory gets over full, the non-professional finds it hard to remember all he needs to.

Both memory and sense of relation, place faculty, come into play in these concerns of the way, and both seem curiously independent of the reflective processes; certainly the unreasoning creatures find their way, very far and back, quite as well as we. Although they may have keener senses, better memory, more faculty, these seem no different in kind from ours.

Some Indians have remarkable gift. The recoveries of Elson are an instance, on his journey inland to recover the body of Leonidas Hubbard in 1904. Cartridges casually buried in the sand of an open beach, with no thought of return, were dug upon accurately five months afterward in several feet of snow. Other articles miles apart were found with the same exactness, the last a camera, left by the way without marks during the party's last days of straits, these of a sort almost obliterating to memory with most persons. All the things were under deep snow when found. Elson was young, and being just out of six years' indoor service was inexperienced even for his age. His gift was almost wholly an inherited one; his grandfather, so to speak, found the articles for him.

There are tolerably experienced ones, on the other hand, who can do little in such matters, can hardly turn a bush without starting away wrong. It is probable that anyone who could qualify in the graphics of a good mathematical course could manage alone after a little practice. Withal the simplest of minds do as well as any, though hardly without previous experience.

In close country the best walking is likely to be had away from streams. If there are flanking hills or ridges, a travel streak is likely to occur some way up their sides. The danger places are the high divides, where several valley heads may look alike and be little different in direction, yet let one down rather shortly into some wrong and out-of-the-way district. Another mistake is the taking a wrong branch of a stream when boating or walking ice. As an instance, Warburton Pike's Peace River adventure may be taken, and altogether as covering about as many things that ought not to be as any — not to relate the story here. The whole book (Barren Grounds of Northern Canada) should be read; no one with a turn for the outright in wilderness travel should miss it.

As much discomfiture of the minor sort comes to the rough-country traveller from taking short cuts as anything else. The call to do it is very strong with some persons; there is more behind the impulse than the mere saving of distance. Almost always it is better, at least quicker and easier, to keep to a known route or path. The swamps, blowdowns, water places, ledges, and tangles of all sorts that turn up, often enough toward night, are surprisingly sure to make one rue the venture. In snow time it is not so bad, for of clear nights one can plod away indefinitely, and water places are then good walking; nevertheless, by and large, one is better off after dark in camp. In hunting, when one is apt to hold on to the last, an electric candle, useful also in camp, is a good thing. Nothing is so good for seeing the compass by, or the footing; if caught by a really dark night one would be very glad to have it. A luminous compass needle is good at night, but difficult to see in daytime.

A pocket whistle is better for calling to a companion than the voice, and under some circumstances a horn is worth carrying. A shot, of course, can be heard farther, and a shot after dark is generally taken as a signal, or two shots are agreed on; at any rate some sort of code is commonly arranged.

Subsisting on the Country.

The various hunting that is done for meat is too wide a subject for much exposition. It may be said, however, that the hunter who under fair conditions can deal with the white-tail deer will have technique enough for practically any of the larger meat game. Still-hunting on the track is the high test; there is nothing to compare with it. The younger bucks are possibly the easiest to hunt, fancying themselves a bit and being inclined to stand and look before going. The old bucks are more likely to have been shot at and to take few chances once the hunter's presence is known. In regions much hunted, a certain proportion of them carry old encysted bullets. Whether hard to hunt or easy, they are not the best of meat, and chiefly attract the trophy hunter. Large horns are a bother to the animal in thickets, and if antlers are an object it is to be noted that some gauge of their spread is afforded by the kind of growth through which the game travels. The does and fawns glide through and under, holding particularly to dense places when disturbed. On shedding their horns the bucks take to the brush too, caribou bucks especially.

Almost all creatures understand perfectly the meaning of a stealthy approach, and above all an approach on their track, which the deer kind are peculiarly sensitive to. On the other hand they are often indifferent to a person or creature obviously about his own concerns, and show curiosity rather than fear. It follows that in noisy times one can do well where game is not much hunted by going straight along through deer places, tramping regardlessly and facing stiffly ahead as if concerned only with getting somewhere. The rolling eye may catch a leg or ear or sheltered form somewhere and the rest is an abrupt stop at some favorable place and a fairly immediate shot. Game does not wait after the hunter is scented, and black bear and wolves are inclined not to wait under any circumstances, though they may turn at some final disappearing point far away.

In still-hunting, beginners are apt to keep the track too closely, as if afraid of losing it. This is unnecessary; it works better to move a few rods away from the track wherever a better view ahead is to be gained. More game is lost by haste than in any other way; tracks several hours old may be very near the animal in case it is lying down. When an animal begins to nip a twig here and there great caution is necessary. If the track is not more than an hour or so old, it is a case of lying down, chewing the cud. If the track of a feeding animal passes into a thicket it may be best to wait, always regarding the wind. When the deer moves it can be seen, often; if not, one is not much the worse and can follow on for another chance. The age of a track can generally be told well enough, at any rate after following it a way. If the track is very fresh the condition of the droppings is an indication. There is a peculiar brightness about snow just kicked up that is unfailing; it dulls fast. Deer commonly feed after daylight, lie down after an hour or two, say at nine, stir and feed again toward noon. In the full-moon period they wander a good deal by night, sleeping by day; this makes bad hunting. Like all game they are easy to get up to when it is snowing, but move little then and it is hard to find a track. In bright, clear days all game is alert. Yet the best still-hunting is on just such days, if only windy and with the trees thrashing. The noise prevents one's being heard.

Not too much should be taken for granted after shooting, even if the game is down; an animal may be knocked off its feet by spinal shock and presently recover and disappear. A good many saddening experiences have come in this way. The preventive is an extra shot.

A saddle of deer packs well *sitting* on one's shoulders, legs front, tail down one's back, spine pointing up. The meat of a good-sized deer can be boned out and packed to camp very comfortably; not cutting too close it will hardly weigh 70 pounds; a medium pack bag will take it all. Or it can be wrapped in the skin the Indian way, placing a spreader stick across first and tying the skin of the hind legs together for a carrying strap.

Against being left out over night, a light axe, say 2¼ pounds, is a great assurance; it is put head down into the bag, always with a sheath, and the bag is tied in around the handle about opposite the neck; otherwise the axe may be slung rather high under the left arm and a little to the rear without being in the way or noisy among sprouts.

Light-colored clothes are a great advantage in snow hunting, and nothing is better to wear outside than a thick white wool undershirt; it turns snow, rain fairly, and does not catch twigs and stubs like a sweater. If the cap is dark it may have a white flannel cover. All northern game fears dark clothes in winter, and it is surprising how near most kinds will let one come in white, of course if not scented. They have no natural enemies of size in white, no ground enemies. It is better to be lighter than one's surroundings at any time of year.

Moose are difficult to track because they travel down wind. Deer and caribou work against it, trusting mainly to their eyes and ears for anything following. There is no way with moose but to flank wide, circling to the track as infrequently as may be to keep its direction. It may be fancied that so strong an animal feels able to smash through in case of happening upon an enemy end-on, but prefers to have notice of the planned wolf-attack behind, — he wants time to get ready. In deep snow caribou and probably moose choose a suitable place to fight if they have warning, treading down the snow and standing clear.

Not satisfied with having the wind after him as he goes, when about to lie down the moose is given to looping around and returning a little distance parallel with his outgoing trail and stopping where he can see back on it for some way; there is little getting a lying moose from that direction.

A calm time with the trees fresh-loaded with snow is perhaps best for tracking moose. Sound does not carry then; a gunshot a little way off sounds as if fired inside a feather bed. A moose is easy to see, and if not in wind of the hunter will stand some time and then turn slowly away. A deer under the same circumstances vanishes with jumps, nevertheless may take a turn of the hill and soon be looking at one's back. The slow-minded moose, apparently unfrightened, gains speed as he goes and may not stop for twenty miles. In ordinary there is no use following, though a provisioned hunter can walk a moose to a shot within three days. This may be done with deer in only a few hours; they get tired, hungry, come to feel pretty safe from their creeping pursuer, and finally let him draw within sight.

Most often it is a mistake to follow a hurt animal at once, and unless approaching night, falling weather, or unusual certainty of the condition of the animal are to be considered, it is better to wait awhile, at least long enough to smoke a pipe. The first performance on a buck, even before bleeding, is castration, to avoid a certain taste. Care must be used in approaching a fallen animal; a nearly gone deer can disable one easily and will do it if possible. A deer on its feet practically always needs a second shot, and sometimes gets away then.

Tracking bears is a doubtful undertaking in forested country. They keep to the tangles more than the taller animals and go far at the least alarm. As with the wolf, they mind the sound of a distant shot, and take to water disconcertingly. To follow a track all day and find it leading out through slush ice across a pond at the last is discouraging. About blueberry lands bears may be watched for successfully from some commanding place. Their cleverness lapses when approached by water; they will let a canoe come rather near. As meat they can be very good or uncommonly bad, but are best in berry time. The fat turns easily in mild weather, but not, for some time, past cooking with.

The stern chase after caribou is also apt to be a long one. The woodland caribou snatches the hanging moss as he goes without much pause, and may hold some pace for miles. Most often sheep-like and hardly a sporting animal, at times he is keenest of all, notably in bright, breezy days.

When hit, a deer goes frantically away, sometimes far; a moose may stay rather near; a caribou, unless pushed, may not go at all, but stand with spread legs until he falls. The moral is to keep well in the background after shooting.

The hanging "old men's beards," which are the woodland caribou's chief winter diet, affect the meat; in taking off the skin a smell of fermented moss is noticeable, and if the meat is to be salted down the bones must be taken out or it will spoil. As winter goes on, woodland meat becomes black and dry, hardly worth having, though farther north where the living is on white ground-moss, which they dig for in the deepest snow, it may keep fair quality throughout the snow period.

Deer probably fight caribou away, and this seems a reasonable cause of the latter's disappearance after deer come into a country. Buck deer are very pugnacious, and as they keep their horns and fighting spirit a month later in the fall than caribou, are unpleasant neighbors for them. Other possible causes are the inroads of deer on the moss supply when they have increased beyond the browse resources of their region, and the occasional dying off, said to occur, of the moss itself. The cause may be something else, something one would not think of. Temperamentally the caribou always has the migration chip on his shoulder; he is an easy and unaccountable disappearer.

The spreading north of deer seems conditioned on the disappearance of wolves, their mere exterminators in deep snow. The long-legged, powerful moose and snowshoe-footed caribou can take care of themselves in ordinary. When pushed the caribou clears his fighting space, sits erect on his haunches, and with his great fore hoofs does killing work.

It may be worth while for the trophy hunter and naturalist, if less so for the subsistence hunter, to know the sex of the game he is tracking. As a rule this is not difficult. The buck's fore feet are generally squarer than the doe's, and he steps wider from side to side; these signs are not invariable, however, and in deep snow there are no clear prints to go by excepting in lying-down places. With the common deer the buck's habit of trailing his toes is a safe indication, also his way of standing beside a low tree or other screen while looking at the hunter. The manner of emptying the bladder is of course characteristic. As for the doe, positive signs are a little wanting. She is rather elusive, feels her duty of self-preservation, and while fairly well off for curiosity, has not her partner's impulse to stand to against intrusion. Her general point of view, as distinguished from his, gets into her track and steering. One may have to follow on a little to be certain, but to find that one had tracked up a doe for a buck to any distance would be a disconcerting experience, at least if one had pretensions as a still-hunter.

What is sometimes not easy to determine at a look is the way a track is going. If there is a clear print, of course, the matter is plain, but in light caving snow it may be doubtful. There is a curious effect of reversal when the snow becomes about a foot deep, for the back of the shank makes exactly the same groove at the rear of the track that the front did in less snow. Of course one never goes very far on the back track before seeing how things are, but at that, one cares neither to make the mistake, nor, oftener than not, to do the extra walking. It is not only the track one is to follow that is concerned, but other tracks about; part of the business is to know how game is moving. A steep slope tells the tale, or a log jumped; there is never much doubt after coming to such places.

In six or eight inches of snow caribou tracks may look surprisingly like a man's. Examination betrays them, but men somewhat used to the woods have walked awhile on them without suspecting what they were. At times no one can be sure, not from looking at a short course of tracks. A caribou will run several rods on a blowdown almost like a cat, placing his snowshoe feet on logs and intersections of branches with no slacking of speed. He may go five miles an hour in ordinary growth, the track getting more and more stale as one follows. Yet he may stop awhile in some downed tree, where the "old men's beards" are many, merging his grizzled winter coat with the gray and white of the old tops in a most invisible way. On a lake or open bog or level space on a mountain top a band may lie and stand about for a day at a time, and these places offer the slow-footed hunter by far his best chance.

Circumspection, a good deal of sitting about, of standing, rather, in snow time, at all events no hurry; seeing thoroughly, microscopically where game may be, patience always, — these things, hard to live to, are the cardinals that bring meat to camp. The wind, of course, must be unfailingly deferred to.

The actual shooting, in forested country, is the easiest thing. Most often one is aiming at only a patch of hair, and sometimes at eighty or one hundred yards the practice is rather fine. A short whistle will always stop a moving animal if it has not seen or smelt the hunter, and so even if started some way off by one hunter and running past another. There is a saying of old still-hunters, — a breed out of date in these days of one- and two-deer bag restrictions, — "When you see a deer, shoot it." The implication is that waiting for a better chance is a losing practice; and it is marvelous how a large animal passing behind a bush can disappear for good and all. The rule has sore experience behind it.

Surplus meat can easily be smoked to last indefinitely, and comes in uncommonly well on light trips from a base. If salt is available it is best to pickle the strips a few hours. A frame three feet square, carried on four forked uprights three feet high, will take care of quite a little meat; this placed on light, green sticks gridironed across. The affair is closed in loosely, top and sides, with bark or splits. Otherwise a small lodge may be built. Hard, clean wood is desirable, but the heat should not reach the meat. A few days' smoking is enough. Half-smoked venison is the confectionery of woods diet and wonderfully good. Fish are split down the back and done like meat, but a saving touch of smoke may be given by slinging them, so split, by the belly skin on horizontal poles about the camp fire one night and another until they are used up. With a little smoking rich fish like salmon can be eaten meal after meal. One of the most trying fish to eat consecutively is the winninish, properly said owanahnish, but it yields to smoke like the rest. One tires of any one kind of fish in a few meals if eaten fresh; no shift of cooking quite avails. There are two remedies: one, the gill-net, which may turn out half a dozen kinds of fish in an over-night setting; the other, the touch of smoke.

A few light steel traps for small game and birds pay well for themselves, as does a coil of snaring-wire for rabbits and the grouse kind. Most creatures can be eaten; few but the scavengers are out of the question. The crow is better than his reputation. Birds and animals count as scavengers, are tabu, when living on dead fish, fish that smell. Young gulls, especially before they can fly, are decidedly good; the old ones want prompt cleaning, also the scraping off of their brassy yellow fat. Probably all water birds are eatable; the fishy ones, loons, coots, cormorants, and the like, are best cut up and soaked in salt and water a few hours before cooking. The owls are well eatable, hawks practicable; herons call for the brine treatment; bitterns go into the stew as they are, Canada lynx also. Coon, woodchuck, and porcupine have a groundy taste unless cooked by an expert. The latter's fat has a mean resinous taste unless fully cooked and it takes as long to boil sweet as a piece of bacon; lying between the muscles, it cannot be got rid of by scraping. Wolverine tastes well enough, muskrat is a prize. Skunk is said to be good — the writer cannot testify; nor as to sculpin, though such as know, reckon it a good fish. Parenthetically, if any not starving cares to try the arch-backed depredators, mink, weasel, and marten, perhaps the otter, one may wish him well; skinning them, for such as have done it, is enough.

Any of a terrapin habit will ask a second help of snapping turtle, of mussels probably, but fresh-water clams are soapy; grasshoppers have no enemies among those who have toasted them; nor snake, though the commoner kinds are reported tasteless and of a dissolving way when stewed. In general, the creatures that go wrong at times by living on carrion disclose their condition by the smell; the out-and-out scavengers like the vulture are past considering. There is a story of some close-feeding immigrant person who cooked and ate a buzzard and simply died.

When the pinch comes, and it does come to many, the entrails of rabbit, ptarmigan, and pike, among other game, are quite to the good; those of ruffed grouse not, and in snow time their crops should be emptied as soon as they are shot — this against laurel poisoning, an acute and serious thing.

The large winter buds of roundwood defer starvation a little, boiled; likewise caribou moss, *Cladonia*, which Eskimo chop fine with a little seal oil and eat raw. Stefansson says oil alone cannot be lived on, though if wads of hair are eaten with it some digestion is enabled. The rock-tripe of the North can really be lived on; it is boiled into a gluey soup. There is no mistaking its leathery palmations, and it may be noted that the short stem that holds it to the rock cuts tough, like a warmed piece of glue. A squirrel or bird helps in a mess of this *waquanapsk*, in fact as an Indian once observed, with scant deference to the material, "the more other things you put in it the better it is."

It is not easy to keep meat in summer. When on the move there is not much to do but wrap it up from the flies. The occasional wetting over of a joint with vinegar keeps these from alighting. Large pieces, not cut across the fiber, keep well in a cold spring. In dry climates meat is run up a pole above fly level. Kept clear of flies, meat does not spoil very fast ordinarily, but blood does, and must be looked out for. Ill-bled meat does not keep. Crop stuff spoils too, and inside belongings generally.

Fish also keep better if bled when caught; they should be at least killed then in decency. For shipping they are to be wiped clean of blood (especially along the backbone), also slime, the gills removed, and each fish wrapped separately, in cloth if possible, but leaves or moss will do. Small game is not skinned or picked, and is wiped out dry without washing. Charcoal comes in well as a sweetener and preservative. Kephart recommends wrapping this in thin cloth for filling the larger spaces. Contrary to prevailing views all firm fish are rather better if laid out in a cool place for a few hours before cooking — the alive taste needs to abate a little. Almost all fresh-water fish are better skinned than scaled. Meat and fish are hurt by freezing, or even being laid on ice, and they spoil quickly after thawing. Salt is damaging to them; it draws juices, hurts flavor. Washing meat and fish does too; as well wash an oyster.

The Camp.

For proper camping, time is needed, fairly an hour of it, and daylight. In the push of travel the latter is often cut short, and the work runs into twilight and dark. As a practice this is not best. It is true that opportunity is to be regarded, that a fair wind is a fair wind, to be made the most of. There will be bad-weather days when one can rest up, but the temptation to make a last few miles is one that most keen travellers yield to oftener than they should. Then, often in chance and evil places, they commit "roughing it," a mistake when unnecessary; there will be enough of that that is unavoidable.

Yet legitimately camp-making can be cut very short at times. After a day's travel any work is hard work, and evasion of it in one degree or another may not be a lapse. The matter is one of weather, or weather and mosquitoes, and in the swing of a trip, these permitting, one may cook and drop down thankfully without more ado. As a matter of fact sleeping sky-over is one of the pleasantest ways when feasible. There is advantage too in a party's sleeping scattered; a very narrow place does for one person, and is easy to find, while as a rule not much levelling is required, nor much bed material. A whole-party bed, on the other hand, may be hard to find, and whatever work is done on it, someone's place may be, only too justly, not to his liking, while if he is off by himself this is at least his own affair.

Of one's various saliences the hip-bone is most likely to suffer; the preventive is a slight hole dug for it. A harder thing to deal with is slope. A little is well enough, but much is very bad; one slides and climbs back again the night through. For moderate slope a small foot-log held by two stakes meets the case, but decided slope is past redeeming. Somewhat an enemy also is sand; inviting to the eye, it makes a tired night without boughs, is less tolerable than smooth rock. Sand makes bad camping in other ways. It gets into everything — eatables, luggage, shoes, perhaps gunlocks; if a piece of food drops there is not much to be done for it. Gravel, on the other hand, is clean.

For an over-night stay a large stump or green tree makes a good back for the fire; the regular three-log back is rather low, and in cold weather is gone before morning. A standing rock is best, but may shell or split when heated. The granites are all bad that way. As competent a Maine Indian as J. Francis was once pinned down by a fragment so large that his companion had to go out for help to lift it off. His lack of caution, however, considering his knowledge of the life, goes to show that the chance of such an accident is slight.

Camping near water level or leaving canoe or cargo where a sudden rise can reach them is also to be done with circumspection. Winter rivers sometimes flood back suddenly for miles, this when the floating ice pans and anchor ice of long rapids accumulate under the solid ice below and choke the channel. An apparently safe camp may find itself emulating a beaver house in short order. Northern natives, though they generally camp high enough, are sometimes held for days on a steep valley side, unable to get away and seeing their supplies diminish.

In the matter of camp sites, summer or winter, large trees are to be looked out for. Aside from danger of their falling, they drip and draw lightning; a site where there are many struck trees about, at any rate, is not a good one to settle in. Not that there is much danger, but a camp under a tall tree is rather a mark, and most of us are a little conscious where lightning is concerned. All in all the small trees are friendliest to camp among.

A snow bed is a good one with a very few boughs; with plenty of them there is no better. A man caught out blanketless sometimes saves himself by digging wholly under, but unless he can stir the body a little he is in poor case. One gets out of close snow with small wish to repeat, though perhaps less cold than damp, bone-conscious, and short of air. The very rabbits keep on top.

Caches.

The caching of food and outfit safely is not always easy to do. Weather alone is easily provided for, unless for a very long time. The trouble is with various sorts of creatures, sometimes including man. Indians use scaffolds eight or ten feet high, projecting over the cut-off trees which they often use for bearing posts; and with care the wolf and wolverine are fairly provided against. Squirrels, expert climbers enough, are not in numbers to count much, nor weasels and martens. A single fisher can do harm. Against ravens, crows, and jays good wrappings are necessary. Where losing the cache would not be serious, a bag cache will do, hung on an evergreen limb as high as one can reach and out of sight of the birds; a tin pail is safer than a bag. A northern wolf can reach higher than a man, this in case meat is hung up. In winter, meat can be frozen into a pond, or built up in a stone cache with wet sand for mortar. Inedible articles, in most northern countries, are safe enough merely buried in the snow.

In bare-ground trips and considerably in snow trips too, food is not fully safe unless in air-tight tin. When it is, the caching difficulty disappears. One has only to toe up the moss, drop a can, turn the moss down again, and the food is there for years. Dry material probably lasts longer in tin than moist, especially where years of freezing into ice and thawing again are concerned. In such conditions rust pin-holes appear finally.

In travel almost anywhere the having at least a third of the provisions in tin gives a security against upset, weather, and predatory creatures that takes a real load from the minds of the party. Cans holding from one to three pounds are convenient, and pack together better if square rather than round. A package of sixty to a hundred pounds weight, shaped like a thin brick, lends itself to all operations.

Cached canoes should be skidded off the ground, well up if snow is to be considered, and somewhat protected from the weight of it. Where there are rabbits or porcupines about, the canoe must be clean of salt; they will eat any salt material. Probably all rodents are untrustworthy here, the large grass-eaters likewise.

Bush fires and thieves have to be considered sometimes. The hiding a canoe from a party of natives in their own country calls for ultimate strategy. One trouble is with the tracks one leaves. Cans can be pitched into thickets from a canoe, or from rocky ground; perhaps the best hiding place is under water, especially for a canoe. The leaving ill-hidden things to be discovered has been successful, the really important ones being carefully concealed elsewhere, and in damp enough places to be missed by fire. A saving thing is that natives do not look for much woods wit in a white man. They are rarely thieves, though their objection to intruders may come to much the same thing.

Carrying.

The rough-ground packing of the world is done very largely by what is known as the head strap, pack strap, or tump-line, in its full development a thick strap some sixteen inches long by two inches wide to go over the front of the head, with a thong seven or eight feet long sewed to each end. The thongs are somewhat less than an inch wide at the head and taper a little to the ends. Sometimes they have buckles at the top, for convenient adjustment.

A fairly well-boned head is necessary for effective use of the strap. A certain proportion of white men cannot use it comfortably. Perhaps the safest arrangement to begin with is a combination now sold which has a tump-line and shoulder straps working together. For carrying on regular roads, professional packers generally use shoulder straps alone, knapsack fashion. In mountain work also, where speed is secondary, the shoulder pack seems preferred, sometimes in the form of the carrying-frame or chair, on account of its great steadiness. But for most ground between the made road and the steep rocks, natural ground, the head strap prevails, and a person who finds that he can use it comfortably is not likely to do as well with anything else. Two "pieces" of 90 to 100 pounds each are the usual load of the Hudson's Bay Company brigades. Exceptional *voyageurs* carry more, and the stories of men carrying 700 pounds of flour a short distance, the last sacks being of course, put on by another person, are probably to be believed. The neck muscles of these great portagers slope almost straight from the top of the neck to the shoulder point.

These are *voyageurs*, professional canoemen and portagers. The hunting Indian, who does only incidental carrying but over rougher ground, is wont to add a second line bearing across the front of his shoulders. Besides taking its share of the weight, this steadies the load, making it almost part of the portager. Instead of straps the Indian is likely to use stout strings, the size of large cod-line, placing a handful of evergreen twigs lengthwise the head to take the cut, which, the weight being partly taken off by the shoulder line, is not severe. There is scope for a good deal of cleverness in this matter of multiplying bearings. An adroit old hand will turn to with a single long line and in a few minutes walk away with his load bearing in six places; there will probably be two lines crossing a pad on his head, two around the front of each shoulder, the result being an elastic net effect hard to improve upon.

The well known ruck-sack, admirable for limited trips, does not make up well with miscellaneous bundles. The round bags now sold by outfitters are preferred by many, carried in pairs upright or across the back in a tump-line. If the bags are not too long the latter way does better in close woods than one would expect, and the strain of stooping under branches and lodged trees to clear a high pack is avoided. Swinging sidewise to edge between trees with a wide pack is sometimes easier than stooping low or climbing over with a high one.

A 100-pound sack of flour carries well lengthwise the back, the tump-line drawing from the two sides at the middle or a little below. If more load is carried, say a round bag or two, flour and all should go crosswise. A full sack of flour, however, is a stiff beginner's load.

Waterproof bags need care against puncture by stubs, are rather easily cut, and of course wear; accordingly they should always be new on starting a trip. The advantage of handles is doubtful, at least for heavy bags; they pull out and leave holes. Leaks can be patched with two scraps of surgical plaster or electrical tape, one inside and one out. The same treatment does for oilskin clothes. Spruce gum and cloth will do, but give way easily.

The most effective bag against water is made double, the outer bag of tough duck for wear, the inner of oiled silk or cotton. To avoid strains on the latter, which has little strength, it should be a little larger than the other. Such bags keep tight better than single ones and are not much heavier, but the common single ones are so readily had now, and on the whole do their work so remarkably well, that they are coming to be more used. Their being somewhat standardized is an advantage, as it is in the case of any outfit that has to be replaced.

Tags of differently colored braid help the eye in distinguishing one bag from another. A conspicuously marked bag for articles that will not bear rough handling is a good institution. For this one bag a state of martial law can be established, and as a matter of practice the heaviest-handed crew will become almost absurdly careful of it, though only if the other bags are off their minds. It is as good as impossible to secure all-round care for a number of bags.

The common meal-bag makes a very usable woods knapsack, substituting tan duck for material. The straps are anchored rather close together just above the middle and caught with buckles near the lower corners. It makes a good hunting bag, being long enough to take an axe, yet flat and imperceptible on the back when empty. In loading such a bag full, the heaviest things are put close to the back and low enough so that the high top will not lean sideways. A pack that rolls from side to side or hangs off behind is virtually no pack at all. The best shape for a pack approaches that of a suit-case or thin brick, at any rate is somewhat flat. One way to arrive at this is to use a tight-rolled blanket or something similar as a back-bone.

Cartridges and the like can be rolled into the blanket, also the axe handle, the sheathed head standing above and clear. The other things are packed on the two sides of the roll, putting nothing front or back. The top of the bag, above the roll, can be filled with any light articles. Such a pack will cling remarkably.

It is not a bad thing to make the bottom of the bag rectangular, say 8 by 15 or 16 inches, and if the bag is a little smaller at bottom than top it can be emptied out with a shake or two, whereas a straight one has to be almost mined out. Such a shoulder bag is handy for side trips on any journey. On the main route it goes into a tump-line along with others, and if waterproof is as good as any of them.

Apparently no one has tried shoulder straps with the Indian breast-line as an auxiliary. In conjunction with the tump-line this is a decided help. It remains also for someone to devise a side-opening bag that is waterproof. The burrowing-down into a deep bag for some article, the alternative being emptying everything out, perhaps to find that what is wanted is somewhere else after all, is always annoying. Certain Indian bags rather point the way; they are wider at the middle than the ends, lace nearly the whole length, pack flat, and are fairly waterproof. They open almost as well as a steamer trunk, with everything near the top.

The Micmacs carry mostly with the breast strap alone — this a sign of white blood and no great habit of portaging — and do fairly well with good loads. More depends upon the man than the method, it would appear, in any case; in the last analysis it is the legs that do the work. Old portagers hardly straighten their knees as they go, but do their heavier packing in a little half-trot, stopping and resting and pushing on again. The French army, reckoned the best marchers in Europe, is said to have taken up this method with remarkable results.

The comprehensive carry-all of occasional portages, so that they are fairly open ones, is the blanket pack. The tump-line is laid across the blanket in two parallel lines, the two sides of the blanket are folded over the thongs nearly to a meeting, and everything is piled in the middle, all sorts to a rocking-chair. The ends of each thong are brought together, thus rolling up the pack, and tied. If it were not that rainy travel and wet canoes call for waterproof coverings, a good, firm blanket might see one through a long trip. As it is the bags have to be along, and on the whole are a more developed vehicle.

A rifle or other compact weight carried in a loop at the breast allows a slightly more erect position than having everything behind, and this is sometimes an advantage; still the best carrying position for the back is a slanting one, back straight but slanting from the hips, center of gravity of load fairly high and close to the body. The carrying yoke, which imposes a perpendicular spine, is not easy to get forward with; the military figure is chiefly for looks and not service.

No one can carry his portaging load very far without resting. Indians wabble off over the barrens awhile pretty fast, then sit down back to a boulder and let this take the load. Coming behind a party of them one sees a string of boulders with large bundles on them but no person in sight. Presently the bundles lift, legs appear under them, and all hurry along. Taking it in this way has a doubtful look at first sight, but there is more under the method than may appear. For one thing, and aside from the familiar lifting of the load with each step, the effort of keeping the load from pitching about is less than in going slow. At a walk this keeps one in strain, but at a pace, just as in bicycling, the load seems to take care of itself. At a pace, again, circulation and breathing are relieved from long constrictions by set muscles and carrying straps, while in turn the muscles themselves do their work better; they bear live shifting strains better than continuing ones. We are developed, like most bipeds, to rather quick motions, and what is to the point as regards the half-run method, are lopers rather than walkers where distance over uneven ground is concerned. For such as have the wind for it the method seems a saving one.

Circulation suffers more perhaps from shoulder straps than any other means of carrying — they bear too near the neck; the upper breathing also is restrained. In uphill work, slow and constricting, but calling seriously on lungs and heart, the face is apt to congest visibly. In control, too, shoulder straps are deficient; a bulky pack inclines to roll and hang off. The Indian head-and-breast hold described is free from these drawbacks, as are most other carrying arrangements, and this may be why, once the use of another means is acquired, few portagers return to shoulder straps excepting for minor purposes.

Man is a good lifter. With practice anyone can move about with twice his own weight on his back; a horse doing the same is hard to imagine. But as a carrier for distance, man is slow — he must have his time. It is the same with hauling in winter; on cold snow the man hauls his own weight, and three miles an hour is his fast pace. The single-hitched dog takes along more than his weight at four miles an hour; on good going twice his weight at five, in extra conditions more than his own weight at a run.

If the working traveller carries sixty pounds over seven or eight miles of portage paths in a day, with paddling in the intervals, he will be tired at night. At the end of a month's trip he can do nearly twice the miles, and perhaps try himself on a sack of flour at 100 pounds. This last the occasional traveller of town traditions is likely to find his limiting service load. A strong man of the woods life can carry this, with little or no path, twenty miles in a day. For the working tripper forty pounds is enough in rough, all-day walking; if he carries more it will shorten his miles.

Deep-Snow Walking.

The practice of the North in travel-camping has of late years turned to the closed tent with a stove. The old, open-fire camping takes more and better wood, and often the latter is scarce near the streams and lakes that afford the best routes. Further, a suitable site may be hard to find and usually a great deal of shovelling has to be done, as a fire cannot be kept long on the surface. Shelter against wind is required or the deep excavation for the tent may drift over. The alternative is the unpleasant one of camping on a wind-blown spot. With a stove, camp can be made almost anywhere.

The site is chosen for dry wood and water, or at least ice. The melting of cold snow is a long disappointing process, though occasionally done in running travel. Larch (juniper) is the best wood, over most of the North, splitting easily and burning well. Spruce is next, or poplar; fir, reluctant and dull.

First of all, snow is tramped down over a space three or four feet larger than the tent; small evergreens are brought in and the branches knocked off — they are struck off like icicles by the mittened hand if it is very cold — and piled in haycock form in the middle of the tent space. The ridge-pole is run through the tent and out, the uprights standing outside. Strings from the top of the tent wall, this a rather low one, are carried to the small stems of the evergreens stripped for the bed, and stuck into the tramped snow a couple of feet outside the tent. The elastic stems let the tent sway slightly in a wind and ease flapping, but seldom or never give way. The bottom of the wall is turned in a foot or less, flat on the tramped snow, and if there is wind, is weighted down with green sticks three or four inches through. There are no loops on the bottom of the wall — they would be useless and only get iced up and frozen beyond unfastening. Last of all the boughs are forked about level with the tail of a snowshoe and the tent is ready. The stove goes just inside the door on four stakes, set only two or three feet into the snow; in fact only the two main uprights of the tent reach ground if there is much snow, all other stakes stand well enough in the snow.

The stove is sheet iron, one foot square and two feet long, the pipe three inches, often with a top elbow to send away the sparks. An old tin plate makes a fair collar, though asbestos ones roll up better and do not squeak on windy nights. The stove weighs about six pounds, the pipe four or five pounds. Frying-pan bread or baker bread, one to two inches thick, is cooked on and around the stove, brought near redness for the purpose.

The tent keeps warm in any weather, but not without rather frequent firing. If a side and the two ends of the stove were lined with thin copper, fire could be kept better partly because the draft and door would not warp and let in undue draught. These stoves are bought almost anywhere at trading places for \$1.50 or \$2 with pipe complete. Sometimes they are placed lengthwise the tent behind the front pole, more often crosswise and on the right as one enters. By the former plan the wood and baggage are saved one handling as they go into their places, but once settled, the other way is rather better. To give room for a stove a tent needs to be about 11 feet long on the ground. The Hudson's Bay tent, practically a wedge tent six or seven and a half feet on the ridge with half cones at the end, and a wall say 16 to 20 inches clear of the snow, gives the necessary length with least cloth.

By taking turn about, a party can keep fire over night even in one of these "tin stoves," as they are called, without much wear; but as a matter of practice almost anyone will sleep cold rather than get up and do stoking. A good deal of fireless sleeping is done, and as the nights in most of the snow country that is still roomy enough for a trip run to 40° and 50° below, the sleeping kit is something to consider. The Far North uses the caribou bag. This can be light and at the same time warm, but is hard to get in nearer regions, and the remarkable woven rabbit robe of the North is also uncertain in supply. The rabbit robe is the heavier, say at 12 pounds. Both are some care between seasons, as to moths and mice, though with either one a person is supposed to sleep out on the snow in any night. Most sleeping bags of the stores are useless in really cold weather, even when very heavy. A convenient bag can be made up of a common down quilt, a lamb's-wool quilt, and a light wool spark cover, which at eight pounds or less for the whole will do its work well. As down quilts are deficient in transpiration it is better to put the wool quilt inside. The surface next one is best of some clingy stuff like thin outing flannel, to prevent the downward passage of cold air, such as occurs with a satin-lined overcoat, which is colder than one lined with clingy material. The outer side of the lamb's-wool bag may be left of the thin muslin that wool quilts usually come in; and the cloth of the down quilt remains as it was likewise. The outer bag is of about the same stuff as a good flannel shirt.

Without trousers, coat, or waistcoat, but with a loose, thick sweater on, or two light ones to take care of the shoulders, a good night can be made at 50° below. A woolen cap is not amiss, nor a pair of stockings. The final touch is a thin head-shawl, such as are sold Indian women at the trading-posts. It is taken by diagonal corners and fluffed loosely about the neck and shoulders to act as a sort of gasket and keep icicle streaks of air from running into the bag. It is well to lay a coat over one, from shoulders to pillow, leaving one side up a little to let in air — there will be no want of circulation at 150° difference between the breath and the outside air.

Spare woolens and clothes may be spread under the sleeping bag for additional warmth below. As to shape, the bag may be carried down full width, but will be heavier and hardly as warm. An attempt to use two down quilts instead of one, results in destroying all ventilation, and one may almost as well keep the head in an air-tight bag as the body. In any case, to avoid perspiration, it is advisable to sleep cool, though not to the shivering point. Winter men mostly agree that sleeping just on the turn of being cold is not only harmless but better for one than being warmer.

In winter a light sack coat is convenient, with an easy sweater to go over it and a hooded frock and woolen sash for wind. The frock may come well to the knees.

As has been said elsewhere, it is a mistake to try for warmth and wind quality in the same garment; the better way is to keep each sort to its function, having the frock as thin and light as possible. Silk would be the thing if it would wear. Light gabardine is perhaps best, but when hot before the fire it catches from a spark and burns fast with white smoke; the filling that makes it waterproof is the cause, no doubt. A balloon-silk tent burns in nearly the same way.

Woolen mittens with leather ones over do well. There is little trouble about the hands; they are mostly swung free and circulate well. The frock must not be allowed to get holes in it; one the size of a pea seems enough to blow one's clothes up with wind in great gales. The neck opening should lace across the chest and have a two- or three-inch flap under it to keep wind out. A handkerchief about the throat keeps the lower part of the hood snug.

In the Arctic, most travellers shave to avoid icing up from the breath, but in deep-snow countries, where fire is had with luncheon, it is easy to clear up the face and the shaving bother can be avoided. Moreover a half inch of beard is a real protection. The moustache should be trimmed pretty close, especially at the ends. Indians have a hard time, with no beard, and high cheek bones and a long nose to guard, but the usual white man with not much but his short nose to consider gets off easier. If a spot catches frost, the warm hand will bring it back. Deeper freezes take snow, but it must be warmed first to the thawing point; very cold snow freezes everything it touches.

Care must be used in passing from steep banks to snow-covered ice. Streams settle as cold weather comes on, and a very thin scale of ice may be holding up the snow over a foot or two wide of open water. In the same way the first ice skids up on bars and boulders, leaving sometimes a weak shell over a heavy current several feet below. There is no safety in places but by trying ahead with a pole.

Dogs are not very useful in midwinter unless a path is made some time ahead; on a fresh one their feet go through. If a route is being worked by stages, keeping a few miles of road under use for a day or two, they are a great advantage. They are used single or tandem for the spread team will not do in thick country. Nor in hummocky, deep snow, could the heavy loads that prevail in the Arctic be hauled out of a hole or jamming place by the driver, whereas those of a hundred or two pounds can be got back and going again without much trouble. A good deal of transportation is done without dogs. On hard spring snow and with a runner sled a single man hauls four or five hundred pounds perhaps 25 miles a day on lakes and streams, but on the gritty snow of midwinter the hauler who makes his ten miles with two hundred pounds on a toboggan does well.

Most toboggans are birch, say 14 inches wide at the widest, near the front, and taper a little to the rear. A cover cloth is laid down, then the load, and after the cover is wrapped over it the whole is lashed criss-cross to fixed lines along the sides of the sled. A well-lashed load will roll down hill like a sausage, sled and all, without being much the worse.

The hard time of sled-pulling comes with rising temperature and sticking; actual thawing may not enter in. A rise of from twenty below to zero makes sticking. Iron runners stick as wooden ones do, but less; cast steel less still. East Labrador hunters find galvanized runners best; the pores are flushed up with zinc and there is no "sucking." At temperatures well below the melting point, sticking can cut the day's miles of a flat toboggan by half. Hard suet helps, rubbed in warm; candle grease helps; oil of any kind makes it much worse. Juniper wood (larch) sticks less than birch. There is no doubt that a knowledge of the "ski-dope" used by experts, a tar-beeswax-tallow type of mixture of varying tempers for corresponding weather, is one of the first things for the would-be snow traveller to acquire.

An ordinary ten-foot toboggan starts about 5/16 of an inch thick, but wears a little in the trip. The thinner it is, following, snake-like, the ups and downs of the trail, the easier it pulls. The stiff toboggans seen about civilization are hopeless. Hauling is best done from the head, at a distance from the toboggan that just clears the snowshoes. The lift gained by the high point of pull is a great help in starting and in getting over hard places, and with a long trace this is lost. Here come in the short shoes, firm of tread, always level, making a good path, and permitting the motive person, poor devil at that, to be close to his load. If it dives at his calves down a pitch, the springy toboggan-curl, *wakauquenigan*, fetches up against them before it can get on way enough to do harm. Any who have hauled iron-pointed runner-sleds over up-and-down ground know what it is for a tired man to have to catapult into the air at the faintest slackening of the lines, and frantically on, to escape the savage crow-bar drive at his ankles. A runner-sled ought to have a tongue, like the old moose-meat sleds of Maine, to hold back with, else boxing gloves on the points.

Pork, flour, and tea are the solid supplies. Snares for rabbits go out overnight at the camping places; ptarmigan and spruce and common partridges come in along the way. Large meat and fish from Indians are the rest. The hunters are over the country then, there is company at times, and good living goes with it. With neither flies nor rains, and good camping everywhere, the winter North, as compared with the same country in summer, has a little the best of it.

Hauling is hard work, rests require fire, and luncheons naturally follow. Two or three hot luncheons on the road are the rule, besides breakfast and supper in camp. Not much is eaten at a time; medium substantials in some amount before starting, a bit of bacon and toasted galette by the way — slow digesters these, but not bulky. A good deal of weak tea goes; the water in it is all one gets until night. The evening meal must be a light one or all stir in the night, and it is a bad thing to kick the covers about at forty below. An hour before camping time a bit of chocolate and bread has a wonderful staying effect and makes camp-making cheerful. It is hard not to be ill-tempered before the fire is going. One is damp, tired, and chilly in the oncoming night-cold, and anything that will bring the men in with songs and jokes, as an inch or two square of chocolate will, is worth considering. Happily camp-making with a stove is not long. In forty minutes from dropping the sled-lines in the twilight two Indians and a not-active white person have found themselves in the tent and settled, fire going, night wood cut, supper under way.

Snowshoeing.

Snowshoeing on uneven ground may begin on very little snow, as little as six inches on a rough, rutted road or trail. The shoes have no back-slip, save feeling out the ground, and help one along surprisingly. So with uneven footing in woods, if the matter is one of merely getting ahead, regardless of noise, shoes may be worth while on eight inches of snow. On spongy bogs they are a saving thing even in summer. For hunting they are noisy, crunching audibly and tapping against sprouts, and as most early-winter travel is incidental to hunting it is common to wait for a foot or more of snow before bothering with shoes at all.

The matter of pattern goes somewhat with the country concerned; the shapes prevailing there, as with the clothing and methods of life generally, may be trusted even if not what one would like best. At least they will work, and oftener than not, better than anything else.

For general service a longish pair 16 or 17 inches wide, fairly small mesh and good beef filling, will do well anywhere south of the St. Lawrence. Farther north a width of 18 or 20 inches is better, the shoe a trifle shorter. The average shoe used in the Northeast is about 24 inches wide and 30 inches long without the tail. The Canadian military shoe, a compromise type something like 18 inches wide and of some length, is hard to improve upon for all-round purposes.

For spring use a small shoe with large mesh and stout filling is sufficient. In northern practice the fine winter shoe is pretty well worn out by that time and something rough cobbled up, perhaps on the winter frames. The white traveller, however, finds it worth while even in winter to have a small extra pair along for used trails and other firm footing. They give the feet a change, save strength when suitable, and when spring comes are ready.

Turned-up shoes are rarely seen short of the Cree region, save as used by the inexperienced. A smallish pair, coarse knit, is nevertheless most desirable for times of thin crust. Flat shoes, at such times, run under and trip one up.

Size of snowshoes counts more than pattern; most beginners have their shoes too small. For dry, loose snow fifty pounds to a square foot is fair practice; that is, a 150-pound person requires three square feet of area in each shoe.

This size is about as much as such a person can use comfortably, but another foot is sometimes added for getting about alone in extremely light snow. The three-foot shoe is a compromise, enabled by the amount of wind-blown snow on lakes and streams that commonly makes up most of the mileage. Some walking also is done on old tracks. In very light snow the strongest man can make few miles a day alone in any case — his largest shoe sometimes sinking ten inches — but two or three men, taking turns breaking, can keep a moderate pace going pretty well through the day.

Patterns range from the long, pointed, Cree tracking-shoe, say 14 or 15 inches wide, to the "round" Labrador types, often made with the bow in two pieces lapped at the sides, and having a mere loop for a tail. A pair of the writer's are 26 by 26 inches over all; or 26 inches wide by about 23½ inches long without the loop. These shorter ones are known to the Indians as *mítshusham*, eagle snowshoes, and the suggestion of an eagle in flight can be readily seen. The round shoe is primarily a hill shoe. Climbing a bank with the round shoe is like going up stairs; the short toe strikes in level, where the long one has to follow the slope and is apt to slip back and perhaps make the rise in switchbacks.

The wide shoe has the advantage of making the best possible path for sleds to follow in, an important matter; a load that binds on the sides is a miserable thing to pull. Further, for camp work, setting traps, and the like the round shape is best; it brings one close up to the work. One trouble with long shoes is that they take quite a space to turn around in; and in bushy ground they get fast, in irons. It may be a matter of some minutes in a narrow place to face around. With the round shoe one simply turns in his tracks almost as if without snowshoes on at all. Curiously, as one would think at first sight, they do well in close growths where the more promising long shoes become bound and helpless.

For travelling in fairly level country with much windblown snow the little Cree tripping-shoe, almost ski-like in running quality, is the speedy thing. It is useless in very light snow, and even the Cree tracking-shoe requires rather easy conditions. In the neck of the Labrador peninsula, where the Cree and the round types meet, the latter has shown a tendency to displace the other. In a more level and open country the turn might be the other way, but beam in a snowshoe, to all who have become used to it, is a feature not readily let go.

The shoes Indians make to sell the unfortunate town person are often enough not as good as they make for themselves, and at that are not always easily obtained. Moreover, the finer art of design is being lost. Fortunately good shoes, perhaps for general use the best to have, can be made anywhere. At a pinch anyone with a mechanical turn can unravel an old pair and learn the weave, and the make of the bows is obvious. The filling makes the shoe. Caribou, fairly put in, does not stretch, and though overrated as to strength, is certainly best for light, deep snow. It should be woven fine; coarse meshes let snow through and the foot wallows. A clean tread implies that all is well with a snowshoe. It must be right in size, shape, and mesh and have filling that does not sag. Without a clean tread, especially in moderate weather, go slip, sore feet, and blisters — *mal de raquette* generally. Here a word for wide shoes again; they keep cleaner. The snow that comes in over the sides is farther from the foot than with narrow ones; there is besides less perimeter for the snow to fall in over — a perfectly round shape has the least possible circumference for its area. Further still, as the service shoe is planned, the tail goes deep while the front stays high and lets over little snow; it shoots up and forward with the step, and whatever snow is over the submerged tail only acts as the feather of an arrow to start the shoe straight.

This is for man's snowshoeing, man going wide, getting over the country. The woman's shoe has less toe, and sinks level. When the snow falls in on the front of it she can lift up (taking her own time) what little it will hold. Her shoes are small, say 20 inches wide; mostly she goes about near camp and on trails already broken. The little side-to-side roll that goes with her eight months of the year on wide snowshoes shows throughout the summer. The men walk it off soon after the snow leaves, but the women do no real walking until snowshoe time is around again.

Ash is the wood for the bows, but brittleness must be looked out for. The best ash, hung up dry a year or two, is apt to break when put to service. It is better to put a house-dry pair of shoes out overnight, or throw them on the snow for a few hours before using; or they can be dipped in water and stood awhile. There is no doubt that bows should be painted or varnished to fill the grain and keep them from picking up damp snow; the only other remedy is to carry a club and keep knocking the sides to shake it off.

Of course almost any wood will make snowshoe bows at a pinch, but hard wood is best for crust and ice. Far-North Indians use larch. In spring and fall the filling needs protection against wear where it comes around the bows; Indians sew on a wrapping of the same parchment from which the filling is cut.

For general use, damp snow or dry, little snow or much, there is hardly any better filling than beef hide, and that of a young horse is equally good. A full-length strip six inches wide just clear of the back bone is the best of a hide; the strings are cut lengthwise. For best results the skin should be soaked Indian fashion, until the hair and the layer in which it is set scrape off, leaving virtually a drumhead parchment. The long strip, from which the filling is cut, improves by being nailed at one end to the end of a plank of the same length, and at the other end to the floor. The free end of the plank is footed a little ahead of the floor nailing, leaning away so as to pull on the green strip. In a day or two all stretch is taken out. The weak places draw out narrower, and filling cut then will stand up in all weathers. The filling, of course wet, should be put in tight, but if too tight it may warp and spoil the bow. Here comes in design; the Indian shapes of bow are so arched that they cannot well draw in. The alternative is more wood and weight, and bad looks, though a shoe so made, if wide and short in the toe and running off straight or even sagging to a short after-crossbar, can walk very well. This shape prevails, or used to, about the Connecticut Lakes of New Hampshire; its virtue was chiefly in having width forward.

The toe-hole should be long in a long shoe and short in a short one. With the latter the toe, well protected, actually plays against and even on the bar at times. How far sanction of toe contact with the bar is to be extended, is a question. Nothing is more to be avoided with long shoes on down slopes. The northern walkers keep the end of the foot well protected, but the short shoe travels more level than a long one, and this is perhaps the main story. But another thing, and to be remembered in considering the success of most professional methods, is that the performer is always in seasoned shape; in the snowshoer's case his toes are wonted to the work. The difference is hard to exaggerate; the same thing is seen in the hands of a man used to manual labor, where not only is the skin hard and calloused but well padded underneath, over the bone. The person of office habits uses up his skin-and-bone hands almost at once, and so, under hard snowshoe wear, his feet. The remedy is not specially devised rigs, unless for temporary use, but giving the points of wear some conditioning beforehand. Even

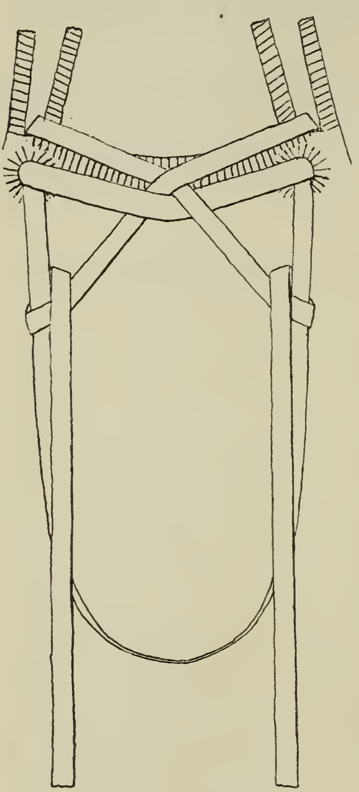

FIG. 4. SNOWSHOE TIE WITH FIXED TOE STRAP

out-door people have to look out for their feet. One's points of application to the outer world are apt to give more trouble than his inner system; a man is better than his extremities. One of the things that make trouble is hard footing, ice, and frozen ground. As an instance, some young Indians coming down a river with an older one, in the phrase of the North "a great snowshoer," made as is their wont a race of their last day's march, the young group against the older man. There was hard ice along the open holes, and old J., running it without snowshoes, gained some lead. The young fellows, remembering certain experienced advice for such cases, held resolutely to the soft snow, away from the water. By the time they had finished their sixty miles they were ahead, still in some form, but poor J., staved up and jarred by the hard bottom, fainted when he entered the cabin.

Ties cling best if narrow, but practice varies here. For level work the single thong without a toe strap is least constricting, a consideration in cold weather, but gives small control. In uneven and obstructed ground the fixed toe strap, say one-half inch wide, is almost necessary. The long thong is crossed in front of the strap to hold it back (Fig. 4). This is the usual form of tie in New England and north to the St. Lawrence. The fixed toe strap shown gives great control. Thongs are best narrow, say ¼ or 5⁄16 of an inch wide; they cling better than wide ones and are better about icing up. An old bootleg cuts into good ties.

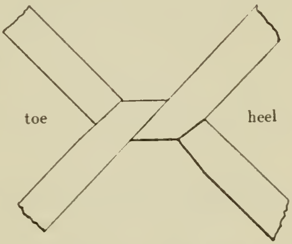

Fig. 5. Half Turn used in Snowshoe Tie

In the West and considerably over the farther North the fixed toe strap is replaced by a half-turn, or a turn and a half or more, of the long thong itself (Figs. 5, 6). The half-hitches at the sides of the foot are the same as shown in the toe-strap arrangement. The method gives less control than the other, but is rather easier on the foot and permits better circulation. For cold-weather walking in fairly level country it is probably the best way of tying. The thong is soft and up to an inch wide. Whether a toe strap is used or not, the second run of the thong is sometimes knotted fast at the half-hitch, leaving only a single turn back of the ankle. Few town-bred men put on their shoes well. Departure from the Indian way is always for the worse in deep-snow work, save to meet certain disabilities of the occasional snowshoer who goes out with unseasoned feet. For such the various toe-cap rigs sold in the shops, more or less rigid and hinge-like, may do at the outset. No heel is admissible even with these, but almost any footwear without one can be worn.

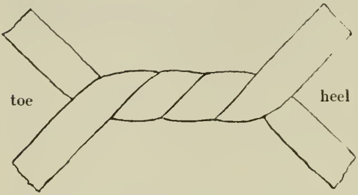

Fig. 6. Snowshoe Tie with Several Turns

Hardened feet are almost essential for day in and out work with the primitive thong and moccasin. Woodsmen begin with the early snows and get their feet broken in gradually, whereas the unlucky tripper often has to begin outright in deep snow and either accept punishing wear or cut down his distance. Previous conditioning in some form is vastly to the good for muscles as well as feet. The lifting is hardest on the former; many a well seasoned snowshoer has come in lifting his shoes by strings tied to the crossbars and operated with the hands.

Micmac Indians make much of eelskin thongs, and salt away the skins in summer for the purpose. It takes two of these for the long thong, sewed together at the head end. The tie is anchored at the very front end of the short toe-hole, and at the crossing on the toe strap, also eelskin, forms a soft nest in which the toe fetches up without damage when one is running down hill. Eelskins do not ice up and on the whole are as good as anything for a longish shoe.

Half-inch lamp-wicking or round wicking makes good ties, though, unless treated with something like the lead-alum mixture used for waterproofing, they ice up at times. Viscol might do as an ice-check, but grease and oil are bad. On the whole the old caribou thong is hard to improve upon. At first it bothers by stretching, but once settled may go weeks in cold weather without untying. The foot is shoved into the long heel-loop (Fig. 7) as it lies on the shoe, turned sharply outward and around toward the tail, swept back with the tie bearing against the back of the ankle, thrust under the toe strap, and the shoe is on. This tie has less control than either of the others described and is only adapted to short shoes. The thong comes back along the sides of the foot without crossing it. A great deal of northern travel is done with this tie. The old hand throws down his shoes, makes a mere double shuffle on them and walks away. Unless to stand the shoes up against being buried in a snowstorm, they

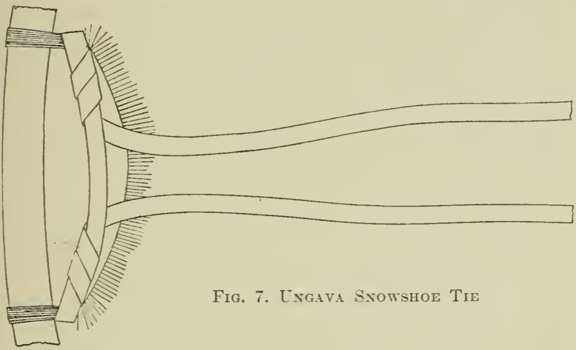

Fig. 7. Ungava Snowshoe Tie

need not be touched with the hands for days at a time. The sight of a novice, head-down and apoplexy impending, devising private methods, is common but uncalled for.

Whatever tie is used should fulfil the requirement of being cast off by a single scrape of the fingers, and in ordinary by a twist of the foot alone. One gets cast sometimes in light snow among bushes in such a way that only one hand is available, perhaps no hand. But the serious matter is getting through the ice; here no chance can be taken.

For footwear on dry snow there is only one good thing — the porous Indian moccasin. Snowshoers keep them from all grease, not even walking where greasy water has been thrown out, nor on green boughs that get them pitchy; a clean but clingy surface is guarded at all pains. As a practice they should be changed on coming into camp;

changed in winter to get the stockings drying and to relieve the feet as well as save the moccasin; changed in summer to avoid all chance of burning them about the fire. Moose moccasins keep their shape better than caribou and are warmer. The tops should be of cloth such as good woolen trousers are made of, and they keep shape better if lined with thin cotton cloth. A ten-inch top saves wearing a snow leggin and is flexible, light, and warm. Leather in general is rather to be avoided in the open; it gets slippery when wet, stretches, is hard to dry, stiff when it is dry.

Eskimo seal boots, "skin boots," are sometimes snowshoed in but get glassy. With thin Indian moccasins over they would do. Canvas moccasins are not bad; an old sack will make a pair. Oil-tan moccasins are poor things, heavy, greasy, and cold.

The stocking matter is a large one. In the cold North whatever is used on the feet, there must be plenty of it. Most beginners have their moccasins like their snowshoes, too small. There is no reason for it; there is room on a snowshoe for any size of foot whatever. Well built-up feet, besides keeping warm, are the better protected against wear, and this is important. Moreover, in warm days the warmth of the feet does not melt the snow and ice up the shoe. A good rule for size in the Hudson's Bay country is to have the moccasin large enough for five pairs of thick woolen stockings. At that the rule of wearing snowshoe ties as loose as the going permits is to be followed in windy times; a chilled foot on a large lake is a near call. If a foot chills one kicks off the shoe, stands on the other foot, and slaps the cold one on the back of the standing ankle until the blood goes down to the toes.

Regular stockings are well enough, but they wear thin under heel and toe in two or three real days' travel. The duffle nips of the North are better, though they wear in the same way. In any case a thin, white-foot cotton sock next the foot, merely for its non-irritant surface, is remarkably better than wool. Lisle thread scours like sand. But for a long snowshoe trip there is nothing of the wool sort like the blanket foot-wrap. A somewhat worn blanket is best, torn in strips about 6 by 20 inches. Three of them will do, or two with a stocking over. They wear evenly, dry easily, need no mending, and laid down under the sleeping bag at night give a good blanket from shoulder to thigh — and one never has too much bed underneath. They are put on in a spiral from the toe, crossing each other.

If feet give trouble either from cold or soreness, a pair of fresh rabbit skins may be put on, always next the foot, skin side in, the moccasins to be filled out with the necessary amount of woolens. It takes a week or more of travel to harden the feet, and toward the last, especially if hauling a load, the punishment may be severe. First a water-blister under the great toe, then a blood-blister, later a pus trouble; and finally, when it seems that one must give up, a horn-like condition almost suddenly succeeds and the problem is over with once and for all. Snowshoe evil in the tendon of the instep or under the knee, or in fact almost anywhere below the chest, is always possible in deep-snow travel, but the toe-bearing once hardened, a trip may go through without further trouble.

In point here is a real advance upon old practice, namely the use of rubbers instead of moccasins in mild weather. They must be heelless and can have cloth tops. Wherever they bear, the shoes must be served with extra thong, *babiche*, to avoid rapid wear. In cold weather rubber hardens and easily crumbles. A rubber dropped on the floor at forty or fifty below zero sounds almost like falling crockery. The usual troublesome balling up of ice under the foot, a great nuisance in damp weather, does not occur with rubbers. They are well worth taking along.

Regarding ski (and in suitable country, they are better than web shoes for getting about light), less service is to be had of them in running travel than might be assumed. They require firm snow. This granted, they are speedy, but the speed of a travelling party is after all only that of its cargo, and in the transportation of this, which distance travel in the end amounts to, they are less effective than the short shoe. There is always breaking out to be done, path-making, and the ski makes as good as no path at all for dogs and sleds or for men on web shoes who come after. For convenience in camp work and the general incidentals of the life there is no comparison, and the absolute grip of the Indian shoe in hauling — this counts greatly — is well beyond that of the sliding ski. The history of polar travel is in favor of the web. Peary prefers it; Nansen, confirmed devotee of the ski, makes his acknowledgments to it. Coming to a light-snow district in his crossing of Greenland the latter put his party on webs — they had never had them on their feet before — and remarked afterward that he did not see how they could have gone through without them. His genius shows in his having them along. Although he held to ski in his polar drift, it is noteworthy that upon his leaving the *Fram* for his ultimate march all the ship's company shifted at once to web shoes. Amundsen, again, had the only doubtful time of his polar march in a period of deep snow, wallowing on ski. Yet there is no really light snow in open countries, not such as is dealt with in the forested sub-Arctic. And Scott, in the same time of light-snow trouble, met his end from exhaustion, where reasonably, if one may say, broad shoes would have taken him through to his cache.

If one were intending to settle down for a time in a region of large lakes and rivers, or open country favorable to ski, a pair would be worth some trouble of transportation for going about. With best conditions they are nearly wings compared with the plodding webs — life preservers in the feathery north deeps as these are. With ski are skill and dash, and impulses of youth. It is not strange that those bred to their use are slow to forsake them, and carry their fliers of the slopes into fields where they sometimes fail.

Light Trips.

For operations of a few weeks, in such country as the semi-barrens of northern America, lightness of outfit may be carried nearly as far as in mountain work. The summer routes follow rivers and lakes, and the good walking of the country, compared with that of most regions farther south, invites foot trips up to ten or fifteen days' extent away from navigation.

The canoe, where much portaging is to be done, can be lightened down to about 55 pounds with little sacrifice;

this for a craft 15 feet by 32 inches, by 14 or 15 inches, with rather full bilges. Made a little full toward the ends, it will carry 600 pounds in common breezes, and close to 900 pounds in flat water. With the ends carried out a little finer, making 16½ or 17 feet of length in all, it will push along well through moderate lake waves. Wind makes more trouble on the open barrens than on moderate-sized waters, and it is not a bad thing to save wind surface by keeping the ends a trifle low; for bad water one can easily deck the ends a little with cloth. For the carrying, a head strap attached to the middle bar is a steadier in winds. For special use a 15-foot canoe can be brought below 50 pounds, skimping the filling of the canvas and economizing a little on wood. The limit of lightness is reached by using light canvas, unfilled, and coated only with a tough, high-grade varnish. A square can of quick-drying varnish would need to be taken along, and at best such a canoe is not for ordinary use.

In northeastern Labrador a party of four made a success of a 15-foot, 56-pound canoe for some weeks by letting two persons paddle through the lakes with the baggage and the other two walk around. The whole party met and fell to on the portages. The saving was considerable, not only in the weight of a second canoe, but the provisions that in a sense would have to be carried to feed it; that is, with an extra canoe to carry, the party would make slower time over the portages and more supplies would be necessary accordingly. In dividing a party in this way care is necessary to keep the two sections in touch when the route is unknown; there are often side streams and deep bays that are better ferried than flanked. Once a party is seriously separated, there is no signal in tolerable weather like a smoke on some commanding spot; a ten-mile signal can be put up in a few minutes with dry wood under and moss over; the farther away the smoke is the denser it looks. The canoe party can spread a tent on poles or a tree; in any case a large, conspicuous mark is necessary.

The tent, for two or three persons, may be a cone, 7½ feet high and 8½ feet across the circle. In cutting the triangles of cloth they should be narrowed a half inch or so at the middle, making the cone slightly concave; otherwise the middle-height cloth will be slack and flutter in the wind. The one pole necessary can generally be found, where the three needed by a wedge tent may tax resources. In any case a center pole can be made by splicing two paddles.

The tent should have a ground strip eight or ten inches wide, to lie flat outside, not as usual inside. When stakes and earth to drive them in are available they hold a tent well, but in glaciated barrens both are often scarce and stones plenty. The latter, good ones of 15 to 20 pounds and upward, are better than stakes. They are laid of course on the ground strip. In gales they may need to be larger and on the weather side laid to touch each other. If the tent slacks under a gust they can be shoved out from inside, and the tent nursed through a hard night with little or no going out.

Mosquitoes are the serious enemy. The tent is sealed against their coming under by carrying a windrow of sand or earth four or five inches high around the edge of the ground strip. Lacking a wheelbarrow one spreads out the sail or fly, shovels a good pile of sand upon it with a paddle, gathers up the corners and swings the load, forty- or fifty-pounds weight, to one's back and so to the tent.

A netting front for the door is a nuisance, is draggly when wet, and easily torn. An inner tent of netting with a bottom is good, but hangs in and narrows the tent space; while even a small hole lets in a surprising number of mosquitoes in real mosquito country. Moreover one carries mosquitoes in on the clothes, to hide awhile in the folds of the netting and bother one later.

A good device is a non-clinging cloth front — satin might do — with a high-up, netted ventilator say three by five inches, with a flap over to tie down when necessary, and a like ventilator close to one's head at the bottom. Then, the front curtain sanded down, the mosquitoes within may be rapidly killed off with a candle, a thousand in ten minutes. It is not necessary actually to touch a mosquito with the flame, but merely hold near it; its wings singe with a slight fizz and the creature drops off the cloth, done for. Of course nothing can be more mosquito-proof than a cloth-bottom tent with a funnel door, but the bottom gets damp, gains weight and bulk, and is hard to dry.

Sufficiently low terms for the cooking kit come to a pint cup for each man, a tin pail according to the party, a large spoon, sheath knives, of course a frying pan. If the last is engaged on meat, the bread must go into the hot ashes. A folding baker is the next most necessary thing, or a second fry pan. When the party is living mainly on fish and game it matters little how the flour is cooked, whether fried in flapjacks or in a solid galette, or baked, or boiled into the soup; the main thing is to get it cooked. Salt is required for all vegetable supplies; meat and fish do well without.

A well tested if unusual form of frying pan is a deepish, rectangular dripping pan, say 12 by 14 inches. The usual round ring should be taken off and a stout square one, 1¾ inches wide and 2 or 2½ inches deep, put in its place. The pan should be as much as 2½ inches deep. The handle is a four-foot stick, the end cut off on a slant and a notch made two inches back from the end on the other side. Being of very thin iron, the pan cannot be laid on the fire but must be held by the cook. It is really a small matter to do this, frying does not take long, and in this way perfect cooking can be had over the meanest green smoking fire, quite as good cooking as with the heaviest cast-iron pan on coals. A turn of fish can be cooked almost before a new fire is fit to put a common pan on at all. Moreover the pan is light, and deep enough to boil or stew in. One stands erect while holding it; there is no bending over. Incidentally a square pan is less likely to tip over than a round one, besides taking fish and most other shapes of food with less waste of room.

A four- or six-quart pail for bringing water and mixing bread in is a decided convenience. Spoons and forks, both of aluminum, are of course good to have. Solid meat is roasted in collops 2 or 2½ inches thick on sticks stood up in favorable locations around the fire. Fish comes to be boiled rather than fried when regularly lived on, but is sometimes roasted on a spit run through lengthwise.

A light oilskin coat is a comprehensive luxury in windy countries; it does for rain and wind, goes down underneath at night, is laid over for drip when the tent leaks, and has even a certain warmth. A good sweater, stout beef moccasins and a spare pair, a waistcoat for the sake of its pockets (woolen back), a visor cap, unless one insists on a brim, fairly thick underclothes, and perhaps an extra suit, a thin, clean pair of trousers to come out to peopled places with — and the rest is commonplace to all camping. For mosquitoes two pair of cotton drill gloves are necessary — they wear out in paddling — and a large head handkerchief and some extra netting. Brussels net, better if made of silk, is the thing in netting, best black. Tar, suet, and pennyroyal are the mixture for face and hands, and in a tin box; liquids and bottles are all wrong. At times netting is not bad over the face even in daytime, but there is not much in covering the face for the man who is doing work. A cloth bag over the head, with a netted hole opposite the mouth, does to sleep under the canoe with, or when out without a tent.

A 1½ Hudson's Bay path axe, 26-inch handle, is enough for the semi-barrens. A pocket axe has a certain handiness, but is a trifling tool save as an auxiliary; a small, double-edged saw will take one through better.

A single, heavy blanket of medium size will do until the ground freezes. In cold, clear nights the tent does for a blanket, and in occasional northers with a little snow it is better to take turns keeping fire, if necessary, than to carry extra blankets for a week or two at a time without needing them. In the matter of rain, a short canoe will roof two men with only part of their legs out, and so long as these are warm a little wet does not hurt them. It is not so bad to be wet when warm, or somewhat cold when dry, but being wet and cold at the same time does mischief.

In windy rains a very slight lee protects one. Lying close up to scrub 18 inches high, so only it is dense enough to turn the wind upward, there is good comfort; against a low rock the same. If the shelter stands too high there may be a back wind that brings rain into the lee.

Beyond birch-bark latitudes the fuzzy, dry twigs low down on evergreens are the best kindling. In continued times of dampness a short candle is a help. Instead of fussing with damp twigs and whittlings and covering the ground with expended matches, the candle, easily lighted, is stood close under the twigs and let alone; before long it dries the near wood and starts it off.

Basic provisions are bacon, some sort of breadstuff, and tea; most countries will supply enough meat or fish to vitalize these if nothing else is carried. Bacon is hard to surpass for the grease element; its original moisture is well dried out in the smoking, one does not tire of it, and it is more wholesome than salt pork. In a cool country there is no need of the commercial wrappings bacon comes in, but the expedient of paring off the rind to lighten weight is doubtful; by the time the grease is fried out of the rind its weight is negligible, and bacon travels better with it on.

Some proportion of the bread supply, say a third, may well be in *erbswurst;* it is usable without cooking and high in food value. A similar material with ground-up dried meat through it, as made formerly by the American Compressed Food Co., Passaic, N. J., is still better. The present United States ration in oval tins is poor stuff, though sustaining. *Erbswurst* is best carried in nearly square tin cans of a pound or two each. One tires of its taste, and partly for this it is worth while to put a lump of hard-dried meat into each can. A certain supply of hard bread, the harder the better, is a convenience, especially for side trips. Compressed tea tablets are nearly as good as loose tea and handier. Flour is best of whole wheat, especially if a game supply is doubtful or wanting.

For getting the living the irreducible minimum in effective shot-guns is a single 28 gauge, weighing 4¼ or 4½ pounds, for black powder. Brass shells are not yet made in this size, excepting the thin Kynock ones, imported; but a few of even these should be taken, as paper shells carried long in the pocket get sweated and swell. The Harrington & Richardson 28 costs only about \$5 and being of such cheap material it is safer to have along an extra set of springs and an odd firing pin.

A .30–30 rifle does well in open country, where hit game can be followed by eye. With smokeless powder the game often stays about after being struck if the hunter keeps out of sight. At times the sound of a bullet striking the ground beyond the animal will turn it toward the hunter. A 20-inch carbine at six pounds, well tried for accuracy, is handy, but a 24-inch barrel is better, and a full magazine better than half. Ivory or "gold" is best for the front sight, which should not be too small, and a tang sight for the rear. A bar sight without notch or mark, turning down flat, is preferred by many. The having a third sight is a good thing, for if one of the three is knocked to one side the other two show what has happened, an important advantage. In serious expeditions, where much may depend on a distant shot, a .25- or .27-caliber, high-power, bolt-action rifle has place. The small bore makes for lightness of ammunition. Stefansson and Hanbury found decided advantage in the extreme range of this type. A 10-inch, .22-caliber pistol for small meat completes the armament.

In lake countries fish is the surest reliance. An experienced northern traveller will make a considerable trip with only a gill net to get his living by. The net may be 120 by 4½ feet and 3½- or 4-inch mesh or more, measured at length—a 4-inch mesh is 2 inches square. Lake narrows and still mouths of streams are natural net places, though some current can be managed with if necessary. Dry sticks are used for floats, split a little at the ends and nipped upon the back line; small stones do for sinkers. A little observation in almost any salt-water neighborhood will show methods of setting.

A few trolls are useful, with a stiffish fly-rod and kit and some large and small bait-hooks. The namaycush trout is the important fish of the North, running in larger lakes to 30 pounds. It takes almost any bait, in fact one of its other Indian names, *kókomesh*, means "the fish that swallows anything." It trolls well with a double spinner, gold and silver, which is good also for pike up to four or five pounds. For large fish the whirling spoon is better. Whitefish, the best fish of the North, are virtually caught only with the net, though in foam eddies they will take a minute fly. A steel rod, barely limber enough to put out a fly, takes less care than a wooden one and serves the pot well. In the long northern twilight the trout kind come close to the river banks and are ready to take anything. Eight or ten feet of line on a stick brings them out as well as a rod and reel. They can be run up the beach summarily with stout tackle; there is no point in playing subsistence fish all over a river. An extra supply may be split down the back and strung on level poles about the fire each night until used up. They dry off enough in a few hours to carry well in a blanket.

In going upon an exclusive fish-and-game diet it is well to remember that natives living in this way use blood, marrow, and to an extent the intestines; and at intervals pound bones into powder and eat that. Apparently it is necessary to eat pretty much the whole animal to get all needed elements. Lean meat may do one well in warm climates, but in cool ones fat must be had, or at least starch. The going off all breadstuff is keenly felt by persons habited to it, and they lose strength. There is dispute as to whether even an Indian can live indefinitely on caribou, rabbits, or ptarmigan. Living on well conditioned bear, beaver, or especially seal, is another matter, one can work on these.

Something ought to be possible in these days of organic chemistry toward making available certain common vegetable materials. The highly organized, intelligent beaver does perfectly on birch and poplar bark, the caribou on starch-containing moss. The elements we require are there, in forms barely beyond our direct use. A little chemistry, and hardly beyond the chemistry of cooking, ought to bring such near-foods within our power of assimilation. Then the state of the wilderness traveller, liberated from his cargo, delivered from his perpetual haunt of failing provisions, would approach that of the caribou, wandering month in and out without care, where he will.

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CAMP COOKING.

BY SINCLAIR KENNEDY.

Utensils.

In choice of cookery utensils the factors are scope of use, portability in transport, and convenience. In other words the article which is (1) useful for most needs, (2) lightest and least bulky to carry, and (3) requiring the least attention when in actual use is the most valuable cooking instrument. A frying pan meets the two first requirements. A pail or a double-boiler meets the first and third requirements; and a reflector-baker is in a like category but is less portable than pail or double-boiler. Tin-ware, aluminum, and aluminoid, on account of their lightness, are the materials most desirable; while enamel-ware, on account of its great weight, is less so. Tin-ware rusts, aluminum bends, and both are affected by acids. Aluminoid, which is an alloy of aluminum and nickel, does not rust and is more rigid than either tin-ware or aluminum; but it is affected by acids. The acid factor can be minimized by the use of an enamel utensil for acid foods, if these are frequently cooked, and a practice can be made of not keeping such foods long. Aluminoid utensils which nest are now generally obtainable and make this substance the best for all cooking utensils except reflector-bakers, plates, cups, spoons, and forks. For these tin-ware is preferable owing to the intense radiation of heat from aluminum or aluminoid.

In temperate climates an expert will get along with one pail, but will find the following kit worth its weight owing to its relative compliance with the three requirements of usefulness, portability, and convenience: a double-boiler, a frying pan, and a reflector-baker. These are valuable in the order named, so that the baker is the first and the frying pan the second thing to discard either before or during a walking trip. In addition a cup and spoon per man are desirable. A fork per man is a luxury. A knife is carried at the belt by everyone.

A double-boiler may consist of any one of various arrangements whereby an inner container is inserted in a pail. One convenient form is to have a handleless lipped pan, such as a miniature milk-pan, of just the right size to slip into the top of a pail and fit rather tightly. In this form the upper portion of the double-boiler may be removed by two sticks or two spoons or two knives inserted one on either side of the pail when the pail is off the fire and on the ground. A transverse wire makes removal easier and can be affixed so as not to prevent use of a cover. Another and less satisfactory form of double boiler consists of one pail hanging within another. This wastes much of the heat applied to the outside pail, but is a convenient makeshift when time is no object, as when cooking cereals after the evening meal before turning in. To avoid this heat-waste an extra cover for the larger pail may be so cut as to permit the smaller pail to drop through it and thus make a tighter utensil. Less desirable than either of these double-boilers are the various ones sold in the shops for use on stoves. Their handles and their lack of nesting-ability forbid their use on any out-door expedition short of wagon- or schooner-travel.

A double-boiler is more convenient than any other one utensil and is of greater value than a frying pan as far as general usefulness is concerned. It is only on the question of portability that any criticism can be made. Moreover, if the expedition is to have a pail, which is unnecessary if a frying pan is taken, then economy of labor suggests that the pail should be in the form of a double-boiler. By utilizing a detachable handle for the inner container of the double-boiler it is possible to convert the inner container into a frying pan. Such a frying pan and double-boiler combined is the best all-round cooking utensil available. Apart from use as a frying pan and as a single pail, these two articles in double-boiler form are useful for making all kinds of cereal and pudding dishes which require indirect heating and low temperatures, as well as soups and stews. They may also be used to cook two dishes over the fuel supply and fire space of one dish. The persistent use of a double-boiler will mean that many meals can be cooked while the cook is seeing to other jobs such as wood chopping, unpacking, or packing.

A frying pan, or inner portion of a double-boiler, should be straight-sided and should nest with any pail or double-boiler taken, and should have a detachable handle that permits extension by a stick. The pan should be at least four inches deep. This aids in deep frying and in the baking of bread or meat. It also permits of use as a stew-pan or boiler.

The reflector-baker should not be in folding form, as it is then less effective for baking and useless for such incidental purposes as washing dishes or clothes. It is best of such size that the other nested utensils can be inserted longitudinally in it, though this is not essential. It should be kept bright and shiny, as this aids its baking power. Ashes and water make a good scouring material and are preferable to sand.

The utensils for holding supplies must be air tight (for example, friction-top cans) for tea, salt, sugar, and cereals. Bolted flour, on the contrary, is better carried in cloth bags, as it becomes self-protected by the crust of flour formed by moisture. This self-protective quality permits the packing of other articles such as cereals in bags within the flour bags, thus saving much weight of metal.

The utensils for cooking should be carried in a cotton (drill) bag with aperture large enough to make insertion easy. The fabric of the bag should be woven closely enough to keep soot from getting out.

Fire.

The fire for cookery purposes should be as small in size and fuel consumption as is possible for the cooking planned. North American woods practice recognizes two types of fires. One, built of sticks arranged in tepee or tent form, is called the Indian fire; the other, of sticks horizontal and either parallel or at right angles to each other, is known as the white-man's fire. Both of these forms have their advantages. The Indian fire, for the boiling of a single pot or the roasting of individual pieces of meat on spits stuck into the ground around the fire, has the advantages of small fuel consumption, good draught, and resistance to rain. The white-man's fire permits the use of more than one pail at a time, and is especially desirable when broiling on horizontal spits or baking with a reflector-baker or during such other processes as require an extended fire.

Each locality that has wood fuel will have its relatively more important fire woods. Generally speaking, a tree or a limb that is dead but still standing upright is the best form of fuel, whether the wood be what is generally called a soft or a hard wood. Roughly speaking, any given wood is at its best fuel stage when it offers its maximum resistance to the axe. Only experience can make this rule of value, and in obtaining this experience the axeman will find that for cooking-fires many trees green are better to burn than other trees dry. For example, using the white-man's fire, green silver or paper birch makes a better fire than dry pine, because the pine makes a very intense and short heat which requires the constant attention of the cook.

It pays to split wood. For most cooking-fires, other than a fire on which a double-boiler is left for an hour or more, the best size of wood for fuel is approximately three to five inches tree-diameter doubly split, that is, into four pieces. Larger trunks or boughs should be resplit to bring them to these quartering dimensions. This size, if properly fed to the fire, gives a strong heat and permits accessibility to the fire. A good rule for one man who does all the work is to obtain the wood, split and prepare it in the form of shavings, kindlings, and fire wood; arrange the food ready for cooking; and then light the fire with one match.

The Indian fire, to boil a single pail for tea for six men or less, should nowhere extend outside of a 12-inch horizontal diameter. The white man's fire, carrying two pails, frying pan, and a reflector-baker for a similar party's substantial meal, should not be more than three feet long by 15 inches wide. These dimensions in both cases are large. Experience will teach the use of smaller fires and progressively better fuel. In connection with the white-man's fire it is often convenient to have fire-dogs of from three to six inches in thickness made of green wood and placed at right angles to the longer dimension of the fire. It is often convenient also to have a back-log effect made of one or more large sticks the length of the fire. This is an aid when using a reflector-baker on the opposite side of the fire. It also forms a convenient shelter for the cook. Remember that a fire which is too high above or too near the ground will not burn properly and that proper horizontal spacing, which varies with the condition and kind of fuel, is likewise essential to effective firing. A well planned, well fed and well attended fire of hard wood should give a steady heat with only slight variation in intensity, and it should always be small enough to permit the cook to sit beside it and hold a frying pan with a 10-inch handle without discomfort from heat or smoke.

Cooking.

Food is cooked by boiling in water, frying in fat or oil, or by broiling or baking. Other methods are mere variants of these. For example, parboiling refers to boiling or sub-boiling and is usually insufficient to prepare thoroughly the food for human consumption. Stewing implies a lengthy boiling and preferably at a relatively gentle heat. Boiling, if the desire is to take the goodness out of the food and transfer it to the water, should be done slowly. If, on the other hand, the water is merely used as a means of applying heat to a food, then it should be boiling briskly before the food is added, so as to obtain the same closing of pores as in broiling.

In frying, the grease may be used either for cooking a given food, or as an additional ingredient to the food. If the former, then it must be "smoking" before the cold food is put into the pan, and this smoking grease should be deep enough to cover the food. If the grease is to be an ingredient, it need not be so hot nor so deep. The first of these processes is "deep frying"; the second is called "sauté" and is the method employed by most inexperienced cooks.

Broiling requires a sudden, intense heat, sufficient to sear the outer portion of the article broiled. This conserves the aroma of the food that might otherwise be evaporated by a slow heat. Baking does not necessarily require the sudden application of heat, as for example in bread-making, where with the use of yeast a gentle heat is desirable at the outset of baking.

Boiling is the most economical method of preparing food, as there need be practically no wastage, providing the food is prepared on a low, boiling fire. Fish, when used continuously as a staple food, is best boiled. Slow boiling adds much to the taste of most vegetables, and when applied to meat foods, in order to extract their nutriment, makes much better soups than when high temperatures are used. Cereals should always be stirred gradually into violently boiling water and then cooked more slowly. Real oatmeal (not the ineffective article called "rolled oats"), cracked wheat, and cornmeal require upwards of one hour, if started by a violent boiling and continued in a double-boiler. It is possible to soften these foods and cook them sufficiently for palatability in 20 minutes, but nothing short of an hour will produce the best results. Tea should be made by pouring fresh water, which has just been brought to the first boil, on dry tea leaves. Cocoa or chocolate should be boiled at least twenty minutes; and milk, if used, should be added just before taking off the fire. For substances that require salt in boiling, add the salt previous to the other ingredients.

Frying, whether in deep fat or in oil, is a convenient method of cooking, and when fat as an article of diet is craved, frying is the usual way of supplying the need. Bread soaked in grease and then toasted is excellent food for out-door men in good condition. The fact that it is indigestible for sedentary householders is no argument against its value when a well conditioned system craves strong food. Under most circumstances food is more wholesome and more appetizing cooked in deep fat.

Broiling or roasting can be done on any green, hardwood stick. By laying the stick horizontally across from crotched uprights at one side of the fire, the old-fashioned spit effect is produced. The meat is turned by turning the stick, and a pan is placed under it, just below the level of the fire, so that the juices which fall into the pan will not evaporate. Basting from this pan of drippings tends to check the outside cooking of the meat, and thus permits the inside to be more uniformly done than it would otherwise be. Cooking meat thus beside the fire rather than over it obviates some danger of burning, as well as of smokiness of taste. Another method of broiling is to thrust one end of the broiling stick into the ground. Length of time of broiling will depend not only on the bulk but on the density of the food.

Baking may be done in a closed receptacle, such as a pail with a lid or a regular baking tin, buried in the ashes of a dying fire; or on a stone, plate, or frying pan similarly disposed in the ashes and tipped sidewise to bake the upper surface. A reflector-baker set beside a living fire may also be used; or a Dutch oven, which is a heavy, cast-iron pail, much too heavy for the ordinary use of campers. If a substance contains sufficient moisture to permit the process, excellent baking is obtained by wrapping it in clay and burying it in ashes or under a fire. This is merely a modification of the beanpot of New England baked beans. Baking in oiled paper is the same idea. Of all these, the reflector-baker is the most convenient and the frying pan the next handiest under most conditions of transport.

Food.

Dry food in adequate containers for a trip should average three pounds per day per man. The time-honored American manifestation of this hypothesis is the "10-10-2 and ¼" of flour, salt pork, sugar, and salt respectively per man per week. Nevertheless most men will ask for more variety, and this is best obtained by adding foods capable of many combinations. For example, chocolate added to the above list will produce not only another food by itself but a drink, a cake, cookies, and a "fudge." Pecan-nut meats not only add a valuable and a very different food but again make, by addition to chocolate and sugar, a new form of cake, cookies, and "fudge." Tapioca, evaporated apples, prunes, and apricots are in the same class. Beans and peas, dried beef, hard-tack, and rice are especially adaptable. Cracked wheat and cracked, parched seed-corn are particularly valuable. The wheat can be prepared after dinner by boiling one hour in the double-boiler and will be ready for reheating in the morning. It is more nourishing and better for the bowels than any more quickly prepared rolled oats. Cracked wheat obviates any need of dried fruits. The corn may be chewed in dry or wet form or boiled quickly. These two staples respectively have been tested as regular foods by Caesar's armies and the American Indians. The Romans used this wheat in the form of wheat pones. Coffee is not a food and is inferior to tea as a stimulant both in its effects and in its weight. Tea need not be made strong. It is the heat of the water that is usually needed. Bread should be made by yeast (magic yeast) or the "sour-dough" process if a temperature of 70° F. for raising is available. That baking powders affect the kidneys in a few days is so well known that in Alaska the experienced man is called a "sour-dough." In the absence of raising temperatures (which can be artificially obtained even in weather that apparently forbids) hard-tack should be used.

Digestibility must also be considered. Butter is very nourishing, and is more easily digested than pork or bacon. If well salted it keeps for many days, even if it melts every day in its friction-top tin. Remember that in countries where game and fish are obtainable, it is often not possible to obtain cereals and grease off the country, and that most men suffer more for lack of these than from scantiness of meat. In the absence of meat beans and peas will be found a fair substitute and are lighter in comparison to their food values.

PERSONAL EQUIPMENT.

1.—CLOTHING AND OUTFIT FOR SUB-ARCTIC TRAVEL.

BY JOHN W. WORTHINGTON.

Clothing.

In summer or in any weather where there is no danger of freezing the ears, the writer prefers a light-weight, soft felt hat with moderate brim, with sweat band removed to give a better grip on the head. This will sometimes be pulled off in diving through brush, but will not blow off and affords reasonable protection from rain and from excessive side light. For other clothes, the following are recommended: woolen shirt, a sweater, usually a linen jumper as a protection to the sweater from snagging, two suits of woolen underwear, one of which is consecrated to sleeping purposes, and woolen trousers. For wading, trousers of a material not too hard woven are preferred, since the worsteds, while resisting snags when dry, are stiff and obstructive when wet. The looser fabrics drain water rapidly, and, if cut short after the fashion of the river-driver, furnish no pockets to hold water, as do knickerbockers. The heavy woolen underwear seems necessary not only for warmth and protection from cold air, but to save the body and limbs from abrasions and bruises which heal slowly when constantly wet. In a surprising proportion of spills and falls in quick water the victim is cut or bruised without his knowledge at the moment of injury. Also, in wading cold streams the drain upon vitality is much less than with lighter clothing. Nevertheless the theory and practice of some persons of experience is contrary to this.

For the feet, use woolen socks, four pair, worn two pair at a time and at least one pair of them reserved for night;

oak-tanned boots of the same height as those for street use, studded at intervals of about one inch with short screw calks over sole, instep, and heel. For wet countries like Newfoundland, some light waterproof foot gear such as the "Barker" shoe is essential, since camp must frequently be made in wet ground. The best shoes will stand wading in a rocky stream about one month. Ordinary hob-nails or Hungarian nails will wear smooth with such work in a few hours, while rubber-soled shoes or moccasins are flimsy and treacherous. For the rest, suspenders, to support the weight of wet trousers, belt, waistcoat (more because of convenient pockets above normal high-water mark than for warmth), woolen handkerchief for the neck, strong but light skin gloves. The "horsehide" working glove is steam-proof and not affected by wet.

Shelter.

A sheet of Egyptian cotton (balloon silk) closely woven but not of the heaviest weight, eight by seven feet, weighs, with necessary rope, $2\frac{1}{8}$ pounds. The best waterproofing is the sugar-of-lead and alum treatment. This makes the cloth waterproof except in the hardest showers, even when touched, and sufficiently spark-proof to be pitched over a hot fire. The treatment is probably familiar and is as follows. Dissolve $\frac{1}{4}$ pound of alum in a pail of water. Dissolve $\frac{1}{4}$ pound of lead acetate in another pail of water. Put the cloth complete in a vessel large enough to contain it loosely bunched, but not folded, with the two solutions. Mix thoroughly and see that the cloth is entirely wetted. A heavy white precipitate falls at once, but another deposit is precipitated slowly in the fiber. Leave the whole soaking over night. Lift out the cloth, allow it to drain and dry without wringing, brush off the white precipitate, and let the cloth air in the open for several days until the smell has disappeared. In use, the shelter may be pitched in a variety of ways to meet conditions. Two such cloths may be used as the roof of a semi-permanent base camp with log sides. Dyeing the cloth brown renders it less conspicuous and saves eye strain. Such dyeing should be done before waterproofing.

An insect-proof shelter of cheese-cloth is made like a rectangular box six feet by three by three without bottom. It is pitched with the top two feet from the ground by means of stakes or by attachment to the shelter cloth, the lower foot of the sides tucked under the edge of the sleeping bag. It should be dyed the same dark color. Its weight is ten ounces.

Bedding.

The amount of bedding necessary depends largely on some personal factor. The following has been found by experience to be comfortable at minimum temperatures with more or less clothing worn at night. For temperatures down to +40° F. wool bag (3½ pounds); +20° F. down bag (7 pounds); +10° F. down bag and wool bag (10½ pounds); 0° F. two down bags and blanket (17 pounds). For northern Maine and Newfoundland in September, minimum temperatures will range from +40° to +18° F. and one down bag is about enough with clothing in reserve for colder nights. Where bough bedding is available, no ground cloth need be taken, but an empty ruck-sack sometimes serves the purpose. In salt-water travel with a canoe, where one must camp in sand or on rocks, and carries are insignificant, a variety of stretcher rigged off the ground and spread by bamboo poles has been used with satisfaction. When overhead shelter is not necessary, the shelter cloth, wrapped around the sleeping bag, will keep off dew and frost, and is sufficiently porous to permit evaporation.

Pack.

A ruck-sack 27 inches square, with an extension top, will contain an individual outfit and food for about ten days without outside packing. It should be so rigged that the straps are attached at the lowest point, leaving no part of the back of the pack to drop below the lower attachments. The following are the essentials of good ruck-sack packing: (1) no pull back, (2) weight low in pack but not on the buttocks, (3) weight close to body, (4) soft contacts with the back. A tump-strap for heavy loads is well enough over a path or in good going, but over boulders, through blowdowns, and in crossing streams and bogs one feels less immediate peril with extra packs thrown on the nape of the neck so that they may be thrown off easily. For river travel in rough water there should be no loose articles that can be packed, and all should be attached to the canoe. All packs should have a waterproof inner lining. A large pillow case treated with oil like a "slicker" is lighter and more trustworthy as an inner bag than the rubber ones of the sporting-goods stores. If this is closed tightly at the top with a cord, a ruck-sack with such an inner bag is difficult to immerse and, if immersed, will keep dry for some time. For the packing of such things as flour, sugar, salt, etc., strong cloth bags, such as the Abercrombie & Fitch food bags, are excellent when the quantity is not great.

2. — ARCTIC CLOTHING AND SLEEPING GEAR.

BY GEORGE P. HOWE, M.D.

The three important desiderata for Arctic clothing are warmth, lightness, and durability. Warmth means the capacity to retain the heat generated by the body. Stationary air is the poorest known conductor, therefore a warm garment must be one that retains much air in its interstices. Impermeability to wind is consequently important, so that whatever one's undergarments may be, a light, wind-proof outer garment of closely woven silk or cotton is necessary. Under this one should wear something capable of retaining a considerable quantity of air in its meshes. As to the relative durability of furs and woolen garments, there is much to be said. Furs, if not too heavy, — as they may easily be even in the coldest climates, — are lighter and pleasanter to wear than woolens, but are less durable and require care such as few white men know how to give. If not dried at frequent intervals, they rot and fall to pieces. If one expects to travel in the company of Indians or Eskimos who would take care of fur garments, these would prove the lightest and most comfortable apparel possible; but if one plans to get on without the aid of natives, woolens are much better.

The dress of the Eskimo of northern Alaska illustrates the ideal type of Arctic clothing. Next to the body they wear a hooded shirt, trousers, and stockings made from the skins of caribou killed late in July or early August, when the last year's coat is shed and the new coat is not yet too thick. This is worn with the hair next the body. The shirt hangs outside the trousers, allowing ventilation which dries up perspiration. Such perspiration as does not dry, wets only the tips of the hairs; and as the caribou skin is not reached it does not rot. A second shirt of caribou skin, also with a hood, is worn with the hair outside, so that driven snow may be stopped by the hair and not wet the hide on melting. This completes the clothing for the body, unless the native has been able to obtain a "wind-shirt" of light cotton or canvas to wear over all. Shoes differ with the time of year: in extreme winter cold, skin shoes are worn with the hair inside; in spring and summer, waterproof seal-skin boots are worn. The entire winter outfit weighs less than our ordinary winter clothes without an overcoat. On entering a hut a native takes off both shirts and his shoes, to avoid sweating them; he usually receives company arrayed only in his trousers and stockings. It is essential to remember that one must avoid wetting one's clothes by perspiration as well as by water from without.

In the matter of sleeping gear one must decide for himself how far weight and comfort are important to him. A healthy man can count on being reasonably comfortable in a sleeping bag made either of cloth lined with down or with cotton wool; or a bag of fur (caribou or mountain-sheep skin for choice), weighing from seven to ten pounds. Under the bag a sleeping skin to be laid on the ground hair downward will be a great comfort; or, if one can carry the weight, two skins, one laid hair down, the other hair up. The object sought is to have as much air space as possible between one's self and the ground. Rubber is of little use in the Arctic because it soon cracks and breaks.

ARMS AND AMMUNITION.

BY JOHN C. PHILLIPS, M.D.

The question of guns and ammunition for the traveller is not such a weighty one today as formerly. The perfection of sporting and defensive arms has progressed at an amazing rate during the past twenty-five years, due in great part to the introduction of the high-power rifle and the invention of new powders. The shot-gun has changed little in effectiveness during the same period, but has been greatly improved for the traveller by the introduction of light, highly choked 20 and 28 gauges.

The large majority of sportsmen-travellers will wish to bring back with them a collection of vertebrate animals. This subject has been treated at length in the chapter on zoological collecting, which includes also a discussion of arms necessary for this kind of work, so that we need here only concern ourselves with the following subjects: (1) arms for purely sporting purposes; (2) arms for supplying the needs of the camp in regions where the traveller cannot procure enough food; (3) arms carried principally for defense.

Arms for Sporting Purposes.

In considering the first of these divisions, it is of course evident that there is at present a very wide range of choice. For the North American continent there is no better rifle than the 6.5-mm. Mannlicher Schauner. This is a very light, short carbine fitted with hair trigger and sling strap, making one of the best arms for use against sheep and goats, where arduous climbing is often necessary. It is, however, a fairly expensive rifle, and at the present time the foreign ammunition is difficult, if not impossible to obtain. The velocity of the bullet is 2564 feet per second and the trajectory is only 5.42 inches at

300 yards. The 9-mm. Mannlicher Schauner is a still more powerful rifle.

The various high-power Winchester rifles need scarcely any introduction among American sportsmen. The .38–55 and .33 Winchester, model 86, are very "sweet-shooting" rifles. Some few men prefer a very heavy shell, such as the Winchester .405, model 1895. If one does not object to the weight of the rifle, 8½ pounds, or the recoil of 26 pounds, it will be found a most excellent arm up to 200 or 250 yards; beyond this it is doubtful if it will compare in accuracy with many smaller calibers. There will be very little game lost if it is hit squarely with this 300-grain bullet. The recoil is disagreeable for light men.

The model '95 is also made to take the U. S. Government .30, the .303 British, etc., but there are certain objections to this box-magazine type of rifle. It is a clumsy shape to carry in various positions, especially when grasped forward of the trigger guard.

For long-range shooting over open country, especially where a little extra weight is no objection, the Ross .280 is perhaps the most deadly rifle yet invented. The velocity is 3100 feet at the muzzle, and the trajectory at 500 yards is said to be only 14 inches. Certain faults have been advanced against the Ross, one of which is that it will not always extract the shell properly. In a military sense it has undoubtedly been a failure.

The writer cannot speak of the Savage rifle from personal experience, but the model 1899 .250–3000 and the .22 "Hi-Power" are the sizes most useful for an expedition where weight must be curtailed. Both these rifles can be fitted with an auxiliary chamber that takes respectively the .25 Stevens rim-fire and the .22 Long rim-fire. Thus the traveller has a large- and a small-game rifle in one.

Perhaps there is no rifle for all-round use in America that equals the U. S. Government Springfield .30, 1906. This can be lightened somewhat from the original weight of 9½ pounds down to 8 or even to 7½ pounds. This sporting Springfield with soft-point ammunition makes almost the ideal rifle, with a trajectory of only about six inches at 300 yards, and a muzzle velocity of 2700 feet per second. The recoil of 11 to 15 pounds (according to the weight of the bullet used) is annoying to some people, but is rarely noticed in the field.

In the writer's opinion, no sportsman should think of going on a big-game expedition without having his rifle fitted with a rear peep-sight, such as the well known Lyman sight. The only exception to this rule would be in cases where men have shot all their lives through open sights and do not care to change.

The question of a battery for an expedition into Africa or India, or where there is likelihood of encountering dangerous game, can scarcely be covered here. It has been exhaustively dealt with in many English works. For an ordinary African trip, a .405 Winchester and a 9-mm. Mannlicher Schauner, besides one heavy, double-barrelled cordite rifle of reliable make, for emergencies, would constitute a fairly economical combination. The double rifle can best be purchased second-hand in London and re-sold on the return trip. For elephant hunting two double rifles would be safer. The .405 with solid ball can be relied upon to do good work against African buffalo, and loaded with soft-point bullets it is none too heavy for some of the larger antelope, whose tenacity of life is often astonishing to one who has hunted American game only. The Ross .280 ought to be an excellent all-round arm for the open shooting of eastern Africa, and the still more reliable Springfield and Savage "Hi-Power" would be nearly as effective at long ranges.

In most long expeditions a shot-gun is usually carried to help supply the "pot" or for incidental sport. If weight of gun, particularly of ammunition, is no objection, a cheap 12 gauge with a good supply of No. 6 and No. 8 shot will be all that is needed. In canoe journeys or where overland packing has to be done, or in dog-sled work, a much lighter and yet very effective arm, such as the Parker 20 gauge, could be carried. The 20 gauges are made to weigh as little as 5 or 5½ pounds, and the ammunition weighs about 23 percent less than the 12-gauge ammunition. For shooting at stationary objects, the 20 gauge is nearly as effective as the 12 gauge, especially when loaded with Nos. 7, 8, or 9 shot; but for wing shooting, only an expert can expect comparable results.

Arms for Supplying the Pot.

Turning now to our second consideration, we will refer briefly to arms carried solely for supplying the camp with meat. These will be as a rule small-caliber rifles, so that the ammunition shall not weigh too much. An attempt will be made to find an arm that uses ammunition light enough to be carried in considerable quantity, so that it can be used against small game, and yet not so light as to be ineffective against deer and other large game. Such combinations can be found in the Winchester .25–35, .32–40, etc. The Savage "Hi-Power" mentioned above, which can use low-power cartridges in auxiliary chambers, is very useful for this purpose. A number of these chambers ought to be carried along, as they are very easily lost or misplaced.

A still better way to approach the food question, in the writer's opinion, is to carry a rifle for big game only, and a .22-caliber, single-shot Smith & Wesson pistol for grouse and other small game. The pistol can be carried on the person at all times. The barrel of such a pistol can be reduced to six inches, but it is much easier to do accurate work with an 8- or a 10-inch barrel. One of these pistols makes little noise and 1000 rounds of smokeless ammunition weigh only eight pounds. The traveller should learn to use a double grip when shooting game with a pistol.

There still remain the three-barrel guns and "freak" weapons of various sorts. Usually these are a delusion and a snare. A safe rule to follow is not to think of taking a combination gun on an expedition until you have assured yourself that the rifle is accurate and the shot barrels are placing a close and accurate pattern. Besides this be certain that you can handle the gun under field conditions.

Some fairly successful combination guns are now being made by the British gunmakers in 20 and 28 gauges. These are the Paradox type with shallow rifling in the last five or six inches of the barrel, and the writer has been informed by the makers (Westley Richards) that they are obtaining accuracy with ball cartridges up to 200 yards or more. With shot, the pattern, of course, is like that of a cylinder gun. All such guns should be very carefully tested before purchase.

For a person who wishes to take one gun, a double-barrel weapon, with one barrel rifle, the other shot, would seem a wiser choice; say a 16- or 20-gauge shot-gun combined with a .30–40 or .38–55 rifle barrel. These guns cannot often be purchased and would have to be made to order (the Charles Daley Company manufactures them).

Many travellers prefer to carry a .22 repeating rifle for small game only. The trouble with this equipment is that big game is pretty sure to put in an appearance when the .22 rifle is handy, while small game abounds when only the large rifle is ready for action.

The writer has always believed that a 20-gauge shot-gun with a high-power rifle barrel underneath could be made, and made light enough and simple enough. He must, however, admit that he has never yet seen one. The nearest approach to the ideal that he can recall was a Daley double 28 gauge with a .25–35 rifle barrel. The rifle hammer was cocked by a cocking lever operated by the right thumb, and once cocked it remained so after each break of the gun until tripped off by a shorter excursion of the same lever. This arm weighed only 6½ pounds. D. Kirkwood of Boston has made three-barrel guns with three locks and three triggers, one "safety" controlling all the hammers, and this seems on the whole a simpler mechanism to operate. "Freak" guns are apt to look tempting in the gun store, but they should never be accepted on their looks alone.

Arms for Defense.

Now as to arms for defense only. There will be several rifles in the party if a dangerous country is to be traversed, and it would be much safer to have all arms of a uniform size, so that a large amount of ammunition can be carried without any risk of getting the various sizes mixed up. No better service rifle probably exists than the U. S. Government Springfield .30.

On caravan journeys across open dangerous country, a light machine-gun, such as the Lewis, might be extremely desirable. Its present high cost is to be reckoned with. All machine-guns are liable to accident, and some extra small parts ought to be carried against a possible break; also there should be one in the party who is able to take down and assemble the gun in quick time.

For side arms the new Colt automatic .25, .38, and .45 calibers have practically usurped the field, the .38 being the best all-round pistol for the traveller. A safe and ever-ready pocket arm which has never yet been beaten, is the .38 hammerless Smith & Wesson, with grip safety. Such a revolver can be carried loosely in the pocket with perfect safety and is always ready. The automatic is not ready when on "safe," and cannot be carried in any other way. A novice, therefore, would be able to shoot his first shot quicker and safer with the Smith & Wesson than with any of the automatic pistols that are fitted with a hard-working and more or less clumsy safety device. After the first shot the advantage is of course with the automatic.

General Advice.

It is well to remind the reader that all the modern high-power rifles foul badly on account of a chemical action which takes place after they have been fired (metal fouling). The traveller, therefore, should be well provided with cleaning rods, wire brushes, and one of the various nitro-solvent cleaning fluids. No modern rifle can be kept long in good condition unless it is cleaned very shortly after shooting, preferably the same day.

In the mountains, extra front sights ought to be carried, because the ivory bead is easily knocked off. A protecting spring clip which slips on over the muzzle of the rifle and covers the front sight is very useful.

In conclusion one can only say that rough notes on fire-arms such as these must of necessity be out of date in five or six years. But the prospective traveller must remember this: almost any rifle is good enough, but it is only good when it is pointed correctly. Before starting, sight your rifle carefully, say for 100 or 150 yards, then mobilize the rear peep-sight or mark its position accurately. Above all things learn to shoot at one medium range and to make allowance for less or greater distance. In this way there will never be any question as to the position of the sights when quick shooting is necessary.

WATER TRAVEL.

The traveller by water routes that require heavy craft is, in the main, compelled to use the facilities which the country affords, as to both boats and men. The people of some regions have, from long practical experience, worked out the equipment and the method best adapted to travel in their country. This, however, is not universally true, and for travel in inland waters where transportation conditions permit a choice of outfit, it is well worth while to consider a type of portable boat of general adaptability. Practically the only such boat is the open canoe, light enough to be transported overland on the shoulders of members of the party, and yet of sufficient capacity to carry the party, its food, and other equipment. While, also, local professional guides might be more skilful, it is desirable that the non-professional members know something of the rudiments of handling such craft and thereby increase the efficiency of the party. With the real expert, the North American Indian, the art is learned by a lifetime of experience under conditions where skill is necessary to the maintenance of life. The suggestions which follow are limited to canoes of the portable type, their equipment, and the rudiments of handling them. Since also their use has been almost entirely restricted to waters such as those of northern North America, these suggestions are based upon experience in those waters only.

1.—EQUIPMENT.

BY WILLIAM B. CABOT.

Canoes.—The cedar-canvas canoe, up to a moderate weight, is probably the best of any for general use. It is stronger than any other of its weight, keeps tight better, and is easily patched. Its advantages are not so marked, however, in the larger sizes. Beyond 100 or 120 pounds weight, and say 19 feet long, the all-wood canoes, like the Peterboro, stand outside wear better. The impact of a heavy, rigid canoe on a hard obstacle is too much for ordinary canvas, and canvas heavy enough to stand runs into weight when filled with paint. It is true that canvas brigade canoes of the Hudson's Bay Company do well up to 28 by 5½ by 2½ feet, with 5000 pounds cargo; but although in careful Indian hands these are perhaps as good as any, the usual travel party might not find them so. A large canoe, at any rate, calls for heavy canvas.

In any case canvas canoes of travelling size should be protected with sheet brass underneath for two feet or so at the ends; they wear very rapidly there and almost always come out patched and leaking. A grummetted hole for the towing line should be provided, just above the water line, because towing from gunwale level is apt to heel the canoe under when the bow takes a current.

The timbering of New England-built canoes is always good, also the canvas; the main thing to look out for is the "filler" or composition used to fill the canvas before painting. Paint is mainly for appearance, and scarcely worth its weight. Extra weight, if admitted at all, would better go into the timbering. The filler, however, is the very life of the canoe. Above all it should be well seasoned before painting; a canoe for the spring should be laid up to harden in the fall. The paint also needs a long time. Canvas painted upon direct without a filler rots and scales in two or three years, though for a season or two really well painted canvas can be as resisting as if regularly filled, perhaps more so. An old canoe is apt to be a bad purchase unless regularly filled.

As to canoe models, there is wide range according to the kinds of water one has to deal with. The extremes may be taken as, on the one hand, the heavy non-portable Gaspé poling boat, scarcely over two feet wide and perhaps twenty-five long; and, on the other, the Hudson's Bay sea canoe of the Indians, short, wide, deep, of great sheer above and below and with definite tumble home. For general travel, models come between, and 125 pounds is about the limit of weight. It is better to keep within weights that the non-professional members of a party can, at a pinch, carry over rough ground. A length of 18 feet is little enough for most travel, and not less than 14 inches of depth. This will carry 900 pounds if the sea is not too rough; 700 pounds for 16-foot length; 800 pounds for 17-foot length. On large lakes, as in many rapids, size is safety. Particularly in these days of water-proof bags, when one can put over the cargo in a lake storm and recover it afterward, an able canoe — better if long enough to drive instead of standing and bobbing — can take one through a great deal. It is well in long lake-traverses to have along some tacks and enough cloth in some form — the tent or fly will do — to furnish two strips fastened the length of the canoe. Laced across the cargo, and drawn up around the paddler's waist, they make the difference between a decked boat and an open one, and the difference means everything at the last.

For getting up strong rivers, a canoe of from 18 to 20 feet does well. It should be 32 or 34 inches wide and pretty straight on the bottom. Indians use rather round-bottomed canoes, and they are safer in rapids; but a travel-party, having to consider the small and shallow waters about heights-of-land, does well to use a little flatter model. The Oldtown guide's model of 1903 may be a trifle too flat but is very nearly right. A straight bottom is best in poling; where rapids are to be run, five or six inches of rise at the ends is better to be able to pivot and dodge, the gunwale sheer in full proportion. In a short, high sea a poling canoe pounds and halts, and spatter comes in. So far as safety is concerned, the duck shape, rising all ways, is the dry one, but it is a stop and go matter; length is necessary to hold speed, but, for rough waters, rise at the ends also, and particularly lines of entrance such as perhaps none but an Indian is fully master of. In the old birch-canoe days of the North every river of size had its model, suited in size and shape to the combination of current, portage, and lake work concerned. The canoe for extended travel must usually be a composite, wider and deeper if the cargo is large; a 16-inch depth for a fairly round canoe of 19-feet length is little enough. It should have crossbars but no seats. A center crossbar is indispensable for handling and portaging. An 18-foot by 33-inch canoe can be counted on for 900 pounds total burden, but not in much sea. The small keel, so commonly used for protection of the bottom, is only a mischief in real service. On the other hand, a very flat canoe is dangerous and structurally weak under cargo.

When on land in exposed places, canoes must be weighted against blowing away and getting damaged. In times of hot sunshine, bushes or other cover ought to be put over them. They should not stand with water in them. Safety from fire, too, should be regarded.

Paddles. — As used by Indians these are short handled, long bladed, 3½ to 4½ inches wide, and thick enough to stand some wear of pushing. If too wide the shoots of water take control in the rapids, and the blades split when caught between stones. A split should be laced together near the end of the blade or it will grow fast. Travel practice leans to a blade of five or six inches wide, the paddle being 5½ to 6 feet long. If one sits high, this length is necessary. The wide cross handle in general use is a doubtful improvement. In paddling bow, one may keep something of the effective Indian control, without too much punishing of knees and ankles, by using a long pack bag laid lengthwise as a cushion in kneeling, the knees braced out against the ribs of the boat. In the privileged middle place one sometimes sits on the bottom, with a backboard against the middle bar. The board gives one an effective brace in paddling. A thin spruce paddle of some width does best here; a heavy one is tiring. Maple, cherry, and poplar make good paddles; spruce frays; ash is too heavy.

Rowing. — There are times when a lone traveller must make distance by canoe. On rivers and small lakes a paddle or pole does well enough single, but on large waters head-wind is a total bar — a single paddle against a blow is futility itself. A loaded canoe even in calm weather is very slow with a single paddle. The kayak, very narrow and light, is fast; so also a fine-lined, light-loaded canoe, though the latter rears and holds against a sea. The only resource is oars, and no better rowboat need be asked than a speedy 18-foot canoe. Unless very wide it must be outrigged. A proper width is 44 to 46 inches between locks. This matter is not to be disregarded; rowing from gunwales 36 or 38 inches apart, while better than paddling, involves serious waste of power.

There are several simple ways of outrigging. One can rig up from an ordinary pile of driftwood in half an hour. A few nails are convenient, though twine lashings, preferably of tarred marlin, do nearly as well. As good a way as any is to lash a couple of four-foot sticks upon two adjacent crossbars, then nail or lash two more between their ends, parallel with the center line of the canoe; the last two carry the row-locks, or pins are set in these false gunwales. As lashings never stay quite tight, it is well to notch down a couple of sticks upon the cross-pieces and again on the crossbar ahead to keep the frame from working back and forth (Fig. 8). For making the pin-holes a ⅞-inch auger bit is convenient, and is, moreover, a generally useful tool for the kit; one can make rafts with it and do any large framing.

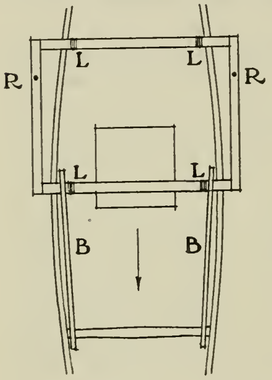

FIG. 8. CANOE RIG FOR USE OF OARS. *B*, FRONT BARS; *L*, FRAME; *R*, HOLE FOR ROW-LOCK.

Another way is to make a V-frame, the apex notched down on the bar ahead of the middle one, the two sticks resting on a third laid on the middle bar. The outer ends of the V reach outboard to a rowing width, and the locks or pins are put as near the ends as may be without splitting. They can be put nearer if the ends are bound or nailed through and clinched. The bearing points on the two crossbars are lashed to the bars. No nails are driven into the canoe itself in any case, and whenever the frame is no longer needed three knife-cuts at the lashings will release it, leaving the boat unmarred. The square frame is better than the V for the fastenings, which take up some length on the gunwale. The latter is best of hard wood, not less than $1\frac{5}{8}$ by $1\frac{5}{8}$ inches in size.

A single pin with a rope withe makes a good row-lock, particularly as the oars may be dropped for shooting without their drifting away. This is in fact the Newfoundlander's shooting rig; it is silent and easy rowing. A 6- or 7-inch box makes a good rowing seat for a 13-inch canoe. This height is brought up a trifle by the sweater or what-not one uses for a cushion. The rower sits in the middle, his back on full recover, just touching the crossbar. Oars are $7\frac{1}{2}$ feet long, with blades (not to crab too heavily or take too careful feathering), not over 4 inches wide.

In rowing backward with no one to steer, there are obvious disadvantages, especially in shooting and in avoiding obstacles. Here comes the usefulness of bow-facing oars. They row easily, are as fast as any, can be trailed for shooting; bad seas can be seen and met to a nicety.

Bow-facing oars do not feather, but with narrow blades this is no great matter, and there is compensation in the relief to wrists and hands. Spoon oars are best, taking less wind than flat ones; also they can be narrower than straight ones, and this counts in wind. A straight blade can be given a tolerable spoon effect by nailing a cleat of triangular section across the end. On a common oar this plays good part as a "mud hook" in pushing and poling on soft bottom and banks, besides being a protection to the oar.

Sails. — A triangular sail (of three or four square yards) is a handy possession. If made of balloon silk (Egyptian cotton), it is a trifle in weight and useful as a rain cover or partial fly for the tent. Still a rectangular fly, say $4\frac{1}{2}$ by 7 to 9 feet, is nearly as good a sail and of more generally useful shape. The spars are a mast and sprit. Indians sail two canoes in catamaran form, poles across, and a blanket to the wind. Their various rigs are put up with light strings to carry away clean in a dangerous puff. In sheltered, flat water, so only that the wind is strong enough, a long canoe will haul closer than one would expect. A step and a crossbar strap should be provided for the mast. For it is worth while to take advantage of even passing winds sometimes, as a relief in long days of rowing or paddling, and without the standing fixtures it is too much trouble to put up a mast for a passing breeze. The step may be small, as the mast may be almost sharp at the bottom, but the strap should be as large as two inches, for all sorts of driftwood are used for masts. When sailing it is doubtful practice, usually, to tie the sheet.

Tracking cords, preferably two for each canoe, about 40 feet long, are necessary in strong waters. The size should be to some extent proportioned to the weight of the canoe and cargo and at least sufficiently great so that the hands are not cut in their use. Good hemp is probably the strongest material usually available, although new hemp kinks when wet. In the event of a capsize in heavy water, it should be remembered that not merely the canoe but its entire capacity of water and the force of the current are factors in the strain to be put upon the tracking cord.

Repair outfit. — For repairs a few short nails and copper tacks should be carried. For a mere cut of the canvas it is desirable to avoid the use of tacks, since the heads are certain to be struck and pulled so that a new hole is made. A better repair is made with solid marine glue, which is softened by heat and worked under the edges of the cut and in the crack between the edges, so that a smooth surface is left. Thin cloth cemented over the crack thus filled and itself filled with a quick-drying waterproof cement makes a repair which will last for years. The most frequent need for repairs comes from the wear and granulation of the filling of the canvas without actual cutting of the fabric. Once the filling is out, water oozes into the canoe, or works back through the sheathing and loosens the canvas generally. The best remedy is to dry the canvas as much as possible, and put on one or two coats of quick-drying shellac or asphaltum. This probably injures the canvas, but the necessity for repair is a sufficient reason for such injury. — J. W. W.

2.—DEADWATER TRAVEL.

BY JOHN W. WORTHINGTON.

The waters of lakes, ponds, bays and inlets of the sea, and the reaches of rivers where the current is so slight or so unobstructed that it creates no difficulties of travel, are usually spoken of as deadwater. By reason of winds and broken seas, deadwaters are not without very real dangers of their own which the inexperienced canoe traveller may not realize.

Swell. — In long, smooth swells (large waves that do not break) a canoe is actually dryer than many other craft of greater freeboard and deeper draft. In a following sea it seems to run rapidly down the slope on the wave front, to halt and settle back slightly in the trough, then rise as the wave crest passes under, and again rush forward. Under such conditions there is no more danger than in flat water. Though shore and landmarks may disappear temporarily, yet from the crests a good lookout may be obtained and the course laid out.

Surf. — Heavy swell, whether smooth or rough, means heavy surf or breakers on a lee shore, and surf running is not always easy. For as in heavy, quick water, there is an actual forward movement of the water itself against which no paddling can prevail. To beach a canoe, it is held just back of the breaking crest, until the wave is broken, then rushed into the water advancing on the beach. Here it soon reaches the receding water, and if this is not met squarely the undertow acts precisely as an eddy, turning the canoe broadside instantly, to be swept back under the next breaker with possible disaster. The remedy is to go overboard as soon as the canoe begins to broach and pull it up the beach out of danger.

A more difficult process is to launch a canoe through surf, as it must go out between breakers. From a steep beach with a short and heavy sea this is not always possible, and one may thus become windbound, even when the water beyond the breakers presents no insuperable obstacle. The best method is to wade into the shallow water, holding the canoe just inside the breakers and directly facing them until a receding wave begins to carry it forward, then to leap in and paddle quickly out over the crest of the next wave before it breaks. The canoe will rear high, but if the weight is well concentrated at the waist the impact as the bow drops will do no serious damage. The need for waterproof packs is obvious.

Breaking water. — Like surf on a beach, heavy breaking water means a forward movement of the water and not mere vertical motion. Fortunately this moving water is usually not deep and soon spends its force. But while in full swing it is irresistible so far as any effort to control the canoe is concerned, and there is no salvation in going overboard. Even if the rising slope of the next wave is met squarely, the effect may be to drive the bow into and under solid water. There is much rough deadwater in which a canoe will not live.

The short, broken seas of fresh water are a danger which manifests itself so gradually as the wind freshens that one may not realize it at first. If the waves are abeam, the water pounds against the sides, flies up, and is blown inboard or actually flows over the gunwale. In a long traverse this water accumulates, settles the canoe, impairs its stability and buoyancy, and may swamp it before an opportunity to bail is reached. In wide, deep water this danger is very serious, as the swamped canoe, although floating, is practically immovable. In such water the crew should always kneel low, the knees well out in the bilge, with freedom to balance the body from the waist. The canoe may then be thrown into the trough of the sea and made to roll naturally, as it would if empty, or even with an exaggerated roll, so that as each crest approaches, the side of the canoe toward it is made to rise and present a higher than normal freeboard. The actual stability is not seriously affected since the bodies of the crew remain vertical. This manoeuver is in accordance with Indian practice.

Wind, by its physical resistance to progress, is another important consideration. Even with the protection of decks so that there is no danger of swamping, one may be blown offshore or backward, in spite of all efforts of paddling. It is here that oars have the advantage. A light canoe may even be capsized by the sudden, unexpected gusts which come in deep narrow valleys, and under high cliffs.

Fog. — A canoe may yaw through an arc of ninety degrees at every wave. The hands of the paddlers are too fully occupied to hold a compass. If the wind or sea is regular, the waves themselves afford some clue to direction, but frequently there is little wind and, especially near high shores, its direction varies from moment to moment. The ordinary pocket compass without a floating dial is the most convenient under such circumstances. It may be laid on a pack within sight of the canoeman so that the desired direction as indicated by the card, with a proper allowance for variation, is toward the bow. If, then, the canoe is turned and held so that the needle is over the north on the card, the right direction is maintained. As in all navigation, leeway and currents are important factors.

Trimming. — The trimming of the canoe in deadwater depends somewhat but not entirely on the direction of the wind. The higher end is always the one more affected, so that with the wind astern a higher bow means easier steering. With a head wind a comparatively lower bow makes the canoe trail out behind it like a weather vane. These principles hold generally true of waters where the seas are not dangerous, but where there is danger of taking water, it is unwise to have the bow so heavy that it will plunge into head seas or the stern so loaded that it will be submerged by following seas.

3.—QUICK-WATER TRAVEL.

BY RALPH W. GRAY.

A KNOWLEDGE of water is the first essential of canoemanship. Swiftly running water shows by the waves or ripples on its surface the character and depth of the bottom over which it runs. The canoeman must tell by the surface of the water ahead whether his canoe will "carry over" the rocks or live through the waves. He should never look into the water in a rapid. The surface tells what is below and indicates the force and direction of currents in time to avoid trouble. Beware of water when it is "white" or frothy. It will not support a swimmer or a canoe. Water rushing past on one or both sides of a rock or other obstacle forms a relatively quiet "tail" or backset eddy on the down-stream side. Such eddies are useful in stopping a canoe in midstream or along the bank. A canoe can be held with practically no effort in an eddy, though the water may be rushing by on both sides within a foot or two. Be careful, however, not to run the canoe too suddenly from an eddy into a current or *vice versa*, for there is much danger of the canoe capsizing if it spins around too suddenly.

"Haystacks" are curling, stationary waves in mid-channel of a swiftly rushing stream. They are apt to be preceded by a stretch of glassy-smooth, swiftly running water. When there are haystacks of any size, there are probably no hidden rocks that the canoe will touch; the danger is that the haystacks may swamp the canoe. Never "rush" haystacks. When the boat strikes them it should be going no faster than the water, preferably slower. It is even advisable, especially with a heavily laden boat which will hold its course well, to paddle vigorously backward. The slower it is going when it strikes the haystacks, the surer it is of riding them successfully.

In general, the inside of the bend of a river is the safer, and the shelving shore on that side affords better opportunities for control of the canoe and for salvage in case of disaster.

Always empty the canoe if it has taken in any water. Water adds enormously to the weight to be controlled, and becomes a shifting ballast that reduces the canoe's stability, causing it to roll like a log.

The inexperienced traveller should be very careful in dealing with large northern rivers. At a low pitch of water, situations are fairly obvious, and may be taken at something like face value. But in times of high water this is by no means the case; the currents sway and change, whirlpools form where none were before, "boils" and violent surges form over rock bottom anywhere. A canoe passing along on smooth water may be suddenly carried four or five rods to one side without warning.

Never risk capsizing in serious travel. Sporting chances under those circumstances are not permissible. It is amazing how blithely a beginner will risk his canoe and cargo without stopping to think that he is in the same breath risking certainly the convenience and possibly the safety of his entire expedition. In wilderness travel the cardinal rule is — never capsize.

In general, any canoe should "trim" evenly: that is, should draw the same water at bow and stern. As an even trim is an approximate matter, however, it is perhaps as well to have the up-stream end of the canoe slightly the lighter, *i. e.*, the bow when going up stream, and the stern when going down. One should, however, depart as little as possible from an even trim.

A canoe, except in the large sizes adapted primarily for cargo, may be handled by one or by two men, but not effectively by more. In navigating a loaded canoe single-handed the canoeman kneels or stands well aft. Since a loaded canoe 18 to 20 feet long manoeuvers very slowly with only one man working, he must use more than ordinary care in picking his course well ahead and keeping to it, especially in running where it will be very difficult for him at the last moment to correct an error in judgment. He must therefore be a good judge of water; but since no team work is necessary he has the advantage of undivided responsibility.

If two men are working, the more skilful should have command and the other should follow his lead. Dividing responsibility is courting disaster. Most amateurs suppose that the heavier of two men in a canoe should have the stern position. This is not true. The positions of the men depend on their skill, not their size, and the trim of the boat can always be adjusted by the disposition of the cargo. In running with the paddle in swift water the more skilful man should sit in the bow. The duty of the stern man is to make the stern follow where the bow leads. In running rough water, it is wise to concentrate the load, as far as practicable, in the waist of the boat. A boat so loaded is lighter at the bow and the stern, and hence rides more easily. Such disposition should not affect the evenness of the trim.

In running, the man in the bow acts as captain, and is responsible for the course. He can see ahead better than the stern man, and his lead should be followed promptly and effectively, without a word being spoken. The stern man has only to watch and follow; whereas if he were to direct the course he would have to shout to the bow man, who, in the noise of a rapid, might easily mistake the command if he heard it at all. The bow man has control of his half of the canoe, and can manage it more effectively

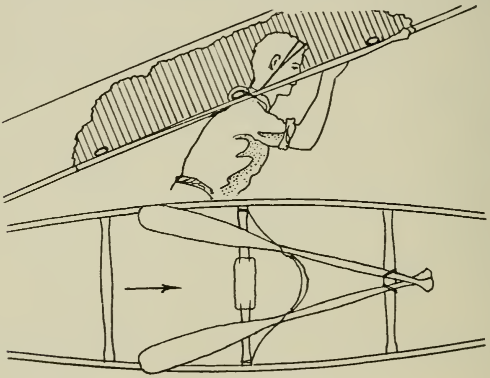

Fig. 9. Carrying Rig for Canoe

and quickly than the stern man can. In the interval between the passage of the bow and the passage of the stern, the stern man has an invaluable moment in which to swing the stern into position.

All this presupposes that both men know their business, and that any difference in skill is slight. It may, however, on occasion, be advisable for the more skilful man to move to bow position if the running is of a complicated nature.

In poling and dropping, the canoeist should stand in the stern. The use of a pole from the bow position in dropping is contrary to fundamental principles, and in poling, at least for amateurs, it is usually a waste of power for both to pole at once. If both wish to pole they had better take turns in the stern position, rather than both try to pole at the same time.

Canoe carrying. — Up to weights of 100 pounds, a canoe is most easily carried by one man alone. For short carries it is simply swung up so that the middle thwart rests back of the neck on the shoulders. In lifting a canoe into this position it is placed on its side with the bottom against the carrier's thighs; he then seizes the middle thwart and, with a quick movement, rolls the canoe up his body until the thwart drops on his shoulders. For longer carries the paddles may be adjusted so that the blades are between the middle thwart and the carrier's shoulders, the handles in the rear and on the inside of the next thwart. Another method is illustrated by the diagram (Fig. 9), showing the use of a tump-line, and the paddle handles forward. Some padding, such as a sweater, is desirable. Special yokes for carrying are not recommended.

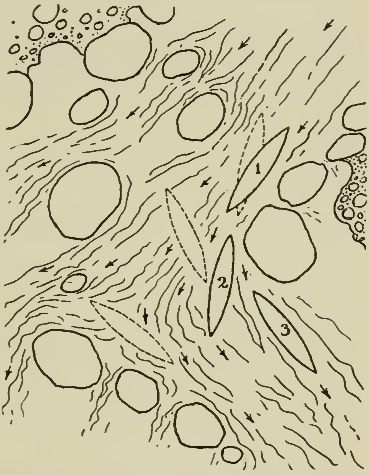

Fig. 10. Running

Running (Fig. 10) is allowing the canoe to drift with the current in a rapid, while the crew guide it or paddle it across the stream. In running, the canoe may be at one time paddled forward and at another time backward; but on the average it travels slower than the current, not faster. This may seem unreasonable at first, for the beginner's idea of "running a rapid" is to put on full speed ahead. Nothing can be more fatal than this. The greater the speed of the canoe through the water, the more difficult it is to avoid obstacles. If it is simply a question of rough water without obstacles, the canoe that is going slowly will ride a wave which, were it going fast, it would plow through, taking water aboard.

In running, the paddle is used to put the canoe in such a position that the current will take it where it should go, and to check the canoe when the speed is too great. (The dotted lines in Fig. 10 indicate the result of misjudgment of currents.) The rate of progress down a rapid should be governed by the difficulties of its passage, whether they are in the form of obstructions or of heavy water. The speed should not be accelerated by paddling. In swiftly running but smooth water without rocks or considerable waves, the canoe may be handled as if the water were slack.

In all rough streams *poles* are necessary. Spruce is by far the best material, as ash, the usual alternative, is too flexible, and also too strong when the pole must be broken. A length of about 12 feet, 1⅜ inches diameter at the butt, tapering to 1⅛ inches at the tip, is about right. The butt should be shod with an iron ferrule and an iron or brass pin about ⅜ of an inch in diameter, projecting about 1 inch or 1¼ inches. The long, conical shoes sometimes used are apt to cramp under rocks with unpleasant frequency. A brass cartridge shell driven into the end of a "barefoot" pole and projecting about ½ inch makes a fair substitute for a regular shoe.

Dropping means holding a boat against the current with a pole and so retarding its progress down stream. The fundamental principle in dropping is that the stern is held, while the water swings the bow. In using a pole, whether poling up or dropping down stream, the canoeman should stand in the stern; using the pole from a sitting position in most cases is futile.

Even in very swiftly running water a canoe can be held stationary with a pole, but not with a paddle. Where the rocks are very close together, and the necessary turnings are frequent and sharp, a pole is used to stop the impetus of the canoe long enough to give time to make the next turn, or to set the canoe over to one side of a threatening rock, before allowing it to drop past, when it is caught ("snubbed") again with the pole and so on. Rocky rapids might be impossible to run without a pole, as, with the paddle alone, one cannot always stop the boat's impetus or slow it down in time to avoid hitting the next boulder.

Dropping with the pole is an operation which should never be undertaken in a rapid except by a trained canoeman. He must be careful not to let the pole cramp ("bite") on the bottom, *i. e.*, catch in a crevice so that it cannot be removed. This is especially to be anticipated when the canoe is moving rapidly against the pole stroke. Do not hold the pole across the body. In case the pole cramps let go of it for a moment, if it is not absolutely indispensable, when it will probably come loose, and can be picked up below. If, however, the conditions ahead are such that it is essential, break it off. It will probably break near the tip which is cramped, and the iron pick on the end will be lost; but that is better than losing the boat.

Both in dropping and in poling up stream, the pole becomes rapidly less effective as the depth becomes over four feet.

Poling. — Poling up stream is the opposite of dropping down stream. In either process, but especially in poling up against a heavy rush of water, a canoe shorter than 18 feet is at a great disadvantage. A 14-foot or a 15-foot canoe is almost impossible to handle under such conditions.

In using a pole, the character of the bottom is an important factor. On hard, coarse gravel or small rocks poling is simple, as the pole gets a good grip without sinking in, cramping, or slipping. Among medium to large boulders, the pole is likely to cramp, especially in dropping. On ledge bottom it is less likely to cramp, but it is sure to slip at times. If the bottom is sand or mud the pole will probably sink in so far that its use is impracticable.

In a fairly heavy-pitched stream with boulders and water from three to four feet deep, there is a "tail" or backset eddy of fairly slack water below each boulder. Standing in the stern of the canoe, push straight up this "tail" till the bow is close to the boulder (Fig. 11). Then let the bow catch the current on the side on which the boat must pass the boulder and almost simultaneously shove the stern out after it. This places the boat full in the rush of the water, headed directly up stream. Then push up into the eye of the current till the boulder is passed and dodge into the tail of slack water next above. Any fisherman who has noticed trout or salmon going up stream against a heavy rush of water will recall that they make use of similar means.

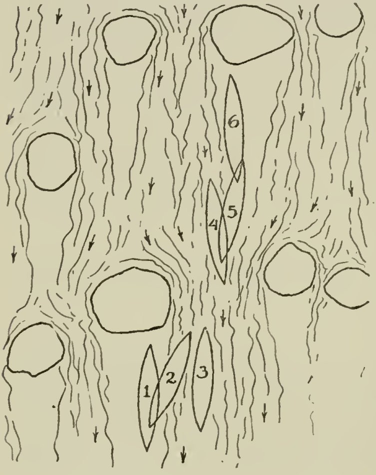

Fig. 11. Poling

In rounding a rock, always keep the up-stream end of the boat close to the rock if possible; the other end will take care of itself. This applies both in up-stream and in down-stream work with pole or paddle.

In swift-water work the canoe is practically never going where it points. It is difficult for a novice to realize that his boat is always drifting, and that its bow gives only a partial indication of the direction in which it is moving.

Dragging means wading and pulling the canoe in a stream too shallow or too much obstructed to permit the use of a pole. Nothing is harder on a canoe, and no form of travel is so slow. It frequently saves carrying, however, and is usually necessary only for short distances. The canoe should be eased as much as possible by lifting, one man on each gunwale. If much dragging is necessary, skids may be rigged of green poles, to protect the bottom. Running water above waist-deep is usually too strong to wade.

Roping or tracking (Fig. 12) means pulling the canoe up or letting it down with a rope along the side of the stream, in places which cannot be navigated otherwise. It is most safely done with two ropes, bow and stern, one man to a rope; but it can be done with one rope only, almost as well. In roping, the up-stream end of the canoe should trim light, for this end (as in all operations) needs most attention. Never let the canoe catch the current too suddenly. The result, if it fills, may be fatal (see dotted outline).

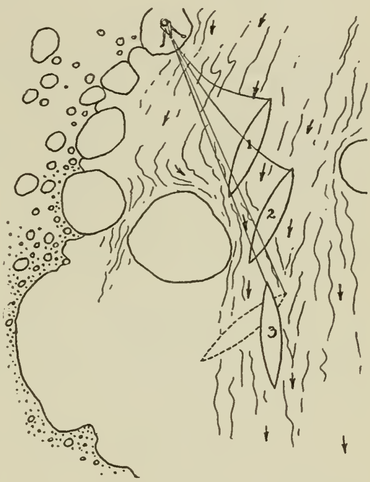

Fig. 12. Roping

Disasters and rescues. — If an accident happens in a very lively place, as is likely, the chances are that effective rescue work of men or cargo cannot be undertaken till the bottom of the rapids is reached. An attempted rescue in such a situation, except in so far as it can be made from shore, will probably result in another accident, making a bad matter worse. Therefore no long rapid should be undertaken except with the greatest caution, and then as far as possible near the shore, where rescue by holding out a pole or throwing a rope is possible. All questionable places should be reconnoitered from the shore before running them, especially in wilderness travel, where loss of cargo would be a serious setback. If a canoe swamps and is held against the rocks with the water pouring in, the canoeist must lift on the up-stream gunwale and let the water spill out *down stream;* if he tries to empty it by spilling it up stream he merely fills it fuller. Obvious as this seems, a beginner almost always tries to empty his canoe the wrong way.

TRAVEL WITH PACK-HORSES.

BY S. PRESCOTT FAY.

Methods and Uses.

Though the transportation of supplies by pack animals dates back to earliest history, it still survives in inaccessible regions where it is the only method possible. We find horses, mules, and in places even burros employed, according to the local conditions. Throughout the Canadian Northwest and in Alaska, horses, especially Indian cayuses when obtainable, are preferred. In the United States mules to a great extent replace them, because the country is not as rough and the mules can stand heavier work. Farther south, in Mexico and in South America, the burro is commonly seen. The United States Army employs pack trains made up of mules; and, for a pad on which the pack rests, it uses the *aparejo* exclusively, as this is easier on the animal's back in continuous work. In the Northwest, however, the cross-tree saddle is commonly used. Both the horse and the mule have their firm advocates, but the mule has the greater strength and endurance. In rough, trailless regions where swamps and muskegs abound, the small horse used to that country seems preferable, although he cannot carry as heavy a load. Mules hate water and their small feet sink deeply into the mud, both great drawbacks. But the general rule should be to employ the type of animal found in the region to be traversed, for local conditions should always govern one's decision.

Type of Horse.

Unless one has had great experience, leave the selection of pack-horses to the guide or outfitter, provided he is reliable. Otherwise observe carefully the following general suggestions. A horse sound in body, chunky and solidly built, with firm, free, springy action should first be looked for. In rough, mountainous country especially, ascertain which have had the most experience on the trail, but if a long difficult trip is contemplated be careful not to get horses that are too old, as they will be unable to stand the hardships. For such a trip young, willing horses of some experience are better, but older and experienced horses are the best, for they know how to manage the load more carefully, find feed better, pick out the best way, and know how to save themselves. Avoid wild, nervous horses and select those that are good feeders. Their weight should be between eight and eleven hundred pounds. Lighter horses cannot carry sufficient loads, while heavier animals, though better for good, easy trails, are too slow and are apt to be clumsy with their feet. However, the type of country and the horse in general use there should be the governing factors. The pack-horse should have a large chest, legs well apart, back straight and short with a deep, large barrel. The hoofs should be broad and sound with elastic, healthy, and fully developed frogs. Low broad withers are an indication of strength in the shoulders. This advice applies equally to mules.

Marches and Loads.

Two hundred and fifty pounds should be the maximum load for steady work, and only the strongest horses should carry that weight; the others should not be packed heavier than two hundred pounds. A large horse can carry three hundred pounds over bad going for a long time; but the chances are that at the end of the trip he will be played out, especially if long days on the trail have been the rule. On a good trail a mule can carry two hundred and fifty pounds for twenty-five miles, day in and day out, without difficulty. It is possible to push animals to their full endurance for a few days with no bad effects; but a good rest should immediately follow. Over ordinary mountain trails the march should be from fifteen to twenty miles a day, at an average rate of from two and a half to three miles an hour. On fine, level trails animals can be kept up to four miles, but it means constant watching and urging them on. Occasional days of rest are very necessary; and, in an ordinary trip, these will come naturally on account of stormy weather or by work compelling the men to remain in camp a day or more. The length of time for travelling is usually from five to seven hours, though sometimes conditions will require a longer day. Of course, in very bad country, it may be impossible to make more than a mile an hour, and on some days as much as twelve hours will have to be spent on the trail; but any such great length of time should, when possible, be avoided. Do not take too few animals, but as many as are consistent with the loads, otherwise sore backs and slow travelling result. Such economy invariably means lost time.

Equipment.

Blankets. — Of these there are two: the corona or sweat blanket, which is put on first, and the saddle or pack blanket. The former is an ordinary, good, single bed blanket, preferably gray, while the latter is usually a heavier one. They are folded twice to make four thicknesses.

Pack cover. — This should be six feet square and of light canvas or heavy duck. It has two uses: either as a wrap in which a number of articles are placed and tied up into a single pack, or as a cover to be thrown over the packs when these are in place on the animal.

Ropes. — First is the lair rope, which is for tying together the pack cover when it is used as a wrap or for tying up an *alforja.* Next is the sling rope, which is used to tie the packs to the saddle. Both of these should be of three-eighths inch best manila and about thirty feet in length. Lastly is the lash rope, with which the hitch is thrown, as described below, and the packs underneath the cover secured in place. It should be of one-half inch best manila and of about fifty feet in length, with a cinch attached, at one end of which is a wooden hook, and at the other a ring.

Alforja. — This is a large bag, of extra heavy duck or canvas, sometimes subdivided inside according to the individual taste. It has an overlapping flap, buckled down. For articles in constant use on the trip it is handier than a pack cover used as described above.

Boxes. — These are sometimes used for special purposes, such as carrying instruments. They may be of wood, fiber, or cowhide. The last is preferable because of its partial flexibility. In any case boxes should be avoided as much as possible, as they are hard on an animal's back.

Cross-tree saddle. — This is composed of two side-saddle boards, similar to the McClellan saddle-tree, connected in front and rear by cross-pieces of wood, shaped like the letter X. Its cinch is usually double, while that of the *aparejo* is of one broad band. Breast straps, breeching, and quarter straps are often invaluable in keeping the loads from slipping, especially in hilly country. Supplies can be carried in wicker baskets and panniers hung on each side or in packs secured and tied on by the sling and lash ropes as described. The latter is the common form used to-day by trappers, hunters, and prospectors in North America.

Aparejo. — This is a pad placed on the blankets like a pack saddle to support and carry the load. It has advantages over the cross-tree saddle owing to its lightness and flexibility, which reduce the chance of gall sores. The great difference is that it has no wooden side boards and is padded with hay so that one blanket is a sufficient protection to the animal's back.

Slinging the Load.

Usually two men are required to pack the horses; but there are methods and hitches by which one man can do the work. To sling the load a man stands on each side of the horse; No. 1, as we will designate him, is on the near side, while No. 2 takes his place on the off side.

First will be explained the two most common methods used with the *aparejo*. No. 1, with the sling rope, forms a bight at about the middle, which he throws across the *aparejo* to No. 2, taking care to keep the two parts separated, according to the size of the loads. No. 2 picks up a pack and places it on the *aparejo*, so that its top will ride flush with the top of the *aparejo*. No. 1 lifts his pack in a similar way, except that he places it so that it will be about four inches higher than the off pack. No. 2, holding his pack with his left hand, and bracing with his shoulder if necessary, grasps the bight of the sling rope with his right hand and throws it across the load to No. 1. The latter, supporting his load in a similar manner, grasps the end of the front rope with his right hand and passes it through the bight or loop from above and draws down taut. Holding this now in the left hand, he leans down and picks up the end of the rear rope. Then a square knot is tied. It is now necessary to brake the near pack, which is higher than its mate. No. 2 holds his pack firmly in place by grasping the ends, while No. 1, by raising the lower edge of the near pack out and up, works it down until it is even with the off pack. When they are flush this stage is completed. There is a variation of this, known as the "double sling," which is used for very long packs. The only difference is that after the sling rope is laid, the bight is spread very far apart; then, when the packs are in place, the ends are tied separately to the forward and rear parts of the bight, respectively.

When the cross-tree saddle is used, slinging the loads is done quite differently. First the sling rope is taken at the middle and a clove hitch is made over the forward forks of the saddle, one half of the rope being on the near side and the other half on the off side. Then the near rope is looped over the rear forks, from the rear forward, with the end down underneath the bight thus formed. The same is done to the off rope. Each man then lifts his pack in place, resting it on the side of the horse in the bight in such a way that the rope will hold the pack firmly against the saddle-board. The packs should be placed up against the forks of the saddle and the slack in the bight taken up with the right hand by pulling down on the end of the rope, while the left hand holds the pack in place. If the pack is heavy, it will be necessary to support it further by placing the shoulder underneath. The end of the rope is then passed around the bight in one full turn. The two ends are then tied together with a square knot over the center of the saddle. If the packs are not even, they can be adjusted by the same method as used in braking with the *aparejo*. If a top pack is carried, it will be placed in the center, previous to tying the knot, so as to rest lengthwise on the forks, or crosswise on the side packs, according to its nature. The square knot will then be tied outside the top pack. Some people prefer to make a bowline knot at the end of the off rope, through which is passed the near rope, and the knot is then made on the near side, well down. There is also a variation for the use of side packs, as in the case of the *aparejo*. The bight is made very large and allowed to hang down low; then the pack is put in place, in the usual way, and, while being supported by the left hand, the bight is grasped in the right hand and carried over the pack and caught over the forks of the saddle both front and rear. Then the end of the rope is brought over the pack and tied to the bight from the side opposite that which was hooked over the forks. In this way each rope is tied separately and to the bight of the opposite rope. No top pack can be carried when this method is used.

The Single-Diamond Hitch.

This hitch, which is the best known, is used with its slight variations throughout the entire western hemisphere, in regions where mules, burros, or horses are used for pack transportation (Fig. 13). In describing it, "No. 1" will refer to the near packer and "No. 2" to the off packer, as before. After the packs are slung in place and the pack cover, if used, has been thrown over the load with its ends tucked under the sides and bottom of the packs, the men take their respective places. No. 1 takes a coiled lash-rope, and, undoing it, drops the cinch, at the end of which is a hook, under the horse. He then runs the rope through his hands from left to right to make sure it is clear. About twelve feet from the end he stops and throws a bight over his near pack from front to rear, while the end of the rope rests on the ground near the horse's hind feet. No. 2 then grasps the hook at the end of the cinch and holds it close against the horse's belly. No. 1

grasps the other end of the cinch, at the rendering ring, taking in the slack, and, running his hand up the rope, forms another bight, which he throws over the load, on which the first bight lies. No. 2 catches this bight in the hook. Then the forward part of the rope forming the second bight is passed under the rear part, thus making the diamond. This diamond is formed so as to come exactly over the rope that makes the first bight, which in turn is drawn through the diamond to the extent of several feet and allowed to hang over loosely in the form of another bight on the off side of the horse. No. 2 then grasps the running part of the rope, which was passed through the hook, and pulls up on it, while No. 1 takes in the slack on his side. When it is as tight as can possibly be made, No. 1 takes the slack, which he has just received, and passes it around the rear, bottom, and front of his near pack, very tightly. Then No. 2 takes in the slack by pulling on the rope which formed the third bight and was left hanging down on the off side of the horse. In doing this he braces himself by putting his left foot against the rear of the off pack, and pulls as hard as possible. Then, without losing any of the slack and holding on to the rope, he himself passes around the pack close to the head of the horse and again bracing with his foot, this time his right, against the front of the off pack, he takes in the remaining slack. After binding the rope closely around the front, bottom, and rear of the off pack, No. 1 takes in this slack by pulling on the end of the rope to the rear, bracing his right foot against the rear of the near

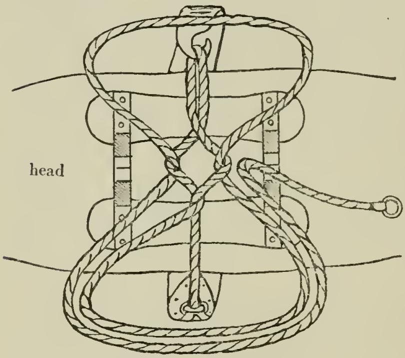

Fig. 13. The Diamond Hitch

pack. The end is then passed around the rear of the near pack and tied securely to the rendering ring by two half-hitches, using a bight rather than the end of the rope if it is too long. The load is thus tightly secured with the use of but one knot, which is at the very end. When that is undone, the whole rope is pulled out without danger of its becoming snarled. There are many other hitches, such as the double diamond, three-quarter, one-man hitch, etc., but the single diamond is by far the most widely used.

Suggestions.

To catch the animals, preparatory to packing, drive them into a corral made by stringing lash-ropes in a semicircle from one tree trunk to another. Then move quietly among them, slip on their halters, and tie them to the trees, preferably apart from one another. It is best at first to blindfold a wild or unbroken horse, until he becomes accustomed to being saddled and packed. Some people who use mules make this practice a rule.

Always brush the animals' backs with the hand, so as to prevent anything from lying under the blanket and causing a sore. Also see that the hair lies smooth. In "cinching up" be careful that the skin under the rendering ring does not wrinkle and get caught, as it will cause a bad gall. If an animal puffs himself up when the cinch or lash-rope is being tightened, never punch or kick him; wait a moment and then tighten up quickly when he is unprepared or has momentarily relaxed.

Make up each load so that its side packs will be well matched as to size and weight. Animals should be loaded according to their strength and condition. If the loads cannot be evenly divided as to weight, it is better to change them about among the horses, so that the same animals will not be forced to carry continuously the heaviest loads. In an "outfit" [1] where freighting is done, that is, commercial transportation, the contents of the loads usually remain the same, so it is best for the same animals to carry the same loads each day. But on a

[1] Common term applied to a pack train.

camping trip for example, the packs are continually being opened, supplies are used, and their contents change; so that in this case the former rule works better. At times it will be necessary to remake entirely both packs and loads, to keep them uniform. Toward the end of a trip, when the loads are greatly reduced, some animals may go without any packs and alternate every few days with the packed animals, so that all have their turn at travelling free. This often saves them from having sore backs.

When possible, packers should work in pairs, as the work is more speedily done in this way and no time is lost. One-man hitches should only be used when it is necessary for a man to work alone.

Never prevent animals from drinking as much as they want during the march, either at fords or other suitable places. They will travel better for it. If deprived of water they will feed poorly and grow thin. Always camp where water is easily accessible from the grazing place.

Under all conditions treat animals with kindness, for they will appreciate it and do more work in the end. Never abuse or scare them, for if once they become suspicious or wild they will be impossible to manage. During the march, on the trail, move quietly among them, and if it is necessary to catch one to adjust his packs, speak to him first, on approaching. Nothing is more likely to result in accident than to permit the animals to become excited and rush about. It is important for them to have confidence in the men of the outfit. The work of catching them, packing, and unpacking will then go on more smoothly and with greater dispatch. In traversing difficult country, confidence is essential in order to have the animals follow closely and without confusion. Its absence results in their continually leaving the trail and thus making trouble, or in balking, an even more exasperating habit.

During the march, care must be used by the packers in watching the packs, to see that they ride easily and do not slip. Unbalanced or misplaced packs result in the animals becoming more tired, and cause sore backs. In the case of a slipping pack an animal often becomes frightened, and is apt to stampede, tearing off the packs if in thick timber.

Never push or hurry animals over a bad ford or through a dangerous place, as it will disconcert them and they may thus lose their footing. Give them their time and they will pick their way safely.

Do not allow animals to stop and graze during the march. The only method of entirely preventing this, is to tie the halter shank very short to some part of the lash-rope. But this is a bad practice, as it does not allow the animals to drink at fords; and with their heads tied up tightly, they are more likely to lose their footing. The best prevention is to watch them continually and keep them at their work. Never permit them to lie down while carrying their load, for if heavily packed they will be unable to get up again. On long marches under extremely heavy loads it is essential to keep them on their feet and continually moving.

In open, level country never stop the "outfit" to rest the animals, as it will only be demoralizing. However, in mountainous regions, where it is necessary at times to ascend excessively steep hills, it is a wise precaution to allow the animals a breathing spell now and then, for it is bad to let them overdo. Try to prevent them from trotting or galloping, as they sometimes will in open country if they become excited. Any gait other than a walk tends to loosen the packs, and sore backs result.

In adjusting a load, select if possible a level piece of ground. If the grade is slight, head the animal down hill, but if very steep and there is no choice head him up hill; otherwise the pack, slipping forward on to his neck, will cause him to lose his balance and fall.

If an animal falls and is unable to regain his feet, remove his pack as quickly as possible, cutting the lash-rope if necessary, preferably at the standing part (near the cinch), as the load will more quickly be released, and then get him to his feet. In rough, mountainous country, such as will be encountered by an explorer or hunter, fallen timber and bad swamps or muskegs will often cause trouble to the animals, resulting in their falling and becoming mired.

Driving a pack train is exasperating work, especially over bad trails or in rough country. The animals must be kept close together and not allowed to straggle; yet it is dangerous to crowd them, as this results in biting, and kicking or driving of some animal out of line, to which the others often prevent his returning. If driven quietly yet firmly, the animals will keep their places in single file.

It is always better to make one drive only, in the day. In a warm climate or in excessively hot weather avoid travelling during the heat. When an extra long march is necessary, if the animals are not accustomed to it or not in condition to stand one long drive, then it is better to halt at noon. In this case unpack them so as to rest and cool their backs, and turn them loose to feed. Never let the packs stay on any longer than necessary. When the loads vary in weight, pack the heavily laden animals last, and on reaching camp unpack them first. Short halts are unavoidable, in order to adjust packs; and on bad or little-used mountain trails they are often necessary to give time to chop away the fallen timber.

Do not expect too much of the animals. In doing their work, even those of only average intelligence sometimes exhibit remarkable feats of judgment. This has a tendency to make one expect more of a pack animal than he should. With sound and gentle animals, having the confidence of the men of the "outfit," it is possible to take them anywhere they can find footing. It is wonderful what dangerous rock slides, steep banks, and treacherous fords they will cross in safety under these conditions.

Packs, saddles, *aparejos*, and blankets should be instantly removed on reaching camp. The animals should first be caught and tied, so as to prevent them from straying, and then as each in turn is unpacked he should be turned loose, where he can roll if he so wishes and immediately begin grazing.

Do not picket an animal unless compelled, as he will feel lonely when the others stray, and often refuse to feed. Hobbling should be avoided as much as possible; but at times it is necessary with a wild animal or one likely to stray far. Yet tight hobbling is cruel and greatly interferes with feeding. Even a tightly hobbled horse will often wander miles. A bell attached to the neck of the leader or any animal likely to stray enables one to locate the animals in the timber or when they are out of sight. In the absence of feed, or when only a few days from the starting point, horses are likely to take the trail back and go miles before they can be headed off. A better method than hobbling is to turn the animals out to graze on the side of camp farthest from home. Then, if the animals start to go back, the ringing of their bells as they pass camp will arouse the party, who can rush out and head them off. If one observes the direction in which they are feeding about dark it will be easy to locate them soon after daylight, as they will not wander far from that spot during the night. If camp is made where there is plenty of food and water, the tendency of the animals to wander will be slight. Food is always the primary consideration in selecting camp for the night, as the success of a trip is dependent on keeping the animals in as good condition as possible. It is important to keep animals well shod, and to replace any lost shoes, as with heavy packs, over rough, rocky ground, their hoofs rapidly wear down and become sore if unshod.

At every opportunity shake and spread out the sweat- and saddle-blankets to air and dry, for when clean and dry the animals' backs will keep in better condition.

During the day's march, one man should, of course, lead the way, either on foot or in the saddle. If there is a trail, he follows it; if none, he chooses the best route. Behind him come the animals which are driven by the rest of the party. The best results are obtained if one man does not drive more than five animals. Hence in a large pack train, one man is assigned to every five animals along the line. Any extra men should follow in the rear unless their services are required in front. Do not divide the animals into groups of less than five, as too many drivers only add confusion. The animals should be allowed to pick their individual way as long as they follow well and keep in their respective places. Never let a horse with a pack jump an obstacle more than two feet high. Jumping fallen logs results in sore backs and should be avoided when possible by détours or chopping. In such places, in mud, or in fords let the animals take their own time and pick their way slowly.

When necessity requires the outfit to travel along a stream always keep away from any steep banks, for the water cutting underneath makes the footing treacherous and an excited animal may jump into the river and swim to the other side out of reach, an awkward situation, since it will often be necessary to cross over in order to drive him back.

In the case of a saddle animal, dismount if the going is dangerous, and either lead him with a loose rein or let him follow in line with the reins tied to the pommel of the saddle. In fording always give the animal his head and let him pick his own way; otherwise, in swift, deep water he is likely to lose his balance and be swept off his feet. Take your feet out of the stirrups so as to be free in case of accident, but hold them down, under the animal's belly, so as to keep the center of gravity as low as possible; for a man sitting so high tends to make the animal top heavy.

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TRAVEL WITH SLED-DOGS.

BY TOWNSEND W. THORNDIKE, M.D.

Characteristics.

The northern sled-dogs are more or less mongrel, the product of breeding the Eskimo dog to European dogs, with perhaps a degree of wolf strain. They may be roughly classified into three groups. The Eskimo or "Husky" dog is found generally along the Arctic coast of North America. The Indian dog or "Gidde" is found in the timber or Indian country, south of the Eskimo region. "Malamut" is the general term for dogs of the Alaskan coast and about the settlements in the interior of the Peninsula.

The "Gidde" and the "Malamut" are as a rule smaller and not such fine animals as the "Husky." They are, however, willing workers and have great power of endurance. The first is apt to be vicious. The term "Gidde" is also applied to puppies and to weak and sickly dogs.

A description of the "Husky" will in general describe the points in all the groups. A fine "Husky" is a very handsome animal. It differs from other varieties in being more wolfish and wild. The body is sturdy, large-boned, and covered with dense, shaggy, coarse hair having tendency to curl. The hair is especially heavy about the neck and shoulders and thin on the legs. A single, long hair may measure eight inches. Under the long hairs is a denser coat of shorter hairs which provides great resistance to wind, cold, and moisture. The coat is usually black, with grayish markings on the chest and tail, but often it is pure white. Under the eyes there are characteristic light spots. When full grown a dog weighs about 130 pounds. The muzzle is long and pointed, with a black nose which possesses well developed powers of scent. The jaw is formidable, armed with strong, white teeth. The eyes are set obliquely. The ears are triangular, erect, and project forward. The expression is suspicious and seldom shows affection or friendliness. The neck is arched on a broad chest and muscular quarters. The tail, round and bushy, is an excellent index of the dog's physical condition; for when the animal is fresh it is curled over the rump, but when fatigued it usually droops. The feet are broad and tough. The animal's motion is quick and graceful.

Opinion differs as to whether the "Husky" is superior to the "Gidde" or the "Malamut" in temper and intelligence. Many believe that the superlative dog for hauling is a mixture of the Eskimo dog and the foxhound, or Russian wolfhound. This cross gives speed, strength, and staying power. Many breeds, however, are employed. At the present writing (1917) Siberian "Huskies" are the superior dogs for racing in the Alaska Derby.

The affinity with the wolf is so close that the "Husky" readily breeds with it, and occasionally one sees a wolf in harness with a team of dogs. A characteristic of these dogs is that they never bark unless they have lived in a neighborhood where there are dogs from the "outside." If moved away from this environment, they soon lose the habit of barking.

These northern dogs are inveterate thieves and born fighters, but nevertheless great cowards; for one will seldom fight singly against a lone adversary. Whenever a fight starts, the noise attracts all the other dogs in the neighborhood and they rush to join in the general mêlée. If one falls he is instantly pounced upon by his companions, and may be torn to pieces if not rescued. Few of them are capable of attachment to man. Occasionally one may meet a dog that is somewhat patronizing, and will greet advances with a peculiar, friendly growl. None, however, will accept any great amount of petting. They are whimsical, and even take a dislike to other dogs, greeting their approach with a snarl. The hardships that Indian dogs bear, are at times terrible. Some drivers think that these dogs work better under a hard master. There seems to be an unremitting struggle for mastery between man and beast. The dogs are constantly on the lookout for the driver's long lash, which is often used with wonderful skill. The sight of a threatening gesture on the part of the driver is sufficient to bring out not only a most plaintive howl from members of the team, but also renewed energy. With well trained dogs and a good driver it is seldom necessary to use coercion. A skilful driver dislikes to punish his team while travelling, as it fatigues the dogs; but the only way to keep them under control is by fear of the whip.

Notwithstanding the grievous discipline to which these animals are subjected by their master, they exhibit a certain respect for him. He provides them with food in comparative abundance during the winter months; he is on the watch that there be no loss of life or severe injuries inflicted during their sanguinary skirmishes with other dogs; he is mindful not to expose them to unnecessary dangers or to overwork them on the trail; he is ever ready to assist in hauling or guiding the sled, and in many little ways he is thoughtful of his team.

Selection of Dogs.

The following points should govern the selection of sled-dogs. The weight of the animal should be for the most part forward; the body long, with deep chest capacity; the musculature of the shoulders well developed; and the loins straight. The legs should be straight, muscular, and sinewy; the soles of the feet well padded and with little feathering. If there is much feathering this should be clipped off during the winter, as it will cause balling of the snow between the toes, thereby incapacitating the animal.

Driving.

Success in the art of dog driving is in proportion to the knowledge the driver possesses of the temperament of each individual dog in his team. The distance it is possible to cover depends on the load and the road. A general rule is that under ordinary circumstances a dog can pull the equal of his own weight. On a hard trail, when the load is heavy, an average of about four miles an hour can be made going at a dog trot. A fair day's work for a good dog under favorable conditions is forty or fifty miles with a load of 100 pounds. Thus, a team of five dogs can transport 500 pounds fifty miles a day. Twelve hours is considered a day's work. Since the establishment of the All-Alaska Sweepstake Dog Race, which was first organized in 1908, records of endurance have been made which are little short of marvelous. In one of these races a team of nine dogs travelled 104 miles without eating, and with only one stop in the whole distance. The breeding and training of racing dogs is now (1917) being conducted in Alaska along careful scientific lines and no doubt present records for endurance and speed will be much reduced.

Some of the dogs have a great dislike for their work and have to be literally dragged to the sled to be harnessed. Others seem to have a certain fondness for it, and evince their feelings by a noisy excitement as they await the command to be off. The tinkling of the bells about their harness seems to act as a stimulus urging them onward. It is credibly stated that in the absence of these sounds a difference in their pace is noticeable. If the sled does not draw readily the dogs will not start until it has been lightened. Some of the dogs are so neurotic that they never make good draught-dogs. They overwork during the day's haul, and so wear themselves out for the work of the next day.

The gaits used in sledding are the walk, the trot, and rarely the gallop. In the bush, or on a new and soft trail, the walk is often the only possible pace. In the open, it is the trot. The driver follows behind the sledge by a kind of running walk, but it is sometimes necessary for him to run in order to keep up. When the trail is level and the load does not require balancing, he often goes ahead of the dogs and sets the pace. Occasionally, the head dog catches the scent of some animal that has crossed the trail, and he is off at once on the scent, pulling the rest of the team with him. It is often with difficulty that the driver gets under headway again. Sometimes the dogs resort to tricks to avoid their work, and their strategy is so very cunning that it takes an experienced eye to detect their malingering.

Harness.

There are different methods of harnessing dogs to the sled. The choice of method depends upon whether the trail leads through timber or open country. Those who live in the interior use the tandem or single-file driving, while the Eskimo, because of the open nature of their country, harness their animals in packs. Perhaps the best arrangement, and the one invariably used by the white man for transportation and racing, is the double file. In this method a long tow-line of leather or rawhide is fastened by one end to the sled, by the other end to the harness of the leader. The other dogs are fastened along this line in pairs, in such a way that the two animals of each pair are on opposite sides of the tow-line. Thus in a team of nine dogs there are four dogs on each side of the tow-line with the leader attached to its forward end. A short line from the collar of each dog is also fastened to the tow-line in order to keep him in place. This method of harnessing allows each dog to work freely and independently, and enables the driver to detect a dog that is not doing his share of the labor.

If dogs are driven in packs, each animal is hitched directly to the sled by his own line. The lines are of varying lengths in order to prevent the dogs crowding each other, but there is no attempt to keep the animals in a given place as in the other methods.

In the tandem harness the most intelligent dog is chosen for leader or "fore-goer" of the team. He sets the pace and keeps the direction. Upon him depends the easy and continuous going of the entire team. The animal next to the sled is known as the steer or "sled" dog. He is the heaviest and is trained to swing the head of the drag away from obstacles. The intermediate dogs steady the outfit. A team trained together is obviously many times better than a picked-up one, as it has uniform gait, fights are less apt to occur among the dogs, and they will combine against a foe. Once the dogs are given their places in the team, they always keep the same location. In this way they accustom themselves to pulling in that position. When not "mushing" (travelling) the dogs usually lie down on the trail. They are not ordinarily unharnessed until the end of the day, unless they have become very tired. They are rested or "spelled" on the journey four times a day, and at the same hour every day.

The dog harness is the same in principle as that for horses. Its essential parts are a collar and traces, but sometimes the trappings are very elaborate. An excellent

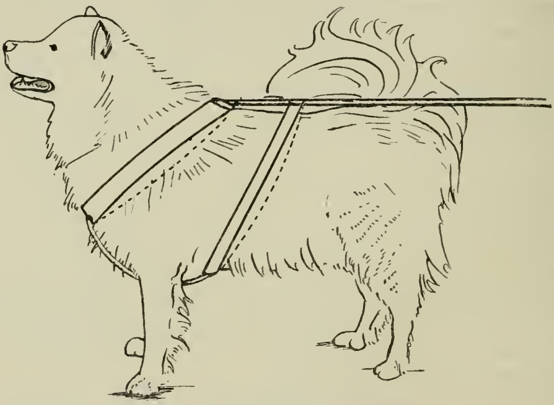


Fig. 14. A Simple Dog Harness

emergency harness that does away with the collar can be made in a short time from rope or rawhide. It consists of a thong passing around the neck, and attached to this three other short thongs, one of which stretches along the back, while the others pass over the chest and join the back strap close to the tail (Fig. 14). The chief points to remember in devising a harness are (1) to adjust the collar so as to bring the pull upon the dog's fore shoulders and (2) to prevent the collar from slipping over the throat so as to choke the animal.

Dog-Sleds.

There are several types of sleds with many modifications. The Yukon sled is about eight feet long, made of hard wood, and provided with runners. There is often attached to the top of the sled some form of box into which a load can be placed, and from the back of which a pair of handles project to be used in guiding the sled. The box is usually made of hide, but canvas, bark, wood, or any other adaptable material can be used. Another type of sled is the toboggan. This is seldom used in Alaska, but is very commonly seen in the Hudson Bay region. In very cold weather wooden runners are the best, but under ordinary circumstances steel ones are used. In the manufacture of the sled no nails should be used, but all parts should be lashed together in order to give greater strength and elasticity.

On the Trail.

There are two methods of guiding the sled. One is from the rear by means of handle bars. This is the usual way on a fair trail with a small load. On a heavy trail with a large load the better plan is to fasten a stout pole about four feet long to the front of the sled on the right side. The man steering the sled walks in front and guides and pulls the sled by means of the pole.

Besides profanity, the common terms employed in sled-travel are "Mush" or "Mush on," signifying to start off; "Whoa," to stop; "Gee" and "Jah," to go to the right or to the left respectively. These exclamations differ in their phonetics according to the region of the country and whether English, French, Indian, or Eskimo predominates.

At the start everything is excitement, Indians shouting, dogs yelping and getting tangled in the harness. This confusion lasts until a start is made. A "tripper" in the meantime has gone ahead in order to make the trail and show the way. This runner keeps two or three miles in advance of the party. Many of the animals, especially the leaders, often display a fretfulness in their desire to catch up with the man, or even the team in front. This irritability is also seen when a team in the rear is attempting to pass one ahead of it. When it is time to rest, the guide in advance selects a camping place and makes a fire. When the stop for the night is made, the dogs are the first to receive attention. They are immediately unharnessed, and the fish for them is placed before the fire to thaw.

Feeding and Care.

The dogs will eat almost anything. Everything must be cached, especially articles made of animal or vegetable matter. Even food stored in tin is not safe. In the winter time, when the dogs are needed, they are fed regularly. In the Arctic regions the food consists chiefly of seal, walrus, and bear, with musk-ox and caribou when they are to be had. In the wooded areas farther to the south the staple food is dried fish. Pemmican is perhaps the best, lightest, and least bulky food to haul. The amount of ration depends upon the amount of labor the dog is called upon to perform. The more work, the greater the allowance. On the average, about three pounds of fish are given daily. The meal is always given at the end of the day's work, because if given in the morning the dog is inclined to be lazy and shirk his work, or may vomit the breakfast soon after he is under way. The fish which is frozen in the winter months is thawed out for the dogs if the travel is in wooded country, but if there is nothing with which to make a fire then it is given in the frozen state. During feeding each driver is obliged to stand over his team to prevent fighting over the food.

There seems to be a clannish tendency among the different bands of dogs in a camp, and even among dogs of a team. There is usually one dog in each which is the master spirit. If a strange team is met while on the trail, the dogs of one team will unite against those of the other, and usually a dog fight ensues.

The driver must be careful during the spring time that the feet of his dogs are not lacerated by the crusted snow. If there is danger of this they should be protected by moccasins made of hide.

Unlike the sporting dogs in civilization, northern dogs are never trained to hunt, though they will wander about the country to hunt and fish for their own subsistence, The only training that they ever have is in learning to haul and to obey the driver.

Hydrophobia probably does not exist among the Eskimo or Indian dogs, but distemper is very common. Fleas are unknown.

A team of good dogs with ordinary care has a life of from eight to ten years. The cost of a dog varies according to the region. In Alaska a good sled-dog will bring from fifty to seventy-five dollars or even more.

CAMEL TRAVEL.

1.—THE DROMEDARY.

BY ORIC BATES.

The two great fields in which the one-humped camel is employed are Africa and Arabia. It is also used in Syria and the Syrian deserts. The Bactrian or two-humped camel belongs to central and farther Asia and is not dealt with in these notes.

Selection of Camels.

The traveller will first consider whether, in view of the nature of his journey, it is better for him to buy his camels or to hire them. For long or dangerous journeys the purchase of camels is to be recommended, as the traveller can then take risks which under other circumstances the cameleers might reasonably refuse. Prices fluctuate according to the season, the state of the camel-market, the number of beasts bought or hired, etc. In hiring, the price ought to include pack saddles and the services of the drivers. One man is usually allowed to every five camels. Riding saddles (*makhlūfas*) must be especially arranged for, and unless obtained from a trustworthy source (*e. g.*, some Government department) should be given a stiff trial. There is something wrong with a saddle that creaks when in use.

It is always advisable, and usually possible, to find some reputable European familiar with camel travel whose advice can be obtained in making arrangements. The advice of professional guides and dragomans should only be taken with the greatest caution, since this class almost always involve the traveller in difficulties, and have only their own extravagant pretensions to recommend them. When the camels are secured, the traveller should note their brands and general appearance, in order to be quite sure afterward that he sets out with the same beasts he has bought or hired. Rheumy-eyed camels, or those which slavver over-much, camels which on rising are seen to tremble slightly in the hind legs, are to be looked on with suspicion; those with bad gall-spots or other obvious ills are to be rejected. A camel which has been often branded about the joints and withers has probably been cauterized for a bad sprain, an infirmity very apt to reappear on a hard march. Most good riding camels have very thick coats of comparatively straight hair, faintly lustrous. The best indication of a camel's general condition is its hump. The hump may be baggy and flaccid, owing to bad or scanty feeding, or else distended with fat as a result of too much green food and too frequent watering. A camel thoroughly fit for desert work will have a hump firm and well filled, but not bloated in appearance.

Hire of Cameleers.

It is usual when hiring men for a journey of more than three weeks to make part payment (but not more than 25 percent) of wages in advance. Once the bargain has been struck, it is well to promise the men a *bakhshîsh*, or present. Such promises ought, however, to be left vague, and it should be plainly stated that if the work is not satisfactory there will be no rewards. It is also well to hint, in cases where a number of men are employed, that the best man of the lot will receive, in addition to his own *bakhshish*, that of the worst man of the crew as well. It often happens that at the end of a journey a traveller, in the pleasurable satisfaction of his safe arrival, good-naturedly gives rewards irrespective of the services his men have rendered him. By so doing he stultifies himself in the eyes of his cameleers and raises difficulties for the next European who employs them.

Baggage and Riding Camels.

The many local varieties of camels all fall into two great classes: riding camels (*hagîn*) and baggage camels (*hamlas*). The former, being of a light build, are not suitable for heavy loads, though capable of doing thirty to forty miles a day (sunrise to sunset), bearing a rider and thirty to fifty pounds additional weight. Usually, when *hagîn* are made to carry loads, they are led and not ridden. Baggage camels in good condition may be charged with loads of from 250 to 400 pounds and will carry them at the rate of 2½ miles an hour for ten hours a day. This they ought to be able to keep up without other rest than that obtained during the night-halts for two or three weeks. Camels can go without water for stretches of from four to six days, provided they are well fed. Most camels can do even more, but not without suffering for it later. A really thirsty camel stumbles on the march and cries during the night. The traveller who contemplates making a forced march ought to carry millet (*dhurra*) enough to issue to each camel two quarts a day: one at dawn, another at night. Great care should be taken lest the millet be pilfered by the men, a caution which applies to all unlocked articles carried by the expedition. When the traveller encounters on his line of march small patches (*ḥattîas*) of desert vegetation suitable for camel fodder, it is a good plan, if not too greatly pressed for time, to let the camels graze as they go. A jaded string of camels, thus refreshed, will afterward more than atone for the delay.

Riding.

The traveller should of course learn to ride a camel before undertaking journeys of any length. He will at first only mount when the camel is kneeling, but will learn quickly "to mount by the neck" of a standing camel. To do this, the rider stands on the beast's near side and with the right hand grips the front edge of the *makhlūfa;* his left hand rests on the back of the camel's neck. From this position the rider jumps and pulls himself up so that the left knee rests beside the left hand on the camel's neck and the right leg hangs straight. The right knee is then brought up so that the rider is kneeling on the camel's neck. He then places the left foot on the neck, shifting his right hand to the fore-post (*el-'amūd*) of the *makhlūfa,* and so clambers into the saddle. The rider ought, until well practised, to have a care least he injure himself seriously on the '*amūd*.

The two common gaits of a riding camel are the walk and the trot. The former is so slow and measured that the rider is in no danger of taking a fall. In trotting, the rider should square his shoulders and sit well back, holding the head-rope in the left hand (palm up) and his camel stick or quirt in the right. Both arms are kept away from the body, for balancing. The feet should be both on one side of the neck or the other; if on the near side, the left foot rests on the right instep, and *vice versa*. Only when the rider is practised and knows his mount ought he to let his feet hang one on either side of the camel's withers, and he ought never, in trotting, to cross his feet on the camel's neck. The head-rope should be held fairly tight and ought never to be let go when mounting or riding. Spirited camels, or vicious ones, have in addition to the head-rope a small leather cord passed through a hole in the left nostril. This serves as a curb and should be kept slack when not in use. Some riding camels can be made to gallop. This gait ought never to be attempted by the novice. In galloping, the rider should lean far back, lock his ankles, and grip the '*amūd* with his knees. If the traveller plans to gallop any distance, he will do well to wear a broad sash of knitted silk bound round the abdomen. This is a restful convenience in trotting long distances; in galloping, it is necessary to prevent rupture.

It is seldom advisable to beat a camel with a stick; more can be done by whirling the camel stick in a circle a few inches above the beast's head. Camel sticks should be fitted with a wrist-thong. They are curved at one end for the purpose of hooking up the head-rope, in case the latter slips out of the hand, and they are useful in guiding the camel, a light tap on the near side of the neck turning the beast to the right, and *vice versa*. Camel quirts are made of heavy hippopotamus hide, but should be used sparingly.

It is worth mentioning that in deserts where there is no cover gazelle may often be stalked with camels. The traveller should dismount and, holding the head-rope in one hand, approach the game from leeward while screened by the camel's shoulder and fore legs. He may, even in the most open country, work his way in this manner to within 200 yards of a gazelle.

Equipment.

The traveller's equipment should always comprise a good compass (Captain Belfield's night-marching compasses are excellent), a pair of binoculars (day-and-night

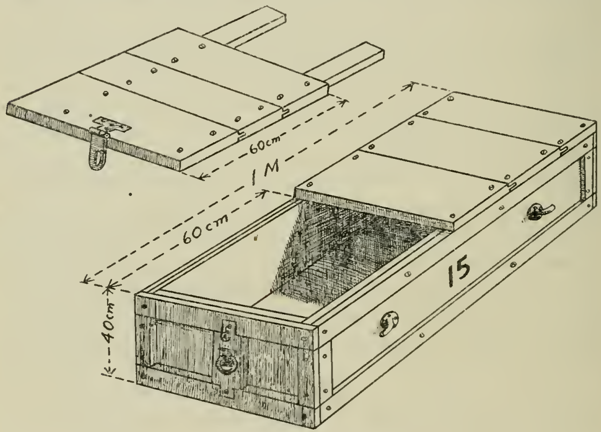


Fig. 15. A Camel-Box

glasses with extending shades), and a good combination knife. A supply of quarter-inch rope for slinging loads is indispensable. A cobbler's kit, containing an awl, a punch, cobbler's needles and thread, a sailor's palm, wax, a square of stout, tanned leather, and a length of rawhide, is essential, since camel travel is attended with many unforeseen breakdowns necessitating saddlery repairs, etc.

The best type of camel-box is the hingeless one shown in the accompanying drawing, Fig. 15. The manner of slinging a pair of these boxes is shown in Fig. 16. The ropes are kept in place by the "spreaders" (cleats) on the boxes, and both loads can be freed by the removal of the stick, *A*.

The best cooking kit is a Primus stove, but this necessitates carrying kerosene. The men, if going over beaten tracks, ought to find fuel enough for themselves by picking up dried camel dung.

Loads should be inventoried by numbers of boxes, and ought to be so arranged that material wanted for special

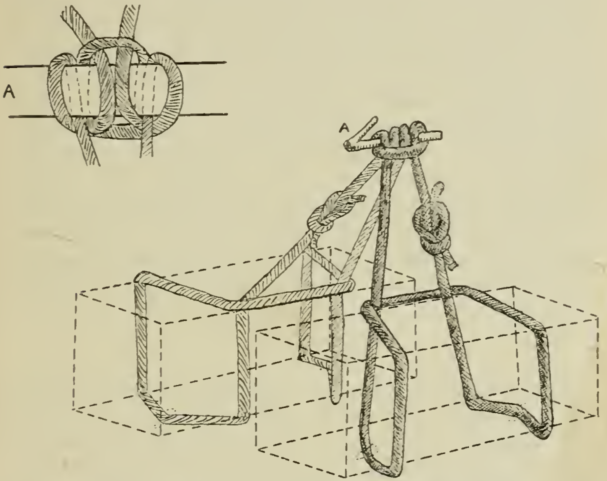


FIG. 16. METHOD OF SLINGING TWO CAMEL-BOXES

occasions may be readily found. Thus, the kitchen-kit, the ammunition, the medical supplies, and comforts, should each be given an individual box.

WATER.

Water should be carried in locked iron tanks. Those shaped like a boat's breaker are the best model, since tanks of square section are apt to spring a leak. A small tin of marine glue, such as is used in paying deck-seams, will be found invaluable for mending leaks. Water carried in skins acquires an unpleasant taste in a day, and ought to be boiled well before using. A clear understanding with regard to water should be made between the traveller and his head-man before the start, and the agreement then entered into should be rigidly adhered to, except in cases of dire necessity. Natives are very imprudent with regard to water, and will recklessly consume their own store if they think they can wheedle or intimidate the traveller into letting them share his. An Arab, being used to desert life, can march two days without water, even in hot weather. On making camp, the traveller should see to it that the tanks are piled around his sleeping-place, and he should sound the tank used by his personal servant for cooking, to make sure the water is not being wasted. This should form part of the regular routine. The water drawn for the day's drinking supply is best carried in *zamzamias*, canvas water bags or felt-covered bottles, which by evaporation keep their contents cool. It is wise to take a good drink before dawn, another with the noon meal, and as much as wanted in the evening. The traveller will soon learn to content himself with this allowance.

Food.

As for food, the following items will be found most useful: tea, sugar, rolled oats, dried fruits, rice, tinned roast beef and mutton, tinned tunny, ship's biscuit, assorted jams and marmalade. The best tinned meats are those specially prepared by the Army and Navy Coöperative Stores (London); the best tinned vegetables are the French ones, and the best tinned fruits are the American. It sometimes happens that a camel is killed for food. The best camel meat comes from the hump and ribs.

General Precautions.

Travellers on caravan journeys must be armed. The traveller should know how to take his weapons to pieces and then reassemble the parts. The best all-round arm is a .303 carbine, taking British service ammunition; but the importation of weapons of this caliber is difficult in Egypt and India, and is forbidden in the Sudan. For these countries the best weapon for desert work is the .310 W. W. Greener (Haymarket, London) double-barreled rifle, sighted to 300 yards and weighing only 6½ pounds. A revolver, .380 Colt ("New Police") or (better) .450 Webley, may also prove an addition of vital importance.

A pocket surgical kit and a few simple remedies such as calomel, "Livingston rousers," quinine, tannin, and Dover's powders should always form a part of the outfit, together with a pound of absorbent cotton, rolls of gauze bandage (½ inch, 1 inch, and 2 inches), surgical tape, a supply of chinosol, and some such dusting powder as aristol. The glare off the desert is often intense, and good care should be taken of the eyes. If the eyes become inflamed an excellent wash may be made by dissolving a teaspoonful of boracic acid in a tumblerful of strong tea, to be applied while hot.

In dealing with the caravaneers, the traveller should usually keep himself apart from them, remembering that an Arab does not understand those familiarities which are allowable in the Occident. The Arab's ideal good master is a man who knows what he wants, insists on having it, is self-possessed, just, and inscrutable. A frigid indifference to everything but his own comfort and the objects of the expedition will, if generally maintained, make the traveller's occasional condescensions seem of real value. A level voice, curt words, and a steady stare will gain him more attention than voluble shouting. If in addition he is kindly and open-handed he may win not only the services he requires, but a certain sort of affection from his men as well.

2.—THE BACTRIAN CAMEL.

BY LANGDON WARNER.

The two-humped camel is better adapted for weight carrying than the dromedary, but is worse for riding. Its range includes Turkestan, Mongolia, Manchuria, and northern China. In these countries one can usually depend upon ponies for riding purposes, even when a camel caravan is necessary for the transport of supplies and equipment. The Mongol rides his camel but the Chinaman leads his, even though carrying less baggage.

Camel Hire.

The traveller in North China and Mongolia who is forced to depend on camel transport is strongly advised to hire and not to buy, and to choose only camels offered by Mongols and tended by them. For although the Mongol uses the same breed as the Chinese, he usually grazes his beasts all summer, so that they have far greater endurance and carrying capacity during the months when they are in use. The business of hiring a caravan in North China is conducted through a "camel-inn," and the keeper of the inn is made responsible, by written documents, for the men and the beasts which he provides. The cost of a sound camel on or near the south border of the Gobi is from 80 to 100 dollars Mexican; but the hire need never be greater than twenty dollars Mexican a month (the Mexican dollar is worth 50 cents in United States currency).

The load should be three hundred and fifty pounds at the very least. It is sometimes advisable to figure the cost of carrying the baggage on a basis of four hundred pounds' weight carried for one month at a rate of eighteen dollars Mexican (or whatever the local camel hire may be), and then to agree to pay this sum without enquiring too closely into the number of camels used in the work. If the camels are hired from Chinese it is necessary to have a document of the agreement signed in duplicate by both parties, and to demand also a guarantee signed by one or more well established Chinese of the locality who will act as bondsmen for the owner. Camels hired in Mongolia proper are best procured of the local head-men or from the herds of one of the Princes. In these cases it is usually impossible to obtain guarantees. The price, however, should not be more than three fourths (generally less) that paid to a Chinese camel-inn. It is also necessary to establish a rate *per diem* for the forfeit to be paid by the camel-inn if the journey takes longer than a specified time through fault of the beasts or their drivers. But in the claiming of this forfeit the traveller should not be too strict.

Care of the Camels.

The pace of a caravan in good condition travelling over easy country in winter may approach 2½ miles an hour. An ill packed, ill nourished caravan, or one travelling in hot weather or over damp or rocky ground, will make much slower progress. The Bactrian camel travels best in the cold months, even over snow and frozen ground. In summer the animals used in Mongolia and Manchuria are packed for short trips only, or else entirely laid off. In winter the Bactrian is protected by exceedingly long hair over an undercoat of wool. When warm weather approaches, both these coverings are shed, leaving the animals unprotected against the sudden climatic changes of extraordinary seasons or hill travel. Camels are extremely susceptible to cold, and when they have prematurely lost their winter coats, the drivers often tie blankets about the necks, chests, and bellies of the animals. As a rule it is hopeless for the white traveller to attempt the cure or alleviation of any of the many ills which may befall his beasts, but it is well to provide a strong antiseptic dressing for sore backs and wounds, and to inquire before setting out if the camel-leader is provided with tar in case a smear is necessary when the camels shed their hair.

Fuel.

Fuel on the way differs according to the country traversed. In the main the caravan men will have the responsibility of fires. The traveller need not give particular thought to fuel, except for a small stock of solid or liquid alcohol which is carried in the cart for use on special occasions only. A Primus forced-draught yacht-stove may well be taken when the weight of the kerosene fuel is no disadvantage. In countries where dung is used for fuel the different sorts are useful in the following order: horse, camel, cow, sheep. The men should be ordered to collect it on the road for the last hour or so before making camp in order to save irritating delays on arrival. If rain threatens at any time of day, men should be sent out to scour the road for dung, which should be put in sacks under tarpaulins. The slightest dampness destroys its usefulness. Where *saxual* brush is used for fuel, the heart of the wood will, even after protracted rains, be found dry enough for fires.

Water.

Water breakers in the form of oval casks are generally carried for the use of the men. The traveller should either secure a pair of these for his exclusive use and disinfect them before starting, or should bring with him from America or Europe the canvas water bags called *zamzamia*, which are mentioned in the first part of this article. All casks must be swelled to a water-tight condition before starting. At least one full-quart canteen covered with felt should be carried. No one but the owner should ever drink from it. If it smells, rinse it out several times with boiling water in which soda has been dissolved. Boil every drop of drinking water. If boiled water is distasteful shake it up with a little air in the canteen. If the water is of bad taste add a dozen drops of unsweetened lime juice or fill the canteen with a weak solution of sugarless tea. One canteen may well be carried always on the saddle and another in the cart. In hot weather, wet the felt and hang the canteen on the shady side of the saddle; the water will soon be quite cool enough for a refreshing drink. A serviceable canteen may be constructed by sewing felt around an empty bottle and fastening it in a cord sling. No water should be drunk by the white man except at halts. Self-denial in this particular will not be difficult after the habit is formed, and results in greater endurance and entire freedom from the constant annoying thirst which attacks the person who continually takes a pull from his canteen. At the camp, however, large amounts of water or very weak tea should be drunk at frequent intervals. This practice as a rule is not observed by the natives, and its value will soon be discovered by the traveller who notices their discomforts from frequent drinking or from short deprivations.

Packing.

Outfit, as well as freight, is best carried in such chests as that described in the first part of this article (Fig. 15). Small trunks, made of a strong, light fiber composition, such as are used by the U. S. Marine Corps, will be found to serve excellently for the standard unit of camel baggage, each one representing a half or a third of a load according to its contents. They are tough and light and cost $8 each at army-outfitting shops. In addition the traveller may have a dress-suit case for his toilet articles and papers. Before starting the suit case should be provided with lips of velvet or, of less value, felt, sewn along the shutting edges of the lid. This is the most effective dust-proof. The camera case should be similarly treated. Tarpaulins for the perishable loads must be provided, as well as extra felts for camp rugs, pads, etc. Methods of packing had best be left to the native drivers. Provided that the traveller's outfit and freight are arranged in small enough parcels, he need not make a personal study of packing camels. It is enough to say here that the load is arranged in evenly balanced units on either side of the kneeling beast and caught in a double sling of rope with two loops on either side. When all is prepared two men simultaneously lift the loads till the four loops meet between the humps. A stick about eighteen inches long is then pushed through the loops to receive the whole strain. In case the caravan is going out empty, expecting to bring back boxed goods or scientific collections, the empty boxes are best packed in the form of numbered units of sides, bottoms, and tops which have been put up and bored for screws and then taken apart. They should be constructed with reinforcing battens like those shown in Fig. 15, even though the top is made to be screwed down permanently.

Food.

Food, even if hunting is expected, is safer to provide without reference to what may be killed on the way. American tinned meats and fruits are the best, German evaporated vegetables and *erbswurst* are invaluable, as are also French brands of dry or tinned soups. Sardines and other tinned fish are seldom satisfactory and often dangerous. Dried apples, raisins, and prunes are indispensable for the action of the bowels. Boiled with sugar and water they may be eaten cold and the juice saved for the next day. A few kept loose in the pocket and eaten uncooked from time to time are refreshing. The best brand of tinned milk is made in America and is unsweetened. Cream is a little more expensive, but on the whole a saving, as it may be thinned to advantage for cooking. Eggs may be kept several weeks if dipped when quite fresh into molten paraffin and then nested in bran or chopped straw but powdered eggs are infinitely better for all purposes except boiling and poaching. It is often found easier to carry sugar in the old-fashioned loaf form, but it is less convenient for use. Sweets in the form of cake chocolate and sweetened biscuit are much craved on long journeys, especially in cold weather. Native visitors generally appreciate them more than anything else but liquor.

Clothing.

Clothing should be cut with an eye to walking as well as riding. High tan boots (not riding boots) are best for the combined riding and walking of a caravan trip. These should be provided with leather shoe-strings and dressed daily with saddle soap, not with polish. Boots with so-called "pressed elk" soles and rubber heels will last longer and are the lightest and most supple. A pair of slippers for camp and a pair of low tan shoes for a change are necessities. In winter, leather breeches are almost necessary as a protection against wind. The thickest rib of corduroy is as warm as the leather on calm days, but is not windproof. A light Swedish dogskin jacket is proof against wind and is the only sort of leather not spoiled by rain. A light *parka* or hooded wind-shirt with cuffs, and throat protected by wind-cuffs with running cords, is even better. A thick sweater and olive-drab army shirts are recommended, as well as winding puttees of the elastic knitted form made of the thinnest, hardest wool. Such puttees are not too warm except in extreme weather, and are far better protection against cold than either leather or canvas leggins. Gloves should be of leather lined with wool or fur, or else so large that woolen gloves may be worn inside of them. If a *parka* is not used a woolen scarf is needed, long enough to wind about the neck and the top of the head to keep sleet and snow from face and neck. Unbleached cotton socks are warmer in winter and cooler in summer than any other kind, wear four or five times as long as dyed socks, and do not poison the feet. When water is plenty a fresh pair should be used each day and the others washed out at night. Outer garments should include a suit of sailor's oilskins and sou'wester; a grey Stetson felt hat; a white or khaki helmet for summer trips in the desert; a native sheepskin coat, or where it can be obtained, a Russian Cossak's *burka*, which is a felt cape long enough to cover the legs when mounted and to stretch over the horse's rump. A *bashlik* of light camel's hair may be obtained where Russian or Caucasian goods are sold. This is a peaked cap with tails on either side long enough to be used for neck scarfs in wind or snow. Native felt boots are excellent for riding and camp use. The summer outfit is the same as that for winter, with the addition of khaki breeches and thin shirts. Woolen blankets and one or two well cured wolf skins lined with flannel will be found better for bed clothes than sheepskins, as the latter invariably smell. The blankets and skins should be sunned and aired every day.

General Suggestions.

As to general kit, a light wall tent, even when a cart is used, will always be found convenient. The best kind has two uprights and a jointed ridge-pole. This tent should be entirely reserved for the traveller's own use, unless he sleeps in his cart and allows his personal servants to make use of the tent. Such an arrangement is sometimes found best when the camel men are Mohammedans and the traveller's servants are of other creeds. Usually the men provide their own shelter. Where a camel-cart is used, this should be of the regular native model. It may be measurably improved for comfort, however, by the addition of a bed-spring and a mattress for the floor. The sides should be padded with felts. Small glass windows should open in either door as well as at the front and back. A spare wheel should be strapped to the cart tail, and strong padlocks placed on the two doors. A hook arranged to keep the doors partly open, yet clear of the wheels, will be found a great convenience. On the under sides of the ribs that support the cart-hood, nail numerous brackets (twenty is not too many) for candles. Above them nail the tops of tin cans to serve as reflectors and to prevent fire. In winter these candles soon warm the interior of the cart and provide ample light for reading. Long lockers set on either side of the mattress, their tops flush with it, will hold each a gun or a rifle. Cartridges are best slung in a handy bag from the cart wall. The revolver, with its belt, hangs over the traveller's head against the front wall of the cart. Money can be stowed in one or more flat dispatch boxes slid under the mattress at the rear end, farthest from the doors. The only other things kept in the cart are books and maps (in a slanting rack on the wall), a hatchet, eating chocolate, pilot bread, and a canteen. Although cooking is out of the question when the cart is in motion, a small alcohol lamp with a cup supported above it will heat soup, coffee, or tea during the short stops. This alcohol burner should never be allowed to take the place of the cooking-fire and should never leave the cart. No native should be allowed to enter the cart at any time. Only the most reliable servant should be entrusted with duplicate keys of the doors, and then with strict orders that he must never hand them to anyone else. When the traveller is not in the cart it should invariably be padlocked. Whether a cart is used or not, a folding camp-cot of wood, such as is used by the American soldiers, will be found useful. It should be cased in a canvas gunny-sack together with its bedding. The latter is most convenient when in the shape of a sleeping bag with woolen blankets inside and sheepskin without. The whole parcel will be about three feet long and two in diameter. Another bag of about the same proportions should be carried for clothes, etc. The sort sold to tourists for soiled clothes is good in shape and size, but usually poor in material. The best form is that made by sailors for their dunnage bags from close-woven duck. Eyelets are made about the mouth and a running cord introduced. A good addition to this bag is a circular piece of cloth, larger than the diameter of the bag, fastened by a few inches of its circumference to the inside about six inches below the mouth. This can be tucked in over the contents to protect them from dust. A hatchet, an axe, nails, screws, and a screw driver are indispensable. Scientific instruments and arms to be carried are discussed under the head of travel with the dromedary. In addition to a good supply of matches, the traveller should carry a dozen or more patent cigar lighters of the sort that does not depend upon spirit for fuel. The best is one of those made on the principle of a flint and steel with wicks impregnated only with salt-peter. These are useful to start dung fires in a wind and also as presents much appreciated by natives.

When making camp, arrange the cooking-fire, the cart, and the tent, flanked by personal baggage, to windward of the camel park. Break camp only when the camels are in from grazing and the loading of freight is well under way. Leave the camp site only when the string is started and the caravan has straightened out. Camels bearing personal baggage should always travel nearest the cart in the second string of camels.

Make a practice of getting acquainted with the caravan dogs and feeding them occasionally. Try to keep one constantly tethered near the cart or tent when in camp. A small terrier dog, especially attached to the traveller's person and used to sleeping with him, will be found a good companion and a guard for camp and cart. He will often be a source of anxiety, however, as it is difficult to prevent his being killed by native dogs.

Concerning the morality of supplying liquor to Mongols and other native tribes who ask for it from passing caravans, the traveller must make up his own mind, but there can be no question of its bad economic effect. The Mongols are fast losing their virtues from unrestrained indulgence in drinks supplied them by the Chinese, and more than one traveller has supplied intoxicants that later proved his own undoing.

The final admonition to the intending traveller with a caravan of Bactrian camels is, "*Don't* ride a camel." When it is absolutely necessary to move with camel transport, bring a pony or two for personal use if the country will support them, even though their feed must be eked out by an extra camel load of grain. With horses one can reach camp many hours ahead of the camels and save time for work and observation. In case of accident fast messengers may be dispatched for aid. Where game is expected wounded animals can be run down. Best of all, side trips can be made off the line of march to distances that would otherwise be impossible. A desert-bred horse can go faster, longer, and over more difficult country than a camel.

FOOT TRANSPORT IN EAST AFRICA.

BY JOHN T. COOLIDGE, Jr.

In those parts of East and Central Africa where the tsetse fly spreads *nagana* disease among domestic animals, the only means of transport is by native carrier. Natives work for only a few cents a day, do not require to be packed or diamond-hitched, and travel faster than animals; consequently they are employed almost as much where the fly is absent, as where the *nagana* renders their use imperative.

Equipment for White Man's Use.

Aside from the equipment pertaining to the purpose of the expedition, the following outfit, which may be obtained at Nairobi (British East Africa), is necessary:

Tent and fly — the size of the tent is not important, but it should have a fly to keep it relatively cool and to keep off the deadly rays of the sun, which have a disastrous effect independent of their heat; folding bed and blankets; canvas bath tub and wash basin; sponge. When water is precious, it is possible to bathe with very little by using a sponge.

Clothes are largely a matter of personal choice. Belts and puttees of leather should be avoided by hunters unless they can be oiled so as not to creak. Sneakers are very useful for stalking silently, and comfortable for travelling. Sun protection is extremely important. Ordinary hats are not safe. A *terai* (two felt hats nested together) or a helmet should be worn.

Surgical and medical kit.

Cook outfit (as specified by the cook when he is employed).

Two kerosene lanterns, for general use and to keep lions and leopards out of camp; two tin buckets; two *pangas* (a sort of knife for cutting brush); one axe.

Food should include plenty of jam and strong sauces, such as Worcestershire. Most people, although indifferent to these at home, crave them in the Tropics. Take an ample variety of food. Without three good meals a day a white man becomes weakened by the climate.

Fiber cases are lightest and best for carrying the equipment and are not eaten by white ants.

Collecting the Caravan.

Outfitting companies in Nairobi undertake all arrangements for travellers. They charge casual visitors an exorbitant rate compared to settlers whose custom they wish to retain. This chapter is intended for those who wish to handle their caravan themselves.

In a caravan it is customary to employ the following: a head-man, who is responsible for the caravan, sees that loads are equal, and distributes rations; a tent boy, who washes his master's clothes, packs his boxes, and waits on the table; a gun boy, who carries his master's gun on a hunting expedition and is sometimes useful as a tracker; a *sais* (groom), to take care of the pony or mule, if there is one; and a cook, who prepares meals for the white members of the party only.

Three *askaris* (soldiers) were formerly taken on all caravans, supposedly to police the porters and to watch the fires at night. Now that lions are less bold and a lantern is as good as a fire, *askaris* are of little use and are seldom taken except by very large caravans.

Porters may be obtained at many points along the railway, but as Nairobi is the best place for buying provisions and outfit, the men may as well be collected there. Porters can be hired in the streets of Nairobi by any white visitor who knows a few words of Swahili. A grammar and dictionary of this language can be obtained from Rowland Ward, Ltd., London, and a short time spent in study gives one enough vocabulary to get along. The alternative is to find an English-speaking servant, who can be employed to bring in porters and act as interpreter.

Porters carry loads of equipment, rations, etc., in 60-pound lots. To determine the required number of porters, find out how many 60-pound loads the equipment will make, and how many days' supply of porters' rations must be carried to make the contemplated journey. In some localities corn meal can be bought from villages along the route.

A porter's entire ration is two pounds of corn meal a day. In addition to his 60-pound load, each porter may be given a 12-pound bag of meal sufficient to last him six days. If more than six days are to be spent out of reach of markets, additional porters must be enrolled to carry corn meal for themselves and the other porters. If no source of supply is to be available for three weeks, twice the number of porters are required, half of them to carry the equipment, the others to carry each his 12-pound bag to last for the first six days, in addition to a 60-pound sack to last himself and one of the outfit porters for two weeks.

If collections are to be brought back, the porters whose sacks of meal are emptied can be loaded with them, but 10 or 15 percent of extra men should be taken to replace lame and sick porters. If there are many ration bearers, and no collections to be made, extra porters are unnecessary.

Tribes from Which to Choose.

Somalis are often used for head-men, gun boys, and tent boys. They are much more intelligent than the natives; polite, clean, and proud. A Somali gun boy would rather die than be seen running away. Their wages are very high, from 60 to 75 rupees ($18 to $24) a month, and they require special rations, rice and ghee, and a separate tent, which increases the porterage. Their arrogant and sometimes relentless behavior as head-men makes them hated by the natives, who usually ask, when offering themselves for employment, whether they are to be in charge of a Somali or one of their own kind. Most white men prefer not to employ them.

Swahilis — Arab and native half breeds from Zanzibar and the Coast — make a specialty of working as tent boys and cooks. As a rule they are polite, clever, and well trained servants, but many of them are deceitful and inclined to steal. The Baganda have much the same characteristics, but are more straightforward. They, likewise, prefer skilled work to carrying loads.

The simple and unsophisticated inland tribes are much more reliable than the partly civilized Swahilis and Baganda. Most of them are ill-mannered, but honest, especially if they have not been long with white men. They do the work of porters primarily, but can be promoted to head-men, gun boys, tent boys, and cooks. A clumsy though trustworthy savage is much more satisfactory than a bowing and scraping Swahili who picks the lock of the supply box.

The inland tribes here referred to comprise the following:

Kavirondos, a child-like, good-natured people, very large and strong. They make the best porters, working without a word of complaint. They do not object to carrying over 60 pounds in an emergency, in which case they should receive extra pay. They are slow, but should not be disturbed or hurried. If left to themselves they will cover as much ground in a day as any other porter.

Wanyamwezi or Rugarugas are likewise people of perfect muscular development. They are not always easy to get, but like the Kavirondos, they should be employed in preference to others.

Wakamba are tall, lanky people with exceptional ability as hunters and trappers. They are skilful at tracking game, and consequently useful as gun boys.

Kikuyus are found in greater numbers in and around Nairobi than any other tribe and most caravans are made up largely of them. They are so heterogeneous that no particular characteristics apply to them as a whole.

Wages.

In East African currency, 100 cents make a rupee, worth in American money about 32 cents.

Professional porters	Rs. 10 per month.
Raw savages	Rs. 4 to 7 per month.
Head-men, gun boys, and cooks . .	Rs. 20 and up (anything over Rs. 30 is high).
Sais . . . . about	Rs. 15.
Askaris	Rs. 12.

When natives are retained, they are given 12 "cents" a day before they begin to draw their regular pay for active service. When porters are retained between journeys in their own town or elsewhere for a part of a month, the law requires that they receive pay for the whole month. To prevent desertion they may be registered for a small fee by the District Commissioner, in which case half wages are paid in advance. Whether registered or not, most of them want a few rupees in advance to leave with their families or for the purchase of supplies. If registered porters desert, the Government undertakes to arrest them. If they desert when not registered, and the traveller fails to catch them and have them imprisoned, he encourages them to repeat the offense with the next employer.

Equipment for Natives.

Natives customarily receive clothing and outfit at the beginning of their employment. There is no limit to what they demand, and they are quick to impose upon an employer who allows it. On the other hand, if they are deprived of what custom recognizes as honestly due them, they will feel wronged and become discontented. The articles with which they are to be provided and their cost at the Indian bazaar at Nairobi, subject to fluctuation, are as follows:

Head-man . . .	blanket (Rs. 5); canteen (Rs. 3); tent (Rs. 5. 50).
Gun boy	the same, and in addition a knife for skinning (Rs. 1); boots (Rs. 10).
Cook	blanket (Rs. 5); canteen (Rs. 3).
Tent boy . . .	same.
Sais	blanket (Rs. 2); canteen (Rs. 3).
Askari	same and in addition a sweater (Rs. 2. 50).
Porter	same as for Askari and cord to tie up load (12c.); cotton bag for rations (25c.). For every six porters one tent (Rs. 5. 50). For every three porters one cooking pot (Rs. 2).

The tent boy will ask for a khaki suit, which one does not have to give him unless one prefers to see him neatly clothed. If the head-boy and gun boy object, for tribal reasons, to sleeping in the same tent, buy an extra one.

Rations.

The porters' and boys' daily ration is two pounds of corn meal or flour. They crave meat, and usually an antelope is shot for the men every few days. Swahilis and Baganda often refuse employment unless they are promised rice. Mohammedans must not eat meat unless one of their number cuts the animal's throat immediately after it is shot.

Hints on Dealing with Natives.

When natives first set out with a new employer, they begin a series of experiments to find out how far he may be imposed upon. If all their demands are granted, instead of being grateful and satisfied, they redouble their efforts. The best course for the employer is to spare no pains in seeing that they are properly equipped and not overloaded, and to reprimand them for every attempt to impose. As soon as they discover that their master is just and firm, they acquire a feeling of respect and loyalty, and from that time on he can treat them as kindly as he likes without impairing their efficiency. Natives who commit serious offences can be sent to the nearest post for punishment, with a note to the officer in charge. Flogging is now illegal.

Although most of the inland people intend to be honest, they give way easily to temptation, and food supplies, especially sugar, left unlocked, are often stolen. The cook must either be given as much sugar as he can eat or the sugar must be kept under lock and key and dispensed to him when he is preparing a meal. All delicate apparatus must be kept locked. Natives love to imitate their employer and play with any instruments which they have seen him use. They like to play with the locks of rifles, so that guns should not be left loaded unless a white man is in camp.

Loyalty often prevents boys from stealing from their employer, but boys from another caravan should not have access to valuables. Their master may be sure that they are honest, and it is true as far as his experience goes, but they have no scruples about stealing from a stranger.

In paying off natives at the end of a journey, too much generosity increases the labor difficulties of the resident European settlers. The average native works only a small part of the year, and the more easily money comes to him, the less time he spends working. Sportsmen have increased native wages so much that coffee planters now have difficulty in making their land pay.

Conduct of March.

When first starting out, porters should be given short marches of eight or ten miles a day to get them hardened. After two or three days they can cover anything under twenty miles in a day. Fifteen miles is a comfortable distance which can be kept up an indefinite number of days. In estimating the time required for a journey, an average of ten miles a day is all that can be expected, when delays are included.

The most comfortable time to travel is in the early morning, starting about four o'clock and camping before the heat of the day. The porters usually rest half an hour in the middle of the march. Stragglers should not be hurried. It is the head-man's duty to see that porters are not lost and that nothing is dropped.

Most Frequent Ills of Porters.

Porters go barefoot and often get septic wounds in their feet and legs. Hence the care of their feet is of great importance. A scalpel and forceps should be taken to remove thorns; curved needles and silk thread or silver wire are useful for sewing up deep cuts. Corrosive sublimate or other disinfectant, plenty of bandages, absorbent cotton, and surgeon's tape are essential. Permanganate of potash should be included in case one of the men should be mauled by a lion or a leopard, or bitten by a snake. Apply an almost saturated solution to tooth or claw wounds and rub the crystals on an opened snake bite.

An ample supply of quinine and laxative is necessary because a native requires about three times the dose of a white man. Constipation is one of the commonest complaints. In wet weather the men get severe colds and coughs, and they are often subject to attacks of malaria. They should be urged not to drink unboiled water, but it is impossible to enforce this precaution.

Other Means of Transport.

Pack donkeys carry the load of two men. They graze as they go, without requiring to be fed. The purchasing price fluctuates from 30 to 75 rupees. One driver should be taken for every four donkeys. They move about twelve miles a day and have to be unpacked and packed at rivers. In plains country a saddle made of two sacks without a girth is all that is necessary. At night the donkeys should be kept together with a lantern burning near them.

A bullock wagon usually costs 20 rupees a day. It is useful for crossing waterless country, as the bullocks can go for three days without water. The movements of bullock wagons are restricted by quarantine regulations.

Local Conditions Unhealthy for White Men.

The sun is so dangerous in the highlands that head gear should not be removed for a moment, even on a cold, cloudy day. Sunstroke is more frequent in the cool highlands than in the hot coast belt.

Water should always be boiled before drinking. Unboiled water contains typhoid and intestinal parasites. Do not take the cook's word for it that the water he brings has been boiled. It usually tastes so badly that it is preferable to disguise it as tea and drink it hot. If the water is thick with mud, clear it with a pinch of alum, and boil the clear surface water.

Persons who have never had malaria may bathe in cold water, but those who have it in their system should not. A hot bath should be taken every night, using plenty of soap to take off the ticks. When ticks are discovered on the person, do not pull them off until they have been forced to let go by a drop of hot candle wax.

Permanganate and rubber tubing for tourniquets should be on hand in case of snake bites. It is not a bad idea to carry these articles in the crown of the helmet. Scratches or bites from animals that eat carrion should be cleaned out scrupulously and washed with permanganate, after a primary wash with "green soap." For the teeth and claws of such animals often carry infection, producing blood poisoning.

Tsetse flies are numerous in and around Victoria Nyanza and in the Kilimanjaro district, but they transmit sleeping sickness only in limited so-called "fly belts." In crossing these belts mosquito net should be worn. Natives suffer from the disease much more than white men. The disease is fatal and incurable.

MOUNTAIN CLIMBING.

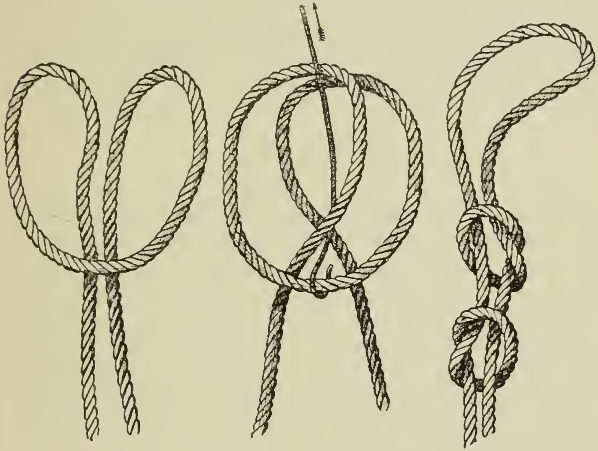
BY HOWARD PALMER.

To the traveller whose experience has been confined to country of moderate relief lying below the line of perpetual snow, mountaineering presents elements of risk and difficulty of an entirely novel kind. It is an art that cannot be learned from a book, nor will the mastery of any set of printed instructions justify a beginner in assuming responsibility for an attempt to solve the mazes of a complicated glacier or the problems of a rugged, snowclad peak. The only way to develop a sound judgment as to what may or may not be undertaken without risk, is actually to do mountain work, preferably under competent guidance, and the following hints are offered chiefly with a view to supplementing and expediting such work in the field.

Necessary Appliances.

A mountaineering party must be provided with a strong rope, hob-nailed shoes, and (in the absence of conventional ice axes) with stout poles. These are absolutely essential, if snow or glaciers are to be attempted. A rope for a party of three should be 100 feet long. It need not all be in actual use, but it is well to have too much rather than too little. For ordinary work 20 feet between each two men is sufficient, and four feet may be allowed to go around each waist. The surplus can be carried in a coil on the shoulders of the last man; it will thus be available for assisting the leader in case he should fall into a crevasse. Swiss woven-linen rope, procurable in this country, is light, strong, and flexible, and is recommended for alpine work.

The best knot to employ is probably that known as "the fisherman's bend," for it may be used to join two ropes together and to tie in both the end men and the middle man. It is also easy to adjust. It can be readily made in one operation as shown by the accompanying diagrams (Figs. 17–19). The rope is turned back on itself, as in Fig. 17, making two bights; one of these is then laid part way across its neighbor, as in Fig. 18, and the knot is completed by drawing the cross-strand in the direction indicated by the hook. Care must be taken when drawing



17 18 19

Figs. 17, 18, 19. Steps in Tying the Fisherman's Bend

taut, that the two knots thus formed are kept separate. The loop may be passed over the head and arms and drawn through the first knot to the tightness required. The outer knot is then worked down to lock it in place, so that the two knots abut closely when the operation is completed.

For alpenstocks, the stems of small trees may be used, with the thick end uppermost and the other end pointed. They should weigh about three pounds, so that in sounding the snow for concealed crevasses a strong blow may be struck. Ice axes, if employed, will be selected to suit the preferences of their users as to weight.

In addition, it is highly desirable that the party should have tinted eye-glasses of some sort, as a protection from the glare of the sun on the snow. Miscellaneous articles such as cameras, gloves, jersies, and field-glasses are usually carried in a rucksack, a small bag slung firmly on the back by means of shoulder straps. It is important in climbing that nothing shall hang loosely from the person and that the arms be left free to swing without interference.

Practiced mountaineers usually have their foot-gear fitted with Swiss wrought-iron edge-nails and sole-nails. For alpine work they are infinitely superior to hob-nails. The increased weight of the boots, however, renders them less suitable for long valley marches than the hob-nailed variety.

Reconnoitering.

In the case of a peak it is usually imperative to make a reconnoitering excursion up the opposite side of an adjacent valley to a considerable height. Only thus can an accurate idea of the relative importance of the different parts of a mountain be gained. Views from below give a magnified prominence to nearer buttresses and slopes, while the critical features near the summit are deceptively blended by foreshortening. A preliminary examination of even a comparatively small mountain is likely to repay well the time taken. Field-glasses are of great assistance in this work, and their revelations often prove decisive in the final selection of the route.

If at first no good way is seen, it may be necessary to go part way around the peak to view another side. A forbidding mountain face not infrequently conceals an easy line of access from a different side. Cliffs and rock faces should always be studied in profile. The traveller need not be surprised if he finds that their true inclination is less than 50°. The angle of a snow slope not seen in profile is very difficult to judge from a distance, but often the length of shadows cast upon it by projecting knobs of rock, or the varying intensity of the sunlight at different times of day, give a valuable indication.

In the case of a glacier pass, particularly if the whole expedition is to be transferred to the other side of the range, it may be worth while to make a flying trip over the entire route in advance. From the summit of a pass, it is very hard to gain any idea of the merits of the descent on the farther side, and without a prior investigation grave difficulties may be encountered. If the approach is long and complicated, and especially if a crevassed glacier must be traversed, it may even be advisable to examine the near side from a commanding elevation. Lateral moraines, *i. e.*, continuous ridges of mixed boulders, gravel, and clay, should be carefully looked for near the edges of glacier tongues, for their even crests frequently afford excellent pathways from the forest up to the region of permanent snow. Between such moraines and the mountainside good going may often be found.

Mountain Sculpture.

Despite the infinite variety in shape and construction which mountain peaks exhibit, they may, from a climber's point of view, be regarded as presenting several faces, or sides, separated from one another by slanting ridges. Such ridges have the widest dissimilarity in sculpture. They may be narrow, jagged knife-edges, or rounded and ill defined. In the former case, they are termed "arêtes," although the word is often loosely used in reference to ridges generally. The faces are, broadly speaking, either flat, convex, or concave. Even when appearing smooth from a distance, they are usually found to be broken by rugged ledges and large, steeply inclined gullies, called "couloirs." Rock peaks are almost always more splintered and irregular in detail than they look.

Arêtes. — It is an axiom of mountaineering that arêtes are selected as routes wherever favorable, since nothing can fall upon a party there, a wider view is to be had of one's surroundings, and there is a better chance to take advantage of any easier way that may appear. Furthermore, as one rises, the arêtes converge in the direction of the summit, so that ordinarily, if one starts on a subordinate spur, he will eventually find himself on a major arête headed straight for the goal. There is thus less chance of losing one's way, both on the ascent and on the descent.

Going astray is especially easy in coming down, when great slopes of broken rock or the endless labyrinth of ledges on a mountain face present a decidedly different appearance from that of the ascent. It is therefore a good plan to look downward frequently during the climb and to erect small cairns that will easily catch the eye at critical points, such as the proper place to leave a ledge or arête, or to get out of a couloir.

Faces. — As it is by no means always possible to ascend by way of an arête, something must be said of the other alternatives. In the case of faces, care should be used to avoid those which are suffering rapid disintegration. Evidences of this are usually unmistakable in the shape of quantities of freshly broken fragments on the slopes below.

Couloirs. — Sloping gullies or couloirs are often utilized to gain the crest of an arête, or to pass from one set of ledges to another. As large couloirs are apt to branch high up and assume a shape roughly resembling half a funnel, they collect most of the stones that fall from the mountain face and discharge them in rattling volleys through the lower end or neck. Hence an inexperienced party must be on its guard against entering large couloirs and had best give them a wide berth. Under proper precautions, however, a party of experts may ascend a gully of this kind without incurring unjustifiable risk. Usually it is possible to avoid the zone of most frequent falls by keeping to the rocks on either side, or by working upward under the protection of jutting masses of rock. In the early morning, before the sun strikes the peak and thawing begins, the danger is comparatively slight; but when it rains, or the wind blows strongly, the contrary is the case. If the back slope of the couloir is snow-covered, or if snow lies above it on the mountain, there is the added risk of avalanches. These are even worse than rock falls, since the chances are greater that the whole party will be swept away. The perils of couloirs are frequently incurred before entering them, for it is just at the bottom that the snow of previous avalanches spreads out in a wide fan, and so often affords the party the only bridge for crossing the bergschrund (to which allusion will presently be made). Do not linger in such places!

Chimneys. — Climbers often avail themselves of cracks and larger rock fissures, termed "chimneys." The latter differ from couloirs in being generally smaller and steeper, sometimes almost vertical. They are usually narrow and rough, and, by presenting opposing walls parallel to each other, enable a party to surmount a cliff otherwise impassable. Cracks in which the fist can be inserted and then clenched often offer excellent holds; it is well to remember this when the rock is otherwise smooth. Rock holds should always be tested before trusting one's full weight to them.

The Start.

Weather. — Having duly selected the route of ascent, the next thing is to await settled weather; for no important mountain expedition should be undertaken until this can be counted on. Two or three clear days ought to be allowed to elapse after a storm before a lofty rock peak, which involves real climbing, is attempted. This is to give the new snow time to melt out of the rock crevices that are to serve as holds. It is not enough to wait until the new snow is no longer visible from below, for as soon as it melts, the water, trickling down and freezing in the cracks and on the surfaces of the rocks, produces a dangerous glaze, known as "verglas," which ought to be avoided when possible. However, no definite interval can be named since conditions vary greatly in different places and even as regards the same mountain, depending upon the season and whether the route is situated on the south or north side of the peak, etc. Whenever the weather makes a change for the worse, while aloft on a mountain, and there is any doubt about the wisdom of advancing, the rule is iron-clad to turn back at once.

Time. — In most alpine work, an early start is vitally important; daybreak or an hour or two before will be none too soon. Surprises of one sort or another are the usual portion of a mountaineering day, and the best work cannot be done when one is worrying about slow progress under unexpected difficulties. Furthermore, in the early hours of the morning, streams are smaller and easier to cross, snowfields are crusted and easier to walk on, bridges over crevasses are safer to pass over, and dangers from falling rocks and ice are least. Again, an early start may enable one to reach the summit before afternoon clouds have a chance to form and before heat-haze blurs the distant landscape. Steep snow slopes exposed to the sun are safer and easier to descend before mid-afternoon. But no arbitrary rule can be laid down; it all depends upon the mountain itself and upon the nature of the climbing.

Pace. — There is perhaps no rule of mountaineering so often violated by the neophyte as that relating to pace. The pace must be slow; it can scarcely be too slow. Rather certainly it will be too rapid at the commencement of the climb and therefore a conscious effort should be made to restrain it. Especially does this admonition apply to persons who are good walkers or good athletes in some other department of sport, for they will be disposed to scoff at the idea that the exertion of climbing can be so very different from that of their own specialty. Climbing is, however, one of the severest forms of bodily exercise and, being often prolonged through a period of from twelve to twenty hours, it demands the avoidance of every motion that reduces one's store of energy without a proportional return. A good rule is: never walk up hill fast enough to get out of breath. This cannot be applied rigidly to actual climbing, by which the mountaineer understands work that involves the use of the hands, the arms, the head, the back, or any other part of the body in addition to the feet; but it is sound doctrine on an ordinary slope. Watch the placing of the feet in order to be sure that they will remain where they are put. A slip or loss of balance, wherever it occurs, is tiring and very bad technique. Strive to mount with a steady, gliding motion. On a path or an easy, open slope, at altitudes less than 12,000 feet, a rate of from 1200 to 1500 feet of altitude an hour is a good average to cover, but when the going becomes harder, as for instance on account of steepness or of sliding stones, or of slushy snow or mud, a rate of 800 feet an hour, or even less, may be deemed satisfactory. At elevations above 12,000 feet, one experiences some difficulty in breathing owing to the rarity of the air, even at a very slow pace.

Halts, etc. — The pace adopted should be so slow that halts to recover breath are seldom necessary at altitudes below 12,000 feet. Halts and the taking of refreshment should be governed chiefly by the finding of good water; but, irrespective of this, the party will doubtless feel the need of a second breakfast two or three hours after the start. It is a mistake to go without food longer than this. A beginner does not, as a rule, realize when he is hungry, and he is apt to think that he is getting a little fagged when really he lacks nourishment. Light repasts should therefore be taken at rather frequent intervals. Personally, the writer does not deem it objectionable or harmful to allay one's thirst with a little water or snow as often as one desires, although there is a difference of opinion on this point.

Glacier Work.

Use of the rope. — As soon as it becomes necessary to cross a glacier, the party should tie on the rope. Even though the ice be free from snow, it will be well to do this, if there are crevasses; a party of beginners will then feel safer. It is a good rule to resort to the rope whenever anybody indicates that it would contribute to his peace of mind, for the so-called "moral support" afforded by the rope is one of its most important functions. It tends to prevent the occurrence of mishaps by reducing the feeling of nervousness which might otherwise give rise to them; and this holds true even though the actual security of the party is not increased. Hence, one should candidly confess if one gets "shaky," and not attempt to appear braver than one really feels.

The rope should never be attached to a belt around the waist, but tied firmly about one's chest beneath the armpits. Breathing ought not, of course, to be interfered with; but a loose loop is almost worse than none, for it is bound to work down; and it would be most unpleasant, to say the least, to find one's self suspended head downward in a crevasse. A party crossing a snowfield with packs must take particular pains to see that the body-loops of the rope do not get too low. The knot of the loop should be worn on the left side.

The first requirement in using the rope is to keep it taut; and to accomplish this better, a small coil should always be held in the left hand. Thus a certain amount of play can be obtained without letting the rope drag. In a situation of danger or of especial difficulty, a strong tension must be maintained so that the slightest slip on the part of the man ahead may be immediately checked. In such places one person only should move at a time, and his neighbors should pay out the rope or pull it in as needed, with the axes driven into the snow nearby to serve as quick grips or belaying pins in case of mishap.

The second rule with respect to the rope is: avoid jerks. This applies with particular force to a party descending ground that is unequally difficult, where one man, relieved by finding easy going, starts off rapidly, forgetting that the others may still be in positions of delicacy. In handling the rope, the needs and respective situations of one's companions must be constantly borne in mind. In ascending, the most experienced member of the party should go first; in descending, last.

Keep a sharp lookout that the rope does not dislodge loose stones, thereby endangering those below, and when the leader is exploring a difficult course belay it around any projecting rock that may be at hand.

These maxims are the very cornerstones of alpine work. They may seem exceedingly simple on paper but they are by no means easy to apply conscientiously in the field. Mountaineering, as a craft, consists very largely in the avoiding or the nullifying of hidden, inert dangers, as contrasted with positive, objective ones, such as falling rocks, strokes of lightning, or hurricanes; and the rope is a most important means to this end when correctly used. When incorrectly used, it may justly be classified as an additional and distinct danger.

Icemanship. — The knack of picking out a safe passage over a crevassed, snow-covered glacier, of choosing almost instinctively the right way through a multitude of concealed pitfalls, is one of the most difficult to acquire of all those which a competent mountaineer must have at his command, and it is almost equally difficult to explain in print.

One of the cardinal principles is always to cross crevasses at right angles to their general trend. This is usually ascertainable by inspection; but if it is not, then punching with ice axe or alpenstock must be resorted to until the direction of the fissure is determined by the weakness or collapse of the snow cover. Where crevasses follow one another in rapid succession transverse to the line of march, and snow bridges are few and far between, long détours will have to be made, and the party will be forced to walk considerable distances parallel to the direction of the fissures. In such circumstances, the utmost care must be taken lest all be over a concealed crevasse at the same time. The safest path is close to the edge of an open fissure. The leader must, of course, never relax his vigilance for a moment. The snow must be thoroughly prodded with his staff, both in advance and on each side, before making a step. When rounding the end of a crevasse, he must be on the lookout to estimate the overhang along the side where he proposes to go. On flat slopes crevasses are usually parallel; on convex surfaces and domes they tend to converge, like the spokes of a wheel, and to become irregular and broken in the direction of the dome. Large protuberances, therefore, should be avoided for the hollows or valleys lying between them. Sometimes a snow-covered glacier is fluted with small channels running directly down the slopes. These channels are thought to be caused by flowing rain water, and where they unite in the bottoms of the hollows on the glaciers there is likely to be a prominent band or groove which is often a useful indication of a relatively safe line of march. It does not, however, preclude the need of sounding for concealed crevasses.

Where two sets of crevasses intersect, separate towers of ice are formed called "seracs." These, especially when covered with snow, offer some of the most difficult going to be had in glacier travel, and had best be avoided entirely by the inexperienced. Where lateral glaciers join the main stream, the pressure tends to close up the crevasses and the going is thus rendered easier. Frequently a good way will be found on the shady side of a glacier, as the snow bridges are likely to be more numerous and in better condition.

In approaching from above, a well defined brink of an ice-fall, or a point of sudden increase in the declivity of a glacier, particular care must be employed. For the interval between crevasses is likely to narrow without warning, and, after springing across one crevasse, it is not pleasant to find one's self directly on the edge of another. It should always be borne in mind that a snow-covered crevasse, which is evidenced by a slight crack on the surface or simply by a concavity in the snow, is likely to be much wider underneath, owing to projecting eaves along the sides. A light fall of new snow, by erasing many of the indications of crevasses, greatly increases the uncertainty of glacier travel.

All the members of the party should step exactly in the leader's footsteps; for he, by his punching, may have discovered dangerous snow close on either side. The rope must be kept taut between the different members, and the attention of all should be concentrated on the work in hand. Should someone step through to the knee or waist, he can generally crawl out by throwing himself forward on his hands. If he goes in completely and is unable to work his way out, he must be pulled up bodily by his companions. Care must be taken to lay an ice axe or pole along the edge of the break to keep the rope from cutting into the snow, or from being itself cut by ice. It is not as easy a matter as some may think to pull a man out of a crevasse. The force must be exerted at great disadvantage, and only in exceptional cases can the rescue be accomplished single-handed. For this reason, three is the smallest party permissible in glacier travel; with four, the factor of safety is greater.

If much walking in snow is done, boots are sure to be often wet through; do not dry them too quickly near a camp fire. If even a small spot of the leather gets overheated, it becomes brittle and will presently crack and drop off. The best way to dry boots is to put them in the hot sun or to hold them near the fire, turning them constantly about.

THE BERGSCHRUND.

As one approaches the upper limits of a glacier, there is almost always a large crevasse or fissure called the "bergschrund," where the moving ice breaks away from the ice and snow that adheres firmly to the rocks of the peaks. It usually occurs along the line where the slope steepens suddenly in its rise toward the peak; though sometimes it may form higher up, or there may be several sections at different levels. Besides the great width and depth of these fissures, the fact that one side often rises from eight to ten feet above the other, and overhangs, renders them obstacles of anxious concern to the mountaineer.

Bergschrunds are at their worst late in the season or after a period of very hot weather. In some situations they may prove entirely insurmountable; but usually a snow or ice bridge is available. It is no objection that such a bridge is steep; rather is this an advantage, since the climber's weight will then be exerted toward its thickest and firmest portion. If at all insecure, the bridge should be crossed on all fours, so as to spread one's weight over as much surface as possible. If the bridge is very rotten it may even be best to "swim" across prone. A bridge cannot be treated too tenderly by the first users; for if it is weakened or broken by them the situation may be decidedly awkward for the other members of the party.

After the leader is across, he should go up the slope a short distance and stamp out a firm seat and foothold in the snow. Then, driving in his staff, he should take a turn around it with the rope and draw in the latter as the others come up. It is well for the party to keep separated on the upper slope, so as to avoid a concentration of strain. In descending a snow slope toward a glacier, it must always be assumed that a bergschrund lies at the bottom, even though no sign of it be evident; and upon approaching the proper place, a sharp lookout should be kept and every precaution taken with rope and ice axe. If no suitable way around the bergschrund appears, and jumping cannot be resorted to, the only thing to do is to lower the different members on the rope. The last man then must jump, or let himself down by looping the rope around his ice axe driven solidly into the snow. The axe is, of course, lost; but fortunately a situation of this description is exceedingly rare.

The Upper Part of the Climb.

Snow slopes. — A steep snow slope in good condition is ascended by kicking steps one above the other, as if mounting a ladder; but on a very steep slope it is usually easier to make a series of zig-zags. The ice axe is planted firmly a little in advance and to the right before taking each step so that if the snow gives way beneath the feet, a fall will not ensue. Two or three strong kicks should be sufficient to produce a secure foothold. A slightly moist state of the snow is probably the most favorable; if it is slithery and mealy from excess of moisture, it is dangerous, and unless the ice axe or alpenstock affords a solid hold when driven in, the party should desist. Inexperienced climbers ought not to attempt to ascend a snow slope steeper than 30° or 35°, unless the going is unquestionably good. Under proper conditions, however, a competent party will surmount acclivities of 60° or more.

If the snow slope is part of a glacier, hanging or otherwise, crevasses must be guarded against exactly as in the regions lower down. Sometimes huge chasms occur high up, which, owing to more frequent snows, are most deceptively masked.

On steep slopes, only one should move at a time, while the others maintain the best possible hold. A concrete case will help make the method clear. Suppose that a party of three is standing on a steep slope in readiness to continue the ascent, with the rope taut between them. No. 3 should first move up to No. 2 and anchor, the latter taking in the rope; No. 2 should next move up to No. 1 in the same manner; then with No. 2 and No. 3 standing solidly in their places and grasping the shafts of their axes close to the surface of the snow for a better purchase (the axes being firmly driven in), the leader may advance, No. 2 watching him closely and paying out the rope as needed. No. 2, in order to have his hands free for its better manipulation, may find it necessary to crook his arm around his axe for a hold, or even to relinquish it and simply stand in the steps. The important thing for him is to be continually on the alert to counteract any mishap to the leader. He should take care to have the rope so placed that if the leader falls, it will loop itself around his axe, *i. e.*, to keep it on the side of the shaft away from the line of his probable course. When the leader has reached the limit of the rope, he should drive in his axe, establish himself in the snow as firmly as he can, and after taking a turn of the rope around his axe, notify No. 3 to come on; whereupon the above described manoeuver is repeated. In this way, the slope is slowly surmounted. The descent of a steep snow slope is described on a following page.

In all this work it is important to stand erect as much as possible, resisting strongly any tendency to lean toward the mountain; for the slightest departure from a vertical position diminishes the holding power of the steps by applying the strain in the direction of the surface and thus increasing the chance of a slip. Particularly does this admonition apply when the party is executing a horizontal traverse.

If the snow is too hard to permit of forming the steps by kicking, the axe must be brought into play either to cut or to scrape out niches. Care should be used that the bottoms slope downward from outside to inside. Step-cutting in ice is beyond the power of a novice and therefore need not be discussed.

Cornices. — Before long, if all goes well, the party will reach the final ridge. As they approach it and the angle eases off, the leader must be on the alert for "cornices," or projecting eaves of snow due to the action of the wind. It is always the best policy to assume that a cornice exists on the opposite side of a crest, unless one has positive knowledge to the contrary. When a cornice is present, it is best to keep just below the crest of the ridge, avoiding the smooth easy top. Owing to their deceptive appearance and to the difficulty of determining the amount of their overhang, which may be twenty feet or more, cornices are exceedingly treacherous. They have been responsible for many serious disasters. Great masses of snow will break away without warning at almost any time of day. As soon as a traveller is off the flat top, and definitely on the slope down which he has a clear view, he is safe from this particular danger.

Arête work. — It is on the final arêtes of mountains that the climber may expect to encounter some of his most interesting and exhilarating work. After a period of several hours, snow slopes or rock ledges tend to grow monotonous; but once the arête is gained, the wider outlook commanded and the variety of conditions to be overcome infuse the enterprise with a new spirit. Arêtes are, of course, of many kinds and many degrees of difficulty, depending upon structure, steepness, or whether composed of rock, of snow, or of ice. The thought of walking along a sharp knife-edge of snow, with abrupt declivities falling away for hundreds or thousands of feet on each side and with nothing in particular to hold on to, is apt to raise apprehensions in the mind of the beginner. A short experience will, however, in the majority of instances, disabuse him of his fears and make him feel perfectly at home. It is scarcely necessary to say that such work is not to be attempted unless conditions are good. A high wind, or the presence of mixed ice and snow, or of very soft snow, might absolutely forbid it.

Generally, summit ridges are composed partly of rock and partly of snow, with deep clefts and upstanding turrets of rock interrupting their continuity here and there. These are often turned by descending a little and traversing along the mountain side. Hardly any two steps are alike. Sometimes the ridge may grow so narrow that it will be necessary to bestride it and work slowly along.

Dizziness. — This, in mountain work, is by no means as common as many people suppose, and for the simple reason that only rarely is it possible to look straight downward. The majority of climbers feel no discomfort if they can see even a fairly steep slope of solid rock or snow stretching away under them for forty or fifty feet, notwithstanding that a sheer precipice may occur lower down out of sight. Dizziness, at least in its milder forms, may be expected to yield to treatment; and, after a few weeks of climbing, beginning with simple expeditions and gradually increasing their degree of difficulty, it will, in all probability, scarcely be felt. It is well to remember that a feeling of nervousness akin to dizziness is more likely to develop coming down than going up. A number of seasons' experience is usually necessary before a beginner can walk straight down over a convex slope of snow that is apparently bottomless and gets steeper and steeper at every stride, without experiencing a queer sensation in the pit of the stomach.

The Descent.

Commonly the descent of a mountain requires less time and less exertion than the ascent, but such is not always the case. Really troublesome places take as long or longer to pass, and may be even more difficult. Despite the fact that most of the party can usually be lowered on the rope with comparative ease, the last man may find it impossible to employ it, in which event an even greater technical skill will be required. Before passing a doubtful place on the way up, therefore, there should always be a certainty of the ability to descend it, unless another way is open.

Going down hill brings a different set of muscles into play, the knees and toes particularly having to sustain an added strain. The method of balance changes also, but, as in climbing, a steady even swing is to be cultivated. Loose stones on ledges, ice slopes, and rotten rock are far more trying to deal with on the descent.

In walking down a slope the staff, or ice axe, should be held with both hands, the right grasping the metal head at about the height of the hip, the left holding the shaft below and farther back, with the point of the shaft directed backward against the slope. If the foot slips, or a rock rolls over, the staff makes an additional point of support and, acting as a brake, prevents a fall. The same method is equally applicable to snow, rock, or grass slopes, of gentle gradient.

The quickest way to descend an easy slope is to turn the body slightly sideways. The whole length of the foot can then be applied to any hold that appears; and even though only the edge of the boot gets a grip, it will suffice. A slightly diagonal course will be necessary. Grass slopes are particularly treacherous in going downhill, so that one must be constantly on guard and treat them with due respect.

In descending a steep snow slope, the steps of the ascent may be utilized. It is best to proceed backward, getting a good hold in the snow with the axe before taking a step. If the snow has softened so as to increase the risk, only one should move at a time and the procedure described on page 168 can be reversed. Where the slope eases off, it is proper to face outward and walk, taking care to kick in and press down the snow strongly with the heels. The staff or axe need not be used but it should be held in readiness, with the point of the shaft directed backward.

Rock Climbing.

Rock climbing throws an unusual strain upon the arms, particularly in descending, when they have to lower the weight of the body in making each downward step. In consequence, firm handholds must always be secured. They are of even greater importance than footholds. It should be made an invariable rule to test every handhold before trusting one's weight to it, both in going up and in coming down. Where the slope is less steep, the ice axe or alpenstock is of great use in reaching downward to test footholds, and in serving to some extent as a crutch, when the step is made. Rock work needs a longer rope than would be employed on a glacier. One hundred feet would perhaps be a minimum length for a party of three on a peak of the first class unknown to them. In walking across broken fragments at the base of a rock slope, it is a good plan to keep to the large stones, to step on sharper edges rather than on flat footholds, and to place the middle of the foot rather than the heel or the toe on projections. Glacier-worn rocks are likely to be more difficult than they look, hence in descending a mountain side by a new route this fact should be borne in mind.

Mountain Sickness.

By "mountain sickness" is meant a feeling of faintness and breathlessness, accompanied perhaps by palpitation of the heart, which sometimes develops during the ascent of a mountain, at almost any height, but especially between 14,000 and 16,000 feet. Weakness in the legs, headache, and nausea are often concomitant symptoms. The sufferer is likely to be completely prostrated and to have to abandon any further participation in the climb. In less acute forms of the malady, a general disinclination to exertion, known as "mountain lassitude;" and a gradual loss of appetite are leading symptoms. Both are likely to supervene during prolonged sojourns at 17,000 feet and above.

The only real cure is to descend as soon as the condition of the sufferer permits. In most cases normal strength and well-being will then return with surprising rapidity. As a preventive, it is suggested that small quantities of sugar be eaten during the climb to counteract the carbonic acid thrown into the blood as a result of the severe muscular exertion.

The subject of mountain sickness is as yet very imperfectly understood, owing largely to the difficulty, not to say impossibility, of dissociating symptoms due to the sufferer's physical exhaustion from symptoms caused solely by the external conditions prevailing at the given altitude on the mountain. It may be said, however, that in nine cases out of ten, on mountains in the Northern Hemisphere, the trouble is due to the lack of training on the part of the victim. Yet in the Andes, at altitudes above 14,000 feet, mountain sickness is prevalent to an unaccountable degree; even the hardiest explorers have succumbed to its attacks.

As to the part played by the rarity of the air alone, the weight of authority at present rates it as slight. One of the perplexing features of the malady is the varying liability of different individuals to its attacks; and of the same individual at different times. Some persons are almost immune.

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HUNTING DANGEROUS GAME.

BY WILLIAM LORD SMITH, M.D.

This subject includes game which is dangerous in itself and harmless game which is dangerous of approach on account of the nature of the country it inhabits.

Barring only one of the Herbivora, the elephant, the most dangerous animals in the long run are the Carnivora for the reason that they are hunters themselves and have killing weapons which they use constantly; all of which makes for better sport, as the game is able to fight back with some chance of victory.

Nearly all the dangerous animals live in the Tropics. The only exceptions are the northern tiger, leopard, and bear. Wolves and wild boar, as hunted today, are not dangerous.

From personal experience with most of the animals in the following list the writer's danger order would be as follows: elephant, tiger, lion, leopard, grizzly bear, rhinoceros, buffalo (African and Indian), gaur, banteng, other bear. The mountain animals may all be dangerous of approach: chamois, sheep, ibex, goats, etc.

The dangerous animals, like human beings, vary widely in individual disposition. Members of the most dangerous families are sometimes timid. They also vary widely according to their habitat. Where they have been much shot, it is naturally the cowards that survive and reproduce.

Man's Equipment.

In hunting dangerous game the most effective weapon is one's own fortitude of mind. Oftentimes the contest between man and beast is decided before a shot is fired, and the stronger personality wins. Given a natural instinct for hunting, the best battery of rifles in the world, a gun-bearer so steady that you can always feel him with your left elbow — all these advantages will avail little unless a crisis precipitates you into an unbeatable attitude of mind. It is common for the mind to become chaotic and the nerves loose-jointed just before coming to shot. When you bring up your rifle this chaos must crystallize immediately into staunch material. Your survival instincts clear your head and act for you. There is little time to think — which is not of much value when you have to split seconds. The thinking must be done in camp.

Safety.

Constant thoughts of safety are dangerous and it will help to remember that you are on the ground to kill and not to escape. A divided motive is a bad cartridge to load with. A bold front, even when backed with an inferior rifle, will often win out. Selous was a fine demonstration of this fact. In the early days of fairly good weapons he was sometimes poorly armed, yet so determined was his stand that he always came through. He kept his eyes and mind on the animal before him.

A crowd is of no value in this kind of hunting. You are better off with a good double rifle and a dependable bearer with an extra gun. If your gun-bearer is not under all conditions at your left elbow, it is better to hunt alone.

One gets the idea that when he arrives in a country of dangerous game he is always in danger. Nothing could be more erroneous; dangerous game is rarely dangerous in the daytime until it is attacked, barring a female with young, and at night the camp is guarded of course with fires, or as in Africa by a *zareba*. It is when you crowd an animal into a corner or wound him that he becomes dangerous. The cardinal rule is to get as near the game as possible before shooting. The closer you are the more deadly the shot, and the less dangerous the encounter.

It adds greatly to the interest and success of an expedition to study the animals beforehand — their instincts and anatomy. Too many men go hunting without knowing exactly where a certain animal's brain lies, how best to break up his shoulder, or to reach the spinal cord in any part of its length. Bad shooting tortures animals and has killed many a hunter.

Rifles.

After long acquaintance, you will grip your rifle with confidence, the butt will settle naturally into your shoulder, and the sights fall instinctively on a vital spot of the game before you. This is only accomplished after careful study at home and long experience in the field, but it is worth while; for a perfect weapon once acquired will always do your bidding.

Go to all the good gun stores — cheap guns are not for dangerous game — and determine what kind of rifle fits you best, then mold it to fit you perfectly. It must qualify for your particular needs as nicely as a well balanced fly-rod. Too many men enter a sporting store and buy a rifle as they would a bag of flour. Usually they buy a club and are obliged to adjust themselves to it for every shot.

Essentials.

Balance. — The gun must come to the shoulder without imposing its weight on the hunter. Every rifle and gun must be fitted to you by a competent gun-maker so that all have: the same drop; the same distance from trigger to shoulder; the same trigger pull (the trigger should be squeezed into action by the grip of the whole hand on the neck of the gun and not unhitched with a forefinger pull). On one African trip the writer's shooting was very bad for a time because his favorite rifle (recently repaired) had been given too heavy a trigger pull.

The *sights* must fall into line with your eye, not be brought into line; and sometimes to accomplish this the butt must be bent to right or left. Your eye must see the game through the sights without any attempt to focus; there must be no blurring when the left eye is closed. If there is blurring it is usually due to the position or shape of the back sight. Try a wider and narrower "V." Try moving the back sight nearer the front sight — farther from your eye. Find the non-blurring point for the back sight. Or, try a level-topped back sight with a perpendicular ivory line or an inverted ivory "V" planted in the middle of it. The ivory clears the eye. The back sight for 50 to 100 yards should be stationary, otherwise when needed it might be flat. Some men shoot best with a Lyman sight (large opening fitted close to the eye). This is a great help in shooting running game. The front sight should be of the right thickness for the eye of the sportsman. When tipped off with an ivory bead it shows up well in the "V" of the back sight. The tip should be on a level with the points of the "V."

For quick shooting it is necessary that the front sight be low; oftentimes the front sight is over half an inch high. Cut it down by a non-reflecting metal rib on top of the barrel made to cover all but the tip of the sight. Changing the range is done by changing the back sight, not by seeing more or less of the front sight.

Estimating Distances.

Heavy rifles have considerable trajectory and a sportsman should be a good judge of distance from 50 to 300 yards. Correct estimates by pacing. Snap your rifle constantly at objects about camp, noting if after squeezing the trigger the sights are still on the object. Never carry anything in the upper right-hand pocket of your shirt or coat. Your rifle butt must slip smoothly into your shoulder from below.

Battery.

A double .450 or .470 (high power), a double 12-bore jungle-gun or paradox (high power), a modern Springfield .30 magazine rifle — these are all that are necessary. A .405 Winchester and a 9-mm. Mauser or Mannlicher are valuable spare rifles.

If expense is an item, an old-fashioned 8-bore rifle (price $100) using a cartridge loaded with 12 drachms of black powder and a 2-ounce ball will answer in place of a .450 (price $400). The 8-bore weighs 16 pounds; the .450 weighs about 11 pounds. The 8-bore is not sure to stop a charging elephant or buffalo.

With the qualifications as stated above one can if necessary cut down to an 8-bore, a Springfield, and a 12-gauge shot-gun (both barrels of the last bored for ball).

The .450 high power will send a full-jacketed bullet clear through the skull of an elephant to his brain, head on, which is the supreme test. The .450 is necessary for elephant and very desirable for buffalo, gaur, seladang, and banteng. The .470 double is as good and can be used in India. The .450 ammunition cannot be carried into India because it is like the government ammunition.

The jungle-gun (price $150, Army & Navy Stores, London) shoots a cartridge containing cordite and a conical lead ball with a hollow point. A brass cap fits snugly over the hollow point. Both barrels are smooth except the terminal two inches, which are well rifled. This remarkable gun weighing eight pounds is sighted up to 300 yards and will kill anything, but is not safe for charging elephant or buffalo. It is a perfect gun for tiger, lion, leopard, and bear. The jungle-gun shoots No. 6 and bigger shot as well as an ordinary shot-gun, which is a great advantage.

Any 12-bore will shoot SSG. shot, a good size for leopard and capable of killing lion, tiger, and bear neatly at ranges within ten feet.

A double rifle is the only gun for dangerous game because it shoots a maximum charge of powder and lead and the two shots can be fired in rapid succession. The mechanism is very simple and will not fail you.

The Springfield with full-jacketed bullet will kill anything but on account of the light bullet is not safe for charging elephant, buffalo, or rhinoceros. The Springfield is a splendid plains-gun because it will shoot a quarter of a mile with slight trajectory. It is quite as valuable for mountain shooting. Dumdum bullets will be found useful for deer and antelope. This rifle should be equipped with the regular army sling, which is of great use in sitting and prone positions (see military instructions for using sling). When the rifle is slung over the back of the shoulder and the weight distributed by pushing the strap forward in the hollow between the thumb and the forefinger, it does not seem to weigh anything like nine pounds.

All rifles and guns should be provided with slings.

Where game is plenty be sure to carry into the field a well stocked cartridge-bag besides the ammunition in your belt or pocket. For an African expedition it is well to take out 500 to 1000 rounds of ammunition for each rifle, depending on the length of time. When mounted on horseback a rifle holster is a necessity. Always carry a .38 automatic pistol or something as heavy in front of your left hip. Many a man has been killed unnecessarily by not having with him a pistol or revolver. If one is pulled down by a beast, unless killed outright there is always a chance to slip a pistol from your belt and get in two or three quick shots. This requires little movement. To draw a knife and plunge it into an animal draws his attention and incites immediate attack. For a good skinning knife there is no better than the Dall DeWeese model (made by Marble). The scoop in the back of the blade near the handle holds the ball of the thumb nicely, which is far better than the forefinger for exerting pressure on the blade in skinning.

Clothes.

Clothes should be adapted in color to suit the environment. Leggin trousers are very useful but in a snake country stout leather leggins must be worn.

In a noisy country shoes should have rope or rubber bottoms. Rope wears better. In an African trip six pair are necessary, besides two pair of stout leather boots, the latter to be used on the march and in snaky districts.

A helmet should be worn in hot countries; elsewhere natives give one the idea.

Animal Equipment.

What have the animals with which to oppose the powerful equipment of man? Let us take each beast in turn.

The elephant. — Huge as he is and unable to gallop, the elephant has a very fast trot and no man can escape him. Over level country a man might run even for 100 yards, —

Sir Samuel Baker once saved his life in this way, — but in a longer race or over rough country a man is doomed. Except in vital spots the elephant absorbs 2-ounce balls as unconcernedly as a pin-cushion absorbs pins and in a frontal attack his massive forehead is ample protection for the deep-seated brain against all but the strongest-hitting rifles. When looking you up in a forest an elephant approaches so silently that you may not suspect his presence until you hear his scream over your head. He has a good nose and ears but his eyes are poor, else elephant-hunting would be suicide. Often he will overlook you in plain sight within a few feet if you do not move. The elephant kills with his trunk, tusks, and feet.

Tigers, lions, leopards. — The lion comes on at a low gallop; the tiger and leopard are more apt to gallop high and spring. As a whole the cat tribe run at great speed and when aroused charge home. There is no escape. They are silent hunters. The tiger and leopard approach unseen. The lion whether fearless or stupid, shows himself needlessly in the open. He has little of the cunning and deceit employed by the tiger and the leopard and is fast disappearing. Rarely do these beasts seek a quarrel with man. All their senses are very keen. They see in the daytime as well as at night. In killing, the lion usually strikes with his paw before using his teeth. The tiger seizes the backbone of the neck with his teeth. The leopard seizes by the throat. The claws are never idle in attack, and are as great a menace as the teeth. The cougar is the least ferocious of the big cats and can only be considered dangerous if one tries to pet him. The jaguar is more dangerous than the cougar but appears to have an undeserved reputation for attack.

Grizzly bear. — Other bears can hardly be considered dangerous excepting the big barren-ground bear, which will at times put up a good fight. One must go a long way today to find a fighting grizzly. The survival of the fittest has bred a race of cowards with a good deal of cunning in avoiding contact with man. He trusts to his sensitive nose and unless cornered forgets his tremendous strength. He dies very hard when in a fighting mood. Bears without young are not quarrelsome. They rely upon their teeth and great power of hugging. When close in they often rise on their hind legs the better to use their forearms.

The rhinoceros. — Except in open country or when surprised within a few feet, the rhinoceros need not be taken too seriously. His nose is good and he will investigate almost any strange smell, often with a clumsy rush which he usually advertises with a sharp steam whistle. His swift gallop makes escape by sheer running out of the question. His eyes are a good deal like hens' eyes and give him a similar crazy way of rushing blindly about. The eyes are planted so flat on the sides of his head that he cannot triangulate his two fields of vision and so he is a poor judge of distance. The fact that he has two distinct fields of vision accounts for his stupidity. What is directly ahead is a doubtful quantity and merely arouses his curiosity. Whenever a rhinoceros gets to you, his horn is a deadly weapon.

Buffalo, gaur, seladang, banteng. — Unprovoked these animals rarely attack. When charging they are very dangerous because of the difficulty in stopping them. The buffalo are especially well protected when head-on, with nose pushed forward, offering no view of the forehead. Their tough skin and heavy bones are well calculated to take a good deal of punishment. They have good senses, especially the sense of smell. When wounded they display great cunning in revenge. Their horns are deadly weapons.

Hunting.

Of course the rifle gives man a great advantage over animals but there are times when he needs every advantage within his reach.

Elephant. — On cleared ground, with a single animal, keep the wind right while stalking him and trust to your rifle. With a herd, approach up-wind, always watching for some avenue of escape in case the whole herd stampedes. In high grass elephant hunting is very dangerous. You walk him up by following a freshly trodden path and shoot him through the head as soon as you see him — always within a few feet. In forested country keep to leeward and with a herd keep outside the circle. Pick out a bull and gradually work toward him. If elephants stampede in a forest everybody looks out for himself — run to cover and keep perfectly still. When shot into a great deal (as on Mt. Kenia), herds of elephants become very irritable and highly dangerous.

Felines. — In hunting lions, tigers, and leopards use all the deceit in your disposition. You cause less suspicion when seen by circling in your approach and keeping your eyes off the animal as much as possible. If not wounded, big cats will often make a bluff charge to try out the metal of the enemy. If wounded and in cover, following is of course very dangerous, and a big double rifle the only safe weapon.

Rhinoceros. — The rhinoceros can usually be stalked within easy shot if the wind is right, even in the open by gradually edging in toward him. The writer has found him easy to kill; others have a different opinion. If unable to stop a charge, sidestep when the rhinoceros is within a few paces. He will pass by straight as a railroad train, when you will have him at your mercy. The Indian rhinoceros may be more dangerous since he is hunted at times in stout reeds, which make dodging very difficult. It is well to remember that at 50 feet a rhinoceros does not recognize a man.

Buffalo, gaur, seladang, banteng. — Get the wind right and move in close. When you come upon a herd of Cape buffalo in the open be careful. A single shot may bring on the whole herd. Your only chance then is to break up the center or hide. Single animals of the bovine type are, with the exception of a surly bull, not very difficult to kill with a heavy rifle but when wounded and in thick cover there is nothing more dangerous because a wise old bull will wait on one side of his retreating pathway.

General Hints.

There are certain general questions in regard to action which are sure to come into the mind of the beginner, of which the following are examples.

To stand or to run. — It is best when facing a single animal to stand your ground. If your mind is muddled with thoughts of escape poor shooting will follow. When facing a herd, for example, of elephants or buffalo, it depends upon conditions. If you have a pair of big rifles at hand you can usually divide a charging herd by severely punishing the animals in the center of the line. But it is not inglorious to run when facing a charging herd and sometimes when facing an individual. Remember that your legs are part of your equipment.

Keeping quiet. — To keep still without any motion while hunting is often essential to success and at times for safety. Few animals are suspicious of an immobile man if the wind is right, and especially is this true of elephant and rhinoceros, on account of their poor sight. By keeping perfectly still when under observation, as you approach these animals, even in open country, you may escape notice, except for a passing glance, until you are within easy shot.

In heavy cover where you cannot see distinctly or perhaps only hear an animal, you can usually force him to move first by keeping still. By moving ever so little under these conditions you may bring on a charge.

Divided motive. — When hunter and animal are completely screened from each other the animal can often be forced to move by giving him a divided motive. Make a slight rustle in one place, circle a little and repeat the noise. The animal, confused in mind as to what he has to deal with, will retreat or show himself. To break through heavy cover to a dangerous animal is folly.

Hunting with dogs also confuses animals. When bayed their glance travels from the pack of dogs to the man and unable to concentrate, the beast seldom charges home. The hunter may get more lions with dogs but he will not have as good sport because the danger is pretty well eliminated.

Pressure. — Stewart Edward White, better than any other hunter, shows how pressure when slowly and steadily applied, will cause a dangerous animal to retreat. White had wounded a big lion, but not so badly as to cripple him. As an experiment the hunter walked steadily toward the lion in plain sight. The lion watched proceedings without moving, then yawned and avoiding the encounter retreated into some brush from which he eventually charged and was killed. There might come a time when a hunter who had damaged his rifle or run out of cartridges, could make use of this method to extricate himself from a doubtful situation.

Open shooting. — Creeping toward game in open country often fails. Usually it is better to walk in, not straight, but by a series of gradually approaching zigzags, keeping on one side of a line drawn straight to the beast and always cutting away when the animal gets nervous. He sees you of course but is led to believe by your manoeuvering that you have business elsewhere.

Where to Aim for Vital Spots.

It is as important to know the vital spots in the various animals as to know your rifle. The writer has tried to put these spots down in order of importance. They are within the skill of a fair marksman at close quarters. Brain and shoulder come first. A shot through the brain kills instantly. A shot through the shoulder breaks up the machinery of locomotion. The spinal column is more difficult to hit but when struck, locomotion at least is stopped. Heart and lung shots cause death but more slowly and the animal may get to you before he dies. Mr. Loring on the Roosevelt Expedition in Africa shot a charging lioness several times through the heart with a small-bore rifle and she would have caught him except for his marvelous activity.

Naturally the spot aimed at is often at some distance from the vital spot.

Elephant.

Front view:

Brain — exactly at base of trunk.

Chest — if trunk raised; middle of chest. If trunk down, between head and shoulder, midway in height, left side if possible.

Side view:

Brain — a spot halfway between the eye and opening of the ear.

Shoulder — middle of body in perpendicular line with fore leg.

Heart — junction of lower and middle perpendicular thirds of body, directly behind upright drawn from fore leg to spine.

Lungs — middle of body directly behind upright line drawn from fore leg to spine.

Rear view:

Aim at sloping spine (a good shot).

Big Cats and Bear.

Front view:

Brain and spinal cord — middle of nose.

Chest — just below chin (if chest is visible) or between shoulder and neck — high up.

Side view:

Brain — base of ear (just behind opening).

Spine — a little above middle of neck.

Shoulder, heart, and lungs — same as in elephant.

Rhinoceros.

Front view:

Brain — impossible.

Spine — at close quarters the rhinoceros lowers his head; aim at middle of neck over the head.

Chest — if head is raised, middle of chest; if head is lowered, between neck and shoulder high up.

Side view:

Brain — base of ear (just behind opening).

Shoulder, heart, and lungs — same as in elephant.

Buffalo, Gaur, Seladang, Banteng.

Front view:

Brain — if nose is down, try forehead; if nose is raised, middle of nose.

Chest — nose raised, middle of chest; nose down, between shoulder and neck, high up.

Side view:

Brain — base of ear (just behind opening).
Shoulder, heart, and lungs — same as in elephant.
Spine — a little above middle of neck.

Night Shooting.

This may be tried when day shooting fails.

Methods. — (1) Watching from a tree over live or dead bait; (2) watching from a covered hole in the ground; (3) watching from a *zareba* (a brush or thorn enclosure). The writer has sat in a tree his share of nights and watched jackals eat the dead bait without getting a shot at the tiger. The strange night sounds of the smaller animals are always interesting but if big game fails to appear the hunter passes many a weary hour waiting for sunrise. When the earth permits digging, watching from a hole dug in the ground is more satisfactory. The hunter makes a hole large enough to hold him comfortably and thatches it over with boughs, grass, and dirt so that the flat roof thus formed will be inconspicuous and on a level with the ground. A gutter is made in the ground at one end through which one can watch and shoot. All débris is carefully removed to a distance and the surroundings made natural. The unfortunate pig, goat, or heifer is then tied securely to a tree root or a strong peg within five or six feet, where it can be distinctly seen. If possible arrange to silhouette the bait against the sky. If carefully carried out this makes an ideal post. Tigers, lions, and leopards do not expect trouble from the ground itself.

The thorn *zareba* has been tried very effectively in Africa with lions and leopards, but it has the same defect of all night shooting, — the game has no show.

Night gun-sights. — There are many devices. Where there is light a long piece of paper pasted on top of the barrel is good. In taking aim the sights are in line with the eye when the white paper disappears on lowering the gun. The best method is to use a barrel electric light. Fasten this under your barrel or barrels with strong cord. Be sure there is insulating material between the gun and the electric battery. The left hand grasps the electric barrel and gun barrel and the left thumb presses the button and throws on the light when game arrives. It is good for 30 or 40 feet.

Special Hunting.

Somali lion hunting. — Lions are frequently seen on open plains in Somaliland and British East Africa even in the daytime. They may be watching a kill made the night before or simply resting under a thorn bush. The method of hunting lions in the open where they see the hunter plainly several hundred yards away and cannot be stalked, originated in Somaliland. The Somalis are splendid horsemen and they found out that a good pony, given 50 yards start, can escape a lion. The lion like all cats dislikes to run any distance and will pull up after he has covered a few hundred yards. Upon sighting the lion the mounted Somali circles him at a safe distance. The lion usually breaks through this circle several times and then lies down watching carefully to see what game is being played upon him. When he sees the white hunter approaching on foot he realizes at once that the strange man is his real enemy and gives all his attention to him. It then becomes the duty of the white hunter to kill the lion before he gets up or to stop him as he charges in.

Tiger hunting in Chinese caves. — In its retreat from central China the ice of the glacial period left behind huge masses of boulders. For some reason tigers became numerous in this country and after the land was deforested they inhabited the caves formed among these boulders. As there were no woods and so no wild game, these tigers became dependent on the villages for their food: goats, heifers, man. They are today practically all man-eaters and there are many of them.

The natives hunt the tigers very little but occasionally when an especially bad beast settles down in the neighborhood they form a hunting party and kill him. Resident Englishmen and a few outsiders have had good sport in the country, and one feels that it is a very legitimate kind of hunting since these tigers do a vast amount of damage. Life is interesting in the Chinese villages and the white hunter is made comfortable in a *josh* house, which is especially prepared upon his arrival.

There are always a number of good hunters and with them one investigates neighboring caves and ties up goats at night on the rocky hillsides to bait the tigers. When a tiger has killed a goat he can be tracked to his cave. The hunters are armed with trident spears three feet long and bamboo torches about a foot longer than the spears. The tunnels leading into the caves are anywhere from ten to fifty yards in length. With one torch-bearer lighting the way the hunter crawls in on hands and feet. If there is but one tunnel leading into the cave, he will find the tiger at home and by the light of the torches get a good shot about five yards away. These tigers are in reality more dangerous when they are prowling loose among the big boulders outside.

Bear hunting. — The usual kind of bear hunting, excepting the inoffensive polar bear, consists in viewing open country where bears feed on berries, grass, etc., or watching a kill made by a bear, or left for his inspection.

Perhaps the most special kind of bear hunting is that practiced by the Aleut Indians of Alaska. These Indians prefer to do their bear hunting in the early spring, March and April into May, when the bears first leave winter quarters and the pelts are in fine condition. The hills are deep in snow and the dark brown bear can be seen at a great distance. Two Aleuts coast the shores of some favorite bay in their light bidarka canoe early in the morning and again toward evening. The bears on leaving their dens are always on the move and when sighted, sometimes miles away, the natives paddle swiftly to a point on the shore where they can intercept them. It is a good hardy sport with plenty of rough water.

Hunting bear by following hounds on horseback, as practiced about Glenwood Springs, Colorado, is expensive but excellent sport.

Chamois hunting. — Like hunting wild sheep and goat, chamois hunting is dangerous because of the habitat of the animal. Anybody whose head remains steady in high places can become a chamois hunter and no sport better repays the effort. The effort is considerable. One must climb daily until height and exertion are scarcely thought of in a long hunt. Personally the writer has never come to thoroughly enjoy standing about on precipices but it is always exhilarating. In shooting, outside of preserves, which can be had by staying in small inns of southern Austria, two or three shots a week is considered liberal and it is enough for it compels one to study the country carefully and work hard for every shot. One may sight a buck at five o'clock in the morning and come to shot at four in the afternoon. After their breakfast the chamois invariably select some spot on a large gravel bed or rock ledge where they can keep the country under their eye until time for the evening meal. Their speed over boulders is wonderful. They will accept the boldest leaps to escape and are rightfully the blue-ribbon animal of Europe. The Tyrolese are a very picturesque and friendly race and hunting with them, upon the skyline of their rough mountains, is the best of sport.

HYGIENE, MEDICINE, AND SURGERY.

BY GEORGE C. SHATTUCK, M.D., WILLIAM J. MIXTER, M.D., AND GEORGE P. HOWE, M.D.[1]

ORDINARY HYGIENE AND MEDICAL TREATMENT.

Principles of Hygiene.

The fundamental principles of hygiene are the same everywhere but modification is required to adapt them to circumstances. The best advice can be summed up in two words: *Keep well.*

Before starting on a trip *be vaccinated against small-pox* and *typhoid fever.* Vaccination does not protect absolutely from either disease, but it reduces enormously the risk of infection and the chance of serious consequences should infection occur. A mixed vaccine can be used which will protect against typhoid and paratyphoid. This is strongly recommended.

The more important hygienic principles will be outlined under separate headings. It seems unnecessary, however, to dilate on the need of sufficient sleep or the value of fresh air. Although the robust may withstand unhygienic conditions for long periods without apparent harm, many learn too late that the best constitution can be damaged beyond repair by persistent abuse or neglect.

Care of Digestion.

Digestion is favored by: (1) simple food, (2) eating slowly and chewing well, (3) regularity of meals, (4) rest after meals, (5) good cooking, (6) regular and normal action of bowels, and (7) sufficient exercise.

Digestion is handicapped by: (1) neglect of the foregoing precautions, (2) over-eating, particularly of "rich"

[1] The writers wish to thank members of the Club and others who have helped them with advice and suggestions.

food, (3) bad teeth, (4) frequent use of alcoholic beverages, and (5) pronounced fatigue, physical or mental.

The digestion of an individual is, more or less, a law unto itself, and those who suffer from weakness of this function soon discover idiosyncrasies which should not be disregarded without good reason.

Food.

Varieties of food fall naturally into two great classes: animal and vegetable; but chemistry teaches that nearly all foods contain nutritive principles of three groups, namely, protein, carbohydrate, and fat. The fundamental difference between animal and vegetable foods, and between different kinds of food of the same class, lies in the various proportions of the nutritive principles contained in them.

Nutrition depends, not on quantity of food swallowed, but on the amount assimilated. To be assimilated readily, food must be well digested; and to be easily digestible it must be well prepared and sufficiently chewed. Peas and beans contain much protein and are a good substitute for meat.

Digestibility. — Foods differ much in digestibility. Speaking broadly, heavy bread, or cake, highly seasoned foods, "rich" sauces, pastry, and fried things, particularly when greasy, unripe fruit, tough meat, insufficiently cooked vegetables, salted meat, ham or bacon in large quantities, and baked beans are difficult to digest. It should be recognized that wholesome food may be rendered indigestible by bad cooking, and that individual digestive peculiarities, climate, and mode of life may be important factors.

When tough meat and coarse vegetables such as turnips, cabbage, canned corn, and baked beans have been well chewed, the distress which so often follows their use will generally be avoided.

Quantity. — The quantity of food required varies in individuals. Hard work, mental or physical, in any climate requires plenty of food. To eat too lightly or at too long intervals is to risk exhaustion, and eating heartily when overtired, may cause indigestion. Exposure to cold necessitates abundance of food and particularly of fat in some form. Inactivity or warm climate call for reduction of food, especially of greasy or oily food and meat. Illness of travellers on trains and steamers is often caused by overeating and constipation.

Diet. — One may thrive on a well selected diet of vegetables alone, but if he lives exclusively on meat, he is almost sure to feel sick. For most persons a large preponderance of vegetables is best. As a rule the diets of "native races" will keep an American or European alive but he may lose weight and strength.

Going for weeks without fresh meat or vegetables will probably bring on scurvy.

For special diet lists, see p. 265.

Drink.

Water. — Perfectly clear water may be so polluted by sewage as to be very dangerous; on the other hand muddy water, or water made brown by decaying leaves is not necessarily unwholesome. Water having a pronounced brackish or alkaline taste increases thirst and causes diarrhoea which may be severe. Many such waters in the United States contain Epsom salts, a purgative, p. 266.

Polluted water may cause typhoid fever, dysentery, or cholera, if there is any about. Therefore, if there is the least doubt about its safety, boil the water for ten minutes before using it for drinking, or drink only distilled or bottled water of a reliable brand. In the Tropics, even spring water is dangerous. Detailed directions for disinfecting water will be found on p. 224. The "spirit with which you drink it" is no safeguard against polluted water. Well water is notoriously dangerous.

Ice, unless known to be made from pure water, should never be put into drinks nor allowed to touch food.

Milk. — Take no chances on raw milk. It can be made safe by boiling. Otherwise there is the risk of typhoid fever and many other diseases.

Tea and coffee are strong stimulants and have no food value beyond that of the cream and sugar taken with them. They improve appetite and digestion in fatigue, and may serve to tide over a period of exhaustion, but to rely on them when rest and food are needed is to mortgage the future.

Cocoa is nutritious, wholesome, and but slightly stimulating.

Alcoholic drinks have a brief stimulating effect followed quickly by depression. Strong alcohol, even in "moderation" is bad for most people, and the man who shows little effect at the time is the more likely to die from it later.

Exercise.

Regular exercise tunes up all bodily functions, improves the action of the bowels, and clears the head. Too much exercise long continued causes exhaustion, and may provoke indigestion, or sleeplessness.

Bowels.

Normal action of the bowels once or twice a day is an important safeguard of health. Such action is favored by exercise, by drinking water freely, by eating foods which stimulate intestinal activity, and above all, by regularity in going to stool, and by allowing sufficient time. The irregular hours incident to ordinary travel tend to cause constipation, and it is almost universal among passengers at sea.

Mild laxatives should be at hand for occasional use, but it is better, when possible, to regulate the bowels by diet. Strong laxatives and purgatives, when used frequently, tend to irritate the bowels and to aggravate constipation.

Hygiene for the Camper.

Personal hygiene. — The inexperienced camper sometimes fails to realize the value of cleanliness of person and clothing. Cleanliness helps to keep the skin in good condition, and prevents or limits the spread of skin diseases such as ring-worm (p. 215), boils, and the like. One frequently hears of parties the members of which have suffered from boils and have blamed the country, when it was far more probably due to paddle handles, axe handles, etc., contaminated with pus.

The feet need careful attention especially in warm weather. They should be kept clean: chafes, blisters, or cuts tended (p. 258); foot gear worn during the day always removed at night, and socks washed frequently. The toe nails ought to be trimmed squarely. When the corners are cut off the nail grows in, and inflammation soon follows.

Clothing. — Woolen garments are nearly always best because they absorb moisture from the skin, are warm even when damp, and dry quickly. The weight of underclothing should suit not only the climate but also the individual. Those who perspire much should dress as lightly as is consistent with comfort, whereas those who sweat little may prefer to dress more warmly. In temperate climates, much warmer underclothing is usually desirable for life out of doors than at home. Heavy woolen socks are best because they do not wrinkle, protect the feet from chafing, and keep them warm when wet. Warmer clothing is needed for cool, damp weather than for cold, dry weather. For information about hot and cold climates see pp. 223 and 219.

Night-clothes and bedding. — Many men sleep better if they carry the night-clothes to which they are accustomed. If night-clothes are not carried, two sets of underclothes can be worn alternately, the change being made at night. This allows for airing and drying.

Bedding should be light enough to prevent dampness from sweating. Evaporation is constant from the skin even when not apparent. Therefore, a waterproof sleeping-bag, even when light, gets soggy. There should be ventilation enough to prevent this, and by sleeping as cool as one can without shivering, perspiration is reduced to the minimum.

Exposure to dampness and cold. — Wet clothing hurts no one who keeps warm by exercise, but it is unwise to stand about when damp. Sweating can often be prevented by unbuttoning the shirt or by taking off the cap, and in cold weather a warm cap and gloves to put on when a halt is made are nearly as good as an overcoat. Chilling from dampness by night or day may bring on diarrhoea, rheumatism, or sore throat, but damp blankets may be warm enough except in cold weather.

To be cold when dry, seldom does harm unless the exposure be so prolonged as to reduce vitality, but to be wet and cold for long is to run more or less serious risk.

Alcohol should never be taken for exposure until shelter has been or is soon to be reached. It increases exhaustion if taken when one is still exposed.

Diet. — Camp cooking is generally bad, but out-door life may enable the digestion to cope with it. Fried meat, heavy biscuits, or much bacon may cause "sour" or acid stomach.

Fresh-killed meat may be unwholesome, but can be eaten in small quantities if tender, or if chopped fine. If too tough to be properly chewed, or if fried to the consistency of leather, it causes diarrhoea.

Meals. — It is better to eat enough through the day than to stuff at night and promptly thereafter to turn in; and in cold weather it may be worth while to have four hot meals including a light supper before going to sleep. When climbing mountains it is best to have no hearty meal but to eat a little every two or three hours. If you begin to feel tired, stop and eat something.

Hygiene of the Camp.

This section is important for large parties, and especially so in warm weather, or when a prolonged stay is to be made in one place.

Water for drinking should be obtained at a point above the camp. Set apart a place for obtaining it. Below this, the horses can be watered, and lower still, washing can be done. Excrement must be deposited at a safe distance, and it may be necessary, when flies are about, to dig latrines, and to cover the excrement immediately with earth to keep flies from it. Not only faeces but also urine may contain the germs of disease which are then carried by flies to the food if flies are allowed access to the excrement. For disinfection of water see p. 224.

Food should be protected from flies, and the cook should wash his hands carefully after attending to the calls of Nature. Failure to do this has caused outbreaks of typhoid or other intestinal infections.

Flies. — Besides protecting the food from flies, it is important to dispose of garbage and dish-water in a cleanly manner. Garbage can be buried or burned, and slops can be poured into the ashes of the fire. An excellent method is to fill a pit with stones and to build the cooking fire upon them. Refuse thrown on the stones is quickly consumed and the dish-water can be poured under the stones.

Horse manure must not be allowed to collect near the camp, because it attracts flies and they breed in it. The presence of many flies in a camp shows neglect of the principles outlined above.

Diagnosis and Treatment of Common Disorders.

General Information.

When the nature of a malady is not apparent the attempt should be made to reach a diagnosis, (1) by questioning the patient as to the location, nature, duration, and mode of onset of his symptoms; (2) by examination of the affected part, or of the body as a whole; and sometimes, (3) by looking at the excretions. Important information can be gained in these ways even by those not trained in medicine.

When no particular disease can be recognized it may still be possible to recognize that the malady is one of a group of diseases, the treatment for which is similar. Failing this, one must fall back on the principal symptoms, and treat these conservatively to afford relief without hampering Nature in the struggle for recovery. For many diseases, indeed, the physician can do no more than treat symptoms while the disease runs its course. Fortunately, many diseases are self-limited, and in most of them the tendency toward spontaneous cure is strong. Therefore, the importance of rest and good care can scarcely be exaggerated and frequently no other treatment is required.

The outline which follows attempts to group the causes of prominent symptoms in such a way that the traveller out of touch with civilization may find it useful as a guide to the probable nature of ailments which he may be called upon to relieve. In such an outline it is inexpedient to mention more than a few of the possible causes of any symptom or group of symptoms. Of the less serious possibilities the commonest have been chosen, and of the more serious those which are not uncommon and which it would be unfortunate to overlook.

Constipation.

Causes. — Lack of exercise, insufficient water drinking, not enough fruit and vegetables, carelessness about evacuating the bowels.

Treatment. — (a) Take daily exercise; (b) drink six to eight glasses of water daily; (c) eat fruit or vegetables and bran-containing bread with every meal; (d) always go to stool at a regular hour, even when this seems unnecessary. There should be no haste. The habit of regularity does much to keep the bowels in order.

Diet. — Fruit in any form, green vegetables, cereals containing husk (*e. g.*, oat meal), and coarse vegetables, such as beets, turnips, or cabbage are helpful.

Medicine. — Cathartics and drugs relieve for the time but tend to increase constipation. These measures are suitable for occasional use where prompt results are important, as when there is a headache, fever, or colic. When diet fails to relieve, or when suitable diet cannot be had, it is better to take a small but efficient dose of medicine daily than to take a larger dose irregularly. Do not take salts of any kind every day unless you are too fat. Salts or saline cathartics should be taken with a full glass of water on getting up in the morning. They are most useful when a prompt clearing out is needed.

After prolonged constipation, or if something disagrees, a thorough evacuation is desired; take from one to three grains of calomel at bed-time and a saline cathartic on getting up. A Seidlitz powder, one or two teaspoonsful of Carlsbad salts, or, if something potent is required, a tablespoonful of Epsom salts (p. 266) will serve.

Enemas (p. 264) should be used when an immediate evacuation is needed. Like cathartics, they increase constipation if used often.

Indigestion or "Biliousness."

Varieties. — Indigestion may show itself by nausea, vomiting, diarrhoea, colic, flatulence, belching, loss of appetite, coated tongue, or "acid stomach," or by a combination of these signs, perhaps with headache, irritability, loss of energy, and general discomfort. There is little or no fever.

Causes. — Indigestible food, too much food, lack of exercise, insufficient chewing, or constipation.

General treatment. — (a) See rules for care of digestion, p. 191. (b) Eat little and take only the plainest and most easily digested kinds of food until well. Greasy or fried things, pastry, and hot or heavy bread are to be avoided. (c) Obtain several free evacuations of the bowels by taking a cathartic and repeating it if the first dose does not act sufficiently.

Cathartics. — Saline cathartics such as Epsom salts or Seidlitz powder act well only when the stomach is empty. They are suitable, therefore, to take before breakfast, and should act in an hour or two. They should not be taken less than three hours after a considerable meal.

Cathartic pills of nearly all kinds act slowly and, therefore, should be taken at bed-time to get results soon after breakfast.

Calomel (p. 267) is one of the best cathartics to use for indigestion. A single one-grain tablet of calomel taken at bed-time has an excellent effect when followed by a level tablespoonful of Epsom salts or a Seidlitz powder on getting up in the morning. If very thorough purgation is desired, or when the bowels are difficult to move, two or three grains of calomel may be taken at night.

Suppose a Seidlitz powder or other saline cathartic has been taken in the morning and that it has failed to act before luncheon. Three courses are open: (a) to wait until evening and then to take calomel or a cathartic pill, (b) to take an enema, (c) to repeat the salts in twice the quantity taken before, and to eat nothing for an hour thereafter in order to give time for the salts to leave the stomach. The choice of method will depend on circumstances and on the amount of discomfort.

Castor oil, although not popular, is one of the best cathartics to take for indigestion. Take it when the stomach is empty, preferably before breakfast or at least three hours after eating. It generally acts in two or three hours, so that it should not be taken at bed-time.

Diarrhoea.

Causes. — When there is little or no fever, diarrhoea may be the sequel of long-continued constipation, or it may be due to undigested or unwholesome food. There is often pain called colic.

Treatment. — (a) Clear the bowels by taking calomel at bed-time and Epsom salts on getting up in the morning. When the discharges no longer have much odor the bowels have been cleared. Do not check the diarrhoea until they are clear. Keep warm and keep quiet. If in the afternoon the bowels have not moved freely take an enema or repeat the salts in larger dose.

(b) After a thorough clearing out, the diarrhoea may stop spontaneously. If it continues, take half a level teaspoonful of bismuth (p. 267) every two hours for five or six doses, and if it still continues take "sun-cholera" tablets. If no medicine is at hand boil some tea until it is strong and take a cupful every few hours. By boiling tea, tannin is extracted from it and tannin stops diarrhoea.

Very severe diarrhoea with fever may be due to food-poisoning or dysentery.

Chronic diarrhoea requires a dose of Epsom salts followed by half-teaspoonful doses of bismuth three or four times daily and a "simple diet."

Colic.

Cause. — Colic or "belly-ache" is a pain in the abdomen due to a cramp of the intestine, resulting from indigestion and often associated with diarrhoea.

Signs. — It may be slight or severe; it lasts but a moment or two at a time, and may return repeatedly at short intervals. It is often accompanied by rumbling in the intestines, by diarrhoea, and sometimes by nausea and vomiting. The knees are instinctively drawn up, or the body bent forward; and pressure on the abdomen helps to relieve pain, as the afflicted person may discover for himself. Appendicitis and other serious conditions may be mistaken for colic and in some of these cathartics are dangerous.

Treatment. — It is essential to empty the bowels of the undigested food which is causing the trouble. Diarrhoea often brings this about and such diarrhoeas should not be checked as long as solid matter or unusually offensive material is being discharged. If watery, nearly odorless discharges continue it should be assumed that the bowel has been cleared, and the diarrhoea should then be checked by drugs (see *Diarrhoea*, p. 200).

In many instances the diarrhoea soon stops spontaneously. In mild attacks no treatment is required. If there is much pain and frequent movements of the bowels, the patient should lie still, cover himself warmly, and apply heat to the abdomen. A hot-water bag or a hot stone will serve, and a cup of tea taken as hot as possible will help to relieve. When pain is very persistent, morphine (p. 268), one-sixth grain, can be taken by mouth or subcutaneously. It should not be repeated in less than four hours and is rarely needed for colic in the absence of more serious conditions.

When the bowels do not act freely of their own accord the quickest remedy is an enema. If the patient has eaten nothing for several hours give a heaping tablespoonful of Epsom salts or one or two of castor oil instead of an enema. The colic may increase for a time but the evil will be cast out and he will soon be well again.

If after eating heartily, one is nauseated, or feels bloated, or has a burning pain at the pit of the stomach called "acid" or "sour" stomach, or if sour liquid rises in the throat (called "heartburn") the stomach must be emptied by vomiting. To cause vomiting run the finger down the throat, or quickly drink several glasses of warm water, or mix a teaspoonful of powdered mustard in a cup of warm water and drink that. If mustard should fail, plenty of warm water with salt in it will have the desired effect.

Colic and diarrhoea are caused sometimes by rapid chilling of the body and especially when perspiring. In such cases the effect follows the cause promptly, evacuations are not particularly offensive, and they can be stopped very soon by getting thoroughly warm.

Vomiting.

Causes. — Vomiting is generally caused by excess of food or drink, sometimes by bad or indigestible food, and sometimes, when associated with fever, it indicates the beginning of an infectious disease. When this is the case there are generally other signs such as pain in the limbs, marked weakness, headache, or a shaking chill. When there is much abdominal pain, think of appendicitis (p. 255).

Treatment. — Vomiting caused by food generally stops promptly after the stomach has emptied itself. When the stomach has been emptied of food, retching sometimes continues at frequent intervals. Slime, which may be white, yellowish, or green, is raised with painful efforts. This can generally be stopped if the affected individual will lie perfectly still. If this does not stop it in a few hours, the stomach should be washed by drinking a large quantity of warm water which, when vomited, leaves the stomach clean. If this procedure fails to relieve, one-sixth grain of morphine should be injected subcutaneously.

When vomiting has been persistent, food should be taken at first very cautiously. A spoonful of weak tea without sugar or cream, a small, thin slice of dry toast, or a spoonful of milk diluted with an equal quantity of plain or charged water should at first be given. If this is kept down it can be repeated several times at intervals of fifteen minutes. In the second hour and afterward the intervals of taking food and the quantity at each feeding can be gradually increased. Later broth, which must be free from grease, undiluted milk, cereals, eggs (boiled, poached, or scrambled), crackers or rice can be taken in small amounts at intervals of from two to four hours. Meanwhile if abdominal pain continues, the bowels should be emptied by means of an enema.

"Acid" or "Sour" Stomach.

Causes. — Indigestion from eating too fast or irregularly, or unsuitable diet, and especially too much bacon or other greasy food.

Signs. — A burning pain in the pit of the stomach which may come on soon after eating or several hours after a meal. The pain is often associated with "water brash" by which is meant that a sour liquid rises in the throat, or by "heartburn" which means that the burning is felt in the front of the chest. The pain is not spasmodic but steady and is often relieved for a time by eating. It has often been called "hunger pain" because the sensation of hunger often goes with it.

Treatment. — (a) Follow rules for care of digestion (p. 191). (b) Clear the bowels with a cathartic. (c) For temporary relief dissolve from one-half to one teaspoonful of cooking soda in a glass of water and drink it. If not relieved in a few minutes, repeat the dose and if the pain still persists, induce vomiting (see *Colic*, p. 200).

Jaundice.

Cause. — Generally a complication of indigestion.

Signs. — Yellow skin and eyes, dark-colored urine, whitish bowel movements, coated tongue, loss of appetite, and mental depression.

Treatment. — As for indigestion (p. 199). Avoid butter, fat, and greasy food especially, and drink ten glasses of water daily. Improvement is shown by fading color of skin, lighter-colored urine, and normal movements. The illness lasts as a rule from one to three weeks.

NOTE. — Jaundice with severe pain in the abdomen and fever above 100° F. may be serious (see *Gall-stones*, p. 256).

Headache.

Causes. — Most often due to constipation, or to indigestion. Sometimes it results from eye-strain caused by too much reading with a poor light or from glare off snow or water. It may be caused by hunger or excessive fatigue. There are many who suffer from frequent headaches affecting one side of the head and associated often with digestive disturbances. Such headaches are spoken of as "sick-headaches" and are called by physicians migraine. Headache with fever of 101° F. or more may mean an infectious disease.

Treatment. — Try to find out the cause of the headache and treat accordingly. If due to excessive use of the eyes or to glare, rest for the eyes and smoked or amber goggles are needed. When due to hunger or fatigue the treatment is obvious. When there is constipation or indigestion treat them appropriately.

Migraine is very often caused by incomplete emptying of the bowels even when there have been daily movements. Therefore, try a cathartic. When very severe, no matter what its cause, headache should be treated as follows: (a) rest in a darkened room; (b) very little food; (c) eight glasses of water during the day; (d) hot or cold applications to the head frequently renewed. An ice-bag or hot-water bag, or towels wrung out of hot or cold water can be used. For real migraine, heat gives more relief than cold. For other kinds of headache, cold is better than heat. (e) Aspirin (p. 268), ten grains every two hours for three or four doses, gives much relief. Do not use morphine for headache, as the habit is almost sure to be formed.

Ear-ache.

Treatment. — (a) Application of cold behind the ear by ice-bag, or by cloths dipped in cold water and changed often. (b) A little warm oil poured into the ear. (c) If pus discharges, the ear must be washed out three or four times a day with a warm solution of boric acid (p. 274) as long as the discharge continues. In the meantime continue to keep it plugged *loosely* with cotton wool which should be frequently changed. (d) Drugs may be tried as for headache. Ear-ache seldom lasts more than a day or two.

Tooth-ache.

Clean out the cavity with a bit of cotton on a match or wire. Put on a clean bit of cotton, dip it in oil of cloves and plug the cavity with it. If the cavity cannot be reached, apply the oil to the gum. If the tooth is loose, pull it out (see p. 238).

Eye Troubles.

Cinders, etc. — Tell patient to open eye wide. If nothing can be seen in it tell him to look up and at the same time pull down lower lid with finger. If nothing is seen then tell him to look down *hard*. Grasp lashes of upper lid firmly, and with the other hand press the head of a match against base of upper lid. Holding the match in place pull lid forward and then turn it back. While holding lid thus drop match and with a clean handkerchief wipe off cinder which will generally be found on upper part of eye-ball. If the eye is very sensitive drop in some holocain solution and wait a few minutes for the effect.

Sore eyes must be protected from the light by a handkerchief, by remaining in the dark, or by suitable glasses (see *Snow-blindness*, p. 220).

Injury to the eye. — Apply clean cloths dipped in cold water and changed frequently on the first day. After that wash eye every few hours with clean cold water and keep it covered with a handkerchief. Use eyes as little as possible. Use boric-acid eye-wash frequently and holocain if needed.

Cough, "Bad Colds," Bronchitis.

Causes. — Cough may be due to sore throat, to a tickling sensation in the throat, or to the need of raising "phlegm" from the lungs, *i. e.*, bronchitis. Bronchitis often follows a "bad cold."

(a) For "bad colds" or sore throat, dress more warmly than usual and cover the throat, keep dry, take a hot drink at bed-time and a cathartic, turn in early and wrap yourself as warmly as you can stand it. If you get a long sleep you will be well or nearly so in the morning.

(b) For a tickle-cough or sore throat, gargle every two hours during the day with half a teaspoonful of cooking soda dissolved in a cup of hot water. Do not smoke.

(c) Bronchitis generally lasts several weeks. It is shown by rattling or wheezing in the chest and by the raising of "phlegm" which comes from below the throat. There is generally a good deal of coughing and spitting in the morning and less during the rest of the day. There may be fever or the affected person may feel well otherwise. If there is fever he should stay in bed. Otherwise keep warm and dry, gargle the throat three times daily, and smoke little if at all.

A cough which lasts more than two months may mean tuberculosis. If you have such a cough, stop smoking entirely, and see a physician as soon as possible. Meanwhile eat and sleep as much as possible. Remember that you may be a danger to others. Hence to prevent spreading disease cover your mouth with a handkerchief when you cough, dispose of all sputum carefully when indoors, and sleep away from others.

"*Rheumatism.*"

This vague term is used to mean pain anywhere in the joints or back, for which there is no obvious cause.

Treatment. — Hot applications, hot baths, liniments, or plasters often do good. For drug treatment see p. 268; for treatment of rheumatism with fever, see p. 214, and for strain of back, etc., see p. 253.

Heart-weakness.

Signs. — The first sign is shortness of breath on *slight exertion.* The shortness of breath increases in the course of days or weeks until it is brought on by lying down. There may be a fluttering sensation in the left side of the chest, or pain near the heart, or dropsy of the legs shown by a swelling of the ankles in the day-time, which disappears at night. When the dropsy increases it extends up the legs and does not all go away at night. The swollen parts feel like putty, and pressure on them with the finger leaves a dent. In severe cases breathing is difficult even when sitting still, or on lying down, and there is dropsy not only of the legs but of the abdomen also. The pulse is rapid, 100 or more, and it may or may not be weak and irregular.

Treatment depends on the rapidity of development of the signs and their severity. When signs of heart-weakness appear suddenly after severe exertion, sit down at once, rest for several hours, thereafter avoid doing anything that brings on any of the symptoms, and give up smoking. When *slight symptoms* develop gradually, take warning. (a) Avoid exertion of all kinds, don't smoke, drink no alcohol, and make for civilization in the *easiest* way. (b) If you try to fight heart-weakness you will only make it worse, but, by good care, a weak heart can be strengthened and kept going a long time. (c) Reduce total consumption of liquids of all kinds to one quart in 24 hours. (d) Eat no hearty meals, but eat a little four or five times daily. (e) Take Epsom salts enough to give several watery movements every other day. One tablespoonful may be enough or two may be required. (f) If you feel perfectly well and if the pulse rate returns to normal after a few days of treatment do not imagine you are cured, provided you had definite signs of heart-weakness, *i. e.*, shortness of breath on slight exertion and dropsy of the legs. The only safety lies in avoiding whatever brings on any of the symptoms.

Severe symptoms, if they have developed gradually, indicate a nearly hopeless condition, but if they came on rapidly they may pass off rapidly. The treatment when there is much dropsy or persistent symptoms should be: (a) reduction of liquid intake to one pint in 24 hours; (b) frequent small meals and a simple diet (p. 265); (c) complete rest in a comfortable position sitting up; (d) hypodermic injections of 1/100 grain of digitalin (p. 270); (e) Epsom salts enough every morning to cause three or more watery movements of the bowels; (f) a hypodermic injection of one-sixth grain of morphine should be given at once if the distress comes on rapidly, and if discomfort prevents sleep, one or two doses of morphine should be given during the night to ensure much-needed rest. Sleep should be taken propped up on several pillows.

High altitudes are dangerous for those with weak hearts. The treatment is as above and removal without exertion to a lower level.

Asthma.

Attacks of shortness of breath coming on only at night, or not brought on by exertion, are not due to weak heart and may be due to simple asthma. This is a disease which recurs again and again for years, is most common in young people, and those who have it know what to do. Morphine should not be used because of the danger of habit-forming.

Asthma beginning in middle life or later generally indicates grave heart or kidney disease and requires treatment by a physician. Morphine, one-sixth grain given subcutaneously, relieves it temporarily.

Piles.

Cause. — Piles result from either constipation or diarrhoea.

Signs. — Piles may be internal and may be evidenced only by bleeding, or they may appear as small lumps outside the back passage and cause much pain.

Treatment. — In order to give piles of either kind a chance to heal, the bowels must be regular, soft, and not too frequent (see *Constipation*, p. 198). For internal piles nothing else can be done except by surgical means.

A recent external pile should be washed with cold water and then pushed well inside the anal opening after each movement of the bowels or whenever it comes out. It then shrinks away in a few days.

Piles which are many days old cannot be cured in this way, but the pain can be diminished by bathing them frequently with ice-water. They will shrivel up in time but are best treated by surgical means.

Venereal Diseases.

Gonorrhea: "*The clap.*" — Treatment: (a) simple diet; (b) *no alcohol whatever;* (c) ten glasses of water daily; (d) wear a suspensory; (e) rest for a few days; (f) an absorbent dressing frequently changed; (g) wash your hands immediately after touching; (h) don't try injections or prescribe any medicine unless you have capsules of sandal-wood oil which are taken by mouth.

Syphilis. — See p. 216.

Chancres are sometimes the first stage of syphilis but may be caused by another kind of infection. Keep them clean by washing them with warm water and apply mercurial ointment twice daily (p. 272).

FEVERS.

Temperature, Pulse, and Respiration.

The normal temperature taken by mouth varies from 98° to 99° F. and is usually 98.6°. Temperatures below 98° may be due to prolonged exposure, to insufficient nourishment, to exhaustion, or to debilitating diseases. Temperatures above 99° are called "fever" and they indicate an infection of some sort, except when caused by exposure to great heat. It is unsafe to go about if you have any fever. Temperatures of 101° or more are serious. Infected wounds cause more or less fever and fever from a wound is serious (see *Sepsis*, p. 240).

The normal pulse rate is between 68 and 75 per minute. Higher pulse rates occur when there is fever or weakness of the heart, and transient rapidity of the pulse may be caused by nervousness or excitement. A pulse rate of 120 or more with fever or with signs of heart-weakness indicates danger.

The usual respiration rate per minute is about 15. Fever increases the rate more or less. Rates of 30 or more are common in pneumonia and in severe cases of heart-weakness in which the patient is so short of breath that he cannot lie down. Rates such as these may be found with high temperatures in typhoid or other diseases and are always a sign of danger.

Diagnostic Suggestions.

(a) Slight fever, generally below 101° and lasting only a few days, may go with a "bad cold," or with indigestion, or some other unimportant disorder. The temperature is apt to be normal in the morning and to reach its height about 4 P. M.

(b) Fever which increases within a few hours to 102° or more is often associated with a shaking chill and may indicate pneumonia or malaria when there has been possible exposure to it.

(c) Fever which increases slowly for several days to 102° or more suggests typhoid or some other infectious disease.

(d) Fever with pain and swelling in the joints is rheumatic fever.

(e) Slight fever recurring more or less regularly in the afternoon for weeks or months suggests tuberculosis of the lungs. In such cases there is usually cough and loss of weight and strength.

(f) Irregular attacks of high fever lasting only a few hours at a time are common in tropical or sub-tropical countries and are generally caused by malaria.

General Rules for Treatment of all Fevers.

No special kind of treatment is valuable for fevers except malaria (p. 228) or rheumatic fever (p. 214).

Conserve strength by rest and thus give the body the best chance of recovery. Stay in bed and don't get up unless absolutely necessary. Don't try to travel. The consequences may be very serious.

Take calomel in the evening to clear the bowels, and follow it the next morning with Epsom salts or a Seidlitz powder. If the results are not satisfactory, take an enema. Take an enema anyway on all succeeding days while the fever lasts. Until the temperature returns to normal it is better to use an enema than to repeat the cathartic.

Drink eight to ten glasses of water daily and take very little if any alcohol.

Eat a little food every two or three hours if you can without nausea. Food should be in liquid form, or soft so as to be easily swallowed, and of the plainest kind. Use liquid or simple diet (p. 265).

The quantity of food must be regulated by appetite and power to digest. High fever, a heavily coated tongue, or nausea indicate that food should be taken in very small amounts at a time.

Diarrhoea or vomiting demand reduction of food, and if persistent should be treated as directed above.

Headache: for treatment see p. 204.

Abdominal pain may be relieved by applications of heat or may require an enema (see *Colic*, p. 200).

Severe pain in the back or limbs, prolonged sleeplessness or delirium may require an occasional dose of morphine, but use it sparingly because it often upsets the stomach even when used hypodermically. Ten grains of aspirin may be given once or twice a day for pain or discomfort.

High fever can be reduced and comfort promoted by sponging once or twice daily with cold water. The best way to do this is to put the patient between blankets and to expose and bathe one portion of the body at a time.

Leave nothing which can be used as a weapon within reach of a delirious patient. Restrain him with the voice, attend him constantly, inject morphine if he cannot be otherwise controlled. A patient that is bound exhausts himself struggling, so that restraint of this kind is a mistake.

The eyes and mouth must be kept clean by swabbing several times daily with warm water or boric-acid solution (p. 274).

Treatment of Unrecognized Fevers.

Try treatment for malaria (p. 228) if there has been a chance of getting it within the year or if the patient has had it within three years. If there is not definite improvement in two days start routine as for typhoid fever (p. 213), and continue it as long as the fever lasts. Send for a doctor if possible, if the fever reaches 102° or more, or if it lasts more than three days.

Treat headache, vomiting, diarrhoea, colic, etc., as above described.

When facilities for transportation are bad, a person who has much fever is more likely to recover if kept as quiet as possible in bed. Remember that a strong man may rally from what appears a hopeless condition, and that most diseases with fever have a limited course.

Fever Due to Minor Ailments.

Slight fever due to minor ailments lasts from one to four or five days.

Treatment should be directed against the cause if known (*e. g.*, sore throat) and beyond that it is only necessary to stay in bed, to evacuate the bowels by means of a cathartic, to eat lightly, and to drink plenty of water. Ten grains of aspirin can be taken three times a day to relieve discomfort.

Do not go about when you have fever. To do so is to risk dangerous complications.

Pneumonia.

Pneumonia comes on after fatigue and exposure, most frequently after a debauch, and sometimes in the course of a "bad cold."

Signs. — Rapid rise of temperature in a few hours to 102° or more; sharp pain in the side of the chest which makes breathing painful; rapid, shallow breathing, rate about 30 per minute. A shaking chill is common at the beginning. There is at first a dry painful cough, and later brownish or bloody sputum is raised.

Treatment. — Whereas this disease runs its course in about a week, it is not important that the patient take much food. The essentials are two: (a) wash the poison out of the blood by giving the patient ten glasses of water each day; (b) spare the patient's strength by helping him in every possible way, because the greatest danger is from heart-weakness. The patient must urinate into a bottle and use a bed-pan of some sort rather than get up; he must be propped up in a comfortable position so that he can breathe more easily; he must be allowed to do nothing for himself which can be done for him.

Pain, when severe in the first few days, must be relieved by hypodermic injections of morphine, one-sixth grain at intervals of from six to twelve hours. Morphine should be used at night if needed to obtain sleep.

Distention of the bowels with gas is a bad sign and must be kept down by enemas.

If the pulse rate goes above 120 per minute or if it becomes irregular, use 1/100 grain of digitalin hypodermically three times daily. It acts slowly and continuously. Tea or black coffee is the best quickly acting stimulant.

Suicide is so common in pneumonia that a patient even when not apparently delirious, should not be left alone. In other respects follow the general rules for fevers.

Typhoid Fever.

Typhoid fever and other fevers which simulate it begin gradually and run a course lasting several weeks. The illness may be comparatively mild or may prove fatal.

Signs. — Fever increasing gradually for several days to 102° or more; loss of appetite; pain in the back and limbs; headache; increasing weakness.

Treatment is the same for typhoid and for all fevers which simulate it, provided that the disease is not malaria.

Owing to the long course of these fevers it is very important to conserve the patient's strength, as in pneumonia.

Food is important. If very little can be taken at a time, it should be offered every hour or two, and if hardly any food be taken, whiskey, well diluted with water, should be given up to a pint in 24 hours. Liquids, including liquid foods and water, should total not less than twelve glasses per day.

When there is fever above 103° or delirium, give a sponge bath every six or eight hours. Violent delirium requires morphine. For abdominal distention use frequent enemas as in pneumonia.

The patient may need to be catheterized every eight hours, particularly if morphine has been used. A symmetrical swelling in the lower central abdomen indicates an over-distended bladder. In other respects follow general rules for fever. Never give the patient up. Even when the condition seems most hopeless recovery may begin.

Rheumatic Fever.

Signs. — Pain, swelling and redness of joints, with fever. The disease generally passes from joint to joint on successive days and may last several weeks. Lasting damage to the heart is a common sequel.

Treatment as for fevers; protection of the affected joints by soft wrappings and, in extreme cases, by the use of splints to prevent motion; aspirin in large doses. When fever, pain, and swelling are gone keep the patient in bed for another week to avoid heart complications. Continue the aspirin, 30 grains daily, for at least two weeks after the last sign of the disease to prevent its return.

NOTE. — For *Fevers of the Tropics,* see p. 227; for *Fever caused by Wounds,* see pp. 241, 242.

SKIN DISEASES.

Skin diseases present such infinite variety and the diagnosis is so difficult that it seems best here to discuss them mainly by groups.

Very Common Diseases.

(a) *Hives* is caused by digestive disturbances. It is characterized by the appearance on the skin of pink swellings which itch very much and which come and go rapidly.

Treatment. — Free evacuation of the bowels and a light diet for a few days. For the itching dissolve one-half teaspoon of cooking soda in a glass of water and paint it on the skin.

(b) "*Prickly heat*" is very troublesome to some persons in hot weather. It attacks chiefly the crotch and arm-pits where sweating is most profuse. The skin is reddened and there is a sensation of burning and itching.

Treatment. — Scrupulous cleanliness of the parts affected and talcum powder or flour.

(c) *Pimples* are superficial infections with formation of pus.

Treatment. — Free use of warm water and soap, avoidance of greasy food, and applications of sulphur ointment (p. 273).

Acute Inflammatory Diseases.

These include sun-burn, ivy poisoning, or anything that develops quickly. There may be redness, itching, or a burning sensation of the skin with slight swelling, or crusts and blisters in which water or pus collects. The skin may then scale off and leave painful ulcers.

Treatment for this group consists in soothing and protective applications. Soap should not be used on them and even plain water may irritate the inflamed parts. Applications of boric ointment, oil, lard or unsalted fat, and protection by covering with thin soft cloth generally do good. If there is pus, apply twice daily sulphur ointment.

Chronic Skin Diseases.

(a) *Chronic eczema* may be localized or may cover the entire body. To heal it is most difficult, and unskilful treatment is apt to make the condition worse.

Treatment. — The traveller is strongly advised not to attempt treatment but if he wishes to try the methods just advised for acute and inflammatory diseases he may do so with little danger and some prospect of benefit.

(b) *Ringworm* is a slowly progressing localized condition often having a ring-like appearance. It is caused by a minute fungus and is mildly communicable by contact. Horses and cats suffer from it. When it comes in the crotch it makes a sharply defined red area and is sometimes called "red-flap."

Treatment. — Free use of soap and water, sulphur ointment twice daily, and thin protective dressing.

If this strong ointment causes increased inflammation stop using it and apply treatment recommended in previous section until the inflammation has disappeared. Then use the sulphur ointment again for a few days.

(c) "*The itch*" (*Scabies*). — This disease is caused by a very small animal parasite which burrows into the skin. The itching is intense at night and the skin is often covered with scratch marks. The eruption consists of small red swellings or dots and is found most often between the fingers and on the fold of the arm-pit and about the groins and genitals. It seldom extends above the shoulder or below the knee.

Treatment. — A hot bath and scrub with soap; then before going to bed apply sulphur ointment all over the body except the head and face. The inner layers of bedding and the underclothes must be boiled or dipped in gasolene to kill the vermin.

Repeat this treatment for four nights in succession unless the skin becomes inflamed. If this happens, omit using the ointment for a few days and then resume treatment.

Syphilis.

Syphilis is found everywhere. It is called a venereal disease because usually, but not always, contracted in the course of sexual intercourse. In its later manifestations its symptoms are too numerous to mention. Fortunately its later are its least contagious forms. The initial symptom is a hard, usually not tender, sore with a dirty ulcerating surface occuring at the point of infection, which may be the lip. The sore appears two or three weeks after exposure and usually lasts about two months. The so-called secondary symptoms make their appearance about six weeks after the sore. They consist of a rash which may be anything from some faint red or copper-colored spots to a general pustular outbreak almost resembling small-pox. A syphilitic rash rarely itches. The glands in the groin, axilla, and neck become enlarged and hard though usually not tender. There may be a sore throat or a rapid falling of the hair, and the occurrence of white patches in the mouth is common. The patient may or may not feel very ill. In the stages described above the disease is highly contagious through drinking cups, eating utensils, and towels as well as by personal contact.

Treatment. — See an experienced physician at the first opportunity, whether signs of the disease then exist or not. Salvarsan or "606" is the best curative but is dangerous except in the hands of a skilful physician. Diarsenol is now used instead of salvarsan. There is no important difference if any.

Mercury is the next best drug. It can be taken in pill form but is most efficient as an ointment (p. 272). An amount of mercurial ointment about the size of a large pea should be placed in the palm and rubbed into the skin of the body where it is free from hair. The rubbing should be continued vigorously until the ointment all disappears. Because irritating to the skin, use a different part of the body each day for a week. Then begin again at the first place and continue for a second week. After this, use the drug alternate weeks for three months, even if all the signs of the disease have disappeared. Mercury has serious ill effects if used in excess.

Tropical Skin Diseases.

(a) "*Dobie itch,*" "*tropical ringworm*" *or* "*gogo,*" "*pinto,*" *and* "*craw-craw*" *or* "*coolie itch*" are caused by minute fungi like that of ringworm.

Treatment for all is the same: namely, soap and warm water and sulphur ointment applied once daily and repeated for a considerable number of days. If the skin becomes inflamed from the ointment stop using it for a few days and apply boric ointment; then continue. Complete cure is difficult if the disease is extensive.

(b) *Tropical ulcer,* "*Yemen ulcer.*" — These ulcers often follow some trivial injury and spread rapidly. The surface is foul and dirty looking.

Treatment. — Clean with soap and water, paint once daily with tincture of iodine (p. 270) until the surface looks clean and red; dress cleanly twice daily.

(c) *Leprosy* is a very chronic disease most common in the Tropics but by no means confined to them. It is very slightly contagious and by no means a dangerous disease to the traveller. The traveller who avoids actual contact with lepers, dirty people, and their bedding need not fear it at all.

Treatment. — It is not worth while to attempt anything beyond the care of local infection or the dressing of ulcers incidental to the disease. Wash your hands afterward and you will be safe.

(d) "*Yaws*" *or* "*fromboesia*" is a tropical skin disease resembling syphilis in many respects. It is common in northern South America and in the Philippines and is rather contagious.

Treatment. — Salvarsan or diarsenol are the only drugs having much effect on it. They are too dangerous to be used except by expert physicians.

Vermin.

(a) *Fleas.* — Where there are many fleas, boots, leggins, and long drawers help much to keep them out. Painting the skin with a strong solution of Epsom salts is said to keep them off, or the underclothes may be dipped in sulpho-naphthol solution (a teaspoonful to two quarts of water), wrung out and dried before wearing. Either of these methods may cause irritation to a sensitive skin.

At night a thin cloth bag can be used to sleep in. Its seams must be tight and the bag should pull well up to the neck; or flake naphthalene (used to keep moths out of clothing) can be scattered in and around the bed. To many its smell is unpleasant. Dalmatian powder or Keating's powder are probably less effective, but they are practically odorless.

(b) *Bed-bugs:* as for fleas at night.

(c) *Lice.* — There are three kinds: the "gray-back" or body louse which inhabits the clothes and body in general, the head louse, and the pubic louse or "crab."

The body louse lays its eggs in the clothing, the head louse in the hair of the head, and the pubic louse in the hair of other parts. It is easy to kill the lice but the eggs are more resistant.

Treatment. — (1) For body lice, boil or steam all clothes and inner layers of bedding in a large pot or oven or dip them in gasolene. Steaming destroys leather garments and they seldom need disinfection except in the Arctic. Wash with soap and water and put on clean clothing.

(2) For head lice clip the hair short which removes the eggs; then shampoo.

(3) For pubic lice clip the affected parts and wash clean or rub on a very little mercurial ointment three times on alternate days.

HYGIENE AND DISEASES OF THE ARCTIC.

Hygiene of the Arctic.

Hygiene in the Arctic is essentially the same as for temperate climates, but a few points require mention.

Food. — Extreme cold increases the capacity to digest fat, and much grease is needed to keep the body warm. Too much grease causes "sour stomach" or diarrhoea which stops in a day or two after correcting the diet. Do not go without vegetables or fresh meat for long. Scurvy results.

Drink. — Snow or ice should not be swallowed except in small quantity. If thirsty hold a piece of ice or a little snow in your hand until wet and then suck off the water quickly. Otherwise your tongue will get sore and thirst will increase. Ice gives more water than snow.

Take no alcohol except in an emergency. If you take it before or during exposure to cold you will probably get frozen. Its only use is to counteract the effects of exposure after a warm shelter has been reached. Tea is far better for this purpose.

Clothing and bedding. — These should be light to prevent sweating, loose everywhere to be warm, and ventilated to keep them dry. Never sleep in a garment which binds anywhere because it impedes circulation, and never use a waterproof sleeping-bag because it becomes soggy. Dampness of night-clothes or bedding must be avoided in cold weather.

Exposure. — Above all don't get wet. There may be springs along the banks of streams or water on the ice. If the feet or any other part get wet change to dry clothing at once or make a fire and dry out.

Diseases of the Arctic.

Frost-bite, or superficial freezing, is generally due to exposure to wind as well as to cold. It shows as a white spot on the skin.

A warm hand held over the spot causes it quickly to disappear, but hard rubbing with the hand, or worse still with snow, is apt to rub off the skin. When there has been loss of skin the resulting ulcer should be treated like a burn (p. 245). Do not pick or chip frozen parts. They heal better if let alone.

Cold exhaustion. — No well man, rightly dressed and well fed, ever froze to death so long as he kept dry. When lost in a blizzard or in darkness, an Indian finds shelter which will prevent the snow from drifting against the warmer parts of the body where it might melt, pulls his arms inside his shirt, squats down and waits for daylight or for moderation of the storm. The principles he follows are three, namely: (a) to keep dry; (b) to save body heat; and (c) to save strength.

Exhaustion comes on in men enfeebled by hardship. To save life a warm shelter must be quickly reached. Then give the man a cup of strong, hot tea, strip and wrap him in blankets previously warmed, and lay him in a comfortable position. If hands and feet stay cold rub them, and presently give him some more tea, or a small drink of brandy. As soon as strength begins to return, give food in small amounts every half hour.

Snow-blindness.

The disease is caused chiefly by glare, and varies in severity from slight irritation to severe inflammation, and even total blindness. The same sort of irritation or inflammation may be caused by the glare of a tropical sun on water or in a desert.

Prevention. — If going to the Arctic, climbing snow mountains, or travelling in the Tropics, take with you the darkest smoked or amber goggles which fit the face closely to exclude light from the side. The Eskimos bind on a piece of wood which has been fitted to the face and provided with a slit to see through. It does not frost as goggles may and is equally good in other respects.

Treatment. — At the first sign of irritation protect the eyes from bright light and use them only when absolutely necessary. If you must go on, rest the eyes by keeping them fixed on a dark object, and blacken the lids, cheeks, and bridge of the nose. Use amber or smoked glasses.

If the eyes become painful and swollen stay in the dark for a few days and let them get well before proceeding; otherwise you may lose your sight.

Meanwhile keep the eyes clean by bathing them outside every few hours with clean warm water and a soft *clean* cloth. Then put in drops of boric-acid or zinc-sulphate solution and grease the edges of the lids with boric ointment to prevent them sticking. If there is much pain put drops of holocain solution in the eyes every four hours.

When blindness develops it is slow to get well and requires prolonged care of the eyes, prevention of exposure to bright light or strain, and wholesome living. As a rule part, at least, of the sight can be restored.

Scurvy.

Cause. — Prolonged deprivation of fresh meat and vegetables.

Prevention. — Never go to the Arctic without fresh vegetables, lime-juice, or something to prevent scurvy.

Signs. — First stage: weakness, apathy, pallor, drawn appearance of face, and sometimes a little swelling of the ankles so that pressure with the finger leaves a dent, and it may be noticed that every little knock leaves a bruise.

Later stage: shortness of breath, faintness, swelling of the gums with or without ulceration, very foul breath, appearance of red or purple spots on the skin. These spots are due to bleeding into the skin, and in very severe cases the skin comes off and leaves ulcers. There may be bleeding from the digestive tract or internal organs so that blood may appear in excretions.

Treatment. — Rapid improvement and prompt recovery generally follow the use of the right food, but in some cases the sufferers die.

(a) Eat fresh vegetables or fruit if any are obtainable. If not, eat preserved vegetables, or drink the juice of fresh meat, or take fresh milk, or eat sauer-kraut, or dried vegetables. Lemonade made from fresh lemons is very good. Preserved lime-juice is good, but when kept long may decompose, and is then less valuable.

(b) Avoid cold and damp and unhygienic surroundings.

(c) The juice of non-poisonous plants may serve in case of need.

Beri-beri.

This disease is dangerous in its severe forms. It is caused by deprivation of certain elements of food the nature of which is not yet known. It is not uncommon in the winter in Newfoundland and probably in many other places where people are reduced for long periods to a monotonous and insufficient diet of flour and tea. If unbolted flour were used instead of white flour this disease would probably be far less common than it is. The symptoms are: pain, swelling and weakness or paralysis of the legs, and death from heart-failure may follow. This disease is quite different from scurvy although it develops under similar conditions.

Treatment. — A wholesome and varied diet will effect a cure within a few weeks and improvement begins promptly. Vegetables of almost any kind are particularly desirable.

Starvation.

Starving people may be ravenously hungry or weak and exhausted. The former may overeat to the point of danger if allowed to do so. The latter may require tea or an alcoholic drink to start them on the road to recovery. They should then be fed with liquids administered frequently in small quantities. When appetite and strength begin to return food can be allowed in moderation.

Vermin.

The body louse is the principal pest. It can be killed in clothing in cold weather by leaving the clothing out over night. The Indian or Eskimo squaws are expert at picking off nits, which are the eggs of the louse. In warm weather clothing can best be cared for by squaws.

Further information about vermin will be found on p. 218.

HYGIENE AND DISEASES OF THE TROPICS.

Hygiene of the Tropics.

Important Rules.

(a) Be vaccinated today against small-pox unless vaccination has "taken" within the year.

Be innoculated today against typhoid and paratyphoid unless you have had the usual three injections within two years.

(b) Drink only water that has been properly sterilized (p. 224) and handled afterward in a cleanly manner, or bottled water sold by a reliable house. Take the same precautions when brushing the teeth. To disregard this rule is to invite death from dysentery, cholera, etc. Even clear spring water in the Tropics is dangerous.

(c) Eat no raw vegetables and no raw fruits which grow near the ground. They may cause dysentery, typhoid fever, cholera, or worms.

(d) Drink no alcohol. Alcohol is the greatest single cause of disease among whites in the Tropics and is ultimately responsible for many deaths from fevers, liver abscess, etc., "Old Resident" to the contrary notwithstanding.

(e) Sleep always under a good net, and protect yourself from mosquitoes after dark. Malaria is carried most often by night-flying mosquitoes and is found practically everywhere in the Tropics.

(f) Don't take hard exercise or expose yourself needlessly to the sun during the hottest part of the day.

(g) Don't over-eat of meat or greasy foods. Keep the bowels clear. A deranged digestion predisposes to dangerous intestinal diseases. Therefore follow the rules for care of digestion (p. 191).

(h) Regular exercise stopping short of fatigue cannot be too strongly advised. It stimulates the digestion and bowels, and keeps the body tuned up.

(i) Baths as a rule should be warm, but after exercise a cool bath may be very refreshing.

(j) Do not neglect seemingly trivial ailments. They may have serious consequences.

(k) If taken sick with fever try quinine, whatever the symptoms, because you may have malaria.

(l) In care of health follow general rules as for temperate climates.

Food.

The quantity of food required in hot weather is less than in cold. Greasy foods, and meat should be restricted and the diet mainly vegetables and fruit. Hard work, however, whether mental or physical, requires plenty of food.

Drinking-water.

Water should always be considered unsafe unless boiled, distilled, or properly disinfected. Intestinal diseases such as typhoid, dysentery, and cholera are most often caused by drinking polluted water. The germs of these diseases can be killed by boiling the water for ten minutes, but heating it without boiling is not sufficient. Instead of boiling the water a chemical disinfectant can be used. Chlorinated lime is the best of these.

The most convenient method for large expeditions is the Lyster bag used in the United States Army. It is made of waterproof canvas, holds forty gallons, and has faucets. Water should always be drawn from the faucets because to dip it out offers opportunity for contamination.

The chlorinated lime is prepared for the United States Army in glass ampules containing 15 grains or one gram each. Break the ampule after filing the neck, dissolve its contents in a cup of water, pour this into the

Lyster bag, and then wait half an hour before using the water.

Chlorinated lime is less satisfactory for disinfecting small quantities of water because it deteriorates on exposure to the air. It keeps fairly well in an air-tight tin or well stoppered bottle and from this supply a stock solution should be made every six days and kept in a well stoppered, colored bottle. To make the stock solution dissolve half a level teaspoonful of lime in a pint of water. Of this solution use one teaspoonful to ten gallons of water, 36 drops to one gallon, or nine drops to one quart, and let it stand half an hour before using. Burroughs, Wellcome & Co. put up chlorinated lime in one-grain tablets and supply directions for using it.

To cool water in small quantities for drinking the "desert" or "Egyptian" water bag, or an unglazed earthen jar is excellent.

For general information about water and other drinks see pp. 193, 196.

Clothing.

Dress like the resident European. He generally wears light woolen or drill outside loose, absorbent underclothing. The underclothing is most important. It should be of light wool, wool and cotton, or wool and silk.

Where sudden changes of temperature come at sundown, or after a shower, take care not to get chilled. When this may happen, wear woolen outer garments and if you perspire freely or are subject to diarrhoea or "colds," wear a flannel "belly-band" or cholera belt. Woolen is much worn in India, Africa, and the Hawaiian Islands. In the Philippines, Java, the Caribbean, and northeastern South America, drill or pongee is suitable. For hunting almost anywhere in the Tropics a light flannel shirt is good.

Hats.

Helmets are much used in India and Africa where the sun is intense. The best substitute for a helmet is a broad-brimmed felt hat with large holes for ventilation.

The Panama hat, unless supplemented by an umbrella, gives insufficient protection.

Mode of Life.

The old-fashioned Spanish architecture and the *siesta* are admirably adapted to life in the Tropics. Don't "hustle." During the hottest part of the day avoid hard work and keep in the shade. Exertion at such times is exhausting, and to take alcohol may bring on heat-exhaustion or sun-stroke. If you must go out, carry an umbrella.

Eyes.

When there is much glare, as for example from smooth water, or in the desert, wear smoked or amber, or Crooke's glass goggles fitting the face closely at the sides. Various shades of these can be obtained. It would seem wise to carry one pair of medium and one pair of dark goggles. Such glasses not only prevent sore eyes (see *Snow-blindness*), but they keep off headache and other ill effects of bright light.

Protection from Insects and Ticks.

A mosquito-net to sleep under is essential. Where there are sand-flies no sleep is possible except under a gauze net because the mesh of a mosquito-net is not small enough to keep out sand-flies.

For methods of keeping off fleas, etc., see p. 218.

To deter biting insects during the day-time various kinds of "fly-dope" are used when a head-net is not considered desirable or practicable. Information on this subject will be found in another chapter.

Ticks, as in some parts of Africa, are often dangerous as carriers of disease. They infest grassy regions or old camp sites. Leggins and trousers soaked in kerosene discourage their attempts to obtain foothold. Sleep off the ground.

Diseases Peculiar to or Commonest in the Tropics.

Effects of Heat.

(a) *Heat-exhaustion* follows exposure to the sun or to great heat. There are apt to be predisposing causes such as debility from disease, excessive fatigue, and especially drunkenness.

Symptoms are faintness, pallor, small weak pulse, clammy skin, and subnormal temperature; sometimes fainting.

Treatment. — Lay the patient on his back in the shade, loosen the clothing, fan him, and give stimulants. Tea is the best stimulant, coffee will do, and failing these, one tablespoonful of liquor, but not more, should be used at a time. If the patient has fainted, put the head low, raise the body, and pour cold water on the forehead. If unconsciousness persists, use stimulants by rectum (p. 264).

(b) *Sun-stroke* develops under conditions like the preceding but is more common in hot weather in the North than in the Tropics.

Symptoms are drowsiness, headache, and weakness, rapidly followed in an hour or two by unconsciousness, perhaps with noisy breathing, dusky or purplish face, rapid pulse, delirium, or even convulsions. The skin is dry and burning hot, the temperature 108° F., more or less. There is danger.

Treatment. — Lay the patient stripped on a rubber sheet with its edges supported to make a trough. If there is ice, break it into small pieces and pack it around his head. Rub the body with ice, and meanwhile be sure to keep a thermometer in the rectum and to look at it often. When the temperature has dropped to 104° remove the ice, dry the skin, wrap the patient in a thin blanket and give stimulants as for heat-exhaustion, above.

If the ice be used too long the patient's temperature will drop quickly below normal. When there is no ice, use cold water. Cases with fever from 103° to 105° require less rigorous treatment. As soon as there is time, give 20 grains of quinine subcutaneously on the chance that the attack was caused by malaria.

If no quinine for subcutaneous use is available give 30 grains by mouth or 40 grains by rectum.

Diseases Carried by Mosquitoes.

(a) *Malaria.* — The worst kinds are found chiefly in the Tropics but malaria is common locally in many temperate climates and may be dangerous even there.

Prevention. — Where there is malaria: (a) always sleep under a mosquito-net. (b) When possible select for the camp high ground where there is a breeze. (c) Smudges help to keep off mosquitoes. Malaria-carrying mosquitoes fly chiefly at night. (d) Protect the ankles in the evening by wearing an extra pair of socks or better, by boots. (e) *Most important of all, take daily after dinner five grains of quinine.* (f) At the first sign of fever or unexplained illness take larger doses of quinine (p. 271).

Recognition of malaria is easy when it shows itself by fever and chills coming on alternate days, or every third day, with usual health between. Such cases are rare in the Tropics where fever, with or without chills, is more often of daily occurrence. The temperature is apt to be very irregular and to drop to normal at some time during each day. In a typical chill there is a cold stage in which the patient shakes and cannot get warm although his temperature be high, the hot stage when he seems to be burning up, and the sweating stage during which the temperature falls rapidly. During a chill the temperature may reach 105° or higher. In other types of malaria there may be only headache, weakness, or vomiting, with little or no fever.

The more dangerous cases may have bloody urine, severe pain like that of appendicitis, suddenly appearing mania, gradually increasing weakness, and fever like typhoid, or symptoms suggesting sun-stroke or heat-exhaustion. Malaria may first appear, or may return, after leaving the Tropics.

Treatment. — Owing to the difficulty of recognizing atypical malaria, take quinine whenever ill in a malarious region or within several months after having been exposed to malaria, no matter what the symptoms are.

For the milder kinds first described, take ten grains of quinine every four hours for a week or until the ears ring. If the ears ring, stop the medicine until its unpleasant effects have passed, and later continue it for a week in as large quantities as can be taken without bad effects. Stay in bed or keep as quiet as possible until well, eat as much of a simple diet as can be taken without distress, and drink at least eight glasses of water daily. If the symptoms were caused by malaria and if the quinine has been taken as directed, the patient will improve rapidly and feel well in a week or less but should continue to take quinine, 20 grains daily for another week. If he does not soon improve under this treatment, he may have some other disease, perhaps dengue (below) or typhoid fever.

The dangerous kinds of malaria mentioned above require large doses of quinine in order to get the effect of the drug quickly. Give 15 grains with a hypodermic syringe intramuscularly. If death seems near, repeat the dose in two hours and again four hours later. If the patient gets worse there is little hope. He may die soon or slowly, or may recover. Send for a doctor at all costs if one can be reached in a few days, but do not transport the patient.

When improvement follows treatment, continue to use quinine subcutaneously or by mouth according to the severity of the illness and give as much as the patient can take without signs of poisoning.

When quinine cannot be given subcutaneously or by mouth, dissolve it in a cup of warm water and give it by rectum as an enema. The dose by rectum should be from 20 to 40 grains according to urgency of symptoms. Treat in other respects as for typhoid.

(b) *Dengue or "break-bone" fever* is common in Mexico, in Texas, and in some parts of the Far East.

Prevention. — As for malaria, except that quinine is of no use. When there is an epidemic avoid crowds and thickly settled places, and leave the locality if possible.

Recognition. — Remarkably severe pain in the back, limbs, etc., with fever which increases for a few days, subsides, and recurs, this sequence lasting about a week. There may be a skin eruption or swollen joints so that dengue may be confused with rheumatism or other kinds of fever.

Treatment. — As for fevers in general (p. 210). Morphine may be needed for the pain. Nearly all cases recover.

(c) *Yellow fever* is a mosquito-borne disease found in parts of Mexico and on the Caribbean Sea where sanitation is bad.

Prevention. — As for malaria. When there is an epidemic avoid crowds and thickly settled parts of the town. Leave if you possibly can. The disease is very dangerous.

(d) *Elephantiasis.* — Wherever there is much of this disease about, it is important to guard against mosquitoes in the same way as in malarial regions (see above).

Other Insect-borne Diseases.

(a) *Plague.* — The infection is carried from man to man or from rat to man probably by the rat flea. There is more or less plague constantly in Hong-kong, Calcutta, Bombay, and other eastern ports, and in some of those of South America.

Prevention. — For the cleanly traveller who does not come in close contact with dirty people the chance of getting plague is negligible except where there is an epidemic. At such times leave promptly if you can. Otherwise avoid the vicinity of filth and protect your legs with high boots.

Recognition is difficult and treatment unsatisfactory but anti-plague serum saves some lives. The traveller is not likely to get plague when beyond the reach of civilization, but, if he gets sick where there is plague about, he should send at once for a doctor.

(b) *Sleeping sickness or trypanosomiasis.* — This disease is widespread in Africa from Senegal to Lake Victoria, and in the Congo Basin. It is transmitted by the bite of tsetse flies that have become infected. These flies are common in the jungle near water but are seldom seen in the open, or above 4500 feet altitude. Sleeping sickness is nearly always fatal after months or years.

Signs vary very much. There is apt to be fever for a week or two, followed by local redness and swelling of the skin which lasts for a few days. This may be followed by fever for weeks which may be intermittent or continuous, slight or high, and very irregular. Headache is common, and after a time the glands of the neck or in other parts of the body become swollen and may be painful. Debility, pallor, and physical or intellectual feebleness develop gradually. The condition called "sleeping sickness" is the terminal stage.

Prevention. — (a) Camp only on open ground, preferably elevated and at a distance of a quarter mile or more from swamps or bodies of water. (b) Wear head-net and gloves by day and sleep under a net at night. (c) Keep away from settlements where the disease is rife.

Treatment is most unsatisfactory. Travel until you reach a good physician. Meanwhile treat symptoms as they arise and save your strength in every possible way.

Intestinal Infections.

(a) *Dysentery.* — Real dysentery is a dangerous infection prevalent in warm climates, in Japan, and in China. In the northern United States severe diarrhoea or ptomaine poisoning are sometimes spoken of as dysentery.

Prevention. — Where dysentery is common, and in all parts of the Tropics, take the same precautions about food and drink as advised on pp. 191, 192.

Recognition. — There is fever, colic, and severe diarrhoea. Slime soon appears in the stools, and later blood as well. There is painful straining at stool and a constant desire to defecate. Some patients get rapidly worse and die in a week, others live longer or begin to recover after several weeks, and still others have alternating periods of constipation and diarrhoea, which becomes chronic. In the severe types there is fever of 102° or more.

Treatment. — In any case in which the symptoms are like dysentery it is safe to treat as such. If the traveller thinks he has dysentery, he should try treatment for diarrhoea. If, after three days, he is much worse, or has fever of 100° or more, he should get a doctor at any cost, but stay where he is. Meanwhile treatment should be as follows: try subcutaneous injections of emetine; hot applications for abdominal pain; repeated small enemas of flour paste to relieve straining. Morphine (p. 269), one-eighth grain, can be injected subcutaneously at intervals of six hours or more to check the pain if necessary. Do not use enough morphine to stop the diarrhoea.

Diet and general care as for typhoid (p. 213) but fluids should be taken in larger amounts to offset the diarrhoea.

(b) *Cholera* is almost entirely confined to the Far East. It is not a serious menace to the traveller except when there is an epidemic starting or in progress.

Prevention. — Under ordinary circumstances carefully observe rules (b) and (c), p. 223, above.

In case of an epidemic get away if possible; otherwise have anti-cholera innoculation and eat only food just cooked and still hot.

Signs. — The disease begins with fever, vomiting, and diarrhoea; the last rapidly increases and becomes so severe that neither food nor liquid can be taken.

Treatment. — Mild cases recover without treatment. For severe cases the unskilled attendant can do nothing except apply hot applications to the abdomen and give morphine subcutaneously, one-eighth grain every four to six hours, if needed, for pain.

If a physician or a nurse can be had who knows how to use salt solution and alkali intravenously, life may be saved. Don't lose an hour. This disease runs its course in a few days.

(c) "*Hook-worm disease*" (*anchylostomiasis*), "*dirt-eater's anemia,*" "*ground itch.*" — This disease is very common in our southern States and in many tropical and subtropical countries. It is characterized by gradual loss of strength accompanied by pallor and lassitude. Unlike malaria, which even in the chronic forms may be expected to show fever at times, hook-worm disease is afebrile. The disease lasts many years.

The symptoms are caused by small, blood-sucking worms which hook themselves to the inside of the intestines, — hence the name of the disease. Hook-worm disease is generally contracted by those who go barefooted where the soil has been contaminated by the intestinal discharges of others having the disease. The parasite enters through the skin of the feet where it produces an eruption known as "ground itch."

Prevention. — Keep the feet clean. Do not go barefooted.

Treatment. — There is no need for haste in obtaining treatment because the disease progresses slowly. Oil of chenopodium, the drug generally employed, is an efficient remedy but precautions are required to make its use safe. It should be prescribed by physicians only.

Bilharzia Disease.

Distribution. — Bilharzia disease (or schistosomiasis) is widely distributed. It is found in the West Indies, Central and South America, Central and South Africa, Asia, India, and Japan. Where it is not very common the traveller need pay no attention to it, but in the dry season in Egypt, in Senegal, or in the Gambia, wherever water is obtained from dug wells, there is danger.

Mode of infection. — The infection is caused by a worm, the eggs of which probably gain access to the body from polluted water when used for drinking or bathing.

Symptoms. — The worm, after development in the body, lays its eggs in the urinary bladder or in the rectum and produces there a chronic inflammation characterized by pain and the discharge of blood, mucus, or pus. When the bladder is attacked the disease is usually believed by the African native to be gonorrhoea. Rectal bilharziosis may be mistaken for piles or for chronic dysentery. The first symptoms probably do not appear for three to six months after the infection took place. The disease is very gradually progressive and generally ends fatally if the patient remains where he contracted it.

Prevention. — Precautions are necessary in regard to drinking water and food as for dysentery (p. 231); but contaminated water may also be dangerous for bathing. If not convenient to have bath-water boiled have it drawn in advance and add enough sulpho-naphthol or other coal-tar disinfectant to give the water a milky appearance, *i. e.*, about two teaspoonfuls to a bucket of water, and let it stand for at least two hours before using. If the mixture be too strong, irritation of the skin will follow its use.

Treatment. — Do not remain in any country in which bilharziosis develops. Seek the best medical advice.

Bites of Poisonous Snakes.

Treatment. — In all cases the immediate object is to get out of the wound as much poison as possible and to prevent the remainder from passing rapidly into the circulation. To do this for bites in the extremities apply tourniquet at once to finger, or to limb *above* the wound. Then slash wound open with a knife to allow free bleeding. If you have permanganate of potash make a strong solution and soak the wound with it. Otherwise wash it thoroughly with water. Leave the tourniquet in place for thirty minutes. After that loosen it for a few seconds every ten minutes for an hour more before taking it off. A tourniquet left on too long causes gangrene of the limb.

Whiskey is useless for snake-bites, but in various places anti-venom sera are made which are beneficial when used immediately against the poison of the kind of snake for which they were made (p. 272).

SURGERY.

Asepsis.

Aseptic methods or surgical cleanliness means the elimination, so far as possible, of all bacteria from the wound, instruments, hands of the operator, and surgical dressings. In the case of instruments and dressings, asepsis can be made absolute by boiling or by exposure to sufficient heat to kill all forms of organic life. Only comparative asepsis can be obtained for wound, neighboring skin of the patient, and the hands of the operator (when rubber gloves are not available). For these purposes scrubbing with soap, warm water, and a brush is most valuable, and antiseptic solutions can be used afterward. Any approach to surgical cleanliness is better than none.

As regards the efficiency of antiseptic fluids or tablets to be dissolved in water, any fluid that destroys organic life is more or less irritating to the skin. The disinfectant now in greatest favor with military surgeons all over the world is tincture of iodine (p. 270). It is used by painting it on the skin, and is of little value if the skin be wet. Alcohol 70 percent is also regarded with favor. Brandy and other distilled liquors contain from 50 to 60 percent of alcohol and so can be used as a disinfectant. If none of these is available, gasoline, benzine, or kerosene may be used for cleansing.

Corrosive sublimate has the disadvantage of coagulating any albuminous matter around, and so protecting bacteria from the solution. Moreover, when in sufficient strength to be very efficient, it is very irritating. Carbolic acid has the same effect. Potassium permanganate, while cleansing and not irritating, has very little bactericidal power.

Dressings and sterile towels. — Gauze for dressings can be carried in small packages already sterilized. It is useful for swabbing out wounds, for packing infected wounds, and for covering clean wounds. As a substitute for it, handkerchiefs or pieces of cloth can be boiled for twenty minutes or soaked for twenty minutes in corrosive-sublimate solution, 1–1000 (p. 271).

Towels can be prepared in the same way and used to lay sterile instruments on or to cover unsterile parts or objects which might be touched by the hands of an operator while at work.

Metal instruments except knives should be tied up in a towel and boiled for twenty minutes. When wanted, the towel is spread out with the instruments upon it. Corrosive solution injures metals.

Knives are dulled by boiling and spoiled by corrosive. They should be soaked in alcohol 70 percent, or carbolic 4 percent, for twenty minutes. Kerosene will serve as well as anything.

"*Suture material*" means silk, catgut, or other substances used for sewing. When used for tying, these materials are called sutures. They should be boiled or soaked in corrosive-sublimate solution, 1–1000, or carried in glass tubes sterilized and ready for use. When the suture material is in such a tube scratch the tube with a file and drop the tube into the corrosive bowl. The operator can then pick it out when needed, break the tube, holding it in a sterile towel or piece of gauze to protect his hands, and get his suture without "breaking his asepsis."

Hands of the operator. — Cut and clean the nails. Scrub the hands and especially the nails with soap and brush, and several changes of warm water for five to ten minutes. Rinse in alcohol, 70 percent, or corrosive sublimate, 1–1000. Then touch nothing not previously sterilized. If you do so, wash the hands again with soap and rinse them thoroughly in the antiseptic. Soap and clean water is more reliable than an antiseptic. Both are better than either alone.

Cleansing of wounds. — Methods vary with the nature of the wound and materials at hand. For the skin around the wound, painting with tincture of iodine is satisfactory. If you have none, scrub it with soap and water, then wash off with corrosive-sublimate solution. If iodine is to be used, do not wet the skin. The wound can be scrubbed out with soap and water, irrigated with warm, boiled water or with corrosive solution, 1–5000, or tincture of iodine can be poured into it. See p. 242, where treatment of different kinds of wounds is described.

Preparation for operation. — The assistance of a second person is very important if the operator is to maintain his asepsis. Before beginning the operation, however trivial, think of every step to be taken and prepare *all* the things that will be needed for every step, as follows:

(a) Get the patient in a convenient position where the light is good. For any but the most trivial operation he should lie down lest he faint. (b) Have a table for the instruments; (c) bowl of corrosive to rinse the hands, and put towels into it if they are to be used; (d) materials and solutions for cleansing the wound; (e) instruments — knife, snaps, forceps, scissors, etc; (f) suture material and needles; (g) sterile material for dressings, etc.; (h) bandage and padded splint if needed.

Uses of Instruments, etc.

The hemostatic forceps, or "snap" is most useful to pick up bleeding vessels. An automatic catch holds them on nti l released. They are useful also as needle holders.

When looking for a bleeding vessel, wipe away the blood with gauze, remove it quickly, and snap directly on the bleeding point. A common mistake is to see the spurting blood and to try to pick up at random the vessel from which it comes. Always take time enough to see exactly where the bleeding comes from and do not poke around in a pool of blood. If it is necessary to apply several pairs of snaps, leave them all in place until convenient to tie all the vessels. After a short time has elapsed, small vessels can be prevented from bleeding by twisting the snap before removing it.

The knife. — It is hardly necessary to speak of the use of the knife any more than to tell the would-be surgeon to decide where he is going to cut and then cut cleanly and firmly in that one place. As a rule cut lengthwise with the limb or body. The same is also true of the use of scissors.

Sutures consist of catgut, silk, or other thread. Catgut is best if at hand for tying bleeding vessels and suturing muscles or deeper layers of wounds. The sterile envelope in which catgut comes, whether of glass or paper, should be carefully opened in order that the contents may not be touched with unclean hands. If in glass tubes these may be soaked in alcohol or corrosive solution for some time and then broken with sterilized hands. If a file is at hand it is well to score the glass in order that it may break easily. Linen, silk, or silkworm gut should be boiled with the instruments. Curved needles should be used for carrying catgut or any suture where a large bite of tissue is to be taken. It is best to hold the needle in a snap. Straight triangular needles should be used for sewing skin, using silk and tying all stitches with the ordinary square knot. The same knot may be used on catgut but it should be tied three times. It is well to remember that horse hair and silkworm gut are both excellent materials for skin sutures. The former is always to be had from the tail of the pack-horse and the latter is in nearly every fisherman's kit in the form of leaders.

To ligate a blood-vessel which has been picked up with a snap, the ligature should be tied down firmly about the tissue beyond the end of the snap. It is always best to have the snap removed by an assistant in order that the tightening process may be completed at the same time. If this is not done the ligature will probably come off. Do not try to tighten again after the snap has been completely removed before tying a second and a third knot. In tying a large vessel, such as an artery of the arm or leg, it is well to remove a little of the soft tissue about in order to see that the ligature is properly applied at right angles to the vessel and in order that it may be tightly drawn up.

Use of the tourniquet. — A tourniquet may be improvised from a handkerchief, piece of cord, or anything which can be firmly tied about the injured part. The usual tourniquet employed by surgeons is a rubber tube drawn around very tightly. If some non-elastic substance such as a handkerchief is used, it is best to tie it loosely; then, using a stick, twist it up windlass fashion until bleeding ceases. It is often an advantage to place a stone or rolled-up handkerchief beneath the tourniquet over the course of the main artery if a limb. It is well to remember that a tourniquet should be applied tight enough to stop the arterial bleeding or else it increases bleeding. A tourniquet should be applied for bleeding in a finger, about the base of the finger; for bleeding in the hand, or arm, high up in the arm pit; and for bleeding in the foot or leg, about the top of the thigh. The tourniquet should be kept on no longer than absolutely necessary. If kept on for more than an hour it is very apt to cause paralysis through too much pressure on the nerves, or if for any very long period, may cause gangrene of the part. When bleeding has been stopped for a time, a clot forms which tends to prevent continuance of the bleeding, but large vessels must be tied or they will continue to bleed.

The wound should be cleaned at once (see p. 236), and the artery, which usually appears as a small whitish tube that does not collapse, identified; this should be picked up with snaps and tied.

Tooth forceps. — It is often necessary for the traveller to pull a tooth. This should not be done unless absolutely necessary as it is very easy to break a tooth and leave the patient nearly as badly off as before. The main thing to remember is to get the blades of the forceps thoroughly applied, well down on the roots of the tooth, pushing them down beneath the gum if necessary, and then to remove the tooth by a combination of a straight pull and slow rocking motion of the forceps to loosen the roots in their sockets.

Bandaging. — A bandage should be firmly and evenly applied, taking care not to draw any one turn tighter than the others. Hold the rolled bandage in the right hand and wind it about the part, letting the roll slip in the hand. Carry it around by passing to the left hand. Bandages applied to irregular parts such as the ankle, should be in the form of a figure 8, a turn being taken first above and then below. The figure-8 turn is practically the basis of all bandaging.

Control of Bleeding.

Kinds of Bleeding.

Bleeding from wounds may be of three kinds: (a) arterial bleeding in which the blood is bright red, flows in a spurting stream, and is not controlled as a rule by a pad over the point of injury; (b) bleeding from a large vein in which the blood is dark in color, runs in a constant stream, and can be easily controlled by slight pressure; (c) capillary oozing from a slight wound is, as its name implies, a steady oozing from the injured surface.

Arterial bleeding demands immediate attention. As a rule it is best to apply a tourniquet if the injury is in a limb (see above, p. 238).

Bleeding from a vein as a rule is very easily controlled. A firm pad of gauze held in place by a rather tight bandage is usually quite sufficient. If a large vein, it sometimes becomes necessary to apply a tourniquet as for an artery but this is unusual. The wound should be cleaned and if the vein is large, it should be tied with catgut.

Bleeding from a ruptured varicose vein is easily and quickly controlled by firm, steady pressure directly on the bleeding point. A small hard pad of gauze should be firmly pressed against the bleeding point by the tip of the finger. When it is evident that the bleeding is controlled, a strap of adhesive plaster or a firm bandage may be substituted for the fingers without removing the pad.

Nose-bleed is often a troublesome sort of hemorrhage, particularly at high altitudes, and is best controlled by sitting the patient upright with the head well back and plugging his nostrils with cotton. Take a strip and carry it back as far as possible with forceps. Use enough to make a firm plug. It is sometimes necessary to plug the back of the nose where it enters the throat. This is quite a difficult procedure and should not be attempted unless absolutely necessary. Ice or other cold applications to the nose are of service at times.

Bleeding from the lungs, stomach, or bowels is practically beyond direct control. The patient should be kept absolutely quiet, should receive morphine one-quarter grain subcutaneously, and should not be stimulated. Stimulation elevates blood pressure and causes bleeding to increase. It is almost an axiom in surgery not to stimulate a bleeding person until after the bleeding has ceased.

Bruises. — Bruises are simply local bleeding under the skin from rupture of small vessels by violence. If extreme they are best treated by immobilization on a splint of the part affected and by the application of cloths soaked in cold water and changed repeatedly. Rupture of a large vessel causes a firm lump to appear. It is formed by clotted blood in the muscles. The same treatment is required as for a severe bruise. If very large, after a day or two it should be opened carefully under aseptic precautions, the blood clot turned out, and a pressure bandage applied. A lump of this sort looks like an ordinary bruise but there is much more swelling and the presence of fluid beneath the skin is shown by the fact that it feels like a rubber bag containing water.

Control of Sepsis.

Sepsis means infection by bacteria and is commonly called inflammation or blood poisoning. It may develop in a wound, large or small, and vary in severity from a localized process, such as a small boil, to a severe illness threatening life. Fresh wounds should be considered septic until they have been cleaned. Pus does not form at once, but always means infection when it is found.

Boils and carbuncles. — When infection takes the form of a boil or a carbuncle (a large boil with several openings), or a definite localized abscess indicated by local redness, swelling, and tenderness, there are two prescribed forms of treatment.

First, one may poultice the afflicted part with hot dressings and wait for the abscess to burst. A poultice is a soft, wet, hot dressing and can be made of any material that will retain heat. It is best made of clean absorbent cotton wrapped in sterile gauze, and wet with some hot mild antiseptic solution such as corrosive sublimate, 1–5000; stronger solutions should never be used for dressings. In case of need a poultice can be made of boiled cloths, or even of oatmeal, bread, crackers, etc., boiled in a cloth bag. The poultice should be changed at least every four hours and may be reinforced by a hot-water bottle or other heater outside the dressing.

If poulticing does not bring the abscess to a head so that it bursts and drains satisfactorily, or if after a reasonable time (24 hours) the condition of the patient seems to grow worse, or the area of the infection seems to be spreading, it should be laid open thoroughly with a knife to allow free drainage. Drainage in this way is adequate, prevents the spread of the infection, and allows healing to begin.

If the operator is not a surgeon he usually errs on the side of an inadequate incision and fears that he will cut some large blood-vessel or other important organ. It is probably safe to say that in any superficial abscess this danger may be absolutely disregarded. In order to be recognized by one not a physician the abscess must be near the surface. There may be much swelling over the abscess. If one succeeds in thoroughly laying open the septic area, and giving proper drainage, marked improvement will be seen in less than 24 hours. If this does not occur, a further incision may be necessary. Prompt and fearless use of the knife would have saved many a man his hand or foot.

Fever, *i. e.*, abnormally high temperature in the presence of infection, is a serious sign. When the infected part is draining adequately there will be no fever. Adequate drainage is important to promote healing and to prevent spread of the infection.

Sepsis in wounds does not show itself at once, but the signs develop after several days. They are heat, redness, swelling, and tenderness around the wound, and sometimes discharge of pus, pain and throbbing in the affected part, and often tenderness and swelling in the arm-pit if the wound be on the hand or arm, or in the groin if it be on the lower extremity. In severe cases with spreading infection, the patient may be very ill and the result fatal. Red streaks running up the limb always mean a serious type of infection.

Treatment demands rest for the affected part by not moving it, more frequent dressings or poultices for the wound, and improved drainage by the insertion of a rubber tube (*e. g.*, a piece of catheter) or by enlarging the opening of the wound to allow free escape of the discharge. If the wound has been sewn up remove every other stitch at least and pull the skin edges apart.

Erysipelas is a superficial infection of the skin which sometimes appears near septic wounds. The progress is shown by a bright red area of slightly swollen skin. The margin is defined, it spreads slowly, and is generally associated with pain, fever, and prostration. It means danger. For general treatment, see p. 210. Locally, paint with tincture of iodine diluted 1 to 3 with water, or a weak antiseptic solution.

Treatment of Wounds.

Cuts. — Do not be too easily alarmed by bleeding. A free flow of blood from a wound tends to wash out any dirt that may have entered with the instrument causing it. Only when the spouting of a pretty fair-sized artery — a thing easily recognized — is present, is there any great harm. Remove promptly any clothing preventing free access to the wound and cover it with the cleanest material available, preferably a clean handkerchief. A handful of leaves picked from a tree, not from the ground, is better than dirty clothing. Firm pressure over this will usually stop bleeding, though a tourniquet may be necessary in some cases. The dressing should be fastened on and the patient moved to the place where the clean dressing is to be done. (For preparation of instruments, materials, aseptic methods, etc., see pp. 234–237.)

After cleaning the wound (p. 236) sew it up with stitches from one-half to one-quarter inch apart. To make a stitch, pass the needle and thread (except the end) through the parts to be sewn together. Tie a square knot, cut off the thread, and proceed in the same way to make the next stitch. These stitches should remain in place from eight to ten days, depending on the amount of tension required to draw the edges of the wound together.

The closing of the wound by stitches and the application of a dressing with a firm bandage will take care of any but very severe arterial bleeding. If a larger artery has been cut, which spurts again on removal of the tourniquet, it should be grasped with snaps and tied.

After care of cuts. — In case the patient complains of an increasing pain or throbbing in the wound, the less it is touched the better. If the wound is comfortable, the dressing need not be removed till the eighth day, when, if union is firm, the stitches may be removed. If on the other hand, the wound becomes increasingly painful, something is wrong. It should be inspected, and if found swollen, reddened, and unduly tender, it is probable that it is infected by bacteria and proper treatment should be instituted (p. 242).

Gun-shot wounds vary greatly in extent and variety. Slight penetrating wounds made by small bullets which do not cut important structures or bones should simply be cleaned at the point of entrance and exit, no effort made to probe, and dressed with sterilized gauze. Penetrating bullet wounds which may involve important organs should be treated by the traveller in a similar manner. Such wounds would often be operated on by a surgeon. On no account should the patient be transported for several days.

Perhaps the most terrible type of gun-shot wound is that inflicted by a shot-gun at close range. Such wounds always cause much shock to the patient. As a rule there is considerable damage and many bits of clothing are driven into the wound. Proceed to operate as directed above (p. 236). Spurting arteries should be tied, the wound should be thoroughly washed with boiled water, bits of clothing removed with forceps, and tincture of iodine poured into the wound. If no iodine is at hand, swab the wound with soap and water. The wound should then be loosely packed with wet sterile cloths. It should not be sewn up at first and not completely at any time. If the patient is extremely weak it is best to do little except to stop the bleeding until the patient's condition has improved (see *Shock*). It is well to remember that shot and other fragments of lead are usually sterile and unless easily removed had best be left *in situ*. Such wounds always become infected and must be appropriately treated (p. 242).

Stab wounds require special care in cleansing because of their depth and small opening which render the escape of pus difficult if the wound should become infected. It is well to wash out thoroughly with boiled water or corrosive sublimate solution, 1–5000, introduced through a boiled rubber catheter. A piece of the catheter can be left in the wound to improve drainage or a strip of sterile gauze or cloth can be pushed to the bottom of the wound to act as a wick. Great care should be taken that such a wick does not plug the opening and prevent the escape of pus, etc. If the wound be deep and the entrance small, it should be enlarged to improve drainage.

Ragged wounds are sure to be infected and cannot be thoroughly cleansed. They should be made as clean as possible by irrigation and iodine or soap and water, and dressed frequently without sewing up.

Penetrating wounds of the chest or abdomen are always very serious. Such wounds should not be operated on except by a surgeon and should *never be irrigated.* The external part of the wound should be carefully cleaned and dressed. The patient should lie quiet, and if necessary for pain or restlessness, morphine should be used subcutaneously in the dose of one-quarter grain and repeated in four hours or more if needed. Food (p. 265) should be given very sparingly in abdominal cases and the bowels should not be moved for two or three days, even by enema. Water should be allowed in small amounts at a time. Such patients should be propped up in bed for the first two days. Unless it be very extensive, do not sew up the wound at all. Never sew it up entirely.

Where muscles or tendons have been cut in a deep wound, the cut ends should be drawn together, if possible, with stitches and the limb then placed in a splint in such a position that there is the least possible tension on the injured parts. In other words, if a tendon in the *palm* of the hand has been sewn together, the hand should be half closed, if on the *back* the hand should be kept straight on a splint.

Penetrating wounds of the joints should be left partly open unless made with a surgically clean instrument. The wound should be thoroughly irrigated with boiled water or corrosive, 1–5000, and drained with a wick of gauze or cloth.

Accidental amputations should be scrubbed and the ragged corners cut off. Then the end of the bone must be cut back with a saw or bone forceps until the injured skin can be drawn together and stitched over it. It is well to remember that skin *stretched* over a stump will invariably die but if not under tension it will almost always live. Do not sew it up tightly or entirely. Drainage is important.

Bites and clawings of animals are sure to be infected and should be thoroughly scrubbed out with soap and water. Then pour in tincture of iodine and dress.

Bites of animals that might have hydrophobia should be cauterized with strong carbolic acid or with a hot iron and dressed without sewing up. They should be kept open for several days (see *Hydrophobia*).

For bites of poisonous snakes, see p. 234.

Burns. — The surface of a burn is necessarily aseptic at the time of burning, as the fire has destroyed all bacteria on the surface. It should not be scrubbed in any event. Pain is best relieved by an oily dressing which does not stick. Olive oil, four parts, and cooking soda, one part, is excellent. Boric ointment or any unsalted fat will serve. Burns should be dressed twice a day.

Burns even of a superficial nature covering two-thirds of the body almost always end fatally.

Fractures.

Fractures are divided into two great groups: simple or closed fractures, and compound fractures. Compound fractures are those in which the bone is protruded through the skin or where there is a cut or laceration running down to or near the bone.

Diagnosis of simple fractures. — Cardinal symptoms of fracture, namely, an abnormal mobility, grating of the bone, etc., are too well known to need much explanation. It is, however, necessary to note that the bones may be fractured and show none of the cardinal signs. The bone may be broken and the broken ends driven together (impacted fracture) or bent (greenstick fracture); or owing to the site of a fracture at the end of a bone, abnormal mobility cannot be demonstrated.

Use of splints. — Splints are easily and quickly improvised in various ways. Padding is most important and is taken up at the end of this section.

(a) Venetian-blind type: made of a number of small sticks tied together like a Venetian blind, the length and weight of the sticks varying with the part to be immobilized. Such a splint should be wide enough to encircle the part completely and long enough completely to immobilize it usually including the joints at each end of the bone involved.

(b) Flat-board splint: cut a thin board to approximately the length and width of the part to be supported. Such splints are usually used in pairs and kept in place with strips of adhesive plaster, and the whole covered by a bandage.

(c) Pillow splint (for fractures of the lower leg and ankle): take an ordinary pillow or a bag of hay or leaves and lay the leg in it lengthwise with the heel four inches from the end. Then fold the edges together under the sole of the foot and over the leg leaving the toes protruding; fasten the edges with safety pins and then strap on three straight boards or sticks, one beneath and one each side running the length of the pillow. Straps, cords, or pieces of bandage may be used to hold the boards in place.

(d) Right-angle splint: cut and bend a large tin can to fit the part, if a finger or thumb. If for the elbow or knee, fasten two pieces of board together at a right angle and brace them with a cross piece. Such splints are often used in conjunction with straight splints.

Padding for splints is best made from several layers of folded sheet-wadding, although clothing, leaves, hay, etc., can also be used. Always remember that it is better to have too much than too little padding, that a tightly applied splint or one in which the padding is not sufficient or improperly adjusted to the irregularities of the part may cause gangrene or paralysis of the part. Whenever possible, have the fingers or toes exposed, then if the circulation is impeded and they become purplish in color or cold, the splint may be loosened.

Fracture of the toes and foot should usually be treated by means of a splint running the full length of the sole of the foot and fastened to the foot by bandages making figure-of-eight turns about the ankle. Occasionally fractured toes can be treated by fastening to another toe by means of adhesive plaster. If this is done, be sure there is padding between the toes, because wherever skin is closely applied to skin beneath a bandage, it will macerate. Fractures of the bones of the foot are usually to be treated with a splint for the sole, as before mentioned. The splint should be carefully padded especially beneath the instep in order that the normal arch may not be lost. Fractures of the bones of the foot require crutches for at least three weeks. Fracture of the heel bone is usually mistaken for severe sprain as it is almost always impacted. Treatment is the same as that for sprain (p. 252) except that the patient should be kept on crutches for a month or until the nearest doctor is reached. Do not attempt to manipulate. Massage only after two weeks.

Fracture of the ankle is usually caused by turning the foot outward. The lower end of the small, outer bone (fibula) is broken usually by being forced outward. The symptoms are pain and swelling about the ankle joint, often with bending of the foot outward. The patient is usually unable to walk, and pressure on the small bone above the fracture will cause severe pain. Apply a pillow splint (see above) and do not allow the patient to walk even with crutches. When the swelling has gone down the pillow can be dispensed with and the foot held in place by well padded splints. Remember to keep the foot turned inward a little more than normal, and at right angles to the leg, because the usual deformity which may result is to have the foot turned outward, so as to give a very faulty weight-bearing surface. Crutches should be used for at least a month.

Fracture of both bones of the leg below the knee. — Abnormal mobility and grating are almost always present. Treatment: pillow splint or Venetian-blind splint (see above) from ankle to thigh at first; later three straight splints well padded from the ankle to thigh. In these fractures it is necessary to align the bones because marked deformity may otherwise result. Crutches for at least five weeks.

Fracture of knee-cap. — Caused by falling on the knee or by direct muscular violence; knee painful and swollen. If the leg be bent, the patient is unable to straighten it owing to the fracture. If there is not much swelling, fragments may be found lying anywhere from one finger breadth to one and one-half inches apart. This fracture is usually operated on if a surgeon is at hand. If there is no surgeon, place the leg on a long splint, from the ankle to fold of buttock, and by means of straps of adhesive plaster running diagonally from above downward on each side of the upper fragment, draw it down and hold it as nearly as possible in place. Keep patient in bed a month. Crutches should be used from two to three months.

Fracture of the thigh. — This fracture is always very serious and the patient should be kept in bed for six weeks to two months unless treated by a surgeon.

For fracture of the lower end of the thigh bone, bend the knee at right angles; place a triangular pad about one foot across under the knee, and bandage ankle and upper thigh to a board running up to the arm-pit and held in place by a swathe.

Fracture of the middle of the thigh is treated by the use of a long straight splint running from the ankle to the arm-pit, the leg being straight with the body. A splint from ankle to crotch is needed on the inside of the leg, and a splint of the Venetian-blind type about the thigh.

A weight of from two to six pounds should be fastened to the foot and lower leg by strips of adhesive plaster attached to a cord which is then led over a pulley at the foot of the bed. Such patients should be kept on their backs at least six weeks and should not use the leg for at least three months.

Fracture of the hip, in other words, the upper end of the thigh bone, is usually impacted. Under no circumstances should this impaction be broken up. The leg is usually shortened and the foot turned outward. Treat in a young person like fractured thigh, except that weights should not be used unless the fracture is free and not impacted. This fracture is most common in old persons and the best treatment is to hold the leg in place by means of sand bags on each side of it in bed, and to keep the patient sitting up in bed as much as possible. The greatest danger in old persons is that they will develop pneumonia if kept too still, and the fracture should be somewhat neglected on that account.

Fracture of the pelvis is usually caused by a crush between two heavy objects such as two cars. The shock is very severe and there is often tearing of the bladder or urinary passage as well. Treatment consists in keeping the patient as quiet as possible by means of sand bags and broad tight swathes about the hips. It is often necessary to draw the urine with a catheter. Keep in bed at least six weeks.

Fracture of the spine or back-bone is usually accompanied by paralysis of the legs and inability to pass water or to move the bowels. It is best treated by keeping the patient quietly in bed. The urine should be drawn every eight or twelve hours with a catheter and great care taken to keep the patient clean and dry underneath lest he develop pressure-sores on the back. Such cases are usually fatal. The same treatment and prognosis hold good for fractures anywhere in the spine, although the higher up the worse the prognosis becomes.

Fracture of the ribs is usually caused by crush or a severe blow on the chest. Symptoms: sharp stabbing pain particularly on deep breathing, with tenderness over the point of fracture. Sometimes the grating can be felt. If one hand be placed on the patient's back-bone and the other on the breast-bone and moderate pressure be exerted, it will cause pain at the point of fracture. Keep the chest swathed with wide strips of adhesive plaster for three weeks.

Fracture of the fingers may be treated in two ways: either by means of a straight splint running from wrist to tip of finger or by closing the hand about a roll of bandage or some such object. As a rule, the latter method is preferable. The method which seems to put the bone in the most normal position should be chosen. The reason why bending the fingers is usually best is that these bones are apt to buckle inward and, if so, the new-forming bone will often involve the tendons of the palm side of the finger causing great disability. The same is true of fractures involving the bones of the hand. A good diagnostic sign of fracture of bones of the hand is that the knuckle of the bone involved is not as prominent when the hand is clenched as in the normal hand. Another sign of fracture of the fingers or bones of the hand is sharp pain caused by pressure against the ends of the fingers. Immobilize for three weeks.

Broken wrist is usually caused by falling heavily on the open hand. Another cause of this fracture is the back-kick of a gasoline motor. As it is impacted in most cases, there is no grating but there is usually considerable deformity. The hand is apparently pushed backward on the wrist from ¼ to ½ inch which gives it more or less the appearance of a silver fork. Such fractures, if possible, should be reduced by loosening the displaced end of the bone and bringing it into line. The hand can then be held in place by anterior and posterior splints from tips of fingers to elbow, with padding beneath the wrist to conform to the normal outline. As this usually requires anaesthesia, it is best to wait until a doctor can be reached. Begin passive motion and massage at the end of two weeks but keep on the anterior splint until three weeks have passed.

Fracture of both bones of the forearm is characterized by abnormal mobility and inability to use arm. Such fractures are difficult to set and the traveller is advised to hold the arm in as normal a position as possible by means of anterior and posterior splints to the forearm and hand and a right-angle splint one leg of which runs down the forearm and the other up to the shoulder on the inside.

Fractures about the elbow, with one exception, are best treated by bending the arm to an acute angle, placing the hand on the opposite collar bone, and strapping the whole firmly down to the body by means of adhesive plaster and bandages. In this case, care should be taken to place pads of cotton or cloth between all skin surfaces to prevent maceration. The one exception is a fracture where the prominent bone at the back of the elbow is broken off. In such cases the end of this bone is drawn upward by the strong muscles at the back of the arm. If this happens, it is necessary to keep the arm out straight and to hold it in place by means of a long wooden splint running from the arm-pit to the wrist.

Fractures of the upper arm are best held in place with the arm bent as in fractures of the elbow. It is usually well to encircle the arm with a splint of Venetian-blind type (p. 246) and put a pad beneath the arm running from arm-pit to elbow. If the break is high, this pad should be considerably thicker at the elbow than it is above in order to tilt the arm outward.

Fracture of the collarbone is usually the result of falling forward on the hands. It almost always heals well but usually with some deformity. Treatment is immobilization of the arm either by means of a sling and bandage about the chest or by means of adhesive strapping about the body with the hand on the opposite shoulder.

Fractures of the jaw are very difficult to treat. The best way for the traveller, at any rate, is to place a firm bandage about the jaw and head, carrying turns from under the jaw to the top of the head and from the front of the chin around the back of the neck. It is very important to keep the mouth thoroughly rinsed out and to feed with liquids. Fractures in the mouth are almost always compound.

Fractures of the skull and concussion of the brain may be treated together here. The symptoms are unconsciousness, or delirium, usually with slow pulse and some rise of temperature, and sometimes bleeding from the ears. Treatment is ice or cold applications to the head, keep the bowels thoroughly opened, and quiet the patient with morphine, one-sixth grain subcutaneously, if absolutely necessary. The patient should be kept quiet for a considerable period after all the symptoms have subsided. He may remain unconscious for days or weeks.

Compound fractures are all very serious. Their treatment consists, first of all, in cleaning the wound. This may be done either by free use of iodine as advised for lacerated wounds or by the use of soap and water and irrigation. For extensive compound fractures of the large bones, probably the latter course is best but can only be done under general anaesthesia. Wounds should be very loosely sewn up and should always be drained. If the wound is thoroughly cleaned out, mortality is low but if the wound is not so treated, mortality from sepsis is probably 40 percent or over. The usual treatment for simple fractures (p. 246) holds good for compound fractures after the wound has been cleaned, except that the part should be immobilized from one to two weeks longer.

Sprains and Strains.

Diagnosis of sprains. — The term sprain is used rather loosely to cover all varieties of strains of joints from a mild wrench which gives little or no trouble to a severe injury with much swelling and tearing of ligaments. Sprains are often difficult to differentiate from dislocations or fractures. It should be remembered that in sprains there is never any bony deformity or grating of fragments of bone and that the joint is in place. It will sometimes be painful and disabling. Often the results are a very persistent disability.

Treatment of sprain consists in immobilization with bandages or strapping with adhesive plaster. During the first few hours much can be done to alleviate suffering and keep down the swelling by bathing in hot and cold water, first one and then the other. The commonest sprain is that of the ankle. The greatest swelling usually appears about the outer side of the ankle joint and the top of the foot. The best treatment is bathing, as suggested, followed by a firm bandage applied over sheet wadding. After most of the swelling has gone down, adhesive plaster can be applied to steady the ankle and permit walking. The plaster should be applied in strips about ¾ of an inch in width passing beneath the foot like a stirrup, closing over the instep, and then running diagonally up the leg toward the back. It is best not to cross the plaster at the back of the leg. Several such strips should be applied, each overlapping the previous one, for about ¼ inch. Such a dressing can often be worn for a week or ten days and allows the patient to get about even with rather a bad ankle.

Strain of the back. — This is often very troublesome and is difficult to treat. Symptoms are stiffness and pain in the back, particularly in the lower portion. The best method of treatment is strapping with adhesive plaster, the straps running from over one hip to the ribs of the other side and crossing at the point of greatest pain. Such strapping should be made of several strips of plaster about two inches in width, each strip overlapping the one beneath about one-half inch. A strain low in the back is very disabling. A leather belt worn fairly tight over the undershirt and just below the upper edge of the hip bone will often give great relief. Adhesive strapping applied to the back at this same level is often of service.

Dislocations.

Diagnosis. — A dislocated joint is one in which the joint surfaces have been so misplaced that they do not come together as they normally should. The condition may be partial or complete and as in fractures may also be simple or compound. The symptoms and signs are: pain, inability to use the joint, and deformity, the last being the most characteristic. There may be much or little swelling. Dislocations should be reduced within a few days if possible, for the longer the delay the greater the difficulty experienced. After reduction the part should be fixed by means of a splint or bandage for a varying length of time depending on the joint involved. As a rule dislocations are fairly easy to reduce if one remembers to stretch the joint as much as possible by traction on the part before trying to slip it back. A general anaesthetic is frequently necessary.

Fingers and toes. — Pull strongly on the fingers and press on the misplaced bone and it will usually slip back quite easily. Splint to be used for about a week.

Wrist and ankle. — Harder to reduce than the above and often complicated by fracture. Reduce in the same general way but immobilize for two to three weeks (see *Fracture of wrist and ankle* for type of splint, pp. 247, 250).

Elbow. — Usually dislocated backward. Traction and manipulation of the joint will generally suffice. It is sometimes necessary partially to bend the arm and then to pull the arm forward and down with one hand used as a fulcrum against the upper part of the forearm. Immobilize at an acute angle, as for fracture of the elbow, for about two weeks. This dislocation is often complicated by fracture, and even if not, the differential diagnosis is often difficult and the treatment much the same except that immobilization is needed for a longer time for fracture.

Shoulder. — This is one of the commonest dislocations. The arm may seem almost normal at first sight. On close examination, it will be found that the outline of the shoulder appears flattened, that the elbow points a little away from the side, and that the distance from the top of the shoulder to the elbow is distinctly longer than on the well side. It is often possible to feel the head of the arm-bone in the arm-pit.

The old method of reduction is best for the traveller because more simple. Lay patient on the floor and sit down by his side, facing him. If his right shoulder, put your right heel (minus the shoe) in his arm-pit. Grasp the hand and arm firmly and pull hard away from the body. Then after the muscles stretch a bit and your foot works up further, draw the arm across his body, thus using your foot as a pry. The bone will usually snap back with considerable difficulty.

Knee. — Dislocation of the knee is rare and almost invariably associated with severe tearing of the ligaments. Reduce with traction and keep on a long posterior splint for at least three weeks.

Hip. — Dislocation of the hip is rare, and aside from traction, the traveller should make no attempt at reduction but get the patient to a doctor with the least possible delay.

Jaw. — Dislocation of the jaw is not uncommon. The mouth is open and the patient is unable to close it. To reduce, place both thumbs inside the mouth, one on each side back of the lower wisdom teeth, and press strongly down and back, at the same time attempting to close the jaws with the fingers which are beneath the chin. Support the chin for a few days with a bandage over the top of the head and warn patient against opening mouth wide for several weeks.

Compound dislocations are to be treated in the same manner as compound fractures as regards the wound, and are nearly as serious. Treat the dislocation as in simple dislocation.

Dangerous Diseases.

The diseases in this group are not very common in persons leading an active outdoor life.

Appendicitis. — The signs are pain, usually severe and constant, at first all over abdomen, later localized, as a rule, in *right lower part.* Firm pressure in the region causes much pain. The muscles over the painful part are strongly contracted and cannot be relaxed. There is generally slight fever and increase of pulse-rate, constipation, and often vomiting. There may be a story of similar attacks lasting for several days at a time. The attack may clear up in a few days without severe symptoms, or an abscess may form around the appendix, or inflammation may spread in the abdomen and cause death.

Treatment. — Absolute rest propped up in bed, abstinence or very light diet, preferably liquids only, cold applications to painful area, and enemas to move the bowels. *Do not give a cathartic* and *do not transport the patient* a long distance until symptoms subside. Send for a surgeon if possible. Recovery without operation is the rule unless the inflammation spreads. Morphine, one-sixth grain subcutaneously, may be given often enough to ease the pain but not to hide the nature of the symptoms.

Inflammation of the gall-bladder. — Pain and other symptoms like appendicitis but situated in the *right upper* abdomen. There may be jaundice and, with it, a dark-colored, greenish urine containing bile which stains white cloth yellow. Treat like appendicitis but do not prop the patient up. As the patient improves, the diet may be increased but as long as any jaundice persists meat should be taken only sparingly and fats not at all.

Gall-stone colic. — Attacks of severe pain in the right upper abdomen, recurring more or less frequently for years without much impairment of health. Pain comes on suddenly, most often at night, may be very severe, and passes off in a few hours leaving a feeling of soreness. The attack is often preceded by a chill and associated with transient fever and vomiting. The danger is that inflammation may develop.

Treatment. — Hot bath or application of heat to abdomen, abstinence or light diet, morphine, one-sixth grain subcutaneously, if needed.

Renal colic. — Due to stone attempting to pass from the kidney. Pain very severe, intermittent, starting in either flank and radiating around abdomen to region of bladder or testicle. There may be vomiting, chills, fever, pallor, and sweating. The urine is often bloody, and it may contain pus.

Treatment. — Hot bath or application of heat, rest, morphine, one-sixth grain subcutaneously and repeat at intervals of from four to eight hours if pain continues to be severe. Abundance of liquid should be taken, preferably hot.

Stone in bladder. — Pain in region of bladder, urine generally bloody. Treatment as for renal stone. If urine is not passed freely, catheterize every eight hours (pp. 234, 262).

Hernia or rupture. — Usually appears in the groin but may come in the navel or in the scar of some abdominal operation. Usually a soft mass which can be pushed back into the abdomen without much force. If the contents of the hernia (intestines, etc.) get caught in the ring they may become strangulated causing pain, vomiting, and stoppage of the bowels. This is a very serious condition. Patient should be kept quiet in bed and given morphine and the attempt made at reduction by gentle pressure. Repeated applications of very cold water for 15 minutes followed by gentle massage may facilitate reduction. If this does not succeed, patient may be etherized and then reduction attempted. When reduction is unsuccessful and the intestine remains strangulated, the disease becomes fatal.

Shock appears soon or within a few hours after serious injury. It is a symptom, not a disease. Patient is very pale, may be unconscious or talking wildly, usually sweating profusely but the skin is clammy. Pulse weak and rapid, or absent. The condition resembles approaching death. Keep patient quiet, wrap in blankets, and apply hot-water bottles. Always be careful that the bottle is only just warm to the touch as it is very easy to cause a terrible burn on an unconscious or semiconscious patient. *Raise the foot of the bed 12 inches* and give hot tea or coffee in small quantity. An enema of hot water or coffee is often of great value and stimulants such as tea or coffee by mouth will help if they can be taken. *Do not on any account move the patient for several hours.*

Hydrophobia is caused by the bite of a mad dog or other animal having the disease. It is not uncommon in skunks on our western plains. For treatment of the wound, see p. 245. The disease in man generally takes several weeks to develop. The only hope of cure is to get the proper treatment, which can be obtained only in large cities. The longer the delay the less the chance of cure. Treatment must be begun before the spasmodic symptoms appear.

Tetanus or "lock-jaw" is a form of infection developing in deep wounds. The germ causing tetanus is common in the soil hence it sometimes follows such an injury as stepping on a nail.

Prevention consists in the giving of antitetanic serum, if at hand, in all such cases soon after the time of injury without waiting for the symptoms to appear. Symptoms are stiffness and rigidity of the muscles of the jaw and back gradually extending all over the body. A sudden jar is often enough to throw the patient into a spasm in which the teeth are clenched, back arched, etc.

Treatment in this stage is almost useless; antitetanic serum should be given and the patient kept quiet with morphine, one-sixth grain subcutaneously, repeated every few hours, and the bowels opened with salts (p. 266). Such cases are nearly always fatal.

The Feet.

Sore feet. — To prevent blisters, soap may be rubbed on the outside of the socks before setting out. On returning to camp all foot-wear should be promptly changed. A delicate skin may not bear vigorous washing with soap, and in such cases the skin should be hardened by bathing the feet with cold water. Alcohol (about 70 percent) or a weak solution of formalin (about 3 percent) is better still and has some antiseptic value. Free use of talcum powder between the toes is advised, especially in hot weather.

Blisters and abrasions must be protected. The best treatment for the latter is a liberal application of sulphur ointment and a thin cloth dressing. A heavy dressing tends to retain sweat and thus to increase softening of the skin. The dressing should be renewed at least twice daily. The ointment minimizes friction; the sulphur is an excellent antiseptic for superficial wounds and under its influence an abrasion will sometimes heal rapidly even though walking be continued. Another method is simply to paint the abraided surface with iodine each day.

Ingrowing toe-nails. — It can safely be said that this condition is always the result of improper cutting of the toe-nails. Always cut straight across and never round off the corners. If an ingrowing toe-nail has occurred, try first, if it is not severe, to raise the nail with a little pad of cotton beneath the corners. If this is impossible keep the nail cut well back or else cut a deep narrow V out of the middle of the nail. If infected and badly inflamed, wash frequently with dilute alcohol or paint with weak iodine solution. If the condition is very severe the parts may be cocainized and the nail cut well back. The operation for radical cure can only be done by a surgeon.

Flatfoot is often very troublesome and any tendency toward it should be treated by a competent physician before the prospective traveller leaves home. If called upon to treat a case, one usually finds the patient more or less incapacitated by pain in the sole of the foot running up the inside of the ankle and back of the leg which is increased on walking. Several narrow overlapping straps of adhesive plaster carried stirrup fashion beneath the arch of the foot and crossing in front of the ankle will usually give relief. The plaster should be carried back on the sides of the ankle but *never across the back* of it. This would impair circulation and cause swelling. Often merely raising the inside of the heel of the shoe from ⅛ to ¼ of an inch particularly if one is walking on badly cut-down trails will give immediate relief. Any amateur cobbler can put on this heel which is commonly known as the Thomas heel. Aspirin will diminish pain.

Resuscitation.

Artificial respiration (for drowning, electric shock, or suffocation). — If the patient has been in the water, it is necessary first to turn him on his face and force the water out of the lungs by lifting him by the waist for a few moments.

The Shaefer method of artificial respiration is probably the best. Turn patient on his stomach with face turned to one side and arms extended above his head. Kneel, facing his head and straddle one or both of his thighs. Place the hands one on either side well out on his lower ribs with the arms straight. Then, by bringing the weight of the operator's body and shoulders forward to the vertical, compress the chest for three seconds. This should be done gradually. At the end of three seconds release the pressure suddenly and entirely. If necessary, a light operator with a heavy patient may lift his knees entirely clear of the ground. The rate of this procedure should not exceed 12 to 15 times per minute. It may be necessary to keep up artificial respiration for two hours.

Fainting. — Keep patient on his back with head low and feet elevated. If he gets up too soon the condition will probably recur. Bathe the face with water if desired but do not drown an unconscious patient with whiskey.

Anaesthesia.

It is sometimes necessary in an emergency for the traveller to give a general anaesthetic. This is a serious step to take as the dangers in inexperienced hands are very real.

Ether is by all odds the safest. Make a cone to fit the face of the patient, preferably of cardboard covered with a towel, and put some cotton or gauze in the top of the cone to contain the ether. Be sure the patient has nothing loose in his mouth (false teeth, tobacco, etc.) and then hold the cone over his face with a little ether on it. Increase the amount of ether gradually, putting on a few teaspoonfuls at a time, and finally, after five to eight minutes, he will become unconscious. It is sometimes necessary to hold him just as he is losing himself. Respiration now becomes labored and noisy and the patient often begins to get blue. As this is a signal for more air pull forward and upward on his jaw with the finger just back of the angle. If this is not enough, put a stick between his teeth and draw his tongue forward with a pair of forceps or a bit of dry cloth. Ether should be added little by little throughout the operation, care being taken to use as little as possible and still keep the patient unconscious. Deeper anaesthesia should only be used under the direction of a doctor. When the patient begins to come out of ether he will vomit and as this happens before consciousness returns, it is of great importance to prevent inhalation of the vomitus which might cause death. Roll him on his side that the vomitus may run out and, if necessary, pry his mouth open and wipe out his throat. Never leave an ether patient alone for a single minute until he is completely out of ether and conscious. If respiration stops, pull the tongue forward and do artificial respiration as for asphyxia or drowning. Be sure the patient has plenty of good fresh air and, if in a house, that the windows are open. When possible give ether only several hours after a meal.

Local anaesthesia is best produced by the use of novocain. If it is desired to use it, learn how before starting on the trip.

Cocaine is also used for this purpose but is dangerous because of the effects of over-dosage. The traveller is strongly urged not to use it in this way.

Morphine for anaesthesia. — The pain of an operation for which ether is not to be used, can be very much diminished by injecting morphine, one-fourth grain subcutaneously about half an hour before beginning to operate.

Transportation of the Sick or Wounded.

It is always well to remember that most persons even if seriously sick can be transported if it is done with care. For example, if a patient is near a railroad, the best method of transportation is by means of a cot bed or stretcher which can be placed in the baggage car. Railroads are always glad to do anything they can to help out. A stretcher is easily improvised from two poles about seven feet long with a cross-bar at the head and foot. The filling should be blankets or canvas stretched tightly about the poles, two or three coats buttoned about them, or small rope or packing cord laced back and forth. Such a stretcher may be carried from the shoulders by means of a pack strap. If the bearers are careful to keep *out* of step, the patient will ride more easily.

If horses are available, the patient should be tied in the saddle if able to sit up at all, pommel and cantle being reinforced by rolls of blanket. If he must be transported lying down, a *travois* is easily made by using two poles about 16 or 18 feet long. These poles should be rather limber, preferably birch saplings, and should be fastened on each side of the saddle, the light end being permitted to drag on the ground. One pole should be at least a foot longer than the other in order to facilitate travel over rough ground. A litter is made between the two poles and the patient is placed on it. The head should be toward the front. By making the poles longer, the litter rides easier and is more limber but is often heavier and more difficult to handle. If two very quiet horses are available, a double-horse litter can be improvised by means of poles 16 or 18 feet long tied to the saddles, the horses travelling tandem.

MEDICAL METHODS, DRUGS, AND EQUIPMENT.

Medical Methods.

The hypodermic syringe is used to inject drugs under the skin, *i. e.*, subcutaneously or hypodermically, or into a muscle, intramuscularly.

(a) The syringe and needle must be boiled, or rinsed with alcohol drawn in and expelled several times. After sterilizing do not allow the needle to touch any unsterile thing before using. If the syringe is of glass, pull out the piston before boiling. If the piston be left in, the syringe will break.

(b) Boil ½ teaspoonful of water in a teaspoon over a flame and dissolve the tablet in this before it cools. *Do not boil the tablet.* Suck the solution into the syringe, elevate needle, and expel air bubbles.

(c) Scrub a small piece of skin of the outer arm, thigh, or abdomen with a cloth wet in alcohol or with soap and water.

(d) Pick up washed skin between left thumb and fore-finger. Insert needle at acute angle ¼ to ½ inch. Inject slowly.

(e) Irritating drugs cause less local soreness if injected intramuscularly. The front of the thigh is suitable. The needle should be inserted vertically for ½ an inch or more if there is much fat.

The catheter is a somewhat flexible tube to be passed to the bladder to draw urine when the patient cannot pass it. A rubber catheter should be thoroughly boiled before using and lubricated with vaseline or catheter lubricant and passed under aseptic conditions — in other words, the hands should be scrubbed as for a surgical operation

(p. 236). The penis should be carefully washed with soap and water, and corrosive sublimate, 1–5000. It should be drawn up strongly (the patient lying on the back) in order to straighten it while the catheter is being passed. Just before the catheter enters the bladder, it will meet a slight resistance in the muscle controlling the bladder. It should only be pushed an inch or two beyond this point. If much resistance is met try a smaller catheter. The urine will run out as soon as the catheter enters the bladder.

The stomach tube is valuable to remove poison recently taken, to wash the stomach after alcoholic excess, or to remove indigestible food causing pain. Most tubes have a mark to indicate the normal distance to which they must be passed to reach the stomach. This is about 20 inches.

Wet the tube in cold water to lubricate it. Then, standing in front of the patient, who should be sitting or lying on the side, insert it *downward* behind the tongue and urge the patient to swallow. If he bites the tube insert a gag of soft wood between the back teeth. If he struggles get behind him, grasp the lower jaw with the palms of the hands, and feed the tube in with the fingers. The tube passes easily when started right.

When the contents of the stomach cease to flow through the tube pour in slowly a pint or more of warm water through the funnel. Lower the funnel and let the water siphon out. Repeat until the water returns clear.

The thermometer. — Medical thermometers of modern type are self-registering, *i. e.*, the top of the mercury remains at the highest point reached. Therefore the thermometer must be read before being used. If the mercury stands at or near 98.6°, the normal temperature, it must be shaken down before the thermometer is used. To do this hold the upper end of the thermometer between thumb and finger, raise the arm, swing it down rapidly and stop it with a jerk. Then read again. If the mercury still stands too high repeat the manoeuver until the desired result is obtained.

Place the bulb of the thermometer *under* the tongue and tell the patient to *close the lips, but not to bite.* Leave the thermometer in place three minutes and see that the lips remain closed.

Before and after using wash thermometer with *cold water. Hot water will break the thermometer.*

If the patient is unconscious take the temperature in the rectum, but grease the thermometer first. Rectal temperatures are from ½ to 1 degree higher than mouth temperatures.

Enemas or rectal "injections." — Enemas are used (a) to clear the bowels, (b) as a means of giving stimulants, (c) to supply water to the body. Different kinds of enemas are used for these various purposes, but any of them can be given with a fountain syringe or with a rubber tube and funnel. The Davidson syringe is satisfactory for most purposes but is less so for stimulants as these are generally given in a small quantity of liquid.

When taking an enema the patient should lie on the back with hips raised or on the left side. If the nozzle of the syringe is hard it should be inserted very gently or it may do serious damage. A slight resistance which can be overcome by slow pressure will be felt at the depth of one or two inches. When this has been passed, the tube has gone far enough. Do not insert more than three inches of the tube.

(a) *Enemas to move the bowels* act by bulk and by slight irritation. To get a good result it is necessary to put in a pint or more of liquid. Warm water and soap-suds generally act well. The patient should take as much as he can hold and endeavor not to expel it at once. If it runs out again without result and without causing intestinal action, which is shown by colicky pain in the abdomen, or if it does not come out in half an hour, try again with cold water.

(b) *Stimulant enemas* are used when patients are extremely weak from "shock" (p. 257) or from any other cause. They are not needed if the patient can swallow and does not vomit. These enemas are intended to be retained. Therefore they should be given very slowly, should not exceed one-half pint in bulk, and should be given at normal body temperature or as near it as may be. If the patient has difficulty in holding the enema, press firmly against the rectum with a towel.

A tumbler of tea or coffee, with a tablespoonful of whiskey or brandy in it, makes a good stimulant enema.

(c) *To supply water* to the body is very important if vomiting has prevented the patient from taking and holding water by mouth for 24 hours or more, or if, as is sometimes the case in severe fevers, the patient is able to swallow little water and the pulse is getting weak.

First, clear the lower bowel by a large injection of plain water. Wait half an hour. Then inject very slowly from one-half to one pint of warm water in which a teaspoonful of salt has been dissolved. Stop the injection the moment the patient has difficulty in holding it and help him to hold it.

If the water comes out, wait half an hour and repeat the injection, using a smaller quantity of water. If the patient continues to need water give injections every eight hours. It is only necessary to clear the bowel once in 24 hours.

Diet Lists.

(a) *Liquid diet.* — Milk, plain or diluted with water, or aerated water; malted milk; broth from which the grease has been skimmed; very thin gruel; white of egg mixed with water. When there is much fever or disturbed digestion milk should be diluted; condensed milk will serve. Broth can be "strengthened" by adding rice or flour.

(b) *Soft solids.*—Gruel; bread and milk; egg—raw, soft-boiled, or poached; toast or cracker softened with hot water or milk; rice; custard; junket, etc.

(c) *Simple diet.* — Ordinary food plainly cooked excluding pastry, fried or greasy foods (except butter), the coarser vegetables (*e. g.*, cabbage, turnips, baked beans), hot bread, and highly seasoned dishes.

Use of Drugs.

General Information.

The use of drugs is often the least important part of treatment. Therefore the reader is urged to turn to the information in the foregoing parts of the chapter before undertaking treatment of any kind. References are supplied in the text.

Some of the drugs mentioned below are official in the United States. After the common name of each of these will be found its designation in the United States Pharmacopoeia or "U. S. P." Most of these drugs are official in other countries as well and even though their names elsewhere may be different they can safely be ordered there under the designation of the "U. S. P." if these letters are put after the official name.

When unofficial drugs are made by several manufacturers the products vary in strength and dosage. Therefore, when using non-official drugs, as digitalin or emetine, it is well to ascertain the dose of the particular preparation which is to be used. The pharmacist from whom they are obtained will generally know something about them, and directions often go with the drug. The official preparations of other countries often differ in strength and therefore in dosage from those of the United States.

To Move the Bowels.

The selection of the drug will depend on whether one has to deal with slight constipation, obstinate constipation, indigestion, or dropsy and whether prompt action is needed.

(a) *For slight constipation* (p. 198), the patient should take the kind of pill which he has found by experience acts well for him or he may try one of the following: (1) "A. S. & B." pill (compound pills of aloin, strychnine, and belladonna, N. F.); dose: one or two pills at bed-time. (2) Epsom salts (*magnesii sulphas*, U. S. P.); dose: one or two teaspoonfuls in a half glass of water one hour before breakfast. (3) Seidlitz powder or Carlsbad salts can be used in the same way and same dose as for Epsom salts.

(b) *For obstinate constipation* (p. 198) when a powerful cathartic is needed, try the "compound cathartic pill" of the U. S. P. Dose: one or two pills at bed-time.

(c) *For indigestion* (p. 199), to clear the intestine the best remedy is castor oil (*oleum ricini*, U. S. P.). Dose: two to four tablespoonfuls, best taken one hour before breakfast or on an empty stomach one hour before a meal. The taste can be disguised with brandy or lemon juice.

Calomel (*hydrargyri chloridummite*, U. S. P.) is also good. Dose: one, two, or three tablets of one grain each at bed-time and follow in the morning with Epsom salts, Seidlitz powder, or Carlsbad salts, as directed above for slight constipation.

(d) *For dropsy in heart disease* (p. 206), watery movements of the bowels are necessary. These are best obtained by large doses of Epsom salts in concentrated solution. Dose: three to six teaspoonfuls dissolved in an ordinary cupful of black coffee or warm water.

(e) *For prompt action* the cathartic should be taken an hour before breakfast or several hours after a meal and no food should be taken in the hour which follows. Epsom or other salts are suitable (see above). If the cathartic does not act within three hours it can be repeated or an enema can be used.

Don't take a quick-acting cathartic at bed-time if you wish to sleep.

Don't take "salts" often in large doses unless you are too fat or have dropsy.

Don't take calomel repeatedly on succeeding days. It is a poisonous mercurial substance.

For Diarrhoea.

After clearing the bowels with castor oil or calomel take subnitrate of bismuth (*bismuthi subnitras*, U. S. P.). Dose: one-half level teaspoonful every few hours. Wash it down with water. If the diarrhoea persists after 24 hours of this treatment "sun cholera tablets" (not official) can be taken, one every four hours.

Caution. — "Sun cholera tablets" contain 3/10 grain of opium each, and cannot be taken indiscriminately, although an occasional dose of two tablets would be safe. For signs of opium poisoning, see morphine (p. 269).

For "Acid Stomach."

Use sodium bicarbonate or "cooking soda," "saleratus" (*sodii bicarbonas*, U. S. P.). Dose: one teaspoonful in a glass of water. It can be taken in unlimited quantities for years and can cause nothing worse than vomiting.

Pain.

The fundamental idea in the treatment of pain is to buy relief at the cheapest price and not to pay more than it is worth, which means that the mildest remedy that is effective for each case should be used, that powerful drugs have a harmful effect which must be reckoned with, and that it is better to suffer pain than to be severely poisoned.

(a) *Slight or moderate pain* can often be relieved by applications of heat or cold to the affected part, by change of position or, in case of a wound, by readjustment of the dressings.

Aspirin (not official) is likely to relieve moderate pain of almost any kind for a time at least. It can be used safely in moderate doses, *i. e.*, one or two 5-grain tablets three times a day. In order not to disturb digestion it should be taken after meals with a full glass of water. Large doses should be given for rheumatic fever (p. 214). The signs of overdose are those of indigestion, perhaps with vomiting, or headache and ringing in the ears. If these signs develop, stop the medicine until they are gone and then continue it if necessary in smaller quantity. In rheumatic fever ten grains of aspirin every two or three hours up to 60 or 80 grains in 24 hours may be required. Every dose should be taken with a full glass of water. If aspirin is unobtainable, use sodium salicylate in the same way.

(b) *Severe pain* can seldom be relieved except by morphine (*morphinae sulphas*, U. S. P.).

Caution. — Never use morphine for a pain which the patient has had often, and never use it daily for more than two weeks no matter how much the patient begs for it. The morphine habit will follow such abuse.

Before giving a dose of morphine count the rate of breathing per minute (normally about 20) and note the size of the pupils of the eyes.

Morphine can be given by dissolving a tablet in a spoonful of water and allowing the patient to swallow it. When used in this way the effect may not be noticed for an hour or more. Quicker action can be obtained by holding the tablet under the tongue until it dissolves, but for prompt and sure effect dissolve a tablet in half a teaspoonful of boiled water and inject it subcutaneously (p. 262).

The dose of morphine for a well developed adult is from 1/8 to 1/4 grain. The dose for children must be figured on this basis in proportion to weight and then reduced by half, because children are very susceptible to morphine. Smaller doses are required also for feeble or elderly persons. The dose can be repeated two or three times at intervals of from two to four hours if *pain* persists.

When using morphine subcutaneously never repeat the dose unless *severe pain* persists, because the danger of overdose is greater when morphine is used in this way.

Signs of overdose or morphine poisoning are heavy stupor with very small pupils. A rate of breathing of 15 per minute shows that the danger line is near. A rate of 10 per minute is serious.

If the breathing falls to 12 per minute give the patient as soon as possible a cupful of strong tea or coffee and repeat it in half an hour if the rate does not increase. If the breathing goes lower get the patient up and keep him awake by any possible means. Pain and activity are the best antidotes, but if a stomach tube is available be on the safe side and wash out the stomach also (p. 263). Otherwise make the patient drink salted warm water until he vomits. The danger is that breathing will stop, but the patient is safe as long as he can be kept awake.

Morphine accumulates in the stomach even when used subcutaneously and the digestion is often upset the day after morphine has been taken. This digestive disturbance may not be noticed after small doses and some individuals are more liable to it than others.

In women, morphine may cause intense nervous excitement instead of the usual relief. If a woman has ever taken morphine with such effect do not try it with her but use aspirin (above) instead.

Opium contains morphine and has the same poisonous effects. It is also a habit-forming drug. The dose is from ¼ to ½ grain in tablet or pill. If ½ grain at a dose has been administered do not give any more for at least four hours. See "sun cholera tablets" (p. 268).

Stimulants.

The use of tea, coffee, and alcohol has been described in the text under *Typhoid fever* (p. 213), *Exposure* (p. 219), *Heat-exhaustion* (p. 227), and *Shock* (p. 257).

For *heart-weakness* (p. 206) from excessive exertion rest is more important than drugs. Hypodermic injections of 1/100 grain of digitalin (not official) may be given once, twice, or three times daily if needed for heart-weakness whether from exertion, or in the course of fevers, or after injury. If the pulse is easily felt and not above 100, no dose is needed unless there is dropsy of the legs as shown by a dent remaining after pressure with the finger over the skin.

It should be injected (p. 262) into the muscle on the front of the thigh or of the chest. It has an irritating effect and leaves sore spots. Therefore if it must be continued many days give it by mouth. The best digitalin is that made by Burroughs, Wellcome & Co.

Antiseptics.

(a) *Tincture of iodine* (*tinctura iodi*, U. S. P.) is not poisonous but cannot be used repeatedly on the skin without causing it to peel off. For this reason surgeons avoid getting it on their hands. It is of great value for cleaning wounds at the first dressing or at the time of operation but cannot be used often without danger of causing inflammation.

(b) *Corrosive sublimate* or bichloride of mercury (*hydrargyri chloridum corrosivum*, U. S. P.) is extremely poisonous if swallowed, and if used in too strong solution it irritates the skin or wound with which it comes in contact. It should be carried in blue tablets so that they cannot be mistaken for other kinds of medicine. They make a blue solution which can be at once recognized.

Read the directions on the bottle and make a solution of required strength. With tablets of the usual size (7 3/10 grains) one should be dissolved in five pints of water to make a solution of 1–5000, or one tablet in one pint of water for a solution of 1–1000. Solutions of 1–1000 are useful for disinfecting towels, etc., but for irrigating or for dressings this solution is dangerously strong. For these purposes use a dilution of 1–5000.

(c) *Coal-tar disinfectants* (not official).—Sulpho-naphthol is probably the best known here. Phinotus oil or some other kind may be preferred. They can be used in dilution of one teaspoonful to a quart of water for cleaning wounds as a substitute for corrosive sublimate, and their use for other purposes has been described (pp. 218, 233).

Drugs for Special Purposes.

(a) *Quinine* (see *Malaria*, p. 228). — The usual signs of overdose are ringing in the ears, headache, and deafness which is transient. To get the full effect of quinine it is very important to have a good preparation of the drug. Old, hard pills may pass through without being absorbed, and the sulphate which is commonly used is soluble with difficulty. If old pills must be used, crush them in water before taking. The quinine-bisulphate pills of five grains each (*quininae bisulphas*, U. S. P.) of Parke, Davis & Co. and of Burroughs, Wellcome & Co. are reliable.

For injection, the bihydrochloride (not official) is one of the best forms. It is rather irritating and therefore best injected intramuscularly (p. 262). Burroughs, Wellcome & Co. make 5-grain hypodermic tablets, three of which will dissolve in one-half teaspoonful of water.

(b) *Emetine hydrochloride* comes in hypodermic tablets of one-half grain each (Parke, Davis & Co. or Burroughs, Wellcome & Co.). Dose: one tablet three times daily injected intramuscularly. Do not take it by mouth. This drug is useful only in amoebic dysentery (p. 231) but should be used promptly to get good results. Therefore if the symptoms indicate amoebic dysentery, try it within a few days and continue its use for at least a week, but not for more than ten days lest harm result. If after a few weeks the dysentery returns, take the drug again as before. It should cure amoebic dysentery within a week if used in the early stages of the disease. It is important to use a good preparation of the drug. Those specified above can be relied upon.

(c) *Anti-venom sera* (p. 234) are prepared in the Pasteur Institute of Lille, France; in Bombay and Kasauli, India; and at São Paulo, Brazil. Serum is obtainable in the countries in which poisonous snakes are the most dangerous, and is undoubtedly valuable for bites of the species of snake against which it is prepared, or bites of closely related species. In India sera are obtainable for use against bites of the cobra, Russell's viper, bungarus or krait, and Enhydrina or sea-snake. In South America serum is made for rattle-snake bites.

The dose of these sera is large, *i. e.*, 20 to 100 cubic centimeters. Therefore a syringe that will hold 30 cc. or 1 oz. is necessary for administering it. Directions as to dose and use of the sera are sent with the vials.

Ointments.

Ointments to be carried in the Tropics must be put up in water-tight containers because they are likely to melt. Ointments which have melted and become separated must be well stirred and then cooled before using.

(a) *Mercurial ointment* (*unguentum hydrargyri*, U. S. P.) is used chiefly to treat syphilis (p. 216) by rubbing it well into the skin, from which it is then absorbed, or on dressings over syphilitic ulcers which develop as a rule years after the original infection and are most common on the legs.

Mercury in any form is very poisonous and this ointment contains 50 percent of metallic mercury. If used often in the same place it will set up severe irritation of the skin. Therefore when used to treat syphilis it should be rubbed in on a different part on each night for a week and then the parts used again in rotation. Avoid the hairy parts when rubbing the ointment in. Never put it on the scalp.

Signs of poisoning result if the drug is used many weeks in succession or in too large quantity. The first sign usually is tenderness of the gums resulting in slight pain when the teeth are snapped together. If the drug is continued, extreme soreness of the mouth with swelling and ulceration of the gums will follow and there will be diarrhoea or other digestive disturbances. Sometimes digestive disturbance or diarrhoea comes first. The use of mercury should be stopped at the first sign of tenderness of the gums or of digestive disturbance.

Dose. — It is safe to rub in daily for two weeks an amount of ointment equal in size to a large pea. Smaller doses are ineffective for syphilis, and if used with care there is no danger of serious consequences.

(b) *Sulphur ointment* (*unguentum sulphuris*, U. S. P.) is used to kill the minute animal parasite which causes the itch and also for the vegetable parasites of the skin, such as ringworm (p. 215).

When used often on a sensitive skin, sulphur ointment may set up irritation. If this happens, stop the ointment until these signs disappear. Then resume its use, if necessary, in smaller quantity. It contains 10 percent of sulphur and is not poisonous. This ointment may be used for infected blisters of the feet (p. 258) or other superficial infections of the skin.

An ointment of about 10 percent strength can be easily made by mixing one ounce of lard or unsalted fat with one drachm of powdered sulphur. The mixing should be very thorough and can be facilitated by warming the lard. Oil can be used as a diluent if necessary. It is too thin to make an ointment and should be well stirred each time before using.

(c) *Boric ointment* (*unguentum acidi borici*, U. S. P.) contains 10 percent of boric acid. It is mildly antiseptic and soothing in its action on inflamed parts. It is useful in dressing burns (p. 245), to prevent gauze dressings from sticking to wounds, and for skin diseases when a soothing and protective application is needed (p. 215).

Eye-washes.

The solutions mentioned below can be used in suitable cases of injury or inflammation of the eye, whatever the cause. One or the other or two of them may be needed according to the symptoms. They should be administered with a dropper.

(a) *Boric acid* (*acidium boricum*, U. S. P.): mild antiseptic and soothing effect. It can be used freely without danger and is excellent to keep the eyes clean by dropping it into them every few hours.

To make the solution dissolve one 5-grain tablet in one-half ounce of clean, warm water and wait until it is completely dissolved. This gives a 2 percent solution.

(b) *Zinc sulphate* (*zinci sulphas*, U. S. P.) is better than boric acid when there is much discharge from the eye or marked inflammation. It has an astringent effect which tends to reduce congestion. It may be used every six or eight hours. To make 0.1 percent solution, the required strength, dissolve a 1-grain tablet in two ounces of water.

(c) *Holocain hydrochloride* (Hoechst & Co.) is a drug far better than cocain for painful inflammation in the eye. In a 1 percent solution it can safely be used every two or three hours. It comes in powder but tablets or capsules containing one grain each can be prepared by the druggist. To make a 1 percent solution dissolve one grain of holocain in two drachms of water.

Medical and Surgical Equipment.

Packing. — A variety of medicine chests and cases are made by Burroughs, Wellcome & Co. The desired contents can be selected and the chest fitted accordingly.

All drug containers should be double labelled and the labels varnished on if the container is of glass, porcelain, or metal; otherwise dampness will cause the labels to come off.

Bottles can be conveniently packed in proper mailing cases obtainable from any druggist. Sterile goods, such as gauze, must be carried in waterproof and hermetically sealed containers if they are to remain sterile. Metal instruments should be carefully cleaned, dried, and oiled before packing and must be protected from dampness. Rubber goods do not keep well unless protected from the air as by wrapping in paraffined paper, and from pressure. They should be powdered with talcum powder.

Medical and Surgical Outfits.

The lists which follow are intended for parties in which there is no physician. Consequently they have been limited to bare necessities such as a layman might be able to use if need be. Lists cannot be made out for every part of the world which the traveller might visit and he is strongly advised to use the lists only as a suggestion and to modify or add to them according to the best advice he can obtain about the region he intends to visit.

Outfit No. 1.

This outfit is designed for small parties travelling for one to three months where no unusual diseases are to be anticipated.

Drugs.

Morphine sulphate, 1 tube of hypodermic tablets, each $\frac{1}{6}$ grain (p. 268).
Digitalin tablets, 1 tube, $\frac{1}{100}$ grain each (p. 270).
"A. S. & B." pills (N. F.), 100 pills (p. 266).
Calomel, 30 tablets, each 1 grain (p. 266).
Epsom salts, $\frac{1}{2}$ pound (p. 266).
Bismuth subnitrate, $\frac{1}{2}$ pound (p. 267).
"Sun cholera" tablets, 1 small bottle (p. 267).
Compound cathartic pills (U. S. P.), 30 pills (p. 267).
Sodium bicarbonate, 4 ounces (p. 268).
Aspirin, 100 tablets, each 5 grains (p. 268).
Tincture of iodine, 4 ounces (p. 270).
Corrosive-sublimate tablets, 30 tablets, each $7\frac{3}{10}$ grains (p. 271).

Boric acid, 30 tablets, each 5 grains (p. 274).
Zinc sulphate, 20 tablets, each 1 grain (p. 274).
Holocain, 20 tablets, each 1 grain (p. 274).
Oil of cloves, ½ ounce.
Boric ointment, 4 ounces.
Sulphur ointment (U. S. P.), 4 ounces (p. 273).
Talcum powder, 2 small tins.

Instruments and Surgical Supplies.

Sheet-wadding, 1 pound.
Compressed cotton, 12 packages (Burroughs, Wellcome & Co.).
Compressed sterilized gauze, 12 packages (Burroughs, Wellcome & Co.).
Surgical knife or scalpel, 1.
Dissecting forceps, 1 pair.
Straight scissors, 1 pair.
Curved scissors, 1 pair.
Hemostatic forceps or snaps, 4 pairs.
Gauze bandages, 6 rolls one inch wide; 12 rolls two inches wide.
Bender bandages, 3 rolls three inches wide.
Straight surgical needles, 2 medium, 2 large.
Curved surgical needles, 2 medium, 2 large.
Silk to fit needles, 2 spools medium, 2 spools large.
Bone-cutting forceps, 1 pair.
Tooth forceps for molars, 1 pair.
Surgical plaster, 1 roll ½-inch wide, 1 roll 3 inches wide.
Catheter, soft rubber, a No. 15 and a No. 20 French.
Clinical thermometer, two 3-minute (quicker thermometers are too fragile).
Hypodermic syringe, one, all metal with solid metal plunger (keep it oiled).
Combination fountain-syringe and hot-water bag.
Medicine droppers, two (for use with eye-washes).

Outfit No. 2.

For parties of six to ten persons for three months, double Outfit No. 1.

For parties of six to ten persons for six months away from civilization add the following:

Ether, 2 pounds in ¼-pound tins.
Mercurial ointment, 4 ounces (p. 272).
Stomach tube.

Outfit No. 3.

For travel in the Tropics take Outfit No. 1 or No. 2 according to the size of the party and length of the trip and add the following:

Quinine bisulphate, 200 pills, 5 grains each.
Quinine bihydrochloride, 30 hypodermic tablets, each 5 grains (p. 271).
Emetine hydrochloride, 100 hypodermic tablets, each ½ grain (p. 271).
Sulphur ointment, double quantity.
Sulpho-naphthol, ½ pint (p. 271). If going to the part of Africa where bilharzia disease (p. 233) is common take 2 to 4 quarts.
Dalmatian or Keating's powder, or naphthalene in flakes, 2 pounds in small packages.
Chlorinated lime (p. 224).
"Desert" or "Egyptian" water-bags, two or three of appropriate size.

A Lyster water-bag may be needed for large expeditions.
Boiling pots, one for each member of the party so that he can quickly boil a pint of water for drinking.
Each man should have with him also a dozen tins of "solid alcohol" for fuel.

Don't forget a mosquito-net, a gauze net, and goggles for each member of the party.

Outfit No. 4.

For travel in the Arctic take Outfit No. 1 or No. 2 according to the size of the party and length of the trip and add the following:

Lime juice or other preparation to prevent scurvy.
Holocain, boric acid, zinc sulphate for eye-washes, double quantity (p. 274).

Don't forget goggles for every member of the party and some extra pairs.

Consider taking *unbolted flour* instead of white flour.

Weights and Measures.

Metric System.

Solids.

1 kg.	=	1 kilogram or 1000 grams (gms.).
0.1 gram (gm.)	=	1 decigram.
0.01 gm.	=	1 centigram.
0.001 gm.	=	1 milligram.

Liquids.

1 liter = 1000 cubic centimeters (cc.).
1 cc. of water weighs 1 gm.

U. S. Apothecaries' Weights.

1 Troy pound = 12 ounces or approximately 373 gm.
1 Troy ounce (℥) = 8 drachms or approximately 30 gm.
1 drachm (drach. or ʒ) = 60 grains or approximately 4 gm.
1 Troy grain (gr.) = 0.065 gm.

U. S. Apothecaries' Measures.

1 pint (0) = 16 fluid ounces (f. ℥) or approximately 480 cc.
1 fluid ounce (f. ℥) = 8 fluid drachms or approximately 30 cc.
1 fluid drachm (f. ʒ) = 60 minims or approximately 4 cc.
1 minim (min.) = 0.062 cc.

Household Measures.

Liquids.

1 pint = roughly 2 tumblerfuls.
1 fluid ounce (f. ℥) = roughly 2 tablespoonfuls or 8 teaspoonfuls.
1 fluid drachm (f. ʒ) = roughly 1 teaspoonful.
1 minim = roughly 1 drop of a watery or 2 of an alcoholic solution.

Solids.

1 drachm (ʒ) of a powder = roughly 1 level teaspoonful.
1 ounce (℥) of a powder = roughly 2 level tablespoonfuls.

Foreign Weights and Measures.

The metric system is used by apothecaries everywhere except in the United States and in Great Britain and its dependencies. The British weights and measures differ from ours but the metric system is everywhere understood. Therefore it should be used outside the United States.

Table of Relative Approximate Values.

Weights.

1 Troy ounce (℥)	= 30 gm.
1 drachm (ʒ)	= 3.88 gm.
1 grain (gr.)	= 0.065 gm.
1 gram (gm.)	= 15 grs.
1 teaspoonful	= roughly 4 gm.

Measures.

1 fluid ounce (f. ℥)	= 30 cc.
1 fluid drachm (f. ʒ)	= 3.70 cc.
1 minim	= 0.06 cc.
1 cc.	= 16 minims.
1 teaspoonful	= roughly 4 cc.

Reference Books.

Popular Books.

Hints to Travellers, 9th ed., vol. 2, pp. 160–256. Published by the Royal Geographical Society, London.
American Red Cross Text-book of First Aid. General edition.
Back-woods Medicine and Surgery. Outing Publishing Company.

Small Reference Books.

Mason: Handbook for the Hospital Corps of the United States Army and Navy. Wm. Wood & Co.

Ashburn: Elements of Military Hygiene. Houghton, Mifflin & Co.

Bidwell: Minor Surgery. Wm. Wood & Co.

Locke: Food Values. D. Appleton & Co.

Large Reference Books.

Harrington: Practical Hygiene. Revised by Richardson-Lea and Febiger.

Roseneau: Preventive Medicine and Hygiene. D. Appleton & Co.

Manson: Tropical Medicine. Wm. Wood & Co.

Castellani and Chalmers: Manual of Tropical Medicine. Wm. Wood & Co.

Osler: Practice of Medicine. D. Appleton & Co.

Sutton: Diseases of the Skin. Moseby & Co., St. Louis.

DETERMINING POSITION BY ASTRONOMICAL OBSERVATIONS.

BY ROBERT W. WILLSON.

It is the aim of these pages to explain the methods by which a traveller with no more than the simplest equipment may find his way to his destination and make a moderately accurate map of his route. The traveller we have in mind is one who, while pursuing the main object of his journey, can spare a few minutes at noon to find his latitude at the point then reached, and a few more later in the day to find his longitude at that time, or perhaps a half hour at morning or evening twilight to determine the latitude and longitude of his camp.

If he desires to make very accurate maps or precise astronomical determinations, he cannot well avoid the use of apparatus which he will find difficulty in transporting over rough country, and he will be obliged to travel somewhat slowly and arrange to make some days' stay in one place occasionally, for the purpose of studying the rates of his time-pieces. Such a traveller, who would desire to have a wide knowledge of the different methods available for finding latitude and longitude, should consult books which give more space to the subject of topographical and geographical observations.

Planning a route, following it, mapping it by dead reckoning, and checking the dead reckoning by astronomical observations, are the matters here taken up. The minimum equipment of apparatus necessary to carry out the various operations consists of a protractor and scale, a compass with sights, a time-piece, a sextant with an artificial horizon, and this volume or a similar set of tables. With this outfit if the correction of the watch is accurately known one may fix his position with an error not exceeding two miles. A careful observer with a good sextant and using all proper precautions will usually not depart from the truth by more than one half that amount. Desirable additions to the equipment are note-books reserved exclusively for this work, a nautical almanac, a surveyor's tape, additional time-pieces, and possibly a theodolite.

Planning a Route.

A traveller must have at least an approximate idea of the position of his objective point. This he may know with considerable accuracy from existing maps or from some special source of information. The course which he must follow from his starting point and the distance which he has to travel are easily found by plotting the two points by their known latitudes and longitudes on a map and making use of the protractor and scale.

If the distance is short any of the ordinary map projections will answer the purpose. In most cases, however, and particularly for longer journeys, the Mercator projection is in several respects the best.

Mercator Maps.

A straight line drawn between two points on a Mercator map gives a constant direction which will always lead a traveller from one to the other, and within moderate areas (say up to 500 miles square) by practically the shortest route. Furthermore, except in high latitudes, the length of such a line gives a close approximation to the distance between the two points.

In a Mercator map of any part of the earth's surface the proportional lengths of the degrees of longitude and latitude are preserved. That is to say, on such a map the sides of any rectangle bounded by two meridians a degree of longitude apart and two parallels a degree of latitude apart, represent in true proportion the difference of latitude *in miles* between the parallels, and the distance in miles between the meridians. This result is attained by drawing the meridians as equidistant vertical lines assumed to be sixty geographical miles apart along the equator, and the parallels as horizontal lines spaced according to their distance in geographical miles from the equator as measured along any meridian.

The geographical mile is about 6080 feet in length, or 1/60 of a degree of longitude as measured along the equator. It is identical with the nautical mile and equivalent to 1.15 statute miles of 5280 feet. One statute mile equals 0.87 geographical miles.

Plotting Mercator Maps.

A convenient scale on which to construct such maps is that in which one geographical mile on the equator, or one minute of longitude, is represented by one millimeter on the map.

This we will call our "standard" scale. A map of the whole surface of either the northern or the southern hemisphere up to latitude 70° plotted on this scale would of course be cumbersome, being 60 mm. times 360 (the circumference of the equator) or 21.6 meters in length and about 6 meters in height. Any portion of this map covering an area even as large as 500 miles square will, however, be of a convenient size and scale for field use. On these standard maps the meridians are represented as vertical lines 60 millimeters apart and the parallels as horizontal lines whose distances from the line of the equator are given in the following table.

Distance of Parallels on Standard Map.

Lat.		Lat.		Lat.		Lat.		Lat.	
°	mm.	°	mm.	°	mm.	°	mm.	°	mm.
1	59.6	16	966.3	31	1946.0	46	3098.7	61	4628.7
2	119.2	17	1028.5	32	2016.0	47	3185.6	62	4754.3
3	178.9	18	1091.0	33	2086.8	48	3274.1	63	4884.1
4	238.6	19	1153.9	34	2158.4	49	3364.1	64	5018.4
5	298.3	20	1217.1	35	2230.9	50	3456.5	65	5157.6
6	358.2	21	1280.8	36	2304.2	51	3550.6	66	5302.1
7	418.2	22	1344.9	37	2378.5	52	3646.7	67	5452.4
8	478.3	23	1409.5	38	2453.8	53	3745.1	68	5609.1
9	538.6	24	1474.5	39	2530.2	54	3845.7	69	5772.7
10	599.0	25	1540.1	40	2607.6	55	3948.8	70	5943.9
11	659.6	26	1606.2	41	2686.2	56	4054.5	71	6123.5
12	720.5	27	1672.9	42	2766.0	57	4163.0	72	6312.5
13	781.5	28	1740.2	43	2847.1	58	4274.4	73	6512.0
14	842.8	29	1808.1	44	2929.5	59	4389.1	74	6723.2
15	904.4	30	1876.7	45	3013.4	60	4507.1	75	6947.7

In measuring distances on the portions of the standard map the number of millimeters corresponding to a given distance in miles will be different according as the selected portion lies in high or in low latitudes. The scale for any given portion may be found by multiplying 100 by the secant of the latitude of the middle point of the map, which will give the number of millimeters corresponding to 100 geographical miles on the map.

The number of millimeters corresponding to 100 miles at each degree of latitude is given in the following table.

Scale of Distances for Standard Map.

Lat.		Lat.		Lat.		Lat.		Lat.	
°	mm.	°	mm.	°	mm.	°	mm.	°	mm.
1	100.0	16	104.0	31	116.7	46	144.0	61	206.3
2	100.1	17	104.6	32	117.9	47	146.6	62	213.0
3	100.1	18	105.1	33	119.2	48	149.4	63	220.3
4	100.2	19	105.8	34	120.6	49	152.4	64	228.1
5	100.4	20	106.4	35	122.1	50	155.6	65	236.6
6	100.5	21	107.1	36	123.6	51	158.9	66	245.9
7	100.7	22	107.8	37	125.2	52	162.4	67	255.9
8	101.0	23	108.6	38	126.9	53	166.2	68	267.0
9	101.2	24	109.5	39	128.7	54	170.1	69	279.0
10	101.5	25	110.3	40	130.5	55	174.3	70	292.4
11	101.9	26	111.3	41	132.5	56	178.8	71	307.2
12	102.2	27	112.2	42	134.6	57	183.6	72	323.6
13	102.6	28	113.3	43	136.7	58	188.7	73	342.0
14	103.1	29	114.3	44	139.0	59	194.2	74	362.8
15	103.5	30	115.5	45	141.4	60	200.0	75	386.4

If the distance between two points on the map is measured with a millimeter scale, and this distance is divided by the proper number from the above table, the result will be the distance between the actual points in miles.

By means of the foregoing tables it is easy to draw directly a map of any portion of the earth's surface upon our standard scale.

For instance, the southern New England States lie between the meridians of longitude 69° and 74° and between the parallels of latitude 41° and 43°. The extreme meridian lines will therefore be 5 × 60 mm. apart, and since by the first of the above tables the parallels 41°, 42°, and 43° are to be represented respectively as 2686.2 mm., 2766.0 mm., and 2847.1 mm. from the line of the equator we must draw the horizontal lines for 41° and 42°, 2766.0 – 2686.2, or 79.8 mm. apart and similarly the lines for 42° and 43° must be 81.1 mm. apart. This gives us a map 30 cm. wide and about 16 cm. high. The number of millimeters representing 100 miles on this map is found in the second table for latitude 42° to be 134.6.

It is obvious that these standard maps may be adapted in size to any special note-book page or other surface by multiplying the dimensions of the standard map by a suitable factor. In such a case the scale of miles for measurement will be found by multiplying the value for

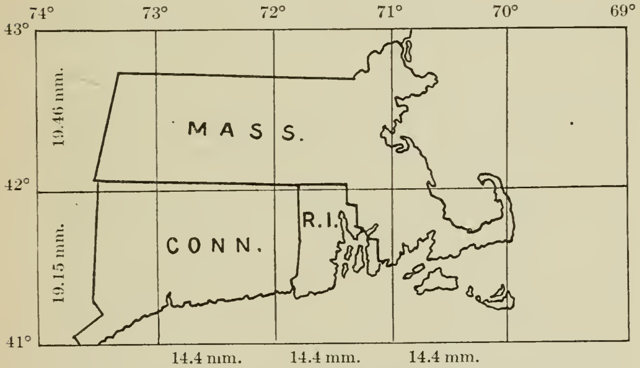


Fig. 20. Reduced Map of Southern New England States

100 miles on the standard by the factor used to convert the map. To illustrate the matter of conversion: if we wish to plot the above-mentioned New England map on this page, where our greatest available width is 72 mm. we must reduce its length from 300 mm. to 72 mm., *i. e.*, the numbers used above must each be multiplied by 72 ÷ 300 or 0.24. This gives us the following values: between the meridians, 0.24 × 60 or 14.4 mm., between the parallels of 41° and 42°, 0.24 × 79.8 or 19.15 mm., and between 42° and 43°, 0.24 × 81.1 or 19.46 mm.

For the distance scale we must take 0.24 × 134.6 or 32.30 mm. per 100 miles.

On nautical charts no scale of miles is given. Distances may be found by the following process. Lay a straight-edged strip of paper between the desired points, mark the points off on to the strip and fold it to get the point midway between the marks, note the approximate middle latitude of the points and apply the strip to the scale of latitude at the side of the map so that the crease mark falls at this middle latitude; note the number of minutes of the scale included between the points on the strip, and take this number as the distance between the points in miles.

Dead Reckoning.

Besides knowing whence he came and whither he is going, a traveller naturally finds it desirable to know where he is at any time during his journey. This he learns approximately by noting the directions in which he has travelled and estimating how far he has come. In a flat country this is obviously simple and fairly accurate. In broken country it is not quite so simple nor is it as accurate since the traveller, of necessity frequently changing his course, must make a fresh note of direction and an estimate of distance for each stretch of travel, and combine all such stretches up to any point which he wishes to locate, into a total "course and distance made good" from the start, or from his last well determined point.

This process is known as "dead reckoning," which for convenience we may hereafter refer to as D. R. It is commonly used for finding the position of a ship at sea, in which case the distance is measured quite accurately by the log, whereas in land travel the distances must be measured by pacing, if that is worth while, or more generally by some less accurate method such as noting the time spent on a given course and, from a knowledge of one's rate of travel under existing conditions, deducing the distance covered. With a little study, and by taking advantage of every possible opportunity to compare one's estimates with the actual distances between known points, experience will make this method sufficiently reliable, since after all it is not necessary that the dead reckoning be absolutely exact if astronomical observations are used to check the positions obtained. Every traveller, however, and the novice in particular should use every means to make his estimates of distance as accurate as circumstances will permit and to keep a constant check on his course by frequent reference to his compass. In this connection it may be noted that every opportunity should be taken to note the bearing of points near the last known point or likely to be visible from the next stopping place.

Dead Reckoning at Sea.

Inasmuch as dead reckoning at sea follows a much more uniform procedure than can usually be conformed to on land it will be best to describe that process in some detail and leave the reader to modify it to suit the conditions of his own journey.

The "log" or reckoning of a voyage is usually begun by taking a compass bearing from the ship, of some visible fixed point and estimating the ship's distance from it, for example, "At 3 P. M. Boston Light bore N 60° W, distant 5 miles." This is called "taking a departure from Boston Light" and begins the computation of the voyage on the supposition that the ship started at the known latitude and longitude of Boston Light and for a distance of 5 miles sailed a course of S 60° E, *i. e.*, the reversed bearing of the point from which the departure was taken. The first course and distance would then be computed and entered in the log as S 60° E, 5 miles, and obviously locates the ship at her true position at the given time, 3 P. M.

With the assumed first course and distance recorded in this manner, the actual courses and distances sailed are entered in the order of their succession, and at any time the D. R. may be computed by combining all into a total course and distance made good from the known fixed point. Ordinarily this is accomplished by adding up values for each stretch that may be read directly from a traverse table, but such a table would occupy forty-five pages of this book while for our purposes it is sufficiently accurate to take these values from the abridged traverse table on page 329 (or graphic table on back cover).

The traverse table resolves each "course and distance" into the equivalent number of geographical miles which it represents in distance north or south and east or west, or into what are commonly called the number of miles of northing or southing and easting or westing made good by a vessel sailing the given course and distance. In the computations these quantities are referred to as the "difference of latitude" and the "departure" respectively. The process by which several successive courses and distances are combined into the equivalent course and distance made good is shown in the following example.

A certain ship takes her departure from Boston Light, bearing N 60° W, distance 5 miles, and then sails as follows: N 37° E, 105 miles; N 79° E, 60 miles; N 11° W, 30 miles.

Each Course and Distance is resolved into Diff. Lat. and Departure as in Example 1 (p. 292), and the sums formed as in the table below:

Course and Distance	N	S	E	W
S 60 E 5 miles	....	2.5	4.3	....
N 37 E 105	83.9	....	63.2	....
N 79 E 60	11.5	....	58.9	....
N 11 W 30	29.5	....	....	5.7
Sums	N 124.9	2.5	E 126.4	5.7
	S 2.5		W 5.7	
Distance made good	N 122.4		E 120.7	

It is plain that if several courses are sailed and combined as in the above table, the numbers in the last line are the total Diff. Lat. and Departure, and that the corresponding Course and Distance made good may be found as in Example 8 (p. 296).

Along the equator, where a degree of longitude is sixty nautical miles, a given number of miles of easting or westing will obviously be an exact measure of the "departure" or difference of longitude. In higher latitudes, however, the convergence of the meridians toward the pole causes them to be actually nearer together in miles while still including between them the same number of units of longitude. From this it is evident that in any higher latitude the degrees, minutes, and seconds of longitude will be shorter than they are along the equator, and that therefore a given number of miles measured along any parallel will cover a greater number of these units than it would if measured along the equator. For instance, thirty nautical miles of departure along the equator measure thirty minutes of longitude, or one half a degree, but measured along the 60th parallel, the convergence of the meridians brings them twice as near together so that, at this latitude, the minutes of longitude are only one half as long and the thirty miles will span sixty of them or one whole degree of longitude.

Dead reckoning at sea necessitates the consideration of certain features not involved in the same work on land. The reading of the compass does not give directly the angle between the true meridian and the direction of the actual path of the ship, or in other words, its "true course." There are three factors which combine to cause this difference: first, the compass north in general differs from the true north by an amount known as the "variation"; second, the presence of magnetic matter in the ship itself produces a "deviation" which usually has different values as the ship heads in different directions, even though the compass has been well compensated; and lastly, as a result of wind pressure and the motion of the sea a ship's course is often toward a point somewhat to leeward of the direction of her head, that is, she makes "leeway." For these three effects corrections must be applied in order to determine the true course from the reading of the compass.

The variation may be found with sufficient accuracy from the charts in common use.

The deviation is usually found from a table arranged for each ship by making careful readings of the compass with the ship's head in different known directions.

The leeway may sometimes be estimated from the angle between the ship's keel and her wake, but an accurate judgment of the value of the leeway under varying conditions, and especially under sail, requires considerable experience.

The correction for deviation is in general more uncertain than that for variation, as the magnetism of the ship is liable to alteration from the shock arising from the pounding of the waves, and its value cannot be well predicted.

It is therefore advisable to make frequent tests of the compass correction by means of astronomical observation, since in this manner the "total correction" is determined at one operation. For this purpose the compass bearing of a point on the horizon directly under the sun is noted, together with the chronometer time of the observation. From the chronometer time, the known longitude, and the equation of time, the local apparent time or the equivalent hour angle of the sun is found. The sun's true bearing may then be computed or taken from suitable tables, and its difference from the compass bearing determines the error of the compass on that point of sailing.

Other astronomical observations are taken to check the D. R. longitude and latitude. These consist of time sights for the longitude and meridian altitudes for the latitude. If these are not taken the D. R. route is likely to deviate more and more from the true track as time goes on, though when sailing within sight of a known coast-line the bearings of fixed points may be substituted for the above to check the D. R. positions. Such bearings give the ship's position more accurately than astronomical observations and should be taken whenever possible.

The usual routine at sea, weather permitting, is to take a morning "time sight" when the sun is as nearly east as possible in order to determine the longitude; a meridian observation at noon to find the latitude; and an afternoon time sight if there is any doubt of the accuracy of the D. R. such as may arise from the uncertain effects of currents or unusually strong winds and heavy seas. The times of taking the time sights are usually convenient also for determining the compass correction by an observation of the sun's bearing. Now, much more than formerly, it has become common practice to make observations of stars for time and latitude. This is done in the morning or evening twilight when both the stars and the horizon are clearly visible, for in full darkness the horizon is not usually well enough seen for accurate observation.

At sea the time-piece used is of special construction and known as a chronometer. It, like the compass, is swung in gimbals to prevent it from responding to the motions of the ship. The chronometer is not suitable for land travel, and for that purpose, pocket watches with lever escapement must be used.

The observations are made with a sextant, the only instrument available at sea, and good measurements with it give the ship's position with an error of perhaps two or three miles. In land journeys, under such conditions as make its use possible, a light theodolite is to be preferred to the sextant if it can be conveniently and safely transported. With careful observations, altitudes may be determined with sufficient accuracy and it is a convenience to be able to measure horizontal angles quickly and directly. Also the compass of the theodolite may be read frequently and the variation found at each observation. It is probable, however, that those who use this book will prefer the more easily portable sextant as being sufficient for all ordinary purposes. With it, at a pinch, the horizontal angle between two points may be computed from the angle between the two points as measured by the sextant in the plane of the great circle joining them, if their approximate altitudes are also known. Also for a less degree of accuracy horizontal angles may be conveniently measured by an ordinary pocket compass provided with sights, and one such compass should always be available.

Preparation of Data and Use of Tables.

There are certain processes with which it is necessary to be familiar before taking up the methods of finding the latitude, longitude, and compass correction, and we will now take these up systematically.

First in order are those which are required in finding the position by dead reckoning; next, those for determining the correction to be applied on account of dip, refraction, parallax, and semidiameter, to the angle observed with the sextant in order to find from it the true altitude of the body observed; and lastly, the ways of finding from the appropriate tables the astronomical data required in solving the spherical triangles by means of which latitude, longitude, and compass correction are determined.

Problems in Dead Reckoning and the Use of the Traverse Table.

I.—The Course and Distance being given from a known point, *A*, to a second point, *B*, to find the difference of latitude and longitude between *A* and *B*, and therefore the latitude and longitude of point *B*.

There are four steps:

1. *To change the course and distance to difference of latitude and departure.*

Enter Table I with the given course as an argument, that is, find in column 1 the number of degrees equal to the course, and take the corresponding number from the column headed *Latitude.* Multiply the given distance in nautical miles by this "latitude factor" and the result is the difference of latitude between *A* and *B* in nautical miles.

With the same argument take the corresponding number from the column headed *Departure*, multiply the given distance by this "departure factor," and the result is the departure in nautical miles.

Example 1.—A ship sails a course N 40° E for a distance of 42 miles.

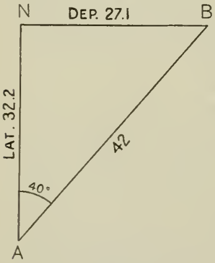


Fig. 21

Opposite the number 40 in column 1 of Table I we find under the heading *Lat.* in column 2 the factor 0.766, and under the heading *Dep.* in column 3 the factor 0.643. The difference of latitude will therefore be

$$42 \times 0.766 = 32.2 \text{ nautical miles.}$$

The departure will be

$$42 \times 0.643 = 27.1 \text{ nautical miles.}$$

In other words the ship when it reaches point *B* will be 32.2 miles farther north and 27.1 miles farther east than it was when it left point *A*.

Note.—It is always a good plan to make a rough sketch like that given above to avoid careless mistakes in the use of the values, and one should remember that "departure" means departure *in miles* from the meridian where the ship's run begins.

2. *To find the middle latitude.*

If the given course increases the initial latitude (that of point *A*), *add* one half the difference of latitude, obtained in Step 1, to the initial latitude. The result is the middle latitude.

If the given course decreases the initial latitude, *subtract* one half the difference in latitude. The result is the middle latitude.

EXAMPLE 2. — If the ship in the preceding section starts from latitude 42° 22′ N her course, being northward, will increase her latitude by an amount found to be 32.2 miles. Since a nautical mile is everywhere very closely equal to a minute of latitude, the ship at the end of her run would have arrived in Lat. 42° 54′ N (42° 22′ + 32′). Thus:

Course	N 40° E	Initial Lat.	42° 22′ N
Dist.	42 miles	½ Diff. Lat.	+16′
Diff. Lat.	32′		
		Mid. Lat.	42° 38′ N

Had she sailed a course S 40° E instead of that given above she would have been decreasing her initial latitude and the computation would appear thus:

Course	S 40° E	Initial Lat.	42° 22′ N
Dist.	42 miles	½ Diff. Lat.	−16′
Diff. Lat.	32′		
		Mid. Lat.	42° 6′ N

3. *To change the departure into the equivalent difference of longitude.*

Enter Table I with the middle latitude as an argument and in column 4 under the heading *Long.* find the corresponding number. Multiply the departure in miles by this number and the result will be the difference of longitude in minutes of arc.

EXAMPLE 3. — To find the difference of longitude which is equivalent to a departure of 27.1 miles when the middle latitude is 42° 6′.

In Table I we find the longitude factors for 42° and 43° are respectively 1.346 and 1.376. Interpolation of these values gives us 1.349 as the longitude factor for 42° 6′.

Multiplying the departure 27.1 miles by 1.349 we obtain the difference of longitude *in minutes of arc* as 36.6′.

NOTE. — In latitudes less than 50° the longitude factor may be taken for the *nearest* degree without interpolation without causing an error of more than 1′ to a degree of longitude. Even in latitude 62° the error of this procedure only reaches 2′ to a degree of longitude.

4. *To find the latitude and longitude of point B.*

Find the difference of latitude by Step 1, and *add* it to the latitude of point *A* if the latitude *increases* in following the given course, or *subtract* it if the latitude *decreases.* The result is the latitude of point *B.*

Find the difference of longitude by Steps 2 and 3 and *add* it to the longitude of point *A* if the longitude *increases* in following the given course, or *subtract* it if the longitude *decreases.* The result is the longitude of point *B.*

EXAMPLE 4. — Find the point reached by a ship starting from Lat. 42° 22′ N, Long. 70° 50′ W, and sailing S 40° E for 42 miles.

By Table I:

Diff. Lat. = 32.2 miles; Dep. = 27.1 miles. (Step 1.)
Mid. Lat. = 42° 22′ − 16′ = 42° 6′ N. (Step 2.)
Diff. Long. = 27.1 × 1.349 = 36.6′. (Step 3.)

Lat.	N 42° 22′	Long. W	70° 50′
Diff. Lat.	32.2	Diff. Long.	− 36.6
Finish	N 41° 50′	W	70° 13′

EXAMPLE 5. — Find the point reached by a ship starting from Cape Frio, Lat. S 23° 1′, Long. W 42° 0′, and sailing 162 miles N 35° E. ANSWER: S 20° 48′, W 40° 20′.

EXAMPLE 6. — A ship leaving a point in Lat. S 2° 32′, Long. E 107° 37′, sails N 35° W, 280 miles. What position does she reach? ANSWER: N 1° 17′, E 104° 56′.

II. — The latitude and longitude of point *A* and of point *B* being given, to find the course and distance between these points.

There are two steps:

1. *To find the difference in latitude, the middle latitude, and the departure.*

Subtract the smaller latitude from the greater, multiply the degrees of the result by 60 and add the minutes; the result is the *difference in latitude* in nautical miles.

To the smaller latitude add one half the difference in latitude and call the result the middle latitude.

Subtract the smaller longitude from the greater, multiply the degrees by 60 and add the minutes; the result is the *difference of longitude* in minutes of arc.

Enter Table I with the middle latitude as an argument and take out the corresponding Lat. factor. Multiply the difference of longitude by this factor and the result is the equivalent *departure* in nautical miles.

EXAMPLE 7. — Find the difference in latitude, the middle latitude, and the departure between the point *A* (Boston), Lat. 42° 19′ N, Long. 70° 53′ W, and the point *B* (Yarmouth, N. S.), Lat. 43° 47′ N, Long. 66° 9′ W.

B Lat.	43° 47′ N	*A* Long.	70° 53′ W
A Lat.	42° 19′ N	*B* Long.	66° 9′ W
Diff. Lat.	1° 28′	Diff. Long.	4° 44′
Diff. Lat.	88′	Diff. Long.	284′
A Lat.	42° 19′ N		
½ Diff. Lat.	44′	284′ × 0.731 (Lat. factor) = Dep. 207.6 miles	
Mid. Lat.	43° 3′ N		

2. *To find the course and distance.*

Divide the departure obtained in Step 1 by the difference of latitude, and seek the result in Table I in the column headed *Tan.* On the same line in column 1 will be found the *course* from *A* to *B*.

With this course enter column 1 and take out the factor on the same line in the column headed *Long.* Multiply the difference of latitude found in Step 1 by this Long. factor and the result will be the *distance* from *A* to *B*.

If the course exceeds 60° it will often be easier to divide the difference of latitude by the Lat. factor, which gives the same result as above.

NOTE. — To determine the letters which must be attached to any particular course, apply the principles that when the ship's latitude is increasing in either hemisphere her course has the same name as the latitude and that when she is increasing her longitude the direction in which she is moving has the same name as the longitude.

Example 8. — In the case of a ship sailing from Boston to Yarmouth, as given in Example 7, what is its course and distance?

From Example 7:

Dep. 208 ÷ 88 Diff. Lat. = 2.363 = Tan. factor of Course.
From Table I, Course = 67°

Course 67°:

From Table I, Long. factor = 2.559	Lat. factor = 0.391
88 × 2.559 = 225.2 miles	88 ÷ 0.391 = 225.5
Distance = 225.2 miles	

Answer: Course N 67° E, distance 225 miles.

Since the N Lat. is increased and the W Long. is decreased, the course is toward N and E.

Corrections to be Applied to Altitudes Observed with the Sextant.

The observation made with the sextant gives directly a reading which is approximately the angle between the two objects brought into coincidence in the field of view. It will be exactly equal to this angle if the divisions of the arc are properly spaced, the index arm turns about the exact center of the graduations, and the reading is exactly zero when the two mirrors are parallel. The normals of the two mirrors and the optical axis of the telescope must also be parallel to the plane of the sextant.

The quality of the graduation and the centering of the index arm are not under the control of the observer. The adjustments of the mirrors and of the telescope may be checked and corrected at any time in a simple manner and are reasonably permanent.

The condition that the mirrors shall be parallel when the reading of the arc is zero is seldom exactly fulfilled and is subject to change, due to variations of temperature and to comparatively slight shocks such as are almost unavoidable under the conditions of all but the smoothest travel.

Index Correction.

It is necessary, therefore, to combine with every sextant observation of an angle, a determination of the actual reading of the arc when the two mirrors are parallel. This is a condition easily realized by bringing the two images of the same object into coincidence in the field of view. If the reading is greater than zero it measures the quantity which must be *subtracted* from all readings to obtain the true angle, that is, the so-called "index correction." If the reading lies below the zero line and therefore on the short continuation of the divided arc to the right of the zero, the index correction must be *added*. No observation is accurate unless the index correction is known and the latter should therefore *always* be determined immediately before or after the reading of the angle.

The object whose images are to be brought into coincidence is, at sea, usually the line of the horizon, and the sextant is held with its plane vertical, the index arm placed near the zero position, and the final adjustment carefully made so that the line seen in the unsilvered portion of the horizon mirror is continuous with the reflection seen in the silvered part. If the reading is *on* the arc, the correction "comes off" all measured angles; if it is *off* the arc, the correction "goes on" to all measured angles. This explains the familiar catch phrase, "When it's on, it's off, and when it's off, it's on."

The index correction is often measured on a star or the sun. If as is sometimes the case, a terrestrial object must be used, it should not be too near, since the two images of a near object are in coincidence when the mirrors are not parallel but make an angle with each other equal to half the angle between lines drawn from the object to the horizon glass and index glass respectively. When the setting is made on an object at a distance of 200 yards, the index reading will be too far to the right, *i. e.*, "off" the arc, by about 1′; at 400 yards, 30″; at 600 yards, 20″; at 1200 yards, 10″; and in general the correction may be taken as $\frac{5700'' \times d}{D}$ where D is the distance of the object in yards, and d is the perpendicular distance in inches of the center of the index mirror from the line joining the center of the horizon mirror to the middle of the telescope objective.

In measuring the angle between two terrestrial objects, the true correction to be applied to *that* angle is obtained by determining the index correction on that one of the two objects which is seen through the horizon glass in measuring the angle between them.

When the object observed is the sun, set the index arm so that the two images of the sun are completely separated. Then turn the tangent screw so that the two adjacent limbs are brought into contact at the point of tangency and take a reading, which will be about 30′ on one side of the zero. Interchange the images and again take a reading with the other two limbs in contact, which will give a nearly equal angle on the other side of the zero. The middle point of the small arc thus covered is evidently the reading when the centers of the two sun discs coincide. Take one half the difference between the two readings as the index correction, positive if the greater reading is off the arc, negative if it is on the arc.

This process is more accurate than the centering of the two images on each other, and the accuracy of the settings may be estimated by dividing the sum of the two readings by 4. If the observation is well made the result will agree nearly with the value of the sun's semidiameter given in Table II. See Example 12, p. 301.

Refraction and Parallax.

Atmospheric refraction causes a body to appear higher above the horizon than it would if not affected by the presence of the atmosphere; parallax causes it to appear lower in the sky than it would if seen from the earth's center, which is the center of the celestial sphere, on which lie all the arcs and angles used in computing latitude, longitude, and compass correction. Every observed altitude, therefore, requires not only an "instrumental" correction for index error, which may be positive or negative, but also a negative correction for the refraction, and a positive correction for parallax.

Dip and Semidiameter.

The dip of the horizon depends on the well known fact that as we rise above the earth's surface the visible horizon (from which we measure) is depressed so that it forms the circumference of the base of a very flat cone with its apex at the observer's eye. It is obvious, therefore, that we measure from a base line that is too low and that for this reason the true altitude is less than the observed altitude. When an observation is thus made from the sea horizon, a negative correction for dip must therefore be applied, and if the altitude of the sun's lower limb is measured, as is usually the case, a positive correction must be added for the sun's semidiameter.

On land the shore-line across a lake may sometimes be conveniently taken as the horizon, and the correction for dip computed by the expression:

$$D = \frac{3}{7}d + 0.56\frac{h}{d},$$

where D = correction in minutes, h = height of eye in feet, and d = distance of shore-line in nautical miles.

For observations with the sextant on land an "artificial horizon" is used, a horizontal mirror formed by a free surface of mercury, or a plane glass plate carefully leveled with a sensitive level. In an emergency molasses, oil, or even water may be used. The inverting telescope should be used with the dark glass attached to its eyepiece. When the sun is observed the sextant is brought into a vertical plane and its telescope is pointed at the image in the artificial horizon. The index arm is moved out until the other image is brought down to coincidence. The angle between the two limbs which are thus brought together is twice the altitude of the sun's lower limb; if the descending image is carried on to coincidence with the farther limb the angle is the double altitude of the upper limb. The mean of two such altitudes needs no correction for semidiameter.

There is of course no correction for dip for angles measured with the artificial horizon and it is to be especially noted that the index correction must be applied *not* to the altitude but to the double altitude actually measured *before* dividing by 2 to find the altitude.

It is well to remember that before noon, if the images are approaching, the observation is made on the upper limb; if the images are separating the observation is on the lower limb. In the afternoon the lower limbs are approaching and the upper limbs separating.

Use of Table II.

All of these corrections except the index error may be taken from Table II which should need but little explanation. The tables of dip are to be relied on to the nearest minute only, as observations made on the sea horizon are necessarily subject to an unknown error of that amount owing to the uncertainty of refraction at very low altitudes.

The following are typical instances of the application of these tables to the correction of an observed altitude.

Example 9. — The observed altitude of a star above the sea horizon is 36° 20′ 20″, the index reading of the sextant on the sea horizon is 1′ 30″ *on* the arc, and the height of the observer's eye, 10 feet.

What is the star's true altitude?

Observed altitude	36° 20′ 20″
Index correction	−1′ 30″
Refraction (Table II)	−1′ 19″
Dip (Table II)	−3′ 6″
True altitude	36° 14′ 25″

Note. — There is of course no correction for parallax or semidiameter in a star observation.

Example 10. — The observed double altitude of a star is 74° 18′ 30″. The reading is then brought nearly to zero and the two images of the star made to coincide and the reading noted as 2′ 30″ to the right of zero.

What is the true altitude?

Observed double altitude	74° 18′ 30″
Index correction	+2′ 30″
	2)74° 21′ 00″
Apparent altitude	37° 10′ 30″
Refraction (Table II)	−1′ 17″
True altitude	37° 9′ 13″

Note. — Always apply the index correction *before* dividing by 2.

Example 11. — On March 1 the observed altitude of the sun's lower limb above the sea horizon is 15° 40′;

height of eye, 40 feet. Index reading when the two images of the horizon are in coincidence, 1′ 50″ on the arc.

What is the true altitude?

Observed altitude	15° 40′ 00″	From Table II.		
Index correction	−1′ 50″	Semidiameter	+16′ 10″	
		Parallax	+8″	
Corrected altitude	15° 38′ 10″	Refraction		−3′ 25″
Correction (see opp.)	+6′ 41″	Dip		−6′ 12″
True altitude	15° 44′ 51″		+16′ 18″	−9′ 37″
		Correction	+ 6′ 41″	

Example 12. — The observed double altitude of the sun's *center*, May 10, is 37° 40′ 40″.

Index readings on sun's limb;

On arc	0° 28′ 00″	Sum	63′ 20″
Off arc	0° 35′ 20″	S. D.	=15′ 50″
Diff.	7′ 20″	Eph. S. D.	=15′ 52″
Index correction	+3′ 40″		

Observed double altitude	37° 40′ 40″
Index correction	+3′ 40″
	2)37° 44′ 20″
Observed altitude	18° 52′ 10″
Parallax	+8″
Refraction	−2′ 49″
True altitude	18° 49′ 29″

All the problems which we have to solve require a knowledge of the *true* altitude of the sun's center, or of a star, which may be obtained from the observed altitude or double altitude by the foregoing methods. The other elements required for the solution of these problems may be taken from the Nautical Almanac or from Tables VI, VII, VIII, and X (pp. 332, 334, 336, 339) in the manner explained in the next section.

The Astronomical Data; Use of the Ephemeris.

In the solution of the problems which follow, if the sun is observed, the astronomical quantities required are the declination of the sun and the equation of time, which may be taken for the year 1916 from Tables VI and VII, for the given time of the observation. The semidiameter if needed, may be found in Table II. If the observed body is a star, its right ascension and declination and the right ascension of the mean sun are to be taken from Tables X and VIII, respectively.

In most problems the latitude and longitude of the place of observation must be known to a degree of approximation readily attained by dead reckoning from the last place of observation.

Observations of the moon and planets cannot be considered here as they require the use of tables too extensive to be included in these pages.

It is always necessary to know the Greenwich Mean Time of the observation. Since the data in the tables are given for Greenwich Mean Noon of the given date, and since all are continually changing with the time, corrections must be applied to obtain their values for the actual time of the observation. These corrections are obtained by multiplying the hourly difference given for each quantity by the number of hours and tenths before or after Greenwich Mean Noon. The correction is to be applied to the tabular value for noon, added or subtracted according as the time is before noon or after noon and as the value is increasing or decreasing. The result should always be checked by noting whether it lies between the next preceding and following values in the table.

For any other year than 1916 apply to the Greenwich Mean Time the correction for the given year according to the directions given on p. 305.

I. *To Find the Sun's Declination for any Given Greenwich Mean Time in the Year 1916.*

1. To the watch time, t, apply the watch correction Δt, which must be added if the watch is slow or subtracted if watch is fast. The result is the true Greenwich Mean Time (G. M. T.). Take the difference between this time and 12^h and call it "elapsed time"; mark it with a minus sign if the G. M. T. is A. M. and with a plus sign if P. M. Reduce this time to hours and tenths.

2. Enter the table with the Greenwich date, finding the month at the top of the column and the day of the month in either the first or the last column, whichever is nearest to the month column, and in the line with the day of the month find the sun's declination for Greenwich Mean Noon.

3. From the same line take out the number from the column headed *H. Diff.* (Hourly Difference) + or − as given in the table. Multiply the H. Diff. by the elapsed time. If both have the *same* sign, mark the product *plus*, if *different* signs, mark the product *minus*.

4. If the correction thus found and the value of the declination at noon have the same sign, add them together; if they have different signs take their difference, affixing the sign of the greater. The result is the sun's declination at the given G. M. T.

EXAMPLE 13. — An observation is made Feb. 14, 1916, when the watch time is $8^h\ 45^m\ 00^s$ A. M., the watch being $1^m\ 45^s$ fast of G. M. T. What is the sun's declination?

Watch time..........	$8^h\ 45^m\ 00^s$ A. M.	
Δt..................	$-1^m\ 45^s$	(subtract when watch is fast)
G. M. T..............	$8^h\ 43^m\ 15^s$ A. M.	
	12^h	
Elapsed T..........	$-3^h\ 16^m\ 45^s = -3.3^h$ nearly	

Table VI. G. M. N.

Sun's Decl........	$-13°\ 22'\ 8''$	H. Diff.............	$+50''$
Corr......	$-2'\ 45''$	El. T...............	-3.3
Sun's Decl. at time of obs.....	$-13°\ 24'\ 53''$	Corr................	$-165''$ $= 2'\ 45''$

EXAMPLE 14. — An observation is made Aug. 10, 1916, at $4^h\ 9^m\ 40^s$ P. M. by a watch which is $2^m\ 35^s$ slow of G. M. T. What is the sun's declination?

Watch time	$4^h\ 9^m\ 40^s$	
Δt..................	$+2^m\ 35^s$	(add when watch is slow)
G. M. T............	$4^h\ 12^m\ 15^s$	
Elapsed T..........	$+4.2$ nearly	

Table VI.

Sun's Decl., G. M. N.	$+15° \ 35' \ 55''$	H. Diff.	$-44''$
Corr.	$- \quad 3' \ 5''$	El. T.	$+4.2$
Decl.	$+15° \ 32' \ 50''$	Corr. . . $-184.8'' =$	$-3' \ 5''$

II. *To Find the Equation of Time for any given G. M. T. in the Year 1916.*

Apply the same rules as for finding the sun's declination except that Table VII is to be used instead of VI, and the expression "Equation of Time" is to be substituted for declination wherever that word occurs. When the sign of the Eq. T. given in the table is plus, the Eq. T. is to be added to G. M. T.; when negative, it is to be subtracted, in order to find the Greenwich Apparent Time.

EXAMPLE 15. — To find the Equation of Time for Feb. 14, 1916, at $8^h \ 43^m \ 15^s$ A. M., G. M. T.

G. M. T.	$8^h \ 43^m \ 15^s$ A. M.
	12^h
Elapsed T.	$-3^h \ 16^m \ 45^s = -3.3^h$ nearly

Table VII. G. M. N.

Eq. T.	$-14' \ 22.7^s$	H. Diff.	$+0.1^s$
Corr.	-0.3	El. T.	-3.3
Eq. T. at time of obs.	$-14' \ 23.0^s$	Corr.	-0.3^s

III. *To Find the Right Ascension of the Mean Sun for any G. M. T. in 1916.*

Enter Table VIII with the given date and take out the R. A. M. S. for Greenwich Mean Noon. Find the elapsed time from noon and with the given G. M. T. as an argument take out the correction from the Correction Table of Table VIII. If the given G. M. T. is marked P. M. add this correction to the value of R. A. M. S. at noon; if the G. M. T. is A. M. subtract the correction.

EXAMPLE 16. — To find the R. A. M. S. on Apr. 21, 1916, at $9^h\ 25^m$ A. M., G. M. T.

G. M. T.	$9^h\ 25^m\ 0^s$	R. A. M. S., G. M. N.	$1^h\ 56^m\ 53.8^s$	Table
	12^h	Corr. for $-2^h\ 35^m$	-25.5^s	VIII
El. T. ..	$-2^h\ 35^m\ 0^s$			
		R. A. M. S. at the time of obs......	$1^h\ 56^m\ 28.3^s$	

IV. *To Find the Sun's Declination, the Equation of Time, or the Right Ascension of the Mean Sun for a given Date of any Year from 1916 to 1932.*

Apply to the given G. M. T. the correction for the given year taken from the table below and with this corrected G. M. T. as an argument take the required values from the Tables VI, VII, VIII.

Year	Jan.–Feb.	Mar.–Dec.	Year	Jan.–Feb.	Mar.–Dec.
	h. m.	h. m.		h. m.	h. m.
1917	+18 12	− 5 48	1925	+19 31	− 4 29
1918	+12 24	−11 36	1926	+13 41	−10 19
1919	+ 6 35	−17 25	1927	+ 7 52	−16 8
1920	+ 0 45	+ 0 45	1928	+ 2 4	+ 2 4
1921	+18 54	− 5 6	1929	+20 16	− 3 44
1922	+13 3	−10 57	1930	+14 29	− 9 31
1923	+ 7 12	−16 48	1931	+ 8 30	−15 30
1924	+ 1 22	+ 1 22	1932	+ 2 49	+ 2 49

EXAMPLE 17. — Find the sun's declination Feb. 10, 1919, at $8^h\ 24^m$ A. M., G. M. T.

G. M. T.	$8^h\ 24^m$ A. M.		
Constant for Feb. 1919...	+6 35		
Corrected G. M. T.	$2^h\ 59^m$ P. M.		
Sun's Decl. at noon (Table VI)	$-14°\ 41'\ 2''$	H. Diff.	$+48''$
Corr.	$+2'\ 24''$	El. T.	$+3$
Sun's Decl.	$-14°\ 38'\ 38''$	Corr.	$+144''$
			$= +2'\ 24''$

Example 18. — What is the equation of time Apr. 21, 1923, at $7^h\ 35^m$ P. M., G. M. T.?

G. M. T.	$7^h\ 35^m$ P. M.		
Constant for Apr., 1923	−16 48		
Corrected G. M. T.	$2^h\ 47^m$ A. M. (2.8 hours)		
Eq. T. noon Apr. 21 (Table VII)	$+1^m\ 17.1^s$	H. Diff.	$+0.5^s$
	−4.6	El. T.	−9.2
Eq. T. $7^h\ 35^m$ P. M., G. M. T.	$+1^m\ 12.5^s$	Corr.	-4.6^s

Example 19. — What is the equation of time Feb. 10, 1928, at 3.36 P. M.?

G. M. T.	$3^h\ 36^m$ P. M.		
Constant for Feb. 1928	+2 4		
Corr. G. M. T. 1916	$5^h\ 40^m$ P. M.		
Eq. T. noon	$-14^m\ 22.8^s$	H. Diff. ...	-0.1^s
Corr.	−0.6	El. T.	+5.7
Eq. T. Feb. 10, 3.36 P. M.	$-14^m\ 23.4^s$		−0.57

Example 20. — What is the right ascension of the mean sun Apr. 21, 1924, at 11.42 A. M., G. M. T.

G. M. T.	$11^h\ 42^m$ A. M.
Constant for Apr. 1924	+1 22
G. M. T. for 1916	$1^h\ 4^m$ P. M.
R. A. M. S. Apr. 21, noon (Table VIII) ...	1 56 53.8
Corr. for $1^h\ 4^m$	+0 10.5
R. A. M. S.	$1^h\ 57^m\ 4.3^s$

Example 21. — What is the R. A. M. S. Aug. 15, 1930, at 7.30 A. M., G. M. T.

G. M. T.	$7^h\ 30^m$ A. M.
Constant for Aug. 1930 ..	−9 31
Corr. G. M. T.	$9^h\ 59^m$ P. M. (Aug. 14.)

R. A. M. S. at noon, Aug. 14 (Table VIII) .	$9^h\ 30^m\ 17.9^s$
Table VIII, Corr. for $9^h\ 59^m$	+1 38.4
R. A. M. S. Aug. 15, 1930, 7.30 A. M., G. M. T.	$9^h\ 31^m\ 56.3^s$

V. *To Find the Right Ascension and Declination of a Star for any Date.*

Take from Table X the values for 1916. For any other date add the product of the annual variation by the number of years and tenths of elapsed time since Jan. 1, 1916. The result is the R. A. or Decl. for the given date.

EXAMPLE 22.—Find the right ascension and declination of Aldebaran for March 1, 1919 ($= 1916.0 + 3.2$ years).

Table X.

R. A. 1916	$4^h\ 31^m\ 5.9^s$	Annual Var......	$+3.4^s$
Corr.	$+10.9^s$	El. T.	$+3.2$
R A. Mar. 1, 1919.	$4^h\ 31^m\ 16.8^s$	Corr.............	$+10.88^s$

Decl. 1916.........	$16°\ 20'\ 28.9''$	Annual Var.......	$+7.0''$
Corr...............	$+22.4''$	El. T.............	$+3.2$
Decl. Mar. 1, 1919..	$16°\ 20'\ 51.3''$	Corr.............	$22.4''$

LATITUDE, LONGITUDE, AND COMPASS CORRECTION BY OBSERVATION OF THE SUN.

The two most important problems are: to find first, the latitude by the sun's meridian altitude; and second, the longitude by observation of the sun's altitude at a time when it is changing rapidly, that is, at some distance from the meridian. In land journeys in or near the Tropics where an artificial horizon must be used, the sun is often too high to be observed by that method at noon; and the latitude must be found by an altitude of Polaris or of some other star.

When the meridian altitude is too great to be conveniently observed the position may often be fixed by two observations of the sun made at lower altitudes and combined by Sumner's method (p. 326).

I. *To Find the Latitude by the Sun's Meridian Altitude.*

1. — The data required are the G. M. T. of observation, *or* the longitude of the place, and the sun's observed altitude and its true declination. It must be noted whether the sun is N or S of the zenith.

2. — Find the true altitude of the center by correcting for index, refraction, dip, parallax, and semidiameter.

3. — (*a*) If the time of the observation was noted, find the corresponding G. M. T. by adding the clock correction, Δt, and for this time take out the sun's declination from Table VI; if north, mark it *plus*, if south, mark it *minus*.

(*b*) If the time of the observation was not noted, that is, if the sun was followed up until its altitude began to decrease, so that the sextant reading was that of the highest altitude, the Greenwich Mean Time for which the declination is to be taken, is that which corresponds to the Apparent Noon of the place of observation and may be found as follows:

Reduce the *west* longitude of the place of observation to hours, minutes, and seconds by dividing by 15, or by Table IV, and the result is the Greenwich Apparent Time of the Local Apparent Noon. (If the longitude is east subtract the longitude from 12^h and the result is the Greenwich Apparent Time.) To this value apply the Eq. T. taken from Table VII for noon of the date in question *but with reversed sign.* The result is the Greenwich Mean Time of the observation. The error involved in neglecting to correct for the change in the Eq. T. in the interval elapsed since Greenwich Mean Noon can never cause an appreciable error in the value of the sun's declination at the moment of observation.

4. — Subtract the true altitude of the sun's center from 90°, thus obtaining the zenith distance; mark it plus if the sun is south and minus if the sun is north of the zenith. Take the algebraic sum of the sun's zenith distance and its declination and the result is the latitude of the observer. If the sign is positive, the latitude is north; if the sign is negative, the latitude is south.

Example 23. — The maximum double altitude of the sun's lower limb was observed Jan. 5, 1916, at Cambridge, long. $4^h\ 44^m\ 28^s$ W of Greenwich, as 49° 24′ 30″ S. of zenith. Index correction −3′ 50″. What is the latitude?

Obs. 2 Alt. ⊙.	49° 24′ 30″	Long.	$4^h\ 44^m\ 28^s$
Index Corr...	−3 50	Eq. T.....	+5 3 (rev'sed sign)
	2)49° 20′ 40″	G. M. T.	4° 49′ 31″
Obs. Alt.....	24° 40′ 20″	"	4.8^h nearly
Refr.........	− 2 6	H. Diff. of Decl..........	+16″
Px..........	+ 8	El. Time................	+4.8
S. D.........	+16 18		
		Corr....................	76.8″
True Alt. ⊙ ..	24° 54′ 40″	"	+1′ 17″
Subtract from	90		
Zenith Dist.	+65° 5′ 20″	Decl...............	−22° 43′ 58″
Decl........	−22 42 41	Corr...............	+1 17
Lat.	+42° 22′ 39″	Decl...............	−22° 42′ 41″

II. *To Find the Longitude by an Observation of the Sun's Altitude.*

The data necessary for this problem are the true altitude of the sun, h, the sun's polar distance, p, the equation of time, an approximate value of the latitude, Lat., and the G. M. T. of the observation. The farther the sun is from the meridian the less is the effect of an erroneous value of the assumed latitude upon the value of the computed longitude.

1. — To the watch time apply the watch correction to find the G. M. T. of the observation. To the G. M. T. apply the Eq. T., which gives the Greenwich Apparent Time. For the G. M. T. take from the Ephemeris, Table VI, the sun's declination and the Eq. T. If the Lat. and Decl. are both north or both south subtract the Decl. from 90°; the result is the polar distance. If the Lat. and Decl. have different names add the Decl. to 90°; the result is the polar distance.

NOTE. — Polar distance is reckoned from the elevated pole and in either hemisphere is greater than 90° in the winter season and less than 90° in the summer. The cosecant of the polar distance is equal to the secant of the declination and this is a convenient check, as mistakes sometimes arise in looking up the cosecant when the polar distance is greater than 90°.

2. — Add together the sun's true altitude, h, the assumed latitude, and the sun's polar distance, p. Divide

the sum by 2 and call the result the "half-sum," *s*. Subtract the sun's altitude from the half-sum and call the result the "remainder."

3. — Take from Table XI the logarithms of the secant of the latitude, the cosecant of the polar distance, the cosine of the half-sum, and sine of the remainder.

4. — Add these four logarithms, divide the sum by 2, and reject 10 from the index. Seek this value in the column of log. sines of Table XI and take out the corresponding local apparent time of the observation from the column headed *A. M.* for a morning observation, or *P. M.* for an afternoon observation.

5. — Subtract the local apparent time from the Greenwich Apparent Time found by Step 1 and the result is the longitude west of Greenwich in time. Convert to degrees by Table V. If the result is negative the longitude is east of Greenwich.

EXAMPLE 24. — About 7 A. M., L. M. T., Nov. 10, 1916, at sea, Lat. by D. R. 27° 15′ S; Long. 36° 19′ W; watch time $9^h\ 5^m\ 30^s$; alt. sun's lower limb 21° 10′; watch $6^m\ 35^s$ slow of G. M.T.; Index Corr. −3′; height of eye, 40 feet.

Watch T. $9^h\ 5^m\ 30^s$	Eq. T., Noon, $16^m +0.3^s$	H. Diff. -0.2^s
Δt. ..... +6 35	Corr. ...... +0.6	El. T. . −2.8
G. M. T. 9 12 5	Eq. T...... $+16^m\ 0.9^s$	Corr. $+0.56^s$
Eq. T.... +16 1		
G. A. T. $9^h\ 28^m\ 6^s$	Decl., Noon −17° 8′ 22″	H. Diff. −42″
	Corr. ..... +1 58	El. T. . −2.8
Obs. Alt. 21° 10′		
Corr. ..... +11	Decl. ..... −17° 6′ 24″	Corr. +117.6″
	p. 72 54	
h, True Alt. 21° 21′	(Lat. & Decl. same name)	

Lat. 27 15	Sec. 0.05109	I. C. + 3′ 0″	
p. 72 54	Csc. 0.01964	Px. + 8	Refr. − 2′ 30″
Sum .... 121° 30′	Cos. 9.68897	S. D. + 16 12	Dip. − 6 12
Half-sum, *s* 60 45	Sin. 9.80259	+ 19′ 20″	− 8′ 42″
Rem., *s*−*h* 39 24	2)19.56229	Total Corr. + 10′ 38″	
L. A. T. $7^h\ 2^m\ 39^s$....	9.78115		

L. A. T.–G. A. T. $2^h\ 25^m\ 27^s$ Table V, 2^h = 30°, 20^m = 5°,
Long. W...... 36° 21′ 45″ 5^m = 1° 15′, 27^s = 6¾′

Example 25. — Apr. 4, 1919, about $3^h\ 50^m$ P. M. Eastern Standard Time at Cambridge, Lat. N 42° 22′ 38″ (Ex. 24). Watch time $8^h\ 44^m\ 0^s$ P.M.; Double Alt. sun's center 53° 7′ 30″; watch $1^m\ 20^s$ fast of G. M. T.; Index Corr. −1′ 20″.

Watch T.	$8^h\ 44^m\ 0^s$	G. M. T.	$8^h\ 42^m\ 40^s$ P. M.
Δt	−1 20	Const. for Apr. 1919.	−17 25
G. M. T.	$8^h\ 42^m\ 40^s$	Arg. for 1916	3 18 A. M.
Eq. T...	−3 12	El. T.	$-\ 8^h\ 42^m = -8.7^h$
G. A. T..	$8^h\ 39^m\ 28^s$		

2 Alt.	53° 7′ 30″	Eq. T., Noon	$-3^m\ 5.5^s$	H. Diff...	$+0.7^s$
I. C. ...	−1 20	Corr.......	−6.1	El. T. ...	−8.7
	2)53 6 10	Eq. T......	$-3^m\ 12^s$	Corr. ...	-6.09^s
Alt...	26 33 5	Decl., Noon	+5° 40′ 29″	H. Diff..	+57″
Ref. Px.	−1 48	Corr.....	−8′ 16″	El. T....	−8.7
h	26 31 17	Decl.	+5° 32′ 13″	Corr.....	−496″

Lat..	42 22 38	Sec.	0.13152
p.....	84 27 47	Csc.	0.00203
	153 21 42		
½Sum	76 40 51	Cos.	9.36244
Rem.	50 9 34	Sin.	9.88527
			2)19.38126
L. A. T.	$3^h\ 54^m\ 59^s$ ...		9.69063

L. A. T........	$3^h\ 54^m\ 59^s$
G. A. T.–L. A. T.	4 44 29
Long..........	71° 7′ 15″

The Compass Correction.

Compass bearings are usually expressed in degrees reckoned from 0° at the north and south points to 90° at the east and west points, but the liability to error is greatly decreased by reducing each bearing to its corresponding magnetic azimuth measured from the north through east, south, and west from 0° to 360°; thus, N 20° E = Az. 20°, S 35° E = 180° − 35° = Az. 145°, S 35° W = 180° + 35° = Az. 215°, N 45° W = 360° − 45° = Az. 315°.

Astronomical azimuth is sometimes computed from 0° to 180° in each direction from the elevated pole, but is now generally reckoned from 0° at the south point through W, N, and E to 360°. In the sections below, however, to follow the analogy of the compass, the astronomical azimuths will be understood to be reckoned from 0° at the north point through E, S, and W to 360°.

With this understanding, the compass correction is the quantity to be *added* to the magnetic azimuth in order to give the true astronomical azimuth, both reckoned from the north point clockwise around the horizon. If the magnetic azimuth is greater than the astronomical azimuth, the correction is negative, and a little consideration shows that in this case the variation (including the deviation if any exists), is west, that is, the north end of the compass needle points west of the true north point.

When the correction is determined by observation of the sun's altitude as in Problem III following, two observations of the compass bearing should be taken: one just before, and one just after the altitude observation. The mean of the two may be taken as the bearing of the sun at the time of the altitude observation.

III. *To Find the Compass Correction by Observation of the Sun.*

1. — In addition to the sun's bearing by compass, the data required are the latitude by dead reckoning, L, the sun's altitude, h, and its polar distance, p, the last requiring an approximate knowledge of the G. M. T.

2. — Add together the sun's altitude, the assumed latitude, and the polar distance; divide by 2 and call the result the half-sum, s. Subtract the sun's polar distance from the half-sum and call the result the remainder.

3. — Take from Table XI the logarithms of the secant of the altitude, the secant of the latitude, the cosine of the half-sum, and the cosine of the remainder (the remainder may be a negative angle but its cosine is the same as that for an equal positive angle).

4. — Add these four logarithms, divide the sum by 2 and reject 10 from the index. Seek this value in the cosine column of Table XI, and the corresponding angle is one half the sun's true bearing reckoned from the elevated pole. Multiply this value by two and the result is the sun's true bearing from the elevated pole, toward the east for an observation before noon, and west for an observation after noon.

5. — From the sun's true bearing from the elevated pole, determine the astronomical azimuth as above defined (p. 311) and from the sun's compass bearing determine the magnetic azimuth from north toward east. Subtract the magnetic azimuth from the true azimuth. The result is the "compass correction."

Since the data required for finding the sun's true bearing are exactly the same as those used in computing the local apparent time, it is obvious that if the sun's compass bearing is taken at the same time as a time sight the compass correction may be found with very little additional computation at the same time that the time sight is worked up for longitude.

If, for instance, at the time of the observation discussed in Example 25 (p. 311) the compass bearing of the sun was observed to be S 85° W, the correction would be computed as shown below, where part of that example is repeated and also, outside of the heavy lines, the computation of the compass correction in the form in which it is usually carried on at the same time as the computation for the longitude.

EXAMPLE 26.

h	26° 31′ 17″	....	Sec. 0.00464
Lat.	42 22 38	Sec. 0.13152	Sec. 0.13152
p	84 27 47	Csc. 0.00203	
Sum	153 21 42		
s	76 40 51	Cos. 9.36244	Cos. 9.36244
Rem.	50 9 34	Sin. 9.88527	
2d Rem., $s-p$	−7° 46′ 56″	....	Cos. 9.99598
		2)9.38126	2)9.53823
L. A. T.	3^h 54^m 59^s P. M.	9.69063	9.76912
G. A. T.	8 39 28 P. M.		
Long.	4^h 44^m 29^s		
	71° 7′ 15″		

Cos. half bearing	9.76912
Half bearing	54° 1′
Sun's true bearing	N 108 2 W
True azimuth	251 58
Observed azimuth (S 85° W).	265 0
Compass correction	−13° 2′

The same process may be applied when a star observation is used for finding the longitude, as in Example 31 (p. 321) where a star is used to find both longitude and compass correction.

The sun's true azimuth may be computed when the latitude and the sun's declination are known, if the local apparent time is given. The solution is usually not so convenient as that described in the last section. The results are given in azimuth tables computed for each degree of declination that the sun can occupy and for all latitudes up to 61°. These tables are in general use at sea where they are easily transported and where a knowledge of the compass correction is far more important, but few travellers would care to carry them on a land journey. Their use is sufficiently explained in the tables themselves.

Star Observations.

In the section immediately preceding are given the methods which will be found most useful in checking by astronomical observations the positions obtained by dead reckoning. However, the following methods should not be neglected as alternatives, especially the determination of latitude by star observation, which indeed, in low latitudes, is the main dependence of travellers on land, where if the sextant is used the altitude must generally be found by means of an "artificial horizon" and where the meridian altitude of the sun is often so great that the "double altitude," which is the angle dealt with, is too great to be measured by the sextant. Even in latitude 45° N, the sun at noon is too high for most sextants during the period from May 10 to August 5, while between latitudes 20° N and 20° S its meridian altitude cannot be measured by the sextant and artificial horizon on any day of the six summer months, so that the observer of necessity must rely upon star observations made on or near the meridian, such as those explained in Examples 29, 30, and 32. For tropical travel the theodolite is therefore to be preferred as it may be used for measuring all angles up to the zenith.

Conversion of Time.

In the reduction of star observations it is frequently necessary to reduce local mean time to local sidereal time. This is done by the following process, which depends upon the principle that the sum of the right ascension and the hour angle of *any* heavenly body at a given instant at any given place equals the hour angle of the vernal equinox, which equals the local sidereal time, that is:

H. A. + R. A. = H. A. of Vernal Equinox = Sid. T.

If the body considered is the mean sun we get the following relation:

Local M. Time + R. A. of Mean Sun = Local Sid. Time.

I. *To Reduce G. M. T. to G. Sid. T.*

In Table VIII is given the right ascension of the mean sun at Greenwich Mean Noon for any date. This quantity is the same as the G. Sid. T. at G. M. N.; for the mean sun is then on the meridian and the right ascension of any heavenly body equals the local sidereal time when it crosses the local meridian. At this instant,

G. M. T. [= 0] + R. A. M. S. = Gr. Sid. T.

If at any instant of G. M. T. we add to the Greenwich Sidereal Time at the previous mean noon, the sidereal interval of time which has *elapsed since* the previous mean noon, we shall obviously have the Greenwich Sidereal Time at the given instant. The required interval of sidereal time is found from the G. M. T. which is of course the interval in hours, minutes, and seconds of mean solar time since the previous G. M. N., and must be changed to the equivalent *sidereal* interval by *adding* the correction from Table VIII (correction table at foot of page). It is first necessary to express the G. M. T. as "astronomical" time reckoned from 0^h at noon through 12^h at midnight to 24^h at noon of the following day.

If the G. M. T. is marked A. M. it is changed to astronomical time by adding 12 to the number of the hours and subtracting one day from the date; if the time is P. M. astronomical time is the same as civil time.

The rule then is:

1. — Write the G. M. T. as astronomical time.

2. — Add to the G. M. T. the corresponding correction from mean to sidereal interval taken from Table VIII (reduction table) and the value of the R. A. M. S. taken from Table VIII. The sum of these three quantities is the Greenwich Sidereal Time.

EXAMPLE 27. — Find the Greenwich Sidereal Time corresponding to $11^h\ 30^m\ 25^s$ P. M., G. M. T., April 20 1927.

R. A. M. S. Apr. 20, 1916, G. M. N. (Table VIII)	$1^h\ 52^m\ 57.3^s$
Table III, constant for Apr. 1927 − $16^h\ 8^m$; Table VIII, red. for $16^h\ 8^m$	−2 39.0
R. A. M. S., G. M., Noon, Apr. 20, 1927.	$1^h\ 50^m\ 18.3^s$
G. M. T.	11 30 25
Table VIII, red. to Sidereal Time for $11^h\ 30^m$ . . .	1 53.3
G. Sidereal Time.	$13^h\ 22^m\ 36.6^s$

EXAMPLE 28. — Find the G. Sid. T. corresponding to $11^h\ 30^m\ 25^s$ A. M., G. M. T., April 20, 1927.

First, change the G. M. T. to astronomical time reckoned from 0^h at noon to 24 at the next noon, that is, call it G. M. T. $23^h\ 30^m\ 25^s$ April 19, and the computation will be as follows:

R. A. M. S. Apr. 19, 1916, G. M. N..	$1^h\ 49^m\ 0.7^s$
Constant for Apr. 1927 − $16^h\ 8^m$; red. to Sid. T. . .	−2 39.0
R. A. M. S. for 1927, Apr. 19, G. M. N..	$1^h\ 46^m\ 21.7^s$
G. M. T. (Astronomical Time)	23 30 25.0
Table V, reduction to sidereal $23^h\ 30.4^m$	3 51.6
G. Sidereal Time, Apr. 19	$25^h\ 20^m\ 38.3^s$
G. Sidereal Time, Apr. 20	$1^h\ 20^m\ 38.3^s$

II. *To Change G. M. T. to the Equivalent Local Sidereal Time at a Given Place.*

It is often necessary to change a given G. M. T. to the Local Sidereal Time of some other place of observation, as in Example 30. To solve this problem change the G. M. T.

to G. Sid. T. by the method of Examples 27 and 28 and find the Local Sid. T. by *subtracting* the longitude if west, or *adding* the longitude if east.

III. *To Change Local Mean Time at a given Place to the Equivalent Local Sidereal Time.*

1. — Change the L. M. T. to G. M. T. by adding the longitude from Greenwich if west, subtracting it if east.

2. — Change the G. M. T. thus obtained to G. Sid. T. by the method of the preceding article.

3. — From the G. Sid. Time subtract the west longitude, or add the longitude if east. The result is the desired Local Sidereal Time.

IV. *To Find the Latitude by the Meridian Altitude of a Star.*

1. — Take from Table VIII the declination of the star for 1916 and also the annual variation of the declination. Multiply the annual variation by the years and tenths elapsed since the beginning of 1916 and add the result algebraically to the declination, which will give the declination for the given date.

2. — From the observed altitude find the star's true altitude by applying the required corrections from Table II. Subtract the star's true altitude from 90°. The result is the star's zenith distance, which is to be marked plus if the star is south of the zenith and minus if it is north. Add the zenith distance algebraically to the star's declination. The sum is equal to the latitude, which is to be marked N if the sum is positive and S if the sum is negative.

It is unnecessary to note the *time* of the observation since the star's declination does not vary sensibly, even in many days.

Example 29. — Feb. 25, 1919, the meridian altitude of Aldebâran is observed as 67° 34′ 10″ above the sea horizon, the star being south of the zenith. Index correction, 0; height of eye, 40 feet.

Decl. of star 1916	+16° 20′ 29″	Annual Variation . .	+7″
Corr.	+22	El. T.	+3.2 years
Decl. 1919	−16° 20′ 51″	Corr.	22.4″

h	67° 34′ 10″	
I. C.	0	
Dip	−6 12	
Refr.	− 23	
True Alt.	67 27 35	
Zen. Dist.	+22 32 25	(positive when south of zenith)
Decl.	+16 20 51	
Lat.	38° 53′ 16″ N	

V. *To Find the Latitude by the Altitude of Polaris at any Time.*

1. — The necessary data are the right ascension and polar distance of Polaris taken from Table X, its true altitude as found by the sextant, and the observed G. M. T. of the observation.

2. — Convert the G. M. T. to Local Sidereal Time (p. 316). From the local sidereal time subtract the star's right ascension and the result is the star's hour angle. Reduce this value to degrees by multiplying by 15, or by Table V.

3. — If the H. A. is between 0° and 90° find the H. A. in Table I, column 1, take out the corresponding latitude factor, by which multiply the star's polar distance; *subtract* the result from the star's corrected altitude and the result is the latitude.

4. — If the star's H. A. is between 90° and 270° take the difference between it and 180°. With the value thus obtained as an argument, take the corresponding latitude factor from Table I, multiply it by the star's polar distance, and *add* the product to the star's corrected altitude. The result is the latitude.

5. — If the H. A. is between 270° and 360° subtract it from 360°. With the value thus obtained as an argument, take out the corresponding latitude factor from Table I. Multiply the star's polar distance by this factor, and *subtract* the result from the observed altitude. The result is the latitude.

EXAMPLE 30. — At sea, Feb. 15, 1919; observation of Polaris for latitude; assumed position N 40° 30′, W 57° 2′; watch-time $9^h\ 50^m\ 46^s$ A. M.; watch $5^m\ 31^s$ fast of G. M. T.; observed altitude 39° 35′; index correction + 1′ 30″; height of eye 40 feet.

	h m s		h m s		s
Watch Time	9 50 46 A.M.	R. A. 1916.0 . .	1 29 44	Ann. Var.	+29
Δt	−5 31	Corr. to 1919.1	+1 30	El. T. . . .	+3.1
G. M. T. . . .	9 45 15 A.M.	R. A.	1 31 14	Corr. . . .	+89.9

	° ′ ″		″
Decl. 1916.0	88 51 25	Ann. Var.	+18.5
Corr. to 1919.1	+57	El. T.	+3.1
Decl.	88 52 22	Corr. . .	+57.25
Polar Dist.	1 7 38		

	h m s
R. A. M. S., Feb. 14,* 1916, G. M. N.	21 32 44.7
Const. for Feb. 1919 $+6^h\ 35^m$, Red.	+1 4.9
R. A. M. S., G. M. N., Feb. 14 . . .	21 33 49.6

	h m s
Gr. Ast. T. Feb. 14	21 45 15
Red. to Sid. Int.	3 34.4
R. A. M. S. . . .	21 33 49.6
Sum	43 22 39
Gr. Sid. T.	19 22 39
Long. W. Subtr.	3 48 8
Local Sid. T. . . .	15 34 31
R. A.	1 31 14
H. A.	$14^h\ 3^m\ 17^s$
H. A.	210° 49′
Diff. from 180°	30° 49′
Lat. factor. . . .	0.859

$0.859 \times 67.6' = 58.07'$

TABLE IV.

50°	= $3^h\ 20^m\ 0^s$
7°	= 28 0
2′	= 0 8
57° 2′	= $3^h\ 48^m\ 8^s$

TABLE V.

14^h	= 210° 0′
3^m	= 0 45′
17^s	= 0 4′
$14^h\ 3^m\ 17^s$	= 210° 49′

	° ′ ″
Obs. Alt.	39 35 0
I. C.	+1 30
Refr.	−1 8
Dip.	−6 12
Tr. Alt.	39 29 10
Corr.	+58 4
Lat.	40 27 14

The correction is positive because the H. A. lies between 90° and 270°.

VI. *To Find the Longitude by the Altitude of a Star.*

1. — The data required are the G. M. T., the right ascension and declination of the star, the R. A. M. S., and

* In finding Sid. T. of a forenoon observation the R. A. M. S. must always be taken out for noon of the preceding date.

the true altitude. It must be noted whether the star was west or east of the meridian.

2. — Add together the star's true altitude, the assumed latitude, and the star's polar distance. Divide this sum by 2 and call the result the half-sum. From the half-sum subtract the star's altitude and call the result the remainder.

3. — Take from Table XI the logarithms of the secant of the latitude, the cosecant of the polar distance, the cosine of the half-sum, and the sine of the remainder.

4. — Add these four logarithms, divide their sum by 2 and reject 10 from the index. Seek this value in the column of log. sines of Table XI and take out the corresponding time from the column headed P. M. This is the star's hour angle and is to be marked positive, if the star was observed west of the meridian. If the star was observed east of the meridian, the H. A. is taken as negative.

5. — To the star's hour angle add its right ascension. The result (rejecting 24^h if necessary) is the Local Sidereal Time. Reduce the G. M. T. to Greenwich Sidereal Time and take the difference between the two times; the result is the longitude, west of Greenwich if the Greenwich time is the greater of the two; east if it is the smaller.

Example 31. — Jan. 15, 1924, twilight observation of Sirius, E of the meridian, to determine the longitude and variation of the compass. Assumed position, Lat. N 14° 48′, Long. W 89° 15′; watch time $0^h\ 45^m$ A. M; watch $3^m\ 4^s$ slow of G. M. T.; obs. 2 alt. of star 38° 5′ 20″; index correction + 2′ 50″; star's bearing by compass S 70° E.

Place of Star.

(Table X) R. A.	$6^h\ 41^m\ 32^s$	$+2.6^s$	Decl.	$-16°\ 36'\ 10''$	$-\ 4.8''$
	$+21$	$\times 8.0$		-38	$\times\ 8.0$
	$6^h\ 41^m\ 53^s$	20.8^s		$-16°\ 36'\ 48''$	$-38.4''$
				$p = 106°\ 36.8'$	

R. A. M. S. Jan. 14, 1916	$19^h\ 30^m\ 31.4^s$
Const. for Jan. 1924, $1^h\ 22^m$; red. for $1^h\ 22^m$	$+13.5$
R. A. M. S. Jan. 14, 1924	$19^h\ 30^m\ 44.9^s$

Watch Time, Jan. 14	$12^h\ 45^m\ 0^s$
Δt.	+3 4
G. M. T.	$12^h\ 48^m\ 24^s$
Red. to sid. $12^h\ 48^m$	2 6.2
R. A. M. S. at noon, Jan. 14	19 30 16.4
G. Sid. T.	$32^h\ 20^m\ 46.6^s$
or,	8 20 47
Local Sid. T. (see computation below)	2 23 51
Long. W.	$5^h\ 56^m\ 56^s$
	89° 14′

2 Alt. of star	38° 5′ 20″		
Index Corr.	+2 50		
	2)38 8 10		
Obs. Alt.	19 4 5		
Refr.	−2 48		
True Alt., h	19 1 17		Sec. 0.02438
Lat.	14 48 0	Sec. 0.01465	Sec. 0.01465
p	106 36 48	Csc. 0.01853	
Sum	140 26 5		
s	70 13	Cos. 9.52952	Cos. 9.52951
Rem. $s-h$	51 12	Sin. 9.89183	
2d Rem., $s-p$	−36° 24′		Cos. 9.90574
		2)19.45453	2)9.47428
H. A.	$-4^h\ 18^m\ 2^s$	9.72726	9.73714
R. A.	6 41 53		
Local Sid. T.	$2^h\ 23^m\ 51^s$		

Cos. half bearing	9.73714
Half bearing	56° 55′
True azimuth	N 113° 50′ E
Compass "	N 110 E
Compass corr.	+ 3° 50′

The part of the above computation outside the heavy lines is added to illustrate the method of computing the compass correction as in Example 26.

Latitude by Circummeridian Altitudes.

The simplicity of the method of determining latitude by a meridian altitude leaves nothing to be desired, but it should not be the sole reliance since the observation must be made at the moment the sun or star attains its greatest altitude, and at the critical moment the object may be concealed by clouds.

Under these circumstances an observation may often be made while the object is *near* the meridian, which will give a result as good as that of a meridian observation, indeed better, since several observations may be made and the mean of the results taken. It is therefore always a good plan, when making a meridian observation, to make several such "circummeridian" observations during the half hour including noon, even if it is intended to use only the maximum altitude in finding the latitude.

The method of computing the latitude from circummeridian observations consists in determining the "reduction to the meridian," that is the small quantity which, added to the observed altitude, will give the value of the actual altitude of the body when on the meridian. From the meridian altitude as thus found the latitude is obtained as explained on page 309.

The method requires that the time of the observation should be noted, as the reduction has the form at^2 where a is a constant depending on the observer's latitude and the declination of the observed body, and t the hour angle in minutes of the body at the time of observation. The constant a or its logarithm being computed, the value of at^2 may be taken by inspection from a table.

To Find the Latitude by Circummeridian Altitudes of the Sun.

1. — Reduce the longitude of the place of observation to hours, minutes, and seconds by dividing by 15, or by Table IV. The result is the G. App. T. of local mean noon if the longitude is west; if the longitude is east, subtract it from 12^h, and the result is the G. App. T. of noon.

2. — Enter Table VII with this G. A. T. as an argument

and take out the Equation of Time. Apply it with reversed sign to the G. A. T. The result is (within 1^s) the equivalent G. M. T. Apply the watch correction with reversed sign and the result is the "Watch Time of Noon."

3. — With the G. M. T. of noon take the sun's declination from the almanac.

4. — Take the difference between the watch time of noon and the time of the observation. The result is the sun's hour angle.

5. — To the constant logarithm 0.29300 add the log. cos. Lat., the log. cos. Decl., and the log. cosec. (Lat. ∼ Decl.)*; call the result log. *a*.

6. — From Table IX with log. *a* as the argument in the upper line, and with H. A. as the vertical argument, take out the reduction to the meridian.

7. — Add the reduction to the observed altitude and find the latitude from the meridian altitude thus obtained as in Example 23.

NOTE. — The reduction must be computed for each observation separately; it is not correct to take the mean of a series of altitudes and assume that it corresponds to the mean of the times.

EXAMPLE 32. — At sea, Oct. 2, 1917; the assumed position at noon being Lat. 37° 50′ N, Long. 50° 15′ W, the meridian altitude of the sun's lower limb is found to be 48° 10′, south of zenith.

The observation being uncertain on account of flying clouds, and the latitude much greater than was expected, two altitudes are taken later and under better conditions. They are as follows:

Watch Time $3^h\ 32^m\ 31^s$	Obs. Alt. 48° 11′ 40″
Watch Time 3 38 58	Obs. Alt. 48 6 50

Index corr. 0; Height of eye, 40 feet; Watch $15^m\ 31^s$ fast of G. M. T.

Local App. Noon (50° 15′ W.) G. A. T....	$3^h\ 21^m$ P. M.
Constant for Oct. 1917, Table III.......	−5 48
Argument for 1916 Almanac	$9^h\ 33^m$ A. M.
Elapsed Time	$-2^h\ 27^m = -2.5^h$ nearly

* The symbol (Lat. ∼ Decl.) represents the meridian zenith distance, which is the difference of Lat. and Decl. when both have the same name, and their sum when they have different names.

	m s		s		′ ″		″
Eq. T., G. M. N.	+10 35	H. Diff.	+0.8	Decl.	−3 33 4	H. Diff.	−58
Correction.....	−2	El. T.	−2.5	Corr.	+2 25	El. T.	−2.5
Eq. T., L. Ap. N.	+10 33	Corr.	−2.0	Decl.	−3 30 39		+145

G. A. T. Local App. Noon	$3^h\ 21^m\ 0^s$	Const. Log........	0.29300
Eq. T. (reversed sign) ...	−10 33	Lat. +37° 50′ Cos.	9.89752
		Decl. −3 31 Cos.	9.99918
G. M. T., L. App. Noon,	3 10 27	L.∼D. 41 21 Csc.	0.18002
Δt reversed sign.......	+15 31		
			0.36972
Watch Time Noon.....	3 25 58	*log. a*	0.370

	Obs. 1.	Obs. 2.	Obs. 3.
Watch Time	$3^h\ 25^m\ 58^s$	$3^h\ 32^m\ 31^s$	$3^h\ 38^m\ 50^s$
Watch Noon	3 25 58	3 25 58	3 25 58
H. A.	0 0	6 33	12 52
log. *a*	0.370	0.370	0.370
Obs. Alt.	48° 10′ 0″	48° 11′ 40″	48° 6′ 50″
Red. to Merid.	0	1 40	6 36
Obs. Merid. Alt.	48° 10′ 0″	48° 13′ 20″	48° 13′ 26″

Mean of Merid. Alt.	48° 12′ 15″	I. C. 0′ 0″	
Corr.	+9 4	Refr. −0 52	Px....+ 0′ 6″
		Dip. −6 12	S. D. . +16 2
True Merid. Alt.	48 21 19		
Zenith Dist.	+41 38 41	−7 4	+16′ 8″
Decl.	−3 30 39	Corr. +9′ 4″	
Lat.	38° 8″ 2′		

To Find the Latitude by Circummeridian Altitudes of a Star.

Circummeridian altitudes of a star are reduced in the same form as those of the sun except in computing the H. A. The rule for finding the watch time of transit depends on the principle that the local sidereal time of transit (H. A. = 0) equals the R. A. of the star (p. 315). The method employed below is not quite exact but the error is negligible in practice.

The results of several observations are obtained with little more labor than is required for a single one. If two stars are observed, one north and the other at a nearly equal altitude south, errors of the sextant are almost completely eliminated. The solution is made a little more compact by applying one half of the I. C. to the altitude instead of adding the I. C. to the observed double altitudes.

1. — Take from Table X the place of the star and from Table VIII the R. A. M. S. for the G. M. N. next previous to the observation.

2. — Assume a watch time (to the nearest even minute) near the middle of the series of observations and apply the watch correction. Change the G. M. T. thus found to local sidereal time (p. 316). From this subtract the star's R. A., and if the result is positive add it to the assumed watch time (if negative, subtract); the time thus obtained is the watch time of the star's transit.

3. — Take the difference between the watch time of transit and that of each observation. The results are the H. A.'s of the respective observations.

4. — Compute log. a, the reduction to the meridian and the latitude, as in Example 32.

Example 33. — The following observations of Sirius are made about 7 P. M., Local Mean Time, March 11, 1921, at a place assumed to be in Lat. 14° 48′ N, Long. 89° 15′ W. Note that the watch times are about 1 A. M., *March 12*, G. M. T.

	h	m	s						
1 Watch Time	1	2	28	2 Alt. 116°	56′	30″	S of zenith	
2		4	21	117	1	20		
3		5	58		4	20	I. C.	+1′ 20″
4		7	23		6	50	Watch	7^m 37^s
5		8	53		9	10	slow of G. M. T	

R. A. 1916.0	$6^h\ 41^m\ 26.8^s$,	Ann. Var.	+2.64″
Corr. to 1921.2	+13.7	El. T.	+5.2
R. A.	$6^h\ 41^m\ 40.5^s$		+13.7″

Decl. 1916.0	−16° 36′ 1″	Ann. Var.	−4.8″
Corr. to 1921.2	−25	El. T.	+5.2
Decl.	−16° 35′ 36″	Corr.	−25.0″

R. A. M. S., March 11, 1916, G. M. N.	$23^h\ 15^m\ 15.1^s$
Constant for 1921 (March) $-5^h\ 6^m$, red.	−50.3
R. A. M. S.	$23^h\ 14^m\ 24.8^s$

At middle observation:			
Watch Time	$1^h\ 5^m\ 0^s$	G. Astr. T.	$13^h\ 12^m\ 37^s$
Δt	+7 37	Red. to Sid. int.	+2 10
		R. A. M. S.	23 14 25
G. M. T.	$1^h\ 12^m\ 37^s$	Sum	$36^h\ 29^m\ 12^s$
		Gr. Sid. T.	$12^h\ 29^m\ 12^s$
		Long. W, subtr.	5 57 0
		Local Sid. T.	$6^h\ 32^m\ 12^s$
Const. log.	0.29300	R. A. of star	6 41 27
Lat. +14° 48′ Cos.	9.98535		
Decl. −16 36 Cos.	9.98151	R. A. − Sid. T.	$+9^m\ 35^s$
L. ∼ D. 31 24 Csc.	0.28315	Watch Time	1 5 0
Log. a	0.54301	W. T. of transit	$1^h\ 14^m\ 35^s$

	1	2	3	4	5
Watch Time	$1^h\ 2^m\ 28^s$	$4^m\ 21^s$	$5^m\ 58^s$	$7^m\ 23^s$	$8^m\ 53^s$
H. A.	12 7	10 14	8 37	7 12	5 42
Obs. 2 Alt.	116° 56′ 30″	61′ 20″	64′ 20″	66′ 50″	69′ 10″
Obs. Alt.	58 28 15	30 40	32 10	33 25	34 35
Red. to Merid.	+ 8 20	6 10	4 10	2 55	1 50
Obs. Merid. Alt.	58° 36′ 35″	36′ 50″	36′ 20″	36′ 20″	36′ 25″

Mean of Obs. Merid. Alt.	58° 36′ 30″
½ I. C.	+40
Refr.	−36
True Merid. Alt.	58° 36′ 34″
Zenith Dist.	+31 23 26
Declination	−16 35 36
Latitude	+14 47 45

The Sumner Line.

It is worth while here to describe a method of treating the ordinary "time sight" which has a very frequent application in practice. Example 25 on page 311 has been solved on the assumption that the latitude was 42° 22′ 38″ and the longitude found to be 71° 7′ 15″. If the problem is solved with a value for the latitude 20′ greater, the longitude will be found to be 71° 26′ 30″, and if the latitude is taken as 20′ less, the longitude will be found to be 70° 48′ 15″. If the three positions,

Lat. 42° 2′ 38″	Long. 70° 48′ 15″
Lat. 42 22 38	Long. 71 7 15
Lat. 42 42 38	Long. 71 26 30

are plotted on the chart, they will be found to lie very nearly on a straight line, and the true position of the observer lies somewhere on the line, in fact at that point of the line where it cuts the parallel of latitude on which the ship actually is at the time of the observation. The line thus determined is called a "Sumner Line." This line is at right angles to the sun's bearing at the time of taking the time sight and is really a small portion of a circle drawn about a point on the earth directly under the sun. At each point of such a circle the apparent altitude of the sun is the same.

If the time sight is taken when the sun is very nearly in the prime vertical, east or west, the line above described lies nearly north and south, and even if the assumed latitude is much in error, so that the exact point of the line is uncertain, the longitude of *all* points being nearly the same, the longitude of the ship is well determined. *The favorable time, therefore, for taking a time sight for longitude is when the sun is in or near the prime vertical.*

A single observation of the sun used to determine a Sumner line sometimes gives useful information even though it does not suffice to give the exact latitude and longitude of the observer. The following instance illustrates this point.

In approaching a river whose trend is known to be from NW to SE, an afternoon time sight taken when the sun bears nearly SW determines a Sumner line parallel to the river, which may be laid down on the chart and the distance from the line to the river measured.

To Find the Longitude by the Intersection of Two Sumner Lines.

If two Sumner lines are found by observation of two stars, one bearing approximately SE and the other approximately SW, and if each observation is reduced as a time sight with two values of the latitude 20 or 40 miles apart, then the intersection of the two Sumner lines thus found gives the position of the observer as well as a combination of a prime vertical longitude and a meridian latitude in the conventional manner. If the G. M. T. is uncertain, however, the longitude of each point on the lines and, therefore, of their intersection is subject to the same uncertainty, just as the ordinary longitude determination by an altitude near the prime vertical is doubtful by an amount exactly equal to the uncertainty of the chronometer correction.

Any two stars may be observed which are far enough from the meridian to be used for a time sight and whose bearings differ by as much as 60°. Such a pair of observable stars can almost always be found for twilight observations. The difference in bearing should be as nearly 90° as possible in order that the Sumner lines may cross nearly at right angles. Neither of the two stars should be very near the prime vertical or the meridian, if both are to be reduced as time sights.

The sun may be used if a sufficient interval elapses between the two observations to allow a change of 45° in its bearing; and if the observer changes his place in the interval both the lines may be drawn on a Mercator map and the line derived from the first observation may be transferred parallel to itself by drawing from each of its ends a line representing the course and distance between the two observations and connecting the ends of the lines so drawn. The parallel line thus drawn cuts the second Sumner line at the observer's position at the second observation. The use of two stars is especially convenient at sea because the interval between the observations may be very short and the exact position of the ship, both in latitude and longitude is found with little delay.

If the observer's position is the same at the two observations, so that no transference of the first Sumner line is necessary, the two lines may be drawn on paper ruled in squares on which degrees of latitude and longitude except near the equator do not have the proper proportional lengths. The two lines will intersect at the right latitude and longitude, although their angles with the meridians are not correctly represented as on a Mercator map.

Example 34. — The following observations were made Nov. 27, 1917, at about $5^h\ 40^m$ P. M., at Cambridge. Assumed position, Lat. 42° 20′ N, Long. 71° 5′ W.

G. M. T.	$10^h\ 38^m\ 36^s$	Alt. of β Ceti 21° 11′ 10″ E of Merid.
	10 44 34	Alt. of Altair 41 38 50 W of Merid.

The following data are taken from Tables X and VIII:

β Ceti	R. A. 0° 39′ 28″	Decl. −18° 26′ 13″	p = 108° 26′
Altair	19 46 47	+ 8 39 2	81 21
R. A. M. S.	$16^h\ 23^m\ 18.9^s$	At G. M. Noon, Nov. 27, 1917.	

The Greenwich sidereal times corresponding to the given G. M. T. are $3^h\ 3^m\ 40^s$ and $3^h\ 9^m\ 39^s$ respectively as computed by the rule on page 316.

The computation of the position of the two Sumner lines from the above data follows. Although two complete computations of the longitude are made for each star, the time required is not doubled, since the angles of the second computation are either the same as those of the first or differ from them by a few minutes only, so that both sets of logarithms may be taken out at the same opening of the tables.

β Ceti, East of Meridian.

Obs. Alt....	21° 11′ 10″				
Refr.......	−2 29				
h	21° 8′ 41″			21° 9′	
Lat.	**42 10**	Sec.	0.13007	**42 40**	0.13353
p	108 26	Csc.	0.02287	108 26	0.02287
Sum	171° 45′			172° 15′	
s	85 52	Cos.	8.85780	86 7	8.83075
$s–h$	64 43	Sin.	9.95627	64 58	9.95716
			2)18.96701		2)18.94431
			9.48350		9.47216
		*H. A.	$-2^h\ 21^m\ 48^s$		$-2^h\ 18^m\ 1^s$
		R. A.	0 39 28		0 39 28
*H. A. + R. A. =		Local Sid. T.	$22^h\ 17^m\ 40^s$		$22^h\ 21^m\ 27^s$
		G. Sid. T.	3 3 40		3 3 40
		Longitude	$4^h\ 46^m\ 0^s$		$4^h\ 42^m\ 13^s$
			71° 30′		**70° 33′**

* In star observations the H. A. may be always looked up in the column of Table XI headed *Time P. M.* and marked negative if the star is east of the meridian. There is less liability to error than in using the *A. M.* column for a star observed east of the meridian and adding 12 hours.

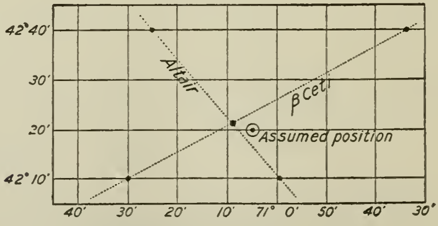
Altair, West of Meridian.

Obs. Alt..	41° 38′ 50″			
Refr. ...	−1 5			
h	41° 37′ 45″		41° 38′	
Lat.	**42 10**	Sec. 0.13007	**42 40**	0.13353
p	81 21	Csc. 0.00497	81 21	0.00497
Sum	165° 9′		165° 39′	
s	82 35	Cos. 9.11087	82 50	9.09606
$s-h$	40 57	Sin. 9.81651	41 12	9.81868
		2)19.06242		2)19.05324
		9.53121		9.52662

H. A.	$2^h\ 38^m\ 55^s$	$2^h\ 37^m\ 10^s$
R. A.	19 46 47	19 46 47
Local Sid. T.	$22^h\ 25^m\ 42^s$	$22^h\ 23^m\ 57^s$
G. Sid. T.	3 9 39	3 9 39
Longitude	$4^h\ 43^m\ 57^s$	$4^h\ 45^m\ 42^s$
	70° 59′	**71° 25′**

On the diagram below is plotted the Sumner line as determined from β Ceti, which passes through the points 42° 10′ N, 71° 30′ W, and 42° 40′ N, 70° 33′ W, together with the Sumner line passing through the points 42° 10′ N, 70° 59′ W, and 42° 40′ N, 71° 25′ W, as determined by the observation of Altair.

FIG. 21 *a*



INTERSECTION OF SUMNER LINES
N 42° 21′, W 71° 9′

TABLE I.

TRAVERSE TABLE FACTORS.

Difference of Latitude and Departure corresponding to a Distance of one nautical mile on different courses.

Multiply the actual distance by the factors given in each column for the given course.

Course Deg.	Lat.	Dep.	Long.	Tan.	Course Deg.	Lat.	Dep.	Long.	Tan.
0	1.000	0.000	1.000	0.000	46	0.695	0.719	1.440	1.036
1	1.000	0.017	1.000	0.017	47	0.682	0.731	1.466	1.072
2	0.999	0.035	1.001	0.035	48	0.669	0.743	1.494	1.111
3	0.999	0.052	1.001	0.052	49	0.656	0.755	1.524	1.150
4	0.998	0.070	1.002	0.070	50	0.643	0.766	1.556	1.192
5	0.996	0.087	1.004	0.087	51	0.629	0.777	1.589	1.235
6	0.995	0.105	1.006	0.105	52	0.616	0.788	1.624	1.280
7	0.993	0.122	1.008	0.123	53	0.602	0.799	1.662	1.327
8	0.990	0.139	1.010	0.141	54	0.588	0.809	1.701	1.376
9	0.988	0.156	1.012	0.158	55	0.574	0.819	1.743	1.428
10	0.985	0.174	1.015	0.176	56	0.559	0.829	1.788	1.483
11	0.982	0.191	1.019	0.194	57	0.545	0.839	1.836	1.540
12	0.978	0.208	1.022	0.213	58	0.530	0.848	1.887	1.600
13	0.974	0.225	1.026	0.231	59	0.515	0.857	1.942	1.664
14	0.970	0.242	1.031	0.249	60	0.500	0.866	2.000	1.732
15	0.966	0.259	1.035	0.268	61	0.485	0.875	2.063	1.804
16	0.961	0.276	1.040	0.287	62	0.469	0.883	2.130	1.881
17	0.956	0.292	1.046	0.306	63	0.454	0.891	2.203	1.963
18	0.951	0.309	1.051	0.325	64	0.438	0.899	2.281	2.050
19	0.946	0.326	1.058	0.344	65	0.423	0.906	2.366	2.145
20	0.940	0.342	1.064	0.364	66	0.407	0.914	2.459	2.246
21	0.934	0.358	1.071	0.384	67	0.391	0.921	2.559	2.356
22	0.927	0.375	1.079	0.404	68	0.375	0.927	2.669	2.475
23	0.921	0.391	1.086	0.424	69	0.358	0.934	2.790	2.605
24	0.914	0.407	1.095	0.445	70	0.342	0.940	2.924	2.748
25	0.906	0.423	1.103	0.466	71	0.326	0.946	3.072	2.904
26	0.899	0.438	1.113	0.488	72	0.309	0.951	3.236	3.078
27	0.891	0.454	1.122	0.510	73	0.292	0.956	3.420	3.271
28	0.883	0.469	1.133	0.532	74	0.276	0.961	3.628	3.487
29	0.875	0.485	1.143	0.554	75	0.259	0.966	3.864	3.732
30	0.866	0.500	1.155	0.577	76	0.242	0.970	4.134	4.011
31	0.857	0.515	1.167	0.601	77	0.225	0.974	4.445	4.332
32	0.848	0.530	1.179	0.625	78	0.208	0.978	4.810	4.705
33	0.839	0.545	1.192	0.649	79	0.191	0.982	5.241	5.145
34	0.829	0.559	1.206	0.675	80	0.174	0.985	5.759	5.671
35	0.819	0.574	1.221	0.700	81	0.156	0.988	6.392	6.314
36	0.809	0.588	1.236	0.727	82	0.139	0.990	7.185	7.115
37	0.799	0.602	1.252	0.754	83	0.122	0.993	8.206	8.144
38	0.788	0.616	1.269	0.781	84	0.105	0.995	9.567	9.514
39	0.777	0.629	1.287	0.810	85	0.087	0.996	11.474	11.430
40	0.766	0.643	1.305	0.839	86	0.070	0.998	14.336	14.301
41	0.755	0.656	1.325	0.869	87	0.052	0.999	19.107	19.081
42	0.743	0.669	1.346	0.900	88	0.035	0.999	28.654	28.636
43	0.731	0.682	1.376	0.933	89	0.017	1.000	57.299	57.290
44	0.719	0.695	1.390	0.966	90	0.000	1.000		
45	0.707	0.707	1.414	1.000		Cos.	Sin.	Sec.	Tan.

To change Departure to Diff. Long. multiply by the factor in Long. column opposite degrees corresponding to mid-latitude.

To change Diff. Long. to Departure multiply by the factor in Lat. column corresponding to mid-latitude.

TABLE II.

Correction of Observed Altitude for Parallax and Refraction																Dip			Semidiameter			
Alt.		Ref.		Px.	Alt.		Ref.		Px.	Alt.	Ref.		Px.			Ht.	Dip		Date		S. D.	
°	′	′	″	″	°	′	′	″	″	°	′	″	″			ft.	′	″			′	″
0	0	−36	29	+9	10	20	−5	09	+9	23	−2	16	+8			1	− 0	59	Jan.	1	16	18
1	0	−24	54	+9	10	40	−5	00	+9	24	−2	10	+8			2	− 1	23	"	22	16	17
2	0	−18	25	+9	11	0	−4	51	+9	25	−2	04	+8			3	− 1	42	"	30	16	16
3	0	−14	25	+9	11	20	−4	43	+9	26	−1	59	+8			4	− 1	58	Feb.	12	16	14
4	0	−11	44	+9	11	40	−4	35	+9	27	−1	54	+8			5	− 2	11	"	22	16	12
5	0	− 9	52	+9	12	0	−4	27	+9	28	−1	49	+8			6	− 2	24	Mar.	1	16	10
5	10	− 9	36	+9	12	20	−4	20	+9	29	−1	45	+8			7	− 2	36	"	9	16	08
5	20	− 9	21	+9	12	40	−4	13	+9	30	−1	41	+8			8	− 2	46	"	17	16	06
5	30	− 9	07	+9	13	0	−4	07	+9	31	−1	37	+8			9	− 2	56	"	24	16	04
5	40	− 8	53	+9	13	20	−4	01	+9	32	−1	33	+7			10	− 3	06	"	31	16	02
5	50	− 8	46	+9	13	40	−3	55	+9	33	−1	29	+7			11	− 3	15	Apr.	8	16	00
6	0	− 8	28	+9	14	0	−3	49	+9	34	−1	26	+7			12	− 3	24	"	15	15	58
6	10	− 8	16	+9	14	20	−3	44	+9	35	−1	23	+7			13	− 3	32	"	23	15	56
6	20	− 8	05	+9	14	40	−3	39	+9	36	−1	20	+7			14	− 3	40	"	30	15	54
6	30	− 7	54	+9	15	0	−3	34	+9	37	−1	17	+7			15	− 3	48	May	9	15	52
6	40	− 7	43	+9	15	20	−3	29	+8	38	−1	14	+7			16	− 3	55	"	19	15	50
6	50	− 7	33	+9	15	40	−3	25	+8	39	−1	11	+7			17	− 4	02	"	31	15	48
7	0	− 7	24	+9	16	0	−3	20	+8	40	−1	09	+7			18	− 4	09	June	9	15	47
7	10	− 7	14	+9	16	20	−3	16	+8	41	−1	07	+7			19	− 4	16	"	21	15	46
7	20	− 7	06	+9	16	40	−3	12	+8	42	−1	05	+7			20	− 4	23	July	16	15	46
7	30	− 6	57	+9	17	0	−3	08	+8	43	−1	02	+6			22	− 4	36	"	28	15	47
7	40	− 6	49	+9	17	20	−3	05	+8	44	−1	00	+6			24	− 4	48	Aug.	5	15	48
7	50	− 6	41	+9	17	40	−3	01	+8	45	−0	58	+6			26	− 5	00	"	17	15	50
8	0	− 6	33	+9	18	0	−2	58	+8	46	−0	56	+6			28	− 5	11	"	28	15	52
8	10	− 6	25	+9	18	20	−2	54	+8	47	−0	54	+6			30	− 5	22	Sept.	5	15	54
8	20	− 6	19	+9	18	40	−2	51	+8	48	−0	52	+6			35	− 5	46	"	13	15	56
8	30	− 6	12	+9	19	0	−2	48	+8	49	−0	51	+6			40	− 6	12	"	21	15	58
8	40	− 6	05	+9	19	20	−2	45	+8	50	−0	49	+6			45	− 6	36	"	28	16	00
8	50	− 5	59	+9	19	40	−2	42	+8	52	−0	45	+5			50	− 6	56	Oct.	5	16	02
9	0	− 5	53	+9	20	0	−2	39	+8	54	−0	42	+5			60	− 7	35	"	13	16	04
9	10	− 5	46	+9	20	20	−2	36	+8	56	−0	39	+5			70	− 8	12	"	20	16	06
9	20	− 5	41	+9	20	40	−2	33	+8	58	−0	36	+5			80	− 8	46	"	28	16	08
9	30	− 5	35	+9	21	0	−2	31	+8	60	−0	34	+4			90	− 9	18	Nov.	4	16	10
9	40	− 5	29	+9	21	20	−2	28	+8	70	−0	21	+3			100	− 9	48	"	13	16	12
9	50	− 5	24	+9	21	40	−2	26	+8	80	−0	10	+2			110	−10	16	"	23	16	14
10	0	− 5	19	+9	22	0	−2	23	+8	90	−0	00	+0			120	−10	42	Dec.	5	16	16

TABLE III.

Year	Jan.–Feb.		Mar.–Dec.		Year	Jan.–Feb.		Mar.–Dec.	
	h.	m.	h.	m.		h.	m.	h.	m.
1917	+18	12	− 5	48	1925	+19	31	− 4	29
1918	+12	24	−11	36	1926	+13	41	−10	19
1919	+ 6	35	−17	25	1927	+ 7	52	−16	8
1920	+ 0	45	+ 0	45	1928	+ 2	4	+ 2	4
1921	+18	54	− 5	6	1929	+20	16	− 3	44
1922	+13	3	−10	57	1930	+14	29	− 9	31
1923	+ 7	12	−16	48	1931	+ 8	30	−15	30
1924	+ 1	22	+ 1	22	1932	+ 2	49	+ 2	49

TABLE IV.

To convert Degrees of Longitude to Time.

Arc	Time		Arc	Time		Arc	Time	
Degs.	h.	min.	Degs.	h.	min.	Degs.	h.	min.
Min.	m.	sec.	Min.	m.	sec.	Min.	m.	sec.
1	0	4	12	0	48	80	5	20
2	0	8	13	0	52	90	6	00
3	0	12	14	0	56	100	6	40
4	0	16	15	0	60	110	7	20
5	0	20	20	1	20	120	8	00
6	0	24	30	2	00	130	8	40
7	0	28	40	2	40	140	9	20
8	0	32	50	3	20	150	10	00
9	0	36	60	4	00	160	10	40
10	0	40	70	4	40	170	11	20
11	0	44	80	5	20	180	12	00

TABLE V.

To convert Time to Degrees of Longitude.

Hrs.	Deg.	Min.	Deg.		Sec.	Deg.
	°		°	′		′
1	15	1	0	15	4	1
2	30	2	0	30	8	2
3	45	3	0	45	12	3
4	60	4	1	00	16	4
5	75	5	1	15	20	5
6	90	6	1	30	24	6
7	105	7	1	45	28	7
8	120	8	2	00	32	8
9	135	9	2	15	36	9
10	150	10	2	30	40	10
11	165	20	5	00	44	11
12	180	30	7	30	48	12
13	195	40	10	00	52	13
14	210	50	12	30	56	14

TABLE VI.

The Sun's Apparent Declination for 1916 at Greenwich Mean Noon.

Day	Jan.	H. Diff.	Feb.	H. Diff.	March	H. Diff.	April	H. Diff.	May	H. Diff.	June	H. Diff.	Day
	° ′ ″	″	° ′ ″	″	° ′ ″	″	° ′ ″	″	° ′ ″	″	° ′ ″	″	
1	−23 05 35	+11	−17 23 37	+42	−07 36 03	+57	+04 31 23	+58	+15 03 44	+45	+22 03 09	+20	1
2	−23 00 52	+12	−17 06 42	+43	−07 13 11	+57	+04 54 31	+58	+15 21 47	+45	+22 11 08	+19	2
3	−22 55 41	+14	−16 49 28	+44	−06 50 14	+58	+05 17 33	+57	+15 39 35	+44	+22 18 45	+19	3
4	−22 50 05	+15	−16 31 56	+44	−06 27 10	+58	+05 40 29	+57	+15 57 07	+43	+22 25 57	+18	4
5	−22 43 58	+16	−16 14 08	+45	−06 04 02	+58	+06 03 20	+57	+16 14 23	+43	+22 32 47	+17	5
6	−22 37 26	+17	−15 56 03	+46	−05 40 48	+58	+06 26 04	+57	+16 31 23	+42	+22 39 12	+16	6
7	−22 30 27	+18	−15 37 41	+46	−05 17 30	+58	+07 48 41	+56	+16 49 06	+41	+22 45 14	+15	7
8	−22 23 01	+19	−15 19 03	+47	−04 54 08	+58	+07 11 11	+56	+17 04 33	+41	+22 50 52	+14	8
9	−22 15 08	+20	−15 00 10	+48	−04 30 42	+59	+07 33 34	+56	+17 20 42	+40	+22 56 06	+13	9
10	−22 06 50	+21	−14 41 02	+48	−04 07 13	+59	+07 55 49	+55	+17 36 34	+39	+23 00 56	+12	10
11	−21 58 06	+22	−14 21 39	+49	−03 43 40	+59	+08 17 56	+55	+17 52 08	+39	+23 05 21	+11	11
12	−21 48 56	+23	−14 02 03	+49	−03 20 06	+59	+08 39 55	+55	+18 07 25	+38	+23 09 22	+10	12
13	−21 39 20	+24	−13 42 12	+50	−02 56 29	+59	+09 01 44	+54	+18 22 23	+37	+23 12 58	+09	13
14	−21 29 20	+26	−13 22 08	+50	−02 32 50	+59	+09 23 25	+54	+18 37 02	+36	+23 16 10	+07	14
15	−21 18 55	+27	−13 01 51	+51	−02 09 10	+59	+09 44 56	+54	+18 51 23	+35	+23 18 58	+06	15
16	−21 08 05	+28	−12 41 21	+51	−01 45 29	+59	+10 06 18	+53	+19 05 24	+35	+23 21 21	+05	16
17	−20 56 51	+29	−12 20 39	+52	−01 21 46	+59	+10 27 30	+53	+19 19 06	+34	+23 23 19	+04	17
18	−20 45 13	+30	−11 59 45	+52	−00 58 04	+59	+10 48 31	+52	+19 32 29	+33	+23 24 53	+03	18
19	−20 33 11	+31	−11 38 40	+53	−00 34 21	+59	+11 09 22	+52	+19 45 31	+32	+23 26 01	+02	19
20	−20 20 46	+32	−11 17 24	+53	−00 10 39	+59	+11 30 01	+51	+19 58 14	+31	+23 26 45	+01	20
21	−20 07 59	+33	−10 55 57	+54	+00 13 02	+59	+11 50 30	+51	+20 10 36	+30	+23 27 04	+01	21
22	−19 54 48	+33	−10 34 20	+54	+00 36 43	+59	+12 10 47	+50	+20 22 38	+30	+23 26 59	−01	22
23	−19 41 16	+34	−10 12 34	+55	+01 00 23	+59	+12 30 52	+50	+20 34 19	+29	+23 26 28	−02	23
24	−19 27 21	+35	−09 50 37	+55	+01 24 01	+59	+12 50 45	+49	+20 45 39	+28	+23 25 33	−03	24
25	−19 13 05	+36	−09 28 32	+55	+01 47 36	+59	+13 10 25	+49	+20 56 37	+27	+23 24 13	−04	25
26	−18 58 27	+37	−09 06 18	+56	+02 11 10	+59	+13 29 52	+48	+21 07 14	+26	+23 22 28	−05	26
27	−18 43 29	+38	−08 43 55	+56	+02 34 41	+59	+13 49 07	+48	+21 17 29	+25	+23 20 18	−06	27
28	−18 28 10	+39	−08 21 25	+56	+02 58 09	+59	+14 08 07	+47	+21 27 22	+24	+23 17 44	−07	28
29	−18 12 31	+40	−07 58 48	+57	+03 21 34	+58	+14 26 54	+47	+21 36 52	+23	+23 14 45	−08	29
30	−17 56 32	+40	.. .. ..	..	+03 44 55	+58	+14 45 26	+46	+21 46 01	+22	+23 11 22	−09	30
31	−17 40 14	+41	.. .. ..	..	+04 08 11	+58	.. .. ..	..	+21 54 46	+21	.. .. ..	..	..

TABLE VI.

Day	July	H. Diff.	August	H. Diff.	September	H. Diff.	October	H. Diff.	November	H. Diff.	December	H. Diff.	Day
	° ′ ″	″	° ′ ″	″	° ′ ″	″	° ′ ″	″	° ′ ″	″	° ′ ″	″	
1	+23 07 34	−10	+18 03 00	−38	+08 18 53	−54	−03 09 47	−58	−14 25 21	−48	−21 48 31	−23	1
2	+23 03 23	−11	+17 47 46	−39	+07 57 02	−55	−03 33 04	−58	−14 44 29	−48	−21 57 39	−22	2
3	+22 58 46	−12	+17 32 14	−39	+07 35 04	−55	−03 56 19	−58	−15 03 23	−47	−22 06 22	−21	3
4	+22 53 46	−13	+17 16 26	−40	+07 12 59	−55	−04 19 31	−58	−15 22 02	−46	−22 14 40	−20	4
5	+22 48 22	−14	+17 00 21	−41	+06 50 47	−56	−04 42 40	−58	−15 40 25	−46	−22 22 31	−19	5
6	+22 42 35	−15	+16 43 59	−41	+06 28 28	−56	−05 05 45	−58	−15 58 33	−45	−22 29 56	−18	6
7	+22 36 23	−16	+16 27 22	−42	+06 06 03	−56	−05 28 46	−57	−16 16 25	−44	−22 36 56	−17	7
8	+22 29 48	−17	+16 10 28	−43	+05 43 32	−56	−05 51 43	−57	−16 34 01	−44	−22 43 28	−16	8
9	+22 22 50	−18	+15 53 19	−43	+05 20 56	−57	−06 14 36	−57	−16 51 20	−43	−22 49 34	−15	9
10	+22 15 29	−19	+15 35 55	−44	+04 58 14	−57	−06 37 23	−57	−17 08 22	−42	−22 55 13	−14	10
11	+22 07 45	−20	+15 18 16	−44	+04 35 27	−57	−07 00 05	−57	−17 25 06	−41	−23 00 24	−12	11
12	+21 59 38	−21	+15 00 22	−45	+04 12 35	−57	−07 22 42	−56	−17 41 32	−41	−23 05 44	−11	12
13	+21 51 09	−22	+14 42 14	−46	+03 49 39	−57	−07 45 12	−56	−17 57 40	−40	−23 09 26	−10	13
14	+21 42 17	−23	+14 23 52	−46	+03 26 38	−58	−07 07 37	−56	−18 13 29	−39	−23 13 15	−09	14
15	+21 33 03	−24	+14 05 16	−47	+03 03 34	−58	−08 29 54	−56	−18 28 59	−38	−23 16 37	−08	15
16	+21 23 27	−24	+13 46 26	−47	+02 40 26	−58	−08 52 04	−55	−18 44 10	−38	−23 19 30	−07	16
17	+21 13 29	−25	+13 27 24	−48	+02 17 15	−58	−09 14 07	−55	−18 59 00	−37	−23 21 56	−05	17
18	+21 03 10	−26	+13 08 08	−48	+01 54 01	−58	−09 36 02	−55	−19 13 31	−36	−23 23 54	−04	18
19	+20 52 29	−27	+12 48 40	−49	+01 30 44	−58	−09 57 49	−54	−19 27 41	−35	−23 25 23	−03	19
20	+20 41 27	−28	+12 29 00	−49	+01 07 26	−58	−10 19 27	−54	−19 41 29	−34	−23 26 24	−02	20
21	+20 30 04	−29	+12 09 07	−50	+00 44 05	−58	−10 40 56	−54	−19 54 57	−33	−23 26 57	−01	21
22	+20 18 20	−30	+11 49 03	−50	+00 20 43	−58	−11 02 16	−53	−20 08 02	−32	−23 27 02	−00	22
23	+20 06 16	−31	+11 28 47	−51	−00 02 41	−58	−11 23 26	−53	−20 20 45	−31	−23 26 38	+02	23
24	+19 53 52	−31	+11 08 21	−51	−00 26 05	−59	−11 44 25	−52	−20 33 06	−30	−23 25 46	+03	24
25	+19 41 07	−32	+10 47 44	−52	−00 49 30	−59	−12 05 14	−52	−20 45 04	−29	−23 24 26	+04	25
26	+19 28 03	−33	+10 26 56	−52	−01 12 54	−59	−12 25 52	−51	−20 56 38	−28	−23 22 37	+05	26
27	+19 14 39	−34	+10 05 58	−53	−01 36 19	−59	−12 46 18	−51	−21 07 49	−27	−23 20 20	+06	27
28	+19 00 57	−35	+09 44 51	−53	−01 59 43	−58	−13 06 32	−50	−21 18 36	−26	−23 17 35	+07	28
29	+18 46 55	−35	+09 23 35	−53	−02 23 05	−58	−13 26 34	−50	−21 28 59	−25	−23 14 23	+09	29
30	+18 32 35	−36	+09 02 09	−54	−02 46 27	−58	−13 46 23	−49	−21 38 57	−24	−23 10 42	+10	30
31	+18 17 56	−37	+08 40 35	−54	.. .. ..	..	−14 05 59	−49	.. .. ..	..	−23 06 33	+11	31

TABLE VII. — *The Equation of Time for 1916 at Greenwich Mean Noon.*

Day	Jan.	H. Diff.	Feb.	H. Diff.	March	H. Diff.	April	H. Diff.	May	H. Diff.	June	H. Diff.	Day
	m s	s	m s	s	m s	s	m s	s	m s	s	m s	s	
1	−03 11.0	−1.2	−13 35.6	−0.4	−12 30.9	+0.5	−03 58.9	+0.7	+02 57.4	+0.3	+02 21.0	−0.4	1
2	−03 40.6	−1.2	−13 44.2	−0.3	−12 18.9	+0.5	−03 41.0	+0.7	+03 04.6	+0.3	+02 14.7	−0.4	2
3	−04 07.8	−1.2	−13 51.9	−0.3	−12 06.5	+0.5	−03 23.2	+0.7	+03 11.2	+0.3	+02 05.1	−0.4	3
4	−04 35.8	−1.2	−13 58.7	−0.3	−11 53.6	+0.5	−03 05.5	+0.7	+03 17.3	+0.2	+01 55.1	−0.4	4
5	−05 03.4	−1.1	−14 04.8	−0.2	−11 40.3	+0.6	−02 48.0	+0.7	+03 22.8	+0.2	+01 41.8	−0.4	5
6	−05 30.6	−1.1	−14 10.0	−0.2	−11 26.5	+0.6	−02 30.7	+0.7	+03 27.8	+0.2	+01 34.1	−0.4	6
7	−05 57.3	−1.1	−14 14.5	−0.2	−11 12.3	+0.6	−02 13.6	+0.7	+03 32.2	+0.2	+01 23.2	−0.5	7
8	−06 23.5	−1.1	−14 18.0	−0.1	−10 57.7	+0.6	−01 56.6	+0.7	+03 36.0	+0.1	+01 12.0	−0.5	8
9	−06 49.2	−1.1	−14 20.8	−0.1	−10 42.7	+0.6	−01 39.9	+0.7	+03 39.3	+0.1	+01 00.5	−0.5	9
10	−07 14.4	−1.0	−14 22.8	−0.1	−10 27.3	+0.6	−01 23.4	+0.7	+03 42.1	+0.1	+00 48.8	−0.5	10
11	−07 39.0	−1.0	−14 24.0	−0.0	−10 11.6	+0.7	−01 07.2	+0.7	+03 44.3	+0.1	+00 36.9	−0.5	11
12	−08 03.1	−1.0	−14 24.3	0.0	−09 55.6	+0.7	−00 51.3	+0.7	+03 45.9	+0.1	+00 24.8	−0.5	12
13	−08 26.5	−1.0	−14 23.9	0.0	−09 39.2	+0.7	−00 35.6	+0.6	+03 47.0	−0.0	+00 12.5	−0.5	13
14	−08 49.2	−0.9	−14 22.7	+0.1	−09 22.6	+0.7	−00 20.3	+0.6	+03 47.5	0.0	+00 00.1	−0.5	14
15	−09 11.4	−0.9	−14 20.8	+0.1	−09 05.6	+0.7	−00 05.2	+0.6	+03 47.5	0.0	−00 12.4	−0.5	15
16	−09 32.8	−0.9	−14 18.1	+0.1	−08 48.5	+0.7	+00 09.4	+0.6	+03 46.9	0.0	−00 25.1	−0.5	16
17	−09 53.6	−0.9	−14 14.6	+0.2	−08 31.1	+0.7	+00 23.8	+0.6	+03 45.7	−0.1	−00 37.9	−0.5	17
18	−10 13.7	−0.8	−14 10.5	+0.2	−08 13.5	+0.7	+00 37.7	+0.6	+03 44.0	−0.1	−00 50.7	−0.5	18
19	−10 33.1	−0.8	−14 05.6	+0.2	−07 55.7	+0.7	+00 51.3	+0.6	+03 41.8	−0.1	−01 03.6	−0.5	19
20	−10 51.7	−0.8	−14 00.1	+0.2	−07 37.7	+0.7	+01 04.4	+0.5	+03 38.9	−0.1	−01 16.6	−0.5	20
21	−11 09.6	−0.7	−13 53.9	+0.3	−07 19.7	+0.8	+01 17.1	+0.5	+03 35.6	−0.2	−01 29.6	−0.5	21
22	−11 26.7	−0.7	−13 47.0	+0.3	−07 01.5	+0.8	+01 29.4	+0.5	+03 31.6	−0.2	−01 42.5	−0.5	22
23	−11 43.1	−0.7	−13 39.5	+0.3	−06 43.2	+0.8	+01 41.2	+0.5	+03 27.1	−0.2	−01 55.5	−0.5	23
24	−11 58.7	−0.6	−13 31.4	+0.3	−06 24.9	+0.8	+01 52.5	+0.5	+03 22.1	−0.2	−02 08.4	−0.5	24
25	−12 13.6	−0.6	−13 22.7	+0.4	−06 06.6	+0.8	+02 03.3	+0.4	+03 16.5	−0.2	−02 21.2	−0.5	25
26	−12 27.7	−0.6	−13 13.4	+0.4	−05 48.2	+0.8	+02 13.7	+0.4	+03 10.5	−0.3	−02 34.0	−0.5	26
27	−12 41.0	−0.5	−13 03.6	+0.4	−05 29.9	+0.8	+02 23.5	+0.4	+03 03.9	−0.3	−02 46.6	−0.5	27
28	−12 53.5	−0.5	−12 53.2	+0.4	−05 11.6	+0.8	+02 32.8	+0.4	+02 56.8	−0.3	−02 59.0	−0.5	28
29	−13 05.2	−0.5	−12 42.3	+0.5	−04 53.3	+0.8	+02 42.5	+0.4	+02 49.3	−0.3	+03 11.3	−0.5	29
30	−13 16.2	−0.4	.. ...	..	−04 35.1	+0.8	+02 49.8	+0.3	+02 41.3	−0.3	−03 23.3	−0.5	30
31	−13 26.3	−0.4	.. ...	..	−04 16.9	+0.8	.. ...	..	+02 32.8	−0.4	.. ...	..	31

TABLE VII.

Day	July	H. Diff.	August	H. Diff.	Sept.	H. Diff.	Oct.	H. Diff.	Nov.	H. Diff.	Dec.	H. Diff.	Day
	m s	s	m s	s	m s	s	m s	s	m s	s	m s	s	
1	−03 35.2	−0.5	−06 10.0	+0.1	+00 00.9	+0.8	+10 16.1	+0.8	+16 19.4	+0.1	+10 54.0	−0.9	1
2	−03 46.8	−0.5	−06 06.3	+0.2	+00 19.9	+0.8	+10 35.1	+0.8	+16 20.5	−0.0	+10 31.2	−0.9	2
3	−03 58.1	−0.5	−06 02.0	+0.2	+00 39.1	+0.8	+10 53.9	+0.8	+16 20.8	−0.0	+10 07.8	−1.0	3
4	−04 09.0	−0.5	−05 57.0	+0.2	+00 58.6	+0.8	+11 12.3	+0.8	+16 20.3	−0.0	+09 43.8	−1.0	4
5	−04 19.7	−0.4	−05 51.4	+0.2	+01 18.3	+0.8	+11 30.4	+0.7	+16 19.1	−0.1	+09 19.3	−1.0	5
6	−04 30.0	−0.4	−05 45.3	+0.3	+01 38.3	+0.8	+11 48.2	+0.7	+16 17.0	−0.1	+08 54.2	−1.1	6
7	−04 40.0	−0.4	−05 38.4	+0.3	+01 58.6	+0.8	+12 05.6	+0.7	+16 14.0	−0.1	+08 28.6	−1.1	7
8	−04 49.5	−0.4	−05 31.0	+0.3	+02 19.0	+0.9	+12 22.6	+0.7	+16 10.3	−0.2	+08 02.5	−1.1	8
9	−04 58.7	−0.4	−05 23.0	+0.3	+02 39.6	+0.9	+12 39.1	+0.7	+16 05.7	−0.2	+07 36.0	−1.1	9
10	−05 07.4	−0.4	−05 14.4	+0.4	+03 00.4	+0.9	+12 55.4	+0.7	+16 00.3	−0.2	+07 09.0	−1.1	10
11	−05 15.7	−0.3	−05 05.2	+0.4	+03 21.3	+0.9	+13 10.9	+0.7	+15 54.0	−0.3	+06 41.6	−1.1	11
12	−05 23.5	−0.3	−04 55.4	+0.4	+03 41.4	+0.9	+13 26.1	+0.6	+15 46.9	−0.3	+06 13.8	−1.2	12
13	−05 30.8	−0.3	−04 45.1	+0.4	+04 03.6	+0.9	+13 40.8	+0.6	+15 38.9	−0.4	+05 45.6	−1.2	13
14	−05 37.7	−0.3	−04 34.2	+0.5	+04 24.8	+0.9	+13 55.0	+0.6	+15 30.1	−0.4	+05 17.1	−1.2	14
15	−05 44.0	−0.3	−04 22.8	+0.5	+04 46.0	+0.9	+14 08.6	+0.6	+15 20.4	−0.4	+04 48.3	−1.2	15
16	−05 49.9	−0.2	−04 10.9	+0.5	+05 07.3	+0.9	+14 21.6	+0.5	+15 09.8	−0.5	+04 19.3	−1.2	16
17	−05 55.3	−0.2	−03 58.4	+0.5	+05 28.6	+0.9	+14 34.1	+0.5	+14 58.4	−0.5	+03 50.1	−1.2	17
18	−06 00.1	−0.2	−03 45.5	+0.5	+05 49.9	+0.9	+14 45.9	+0.5	+14 46.1	−0.5	+03 20.4	−1.2	18
19	−06 04.5	−0.2	−03 32.1	+0.6	+06 11.1	+0.9	+14 57.1	+0.5	+14 33.0	−0.6	+02 50.7	−1.2	19
20	−06 08.3	−0.1	−03 18.2	+0.6	+06 32.3	+0.9	+15 07.7	+0.4	+14 19.0	−0.6	+02 20.9	−1.2	20
21	−06 11.6	−0.1	−03 03.8	+0.6	+06 53.4	+0.9	+15 17.6	+0.4	+14 04.2	−0.6	+01 51.0	−1.2	21
22	−06 14.3	−0.1	−02 49.0	+0.6	+07 14.0	+0.9	+15 26.8	+0.4	+13 48.6	−0.7	+01 21.0	−1.3	22
23	−06 16.5	−0.1	−02 37.8	+0.6	+07 35.3	+0.9	+15 35.3	+0.3	+13 32.2	−0.7	+00 50.9	−1.3	23
24	−06 18.1	−0.1	−02 18.1	+0.7	+07 56.1	+0.9	+15 43.2	+0.3	+13 15.0	−0.7	+00 20.9	−1.3	24
25	−06 19.2	−0.0	−02 02.0	+0.7	+08 16.7	+0.9	+15 50.3	+0.3	+12 57.0	−0.8	−00 09.1	−1.2	25
26	−06 19.6	−0.0	−01 45.6	+0.7	+08 37.1	+0.8	+15 56.7	+0.3	+12 38.2	−0.8	−00 39.0	−1.2	26
27	−06 19.5	−0.0	−01 28.7	+0.7	+08 57.3	+0.8	+16 02.4	+0.2	+12 18.8	−0.8	−01 08.8	−1.2	27
28	−06 18.8	−0.0	−01 11.5	+0.7	+09 17.5	+0.8	+16 07.3	+0.2	+11 58.6	−0.9	−01 38.4	−1.2	28
29	−06 17.5	+0.1	−00 53.9	+0.7	+09 37.2	+0.8	+16 11.5	+0.2	+11 37.7	−0.9	−02 07.8	−1.2	29
30	−06 15.6	+0.1	−00 35.9	+0.8	+09 56.8	+0.8	+16 14.9	+0.1	+11 16.2	−0.9	−02 37.0	−1.2	30
31	−06 13.1	+0.1	−00 17.7	+0.8	.. ...	..	+16 17.5	+0.1	.. ...	..	−03 05.9	−1.2	31

TABLE VIII.

Day of Month	Right Ascension of the Mean Sun at Greenwich Mean Noon					
	January	February	March	April	May	June
	h m s	h m s	h m s	h m s	h m s	h m s
1	18 39 16.2	20 41 29.5	22 35 49.6	0 38 2.7	2 36 19.4	4 38 32.6
2	18 43 12.8	20 45 26.0	22 39 46.1	0 41 59.3	2 40 15.9	4 42 29.2
3	18 47 9.3	20 49 22.6	22 43 42.7	0 45 55.8	2 44 12.5	4 46 25.7
4	18 51 5.9	20 53 19.2	22 47 39.2	0 49 52.4	2 48 9.0	4 50 22.3
5	18 55 2.4	20 57 15.7	22 51 35.8	0 53 49.0	2 52 5.6	4 54 18.8
6	18 58 59.0	21 1 12.3	22 55 32.3	0 57 45.5	2 56 2.1	4 58 15.4
7	19 2 55.5	21 5 8.8	22 59 28.9	1 1 42.0	2 59 58.7	5 2 12.0
8	19 6 52.1	21 9 5.4	23 3 25.4	1 5 38.6	3 3 55.2	5 6 8.5
9	19 10 48.7	21 13 1.9	23 7 22.0	1 9 35.2	3 7 51.8	5 10 5.1
10	19 14 45.2	21 16 58.5	23 11 18.6	1 13 31.7	3 11 48.4	5 14 1.6
11	19 18 41.8	21 20 55.0	23 15 15.1	1 17 28.3	3 15 44.9	5 17 58.2
12	19 22 38.3	21 24 51.6	23 19 11.7	1 21 24.8	3 19 41.5	5 21 54.8
13	19 26 34.9	21 28 48.2	23 23 8.2	1 25 21.4	3 23 38.0	5 25 51.3
14	19 30 31.4	21 32 44.7	23 27 4.8	1 29 17.9	3 27 34.6	5 29 47.9
15	19 34 28.0	21 36 41.3	23 31 1.3	1 33 14.5	3 31 31.2	5 33 44.4
16	19 38 24.6	21 40 37.8	23 34 57.9	1 37 11.0	3 35 27.7	5 37 41.0
17	19 42 21.1	21 44 34.4	23 38 54.4	1 41 7.6	3 39 24.3	5 41 37.6
18	19 46 17.7	21 48 30.9	23 42 51.0	1 45 4.2	3 43 20.8	5 45 34.1
19	19 50 14.2	21 52 27.5	23 46 47.5	1 49 0.7	3 47 17.4	5 49 30.7
20	19 54 10.8	21 56 24.0	23 50 44.1	1 52 57.3	3 51 13.9	5 53 27.2
21	19 58 7.4	22 0 20.6	23 54 40.6	1 56 53.8	3 55 10.5	5 57 23.8
22	20 2 3.9	22 4 17.1	23 58 37.2	2 0 50.4	3 59 7.0	6 1 20.3
23	20 6 0.5	22 8 13.7	0 2 33.8	2 4 46.9	4 3 3.6	6 5 16.9
24	20 9 57.0	22 12 10.2	0 6 30.3	2 8 43.5	4 7 0.2	6 9 13.5
25	20 13 53.6	22 16 6.8	0 10 26.9	2 12 40.0	4 10 56.7	6 13 10.0
26	20 17 50.1	22 20 3.4	0 14 23.4	2 16 36.6	4 14 53.3	6 17 6.6
27	20 21 46.7	22 23 59.9	0 18 20.0	2 20 33.1	4 18 49.8	6 21 3.1
28	20 25 43.2	22 27 56.5	0 22 16.5	2 24 29.7	4 22 46.4	6 24 59.7
29	20 29 39.8	22 31 53.0	0 26 13.1	2 28 26.2	4 26 43.0	6 28 56.2
30	20 33 36.4	22 35 49.6	0 30 9.6	2 32 22.8	4 30 39.5	6 32 52.8
31	20 37 32.9	22 39 46.1	0 34 6.2	2 36 19.4	4 34 36.1	6 36 49.4

Correction to be added to R. A. M. S. at G. M. N. for Time past Noon.

Time	0 m	6 m	12 m	18 m	24 m	30 m	36 m	42 m	48 m	54 m	60 m
h	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
0	0 0.0	0 1.0	0 2.0	0 3.0	0 3.9	0 4.9	0 5.9	0 6.9	0 7.9	0 8.9	0 9.9
1	0 9.9	0 10.8	0 11.8	0 12.8	0 13.8	0 14.8	0 15.8	0 16.8	0 17.7	0 18.7	0 19.7
2	0 19.7	0 20.7	0 21.7	0 22.7	0 23.7	0 24.6	0 25.6	0 26.6	0 27.6	0 28.6	0 29.6
3	0 29.6	0 30.6	0 31.5	0 32.5	0 33.5	0 34.5	0 35.5	0 36.5	0 37.5	0 38.4	0 39.4
4	0 39.4	0 40.4	0 41.4	0 42.4	0 43.4	0 44.4	0 45.3	0 46.3	0 47.3	0 48.3	0 49.3
5	0 49.3	0 50.3	0 51.3	0 52.2	0 53.2	0 54.2	0 55.2	0 56.2	0 57.2	0 58.2	0 59.1
6	0 59.1	1 0.1	1 1.1	1 2.1	1 3.1	1 4.1	1 5.1	1 6.0	1 7.0	1 8.0	1 9.0
7	1 9.0	1 10.0	1 11.0	1 12.0	1 12.9	1 13.9	1 14.9	1 15.9	1 16.9	1 17.9	1 18.9
8	1 18.9	1 19.8	1 20.8	1 21.8	1 22.8	1 23.8	1 24.8	1 25.7	1 26.7	1 27.7	1 28.7
9	1 28.7	1 29.7	1 30.7	1 31.7	1 32.7	1 33.6	1 34.6	1 35.6	1 36.6	1 37.6	1 38.6
10	1 38.6	1 39.6	1 40.5	1 41.5	1 42.5	1 43.5	1 44.5	1 45.5	1 46.5	1 47.4	1 48.4
11	1 48.4	1 49.4	1 50.4	1 51.4	1 52.4	1 53.3	1 54.3	1 55.3	1 56.3	1 57.3	1 58.3

TABLE VIII.

Day of Month	Right Ascension of the Mean Sun at Greenwich Mean Noon					
	July	August	September	October	November	December
	h m s	h m s	h m s	h m s	h m s	h m s
1	6 36 49.4	8 39 2.6	10 41 15.8	12 39 32.4	14 41 45.6	16 40 2.3
2	6 40 45.9	8 42 59.2	10 45 12.4	12 43 29.0	14 45 42.2	16 43 58.9
3	6 44 42.5	8 46 55.8	10 49 9.0	12 47 25.6	14 49 38.7	16 47 55.4
4	6 48 39.0	8 50 52.3	10 53 5.5	12 51 22.1	14 53 35.3	16 51 52.0
5	6 52 35.6	8 54 48.9	10 57 2.1	12 55 18.7	14 57 31.8	16 55 48.6
6	6 56 32.2	8 58 45.4	11 0 58.6	12 59 15.2	15 1 28.4	16 59 45.1
7	7 0 28.7	9 2 42.0	11 4 55.2	13 3 11.8	15 5 25.0	17 3 41.7
8	7 4 25.3	9 6 38.5	11 8 51.7	13 7 8.3	15 9 21.5	17 7 38.2
9	7 8 21.8	9 10 35.1	11 12 48.3	13 11 4.9	15 13 18.1	17 11 34.8
10	7 12 18.4	9 14 31.6	11 16 44.8	13 15 1.4	15 17 14.6	17 15 31.4
11	7 16 14.9	9 18 28.2	11 20 41.4	13 18 58.0	15 21 11.2	17 19 27.9
12	7 20 11.5	9 22 24.8	11 24 37.9	13 22 54.5	15 25 7.7	17 23 24.5
13	7 24 8.1	9 26 21.3	11 28 34.5	13 26 51.1	15 29 4.3	17 27 21.0
14	7 28 4.6	9 30 17.9	11 32 31.0	13 30 47.6	15 33 0.8	17 31 17.6
15	7 32 1.2	9 34 14.4	11 36 27.6	13 34 44.2	15 36 57.4	17 35 14.1
16	7 35 57.7	9 38 11.0	11 40 24.2	13 38 40.8	15 40 54.0	17 39 10.7
17	7 39 54.3	9 42 7.5	11 44 20.7	13 42 37.3	15 44 50.5	17 43 7.3
18	7 43 50.8	9 46 4.1	11 48 17.3	13 46 33.9	15 48 47.1	17 47 3.8
19	7 47 47.4	9 50 0.6	11 52 13.8	13 50 30.4	15 52 43.6	17 51 0.4
20	7 51 44.0	9 53 57.2	11 56 10.4	13 54 27.0	15 56 40.2	17 54 56.9
21	7 55 40.5	9 57 53.8	12 0 6.9	13 58 23.5	16 0 36.8	17 58 53.5
22	7 59 37.1	10 1 50.3	12 4 3.5	14 2 20.1	16 4 33.3	18 2 50.0
23	8 3 33.6	10 5 46.9	12 8 0.0	14 6 16.6	16 8 29.9	18 6 46.6
24	8 7 30.2	10 9 43.4	12 11 56.6	14 10 13.2	16 12 26.4	18 10 43.2
25	8 11 26.8	10 13 40.0	12 15 53.1	14 14 9.7	16 16 23.0	18 14 39.7
26	8 15 23.3	10 17 36.5	12 19 49.7	14 18 6.3	16 20 19.5	18 18 36.3
27	8 19 19.9	10 21 33.1	12 23 46.2	14 22 2.8	16 24 16.1	18 22 32.8
28	8 23 16.4	10 25 29.6	12 27 42.8	14 25 59.4	16 28 12.6	18 26 29.4
29	8 27 13.0	10 29 26.2	12 31 39.3	14 29 56.0	16 32 9.2	18 30 26.0
30	8 31 9.5	10 33 22.7	12 35 35.9	14 33 52.5	16 36 5.8	18 34 22.5
31	8 35 6.1	10 37 19.3	12 39 32.4	14 37 49.1	16 40 2.3	18 38 19.1

Correction to be added to R. A. M. S. at G. M. N. for Time past Noon.

Time	0 m	6 m	12 m	18 m	24 m	30 m	36 m	42 m	48 m	54 m	60 m
h	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
12	1 58.3	1 59.3	2 0.2	2 1.2	2 2.2	2 3.2	2 4.2	2 5.2	2 6.2	2 7.1	2 8.1
13	2 8.1	2 9.1	2 10.1	2 11.1	2 12.1	2 13.1	2 14.0	2 15.0	2 16.0	2 17.0	2 18.0
14	2 18.0	2 19.0	2 20.0	2 20.9	2 21.9	2 22.9	2 23.9	2 24.9	2 25.9	2 26.9	2 27.8
15	2 27.8	2 28.8	2 29.8	2 30.8	2 31.8	2 32.8	2 33.8	2 34.7	2 35.7	2 36.7	2 37.7
16	2 37.7	2 38.7	2 39.7	2 40.7	2 41.6	2 42.6	2 43.6	2 44.6	2 45.6	2 46.6	2 47.6
17	2 47.6	2 48.5	2 49.5	2 50.5	2 51.5	2 52.5	2 53.5	2 54.5	2 55.4	2 56.4	2 57.4
18	2 57.4	2 58.4	2 59.4	3 0.4	3 1.4	3 2.3	3 3.3	3 4.3	3 5.3	3 6.3	3 7.3
19	3 7.3	3 8.3	3 9.2	3 10.2	3 11.2	3 12.2	3 13.2	3 14.2	3 15.2	3 16.1	3 17.1
20	3 17.1	3 18.1	3 19.1	3 20.1	3 21.1	3 22.1	3 23.0	3 24.0	3 25.0	3 26.0	3 37.0
21	3 27.0	3 28.0	3 29.0	3 29.9	3 30.9	3 31.9	3 32.9	3 33.9	3 34.9	3 35.9	3 36.8
22	3 36.8	3 37.8	3 38.8	3 39.8	3 40.8	3 41.8	3 42.8	3 43.7	3 44.7	3 45.7	3 46.7
23	3 46.7	3 47.7	3 48.7	3 49.7	3 50.6	3 51.6	3 52.6	3 53.6	3 54.6	3 55.6	3 56.6

TABLE IX.

Reduction to the Meridian.

H. A.	Log *a*.												
	0.000	0.200	0.240	0.280	0.320	0.360	0.400	0.440	0.480	0.520	0.560	0.600	0.640
1m 0s	1″	2″	2″	′ 2″	2″	3″	3″	3″	3″	3″	4″	4″	4″
2 0	4	6	7	8	8	9	10	11	12	13	14	16	17
3 0	9	14	16	17	19	21	23	25	27	30	33	36	39
4 0	16	25	28	31	34	37	40	44	48	53	58	1′ 4	1′ 10
4 30	20	32	35	39	42	46	51	56	1′ 1	1′ 7	1′ 13	1 20	1 28
5 0	25	40	43	48	52	57	1′ 3	1′ 9	1 15	1 23	1 31	1 39	1 49
30	30	48	53	58	1′ 3	1′ 9	1 16	1 23	1 31	1 40	1 50	2 0	2 12
6 0	36	57	1′ 3	1 8	1 15	1 22	1 30	1 39	1 49	1 59	2 11	2 23	2 37
30	42	1′ 7	1 13	1 21	1 28	1 37	1 46	1 56	2 7	2 20	2 33	2 48	3 4
7 0	49	1 18	1 25	1 34	1 42	1 52	2 3	2 15	2 28	2 42	2 58	3 15	3 34
30	56	1 29	1 38	1 47	1 57	2 9	2 21	2 35	2 50	3 6	3 24	3 41	4 5
8 0	1′ 4	1 42	1 52	2 2	2 14	2 27	2 41	2 56	3 13	3 32	3 52	4 15	4 39
30	1 12	1 55	2 6	2 18	2 31	2 45	3 1	3 19	3 38	3 59	4 22	4 47	5 15
9 0	1 21	2 9	2 21	2 35	2 49	3 5	3 23	3 43	4 5	4 28	4 54	5 22	5 53
30	1 30	2 24	2 37	2 52	3 9	3 27	3 46	4 8	4 32	4 59	5 27	5 59	6 33
10 0	1 40	2 39	2 54	3 11	3 29	3 49	4 11	4 35	5 2	5 31	6 3	6 38	7 16
20	1 47	2 50	3 6	3 24	3 44	4 5	4 29	4 54	5 23	5 54	6 28	7 5	7 46
40	1 54	3 1	3 18	3 37	3 58	4 21	4 46	5 13	5 44	6 17	6 54	7 34	8 17
11 0	2 1	3 12	3 30	3 51	4 12	4 37	5 4	5 33	6 5	6 41	7 19	8 2	8 48
20	2 8	3 24	3 43	4 4	4 28	4 53	5 21	5 52	6 27	7 4	7 45	8 29	9 18
40	2 16	3 36	3 57	4 20	4 44	5 11	5 41	6 14	6 51	7 30	8 14	9 1	9 53
12 0	2 24	3 48	4 11	4 35	5 1	5 30	6 1	6 36	7 15	7 57	8 43	9 33	10 28
20	2 32	4 2	4 24	4 50	5 18	5 48	6 22	6 58	7 39	8 23	9 12	10 5	11 3
40	2 40	4 16	4 39	5 6	5 35	6 6	6 43	7 23	8 5	8 51	9 44	10 39	11 40
13 0	2 49	4 29	4 54	5 23	5 53	6 27	7 4	7 45	8 30	9 19	10 13	11 13	12 17
20	2 58	4 43	5 10	5 40	6 12	6 48	7 27	8 10	8 58	9 49	10 46	11 48	12 56
40	3 7	4 57	5 25	5 57	6 31	7 8	7 49	8 34	9 25	10 19	11 19	12 24	13 35
14 0	3 16	5 12	5 41	6 14	6 50	7 29	8 12	8 59	9 52	10 49	11 51	13 0	14 15
20	3 25	5 26	5 57	6 32	7 8	7 49	8 35	9 24	10 19	11 19	12 24	13 35	14 54
40	3 35	5 42	6 14	6 51	7 29	8 12	9 0	9 51	10 49	11 52	13 0	14 16	15 37
15 0	3 45	5 57	6 31	7 10	7 50	8 35	9 25	10 19	11 19	12 25	13 37	14 55	16 21

TABLE X.

Places of Bright Stars for 1916.

Star	Magnitude	R.A. 1916.0	Annual Variation	Decl. 1916.0	Annual Variation	
		h m s	s	° ′ ″	″	
α Andromedae	2.2	0 4 2.5	+ 3.10	+28 37 36	+19.9	
β Cassiopeiae	2.4	0 4 41.2	+ 3.19	+58 41 11	+19.9	
β Ceti	2.2	0 39 22.4	+ 3.01	−18 26 51	+19.8	
α Urs. Min.	2.1	1 29 44.3	+28.78	+88 51 25	+18.5	Polaris
α Eridani	0.6	1 34 35.2	+ 2.24	−57 39 48	+18.3	Achernar
α Arietis	2.2	2 2 26.1	+ 3.38	+23 3 57	+17.1	
α Persei	1.9	3 18 19.1	+ 4.27	+49 33 47	+13.0	
α Tauri	1.1	4 31 5.9	+ 3.44	+16 20 29	+ 7.4	Aldebaran
β Orionis	0.3	5 10 30.0	+ 2.88	− 8 17 52	+ 4.3	Rigel
α Aurigae	0.2	5 10 28.9	+ 4.43	+45 54 50	+ 3.9	Capella
γ Orionis	1.7	5 20 37.5	+ 3.22	+ 6 16 28	+ 3.4	
ε Orionis	1.8	5 31 57.0	+ 3.04	− 1 15 17	+ 2.4	Bellatrix
α Orionis	1.0-1.4	5 50 37.4	+ 3.25	+ 7 23 32	+ 0.8	Betelgeux
α Argus	−0.9	6 22 5.2	+ 1.33	−52 38 58	− 1.9	Canopus
α Can. Maj.	−1.6	6 41 26.8	+ 2.64	−16 36 1	− 4.8	Sirius
α Can. Min.	0.5	7 34 54.3	+ 3.14	+ 5 26 27	− 9.1	Procyon
β Geminorum	1.2	7 40 10.7	+ 3.68	+28 13 48	− 8.5	Pollux
ε Argus	1.7	8 20 47.5	+ 1.23	−59 14 20	−11.5	
β Argus	1.8	9 12 17.0	+ 0.67	−69 22 16	−14.8	
α Hydrae	2.2	9 23 27.6	+ 2.95	− 8 17 38	−15.5	
α Leonis	1.3	10 3 54.0	+ 3.20	+12 22 42	−17.5	Regulus
α Urs. Maj.	2.0	10 58 33.4	+ 3.73	+62 12 17	−19.4	
β Leonis	2.2	11 44 46.6	+ 3.06	+15 2 30	−20.1	Denebola
α Crucis	1.1	12 21 55.2	+ 3.31	−62 38 2	−20.0	
γ Crucis	1.6	12 26 29.7	+ 3.30	−56 38 34	−20.2	
β Crucis	1.5	12 42 48.2	+ 3.48	−59 13 47	−19.7	
ζ Urs. Maj.	2.2	13 20 32.9	+ 2.42	+55 21 50	−18.8	Mizar
α Virginis	1.2	13 20 45.9	+ 3.16	−10 43 23	−18.8	Spica
θ Centauri	2.3	14 1 44.0	+ 3.52	−35 57 26	−17.8	
α Boötis	0.2	14 11 49.8	+ 2.74	+19 37 9	−18.8	Arcturus
α Centauri	0.1	14 33 53.0	+ 4.06	−60 29 22	−15.0	
β Urs. Min.	2.2	14 50 56.3	− 0.20	+74 29 56	−14.7	
α Cor. Bor.	2.3	15 31 7.9	+ 2.54	+26 59 48	−12.2	
δ Scorpii	2.5	15 55 21.8	+ 3.54	−22 23 1	−10.4	
α Scorpii	1.2	16 24 15.2	+ 3.67	−26 14 48	− 8.2	Antares
α Tri. Aust.	1.9	16 39 45.4	+ 6.32	−68 52 31	− 6.9	
η Ophiuchi	2.6	17 5 33.5	+ 3.44	−15 37 19	− 4.6	
λ Scorpii	1.7	17 27 54.2	+ 4.07	−37 2 37	− 2.8	
α Ophiuchi	2.1	17 31 2.1	+ 2.78	+12 37 13	− 2.8	
γ Draconis	2.4	17 54 39.3	+ 1.39	+51 29 54	− 0.5	
ε Sagittarii	2.0	18 18 35.8	+ 3.98	−34 25 31	+ 1.5	
α Lyrae	0.1	18 34 5.7	+ 2.03	+38 42 17	+ 3.3	Vega
σ Sagittarii	2.1	18 50 3.4	+ 3.72	−26 24 8	+ 4.3	
α Aquilae	0.9	19 46 41.1	+ 2.93	+ 8 38 44	+ 9.4	Altair
α Pavonis	2.1	20 19 0.6	+ 4.76	−57 0 19	+11.3	
α Cygni	1.3	20 38 34.1	+ 2.04	+44 58 47	+12.8	Deneb
ε Pegasi	2.5	21 40 3.6	+ 2.95	+ 9 29 22	+16.4	
α Gruis	2.2	22 2 56.7	+ 3.79	−47 22 7	+17.3	
α Pisc. Austr.	1.3	22 53 0.7	+ 3.32	−30 4 4	+19.0	Fomalhaut
α Pegasi	2.6	23 0 34.5	+ 2.99	+14 45 11	+19.3	

LOGARITHMIC FUNCTIONS.

TABLE XI

Log. Sines, Tangents, and Secants.

0° 179°

M.	Hour A. M.	Hour P. M.	Sine.	Diff. 1′.	Cosecant.	Tangent.	Diff. 1′.	Cotangent.	Secant.	Cosine.	M
0	12 0 0	0 0 0	Inf. neg.		Infinite.	Inf. neg.		Infinite.	10.00000	10.00000	60
1	11 59 52	0 8	6.46373	30103	13.53627	6.46373	30103	13.53627	00000	00000	59
2	59 44	0 16	76476	17609	23524	76476	17609	23524	00000	00000	58
3	59 36	0 24	94085	12494	05915	94085	12494	05915	00000	00000	57
4	59 28	0 32	7.06579	9691	12.93421	7.06579	9691	12.93421	00000	00000	56
5	11 59 20	0 0 40	7.16270	7918	12 83730	7.16270	7918	12.83730	10.00000	10.00000	55
6	59 12	0 48	24188	6694	75812	24188	6694	75812	00000	00000	54
7	59 4	0 56	30882	5800	69118	30882	5800	69118	00000	00000	53
8	58 56	1 4	36682	5115	63318	36682	5115	63318	00000	00000	52
9	58 48	1 12	41797	4576	58203	41797	4576	58203	00000	00000	51
10	11 58 40	0 1 20	7.46373	4139	12.53627	7.46373	4139	12.53627	10.00000	10.00000	50
11	58 32	1 28	50512	3779	49488	50512	3779	49488	00000	00000	49
12	58 24	1 36	54291	3476	45709	54291	3476	45709	00000	00000	48
13	58 16	1 44	57767	3218	42233	57767	3219	42233	00000	00000	47
14	58 8	1 52	60985	2997	39015	60986	2996	39014	00000	00000	46
15	11 58 0	0 2 0	7.63982	2802	12.36018	7.63982	2803	12.36018	10.00000	10.00000	45
16	57 52	2 8	66784	2633	33216	66785	2633	33215	00000	00000	44
17	57 44	2 16	69417	2483	30583	69418	2482	30582	00001	9.99999	43
18	57 36	2 24	71900	2348	28100	71900	2348	28100	00001	99999	42
19	57 28	2 32	74248	2227	25752	74248	2228	25752	00001	99999	41
20	11 57 20	0 2 40	7 76475	2119	12.23525	7.76476	2119	12.23524	10.00001	9.99999	40
21	57 12	2 48	78594	2021	21406	78595	2020	21405	00001	99999	39
22	57 4	2 56	80615	1930	19385	80615	1931	19385	00001	99999	38
23	56 56	3 4	82545	1848	17455	82546	1848	17454	00001	99999	37
24	56 48	3 12	84393	1773	15607	84394	1773	15606	00001	99999	36
25	11 56 40	0 3 20	7 86166	1704	12.13834	7.86167	1704	12.13833	10.00001	9.99999	35
26	56 32	3 28	87870	1639	12130	87871	1639	12129	00001	99999	34
27	56 24	3 36	89509	1579	10491	89510	1579	10490	00001	99999	33
28	56 16	3 44	91088	1524	08912	91089	1524	08911	00001	99999	32
29	56 8	3 52	92612	1472	07388	92613	1473	07387	00002	99998	31
30	11 56 0	0 4 0	7 94084	1424	12.05916	7 94086	1424	12.05914	10 00002	9 99998	30
31	55 52	4 8	95508	1379	04492	95510	1379	04490	00002	99998	29
32	55 44	4 16	96887	1336	03113	96889	1336	03111	00002	99998	28
33	55 36	4 24	98223	1297	01777	98225	1297	01775	00002	99998	27
34	55 28	4 32	99520	1259	00480	99522	1259	00478	00002	99998	26
35	11 55 20	0 4 40	8.00779	1223	11.99221	8.00781	1223	11.99219	10.00002	9.99998	25
36	55 12	4 48	02002	1190	97998	02004	1190	97996	00002	99998	24
37	55 4	4 56	03192	1158	96808	03194	1159	96806	00003	99997	23
38	54 56	5 4	04350	1128	95650	04353	1128	95647	00003	99997	22
39	54 48	5 12	05478	1100	94522	05481	1100	94519	00003	99997	21
40	11 54 40	0 5 20	8 06578	1072	11.93422	8.06581	1072	11.93419	10.00003	9.99997	20
41	54 32	5 28	07650	1046	92350	07653	1047	92347	00003	99997	19
42	54 24	5 36	08696	1022	91304	08700	1022	91300	00003	99997	18
43	54 16	5 44	09718	999	90282	09722	998	90278	00003	99997	17
44	54 8	5 52	10717	976	89283	10720	976	89280	00004	99996	16
45	11 54 0	0 6 0	8 11693	954	11.88307	8.11696	955	11.88304	10.00004	9.99996	15
46	53 52	6 8	12647	934	87353	12651	934	87349	00004	99996	14
47	53 44	6 16	13581	914	86419	13585	915	86415	00004	99996	13
48	53 36	6 24	14495	896	85505	14500	895	85500	00004	99996	12
49	53 28	6 32	15391	877	84609	15395	878	84605	00004	99996	11
50	11 53 20	0 6 40	8.16268	860	11.83732	8.16273	860	11.83727	10.00005	99995	10
51	53 12	6 48	17128	843	82872	17133	843	82867	00005	99995	9
52	53 4	6 56	17971	827	82029	17976	828	82024	00005	99995	8
53	52 56	7 4	18798	812	81202	18804	812	81196	00005	99995	7
54	52 48	7 12	19610	797	80390	19616	797	80384	00005	99995	6
55	11 52 40	0 7 20	8.20407	782	11.79593	8.20413	782	11.79587	10.00006	9.99994	5
56	52 32	7 28	21189	769	78811	21195	769	78805	00006	99994	4
57	52 24	7 36	21958	755	78042	21964	756	78036	00006	99994	3
58	52 16	7 44	22713	743	77287	22720	742	77280	00006	99994	2
59	52 8	7 52	23456	730	76544	23462	730	76538	00006	99994	1
60	52 0	8 0	24186	717	75814	24192	718	75808	00007	99993	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff. 1′.	Secant.	Cotangent.	Diff. 1′.	Tangent.	Cosecant.	Sine.	M.

90° 89°

TABLE XI

Log. Sines, Tangents, and Secants.

1° 178°

M.	Hour A. M.	Hour P. M.	Sine.	Diff. 1'.	Cosecant	Tangent.	Diff. 1'.	Cotangent.	Secant.	Cosine.	M.
0	11 52 0	0 8 0	8.24186	717	11.75814	8.24192	718	11.75808	10.00007	9.99993	60
1	51 52	8 8	24903	706	75097	24910	706	75090	00007	99993	59
2	51 44	8 16	25609	695	74391	25616	696	74384	00007	99993	58
3	51 36	8 24	26304	684	73696	26312	684	73688	00007	99993	57
4	51 28	8 32	26988	673	73012	26996	673	73004	00008	99992	56
5	11 51 20	0 8 40	8.27661	663	11.72339	8.27669	663	11.72331	10.00008	9.99992	55
6	51 12	8 48	28324	653	71676	28332	654	71668	00008	99992	54
7	51 4	8 56	28977	644	71023	28986	643	71014	00008	99992	53
8	50 56	9 4	29621	634	70379	29629	634	70371	00008	99992	52
9	50 48	9 12	30255	624	69745	30263	625	69737	00009	99991	51
10	11 50 40	0 9 20	8.30879	616	11.69121	8.30888	617	11.69112	10.00009	9.99991	50
11	50 32	9 28	31495	608	68505	31505	607	68495	00009	99991	49
12	50 24	9 36	32103	599	67897	32112	599	67888	00010	99990	48
13	50 16	9 44	32702	590	67298	32711	591	67289	00010	99990	47
14	50 8	9 52	33292	583	66708	33302	584	66698	00010	99990	46
15	11 50 0	0 10 0	8.33875	575	11.66125	8.33886	575	11.66114	10.00010	99990	45
16	49 52	10 8	34450	568	65550	34461	568	65539	00011	99989	44
17	49 44	10 16	35018	560	64982	35029	561	64971	00011	99989	43
18	49 36	10 24	35578	553	64422	35590	553	64410	00011	99989	42
19	49 28	10 32	36131	547	63869	36143	546	63857	00011	99989	41
20	11 49 20	0 10 40	8.36678	539	11.63322	8.36689	540	11.63311	10.00012	9.99988	40
21	49 12	10 48	37217	533	62783	37229	533	62771	00012	99988	39
22	49 4	10 56	37750	526	62250	37762	527	62238	00012	99988	38
23	48 56	11 4	38276	520	61724	38289	520	61711	00013	99987	37
24	48 48	11 12	38796	514	61204	38809	514	61191	00013	99987	36
25	11 48 40	0 11 20	8.39310	508	11.60690	8.39323	509	11.60677	10.00013	9.99987	35
26	48 32	11 28	30818	502	60182	39832	502	60168	00014	99986	34
27	48 24	11 36	40320	496	59680	40334	496	59666	00014	99986	33
28	48 16	11 44	40816	491	59184	40830	491	59170	00014	99986	32
29	48 8	11 52	41307	485	58693	41321	486	58679	00015	99985	31
30	11 48 0	0 12 0	8.41792	480	11.58208	8.41807	480	11.58193	10.00015	9.99985	30
31	47 52	12 8	42272	474	57728	42287	475	57713	00015	99985	29
32	47 44	12 16	42746	470	57254	42762	470	57238	00016	99984	28
33	47 36	12 24	43216	464	56784	43232	464	56768	00016	99984	27
34	47 28	12 32	43680	459	56320	43696	460	56304	00016	99984	26
35	11 47 20	0 12 40	8.44139	455	11.55861	8.44156	455	11.55844	10.00017	9.99983	25
36	47 12	12 48	44594	450	55406	44611	450	55389	00017	99983	24
37	47 4	12 56	45044	445	54956	45061	446	54939	00017	99983	23
38	46 56	13 4	45489	441	54511	45507	441	54493	00018	99982	22
39	46 48	13 12	45930	436	54070	45948	437	54052	00018	99982	21
40	11 46 40	0 13 20	8.46366	433	11.53634	8.46385	432	11.53615	10.00018	9.99982	20
41	46 32	13 28	46799	427	53201	46817	428	53183	00019	99981	19
42	46 24	13 36	47226	424	52774	47245	424	52755	00019	99981	18
43	46 16	13 44	47650	419	52350	47669	420	52331	00019	99981	17
44	46 8	13 52	48069	416	51931	48089	416	51911	00020	99980	16
45	11 46 0	0 14 0	8.48485	411	11.51515	8.48505	412	11.51495	10.00020	9.99980	15
46	45 52	14 8	48896	408	51104	48917	408	51083	00021	99979	14
47	45 44	14 16	49304	404	50696	49325	404	50675	00021	99979	13
48	45 36	14 24	49708	400	50292	49729	401	50271	00021	99979	12
49	45 28	14 32	50108	396	49892	50130	397	49870	00022	99978	11
50	11 45 20	0 14 40	8.50504	393	11.49496	8.50527	393	11.49473	10.00022	9.99978	10
51	45 12	14 48	50897	390	49103	50920	390	49080	00023	99977	9
52	45 4	14 56	51287	386	48713	51310	386	48690	00023	99977	8
53	44 56	15 4	51673	382	48327	51696	383	48304	00023	99977	7
54	44 48	15 12	52055	379	47945	52079	380	47921	00024	99976	6
55	11 44 40	0 15 20	8.52434	376	11.47566	8.52459	376	11.47541	10.00024	9.99976	5
56	44 32	15 28	52810	373	47190	52835	373	47165	00025	99975	4
57	44 24	15 36	53183	369	46817	53208	370	46792	00025	99975	3
58	44 16	15 44	53552	367	46448	53578	367	46422	00026	99974	2
59	44 8	15 52	53919	363	46081	53945	363	46055	00026	99974	1
60	44 0	16 0	54282	360	45718	54308	361	45692	00026	99974	0
M.	Hour P. M.	Hour A. M.	Cosine	Diff. 1'.	Secant.	Cotangent	Diff. 1'.	Tangent.	Cosecant	Sine.	M.

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TABLE XI

Log. Sines, Tangents, and Secants.

2° 177°

M.	Hour A. M.	Hour P. M.	Sine	Diff 1′.	Cosecant	Tangent	Diff 1′	Cotangent.	Secant	Cosine	M.
0	11 44 0	0 16 0	8 54282	360	11 45718	8 54308	361	11 45692	10.00026	9.99974	60
1	43 52	16 8	54642	357	45358	54669	358	45331	00027	99973	59
2	43 44	16 16	54999	355	45001	55027	355	44973	00027	99973	58
3	43 36	16 24	55354	351	44646	55382	352	44618	00028	99972	57
4	43 28	16 32	55705	349	44295	55734	349	44266	00028	99972	56
5	11 43 20	0 16 40	8 56054	346	11 43946	8 56083	346	11.43917	10.00029	9 99971	55
6	43 12	16 48	56400	343	43600	56429	344	43571	00029	99971	54
7	43 4	16 56	56743	341	43257	56773	341	43227	00030	99970	53
8	42 56	17 4	57084	337	42916	57114	338	42886	00030	99970	52
9	42 48	17 12	57421	336	42579	57452	336	42548	00031	99969	51
10	11 42 40	0 17 20	8 57757	332	11.42243	8.57788	333	11.42212	10.00031	9 99969	50
11	42 32	17 28	58089	330	41911	58121	330	41879	00032	99968	49
12	42 24	17 36	58419	328	41581	58451	328	41549	00032	99968	48
13	42 16	17 44	58747	325	41253	58779	326	41221	00033	99967	47
14	42 8	17 52	59072	323	40928	59105	323	40895	00033	99967	46
15	11 42 0	0 18 0	8.59395	320	11.40605	8.59428	321	11.40572	10.00033	9.99967	45
16	41 52	18 8	59715	318	40285	59749	319	40251	00034	99966	44
17	41 44	18 16	60033	316	39967	60068	316	39932	00034	99966	43
18	41 36	18 24	60349	313	39651	60384	314	39616	00035	99965	42
19	41 28	18 32	60662	311	39338	60698	311	39302	00036	99964	41
20	11 41 20	0 18 40	8 60973	309	11.39027	8.61009	310	11 38991	10.00036	9 99964	40
21	41 12	18 48	61282	307	38718	61319	307	38681	00037	99963	39
22	41 4	18 56	61589	305	38411	61626	305	38374	00037	99963	38
23	40 56	19 4	61894	302	38106	61931	303	38069	00038	99962	37
24	40 48	19 12	62196	301	37804	62234	301	37766	00038	99962	36
25	11 40 40	0 19 20	8.62497	298	11.37503	8.62535	299	11 37465	10.00039	9.99961	35
26	40 32	19 28	62795	296	37205	62834	297	37166	00039	99961	34
27	40 24	19 36	63091	294	36909	63131	295	36869	00040	99960	33
28	40 16	19 44	63385	293	36615	63426	292	36574	00040	99960	32
29	40 8	19 52	63678	290	36322	63718	291	36282	00041	99959	31
30	11 40 0	0 20 0	8.63968	288	11.36032	8.64009	289	11 35991	10.00041	9.99959	30
31	39 52	20 8	64256	287	35744	64298	287	35702	00042	99958	29
32	39 44	20 16	64543	284	35457	64585	285	35415	00042	99958	28
33	39 36	20 24	64827	283	35173	64870	284	35130	00043	99957	27
34	39 28	20 32	65110	281	34890	65154	281	34846	00044	99956	26
35	11 39 20	0 20 40	8.65391	279	11.34609	8.65435	280	11.34565	10.00044	9.99956	25
36	39 12	20 48	65670	277	34330	65715	278	34285	00045	99955	24
37	39 4	20 56	65947	276	34053	65993	276	34007	00045	99955	23
38	38 56	21 4	66223	274	33777	66269	274	33731	00046	99954	22
39	38 48	21 12	66497	272	33503	66543	273	33457	00046	99954	21
40	11 38 40	0 21 20	8.66769	270	11.33231	8.66816	271	11.33184	10.00047	9.99953	20
41	38 32	21 28	67039	269	32961	67087	269	32913	00048	99952	19
42	38 24	21 36	67308	267	32692	67356	268	32644	00048	99952	18
43	38 16	21 44	67575	266	32425	67624	266	32376	00049	99951	17
44	38 8	21 52	67841	263	32159	67890	264	32110	00049	99951	16
45	11 38 0	0 22 0	8.68104	263	11.31896	8.68154	263	11.31846	10.00050	9.99950	15
46	37 52	22 8	68367	260	31633	68417	261	31583	00051	99949	14
47	37 44	22 16	68627	259	31373	68678	260	31322	00051	99949	13
48	37 36	22 24	68886	258	31114	68938	258	31062	00052	99948	12
49	37 28	22 32	69144	256	30856	69196	257	30804	00052	99948	11
50	11 37 20	0 22 40	8.69400	254	11.30600	8.69453	255	11.30547	10.00053	9.99947	10
51	37 12	22 48	69654	253	30346	69708	254	30292	00054	99946	9
52	37 4	22 56	69907	252	30093	69962	252	30038	00054	99946	8
53	36 56	23 4	70159	250	29841	70214	251	29786	00055	99945	7
54	36 48	23 12	70409	249	29591	70465	249	29535	00056	99944	6
55	11 36 40	0 23 20	8.70658	247	11.29342	8.70714	248	11.29286	10.00056	9.99944	5
56	36 32	23 28	70905	246	29095	70962	246	29038	00057	99943	4
57	36 24	23 36	71151	244	28849	71208	245	28792	00058	99942	3
58	36 16	23 44	71395	243	28605	71453	244	28547	00058	99942	2
59	36 8	23 52	71638	242	28362	71697	243	28303	00059	99941	1
60	36 0	24 0	71880	240	28120	71940	241	28060	00060	99940	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff. 1′.	Secant.	Cotangent.	Diff. 1′.	Tangent.	Cosecant.	Sine.	M.

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TABLE XI

Log. Sines, Tangents, and Secants.

3° 176°

M.	Hour A. M.	Hour P. M.	Sine.	Diff. 1'.	Cosecant.	Tangent.	Diff. 1'.	Cotangent.	Secant.	Cosine.	M.
0	11 36 0	0 24 0	8. 71880	240	11. 28120	8. 71940	241	11. 28060	10. 00060	9. 99940	60
1	35 52	24 8	72120	239	27880	72181	239	27819	00060	99940	59
2	35 44	24 16	72359	238	27641	72420	239	27580	00061	99939	58
3	35 36	24 24	72597	237	27403	72659	237	27341	00062	99938	57
4	35 28	24 32	72834	235	27166	72896	236	27104	00062	99938	56
5	11 35 20	0 24 40	8. 73069	234	11. 26931	8. 73132	234	11. 26868	10. 00063	9. 99937	55
6	35 12	24 48	73303	232	26697	73366	234	26634	00064	99936	54
7	35 4	24 56	73535	232	26465	73600	232	26400	00064	99936	53
8	34 56	25 4	73767	230	26233	73832	231	26168	00065	99935	52
9	34 48	25 12	73997	229	26003	74063	229	25937	00066	99934	51
10	11 34 40	0 25 20	8. 74226	228	11. 25774	8. 74292	229	11. 25708	10. 00066	9. 99934	50
11	34 32	25 28	74454	226	25546	74521	227	25479	00067	99933	49
12	34 24	25 36	74680	226	25320	74748	226	25252	00068	99932	48
13	34 16	25 44	74906	224	25094	74974	225	25026	00068	99932	47
14	34 8	25 52	75130	223	24870	75199	224	24801	00069	99931	46
15	11 34 0	0 26 0	8. 75353	222	11. 24647	8. 75423	222	11. 24577	10. 00070	9. 99930	45
16	33 52	26 8	75575	220	24425	75645	222	24355	00071	99929	44
17	33 44	26 16	75795	220	24205	75867	220	24133	00071	99929	43
18	33 36	26 44	76015	219	23985	76087	219	23913	00072	99928	42
19	33 28	26 32	76234	217	23766	76306	219	23694	00073	99927	41
20	11 33 20	0 26 40	8. 76451	216	11. 23549	8. 76525	217	11. 23475	10. 00074	9. 99926	40
21	33 12	26 48	76667	216	23333	76742	216	23258	00074	99926	39
22	33 4	26 56	76883	214	23117	76958	215	23042	00075	99925	38
23	32 56	27 4	77097	213	22903	77173	214	22827	00076	99924	37
24	32 48	27 12	77310	212	22690	77387	213	22613	00077	99923	36
25	11 32 40	0 27 20	8. 77522	211	11. 22478	8. 77600	211	11. 22400	10. 00077	9. 99923	35
26	32 32	27 28	77733	210	22267	77811	211	22189	00078	99922	34
27	32 24	27 36	77943	209	22057	78022	210	21978	00079	99921	33
28	32 16	27 44	78152	208	21848	78232	209	21768	00080	99920	32
29	32 8	27 52	78360	208	21640	78441	208	21559	00080	99920	31
30	11 32 0	0 28 0	8. 78568	206	11. 21432	8. 78649	206	11. 21351	10. 00081	9. 99919	30
31	31 52	28 8	78774	205	21226	78855	206	21145	00082	99918	29
32	31 44	28 16	78979	204	21021	79061	205	20939	00083	99917	28
33	31 36	28 24	79183	203	20817	79266	204	20734	00083	99917	27
34	31 28	28 32	79386	202	20614	79470	203	20530	00084	99916	26
35	11 31 20	0 28 40	8. 79588	201	11. 20412	8. 79673	202	11. 20327	10. 00085	9. 99915	25
36	31 12	28 48	79789	201	20211	79875	201	20125	00086	99914	24
37	31 4	28 56	79990	199	20010	80076	201	19924	00087	99913	23
38	30 56	29 4	80189	199	19811	80277	199	19723	00087	99913	22
39	30 48	29 12	80388	197	19612	80476	198	19524	00088	99912	21
40	11 30 40	0 29 20	8. 80585	197	11. 19415	8. 80674	198	11. 19326	10. 00089	9. 99911	20
41	30 32	29 28	80782	196	19218	80872	196	19128	00090	99910	19
42	30 24	29 36	80978	195	19022	81068	196	18932	00091	99909	18
43	30 16	29 44	81173	194	18827	81264	195	18736	00091	99909	17
44	30 8	29 52	81367	193	18633	81459	194	18541	00092	99908	16
45	11 30 0	0 30 0	8. 81560	192	11. 18440	8. 81653	193	11. 18347	10. 00093	9. 99907	15
46	29 52	30 8	81752	192	18248	81846	192	18154	00094	99906	14
47	29 44	30 16	81944	190	18056	82038	192	17962	00095	99905	13
48	29 36	30 24	82134	190	17866	82230	190	17770	00096	99904	12
49	29 28	30 32	82324	189	17676	82420	190	17580	00096	99904	11
50	11 29 20	0 30 40	8. 82513	188	11. 17487	8. 82610	189	11. 17390	10. 00097	9. 99903	10
51	29 12	30 48	82701	187	17299	82799	188	17201	00098	99902	9
52	29 4	30 56	82888	187	17112	82987	188	17013	00099	99901	8
53	28 56	31 4	83075	186	16925	83175	186	16825	00100	99900	7
54	28 48	31 12	83261	185	16739	83361	186	16639	00101	99899	6
55	11 28 40	0 31 20	8. 83446	184	11. 16554	8. 83547	185	11. 16453	10. 00102	9. 99898	5
56	28 32	31 28	83630	183	16370	83732	184	16268	00102	99898	4
57	28 24	31 36	83813	183	16187	83916	184	16084	00103	99897	3
58	28 16	31 44	83996	181	16004	84100	182	15900	00104	99896	2
59	28 8	31 52	84177	181	15823	84282	182	15718	00105	99895	1
60	28 0	32 0	84358	181	15642	84464	182	15536	00106	99894	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff. 1'.	Secant.	Cotangent.	Diff. 1'.	Tangent.	Cosecant.	Sine.	M.

93° 86°

TABLE XI

Log. Sines, Tangents, and Secants.

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M.	Hour A. M.	Hour P. M.	Sine.	Diff. 1'.	Cosecant.	Tangent.	Diff. 1'.	Cotangent.	Secant.	Cosine.	M.
0	11 28 0	0 32 0	8.84358	181	11.15642	8.84464	182	11.15536	10.00106	9.99894	60
1	27 52	32 8	84539	179	15461	84646	180	15354	00107	99893	59
2	27 44	32 16	84718	179	15282	84826	180	15174	00108	99892	58
3	27 36	32 24	84897	178	15103	85006	179	14994	00109	99891	57
4	27 28	32 32	85075	177	14925	85185	178	14815	00109	99891	56
5	11 27 20	0 32 40	8.85252	177	11.14748	8.85363	177	11.14637	10.00110	9.99890	55
6	27 12	32 48	85429	176	14571	85540	177	14460	00111	99889	54
7	27 4	32 56	85605	175	14395	85717	176	14283	00112	99888	53
8	26 56	33 4	85780	175	14220	85893	176	14107	00113	99887	52
9	26 48	33 12	85955	173	14045	86069	174	13931	00114	99886	51
10	11 26 40	0 33 20	8.86128	173	11.13872	8.86243	174	11.13757	10.00115	9.99885	50
11	26 32	33 28	86301	173	13699	86417	174	13583	00116	99884	49
12	26 24	33 36	86474	171	13526	86591	172	13409	00117	99883	48
13	26 16	33 44	86645	171	13355	86763	172	13237	00118	99882	47
14	26 8	33 52	86816	171	13184	86935	171	13065	00119	99881	46
15	11 26 0	34 0	8.86987	169	11.13013	8.87106	171	11.12894	10.00120	9.99880	45
16	25 52	34 8	87156	169	12844	87277	170	12723	00121	99879	44
17	25 44	34 16	87325	169	12675	87447	169	12553	00121	99879	43
18	25 36	34 24	87494	167	12506	87616	169	12384	00122	99878	42
19	25 28	34 32	87661	168	12339	87785	168	12215	00123	99877	41
20	11 25 20	0 34 40	8.87829	166	11.12171	8.87953	167	11.12047	10.00124	9.99876	40
21	25 12	34 48	87995	166	12005	88120	167	11880	00125	99875	39
22	25 4	34 56	88161	165	11839	88287	166	11713	00126	99874	38
23	24 56	35 4	88326	164	11674	88453	165	11547	00127	99873	37
24	24 48	35 12	88490	164	11510	88618	165	11382	00128	99872	36
25	11 24 40	0 35 20	8.88654	163	11.11346	8.88783	165	11.11217	10.00129	9.99871	35
26	24 32	35 28	88817	163	11183	88948	163	11052	00130	99870	34
27	24 24	35 36	88980	162	11020	89111	163	10889	00131	99869	33
28	24 16	35 44	89142	162	10858	89274	163	10726	00132	99868	32
29	24 8	35 52	89304	160	10696	89437	161	10563	00133	99867	31
30	11 24 0	0 36 0	8.89464	161	11.10536	8.89598	162	11.10402	10.00134	9.99866	30
31	23 52	36 8	89625	159	10375	89760	160	10240	00135	99865	29
32	23 44	36 16	89784	159	10216	89920	160	10080	00136	99864	28
33	23 36	36 24	89943	159	10057	90080	160	09920	00137	99863	27
34	23 28	36 32	90102	158	09898	90240	159	09760	00138	99862	26
35	11 23 20	0 36 40	8.90260	157	11.09740	8.90399	158	11.09601	10.00139	9.99861	25
36	23 12	36 48	90417	157	09583	90557	158	09443	00140	99860	24
37	23 4	36 56	90574	156	09426	90715	157	09285	00141	99859	23
38	22 56	37 4	90730	155	09270	90872	157	09128	00142	99858	22
39	22 48	37 12	90885	155	09115	91029	156	08971	00143	99857	21
40	11 22 40	0 37 20	8.91040	155	11.08960	8.91185	155	11.08815	10.00144	9.99856	20
41	22 32	37 28	91195	154	08805	91340	155	08660	00145	99855	19
42	22 24	37 36	91349	153	08651	91495	155	08505	00146	99854	18
43	22 16	37 44	91502	153	08498	91650	153	08350	00147	99853	17
44	22 8	37 52	91655	152	08345	91803	154	08197	00148	99852	16
45	11 22 0	0 38 0	8.91807	152	11.08193	8.91957	153	11.08043	10.00149	9.99851	15
46	21 52	38 8	91959	151	08041	92110	152	07890	00150	99850	14
47	21 44	38 16	92110	151	07890	92262	152	07738	00152	99848	13
48	21 36	38 24	92261	150	07739	92414	151	07586	00153	99847	12
49	21 28	38 32	92411	150	07589	92565	151	07435	00154	99846	11
50	11 21 20	0 38 40	8.92561	149	11.07439	8.92716	150	11.07284	10.00155	9.99845	10
51	21 12	38 48	92710	149	07290	92866	150	07134	00156	99844	9
52	21 4	38 56	92859	148	07141	93016	149	06984	00157	99843	8
53	20 56	39 4	93007	147	06993	93165	148	06835	00158	99842	7
54	20 48	39 12	93154	147	06846	93313	149	06687	00159	99841	6
55	11 20 40	0 39 20	8.93301	147	11.06699	8.93462	147	11.06538	10.00160	9.99840	5
56	20 32	39 28	93448	146	06552	93609	147	06391	00161	99839	4
57	20 24	39 36	93594	146	06406	93756	147	06244	00162	99838	3
58	20 16	39 44	93740	145	06260	93903	146	06097	00163	99837	2
59	20 8	39 52	93885	145	06115	94049	146	05951	00164	99836	1
60	20 0	40 0	94030	144	05970	94195	145	05805	00166	99834	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff. 1'.	Secant.	Cotangent.	Diff. 1'.	Tangent.	Cosecant.	Sine.	M.

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TABLE XI

Log. Sines, Tangents, and Secants.

5° 174°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	11 20 00	0 40 0	8. 94030	0	11. 05970	8. 94195	0	11. 05805	10. 00166	0	9. 99834	60
1	19 52	40 8	94174	2	05826	94340	2	05660	00167	0	99833	59
2	19 44	40 16	94317	4	05683	94485	4	05515	00168	0	99832	58
3	19 36	40 24	94461	7	05539	94630	7	05370	00169	0	99831	57
4	19 28	40 32	94603	9	05397	94773	9	05227	00170	0	99830	56
5	11 19 20	0 40 40	8. 94746	11	11. 05254	8. 94917	11	11. 05083	10. 00171	0	9. 99829	55
6	19 12	40 48	94887	13	05113	95060	13	04940	00172	0	99828	54
7	19 4	40 56	95029	15	04971	95202	15	04798	00173	0	99827	53
8	18 56	41 4	95170	18	04830	95344	18	04656	00175	0	99825	52
9	18 48	41 12	95310	20	04690	95486	20	04514	00176	0	99824	51
10	11 18 40	0 41 20	8. 95450	22	11. 04550	8. 95627	22	11. 04373	10. 00177	0	9. 99823	50
11	18 32	41 28	95589	24	04411	95767	24	04233	00178	0	99822	49
12	18 24	41 36	95728	26	04272	95908	27	04092	00179	0	99821	48
13	18 16	41 44	95867	29	04133	96047	29	03953	00180	0	99820	47
14	18 8	41 52	96005	31	03995	96187	31	03813	00181	0	99819	46
15	11 18 0	0 42 0	8. 96143	33	11. 03857	8. 96325	33	11. 03675	10. 00183	0	9. 99817	45
16	17 52	42 8	96280	35	03720	96464	35	03536	00184	0	99816	44
17	17 44	42 16	96417	37	03583	96602	38	03398	00185	0	99815	43
18	17 36	42 24	96553	39	03447	96739	40	03261	00186	0	99814	42
19	17 28	42 32	96689	42	03311	96877	42	03123	00187	0	99813	41
20	11 17 20	0 42 40	8. 96825	44	11. 03175	8. 97013	44	11. 02987	10. 00188	0	9. 99812	40
21	17 12	42 48	96960	46	03040	97150	46	02850	00190	0	99810	39
22	17 4	42 56	97095	48	02905	97285	49	02715	00191	0	99809	38
23	16 56	43 4	97229	50	02771	97421	51	02579	00192	0	99808	37
24	16 48	43 12	97363	53	02637	97556	53	02444	00193	0	99807	36
25	11 16 40	0 43 20	8. 97496	55	11. 02504	8. 97691	55	11. 02309	10. 00194	1	9. 99806	35
26	16 32	43 28	97629	57	02371	97825	58	02175	00196	1	99804	34
27	16 24	43 36	97762	59	02238	97959	60	02041	00197	1	99803	33
28	16 16	43 44	97894	61	02106	98092	62	01908	00198	1	99802	32
29	16 8	43 52	98026	64	01974	98225	64	01775	00199	1	99801	31
30	11 16 0	0 44 0	8. 98157	66	11. 01843	8. 98358	66	11. 01642	10. 00200	1	9. 99890	30
31	15 52	44 8	98288	68	01712	98490	69	01510	00202	1	99798	29
32	15 44	44 16	98419	70	01581	98622	71	01378	00203	1	99797	28
33	15 36	44 24	98549	72	01451	98753	73	01247	00204	1	99796	27
34	15 28	44 32	98679	75	01321	98884	75	01116	00205	1	99795	26
35	11 15 20	0 44 40	8. 98808	77	11. 01192	8. 99015	77	11. 00985	10. 00207	1	9. 99793	25
36	15 12	44 48	98937	79	01063	99145	80	00855	00208	1	99792	24
37	15 4	44 56	99066	81	00934	99275	82	00725	00209	1	99791	23
38	14 56	45 4	99194	83	00806	99405	84	00595	00210	1	99790	22
39	14 48	45 12	99322	86	00678	99534	86	00466	00212	1	99788	21
40	11 14 40	0 45 20	8. 99450	88	11. 00550	8. 99662	89	11. 00338	10. 00213	1	9. 99787	20
41	14 32	45 28	99577	90	00423	99791	91	00209	00214	1	99786	19
42	14 24	45 36	99704	92	00296	99919	93	00081	00215	1	99785	18
43	14 16	45 44	99830	94	00170	9. 00046	95	10. 99954	00217	1	99783	17
44	14 8	45 52	99956	96	00044	00174	97	99826	00218	1	99782	16
45	11 14 0	0 46 0	9. 00082	99	10. 99918	9. 00301	100	10. 99699	10. 00219	1	9. 99781	15
46	13 52	46 8	00207	101	99793	00427	102	99573	00220	1	99780	14
47	13 44	46 16	00332	103	99668	00553	104	99447	00222	1	99778	13
48	13 36	46 24	00456	105	99544	00679	106	99321	00223	1	99777	12
49	13 28	46 32	00581	107	99419	00805	108	99195	00224	1	99776	11
50	11 13 20	0 46 40	9. 00704	110	10. 99296	9. 00930	111	10. 99070	10. 00225	1	9. 99775	10
51	13 12	46 48	00828	112	99172	01055	113	98945	00227	1	99773	9
52	13 4	46 56	00951	114	99049	01179	115	98821	00228	1	99772	8
53	12 56	47 4	01074	116	98926	01303	117	98697	00229	1	99771	7
54	12 48	47 12	01196	118	98804	01427	120	98573	00231	1	99769	6
55	11 12 40	0 47 20	9. 01318	121	10. 98682	9. 01550	122	10. 98450	10. 00232	1	99768	5
56	12 32	47 28	01440	123	98560	01673	124	98327	00233	1	99767	4
57	12 24	47 36	01561	125	98439	01796	126	98204	00235	1	99765	3
58	12 16	47 44	01682	127	98318	01918	128	98082	00236	1	99764	2
59	12 8	47 52	01803	129	98197	02040	131	97960	00237	1	99763	1
60	12 0	48 0	01923	132	98077	02162	133	97838	00239	1	99761	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
			A		A	B		B	C		C	

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Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop parts of cols.	A	16	33	49	66	82	99	115
	B	17	33	50	66	83	100	116
	C	0	0	0	1	1	1	1

TABLE XI

Log. Sines, Tangents, and Secants.

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M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	11 12 0	0 48 0	9.01923	0	10.98077	9.02162	0	10.97838	10.00239	0	9.99761	60
1	11 52	48 8	02043	2	97957	02283	2	97717	00240	0	99760	59
2	11 44	48 16	02163	4	97837	02404	4	97596	00241	0	99759	58
3	11 36	48 24	02283	6	97717	02525	6	97475	00243	0	99757	57
4	11 28	48 32	02402	7	97598	02645	8	97355	00244	0	99756	56
5	11 11 20	0 48 40	9.02520	9	10.97480	9.02766	9	10.97234	10.00245	0	9.99755	55
6	11 12	48 48	02639	11	97361	02885	11	97115	00247	0	99753	54
7	11 4	48 56	02757	13	97243	03005	13	96995	00248	0	99752	53
8	10 56	49 4	02874	15	97126	03124	15	96876	00249	0	99751	52
9	10 48	49 12	02992	17	97008	03242	17	96758	00251	0	99749	51
10	11 10 40	0 49 20	9.03109	19	10.96891	9.03361	19	10.96639	10.00252	0	9.99748	50
11	10 32	49 28	03226	20	96774	03479	21	96521	00253	0	99747	49
12	10 24	49 36	03342	22	96658	03597	23	96403	00255	0	99745	48
13	10 16	49 44	03458	24	96542	03714	24	96286	00256	0	99744	47
14	10 8	49 52	03574	26	96426	03832	26	96168	00258	0	99742	46
15	11 10 0	0 50 0	9.03690	28	10.96310	9.03948	28	10.96052	10.00259	0	9.99741	45
16	9 52	50 8	03805	30	96195	04065	30	95935	00260	0	99740	44
17	9 44	50 16	03920	31	96080	04181	32	95819	00262	0	99738	43
18	9 36	50 24	04034	33	95966	04297	34	95703	00263	0	99737	42
19	9 28	50 32	04149	35	95851	04413	36	95587	00264	0	99736	41
20	11 9 20	0 50 40	9.04262	37	10.95738	9.04528	38	10.95472	10.00266	0	9.99734	40
21	9 12	50 48	04376	39	95624	04643	39	95357	00267	1	99733	39
22	9 4	50 56	04490	41	95510	04758	41	95242	00269	1	99731	38
23	8 56	51 4	04603	43	95397	04873	43	95127	00270	1	99730	37
24	8 48	51 12	04715	44	95285	04987	45	95013	00272	1	99728	36
25	11 8 40	0 51 20	9.04828	46	10.95172	9.05101	47	10.94899	10.00273	1	9.99727	35
26	8 32	51 28	04940	48	95060	05214	49	94786	00274	1	99726	34
27	8 24	51 36	05052	50	94948	05328	51	94672	00276	1	99724	33
28	8 16	51 44	05164	52	94836	05441	53	94559	00277	1	99723	32
29	8 8	51 52	05275	54	94725	05553	54	94447	00279	1	99721	31
30	11 8 0	0 52 0	9.05386	56	10.94614	9.05666	56	10.94334	10.00280	1	9.99720	30
31	7 52	52 8	05497	57	94503	05778	58	94222	00282	1	99718	29
32	7 44	52 16	05607	59	94393	05890	60	94110	00283	1	99717	28
33	7 36	52 24	05717	61	94283	06002	62	93998	00284	1	99716	27
34	7 28	52 32	05827	63	94173	06113	64	93887	00286	1	99714	26
35	11 7 20	0 52 40	9.05937	65	10.94063	9.06224	66	10.93776	10.00287	1	9.99713	25
36	7 12	52 48	06046	67	93954	06335	68	93665	00289	1	99711	24
37	7 4	52 56	06155	69	93845	06445	69	93555	00290	1	99710	23
38	6 56	53 4	06264	70	93736	06556	71	93444	00292	1	99708	22
39	6 48	53 12	06372	72	93628	06666	73	93334	00293	1	99707	21
40	11 6 40	0 53 20	9.06481	74	10.93519	9.06775	75	10.93225	10.00295	1	9.99705	20
41	6 32	53 28	06589	76	93411	06885	77	93115	00296	1	99704	19
42	6 24	53 36	06696	78	93304	06994	79	93006	00298	1	99702	18
43	6 16	53 44	06804	80	93196	07103	81	92897	00299	1	99701	17
44	6 8	53 52	06911	81	93089	07211	83	92789	00301	1	99699	16
45	11 6 0	0 54 0	9.07018	83	10.92982	9.07320	84	10.92680	10.00302	1	9.99698	15
46	5 52	54 8	07124	85	92876	07428	86	92572	00304	1	99696	14
47	5 44	54 16	07231	87	92769	07536	88	92464	00305	1	99695	13
48	5 36	54 24	07337	89	92663	07643	90	92357	00307	1	99693	12
49	5 28	54 32	07442	91	92558	07751	92	92249	00308	1	99692	11
50	11 5 20	0 54 40	9.07548	93	10.92452	9.07858	94	10.92142	10.00310	1	9.99690	10
51	5 12	54 48	07653	94	92347	07964	96	92036	00311	1	99689	9
52	5 4	54 56	07758	96	92242	08071	98	91929	00313	1	99687	8
53	4 56	55 4	07863	98	92137	08177	99	91823	00314	1	99686	7
54	4 48	55 12	07968	100	92032	08283	101	91717	00316	1	99684	6
55	11 4 40	0 55 20	9.08072	102	10.91928	9.08389	103	10.91611	10.00317	1	9.99683	5
56	4 32	55 28	08176	104	91824	08495	105	91505	00319	1	99681	4
57	4 24	55 36	08280	106	91720	08600	107	91400	00320	1	99680	3
58	4 16	55 44	08383	107	91617	08705	109	91295	00322	1	99678	2
59	4 8	55 52	08486	109	91514	08810	111	91190	00323	1	99677	1
60	4 0	56 0	08589	111	91411	08914	113	91086	00325	1	99675	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
96°			A		A	B		B	C		C	83°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	14	28	42	56	69	83	97
	B	14	28	42	56	70	84	98
	C	0	0	1	1	1	1	1

TABLE XI

Log. Sines, Tangents, and Secants.

9° 170°

M	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	10 48 0	1 12 0	9. 19433	0	10. 80567	9. 19971	0	10. 80029	10. 00538	0	9. 99462	60
1	47 52	12 8	19513	1	80487	20053	1	79947	00540	0	99460	59
2	47 44	12 16	19592	3	80408	20134	3	79865	00542	0	99458	58
3	47 36	12 24	19672	4	80328	20216	4	79784	00544	0	99456	57
4	47 28	12 32	19751	5	80249	20297	5	79703	00546	0	99454	56
5	10 47 20	1 12 40	9. 19830	6	10. 80170	9. 20378	6	10. 79622	10. 00548	0	9. 99452	55
6	47 12	12 48	19909	8	80091	20459	8	79541	00550	0	99450	54
7	47 4	12 56	19988	9	80012	20540	9	79460	00552	0	99448	53
8	46 56	13 4	20067	10	79933	20621	10	79379	00554	0	99446	52
9	46 48	13 12	20145	11	79855	20701	12	79299	00556	0	99444	51
10	10 46 40	1 13 20	9. 20223	13	10. 79777	9. 20782	13	10. 79218	10. 00558	0	9. 99442	50
11	46 32	13 28	20302	14	79698	20862	14	79138	00560	0	99440	49
12	46 24	13 36	20380	15	79620	20942	16	79058	00562	0	99438	48
13	46 16	13 44	20458	16	79542	21022	17	78978	00564	0	99436	47
14	46 8	13 52	20535	18	79465	21102	18	78898	00566	0	99434	46
15	10 46 0	1 14 0	9. 20613	19	10. 79387	9. 21182	19	10. 78818	10. 00568	1	9. 99432	45
16	45 52	14 8	20691	20	79309	21261	21	78739	00571	1	99429	44
17	45 44	14 16	20768	21	79232	21341	22	78659	00573	1	99427	43
18	45 36	14 24	20845	23	79155	21420	23	78580	00575	1	99425	42
19	45 28	14 32	20922	24	79078	21499	25	78501	00577	1	99423	41
20	10 45 20	1 14 40	9. 20999	25	10. 79001	9. 21578	26	10. 78422	10. 00579	1	9. 99421	40
21	45 12	14 48	21076	26	78924	21657	27	78343	00581	1	99419	39
22	45 4	14 56	21153	28	78847	21736	28	78264	00583	1	99417	38
23	44 56	15 4	21229	29	78771	21814	30	78186	00585	1	99415	37
24	44 48	15 12	21306	30	78694	21893	31	78107	00587	1	99413	36
25	10 44 40	1 15 20	9. 21382	31	10. 78618	9. 21971	32	10. 78029	10. 00589	1	9. 99411	35
26	44 32	15 28	21458	33	78542	22049	34	77951	00591	1	99409	34
27	44 24	15 36	21534	34	78466	22127	35	77873	00593	1	99407	33
28	44 16	15 44	21610	35	78390	22205	36	77795	00596	1	99404	32
29	44 8	15 52	21685	37	78315	22283	38	77717	00598	1	99402	31
30	10 44 0	1 16 0	9. 21761	38	10. 78239	9. 22361	39	10. 77639	10. 00600	1	9. 99400	30
31	43 52	16 8	21836	39	78164	22438	40	77562	00602	1	99398	29
32	43 44	16 16	21912	40	78088	22516	41	77484	00604	1	99396	28
33	43 36	16 24	21987	42	78013	22593	43	77407	00606	1	99394	27
34	43 28	16 32	22062	43	77938	22670	44	77330	00608	1	99392	26
35	10 43 20	1 16 40	9. 22137	44	10. 77863	9. 22747	45	10. 77253	10. 00610	1	9. 99390	25
36	43 12	16 48	22211	45	77789	22824	47	77176	00612	1	99388	24
37	43 4	16 56	22286	47	77714	22901	48	77099	00615	1	99385	23
38	42 56	17 4	22361	48	77639	22977	49	77023	00617	1	99383	22
39	42 48	17 12	22435	49	77565	23054	50	76946	00619	1	99381	21
40	10 42 40	1 17 20	9. 22509	50	10. 77491	9. 23130	52	10. 76870	10. 00621	1	9. 99379	20
41	42 32	17 28	22583	52	77417	23206	53	76794	00623	1	99377	19
42	42 24	17 36	22657	53	77343	23283	54	76717	00625	1	99375	18
43	42 16	17 44	22731	54	77269	23359	56	76641	00628	2	99372	17
44	42 8	17 52	22805	55	77195	23435	57	76565	00630	2	99370	16
45	10 42 0	1 18 0	9. 22878	57	10. 77122	9. 23510	58	10. 76490	10. 00632	2	9. 99368	15
46	41 52	18 8	22952	58	77048	23586	60	76414	00634	2	99366	14
47	41 44	18 16	23025	59	76975	23661	61	76339	00636	2	99364	13
48	41 36	18 24	23098	60	76902	23737	62	76263	00638	2	99362	12
49	41 28	18 32	23171	62	76829	23812	63	76188	00641	2	99359	11
50	10 41 20	1 18 40	9. 23244	63	10. 76756	9. 23887	65	10. 76113	10. 00643	2	9. 99357	10
51	41 12	18 48	23317	64	76683	23962	66	76038	00645	2	99355	9
52	41 4	18 56	23390	65	76610	24037	67	75963	00647	2	99353	8
53	40 56	19 4	23462	67	76538	24112	69	75888	00649	2	99351	7
54	40 48	19 12	23535	68	76465	24186	70	75814	00652	2	99348	6
55	10 40 40	1 19 20	9. 23607	69	10. 76393	9. 24261	71	10. 75739	10. 00654	2	9. 99346	5
56	40 32	19 28	23679	71	76321	24335	73	75665	00656	2	99344	4
57	40 24	19 36	23752	72	76248	24410	74	75590	00658	2	99342	3
58	40 16	19 44	23823	73	76177	24484	75	75516	00660	2	99340	2
59	40 8	19 52	23895	74	76105	24558	76	75442	00663	2	99337	1
60	40 0	20 0	23967	76	76033	24632	78	75368	00665	2	99335	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant	Diff.	Sine.	M.
99°			A		A	B		B	C		C	80°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	9	19	28	38	47	57	66
	B	10	19	29	39	49	58	68
	C	0	1	1	1	1	2	2

TABLE XI

Log. Sines, Tangents, and Secants.

10° 169°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	10 40 0	1 20 0	9.23967	0	10.76033	9.24632	0	10.75368	10.00665	0	9.99335	60
1	39 52	20 8	24039	1	75961	24706	1	75294	00667	0	99333	59
2	39 44	20 16	24110	2	75890	24779	2	75221	00669	0	99331	58
3	39 36	20 24	24181	3	75819	24853	4	75147	00672	0	99328	57
4	39 28	20 32	24253	5	75747	24926	5	75074	00674	0	99326	56
5	10 39 20	1 20 40	9.24324	6	10.75676	9.25000	6	10.75000	10.00676	0	9.99324	55
6	39 12	20 48	24395	7	75605	25073	7	74927	00678	0	99322	54
7	39 4	20 56	24466	8	75534	25146	8	74854	00681	0	99319	53
8	38 56	21 4	24536	9	75464	25219	9	74781	00683	0	99317	52
9	38 48	21 12	24607	10	75393	25292	11	74708	00685	0	99315	51
10	10 38 40	1 21 20	9.24677	11	10.75323	9.25365	12	10.74635	10.00687	0	9.99313	50
11	38 32	21 28	24748	13	75252	25437	13	74563	00690	0	99310	49
12	38 24	21 36	24818	14	75182	25510	14	74490	00692	0	99308	48
13	38 16	21 44	24888	15	75112	25582	15	74418	00694	1	99306	47
14	38 8	21 52	24958	16	75042	25055	16	74345	00696	1	99304	46
15	10 38 0	1 22 0	9.25028	17	10.74972	9.25727	18	10.74273	10.00699	1	9.99301	45
16	37 52	22 8	25098	18	74902	25799	19	74201	00701	1	99299	44
17	37 44	22 16	25168	19	74832	25871	20	74129	00703	1	99297	43
18	37 36	22 24	25237	20	74763	25943	21	74057	00706	1	99294	42
19	37 28	22 32	25307	22	74693	26015	22	73985	00708	1	99292	41
20	10 37 20	1 22 40	9.25376	23	10.74624	9.26086	24	10.73914	10.00710	1	9.99290	40
21	37 12	22 48	25445	24	74555	26158	25	73842	00712	1	99288	39
22	37 4	22 56	25514	25	74486	26229	26	73771	00715	1	99285	38
23	36 56	23 4	25583	26	74417	26301	27	73699	00717	1	99283	37
24	36 48	23 12	25652	27	74348	26372	28	73628	00719	1	99281	36
25	10 36 40	1 23 20	9.25721	28	10.74279	9.26443	29	10.73557	10.00722	1	9.99278	35
26	36 32	23 28	25790	30	74210	26514	31	73486	00724	1	99276	34
27	36 24	23 36	25858	31	74142	26585	32	73415	00726	1	99274	33
28	36 16	23 44	25927	32	74073	26655	33	73345	00729	1	99271	32
29	36 8	23 52	25995	33	74005	26726	34	73274	00731	1	99269	31
30	10 36 0	1 24 0	9.26063	34	10.73937	9.26797	35	10.73203	10.00733	1	9.99267	30
31	35 52	24 8	26131	35	73869	26867	36	73133	00736	1	99264	29
32	35 44	24 16	26199	36	73801	26937	38	73063	00738	1	99262	28
33	35 36	24 24	26267	38	73733	27008	39	72992	00740	1	99260	27
34	35 28	24 32	26335	39	73665	27078	40	72922	00743	1	99257	26
35	10 35 20	1 24 40	9.26403	40	10.73597	9.27148	41	10.72852	10.00745	1	9.99255	25
36	35 12	24 48	26470	41	73530	27218	42	72782	00748	1	99252	24
37	35 4	24 56	26538	42	73462	27288	44	72712	00750	1	99250	23
38	34 56	25 4	26605	43	73395	27357	45	72643	00752	1	99248	22
39	34 48	25 12	26672	44	73328	27427	46	72573	00755	2	99245	21
40	10 34 40	1 25 20	9.26739	45	10.73261	9.27496	47	10.72504	10.00757	2	9.99243	20
41	34 32	25 28	26806	47	73194	27566	48	72434	00759	2	99241	19
42	34 24	25 36	26873	48	73127	27635	49	72365	00762	2	99238	18
43	34 16	25 44	26940	49	73060	27704	51	72296	00764	2	99236	17
44	34 8	25 52	27007	50	72993	27773	52	72227	00767	2	99233	16
45	10 34 0	1 26 0	9.27073	51	10.72927	9.27842	53	10.72158	10.00769	2	9.99231	15
46	33 52	26 8	27140	52	72860	27911	54	72089	00771	2	99229	14
47	33 44	26 16	27206	53	72794	27980	55	72020	00774	2	99226	13
48	33 36	26 24	27273	55	72727	28049	56	71951	00776	2	99224	12
49	33 28	26 32	27339	56	72661	28117	58	71883	00779	2	99221	11
50	10 33 20	1 26 40	9.27405	57	10.72595	9.28186	59	10.71814	10.00781	2	9.99219	10
51	33 12	26 48	27471	58	72529	28254	60	71746	00783	2	99217	9
52	33 4	26 56	27537	59	72463	28323	61	71677	00786	2	99214	8
53	32 56	27 4	27602	60	72398	28391	62	71609	00788	2	99212	7
54	32 48	27 12	27668	61	72332	28459	63	71541	00791	2	99209	6
55	10 32 40	1 27 20	9.27734	63	10.72266	9.28527	65	10.71473	10.00793	2	9.99207	5
56	32 32	27 28	27799	64	72201	28595	66	71405	00796	2	99204	4
57	32 24	27 36	27864	65	72136	28662	67	71338	00798	2	99202	3
58	32 16	27 44	27930	66	72070	28730	68	71270	00800	2	99200	2
59	32 8	27 52	27995	67	72005	28798	69	71202	00803	2	99197	1
60	32 0	28 0	28060	68	71940	28865	71	71135	00805	2	99195	0
M.	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant.	Cotangent.	Diff.	Tangent	Cosecant.	Diff.	Sine.	M.
100°			A		A	B		B	C		C	79°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	9	17	26	34	43	51	60
	B	9	18	26	35	44	53	62
	C	0	1	1	1	1	2	2

TABLE XI

Log. Sines, Tangents, and Secants.

11° | | 168°

M	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	10 32 0	1 28 0	9. 28060	0	10. 71940	9. 28865	0	10. 71135	10. 00805	0	9. 99195	60
1	31 52	28 8	28125	1	71875	28933	1	71067	00808	0	99192	59
2	31 44	28 16	28190	2	71810	29000	2	71000	00810	0	99190	58
3	31 36	28 24	28254	3	71746	29067	3	70933	00813	0	99187	57
4	31 28	28 32	28319	4	71681	29134	4	70866	00815	0	99185	56
5	10 31 20	1 28 40	9. 28384	5	10. 71616	9. 29201	5	10. 70799	10. 00818	0	9. 99182	55
6	31 12	28 48	28448	6	71552	29268	6	70732	00820	0	99180	54
7	31 4	28 56	28512	7	71488	29335	8	70665	00823	0	99177	53
8	30 56	29 4	28577	8	71423	29402	9	70598	00825	0	99175	52
9	30 48	29 12	28641	9	71359	29468	10	70532	00828	0	99172	51
10	10 30 40	1 29 20	9. 28705	10	10. 71295	9. 29535	11	10. 70465	10. 00830	0	9. 99170	50
11	30 32	29 28	28769	11	71231	29601	12	70399	00833	0	99167	49
12	30 24	29 36	28833	12	71167	29668	13	70332	00835	1	99165	48
13	30 16	29 44	28896	13	71104	29734	14	70266	00838	1	99162	47
14	30 8	29 52	28960	14	71040	29800	15	70200	00840	1	99160	46
15	10 30 0	1 30 0	9. 29024	16	10. 70976	9. 29866	16	10. 70134	10. 00843	1	9. 99157	45
16	29 52	30 8	29087	17	70913	29932	17	70068	00845	1	99155	44
17	29 44	30 16	29150	18	70850	29998	18	70002	00848	1	99152	43
18	29 36	30 24	29214	19	70786	30064	19	69936	00850	1	99150	42
19	29 28	30 32	29277	20	70723	30130	20	69870	00853	1	99147	41
20	10 29 20	1 30 40	9. 29340	21	10. 70660	9. 30195	22	10. 69805	10. 00855	1	9. 99145	40
21	29 12	30 48	29403	22	70597	30261	23	69739	00858	1	99142	39
22	29 4	30 56	29466	23	70534	30326	24	69674	00860	1	99140	38
23	28 56	31 4	29529	24	70471	30391	25	69609	00863	1	99137	37
24	28 48	31 12	29591	25	70409	30457	26	69543	00865	1	99135	36
25	10 28 40	1 31 20	9. 29654	26	10. 70346	9. 30522	27	10. 69478	10. 00868	1	9. 99132	35
26	28 32	31 28	29716	27	70284	30587	28	69413	00870	1	99130	34
27	28 24	31 36	29779	28	70221	30652	29	69348	00873	1	99127	33
28	28 16	31 44	29841	29	70159	30717	30	69283	00876	1	99124	32
29	28 8	31 52	29903	30	70097	30782	31	69218	00878	1	99122	31
30	10 28 0	1 32 0	9. 29966	31	10. 70034	9. 30846	32	10. 69154	10. 00881	1	9. 99119	30
31	27 52	32 8	30028	32	69972	30911	33	69089	00883	1	99117	29
32	27 44	32 16	30090	33	69910	30975	35	69025	00886	1	99114	28
33	27 36	32 24	30151	34	69849	31040	36	68960	00888	1	99112	27
34	27 28	32 32	30213	35	69787	31104	37	68896	00891	1	99109	26
35	10 27 20	1 32 40	9. 30275	36	10. 69725	9. 31168	38	10. 68832	10. 00894	2	9. 99106	25
36	27 12	32 48	30336	37	69664	31233	39	68767	00896	2	99104	24
37	27 4	32 56	30398	38	69602	31297	40	68703	00899	2	99101	23
38	26 56	33 4	30459	39	69541	31361	41	68639	00901	2	99099	22
39	26 48	33 12	30521	40	69479	31425	42	68575	00904	2	99096	21
40	10 26 40	1 33 20	9. 30582	41	10. 69418	9. 31489	43	10. 68511	10. 00907	2	9. 99093	20
41	26 32	33 28	30643	42	69357	31552	44	68448	00909	2	99091	19
42	26 24	33 36	30704	43	69296	31616	45	68384	00912	2	99088	18
43	26 16	33 44	30765	45	69235	31679	46	68321	00914	2	99086	17
44	26 8	33 52	30826	46	69174	31743	47	68257	00917	2	99083	16
45	10 26 0	1 34 0	9. 30887	47	10. 69113	9. 31806	49	10. 68194	10. 00920	2	9. 99080	15
46	25 52	34 8	30947	48	69053	31870	50	68130	00922	2	99078	14
47	25 44	34 16	31008	49	68992	31933	51	68067	00925	2	99075	13
48	25 36	34 24	31068	50	68932	31996	52	68004	00928	2	99072	12
49	25 28	34 32	31129	51	68871	32059	53	67941	00930	2	99070	11
50	10 25 20	1 34 40	9. 31189	52	10. 68811	9. 32122	54	10. 67878	10. 00933	2	9. 99067	10
51	25 12	34 48	31250	53	68750	32185	55	67815	00936	2	99064	9
52	25 4	34 56	31310	54	68690	32248	56	67752	00938	2	99062	8
53	24 56	35 4	31370	55	68630	32311	57	67689	00941	2	99059	7
54	24 48	35 12	31430	56	68570	32373	58	67627	00944	2	99056	6
55	10 24 40	1 35 20	9. 31490	57	10. 68510	9. 32436	59	10. 67564	10. 00946	2	9. 99054	5
56	24 32	35 28	31549	58	68451	32498	60	67502	00949	2	99051	4
57	24 24	35 36	31609	59	68391	32561	61	67439	00952	2	99048	3
58	24 16	35 44	31669	60	68331	32623	63	67377	00954	2	99046	2
59	24 8	35 52	31728	61	68272	32685	64	67315	00957	3	99043	1
60	24 0	36 0	31788	62	68212	32747	65	67253	00960	3	99040	0
M	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
101°			A		A	B		B	C		C	78°

Seconds of time ……		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	8	16	23	31	39	47	54
	B	8	16	24	32	40	49	57
	C	0	1	1	1	2	2	2

TABLE XI

Log. Sines, Tangents, and Secants.

12° | 167°

M.	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	10 24 0	1 36 0	9.31788	0	10.68212	9.32747	0	10.67253	10.00960	0	9.99040	60
1	23 52	36 8	31847	1	68153	32810	1	67190	00962	0	99038	59
2	23 44	36 16	31907	2	68093	32872	2	67128	00965	0	99035	58
3	23 36	36 24	31966	3	68034	32933	3	67067	00968	0	99032	57
4	23 28	36 32	32025	4	67975	32995	4	67005	00970	0	99030	56
5	10 23 20	1 36 40	9.32084	5	10.67916	9.33057	5	10.66943	10.00973	0	9.99027	55
6	23 12	36 48	32143	6	67857	33119	6	66881	00976	0	99024	54
7	23 4	36 56	32202	7	67798	33180	7	66820	00978	0	99022	53
8	22 56	37 4	32261	8	67739	33242	8	66758	00981	0	99019	52
9	22 48	37 12	32319	9	67681	33303	9	66697	00984	0	99016	51
10	10 22 40	1 37 20	9.32378	10	10.67622	9.33365	10	10.66635	10.00987	0	9.99013	50
11	22 32	37 28	32437	10	67563	33426	11	66574	00989	1	99011	49
12	22 24	37 36	32495	11	67505	33487	12	66513	00992	1	99008	48
13	22 16	37 44	32553	12	67447	33548	13	66452	00995	1	99005	47
14	22 8	37 52	32612	13	67388	33609	14	66391	00998	1	99002	46
15	10 22 0	1 38 0	9.32670	14	10.67330	9.33670	15	10.66330	10.01000	1	9.99000	45
16	21 52	38 8	32728	15	67272	33731	16	66269	01003	1	98997	44
17	21 44	38 16	32786	16	67214	33792	17	66208	01006	1	98994	43
18	21 36	38 24	32844	17	67156	33853	18	66147	01009	1	98991	42
19	21 28	38 32	32902	18	67098	33913	19	66087	01011	1	98989	41
20	10 21 20	1 38 40	9.32960	19	10.67040	9.33974	20	10.66026	10.01014	1	9.98986	40
21	21 12	38 48	33018	20	66982	34034	21	65966	01017	1	98983	39
22	21 4	38 56	33075	21	66925	34095	22	65905	01020	1	98980	38
23	20 56	39 4	33133	22	66867	34155	23	65845	01022	1	98978	37
24	20 48	39 12	33190	23	66810	34215	24	65785	01025	1	98975	36
25	10 20 40	1 39 20	9.33248	24	10.66752	9.34276	25	10.65724	10.01028	1	9.98972	35
26	20 32	39 28	33305	25	66695	34336	26	65664	01031	1	98969	34
27	20 24	39 36	33362	26	66638	34396	27	65604	01033	1	98967	33
28	20 16	39 44	33420	27	66580	34456	28	65544	01036	1	98964	32
29	20 8	39 52	33477	28	66523	34516	29	65484	01039	1	98961	31
30	10 20 0	1 40 0	9.33534	29	10.66466	9.34576	30	10.65424	10.01042	1	9.98958	30
31	19 52	40 8	33591	29	66409	34635	31	65365	01045	1	98955	29
32	19 44	40 16	33647	30	66353	34695	32	65305	01047	1	98953	28
33	19 36	40 24	33704	31	66296	34755	33	65245	01050	2	98950	27
34	19 28	40 32	33761	32	66239	34814	34	65186	01053	2	98947	26
35	10 19 20	1 40 40	9.33818	33	10.66182	9.34874	35	10.65126	10.01056	2	9.98944	25
36	19 12	40 48	33874	34	66126	34933	36	65067	01059	2	98941	24
37	19 4	40 56	33931	35	66069	34992	37	65008	01062	2	98938	23
38	18 56	41 4	33987	36	66013	35051	38	64949	01064	2	98936	22
39	18 48	41 12	34043	37	65957	35111	39	64889	01067	2	98933	21
40	10 18 40	1 41 20	9.34100	38	10.65900	9.35170	40	10.64830	10.01070	2	9.98930	20
41	18 32	41 28	34156	39	65844	35229	41	64771	01073	2	98927	19
42	18 24	41 36	34212	40	65788	35288	42	64712	01076	2	98924	18
43	18 16	41 44	34268	41	65732	35347	43	64653	01079	2	98921	17
44	18 8	41 52	34324	42	65676	35405	44	64595	01081	2	98919	16
45	10 18 0	1 42 0	9.34380	43	10.65620	9.35464	45	10.64536	10.01084	2	9.98916	15
46	17 52	42 8	34436	44	65564	35523	46	64477	01087	2	98913	14
47	17 44	42 16	34491	45	65509	35581	47	64419	01090	2	98910	13
48	17 36	42 24	34547	46	65453	35640	48	64360	01093	2	98907	12
49	17 28	42 32	34602	47	65398	35698	49	64302	01096	2	98904	11
50	10 17 20	1 42 40	9.34658	48	10.65342	9.35757	50	10.64243	10.01099	2	9.98901	10
51	17 12	42 48	34713	48	65287	35815	51	64185	01102	2	98898	9
52	17 4	42 56	34769	49	65231	35873	52	64127	01104	2	98896	8
53	16 56	43 4	34824	50	65176	35931	53	64069	01107	2	98893	7
54	16 48	43 12	34879	51	65121	35989	54	64011	01110	3	98890	6
55	10 16 40	1 43 20	9.34934	52	10.65066	9.36047	55	10.63953	10.01113	3	9.98887	5
56	16 32	43 28	34989	53	65011	36105	56	63895	01116	3	98884	4
57	16 24	43 36	35044	54	64956	36163	57	63837	01119	3	98881	3
58	16 16	43 44	35099	55	64901	36221	58	63779	01122	3	98878	2
59	16 8	43 52	35154	56	64846	36279	59	63721	01125	3	98875	1
60	16 0	44 0	35209	57	64791	36336	60	63664	01128	3	98872	0
M.	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
			A		A	B		B	C		C	

102° | 77°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	7	14	21	29	36	43	50
	B	7	15	22	29	37	45	52
	C	0	1	1	1	2	2	2

TABLE XI

Log. Sines, Tangents, and Secants.

13° 166°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	10 16 0	1 44 0	9.35209	0	10.64791	9.36336	0	10.63664	10.01128	0	9.98872	60
1	15 52	44 8	35263	1	64737	36394	1	63606	01131	0	98869	59
2	15 44	44 16	35318	2	64682	36452	2	63548	01133	0	98867	58
3	15 36	44 24	35373	3	64627	36509	3	63491	01136	0	98864	57
4	15 28	44 32	35427	4	64573	36566	4	63434	01139	0	98861	56
5	10 15 20	1 44 40	9.35481	4	10.64519	9.36624	5	10.63376	10.01142	0	9.98858	55
6	15 12	44 48	35536	5	64464	36681	6	63319	01145	0	98855	54
7	15 4	44 56	35590	6	64410	36738	6	63262	01148	0	98852	53
8	14 56	45 4	35644	7	64356	36795	7	63205	01151	0	98849	52
9	14 48	45 12	35698	8	64302	36852	8	63148	01154	0	98846	51
10	10 14 40	1 45 20	9.35752	9	10.64248	9.36909	9	10.63091	10.01157	1	9.98843	50
11	14 32	45 28	35806	10	64194	36966	10	63034	01160	1	98840	49
12	14 24	45 36	35860	11	64140	37023	11	62977	01163	1	98837	48
13	14 16	45 44	35914	11	64086	37080	12	62920	01166	1	98834	47
14	14 8	45 52	35968	12	64032	37137	13	62863	01169	1	98831	46
15	10 14 0	1 46 0	9.36022	13	10.63978	9.37193	14	10.62807	10.01172	1	9.98828	45
16	13 52	46 8	36075	14	63925	37250	15	62750	01175	1	98825	44
17	13 44	46 16	36129	15	63871	37306	16	62694	01178	1	98822	43
18	13 36	46 24	36182	16	63818	37363	17	62637	01181	1	98819	42
19	13 28	46 32	36236	17	63764	37419	18	62581	01184	1	98816	41
20	10 13 20	1 46 40	9.36289	18	10.63711	9.37476	19	10.62524	10.01187	1	9.98813	40
21	13 12	46 48	36342	18	63658	37532	19	62468	01190	1	98810	39
22	13 4	46 56	36395	19	63605	37588	20	62412	01193	1	98807	38
23	12 56	47 4	36449	20	63551	37644	21	62356	01196	1	98804	37
24	12 48	47 12	36502	21	63498	37700	22	62300	01199	1	98801	36
25	10 12 40	1 47 20	9.36555	22	10.63445	9.37756	23	10.62244	10.01202	1	9.98798	35
26	12 32	47 28	36608	23	63392	37812	24	62188	01205	1	98795	34
27	12 24	47 36	36660	24	63340	37868	25	62132	01208	1	98792	33
28	12 16	47 44	36713	25	63287	37924	26	62076	01211	1	98789	32
29	12 8	47 52	36766	25	63234	37980	27	62020	01214	1	98786	31
30	10 12 0	1 48 0	9.36819	26	10.63181	9.38035	28	10.61965	10.01217	2	9.98783	30
31	11 52	48 8	36871	27	63129	38091	29	61909	01220	2	98780	29
32	11 44	48 16	36924	28	63076	38147	30	61853	01223	2	98777	28
33	11 36	48 24	36976	29	63024	38202	31	61798	01226	2	98774	27
34	11 28	48 32	37028	30	62972	38257	32	61743	01229	2	98771	26
35	10 11 20	1 48 40	9.37081	31	10.62919	9.38313	32	10.61687	10.01232	2	9.98768	25
36	11 12	48 48	37133	32	62867	38368	33	61632	01235	2	98765	24
37	11 4	48 56	37185	32	62815	38423	34	61577	01238	2	98762	23
38	10 56	49 4	37237	33	62763	38479	35	61521	01241	2	98759	22
39	10 48	49 12	37289	34	62711	38534	36	61466	01244	2	98756	21
40	10 10 40	1 49 20	9.37341	35	10.62659	9.38589	37	10.61411	10.01247	2	9.98753	20
41	10 32	49 28	37393	36	62607	38644	38	61356	01250	2	98750	19
42	10 24	49 36	37445	37	62555	38699	39	61301	01254	2	98746	18
43	10 16	49 44	37497	38	62503	38754	40	61246	01257	2	98743	17
44	10 8	49 52	37549	39	62451	38808	41	61192	01260	2	98740	16
45	10 10 0	1 50 0	9.37600	39	10.62400	9.38863	42	10.61137	10.01263	2	9.98737	15
46	9 52	50 8	37652	40	62348	38918	43	61082	01266	2	98734	14
47	9 44	50 16	37703	41	62297	38972	44	61028	01269	2	98731	13
48	9 36	50 24	37755	42	62245	39027	45	60973	01272	2	98728	12
49	9 28	50 32	37806	43	62194	39082	45	60918	01275	2	98725	11
50	10 9 20	1 50 40	9.37858	44	10.62142	9.39136	46	10.60864	10.01278	3	9.98722	10
51	9 12	50 48	37909	45	62091	39190	47	60810	01281	3	98719	9
52	9 4	50 56	37960	46	62040	39245	48	60755	01285	3	98715	8
53	8 56	51 4	38011	47	61989	39299	49	60701	01288	3	98712	7
54	8 48	51 12	38062	47	61938	39353	50	60647	01291	3	98709	6
55	10 8 40	1 51 20	9.38113	48	10.61887	9.39407	51	10.60593	10.01294	3	9.98706	5
56	8 32	51 28	38164	49	61836	39461	52	60539	01297	3	98703	4
57	8 24	51 36	38215	50	61785	39515	53	60485	01300	3	98700	3
58	8 16	51 44	38266	51	61734	39569	54	60431	01303	3	98697	2
59	8 8	51 52	38317	52	61683	39623	55	60377	01306	3	98694	1
60	8 0	52 0	38368	53	61632	39677	56	60323	01310	3	98690	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
103°			A		A	B		B	C		C	76°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	7	13	20	26	33	39	46
	B	7	14	21	28	35	42	49
	C	0	1	1	2	2	2	3

TABLE XI

Log. Sines, Tangents, and Secants.

14° | 165°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	10 8 0	1 52 0	9.38368	0	10.61632	9.39677	0	10.60323	10.01310	0	9.98690	60
1	7 52	52 8	38418	1	61582	39731	1	60269	01313	0	98687	59
2	7 44	52 16	38469	2	61531	39785	2	60215	01316	0	98684	58
3	7 36	52 24	38519	2	61481	39838	3	60162	01319	0	98681	57
4	7 28	52 32	38570	3	61430	39892	3	60108	01322	0	98678	56
5	10 7 20	1 52 40	9.38620	4	10.61380	9.39945	4	10.60055	10.01325	0	9.98675	55
6	7 12	52 48	38670	5	61330	39999	5	60001	01329	0	98671	54
7	7 4	52 56	38721	6	61279	40052	6	59948	01332	0	98668	53
8	6 56	53 4	38771	7	61229	40106	7	59894	01335	0	98665	52
9	6 48	53 12	38821	7	61179	40159	8	59841	01338	0	98662	51
10	10 6 40	1 53 20	9.38871	8	10.61129	9.40212	9	10.59788	10.01341	1	9.98659	50
11	6 32	53 28	38921	9	61079	40266	10	59734	01344	1	98656	49
12	6 24	53 36	38971	10	61029	40319	10	59681	01348	1	98652	48
13	6 16	53 44	39021	11	60979	40372	11	59628	01351	1	98649	47
14	6 8	53 52	39071	11	60929	40425	12	59575	01354	1	98646	46
15	10 6 0	1 54 0	9.39121	12	10.60879	9.40478	13	10.59522	10.01357	1	9.98643	45
16	5 52	54 8	39170	13	60830	40531	14	59469	01360	1	98640	44
17	5 44	54 16	39220	14	60780	40584	15	59416	01364	1	98636	43
18	5 36	54 24	39270	15	60730	40636	16	59364	01367	1	98633	42
19	5 28	54 32	39319	15	60681	40689	17	59311	01370	1	98630	41
20	10 5 20	1 54 40	9.39369	16	10.60631	9.40742	17	10.59258	10.01373	1	9.98627	40
21	5 12	54 48	39418	17	60582	40795	18	59205	01377	1	98623	39
22	5 4	54 56	39467	18	60533	40847	19	59153	01380	1	98620	38
23	4 56	55 4	39517	19	60483	40900	20	59100	01383	1	98617	37
24	4 48	55 12	39566	20	60434	40952	21	59048	01386	1	98614	36
25	10 4 40	1 55 20	9.39615	20	10.60385	9.41005	22	10.58995	10.01390	1	9.98610	35
26	4 32	55 28	39664	21	60336	41057	23	58943	01393	1	98607	34
27	4 24	55 36	39713	22	60287	41109	23	58891	01396	1	98604	33
28	4 16	55 44	39762	23	60238	41161	24	58839	01399	2	98601	32
29	4 8	55 52	39811	24	60189	41214	25	58786	01403	2	98597	31
30	10 4 0	1 56 0	9.39860	24	10.60140	9.41266	26	10.58734	10.01406	2	9.98594	30
31	3 52	56 8	39909	25	60091	41318	27	58682	01409	2	98591	29
32	3 44	56 16	39958	26	60042	41370	28	58630	01412	2	98588	28
33	3 36	56 24	40006	27	59994	41422	29	58578	01416	2	98584	27
34	3 28	56 32	40055	28	59945	41474	30	58526	01419	2	98581	26
35	10 3 20	1 56 40	9.40103	29	10.59897	9.41526	30	10.58474	10.01422	2	9.98578	25
36	3 12	56 48	40152	29	59848	41578	31	58422	01426	2	98574	24
37	3 4	56 56	40200	30	59800	41629	32	58371	01429	2	98571	23
38	2 56	57 4	40249	31	59751	41681	33	58319	01432	2	98568	22
39	2 48	57 12	40297	32	59703	41733	34	58267	01435	2	98565	21
40	10 2 40	1 57 20	9.40346	33	10.59654	9.41784	35	10.58216	10.01439	2	9.98561	20
41	2 32	57 28	40394	33	59606	41836	36	58164	01442	2	98558	19
42	2 24	57 36	40442	34	59558	41887	36	58113	01445	2	98555	18
43	2 16	57 44	40490	35	59510	41939	37	58061	01449	2	98551	17
44	2 8	57 52	40538	36	59462	41990	38	58010	01452	2	98548	16
45	10 2 0	1 58 0	9.40586	37	10.59414	9.42041	39	10.57959	10.01455	2	9.98545	15
46	1 52	58 8	40634	37	59366	42093	40	57907	01459	3	98541	14
47	1 44	58 16	40682	38	59318	42144	41	57856	01462	3	98538	13
48	1 36	58 24	40730	39	59270	42195	42	57805	01465	3	98535	12
49	1 28	58 32	40778	40	59222	42246	43	57754	01469	3	98531	11
50	10 1 20	1 58 40	9.40825	41	10.59175	9.42297	43	10.57703	10.01472	3	9.98528	10
51	1 12	58 48	40873	42	59127	42348	44	57652	01475	3	98525	9
52	1 4	58 56	40921	42	59079	42399	45	57601	01479	3	98521	8
53	0 56	59 4	40968	43	59032	42450	46	57550	01482	3	98518	7
54	0 48	59 12	41016	44	58984	42501	47	57499	01485	3	98515	6
55	10 0 40	1 59 20	9.41063	45	10.58937	9.42552	48	10.57448	10.01489	3	9.98511	5
56	0 32	59 28	41111	46	58889	42603	49	57397	01492	3	98508	4
57	0 24	59 36	41158	46	58842	42653	50	57347	01495	3	98505	3
58	0 16	59 44	41205	47	58795	42704	50	57296	01499	3	98501	2
59	0 8	59 52	41252	48	58748	42755	51	57245	01502	3	98498	1
60	0 0	2 0 0	41300	49	58700	42805	52	57195	01506	3	98494	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
104°			A		A	B		B	C		C	75°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	6	12	18	24	31	37	43
	B	7	13	20	26	33	39	46
	C	0	1	1	2	2	2	3

TABLE XI

Log. Sines, Tangents, and Secants.

15° 164°

M.	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent	Diff.	Cotangent	Secant.	Diff.	Cosine.	M.
0	10 0 0	2 0 0	9.41300	0	10.58700	9.42805	0	10.57195	10.01506	0	9.98494	60
1	9 59 52	0 8	41347	1	58653	42856	1	57144	01509	0	98491	59
2	59 44	0 16	41394	2	58606	42906	2	57094	01512	0	98488	58
3	59 36	0 24	41441	2	58559	42957	2	57043	01516	0	98484	57
4	59 28	0 32	41488	3	58512	43007	3	56993	01519	0	98481	56
5	9 59 20	2 0 40	9.41535	4	10.58465	9.43057	4	10.56943	10.01523	0	9.98477	55
6	59 12	0 48	41582	5	58418	43108	5	56892	01526	0	98474	54
7	59 4	0 56	41628	5	58372	43158	6	56842	01529	0	98471	53
8	58 56	1 4	41675	6	58325	43208	7	56792	01533	0	98467	52
9	58 48	1 12	41722	7	58278	43258	7	56742	01536	1	98464	51
10	9 58 40	2 1 20	9.41768	8	10.58232	9.43308	8	10.56692	10.01540	1	9.98460	50
11	58 32	1 28	41815	8	58185	43358	9	56642	01543	1	98457	49
12	58 24	1 36	41861	9	58139	43408	10	56592	01547	1	98453	48
13	58 16	1 44	41908	10	58092	43458	11	56542	01550	1	98450	47
14	58 8	1 52	41954	11	58046	43508	11	56492	01553	1	98447	46
15	9 58 0	2 2 0	9.42001	11	10.57999	9.43558	12	10.56442	10.01557	1	9.98443	45
16	57 52	2 8	42047	12	57953	43607	13	56393	01560	1	98440	44
17	57 44	2 16	42093	13	57907	43657	14	56343	01564	1	98436	43
18	57 36	2 24	42140	14	57860	43707	15	56293	01567	1	98433	42
19	57 28	2 32	42186	14	57814	43756	16	56244	01571	1	98429	41
20	9 57 20	2 2 40	9.42232	15	10.57768	9.43806	16	10.56194	10.01574	1	9.98426	40
21	57 12	2 48	42278	16	57722	43855	17	56145	01578	1	98422	39
22	57 4	2 56	42324	17	57676	43905	18	56095	01581	1	98419	38
23	56 56	3 4	42370	17	57630	43954	19	56046	01585	1	98415	37
24	56 48	3 12	42416	18	57584	44004	20	55996	01588	1	98412	36
25	9 56 40	2 3 20	9.42461	19	10.57539	9.44053	20	10.55947	10.01591	1	9.98409	35
26	56 32	3 28	42507	20	57493	44102	21	55898	01595	2	98405	34
27	56 24	3 36	42553	21	57447	44151	22	55849	01598	2	98402	33
28	56 16	3 44	42599	21	57401	44201	23	55799	01602	2	98398	32
29	56 8	3 52	42644	22	57356	44250	24	55750	01605	2	98395	31
30	9 56 0	2 4 0	9.42690	23	10.57310	9.44299	25	10.55701	10.01609	2	9.98391	30
31	55 52	4 8	42735	24	57265	44348	25	55652	01612	2	98388	29
32	55 44	4 16	42781	24	57219	44397	26	55603	01616	2	98384	28
33	55 36	4 24	42826	25	57174	44446	27	55554	01619	2	98381	27
34	55 28	4 32	42872	26	57128	44495	28	55505	01623	2	98377	26
35	9 55 20	2 4 40	9.42917	27	10.57083	9.44544	29	10.55456	10.01627	2	9.98373	25
36	55 12	4 48	42962	27	57038	44592	29	55408	01630	2	98370	24
37	55 4	4 56	43008	28	56992	44641	30	55359	01634	2	98366	23
38	54 56	5 4	43053	29	56947	44690	31	55310	01637	2	98363	22
39	54 48	5 12	43098	30	56902	44738	32	55262	01641	2	98359	21
40	9 54 40	2 5 20	9.43143	30	10.56857	9.44787	33	10.55213	10.01644	2	9.98356	20
41	54 32	5 28	43188	31	56812	44836	34	55164	01648	2	98352	19
42	54 24	5 36	43233	32	56767	44884	34	55116	01651	2	98349	18
43	54 16	5 44	43278	33	56722	44933	35	55067	01655	3	98345	17
44	54 8	5 52	43323	33	56677	44981	36	55019	01658	3	98342	16
45	9 54 0	2 6 0	9.43367	34	10.56633	9.45029	37	10.54971	10.01662	3	9.98338	15
46	53 52	6 8	43412	35	56588	45078	38	54922	01666	3	98334	14
47	53 44	6 16	43457	36	56543	45126	38	54874	01669	3	98331	13
48	53 36	6 24	43502	36	56498	45174	39	54826	01673	3	98327	12
49	53 28	6 32	43546	37	56454	45222	40	54778	01676	3	98324	11
50	9 53 20	2 6 40	9.43591	38	10.56409	9.45271	41	10.54729	10.01680	3	9.98320	10
51	53 12	6 48	43635	39	56365	45319	42	54681	01683	3	98317	9
52	53 4	6 56	43680	39	56320	45367	43	54633	01687	3	98313	8
53	52 56	7 4	43724	40	56276	45415	43	54585	01691	3	98309	7
54	52 48	7 12	43769	41	56231	45463	44	54537	01694	3	98306	6
55	9 52 40	2 7 20	9.43813	42	10.56187	9.45511	45	10.54489	10.01698	3	9.98302	5
56	52 32	7 28	43857	43	56143	45559	46	54441	01701	3	98299	4
57	52 24	7 36	43901	43	56099	45606	47	54394	01705	3	98295	3
58	52 16	7 44	43946	44	56054	45654	47	54346	01709	3	98291	2
59	52 8	7 52	43990	45	56010	45702	48	54298	01712	3	98288	1
60	52 0	8 0	44034	46	55966	45750	49	54250	01716	4	98284	0
M.	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
105°			A		A	B		B	C		C	74°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop parts of cols.	A	6	11	17	23	28	34	40
	B	6	12	18	25	31	37	43
	C	0	1	1	2	2	3	3

TABLE XI

Log. Sines, Tangents, and Secants.

16° | 163°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant.	Diff.	Cosine.	M.
0	9 52 0	2 8 0	9.44034	0	10.55966	9.45750	0	10.54250	10.01716	0	9.98284	60
1	51 52	8 8	44078	1	55922	45797	1	54203	01719	0	98281	59
2	51 44	8 16	44122	1	55878	45845	2	54155	01723	0	98277	58
3	51 36	8 24	44166	2	55834	45892	2	54108	01727	0	98273	57
4	51 28	8 32	44210	3	55790	45940	3	54060	01730	0	98270	56
5	9 51 20	2 8 40	9.44253	4	10.55747	9.45987	4	10.54013	10.01734	0	9.98266	55
6	51 12	8 48	44297	4	55703	46035	5	53965	01738	0	98262	54
7	51 4	8 56	44341	5	55659	46082	5	53918	01741	0	98259	53
8	50 56	9 4	44385	6	55615	46130	6	53870	01745	0	98255	52
9	50 48	9 12	44428	6	55572	46177	7	53823	01749	1	98251	51
10	9 50 40	2 9 20	9.44472	7	10.55528	9.46224	8	10.53776	10.01752	1	9.98248	50
11	50 32	9 28	44516	8	55484	46271	9	53729	01756	1	98244	49
12	50 24	9 36	44559	9	55441	46319	9	53681	01760	1	98240	48
13	50 16	9 44	44602	9	55398	46366	10	53634	01763	1	98237	47
14	50 8	9 52	44646	10	55354	46413	11	53587	01767	1	98233	46
15	9 50 0	2 10 0	9.44689	11	10.55311	9.46460	12	10.53540	10.01771	1	9.98229	45
16	49 52	10 8	44733	11	55267	46507	12	53493	01774	1	98226	44
17	49 44	10 16	44776	12	55224	46554	13	53446	01778	1	98222	43
18	49 36	10 24	44819	13	55181	46601	14	53399	01782	1	98218	42
19	49 28	10 32	44862	14	55138	46648	15	53352	01785	1	98215	41
20	9 49 20	2 10 40	9.44905	14	10.55095	9.46694	15	10.53306	10.01789	1	9.98211	40
21	49 12	10 48	44948	15	55052	46741	16	53259	01793	1	98207	39
22	49 4	10 56	44992	16	55008	46788	17	53212	01796	1	98204	38
23	48 56	11 4	45035	16	54965	46835	18	53165	01800	1	98200	37
24	48 48	11 12	45077	17	54923	46881	19	53119	01804	1	98196	36
25	9 48 40	2 11 20	9.45120	18	10.54880	9.46928	19	10.53072	10.01808	2	9.98192	35
26	48 32	11 28	45163	18	54837	46975	20	53025	01811	2	98189	34
27	48 24	11 36	45206	19	54794	47021	21	52979	01815	2	98185	33
28	48 16	11 44	45249	20	54751	47068	22	52932	01819	2	98181	32
29	48 8	11 52	45292	21	54708	47114	22	52886	01823	2	98177	31
30	9 48 0	2 12 0	9.45334	21	10.54666	9.47160	23	10.52840	10.01826	2	9.98174	30
31	47 52	12 8	45377	22	54623	47207	24	52793	01830	2	98170	29
32	47 44	12 16	45419	23	54581	47253	25	52747	01834	2	98166	28
33	47 36	12 24	45462	23	54538	47299	26	52701	01838	2	98162	27
34	47 28	12 32	45504	24	54496	47346	26	52654	01841	2	98159	26
35	9 47 20	2 12 40	9.45547	25	10.54453	9.47392	27	10.52608	10.01845	2	9.98155	25
36	47 12	12 48	45589	26	54411	47438	28	52562	01849	2	98151	24
37	47 4	12 56	45632	26	54368	47484	29	52516	01853	2	98147	23
38	46 56	13 4	45674	27	54326	47530	29	52470	01856	2	98144	22
39	46 48	13 12	45716	28	54284	47576	30	52424	01860	2	98140	21
40	9 46 40	2 13 20	9.45758	28	10.54242	9.47622	31	10.52378	10.01864	2	9.98136	20
41	46 32	13 28	45801	29	54199	47668	32	52332	01868	3	98132	19
42	46 24	13 36	45843	30	54157	47714	32	52286	01871	3	98129	18
43	46 16	13 44	45885	31	54115	47760	33	52240	01875	3	98125	17
44	46 8	13 52	45927	31	54073	47806	34	52194	01879	3	98121	16
45	9 46 0	2 14 0	9.45969	32	10.54031	9.47852	35	10.52148	10.01883	3	9.98117	15
46	45 52	14 8	46011	33	53989	47897	36	52103	01887	3	98113	14
47	45 44	14 16	46053	33	53947	47943	36	52057	01890	3	98110	13
48	45 36	14 24	46095	34	53905	47989	37	52011	01894	3	98106	12
49	45 28	14 32	46136	35	53864	48035	38	51965	01898	3	98102	11
50	9 45 20	2 14 40	9.46178	36	10.53822	9.48080	39	10.51920	10.01902	3	9.98098	10
51	45 12	14 48	46220	36	53780	48126	39	51874	01906	3	98094	9
52	45 4	14 56	46262	37	53738	48171	40	51829	01910	3	98090	8
53	44 56	15 4	46303	38	53697	48217	41	51783	01913	3	98087	7
54	44 48	15 12	46345	38	53655	48262	42	51738	01917	3	98083	6
55	9 44 40	2 15 20	9.46386	39	10.53614	9.48307	43	10.51693	10.01921	3	9.98079	5
56	44 32	15 28	46428	40	53572	48353	43	51647	01925	3	98075	4
57	44 24	15 36	46469	41	53531	48398	44	51602	01929	4	98071	3
58	44 16	15 44	46511	41	53489	48443	45	51557	01933	4	98067	2
59	44 8	15 52	46552	42	53448	48489	46	51511	01937	4	98063	1
60	44 0	16 0	46594	43	53406	48534	46	51466	01940	4	98060	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
106°			A		A	B		B	C		C	73°

Seconds of time ……		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	5	11	16	21	27	32	37
	B	6	12	17	23	29	35	41
	C	0	1	1	2	2	3	3

TABLE XI

Log. Sines, Tangents, and Secants.

17° 162°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	9 44 0	2 16 0	9.46594	0	10.53406	9.48534	0	10.51466	10.01940	0	9.98060	60
1	43 52	16 8	46635	1	53365	48579	1	51421	01944	0	98056	59
2	43 44	16 16	46676	1	53324	48624	1	51376	01948	0	98052	58
3	43 36	16 24	46717	2	53283	48669	2	51331	01952	0	98048	57
4	43 28	16 32	46758	3	53242	48714	3	51286	01956	0	98044	56
5	9 43 20	2 16 40	9.46800	3	10.53200	9.48759	4	10.51241	10.01960	0	9.98040	55
6	43 12	16 48	46841	4	53159	48804	4	51196	01964	0	98036	54
7	43 4	16 56	46882	5	53118	48849	5	51151	01968	0	98032	53
8	42 56	17 4	46923	5	53077	48894	6	51106	01971	1	98029	52
9	42 48	17 12	46964	6	53036	48939	7	51061	01975	1	98025	51
10	9 42 40	2 17 20	9.47005	7	10.52995	9.48984	7	10.51016	10.01979	1	9.98021	50
11	42 32	17 28	47045	7	52955	49029	8	50971	01983	1	98017	49
12	42 24	17 36	47086	8	52914	49073	9	50927	01987	1	98013	48
13	42 16	17 44	47127	9	52873	49118	10	50882	01991	1	98009	47
14	42 8	17 52	47168	9	52832	49163	10	50837	01995	1	98005	46
15	9 42 0	2 18 0	9.47209	10	10.52791	9.49207	11	10.50793	10.01999	1	9.98001	45
16	41 52	18 8	47249	11	52751	49252	12	50748	02003	1	97997	44
17	41 44	18 16	47290	11	52710	49296	12	50704	02007	1	97993	43
18	41 36	18 24	47330	12	52670	49341	13	50659	02011	1	97989	42
19	41 28	18 32	47371	13	52629	49385	14	50615	02014	1	97986	41
20	9 41 20	2 18 40	9.47411	13	10.52589	9.49430	15	10.50570	10.02018	1	9.97982	40
21	41 12	18 48	47452	14	52548	49474	15	50526	02022	1	97978	39
22	41 4	18 56	47492	15	52508	49519	16	50481	02026	1	97974	38
23	40 56	19 4	47533	15	52467	49563	17	50437	02030	2	97970	37
24	40 48	19 12	47573	16	52427	49607	18	50393	02034	2	97966	36
25	9 40 40	2 19 20	9.47613	17	10.52387	9.49652	18	10.50348	10.02038	2	9.97962	35
26	40 32	19 28	47654	17	52346	49696	19	50304	02042	2	97958	34
27	40 24	19 36	47694	18	52306	49740	20	50260	02046	2	97954	33
28	40 16	19 44	47734	19	52266	49784	21	50216	02050	2	97950	32
29	40 8	19 52	47774	19	52226	49828	21	50172	02054	2	97946	31
30	9 40 0	2 20 0	9.47814	20	10.52186	9.49872	22	10.50128	10.02058	2	9.97942	30
31	39 52	20 8	47854	21	52146	49916	23	50084	02062	2	97938	29
32	39 44	20 16	47894	21	52106	49960	24	50040	02066	2	97934	28
33	39 36	20 24	47934	22	52066	50004	24	49996	02070	2	97930	27
34	39 28	20 32	47974	23	52026	50048	25	49952	02074	2	97926	26
35	9 39 20	2 20 40	9.48014	23	10.51986	9.50092	26	10.49908	10.02078	2	9.97922	25
36	39 12	20 48	48054	24	51946	50136	26	49864	02082	2	97918	24
37	39 4	20 56	48094	25	51906	50180	27	49820	02086	2	97914	23
38	38 56	21 4	48133	25	51867	50223	28	49777	02090	3	97910	22
39	38 48	21 12	48173	26	51827	50267	29	49733	02094	3	97906	21
40	9 38 40	2 21 20	9.48213	27	10.51787	9.50311	29	10.49689	10.02098	3	9.97902	20
41	38 32	21 28	48252	27	51748	50355	30	49645	02102	3	97898	19
42	38 24	21 36	48292	28	51708	50398	31	49602	02106	3	97894	18
43	38 16	21 44	48332	29	51668	50442	32	49558	02110	3	97890	17
44	38 8	21 52	48371	29	51629	50485	32	49515	02114	3	97886	16
45	9 38 0	2 22 0	9.48411	30	10.51589	9.50529	33	10.49471	10.02118	3	9.97882	15
46	37 52	22 8	48450	31	51550	50572	34	49428	02122	3	97878	14
47	37 44	22 16	48490	31	51510	50616	35	49384	02126	3	97874	13
48	37 36	22 24	48529	32	51471	50659	35	49341	02130	3	97870	12
49	37 28	22 32	48568	33	51432	50703	36	49297	02134	3	97866	11
50	9 37 20	2 22 40	9.48607	33	10.51393	9.50746	37	10.49254	10.02139	3	9.97861	10
51	37 12	22 48	48647	34	51353	50789	37	49211	02143	3	97857	9
52	37 4	22 56	48686	35	51314	50833	38	49167	02147	3	97853	8
53	36 56	23 4	48725	35	51275	50876	39	49124	02151	4	97849	7
54	36 48	23 12	48764	36	51236	50919	40	49081	02155	4	97845	6
55	9 36 40	2 23 20	9.48803	37	10.51197	9.50962	40	10.49038	10.02159	4	9.97841	5
56	36 32	23 28	48842	37	51158	51005	41	48995	02163	4	97837	4
57	36 24	23 36	48881	38	51119	51048	42	48952	02167	4	97833	3
58	36 16	23 44	48920	39	51080	51092	43	48908	02171	4	97829	2
59	36 8	23 52	48959	39	51041	51135	43	48865	02175	4	97825	1
60	36 0	24 0	48998	40	51002	51178	44	48822	02179	4	97821	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

107° A A B B C C 72°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	5	10	15	20	25	30	35
	B	6	11	17	22	28	33	39
	C	0	1	1	2	2	3	3

TABLE XI

Log Sines, Tangents, and Secants.

18° 161°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	9 36 0	2 24 0	9.48998	0	10.51002	9.51178	0	10.48822	10.02179	0	9.97821	60
1	35 52	24 8	49037	1	50963	51221	1	48779	02183	0	97817	59
2	35 44	24 16	49076	1	50924	51264	1	48736	02188	0	97812	58
3	35 36	24 24	49115	2	50885	51306	2	48694	02192	0	97808	57
4	35 28	24 32	49153	3	50847	51349	3	48651	02196	0	97804	56
5	9 35 20	2 24 40	9.49192	3	10.50808	9.51392	3	10.48608	10.02200	0	9.97800	55
6	35 12	24 48	49231	4	50769	51435	4	48565	02204	0	97796	54
7	35 4	24 56	49269	4	50731	51478	5	48522	02208	0	97792	53
8	34 56	25 4	49308	5	50692	51520	6	48480	02212	1	97788	52
9	34 48	25 12	49347	6	50653	51563	6	48437	02216	1	97784	51
10	9 34 40	2 25 20	9.49385	6	10.50615	9.51606	7	10.48394	10.02221	1	9.97779	50
11	34 32	25 28	49424	7	50576	51648	8	48352	02225	1	97775	49
12	34 24	25 36	49462	8	50538	51691	8	48309	02229	1	97771	48
13	34 16	25 44	49500	8	50500	51734	9	48266	02233	1	97767	47
14	34 8	25 52	49539	9	50461	51776	10	48224	02237	1	97763	46
15	9 34 0	2 26 0	9.49577	9	10.50423	9.51819	10	10.48181	10.02241	1	9.97759	45
16	33 52	26 8	49615	10	50385	51861	11	48139	02246	1	97754	44
17	33 44	26 16	49654	11	50346	51903	12	48097	02250	1	97750	43
18	33 36	26 24	49692	11	50308	51946	13	48054	02254	1	97746	42
19	33 28	26 32	49730	12	50270	51988	13	48012	02258	1	97742	41
20	9 33 20	2 26 40	9.49768	13	10.50232	9.52031	14	10.47969	10.02262	1	9.97738	40
21	33 12	26 48	49806	13	50194	52073	15	47927	02266	1	97734	39
22	33 4	26 56	49844	14	50156	52115	15	47885	02271	2	97729	38
23	32 56	27 4	49882	14	50118	52157	16	47843	02275	2	97725	37
24	32 48	27 12	49920	15	50080	52200	17	47800	02279	2	97721	36
25	9 32 40	2 27 20	9.49958	16	10.50042	9.52242	17	10.47758	10.02283	2	9.97717	35
26	32 32	27 28	49996	16	50004	52284	18	47716	02287	2	97713	34
27	32 24	27 36	50034	17	49966	52326	19	47674	02292	2	97708	33
28	32 16	27 44	50072	18	49928	52368	20	47632	02296	2	97704	32
29	32 8	27 52	50110	18	49890	52410	20	47590	02300	2	97700	31
30	9 32 0	2 28 0	9.50148	19	10.49852	9.52452	21	10.47548	10.02304	2	9.97696	30
31	31 52	28 8	50185	20	49815	52494	22	47506	02309	2	97691	29
32	31 44	28 16	50223	20	49777	52536	22	47464	02313	2	97687	28
33	31 36	28 24	50261	21	49739	52578	23	47422	02317	2	97683	27
34	31 28	28 32	50298	21	49702	52620	24	47380	02321	2	97679	26
35	9 31 20	2 28 40	9.50336	22	10.49664	9.52661	24	10.47339	10.02326	2	9.97674	25
36	31 12	28 48	50374	23	49626	52703	25	47297	02330	3	97670	24
37	31 4	28 56	50411	23	49589	52745	26	47255	02334	3	97666	23
38	30 56	29 4	50449	24	49551	52787	27	47213	02338	3	97662	22
39	30 48	29 12	50486	25	49514	52829	27	47171	02343	3	97657	21
40	9 30 40	2 29 20	9.50523	25	10.49477	9.52870	28	10.47130	10.02347	3	9.97653	20
41	30 32	29 28	50561	26	49439	52912	29	47088	02351	3	97649	19
42	30 24	29 36	50598	26	49402	52953	29	47047	02355	3	97645	18
43	30 16	29 44	50635	27	49365	52995	30	47005	02360	3	97640	17
44	30 8	29 52	50673	28	49327	53037	31	46963	02364	3	97636	16
45	9 30 0	2 30 0	9.50710	28	10.49290	9.53078	31	10.46922	10.02368	3	9.97632	15
46	29 52	30 8	50747	29	49253	53120	32	46880	02372	3	97628	14
47	29 44	30 16	50784	30	49216	53161	33	46839	02377	3	97623	13
48	29 36	30 24	50821	30	49179	53202	34	46798	02381	3	97619	12
49	29 28	30 32	50858	31	49142	53244	34	46756	02385	3	97615	11
50	9 29 20	2 30 40	9.50896	31	10.49104	9.53285	35	10.46715	10.02390	4	9.97610	10
51	29 12	30 48	50933	32	49067	53327	36	46673	02394	4	97606	9
52	29 4	30 56	50970	33	49030	53368	36	46632	02398	4	97602	8
53	28 56	31 4	51007	33	48993	53409	37	46591	02403	4	97597	7
54	28 48	31 12	51043	34	48957	53450	38	46550	02407	4	97593	6
55	9 28 40	2 31 20	9.51080	35	10.48920	9.53492	38	10.46508	10.02411	4	9.97589	5
56	28 32	31 28	51117	35	48883	53533	39	46467	02416	4	97584	4
57	28 24	31 36	51154	36	48846	53574	40	46426	02420	4	97580	3
58	28 16	31 44	51191	37	48809	53615	41	46385	02424	4	97576	2
59	28 8	31 52	51227	37	48773	53656	41	46344	02429	4	97571	1
60	28 0	32 0	51264	38	48736	53697	42	46303	02433	4	97567	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

108° A A B B C C 71°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	5	9	14	19	24	28	33
	B	5	10	16	21	26	31	37
	C	1	1	2	2	3	3	4

TABLE XI

Log. Sines, Tangents, and Secants.

19° 160°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	9 28 0	2 32 0	9.51264	0	10.48736	9.53697	0	10.46303	10.02433	0	9.97567	60
1	27 52	32 8	51301	1	48699	53738	1	46262	02437	0	97563	59
2	27 44	32 16	51338	1	48662	53779	1	46221	02442	0	97558	58
3	27 36	32 24	51374	2	48626	53820	2	46180	02446	0	97554	57
4	27 28	32 32	51411	2	48589	53861	3	46139	02450	0	97550	56
5	9 27 20	2 32 40	9.51447	3	10.48553	9.53902	3	10.46098	10.02455	0	9.97545	55
6	27 12	32 48	51484	4	48516	53943	4	46057	02459	0	97541	54
7	27 4	32 56	51520	4	48480	53984	5	46016	02464	1	97536	53
8	26 56	33 4	51557	5	48443	54025	5	45975	02468	1	97532	52
9	26 48	33 12	51593	5	48407	54065	6	45935	02472	1	97528	51
10	9 26 40	2 33 20	9.51629	6	10.48371	9.54106	7	10.45894	10.02477	1	9.97523	50
11	26 32	33 28	51666	7	48334	54147	7	45853	02481	1	97519	49
12	26 24	33 36	51702	7	48298	54187	8	45813	02485	1	97515	48
13	26 16	33 44	51738	8	48262	54228	9	45772	02490	1	97510	47
14	26 8	33 52	51774	8	48226	54269	9	45731	02494	1	97506	46
15	9 26 0	2 34 0	9.51811	9	10.48189	9.54309	10	10.45691	10.02499	1	9.97501	45
16	25 52	34 8	51847	10	48153	54350	11	45650	02503	1	97497	44
17	25 44	34 16	51883	10	48117	54390	11	45610	02508	1	97492	43
18	25 36	34 24	51919	11	48081	54431	12	45569	02512	1	97488	42
19	25 28	34 32	51955	11	48045	54471	13	45529	02516	1	97484	41
20	9 25 20	2 34 40	9.51991	12	10.48009	9.54512	13	10.45488	10.02521	1	9.97479	40
21	25 12	34 48	52027	12	47973	54552	14	45448	02525	2	97475	39
22	25 4	34 56	52063	13	47937	54593	15	45407	02530	2	97470	38
23	24 56	35 4	52099	14	47901	54633	15	45367	02534	2	97466	37
24	24 48	35 12	52135	14	47865	54673	16	45327	02539	2	97461	36
25	9 24 40	2 35 20	9.52171	15	10.47829	9.54714	17	10.45286	10.02543	2	9.97457	35
26	24 32	35 28	52207	15	47793	54754	17	45246	02547	2	97453	34
27	24 24	35 36	52242	16	47758	54794	18	45206	02552	2	97448	33
28	24 16	35 44	52278	17	47722	54835	19	45165	02556	2	97444	32
29	24 8	35 52	52314	17	47686	54875	19	45125	02561	2	97439	31
30	9 24 0	2 36 0	9.52350	18	10.47650	9.54915	20	10.45085	10.02565	2	9.97435	30
31	23 52	36 8	52385	18	47615	54955	21	45045	02570	2	97430	29
32	23 44	36 16	52421	19	47579	54995	21	45005	02574	2	97426	28
33	23 36	36 24	52456	20	47544	55035	22	44965	02579	2	97421	27
34	23 28	36 32	52492	20	47508	55075	23	44925	02583	3	97417	26
35	9 23 20	2 36 40	9.52527	21	10.47473	9.55115	23	10.44885	10.02588	3	9.97412	25
36	23 12	36 48	52563	21	47437	55155	24	44845	02592	3	97408	24
37	23 4	36 56	52598	22	47402	55195	25	44805	02597	3	97403	23
38	22 56	37 4	52634	23	47366	55235	25	44765	02601	3	97399	22
39	22 48	37 12	52669	23	47331	55275	26	44725	02606	3	97394	21
40	9 22 40	2 37 20	9.52705	24	10.47295	9.55315	27	10.44685	10.02610	3	9.97390	20
41	22 32	37 28	52740	24	47260	55355	27	44645	02615	3	97385	19
42	22 24	37 36	52775	25	47225	55395	28	44605	02619	3	97381	18
43	22 16	37 44	52811	26	47189	55434	29	44566	02624	3	97376	17
44	22 8	37 52	52846	26	47154	55474	29	44526	02628	3	97372	16
45	9 22 0	2 38 0	9.52881	27	10.47119	9.55514	30	10.44486	10.02633	3	9.97367	15
46	21 52	38 8	52916	27	47084	55554	31	44446	02637	3	97363	14
47	21 44	38 16	52951	28	47049	55593	31	44407	02642	3	97358	13
48	21 36	38 24	52986	29	47014	55633	32	44367	02647	4	97353	12
49	21 28	38 32	53021	29	46979	55673	33	44327	02651	4	97349	11
50	9 21 20	2 38 40	9.53056	30	10.46944	9.55712	33	10.44288	10.02656	4	9.97344	10
51	21 12	38 48	53092	30	46908	55752	34	44248	02660	4	97340	9
52	21 4	38 56	53126	31	46874	55791	35	44209	02665	4	97335	8
53	20 56	39 4	53161	32	46839	55831	35	44169	02669	4	97331	7
54	20 48	39 12	53196	32	46804	55870	36	44130	02674	4	97326	6
55	9 20 40	2 39 20	9.53231	33	10.46769	9.55910	37	10.44090	10.02678	4	9.97322	5
56	20 32	39 28	53266	33	46734	55949	37	44051	02683	4	97317	4
57	20 24	39 36	53301	34	46699	55989	38	44011	02688	4	97312	3
58	20 16	39 44	53336	34	46664	56028	39	43972	02692	4	97308	2
59	20 8	39 52	53370	35	46630	56067	39	43933	02697	4	97303	1
60	20 0	40 0	53405	36	46595	56107	40	43893	02701	4	97299	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
109°			A		A	B		B	C		C	70°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	4	9	13	18	22	27	31
	B	5	10	15	20	25	30	35
	C	1	1	2	2	3	3	4

TABLE XI

Log. Sines, Tangents, and Secants.

20° 159°

M.	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	9 20 0	2 40 0	9.53405	0	10.46595	9.56107	0	10.43893	10.02701	0	9.97299	60
1	19 52	40 8	53440	1	46560	56146	1	43854	02706	0	97294	59
2	19 44	40 16	53475	1	46525	56185	1	43815	02711	0	97289	58
3	19 36	40 24	53509	2	46491	56224	2	43776	02715	0	97285	57
4	19 28	40 32	53544	2	46456	56264	3	43736	02720	0	97280	56
5	9 19 20	2 40 40	9.53578	3	10.46422	9.56303	3	10.43697	10.02724	0	9.97276	55
6	19 12	40 48	53613	3	46387	56342	4	43658	02729	0	97271	54
7	19 4	40 56	53647	4	46353	56381	4	43619	02734	1	97266	53
8	18 56	41 4	53682	5	46318	56420	5	43580	02738	1	97262	52
9	18 48	41 12	53716	5	46284	56459	6	43541	02743	1	97257	51
10	9 18 40	2 41 20	9.53751	6	10.46249	9.56498	6	10.43502	10.02748	1	9.97252	50
11	18 32	41 28	53785	6	46215	56537	7	43463	02752	1	97248	49
12	18 24	41 36	53819	7	46181	56576	8	43424	02757	1	97243	48
13	18 16	41 44	53854	7	46146	56615	8	43385	02762	1	97238	47
14	18 8	41 52	53888	8	46112	56654	9	43346	02766	1	97234	46
15	9 18 0	2 42 0	9.53922	8	10.46078	9.56693	10	10.43307	10.02771	1	9.97229	45
16	17 52	42 8	53957	9	46043	56732	10	43268	02776	1	97224	44
17	17 44	42 16	53991	10	46009	56771	11	43229	02780	1	97220	43
18	17 36	42 24	54025	10	45975	56810	12	43190	02785	1	97215	42
19	17 28	42 32	54059	11	45941	56849	12	43151	02790	1	97210	41
20	9 17 20	2 42 40	9.54093	11	10.45907	9.56887	13	10.43113	10.02794	2	9.97206	40
21	17 12	42 48	54127	12	45873	56926	13	43074	02799	2	97201	39
22	17 4	42 56	54161	12	45839	56965	14	43035	02804	2	97196	38
23	16 56	43 4	54195	13	45805	57004	15	42996	02808	2	97192	37
24	16 48	43 12	54229	14	45771	57042	15	42958	02813	2	97187	36
25	9 16 40	2 43 20	9.54263	14	10.45737	9.57081	16	10.42919	10.02818	2	9.97182	35
26	16 32	43 28	54297	15	45703	57120	17	42880	02822	2	97178	34
27	16 24	43 36	54331	15	45669	57158	17	42842	02827	2	97173	33
28	16 16	43 44	54365	16	45635	57197	18	42803	02832	2	97168	32
29	16 8	43 52	54399	16	45601	57235	19	42765	02837	2	97163	31
30	9 16 0	2 44 0	9.54433	17	10.45567	9.57274	19	10.42726	10.02841	2	9.97159	30
31	15 52	44 8	54466	17	45534	57312	20	42688	02846	2	97154	29
32	15 44	44 16	54500	18	45500	57351	21	42649	02851	3	97149	28
33	15 36	44 24	54534	19	45466	57389	21	42611	02855	3	97145	27
34	15 28	44 32	54567	19	45433	57428	22	42572	02860	3	97140	26
35	9 15 20	2 44 40	9.54601	20	10.45399	9.57466	22	10.42534	10.02865	3	9.97135	25
36	15 12	44 48	54635	20	45365	57504	23	42496	02870	3	97130	24
37	15 4	44 56	54668	21	45332	57543	24	42457	02874	3	97126	23
38	14 56	45 4	54702	21	45298	57581	24	42419	02879	3	97121	22
39	14 48	45 12	54735	22	45265	57619	25	42381	02884	3	97116	21
40	9 14 40	2 45 20	9.54769	23	10.45231	9.57658	26	10.42342	10.02889	3	9.97111	20
41	14 32	45 28	54802	23	45198	57696	26	42304	02893	3	97107	19
42	14 24	45 36	54836	24	45164	57734	27	42266	02898	3	97102	18
43	14 16	45 44	54869	24	45131	57772	28	42228	02903	3	97097	17
44	14 8	45 52	54903	25	45097	57810	28	42190	02908	3	97092	16
45	9 14 0	2 46 0	9.54936	25	10.45064	9.57849	29	10.42151	10.02913	4	9.97087	15
46	13 52	46 8	54969	26	45031	57887	30	42113	02917	4	97083	14
47	13 44	46 16	55003	26	44997	57925	30	42075	02922	4	97078	13
48	13 36	46 24	55036	27	44964	57963	31	42037	02927	4	97073	12
49	13 28	46 32	55069	28	44931	58001	31	41999	02932	4	97068	11
50	9 13 20	2 46 40	9.55102	28	10.44898	9.58039	32	10.41961	10.02937	4	9.97063	10
51	13 12	46 48	55136	29	44864	58077	33	41923	02941	4	97059	9
52	13 4	46 56	55169	29	44831	58115	33	41885	02946	4	97054	8
53	12 56	47 4	55202	30	44798	58153	34	41847	02951	4	97049	7
54	12 48	47 12	55235	30	44765	58191	35	41809	02956	4	97044	6
55	9 12 40	2 47 20	9.55268	31	10.44732	9.58229	35	10.41771	10.02961	4	9.97039	5
56	12 32	47 28	55301	32	44699	58267	36	41733	02965	4	97035	4
57	12 24	47 36	55334	32	44666	58304	37	41696	02970	4	97030	3
58	12 16	47 44	55367	33	44633	58342	37	41658	02975	5	97025	2
59	12 8	47 52	55400	33	44600	58380	38	41620	02980	5	97020	1
60	12 0	48 0	55433	34	44567	58418	39	41582	02985	5	97015	0
M.	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

110° A A B B C C 69°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	4	8	13	17	21	25	30
	B	5	10	14	19	24	29	34
	C	1	1	2	2	3	4	4

TABLE XI

Log. Sines, Tangents, and Secants.

21°												158°
M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	9 12 0	2 48 0	9.55433	0	10.44567	9.58418	0	10.41582	10.02985	0	9.97015	60
1	11 52	48 8	55466	1	44534	58455	1	41545	02990	0	97010	59
2	11 44	48 16	55499	1	44501	58493	1	41507	02995	0	97005	58
3	11 36	48 24	55532	2	44468	58531	2	41469	02999	0	97001	57
4	11 28	48 32	55564	2	44436	58569	2	41431	03004	0	96996	56
5	9 11 20	2 48 40	9.55597	3	10.44403	9.58606	3	10.41394	10.03009	0	9.96991	55
6	11 12	48 48	55630	3	44370	58644	4	41356	03014	0	96986	54
7	11 4	48 56	55663	4	44337	58681	4	41319	03019	1	96981	53
8	10 56	49 4	55695	4	44305	58719	5	41281	03024	1	96976	52
9	10 48	49 12	55728	5	44272	58757	6	41243	03029	1	96971	51
10	9 10 40	2 49 20	9.55761	5	10.44239	9.58794	6	10.41206	10.03034	1	9.96966	50
11	10 32	49 28	55793	6	44207	58832	7	41168	03038	1	96962	49
12	10 24	49 36	55826	6	44174	58869	7	41131	03043	1	96957	48
13	10 16	49 44	55858	7	44142	58907	8	41093	03048	1	96952	47
14	10 8	49 52	55891	7	44109	58944	9	41056	03053	1	96947	46
15	9 10 0	2 50 0	9.55923	8	10.44077	9.58981	9	10.41019	10.03058	1	9.96942	45
16	9 52	50 8	55956	9	44044	59019	10	40981	03063	1	96937	44
17	9 44	50 16	55988	9	44012	59056	10	40944	03068	1	96932	43
18	9 36	50 24	56021	10	43979	59094	11	40906	03073	1	96927	42
19	9 28	50 32	56053	10	43947	59131	12	40869	03078	2	96922	41
20	9 9 20	2 50 40	9.56085	11	10.43915	9.59168	12	10.40832	10.03083	2	9.96917	40
21	9 12	50 48	56118	11	43882	59205	13	40795	03088	2	96912	39
22	9 4	50 56	56150	12	43850	59243	14	40757	03093	2	96907	38
23	8 56	51 4	56182	12	43818	59280	14	40720	03097	2	96903	37
24	8 48	51 12	56215	13	43785	59317	15	40683	03102	2	96898	36
25	9 8 40	2 51 20	9.56247	13	10.43753	9.59354	15	10.40646	10.03107	2	9.96893	35
26	8 32	51 28	56279	14	43721	59391	16	40609	03112	2	96888	34
27	8 24	51 36	56311	14	43689	59429	17	40571	03117	2	96883	33
28	8 16	51 44	56343	15	43657	59466	17	40534	03122	2	96878	32
29	8 8	51 52	56375	16	43625	59503	18	40497	03127	2	96873	31
30	9 8 0	2 52 0	9.56408	16	10.43592	9.59540	19	10.40460	10.03132	2	9.96868	30
31	7 52	52 8	56440	17	43560	59577	19	40423	03137	3	96863	29
32	7 44	52 16	56472	17	43528	59614	20	40386	03142	3	96858	28
33	7 36	52 24	56504	18	43496	59651	20	40349	03147	3	96853	27
34	7 28	52 32	56536	18	43464	59688	21	40312	03152	3	96848	26
35	9 7 20	2 52 40	9.56568	19	10.43432	9.59725	22	10.40275	10.03157	3	9.96843	25
36	7 12	52 48	56599	19	43401	59762	22	40238	03162	3	96838	24
37	7 4	52 56	56631	20	43369	59799	23	40201	03167	3	96833	23
38	6 56	53 4	56663	20	43337	59835	23	40165	03172	3	96828	22
39	6 48	53 12	56695	21	43305	59872	24	40128	03177	3	96823	21
40	9 6 40	2 53 20	9.56727	21	10.43273	9.59909	25	10.40091	10.03182	3	9.96818	20
41	6 32	53 28	56759	22	43241	59946	25	40054	03187	3	96813	19
42	6 24	53 36	56790	22	43210	59983	26	40017	03192	3	96808	18
43	6 16	53 44	56822	23	43178	60019	27	39981	03197	4	96803	17
44	6 8	53 52	56854	24	43146	60056	27	39944	03202	4	96798	16
45	9 6 0	2 54 0	9.56886	24	10.43114	9.60093	28	10.39907	10.03207	4	9.96793	15
46	5 52	54 8	56917	25	43083	60130	28	39870	03212	4	96788	14
47	5 44	54 16	56949	25	43051	60166	29	39834	03217	4	96783	13
48	5 36	54 24	56980	26	43020	60203	30	39797	03222	4	96778	12
49	5 28	54 32	57012	26	42988	60240	30	39760	03228	4	96772	11
50	9 5 20	2 54 40	9.57044	27	10.42956	9.60276	31	10.39724	10.03233	4	9.96767	10
51	5 12	54 48	57075	27	42925	60313	31	39687	03238	4	96762	9
52	5 4	54 56	57107	28	42893	60349	32	39651	03243	4	96757	8
53	4 56	55 4	57138	28	42862	60386	33	39614	03248	4	96752	7
54	4 48	55 12	57169	29	42831	60422	33	39578	03253	4	96747	6
55	9 4 40	2 55 20	9.57201	29	10.42799	9.60459	34	10.39541	10.03258	5	9.96742	5
56	4 32	55 28	57232	30	42768	60495	35	39505	03263	5	96737	4
57	4 24	55 36	57264	30	42736	60532	35	39468	03268	5	96732	3
58	4 16	55 44	57295	31	42705	60568	36	39432	03273	5	96727	2
59	4 8	55 52	57326	32	42674	60605	36	39395	03278	5	96722	1
60	4 0	56 0	57358	32	42642	60641	37	39359	03283	5	96717	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
111°			A		A	B		B	C		C	68°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	4	8	12	16	20	24	28
	B	5	9	14	19	23	28	32
	C	1	1	2	2	3	4	4

TABLE XI

Log. Sines, Tangents, and Secants.

22° 157°

M	Hour A. M.	Hour P. M.	Sine.	Diff	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	9 4 0	2 56 0	9.57358	0	10.42642	9.60641	0	10.39359	10.03283	0	9.96717	60
1	3 52	56 8	57389	1	42611	60677	1	39323	03289	0	96711	59
2	3 44	56 16	57420	1	42580	60714	1	39286	03294	0	96706	58
3	3 36	56 24	57451	2	42549	60750	2	39250	03299	0	96701	57
4	3 28	56 32	57482	2	42518	60786	2	39214	03304	0	96696	56
5	9 3 20	2 56 40	9.57514	3	10.42486	9.60823	3	10.39177	10.03309	0	9.96691	55
6	3 12	56 48	57545	3	42455	60859	4	39141	03314	1	96686	54
7	3 4	50 56	57576	4	42424	60895	4	39105	03319	1	96681	53
8	2 56	57 4	57607	4	42393	60931	5	39069	03324	1	96676	52
9	2 48	57 12	57638	5	42362	60967	5	39033	03330	1	96670	51
10	9 2 40	2 57 20	9.57669	5	10.42331	9.61004	6	10.38996	10.03335	1	9.96665	50
11	2 32	57 28	57700	6	42300	61040	7	38960	03340	1	96660	49
12	2 24	57 36	57731	6	42269	61076	7	38924	03345	1	96655	48
13	2 16	57 44	57762	7	42238	61112	8	38888	03350	1	96650	47
14	2 8	57 52	57793	7	42207	61148	8	38852	03355	1	96645	46
15	9 2 0	2 58 0	9.57824	8	10.42176	9.61184	9	10.38816	10.03360	1	9.96640	45
16	1 52	58 8	57855	8	42145	61220	10	38780	03366	1	96634	44
17	1 44	58 16	57885	9	42115	61256	10	38744	03371	1	96629	43
18	1 36	58 24	57916	9	42084	61292	11	38708	03376	2	96624	42
19	1 28	58 32	57947	10	42053	61328	11	38672	03381	2	96619	41
20	9 1 20	2 58 40	9.57978	10	10.42022	9.61364	12	10.38636	10.03386	2	9.96614	40
21	1 12	58 48	58008	11	41992	61400	13	38600	03392	2	96608	39
22	1 4	58 56	58039	11	41961	61436	13	38564	03397	2	96603	38
23	0 56	59 4	58070	12	41930	61472	14	38528	03402	2	96598	37
24	0 48	59 12	58101	12	41899	61508	14	38492	03407	2	96593	36
25	9 0 40	2 59 20	9.58131	13	10.41869	9.61544	15	10.38456	10.03412	2	9.96588	35
26	0 32	59 28	58162	13	41838	61579	15	38421	03418	2	96582	34
27	0 24	59 36	58192	14	41808	61615	16	38385	03423	2	96577	33
28	0 16	59 44	58223	14	41777	61651	17	38349	03428	2	96572	32
29	0 8	59 52	58253	15	41747	61687	17	38313	03433	3	96567	31
30	9 0 0	3 0 0	9.58284	15	10.41716	9.61722	18	10.38278	10.03438	3	9.96562	30
31	8 59 52	0 8	58314	16	41686	61758	18	38242	03444	3	96556	29
32	59 44	0 16	58345	16	41655	61794	19	38206	03449	3	96551	28
33	59 36	0 24	58375	17	41625	61830	20	38170	03454	3	96546	27
34	59 28	0 32	58406	17	41594	61865	20	38135	03459	3	96541	26
35	8 59 20	3 0 40	9.58436	18	10.41564	9.61901	21	10.38099	10.03465	3	9.96535	25
36	59 12	0 48	58467	18	41533	61936	21	38064	03470	3	96530	24
37	59 4	0 56	58497	19	41503	61972	22	38028	03475	3	96525	23
38	58 56	1 4	58527	19	41473	62008	23	37992	03480	3	96520	22
39	58 48	1 12	58557	20	41443	62043	23	37957	03486	3	96514	21
40	8 58 40	3 1 20	9.58588	20	10.41412	9.62079	24	10.37921	10.03491	3	9.96509	20
41	58 32	1 28	58618	21	41382	62114	24	37886	03496	4	96504	19
42	58 24	1 36	58648	21	41352	62150	25	37850	03502	4	96498	18
43	58 16	1 44	58678	22	41322	62185	26	37815	03507	4	96493	17
44	58 8	1 52	58709	22	41291	62221	26	37779	03512	4	96488	16
45	8 58 0	3 2 0	9.58739	23	10.41261	9.62256	27	10.37744	10.03517	4	9.96483	15
46	57 52	2 8	58769	23	41231	62292	27	37708	03523	4	96477	14
47	57 44	2 16	58799	24	41201	62327	28	37673	03528	4	96472	13
48	57 36	2 24	58829	24	41171	62362	29	37638	03533	4	96467	12
49	57 28	2 32	58859	25	41141	62398	29	37602	03539	4	96461	11
50	8 57 20	3 2 40	9.58889	25	10.41111	9.62433	30	10.37567	10.03544	4	9.96456	10
51	57 12	2 48	58919	26	41081	62468	30	37532	03549	4	96451	9
52	57 4	2 56	58949	26	41051	62504	31	37496	03555	5	96445	8
53	56 56	3 4	58979	27	41021	62539	32	37461	03560	5	96440	7
54	56 48	3 12	59009	27	40991	62574	32	37426	03565	5	96435	6
55	8 56 40	3 3 20	9.59039	28	10.40961	9.62609	33	10.37391	10.03571	5	9.96429	5
56	56 32	3 28	59069	28	40931	62645	33	37355	03576	5	96424	4
57	56 24	3 36	59098	29	40902	62680	34	37320	03581	5	96419	3
58	56 16	3 44	59128	29	40872	62715	35	37285	03587	5	96413	2
59	56 8	3 52	59158	30	40842	62750	35	37250	03592	5	96408	1
60	56 0	4 0	59188	31	40812	62785	36	37215	03597	5	96403	0
M.	Hour P. M.	Hour A. M	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
112°			A		A	B		B	C		C	67°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	4	8	11	15	19	23	27
	B	4	9	13	18	22	27	31
	C	1	1	2	3	3	4	5

TABLE XI

Log. Sines, Tangents, and Secants.

23° | 156°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 56 0	3 4 0	9.59188	0	10.40812	9.62785	0	10.37215	10.03597	0	9.96403	60
1	55 52	4 8	59218	0	40782	62820	1	37180	03603	0	96397	59
2	55 44	4 16	59247	1	40753	62855	1	37145	03608	0	96392	58
3	55 36	4 24	59277	1	40723	62890	2	37110	03613	0	96387	57
4	55 28	4 32	59307	2	40693	62926	2	37074	03619	0	96381	56
5	8 55 20	3 4 40	9.59336	2	10.40664	9.62961	3	10.37039	10.03624	0	9.96376	55
6	55 12	4 48	59366	3	40634	62996	3	37004	03630	1	96370	54
7	55 4	4 56	59396	3	40604	63031	4	36969	03635	1	96365	53
8	54 56	5 4	59425	4	40575	63066	5	36934	03640	1	96360	52
9	54 48	5 12	59455	4	40545	63101	5	36899	03646	1	96354	51
10	8 54 40	3 5 20	9.59484	5	10.40516	9.63135	6	10.36865	10.03651	1	9.96349	50
11	54 32	5 28	59514	5	40486	63170	6	36830	03657	1	96343	49
12	54 24	5 36	59543	6	40457	63205	7	36795	03662	1	96338	48
13	54 16	5 44	59573	6	40427	63240	7	36760	03667	1	96333	47
14	54 8	5 52	59602	7	40398	63275	8	36725	03673	1	96327	46
15	8 54 0	3 6 0	9.59632	7	10.40368	9.63310	9	10.36690	10.03678	1	9.96322	45
16	53 52	6 8	59661	8	40339	63345	9	36655	03684	1	96316	44
17	53 44	6 16	59690	8	40310	63379	10	36621	03689	2	96311	43
18	53 36	6 24	59720	9	40280	63414	10	36586	03695	2	96305	42
19	53 28	6 32	59749	9	40251	63449	11	36551	03700	2	96300	41
20	8 53 20	3 6 40	9.59778	10	10.40222	9.63484	12	10.36516	10.03706	2	9.96294	40
21	53 12	6 48	59808	10	40192	63519	12	36481	03711	2	96289	39
22	53 4	6 56	59837	11	40163	63553	13	36447	03716	2	96284	38
23	52 56	7 4	59866	11	40134	63588	13	36412	03722	2	96278	37
24	52 48	7 12	59895	12	40105	63623	14	36377	03727	2	96273	36
25	8 52 40	3 7 20	9.59924	12	10.40076	9.63657	14	10.36343	10.03733	2	9.96267	35
26	52 32	7 28	59954	13	40046	63692	15	36308	03738	2	96262	34
27	52 24	7 36	59983	13	40017	63726	16	36274	03744	2	96256	33
28	52 16	7 44	60012	14	39988	63761	16	36239	03749	3	96251	32
29	52 8	7 52	60041	14	39959	63796	17	36204	03755	3	96245	31
30	8 52 0	3 8 0	9.60070	15	10.39930	9.63830	17	10.36170	10.03760	3	9.96240	30
31	51 52	8 8	60099	15	39901	63865	18	36135	03766	3	96234	29
32	51 44	8 16	60128	15	39872	63899	18	36101	03771	3	96229	28
33	51 36	8 24	60157	16	39843	63934	19	36066	03777	3	96223	27
34	51 28	8 32	60186	16	39814	63968	20	36032	03782	3	96218	26
35	8 51 20	3 8 40	9.60215	17	10.39785	9.64003	20	10.35997	10.03788	3	9.96212	25
36	51 12	8 48	60244	17	39756	64037	21	35963	03793	3	96207	24
37	51 4	8 56	60273	18	39727	64072	21	35928	03799	3	96201	23
38	50 56	9 4	60302	18	39698	64106	22	35894	03804	3	96196	22
39	50 48	9 12	60331	19	39669	64140	22	35860	03810	4	96190	21
40	8 50 40	3 9 20	9.60359	19	10.39641	9.64175	23	10.35825	10.03815	4	9.96185	20
41	50 32	9 28	60388	20	39612	64209	24	35791	03821	4	96179	19
42	50 24	9 36	60417	20	39583	64243	24	35757	03826	4	96174	18
43	50 16	9 44	60446	21	39554	64278	25	35722	03832	4	96168	17
44	50 8	9 52	60474	21	39526	64312	25	35688	03838	4	96162	16
45	8 50 0	3 10 0	9.60503	22	10.39497	9.64346	26	10.35654	10.03843	4	9.96157	15
46	49 52	10 8	60532	22	39468	64381	26	35619	03849	4	96151	14
47	49 44	10 16	60561	23	39439	64415	27	35585	03854	4	96146	13
48	49 36	10 24	60589	23	39411	64449	28	35551	03860	4	96140	12
49	49 28	10 32	60618	24	39382	64483	28	35517	03865	4	96135	11
50	8 49 20	3 10 40	9.60646	24	10.39354	9.64517	29	10.35483	10.03871	5	9.96129	10
51	49 12	10 48	60675	25	39325	64552	29	35448	03877	5	96123	9
52	49 4	10 56	60704	25	39296	64586	30	35414	03882	5	96118	8
53	48 56	11 4	60732	26	39268	64620	31	35380	03888	5	96112	7
54	48 48	11 12	60761	26	39239	64654	31	35346	03893	5	96107	6
55	8 48 40	3 11 20	9.60789	27	10.39211	9.64688	32	10.35312	10.03899	5	9.96101	5
56	48 32	11 28	60818	27	39182	64722	32	35278	03905	5	96095	4
57	48 24	11 36	60846	28	39154	64756	33	35244	03910	5	96090	3
58	48 16	11 44	60875	28	39125	64790	33	35210	03916	5	96084	2
59	48 8	11 52	60903	29	39097	64824	34	35176	03921	5	96079	1
60	48 0	12 0	60931	29	39069	64858	35	35142	03927	6	96073	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
113°			A		A	B		B	C		C	66°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop parts of cols.	A	4	7	11	15	18	22	25
	B	4	9	13	17	22	26	31
	C	1	1	2	3	3	4	5

TABLE XI

Log. Sines, Tangents, and Secants.

21° 155°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 48 0	3 12 0	9.60931	0	10.39069	9.64858	0	10.35142	10.03927	0	9.96073	60
1	47 52	12 8	60960	0	39040	64892	1	35108	03933	0	96067	59
2	47 44	12 16	60988	1	39012	64926	1	35074	03938	0	96062	58
3	47 36	12 24	61016	1	38984	64960	2	35040	03944	0	96056	57
4	47 28	12 32	61045	2	38955	64994	2	35006	03950	0	96050	56
5	8 47 20	3 12 40	9.61073	2	10.38927	9.65028	3	10.34972	10.03955	0	9.96045	55
6	47 12	12 48	61101	3	38899	65062	3	34938	03961	1	96039	54
7	47 4	12 56	61129	3	38871	65096	4	34904	03966	1	96034	53
8	46 56	13 4	61158	4	38842	65130	4	34870	03972	1	96028	52
9	46 48	13 12	61186	4	38814	65164	5	34836	03978	1	96022	51
10	8 46 40	3 13 20	9.61214	5	10.38786	9.65197	6	10.34803	10.03983	1	9.96017	50
11	46 32	13 28	61242	5	38758	65231	6	34769	03989	1	96011	49
12	46 24	13 36	61270	6	38730	65265	7	34735	03995	1	96005	48
13	46 16	13 44	61298	6	38702	65299	7	34701	04000	1	96000	47
14	46 8	13 52	61326	6	38674	65333	8	34667	04006	1	95994	46
15	8 46 0	3 14 0	9.61354	7	10.38646	9.65366	8	10.34634	10.04012	1	9.95988	45
16	45 52	14 8	61382	7	38618	65400	9	34600	04018	2	95982	44
17	45 44	14 16	61411	8	38589	65434	9	34566	04023	2	95977	43
18	45 36	14 24	61438	8	38562	65467	10	34533	04029	2	95971	42
19	45 28	14 32	61466	9	38534	65501	11	34499	04035	2	95965	41
20	8 45 20	3 14 40	9.61494	9	10.38506	9.65535	11	10.34465	10.04040	2	9.95960	40
21	45 12	14 48	61522	10	38478	65568	12	34432	04046	2	95954	39
22	45 4	14 56	61550	10	38450	65602	12	34398	04052	2	95948	38
23	44 56	15 4	61578	11	38422	65636	13	34364	04058	2	95942	37
24	44 48	15 12	61606	11	38394	65669	13	34331	04063	2	95937	36
25	8 44 40	3 15 20	9.61634	12	10.38366	9.65703	14	10.34297	10.04069	2	9.95931	35
26	44 32	15 28	61662	12	38338	65736	15	34264	04075	2	95925	34
27	44 24	15 36	61689	12	38311	65770	15	34230	04080	3	95920	33
28	44 16	15 44	61717	13	38283	65803	16	34197	04086	3	95914	32
29	44 8	15 52	61745	13	38255	65837	16	34163	04092	3	95908	31
30	8 44 0	3 16 0	9.61773	14	10.38227	9.65870	17	10.34130	10.04098	3	9.95902	30
31	43 52	16 8	61800	14	38200	65904	17	34096	04103	3	95897	29
32	43 44	16 16	61828	15	38172	65937	18	34063	04109	3	95891	28
33	43 36	16 24	61856	15	38144	65971	18	34029	04115	3	95885	27
34	43 28	16 32	61883	16	38117	66004	19	33996	04121	3	95879	26
35	8 43 20	3 16 40	9.61911	16	10.38089	9.66038	20	10.33962	10.04127	3	9.95873	25
36	43 12	16 48	61939	17	38061	66071	20	33929	04132	3	95868	24
37	43 4	16 56	61966	17	38034	66104	21	33896	04138	4	95862	23
38	42 56	17 4	61994	18	38006	66138	21	33862	04144	4	95856	22
39	42 48	17 12	62021	18	37979	66171	22	33829	04150	4	95850	21
40	8 42 40	3 17 20	9.62049	18	10.37951	9.66204	22	10.33796	10.04156	4	9.95844	20
41	42 32	17 28	62076	19	37924	66238	23	33762	04161	4	95839	19
42	42 24	17 36	62104	19	37896	66271	23	33729	04167	4	95833	18
43	42 16	17 44	62131	20	37869	66304	24	33696	04173	4	95827	17
44	42 8	17 52	62159	20	37841	66337	25	33663	04179	4	95821	16
45	8 42 0	3 18 0	9.62186	21	10.37814	9.66371	25	10.33629	10.04185	4	9.95815	15
46	41 52	18 8	62214	21	37786	66404	26	33596	04190	4	95810	14
47	41 44	18 16	62241	22	37759	66437	26	33563	04196	5	95804	13
48	41 36	18 24	62268	22	37732	66470	27	33530	04202	5	95798	12
49	41 28	18 32	62296	23	37704	66503	27	33497	04208	5	95792	11
50	8 41 20	3 18 40	9.62323	23	10.37677	9.66537	28	10.33463	10.04214	5	9.95786	10
51	41 12	18 48	62350	24	37650	66570	28	33430	04220	5	95780	9
52	41 4	18 56	62377	24	37623	66603	29	33397	04225	5	95775	8
53	40 56	19 4	62405	24	37595	66636	30	33364	04231	5	95769	7
54	40 48	19 12	62432	25	37568	66669	30	33331	04237	5	95763	6
55	8 40 40	3 19 2	9.62459	25	10.37541	9.66702	31	10.33298	10.04243	5	9.95757	5
56	40 32	19 28	62486	26	37514	66735	31	33265	04249	5	95751	4
57	40 24	19 36	62513	26	37487	66768	32	33232	04255	5	95745	3
58	40 16	19 44	62541	27	37459	66801	32	33199	04261	6	95739	2
59	40 8	19 52	62568	27	37432	66834	33	33166	04267	6	95733	1
60	40 0	20 0	62595	28	37405	66867	33	33133	04272	6	95728	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

114° A A B B C C 65°

Seconds of time ……		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	3	7	10	14	17	21	24
	B	4	8	13	17	21	25	29
	C	1	1	2	3	4	4	5

TABLE XI

Log. Sines, Tangents, and Secants.

25° | 154°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant	Diff.	Cosine	M.
0	8 40 0	3 20 0	9.62595	0	10.37405	9.66867	0	10.33133	10.04272	0	9.95728	60
1	39 52	20 8	62622	0	37378	66900	1	33100	04278	0	95722	59
2	39 44	20 16	62649	1	37351	66933	1	33067	04284	0	95716	58
3	39 36	20 24	62676	1	37324	66966	2	33034	04290	0	95710	57
4	39 28	20 32	62703	2	37297	66999	2	33001	04296	0	95704	56
5	8 39 20	3 20 40	9.62730	2	10.37270	9.67032	3	10.32968	10.04302	1	9.95698	55
6	39 12	20 48	62757	3	37243	67065	3	32935	04308	1	95692	54
7	39 4	20 56	62784	3	37216	67098	4	32902	04314	1	95686	53
8	38 56	21 4	62811	4	37189	67131	4	32869	04320	1	95680	52
9	38 48	21 12	62838	4	37162	67163	5	32837	04326	1	95674	51
10	8 38 40	3 21 20	9.62865	4	10.37135	9.67196	5	10.32804	10.04332	1	9.95668	50
11	38 32	21 28	62892	5	37108	67229	6	32771	04337	1	95663	49
12	38 24	21 36	62918	5	37082	67262	7	32738	04343	1	95657	48
13	38 16	21 44	62945	6	37055	67295	7	32705	04349	1	95651	47
14	38 8	21 52	62972	6	37028	67327	8	32673	04355	1	95645	46
15	8 38 0	3 22 0	9.62999	7	10.37001	9.67360	8	10.32640	10.04361	2	9.95639	45
16	37 52	22 8	63026	7	36974	67393	9	32607	04367	2	95633	44
17	37 44	22 16	63052	8	36948	67426	9	32574	04373	2	95627	43
18	37 36	22 24	63079	8	36921	67458	10	32542	04379	2	95621	42
19	37 28	22 32	63106	8	36894	67491	10	32509	04385	2	95615	41
20	8 37 20	3 22 40	9.63133	9	10.36867	9.67524	11	10.32476	10.04391	2	9.95609	40
21	37 12	22 48	63159	9	36841	67556	11	32444	04397	2	95603	39
22	37 4	22 56	63186	10	36814	67589	12	32411	04403	2	95597	38
23	36 56	23 4	63213	10	36787	67622	12	32378	04409	2	95591	37
24	36 48	23 12	63239	11	36761	67654	13	32346	04415	2	95585	36
25	8 36 40	3 23 20	9.63266	11	10.36734	9.67687	14	10.32313	10.04421	3	9.95579	35
26	36 32	23 28	63292	11	36708	67719	14	32281	04427	3	95573	34
27	36 24	23 36	63319	12	36681	67752	15	32248	04433	3	95567	33
28	36 16	23 44	63345	12	36655	67785	15	32215	04439	3	95561	32
29	36 8	23 52	63372	13	36628	67817	16	32183	04445	3	95555	31
30	8 36 0	3 24 0	9.63398	13	10.36602	9.67850	16	10.32150	10.04451	3	9.95549	30
31	35 52	24 8	63425	14	36575	67882	17	32118	04457	3	95543	29
32	35 44	24 16	63451	14	36549	67915	17	32085	04463	3	95537	28
33	35 36	24 24	63478	15	36522	67947	18	32053	04469	3	95531	27
34	35 28	24 32	63504	15	36496	67980	18	32020	04475	3	95525	26
35	8 35 20	3 24 40	9.63531	15	10.36469	9.68012	19	10.31988	10.04481	4	9.95519	25
36	35 12	24 48	63557	16	36443	68044	20	31956	04487	4	95513	24
37	35 4	24 56	63583	16	36417	68077	20	31923	04493	4	95507	23
38	34 56	25 4	63610	17	36390	68109	21	31891	04500	4	95500	22
39	34 48	25 12	63636	17	36364	68142	21	31858	04506	4	95494	21
40	8 34 40	3 25 20	9.63662	18	10.36338	9.68174	22	10.31826	10.04512	4	9.95488	20
41	34 32	25 28	63689	18	36311	68206	22	31794	04518	4	95482	19
42	34 24	25 36	63715	19	36285	68239	23	31761	04524	4	95476	18
43	34 16	25 44	63741	19	36259	68271	23	31729	04530	4	95470	17
44	34 8	25 52	63767	19	36233	68303	24	31697	04536	4	95464	16
45	8 34 0	3 26 0	9.63794	20	10.36206	9.68336	24	10.31664	10.04542	5	9.95458	15
46	33 52	26 8	63820	20	36180	68368	25	31632	04548	5	95452	14
47	33 44	26 16	63846	21	36154	68400	25	31600	04554	5	95446	13
48	33 36	26 24	63872	21	36128	68432	26	31568	04560	5	95440	12
49	33 28	26 32	63898	22	36102	68465	27	31535	04566	5	95434	11
50	8 33 20	3 26 40	9.63924	22	10.36076	9.68497	27	10.31503	10.04573	5	9.95427	10
51	33 12	26 48	63950	23	36050	68529	28	31471	04579	5	95421	9
52	33 4	26 56	63976	23	36024	68561	28	31439	04585	5	95415	8
53	32 56	27 4	64002	23	35998	68593	29	31407	04591	5	95409	7
54	32 48	27 12	64028	24	35972	68626	29	31374	04597	5	95403	6
55	8 32 40	3 27 20	9.64054	24	10.35946	9.68658	30	10.31342	10.04603	6	9.95397	5
56	32 32	27 28	64080	25	35920	68690	30	31310	04609	6	95391	4
57	32 24	27 36	64106	25	35894	68722	31	31278	04616	6	95384	3
58	32 16	27 44	64132	26	35868	68754	31	31246	04622	6	95378	2
59	32 8	27 52	64158	26	35842	68786	32	31214	04628	6	95372	1
60	32 0	28 0	64184	26	35816	68818	33	31182	04634	6	95366	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
115°			A		A	B		B	C		C	64°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	3	7	10	13	17	20	23
	B	4	8	12	16	20	24	28
	C	1	1	2	3	4	5	5

TABLE XI

Log. Sines, Tangents, and Secants.

26° | 153°

M	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 32 0	3 28 0	9.64184	0	10.35816	9.68818	0	10.31182	10.04634	0	9.95366	60
1	31 52	28 8	64210	0	35790	68850	1	31150	04640	0	95360	59
2	31 44	28 16	64236	1	35764	68882	1	31118	04646	0	95354	58
3	31 36	28 24	64262	1	35738	68914	2	31086	04652	0	95348	57
4	31 28	28 32	64288	2	35712	68946	2	31054	04659	0	95341	56
5	8 31 20	3 28 40	9.64313	2	10.35687	9.68978	3	10.31022	10.04665	1	9.95335	55
6	31 12	28 48	64339	3	35661	69010	3	30990	04671	1	95329	54
7	31 4	28 56	64365	3	35635	69042	4	30958	04677	1	95323	53
8	30 56	29 4	64391	3	35609	69074	4	30926	04683	1	95317	52
9	30 48	29 12	64417	4	35583	69106	5	30894	04690	1	95310	51
10	8 30 40	3 29 20	9.64442	4	10.35558	9.69138	5	10.30862	10.04696	1	9.95304	50
11	30 32	29 28	64468	5	35532	69170	6	30830	04702	1	95298	49
12	30 24	29 36	64494	5	35506	69202	6	30798	04708	1	95292	48
13	30 16	29 44	64519	5	35481	69234	7	30766	04714	1	95286	47
14	30 8	29 52	64545	6	35455	69266	7	30734	04721	1	95279	46
15	8 30 0	3 30 0	9.64571	6	10.35429	9.69298	8	10.30702	10.04727	2	9.95273	45
16	29 52	30 8	64596	7	35404	69329	8	30671	04733	2	95267	44
17	29 44	30 16	64622	7	35378	69361	9	30639	04739	2	95261	43
18	29 36	30 24	64647	8	35353	69393	9	30607	04746	2	95254	42
19	29 28	30 32	64673	8	35327	69425	10	30575	04752	2	95248	41
20	8 29 20	3 30 40	9.64698	8	10.35302	9.69457	11	10.30543	10.04758	2	9.95242	40
21	29 12	30 48	64724	9	35276	69488	11	30512	04764	2	95236	39
22	29 4	30 56	64749	9	35251	69520	12	30480	04771	2	95229	38
23	28 56	31 4	64775	10	35225	69552	12	30448	04777	2	95223	37
24	28 48	31 12	64800	10	35200	69584	13	30416	04783	3	95217	36
25	8 28 40	3 31 20	9.64826	11	10.35174	9.69615	13	10.30385	10.04789	3	9.95211	35
26	28 32	31 28	64851	11	35149	69647	14	30353	04796	3	95204	34
27	28 24	31 36	64877	11	35123	69679	14	30321	04802	3	95198	33
28	28 16	31 44	64902	12	35098	69710	15	30290	04808	3	95192	32
29	28 8	31 52	64927	12	35073	69742	15	30258	04815	3	95185	31
30	8 28 0	3 32 0	9.64953	13	10.35047	9.69774	16	10.30226	10.04821	3	9.95179	30
31	27 52	32 8	64978	13	35022	69805	16	30195	04827	3	95173	29
32	27 44	32 16	65003	14	34997	69837	17	30163	04833	3	95167	28
33	27 36	32 24	65029	14	34971	69868	17	30132	04840	3	95160	27
34	27 28	32 32	65054	14	34946	69900	18	30100	04846	4	95154	26
35	8 27 20	3 32 40	9.65079	15	10.34921	9.69932	18	10.30068	10.04852	4	9.95148	25
36	27 12	32 48	65104	15	34896	69963	19	30037	04859	4	95141	24
37	27 4	32 56	65130	16	34870	69995	20	30005	04865	4	95135	23
38	26 56	33 4	65155	16	34845	70026	20	29974	04871	4	95129	22
39	26 48	33 12	65180	16	34820	70058	21	29942	04878	4	95122	21
40	8 26 40	3 33 20	9.65205	17	10.34795	9.70089	21	10.29911	10.04884	4	9.95116	20
41	26 32	33 28	65230	17	34770	70121	22	29879	04890	4	95110	19
42	26 24	33 36	65255	18	34745	70152	22	29848	04897	4	95103	18
43	26 16	33 44	65281	18	34719	70184	23	29816	04903	5	95097	17
44	26 8	33 52	65306	19	34694	70215	23	29785	04910	5	95090	16
45	8 26 0	3 34 0	9.65331	19	10.34669	9.70247	24	10.29753	10.04916	5	9.95084	15
46	25 52	34 8	65356	19	34644	70278	24	29722	04922	5	95078	14
47	25 44	34 16	65381	20	34619	70309	25	29691	04929	5	95071	13
48	25 36	34 24	65406	20	34594	70341	25	29659	04935	5	95065	12
49	25 28	34 32	65431	21	34569	70372	26	29628	04941	5	95059	11
50	8 25 20	3 34 40	9.65456	21	10.34544	9.70404	26	10.29596	10.04948	5	9.95052	10
51	25 12	34 48	65481	22	34519	70435	27	29565	04954	5	95046	9
52	25 4	34 56	65506	22	34494	70466	27	29534	04961	5	95039	8
53	24 56	35 4	65531	22	34469	70498	28	29502	04967	6	95033	7
54	24 48	35 12	65556	23	34444	70529	28	29471	04973	6	95027	6
55	8 24 40	3 35 20	9.65580	23	10.34420	9.70560	29	10.29440	10.04980	6	9.95020	5
56	24 32	35 28	65605	24	34395	70592	30	29408	04986	6	95014	4
57	24 24	35 36	65630	24	34370	70623	30	29377	04993	6	95007	3
58	24 16	35 44	65655	25	34345	70654	31	29346	04999	6	95001	2
59	24 8	35 52	65680	25	34320	70685	31	29315	05005	6	94995	1
60	24 0	36 0	65705	25	34295	70717	32	29283	05012	6	94988	0
M	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

116°			A		A	B		B	C		C	63°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	3	6	10	13	16	19	22
	B	4	8	12	16	20	24	28
	C	1	2	2	3	4	5	6

TABLE XI

Log. Sines, Tangents, and Secants.

27° **152°**

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 24 0	3 36 0	9. 65705	0	10. 34295	9. 70717	0	10. 29283	10. 05012	0	9. 94988	60
1	23 52	36 8	65729	0	34271	70748	1	29252	05018	0	94982	59
2	23 44	36 16	65754	1	34246	70779	1	29221	05025	0	94975	58
3	23 36	36 24	65779	1	34221	70810	2	29190	05031	0	94969	57
4	23 28	36 32	65804	2	34196	70841	2	29159	05038	0	94962	56
5	8 23 20	3 36 40	9. 65828	2	10. 34172	9. 70873	3	10. 29127	10. 05044	1	9. 94956	55
6	23 12	36 48	65853	2	34147	70904	3	29096	05051	1	94949	54
7	23 4	36 56	65878	3	34122	70935	4	29065	05057	1	94943	53
8	22 56	37 4	65902	3	34098	70966	4	29034	05064	1	94936	52
9	22 48	37 12	65927	4	34073	70997	5	29003	05070	1	94930	51
10	8 22 40	3 37 20	9. 65952	4	10. 34048	9. 71028	5	10. 28972	10. 05077	1	9. 94923	50
11	22 32	37 28	65976	4	34024	71059	6	28941	05083	1	94917	49
12	22 24	37 36	66001	5	33999	71090	6	28910	05089	1	94911	48
13	22 16	37 44	66025	5	33975	71121	7	28879	05096	1	94904	47
14	22 8	37 52	66050	6	33950	71153	7	28847	05102	2	94898	46
15	8 22 0	3 38 0	9. 66075	6	10. 33925	9. 71184	8	10. 28816	10. 05109	2	9. 94891	45
16	21 52	38 8	66099	6	33901	71215	8	28785	05115	2	94885	44
17	21 44	38 16	66124	7	33876	71246	9	28754	05122	2	94878	43
18	21 36	38 24	66148	7	33852	71277	9	28723	05129	2	94871	42
19	21 28	38 32	66173	8	33827	71308	10	28692	05135	2	94865	41
20	8 21 20	3 38 40	9. 66197	8	10. 33803	9. 71339	10	10. 28661	10. 05142	2	9. 94858	40
21	21 12	38 48	66221	8	33779	71370	11	28630	05148	2	94852	39
22	21 4	38 56	66246	9	33754	71401	11	28599	05155	2	94845	38
23	20 56	39 4	66270	9	33730	71431	12	28569	05161	3	94839	37
24	20 48	39 12	66295	10	33705	71462	12	28538	05168	3	94832	36
25	8 20 40	3 39 20	9. 66319	10	10. 33681	9. 71493	13	10. 28507	10. 05174	3	9. 94826	35
26	20 32	39 28	66343	11	33657	71524	13	28476	05181	3	94819	34
27	20 24	39 36	66368	11	33632	71555	14	28445	05187	3	94813	33
28	20 16	39 44	66392	11	33608	71586	14	28414	05194	3	94806	32
29	20 8	39 52	66416	12	33584	71617	15	28383	05201	3	94799	31
30	8 20 0	3 40 0	9. 66441	12	10. 33559	9. 71648	15	10. 28352	10. 05207	3	9. 94793	30
31	19 52	40 8	66465	13	33535	71679	16	28321	05214	3	94786	29
32	19 44	40 16	66489	13	33511	71709	16	28291	05220	4	94780	28
33	19 36	40 24	66513	13	33487	71740	17	28260	05227	4	94773	27
34	19 28	40 32	66537	14	33463	71771	17	28229	05233	4	94767	26
35	8 19 20	3 40 40	9. 66562	14	10. 33438	9. 71802	18	10. 28198	10. 05240	4	9. 94760	25
36	19 12	40 48	66586	15	33414	71833	19	28167	05247	4	94753	24
37	19 4	40 56	66610	15	33390	71863	19	28137	05253	4	94747	23
38	18 56	41 4	66634	15	33366	71894	20	28106	05260	4	94740	22
39	18 48	41 12	66658	16	33342	71925	20	28075	05266	4	94734	21
40	8 18 40	3 41 20	9. 66682	16	10. 33318	9. 71955	21	10, 28045	10. 05273	4	9. 94727	20
41	18 32	41 28	66706	17	33294	71986	21	28014	05280	4	94720	19
42	18 24	41 36	66731	17	33269	72017	22	27983	05286	5	94714	18
43	18 16	41 44	66755	17	33245	72048	22	27952	05293	5	94707	17
44	18 8	41 52	66779	18	33221	72078	23	27922	05300	5	94700	16
45	8 18 0	3 42 0	9. 66803	18	10. 33197	9. 72109	23	10. 27891	10. 05306	5	9. 94694	15
46	17 52	42 8	66827	19	33173	72140	24	27860	05313	5	94687	14
47	17 44	42 16	66851	19	33149	72170	24	27830	05320	5	94680	13
48	17 36	42 24	66875	19	33125	72201	25	27799	05326	5	94674	12
49	17 28	42 32	66899	20	33101	72231	25	27769	05333	5	94667	11
50	8 17 20	3 42 40	9. 66922	20	10. 33078	9. 72262	26	10. 27738	10. 05340	5	9. 94660	10
51	17 12	42 48	66946	21	33054	72293	26	27707	05346	6	94654	9
52	17 4	42 56	66970	21	33030	72323	27	27677	05353	6	94647	8
53	16 56	43 4	66994	21	33006	72354	27	27646	05360	6	94640	7
54	16 48	43 12	67018	22	32982	72384	28	27616	05366	6	94634	6
55	8 16 40	3 43 20	9. 67042	22	10. 32958	9. 72415	28	10. 27585	10. 05373	6	9. 94627	5
56	16 32	43 28	67066	23	32934	72445	29	27555	05380	6	94620	4
57	16 24	43 36	67090	23	32910	72476	29	27524	05386	6	94614	3
58	16 16	43 44	67113	23	32887	72506	30	27494	05393	6	94607	2
59	16 8	43 52	67137	24	32863	72537	30	27463	05400	6	94600	1
60	16 0	44 0	67161	24	32839	72567	31	27433	05407	7	94593	0
M.	Hour P. M.	Hour A. M	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant	Diff.	Sine.	M.
117°			A		A	B		B	C		C	62°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	3	6	9	12	15	18	21
	B	4	8	12	15	19	23	27
	C	1	2	2	3	4	5	6

TABLE XI

Log. Sines, Tangents, and Secants.

28° 151°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 16 0	3 44 0	9.67161	0	10.32839	9.72567	0	10.27433	10.05407	0	9.94593	60
1	15 52	44 8	67185	0	32815	72598	1	27402	05413	0	94587	59
2	15 44	44 16	67208	1	32792	72628	1	27372	05420	0	94580	58
3	15 36	44 24	67232	1	32768	72659	2	27341	05427	0	94573	57
4	15 28	44 32	67256	2	32744	72689	2	27311	05433	0	94567	56
5	8 15 20	3 44 40	9.67280	2	10.32720	9.72720	3	10.27280	10.05440	1	9.94560	55
6	15 12	44 48	67303	2	32697	72750	3	27250	05447	1	94553	54
7	15 4	44 56	67327	3	32673	72780	4	27220	05454	1	94546	53
8	14 56	45 4	67350	3	32650	72811	4	27189	05460	1	94540	52
9	14 48	45 12	67374	3	32626	72841	5	27159	05467	1	94533	51
10	8 14 40	3 45 20	9.67398	4	10.32602	9.72872	5	10.27128	10.05474	1	9.94526	50
11	14 32	45 28	67421	4	32579	72902	6	27098	05481	1	94519	49
12	14 24	45 36	67445	5	32555	72932	6	27068	05487	1	94513	48
13	14 16	45 44	67468	5	32532	72963	7	27037	05494	1	94506	47
14	14 8	45 52	67492	5	32508	72993	7	27007	05501	2	94499	46
15	8 14 0	3 46 0	9.67515	6	10.32485	9.73023	8	10.26977	10.05508	2	9.94492	45
16	13 52	46 8	67539	6	32461	73054	8	26946	05515	2	94485	44
17	13 44	46 16	67562	7	32438	73084	9	26916	05521	2	94479	43
18	13 36	46 24	67586	7	32414	73114	9	26886	05528	2	94472	42
19	13 28	46 32	67609	7	32391	73144	10	26856	05535	2	94465	41
20	8 13 20	3 46 40	9.67633	8	10.32367	9.73175	10	10.26825	10.05542	2	9.94458	40
21	13 12	46 48	67656	8	32344	73205	11	26795	05549	2	94451	39
22	13 4	46 56	67680	9	32320	73275	11	26765	05555	3	94445	38
23	12 56	47 4	67703	9	32297	73265	12	26735	05562	3	94438	37
24	12 48	47 12	67726	9	32274	73295	12	26705	05569	3	94431	36
25	8 12 40	3 47 20	9.67750	10	10.32250	9.73326	13	10.26674	10.05576	3	9.94424	35
26	12 32	47 28	67773	10	32227	73356	13	26644	05583	3	94417	34
27	12 24	47 36	67796	10	32204	73386	14	26614	05590	3	94410	33
28	12 16	47 44	67820	11	32180	73416	14	26584	05596	3	94404	32
29	12 8	47 52	67843	11	32157	73446	15	26554	05603	3	94397	31
30	8 12 0	3 48 0	9.67866	12	10.32134	9.73476	15	10.26524	10.05610	3	9.94390	30
31	11 52	48 8	67890	12	32110	73507	16	26493	05617	4	94383	29
32	11 44	48 16	67913	12	32087	73537	16	26463	05624	4	94376	28
33	11 36	48 24	67936	13	32064	73567	17	26433	05631	4	94369	27
34	11 28	48 32	67959	13	32041	73597	17	26403	05638	4	94362	26
35	8 11 20	3 48 40	9.67982	14	10.32018	9.73627	18	10.26373	10.05645	4	9.94355	25
36	11 12	48 48	68006	14	31994	73657	18	26343	05651	4	94349	24
37	11 4	48 56	68029	14	31971	73687	19	26313	05658	4	94342	23
38	10 56	49 4	68052	15	31948	73717	19	26283	05665	4	94335	22
39	10 48	49 12	68075	15	31925	73747	20	26253	05672	4	94328	21
40	8 10 40	3 49 20	9.68098	16	10.31902	9.73777	20	10.26223	10.05679	5	9.94321	20
41	10 32	49 28	68121	16	31879	73807	21	26193	05686	5	94314	19
42	10 24	49 36	68144	16	31856	73837	21	26163	05693	5	94307	18
43	10 16	49 44	68167	17	31833	73867	22	26133	05700	5	94300	17
44	10 8	49 52	68190	17	31810	73897	22	26103	05707	5	94293	16
45	8 10 0	3 50 0	9.68213	17	10.31787	9.73927	23	10.26073	10.05714	5	9.94286	15
46	9 52	50 8	68237	18	31763	73957	23	26043	05721	5	94279	14
47	9 44	50 16	68260	18	31740	73987	24	26013	05727	5	94273	13
48	9 36	50 24	68283	19	31717	74017	24	25983	05734	5	94266	12
49	9 28	50 32	68305	19	31695	74047	25	25953	05741	6	94259	11
50	8 9 20	3 50 40	9.68328	19	10.31672	9.74077	25	10.25923	10.05748	6	9.94252	10
51	9 12	50 48	68351	20	31649	74107	26	25893	05755	6	94245	9
52	9 4	50 56	68374	20	31626	74137	26	25863	05762	6	94238	8
53	8 56	51 4	68397	21	31603	74166	27	25834	05769	6	94231	7
54	8 48	51 12	68420	21	31580	74196	27	25804	05776	6	94224	6
55	8 8 40	3 51 20	9.68443	21	10.31557	9.74226	28	10.25774	10.05783	6	9.94217	5
56	8 32	51 28	68466	22	31534	74256	28	25744	05790	6	94210	4
57	8 24	51 36	68489	22	31511	74286	29	25714	05797	7	94203	3
58	8 16	51 44	68512	22	31488	74316	29	25684	05804	7	94196	2
59	8 8	51 52	68534	23	31466	74345	30	25655	05811	7	94189	1
60	8 0	52 0	68557	23	31443	74375	30	25625	05818	7	94182	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

118° A A B B C C 61°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	3	6	9	12	15	17	20
	B	4	8	11	15	19	23	26
	C	1	2	3	3	4	5	6

TABLE XI

Log. Sines, Tangents, and Secants.

29° | 150°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 8 0	3 52 0	9.68557	0	10.31443	9.74375	0	10.25625	10.05818	0	9.94182	60
1	7 52	52 8	68580	0	31420	74405	0	25595	05825	0	94175	59
2	7 44	52 16	68603	1	31397	74435	1	25565	05832	0	94168	58
3	7 36	52 24	68625	1	31375	74465	1	25535	05839	0	94161	57
4	7 28	52 32	68648	1	31352	74494	2	25506	05846	0	94154	56
5	8 7 20	3 52 40	9.68671	2	10.31329	9.74524	2	10.25476	10.05853	1	9.94147	55
6	7 12	52 48	68694	2	31306	74554	3	25446	05860	1	94140	54
7	7 4	52 56	68716	3	31284	74583	3	25417	05867	1	94133	53
8	6 56	53 4	68739	3	31261	74613	4	25387	05874	1	94126	52
9	6 48	53 12	68762	3	31238	74643	4	25357	05881	1	94119	51
10	8 6 40	3 53 20	9.68784	4	10.31216	9.74673	5	10.25327	10.05888	1	9.94112	50
11	6 32	53 28	68807	4	31193	74702	5	25298	05895	1	94105	49
12	6 24	53 36	68829	4	31171	74732	6	25268	05902	1	94098	48
13	6 16	53 44	68852	5	31148	74762	6	25238	05910	2	94090	47
14	6 8	53 52	68875	5	31125	74791	7	25209	05917	2	94083	46
15	8 6 0	3 54 0	9.68897	6	10.31103	9.74821	7	10.25179	10.05924	2	9.94076	45
16	5 52	54 8	68920	6	31080	74851	8	25149	05931	2	94069	44
17	5 44	54 16	68942	6	31058	74880	8	25120	05938	2	94062	43
18	5 36	54 24	68965	7	31035	74910	9	25090	05945	2	94055	42
19	5 28	54 32	68987	7	31013	74939	9	25061	05952	2	94048	41
20	8 5 20	3 54 40	9.69010	7	10.30990	9.74969	10	10.25031	10.05959	2	9.94041	40
21	5 12	54 48	69032	8	30968	74998	10	25002	05966	3	94034	39
22	5 4	54 56	69055	8	30945	75028	11	24972	05973	3	94027	38
23	4 56	55 4	69077	9	30923	75058	11	24942	05980	3	94020	37
24	4 48	55 12	69100	9	30900	75087	12	24913	05988	3	94012	36
25	8 4 40	3 55 20	9.69122	9	10.30878	9.75117	12	10.24883	10.05995	3	9.94005	35
26	4 32	55 28	69144	10	30856	75146	13	24854	06002	3	93998	34
27	4 24	55 36	69167	10	30833	75176	13	24824	06009	3	93991	33
28	4 16	55 44	69189	10	30811	75205	14	24795	06016	3	93984	32
29	4 8	55 52	69212	11	30788	75235	14	24765	06023	3	93977	31
30	8 4 0	3 56 0	9.69234	11	10.30766	9.75264	15	10.24736	10.06030	4	9.93970	30
31	3 52	56 8	69256	12	30744	75294	15	24706	06037	4	93963	29
32	3 44	56 16	69279	12	30721	75323	16	24677	06045	4	93955	28
33	3 36	56 24	69301	12	30699	75353	16	24647	06052	4	93948	27
34	3 28	56 32	69323	13	30677	75382	17	24618	06059	4	93941	26
35	8 3 20	3 56 40	9.69345	13	10.30655	9.75411	17	10.24589	10.06066	4	9.93934	25
36	3 12	56 48	69368	13	30632	75441	18	24559	06073	4	93927	24
37	3 4	56 56	69390	14	30610	75470	18	24530	06080	4	93920	23
38	2 56	57 4	69412	14	30588	75500	19	24500	06088	5	93912	22
39	2 48	57 12	69434	15	30566	75529	19	24471	06095	5	93905	21
40	8 2 40	3 57 20	9.69456	15	10.30544	9.75558	20	10.24442	10.06102	5	9.93898	20
41	2 32	57 28	69479	15	30521	75588	20	24412	06109	5	93891	19
42	2 24	57 36	69501	16	30499	75617	21	24383	06116	5	93884	18
43	2 16	57 44	69523	16	30477	75647	21	24353	06124	5	93876	17
44	2 8	57 52	69545	16	30455	75676	22	24324	06131	5	93869	16
45	8 2 0	3 58 0	9.69567	17	10.30433	9.75705	22	10.24295	10.06138	5	9.93862	15
46	1 52	58 8	69589	17	30411	75735	23	24265	06145	5	93855	14
47	1 44	58 16	69611	17	30389	75764	23	24236	06153	6	93847	13
48	1 36	58 24	69633	18	30367	75793	24	24207	06160	6	93840	12
49	1 28	58 32	69655	18	30345	75822	24	24178	06167	6	93833	11
50	8 1 20	3 58 40	9.69677	19	10.30323	9.75852	25	10.24148	10.06174	6	9.93826	10
51	1 12	58 48	69699	19	30301	75881	25	24119	06181	6	93819	9
52	1 4	58 56	69721	19	30279	75910	26	24090	06189	6	93811	8
53	0 56	59 4	69743	20	30257	75939	26	24061	06196	6	93804	7
54	0 48	59 12	69765	20	30235	75969	27	24031	06203	6	93797	6
55	8 0 40	3 59 20	9.69787	20	10.30213	9.75998	27	10.24002	10.06211	7	9.93789	5
56	0 32	59 28	69809	21	30191	76027	28	23973	06218	7	93782	4
57	0 24	59 36	69831	21	30169	76056	28	23944	06225	7	93775	3
58	0 16	59 44	69853	22	30147	76086	29	23914	06232	7	93768	2
59	0 8	59 52	69875	22	30125	76115	29	23885	06240	7	93760	1
60	0 0	4 0 0	69897	22	30103	76144	29	23856	06247	7	93753	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M
119°			A		A	B		B	C		C	60°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	3	6	8	11	14	17	20
	B	4	7	11	15	18	22	25
	C	1	2	3	4	4	5	6

TABLE XI

Log. Sines, Tangents, and Secants.

30° 149°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	8 0 0	4 0 0	9.69897	0	10.30103	9.76144	0	10.23856	10.06247	0	9.93753	60
1	7 59 52	0 8	69919	0	30081	76173	0	23827	06254	0	93746	59
2	59 44	0 16	69941	1	30059	76202	1	23798	06262	0	93738	58
3	59 36	0 24	69963	1	30037	76231	1	23769	06269	0	93731	57
4	59 28	0 32	69984	1	30016	76261	2	23739	06276	0	93724	56
5	7 59 20	4 0 40	9.70006	2	10.29994	9.76290	2	10.23710	10.06283	1	9.93717	55
6	59 12	0 48	70028	2	29972	76319	3	23681	06291	1	93709	54
7	59 4	0 56	70050	3	29950	76348	3	23652	06298	1	93702	53
8	58 56	1 4	70072	3	29928	76377	4	23623	06305	1	93695	52
9	58 48	1 12	70093	3	29907	76406	4	23594	06313	1	93687	51
10	7 58 40	4 1 20	9.70115	4	10.29885	9.76435	5	10.23565	10.06320	1	9.93680	50
11	58 32	1 28	70137	4	29863	76464	5	23536	06327	1	93673	49
12	58 24	1 36	70159	4	29841	76493	6	23507	06335	1	93665	48
13	58 16	1 44	70180	5	29820	76522	6	23478	06342	2	93658	47
14	58 8	1 52	70292	5	29798	76551	7	23449	06350	2	93650	46
15	7 58 0	4 2 0	9.70224	5	10.29776	9.76580	7	10.23420	10,06357	2	9.93643	45
16	57 52	2 8	70245	6	29755	76609	8	23391	06364	2	93636	44
17	57 44	2 16	70267	6	29733	76639	8	23361	06372	2	93628	43
18	57 36	2 24	70288	6	29712	76668	9	23332	06379	2	93621	42
19	57 28	2 32	70310	7	29690	76697	9	23303	06386	2	93614	41
20	7 57 20	4 2 40	9.70332	7	10.29668	9.76725	10	10.23275	10.06394	2	9.93606	40
21	57 12	2 48	70353	8	29647	76754	10	23246	06401	3	93599	39
22	57 4	2 56	70375	8	29625	76783	11	23217	06409	3	93591	38
23	56 56	3 4	70396	8	29604	76812	11	23188	06416	3	93584	37
24	56 48	3 12	70418	9	29582	76841	12	23159	06423	3	93577	36
25	7 56 40	4 3 20	9.70439	9	10.29561	9.76870	12	10.23130	10.06431	3	9.93569	35
26	56 32	3 28	70461	9	29539	76899	13	23101	06438	3	93562	34
27	56 24	3 36	70482	10	29518	76928	13	23072	06446	3	93554	33
28	56 16	3 44	70504	10	29496	76957	13	23043	06453	3	93547	32
29	56 8	3 52	70525	10	29475	76986	14	23014	06461	4	93539	31
30	7 56 0	4 4 0	9.70547	11	10.29453	9.77015	14	10.22985	10.06468	4	9.93532	30
31	55 52	4 8	70568	11	29432	77044	15	22956	06475	4	93525	29
32	55 44	4 16	70590	11	29410	77073	15	22927	06483	4	93517	28
33	55 36	4 24	70611	12	29389	77101	16	22899	06490	4	93510	27
34	55 28	4 32	70633.	12	29367	77130	16	22870	06498	4	93502	26
35	7 55 20	4 4 40	9.70654	13	10.29346	9.77159	17	10.22841	10.06505	4	9.93495	25
36	55 12	4 48	70675	13	29325	77188	17	22812	06513	4	93487	24
37	55 4	4 56	70697	13	29303	77217	18	22783	06520	5	93480	23
38	54 56	5 4	70718	14	29282	77246	18	22754	06528	5	93472	22
39	54 48	5 12	70739	14	29261	77274	19	22726	06535	5	93465	21
40	7 54 40	4 5 20	9.70761	14	10.29239	9.77303	19	10.22697	10.06543	5	9.93457	20
41	54 32	5 28	70782	15	29218	77332	20	22668	06550	5	93450	19
42	54 24	5 36	70803	15	29197	77361	20	22639	06558	5	93442	18
43	54 16	5 44	70824	15	29176	77390	21	22610	06565	5	93435	17
44	54 8	5 52	70846	16	29154	77418	21	22582	06573	5	93427	16
45	7 54 0	4 6 0	9.70867	16	10.29133	9.77447	22	10.22553	10.06580	6	9.93420	15
46	53 52	6 8	70888	16	29112	77476	22	22524	06588	6	93412	14
47	53 44	6 16	70909	17	29091	77505	23	22495	06595	6	93405	13
48	53 36	6 24	70931	17	29069	77533	23	22467	06603	6	93397	12
49	53 28	6 32	70952	18	29048	77562	24	22438	06610	6	93390	11
50	7 53 20	4 6 40	9.70973	18	10.29027	9.77591	24	10.22409	10.06618	6	9.93382	10
51	53 12	6 48	70994	18	29006	77619	25	22381	06625	6	93375	9
52	53 4	6 56	71015	19	28985	77648	25	22352	06633	6	93367	8
53	52 56	7 4	71036	19	28964	77677	26	22323	06640	7	93360	7
54	52 48	7 12	71058	19	28942	77706	26	22294	06648	7	93352	6
55	7 52 40	4 7 20	9.71079	20	10.28921	9.77734	26	10.22266	10.06656	7	9.93344	5
56	52 32	7 28	71100	20	28900	77763	27	22237	06663	7	93337	4
57	52 24	7 36	71121	20	28879	77791	27	22209	06671	7	93329	3
58	52 16	7 44	71142	21	28858	77820	28	22180	06678	7	93322	2
59	52 8	7 52	71163	21	28837	77849	28	22151	06686	7	93314	1
60	52 0	8 0	71184	21	28816	77877	29	22123	06693	7	93307	0
M.	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant	Cotangent.	Diff.	Tangent	Cosecant.	Diff.	Sine.	M.
120°			A		A	B		B	C		C	59°

Seconds of time		1	2	3	4	5	6	7
Prop. parts of cols.	A	3	5	8	11	13	16	19
	B	4	7	11	14	18	22	25
	C	1	2	3	4	5	6	7

TABLE XI

Log. Sines, Tangents, and Secants.

31° | 148°

M	Hour A. M.	Hour P. M.	Sine	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant	Diff.	Cosine.	M.
0	7 52 0	4 8 0	9. 71184	0	10. 28816	9 77877	0	10. 22123	10. 06693	0	9. 93307	60
1	51 52	8 8	71205	0	28795	77906	0	22094	06701	0	93299	59
2	51 44	8 16	71226	1	28774	77935	1	22065	06709	0	93291	58
3	51 36	8 24	71247	1	28753	77963	1	22037	06716	0	93284	57
4	51 28	8 32	71268	1	28732	77992	2	22008	06724	1	93276	56
5	7 51 20	4 8 40	9. 71289	2	10. 28711	9. 78020	2	10. 21980	10. 06731	1	9. 93269	55
6	51 12	8 48	71310	2	28690	78049	3	21951	06739	1	93261	54
7	51 4	8 56	71331	2	28669	78077	3	21923	06747	1	93253	53
8	50 56	9 4	71352	3	28648	78106	4	21894	06754	1	93246	52
9	50 48	9 12	71373	3	28627	78135	4	21865	06762	1	93238	51
10	7 50 40	4 9 20	9. 71393	3	10. 28607	9. 78163	5	10. 21837	10. 06770	1	9. 93230	50
11	50 32	9 28	71414	4	28586	78192	5	21808	06777	1	93223	49
12	50 24	9 36	71435	4	28565	78220	6	21780	06785	2	93215	48
13	50 16	9 44	71456	4	28544	78249	6	21751	06793	2	93207	47
14	50 8	9 52	71477	5	28523	78277	7	21723	06800	2	93200	46
15	7 50 0	4 10 0	9. 71498	5	10. 28502	9. 78306	7	10. 21694	10. 06808	2	9 93192	45
16	49 52	10 8	71519	5	28481	78334	8	21666	06816	2	93184	44
17	49 44	10 16	71539	6	28461	78363	8	21637	06823	2	93177	43
18	49 36	10 24	71560	6	28440	78391	9	21609	06831	2	93169	42
19	49 28	10 32	71581	7	28419	78419	9	21581	06839	2	93161	41
20	7 49 20	4 10 40	9. 71602	7	10 28398	9. 78448	9	10. 21552	10. 06846	3	9. 93154	40
21	49 12	10 48	71622	7	28378	78476	10	21524	06854	3	93146	39
22	49 4	10 56	71643	8	28357	78505	10	21495	06862	3	93138	38
23	48 56	11 4	71664	8	28336	78533	11	21467	06869	3	93131	37
24	48 48	11 12	71685	8	28315	78562	11	21438	06877	3	93123	36
25	7 48 40	4 11 20	9. 71705	9	10. 28295	9. 78590	12	10. 21410	10. 06885	3	9. 93115	35
26	48 32	11 28	71726	9	28274	78618	12	21382	06892	3	93108	34
27	48 24	11 36	71747	9	28253	78647	13	21353	06900	3	93100	33
28	48 16	11 44	71767	10	28233	78675	13	21325	06908	4	93092	32
29	48 8	11 52	71788	10	28212	78704	14	21296	06916	4	93084	31
30	7 48 0	4 12 0	9. 71809	10	10. 28191	9. 78732	14	10. 21268	10. 06923	4	9 93077	30
31	47 52	12 8	71829	11	28171	78760	15	21240	06931	4	93069	29
32	47 44	12 16	71850	11	28150	78789	15	21211	06939	4	93061	28
33	47 36	12 24	71870	11	28130	78817	16	21183	06947	4	93053	27
34	47 28	12 32	71891	12	28109	78845	16	21155	06954	4	93046	26
35	7 47 20	4 12 40	9. 71911	12	10. 28089	9. 78874	17	10. 21126	10. 06962	5	9. 93038	25
36	47 12	12 48	71932	12	28068	78902	17	21098	06970	5	93030	24
37	47 4	12 56	71952	13	28048	78930	17	21070	06978	5	93022	23
38	46 56	13 4	71973	13	28027	78959	18	21041	06986	5	93014	22
39	46 48	13 12	71994	13	28006	78987	18	21013	06993	5	93007	21
40	7 46 40	4 13 20	9. 72014	14	10. 27986	9. 79015	19	10. 20985	10. 07001	5	9. 92999	20
41	46 32	13 28	72034	14	27966	79043	19	20957	07009	5	92991	19
42	46 24	13 36	72055	14	27945	79072	20	20928	07017	5	92983	18
43	46 16	13 44	72075	15	27925	79100	20	20900	07024	6	92976	17
44	46 8	13 52	72096	15	27904	79128	21	20872	07032	6	92968	16
45	7 46 0	4 14 0	9. 72116	15	10. 27884	9 79156	21	10. 20844	10. 07040	6	9. 92960	15
46	45 52	14 8	72137	16	27863	79185	22	20815	07048	6	92952	14
47	45 44	14 16	72157	16	27843	79213	22	20787	07056	6	92944	13
48	45 36	14 24	72177	16	27823	79241	23	20759	07064	6	92936	12
49	45 28	14 32	72198	17	27802	79269	23	20731	07071	6	92929	11
50	7 45 20	4 14 40	9. 72218	17	10. 27782	9. 79297	24	10. 20703	10. 07079	6	9. 92921	10
51	45 12	14 48	72238	18	27762	79326	24	20674	07087	7	92913	9
52	45 4	14 56	72259	18	27741	79354	25	20646	07095	7	92905	8
53	44 56	15 4	72279	18	27721	79382	25	20618	07103	7	92897	7
54	44 48	15 12	72299	19	27701	79410	26	20590	07111	7	92889	6
55	7 44 40	4 15 20	9. 72320	19	10. 27680	9. 79438	26	10. 20562	10. 07119	7	9. 92881	5
56	44 32	15 28	72340	19	27660	79466	26	20534	07126	7	92874	4
57	44 24	15 36	72360	20	27640	79495	27	20505	07134	7	92866	3
58	44 16	15 44	72381	20	27619	79523	27	20477	07142	7	92858	2
59	44 8	15 52	72401	20	27599	79551	28	20449	07150	8	92850	1
60	44 0	16 0	72421	21	27579	79579	28	20421	07158	8	92842	0
M	Hour P. M.	Hour A. M.	Cosine.	Diff	Secant	Cotangent	Diff.	Tangent	Cosecant	Diff	Sine	M.
121°			A		A	B		B	C		C	58°

Seconds of time ……		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	3	5	8	10	13	15	18
	B	4	7	11	14	18	21	25
	C	1	2	3	4	5	6	7

TABLE XI

Log. Sines, Tangents, and Secants.

32°												147°
M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant	Tangent.	Diff	Cotangent.	Secant	Diff	Cosine	M
0	7 44 0	4 16 0	9. 72421	0	10. 27579	9. 79579	0	10. 20421	10 07158	0	9. 92842	60
1	43 52	16 8	72441	0	27559	79607	0	20393	07166	0	92834	59
2	43 44	16 16	72461	1	27539	79635	1	20365	07174	0	92826	58
3	43 36	16 24	72482	1	27518	79663	1	20337	07182	0	92818	57
4	43 28	16 32	72502	1	27498	79691	2	20309	07190	1	92810	56
5	7 43 20	4 16 40	9. 72522	2	10. 27478	9. 79719	2	10. 20281	10. 07197	1	9. 92803	55
6	43 12	16 48	72542	2	27458	79747	3	20253	07205	1	92795	54
7	43 4	16 56	72562	2	27438	79776	3	20224	07213	1	92787	53
8	42 56	17 4	72582	3	27418	79804	4	20196	07221	1	92779	52
9	42 48	17 12	72602	3	27398	79832	4	20168	07229	1	92771	51
10	7 42 40	4 17 20	9. 72622	3	10. 27378	9. 79860	5	10. 20140	10. 07237	1	9. 92763	50
11	42 32	17 28	72643	4	27357	79888	5	20112	07245	1	92755	49
12	42 24	17 36	72663	4	27337	79916	6	20084	07253	2	92747	48
13	42 16	17 44	72683	4	27317	79944	6	20056	07261	2	92739	47
14	42 8	17 52	72703	5	27297	79972	7	20028	07269	2	92731	46
15	7 42 0	4 18 0	9. 72723	5	10. 27277	9. 80000	7	10. 20000	10. 07277	2	9. 92723	45
16	41 52	18 8	72743	5	27257	80028	7	19972	07285	2	92715	44
17	41 44	18 16	72763	6	27237	80056	8	19944	07293	2	92707	43
18	41 36	18 24	72783	6	27217	80084	8	19916	07301	2	92699	42
19	41 28	18 32	72803	6	27197	80112	9	19888	07309	3	92691	41
20	7 41 20	4 18 40	9. 72823	7	10. 27177	9. 80140	9	10. 19860	10. 07317	3	9. 92683	40
21	41 12	18 48	72843	7	27157	80168	10	19832	07325	3	92675	39
22	41 4	18 56	72863	7	27137	80195	10	19805	07333	3	92667	38
23	40 56	19 4	72883	8	27117	80223	11	19777	07341	3	92659	37
24	40 48	19 12	72902	8	27098	80251	11	19749	07349	3	92651	36
25	7 40 40	4 19 20	9. 72922	8	10. 27078	9. 80279	12	10. 19721	10. 07357	3	9. 92643	35
26	40 32	19 28	72942	9	27058	80307	12	19693	07365	3	92635	34
27	40 24	19 36	72962	9	27038	80335	13	19665	07373	4	92627	33
28	40 16	19 44	72982	9	27018	80363	13	19637	07381	4	92619	32
29	40 8	19 52	73002	10	26998	80391	13	19609	07389	4	92611	31
30	7 40 0	4 20 0	9. 73022	10	10. 26978	9. 80419	14	10. 19581	10. 07397	4	9. 92603	30
31	39 52	20 8	73041	10	26959	80447	14	19553	07405	4	92595	29
32	39 44	20 16	73061	11	26939	80474	15	19526	07413	4	92587	28
33	39 36	20 24	73081	11	26919	80502	15	19498	07421	4	92579	27
34	39 28	20 32	73101	11	26899	80530	16	19470	07429	5	92571	26
35	7 39 20	4 20 40	9. 73121	12	10. 26879	9. 80558	16	10. 19442	10. 07437	5	9. 92563	25
36	39 12	20 48	73140	12	26860	80586	17	19414	07445	5	92555	24
37	39 4	20 56	73160	12	26840	80614	17	19386	07454	5	92546	23
38	38 56	21 4	73180	13	26820	80642	18	19358	07462	5	92538	22
39	38 48	21 12	73200	13	26800	80669	18	19331	07470	5	92530	21
40	7 38 40	4 21 20	9. 73219	13	10. 26781	9. 80697	19	10. 19303	10. 07478	5	9. 92522	20
41	38 32	21 28	73239	14	26761	80725	19	19275	07486	6	92514	19
42	38 24	21 36	73259	14	26741	80753	20	19247	07494	6	92506	18
43	38 16	21 44	73278	14	26722	80781	20	19219	07502	6	92498	17
44	38 8	21 52	73298	15	26702	80808	20	19192	07510	6	92490	16
45	7 38 0	4 22 0	9. 73318	15	10. 26682	9. 80836	21	10. 19164	10. 07518	6	9. 92482	15
46	37 52	22 8	73337	15	26663	80864	21	19136	07527	6	92473	14
47	37 44	22 16	73357	16	26643	80892	22	19108	07535	6	92465	13
48	37 36	22 24	73377	16	26623	80919	22	19081	07543	6	92457	12
49	37 28	22 32	73396	16	26604	80947	23	19053	07551	7	92449	11
50	7 37 20	4 22 40	9. 73416	17	10. 26584	9. 80975	23	10. 19025	10. 07559	7	9. 92441	10
51	37 12	22 48	73435	17	26565	81003	24	18997	07567	7	92433	9
52	37 4	22 56	73455	17	26545	81030	24	18970	07575	7	92425	8
53	36 56	23 4	73474	18	26526	81058	25	18942	07584	7	92416	7
54	36 48	23 12	73494	18	26506	81086	25	18914	07592	7	92408	6
55	7 36 40	4 23 20	9. 73513	18	10. 26487	9. 81113	26	10. 18887	10. 07600	7	9. 92400	5
56	36 32	23 28	73533	19	26467	81141	26	18859	07608	8	92392	4
57	36 24	23 36	73552	19	26448	81169	26	18831	07616	8	92384	3
58	36 16	23 44	73572	19	26428	81196	27	18804	07624	8	92376	2
59	36 8	23 52	73591	20	26409	81224	27	18776	07633	8	92367	1
60	36 0	24 0	73611	20	26389	81252	28	18748	07641	8	92359	0
M.	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant.	Cotangent	Diff	Tangent	Cosecant	Diff	Sine	M
122°			A		A	B		B	C		C	57°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	5	7	10	12	15	17
	B	3	7	10	14	17	21	24
	C	1	2	3	4	5	6	7

TABLE XI

Log. Sines, Tangents, and Secants.

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M.	Hour A. M.	Hour P. M.	Sine	Diff.	Cosecant.	Tangent	Diff.	Cotangent.	Secant.	Diff.	Cosine	M.
0	7 36 0	4 24 0	9.73611	0	10.26389	9.81252	0	10.18748	10.07641	0	9.92359	60
1	35 52	24 8	73630	0	26370	81279	0	18721	07649	0	92351	59
2	35 44	24 16	73650	1	26350	81307	1	18693	07657	0	92343	58
3	35 36	24 24	73669	1	26331	81335	1	18665	07665	0	92335	57
4	35 28	24 32	73689	1	26311	81362	2	18638	07674	1	92326	56
5	7 35 20	4 24 40	9.73708	2	10 26292	9.81390	2	10.18610	10.07682	1	9.92318	55
6	35 12	24 48	73727	2	26273	81418	3	18582	07690	1	92310	54
7	35 4	24 56	73747	2	26253	81445	3	18555	07698	1	92302	53
8	34 56	25 4	73766	3	26234	81473	4	18527	07707	1	92293	52
9	34 48	25 12	73785	3	26215	81500	4	18500	07715	1	92285	51
10	7 34 40	4 25 20	9.73805	3	10.26195	9.81528	5	10.18472	10.07723	1	9.92277	50
11	34 32	25 28	73824	3	26176	81556	5	18444	07731	2	92269	49
12	34 24	25 36	73843	4	26157	81583	5	18417	07740	2	92260	48
13	34 16	25 44	73863	4	26137	81611	6	18389	07748	2	92252	47
14	34 8	25 52	73882	4	26118	81638	6	18362	07756	2	92244	46
15	7 34 0	4 26 0	9.73901	5	10.26099	9.81066	7	10.18334	10.07765	2	9.92235	45
16	33 52	26 8	73921	5	26079	81693	7	18307	07773	2	92227	44
17	33 44	26 16	73940	5	26060	81721	8	18279	07781	2	92219	43
18	33 36	26 24	73959	6	26041	81748	8	18252	07789	3	92211	42
19	33 28	26 32	73978	6	26022	81776	9	18224	07798	3	92202	41
20	7 33 20	4 26 40	9.73997	6	10.26003	9.81803	9	10.18197	10.07806	3	9.92194	40
21	33 12	26 48	74017	7	25983	81831	10	18169	07814	3	92186	39
22	33 4	26 56	74036	7	25964	81858	10	18142	07823	3	92177	38
23	32 56	27 4	74055	7	25945	81886	11	18114	07831	3	92169	37
24	32 48	27 12	74074	8	25920	81913	11	18087	07839	3	92161	36
25	7 32 40	4 27 20	9.74093	8	10.25907	9.81941	11	10.18059	10.07848	3	9.92152	35
26	32 32	27 28	74113	8	25887	81968	12	18032	07856	4	92144	34
27	32 24	27 36	74132	9	25868	81996	12	18004	07864	4	92136	33
28	32 16	27 44	74151	9	25849	82023	13	17977	07873	4	92127	32
29	32 8	27 52	74170	9	25830	82051	13	17949	07881	4	92119	31
30	7 32 0	4 28 0	9.74189	10	10.25811	9.82078	14	10.17922	10.07889	4	9.92111	30
31	31 52	28 8	74208	10	25792	82106	14	17894	07898	4	92102	29
32	31 44	28 16	74227	10	25773	82133	15	17867	07906	4	92094	28
33	31 36	28 24	74246	10	25754	82161	15	17839	07914	5	92086	27
34	31 28	28 32	74265	11	25735	82188	16	17812	07923	5	92077	26
35	7 31 20	4 28 40	9.74284	11	10.25716	9.82215	16	10.17785	10.07931	5	9.92069	25
36	31 12	28 48	74303	11	25697	82243	16	17757	07940	5	92060	24
37	31 4	28 56	74322	12	25678	82270	17	17730	07948	5	92052	23
38	30 56	29 4	74341	12	25659	82298	17	17702	07956	5	92044	22
39	30 48	29 12	74360	12	25640	82325	18	17675	07965	5	92035	21
40	7 30 40	4 29 20	9.74379	13	10.25621	9.82352	18	10.17648	10.07973	6	9.92027	20
41	30 32	29 28	74398	13	25602	82380	19	17620	07982	6	92018	19
42	30 24	29 36	74417	13	25583	82407	19	17593	07990	6	92010	18
43	30 16	29 44	74436	14	25564	82435	20	17565	07998	6	92002	17
44	30 8	29 52	74455	14	25545	82462	20	17538	08007	6	91993	16
45	7 30 0	4 30 0	9.74474	14	10.25526	9.82489	21	10.17511	10.08015	6	9.91985	15
46	29 52	30 8	74493	15	25507	82517	21	17483	08024	6	91976	14
47	29 44	30 16	74512	15	25488	82544	22	17456	08032	7	91968	13
48	29 36	30 24	74531	15	25469	82571	22	17429	08041	7	91959	12
49	29 28	30 32	74549	16	25451	82599	22	17401	08049	7	91951	11
50	7 29 20	4 30 40	9.74568	16	10.25432	9.82626	23	10.17374	10.08058	7	9.91042	10
51	29 12	30 48	74587	16	25413	82653	23	17347	08066	7	91934	9
52	29 4	30 56	74606	17	25394	82681	24	17319	08075	7	91925	8
53	28 56	31 4	74625	17	25375	82708	24	17292	08083	7	91917	7
54	28 48	31 12	74644	17	25356	82735	25	17265	08092	8	91908	6
55	7 28 40	4 31 20	9.74662	17	10.25338	9.82762	25	10.17238	10.08100	8	9.91900	5
56	28 32	31 28	74681	18	25319	82790	26	17210	08109	8	91891	4
57	28 24	31 36	74700	18	25300	82817	26	17183	08117	8	91883	3
58	28 16	31 44	74719	18	25281	82844	27	17156	08126	8	91874	2
59	28 8	31 52	74737	19	25263	82871	27	17129	08134	8	91866	1
60	28 0	32 0	74756	19	25244	82899	27	17101	08143	8	91857	0
M.	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant	Cotangent	Diff.	Tangent	Cosecant	Diff.	Sine	M
			A		A	B		B	C		C	

123° | 56°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	5	7	10	12	15	17
	B	3	7	10	14	17	21	24
	C	1	2	3	4	5	6	7

TABLE XI

Log. Sines, Tangents, and Secants.

34° | 145°

M	Hour A. M	Hour P. M.	Sine.	Diff.	Cosecant	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine	M
0	7 28 0	4 32 0	9.74756	0	10.25244	9.82899	0	10.17101	10.08143	0	9.91857	60
1	27 52	32 8	74775	0	25225	82926	0	17074	08151	0	91849	59
2	27 44	32 16	74794	1	25206	82953	1	17047	08160	0	91840	58
3	27 36	32 24	74812	1	25188	82980	1	17020	08168	0	91832	57
4	27 28	32 32	74831	1	25169	83008	2	16992	08177	1	91823	56
5	7 27 20	4 32 40	9.74850	2	10.25150	9.83035	2	10.16965	10.08185	1	9.91815	55
6	27 12	32 48	74868	2	25132	83062	3	16938	08194	1	91806	54
7	27 4	32 56	74887	2	25113	83089	3	16911	08202	1	91798	53
8	26 56	33 4	74906	2	25094	83117	4	16883	08211	1	91789	52
9	26 48	33 12	74924	3	25076	83144	4	16856	08219	1	91781	51
10	7 26 40	4 33 20	9.74943	3	10.25057	9.83171	5	10.16829	10.08228	1	9.91772	50
11	26 32	33 28	74961	3	25039	83198	5	16802	08237	2	91763	49
12	26 24	33 36	74980	4	25020	83225	5	16775	08245	2	91755	48
13	26 16	33 44	74999	4	25001	83252	6	16748	08254	2	91746	47
14	26 8	33 52	75017	4	24983	83280	6	16720	08262	2	91738	46
15	7 26 0	4 34 0	9.75036	5	10.24964	9.83307	7	10.16693	10.08271	2	9.91729	45
16	25 52	34 8	75054	5	24946	83334	7	16666	08280	2	91720	44
17	25 44	34 16	75073	5	24927	83361	8	16639	08288	2	91712	43
18	25 36	34 24	75091	6	24909	83388	8	16612	08297	3	91703	42
19	25 28	34 32	75110	6	24890	83415	9	16585	08305	3	91695	41
20	7 25 20	4 34 40	9.75128	6	10.24872	9.83442	9	10.16558	10.08314	3	9.91686	40
21	25 12	34 48	75147	6	24853	83470	9	16530	08323	3	91677	39
22	25 4	34 56	75165	7	24835	83497	10	16503	08331	3	91669	38
23	24 56	35 4	75184	7	24816	83524	10	16476	08340	3	91660	37
24	24 48	35 12	75202	7	24798	83551	11	16449	08349	3	91651	36
25	7 24 40	4 35 20	9.75221	8	10.24779	9.83578	11	10.16422	10.08357	4	9.91643	35
26	24 32	35 28	75239	8	24761	83605	12	16395	08366	4	91634	34
27	24 24	35 36	75258	8	24742	83632	12	16368	08375	4	91625	33
28	24 16	35 44	75276	9	24724	83659	13	16341	08383	4	91617	32
29	24 8	35 52	75294	9	24706	83686	13	16314	08392	4	91608	31
30	7 24 0	4 36 0	9.75313	9	10.24687	9.83713	14	10.16287	10.08401	4	9.91599	30
31	23 52	36 8	75331	9	24669	83740	14	16260	08409	4	91591	29
32	23 44	36 16	75350	10	24650	83768	14	16232	08418	5	91582	28
33	23 36	36 24	75368	10	24632	83795	15	16205	08427	5	91573	27
34	23 28	36 32	75386	10	24614	83822	15	16178	08435	5	91565	26
35	7 23 20	4 36 40	9.75405	11	10.24595	9.83849	16	10.16151	10.08444	5	9.91556	25
36	23 12	36 48	75423	11	24577	83876	16	16124	08453	5	91547	24
37	23 4	36 56	75441	11	24559	83903	17	16097	08462	5	91538	23
38	22 56	37 4	75459	12	24541	83930	17	16070	08470	5	91530	22
39	22 48	37 12	75478	12	24522	83957	18	16043	08479	6	91521	21
40	7 22 40	4 37 20	9.75496	12	10.24504	9.83984	18	10.16016	10.08488	6	9.91512	20
41	22 32	37 28	75514	13	24486	84011	18	15989	08496	6	91504	19
42	22 24	37 36	75533	13	24467	84038	19	15962	08505	6	91495	18
43	22 16	37 44	75551	13	24449	84065	19	15935	08514	6	91486	17
44	22 8	37 52	75569	13	24431	84092	20	15908	08523	6	91477	16
45	7 22 0	4 38 0	9.75587	14	10.24413	9.84119	20	10.15881	10.08531	7	9.91469	15
46	21 52	38 8	75605	14	24395	84146	21	15854	08540	7	91460	14
47	21 44	38 16	75624	14	24376	84173	21	15827	08549	7	91451	13
48	21 36	38 24	75642	15	24358	84200	22	15800	08558	7	91442	12
49	21 28	38 32	75660	15	24340	84227	22	15773	08567	7	91433	11
50	7 21 20	4 38 40	9.75678	15	10.24322	9.84254	23	10.15746	10.08575	7	9.91425	10
51	21 12	38 48	75696	16	24304	84280	23	15720	08584	7	91416	9
52	21 4	38 56	75714	16	24286	84307	23	15693	08593	8	91407	8
53	20 56	39 4	75733	16	24267	84334	24	15666	08602	8	91398	7
54	20 48	39 12	75751	17	24249	84361	24	15639	08611	8	91389	6
55	7 20 40	4 39 20	9.75769	17	10.24231	9.84388	25	10.15612	10.08619	8	9.91381	5
56	20 32	39 28	75787	17	24213	84415	25	15585	08628	8	91372	4
57	20 24	39 36	75805	17	24195	84442	26	15558	08637	8	91363	3
58	20 16	39 44	75823	18	24177	84469	26	15531	08646	8	91354	2
59	20 8	39 52	75841	18	24159	84496	27	15504	08655	9	91345	1
60	20 0	40 0	75859	18	24141	84523	27	15477	08664	9	91336	0
M	Hour P. M	Hour A. M	Cosine	Diff.	Secant	Cotangent	Diff.	Tangent	Cosecant	Diff.	Sine.	M.
124°			A		A	B		B	C		C	55°

Seconds of time ……		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	5	7	9	11	14	16
	B	3	7	10	14	17	20	24
	C	1	2	3	4	5	7	8

TABLE XI

Log. Sines, Tangents, and Secants.

35° 144°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	7 20 0	4 40 0	9. 75859	0	10. 24141	9. 84523	0	10. 15477	10. 08664	0	9. 91336	60
1	19 52	40 8	75877	0	24123	84550	0	15450	08672	0	91328	59
2	19 44	40 16	75895	1	24105	84576	1	15424	08681	0	91319	58
3	19 36	40 24	75913	1	24087	84603	1	15397	08690	0	91310	57
4	19 28	40 32	75931	1	24069	84630	2	15370	08699	1	91301	56
5	7 19 20	4 40 40	9. 75949	1	10. 24051	9. 84657	2	10. 15343	10. 08708	1	9. 91292	55
6	19 12	40 48	75967	2	24033	84684	3	15316	08717	1	91283	54
7	19 4	40 56	75985	2	24015	84711	3	15289	08726	1	91274	53
8	18 56	41 4	76003	2	23997	84738	4	15262	08734	1	91266	52
9	18 48	41 12	76021	3	23979	84764	4	15236	08743	1	91257	51
10	7 18 40	4 41 20	9. 76039	3	10. 23961	9. 84791	4	10. 15209	10. 08752	2	9. 91248	50
11	18 32	41 28	76057	3	23943	84818	5	15182	08761	2	91239	49
12	18 24	41 36	76075	4	23925	84845	5	15155	08770	2	91230	48
13	18 16	41 44	76093	4	23907	84872	6	15128	08779	2	91221	47
14	18 8	41 52	76111	4	23889	84899	6	15101	08788	2	91212	46
15	7 18 0	4 42 0	9. 76129	4	10. 23871	9. 84925	7	10. 15075	10. 08797	2	9. 91203	45
16	17 52	42 8	76146	5	23854	84952	7	15048	08806	2	91194	44
17	17 44	42 16	76164	5	23836	84979	8	15021	08815	3	91185	43
18	17 36	42 24	76182	5	23818	85006	8	14994	08824	3	91176	42
19	17 28	42 32	76200	6	23800	85033	8	14967	08833	3	91167	41
20	7 17 20	4 42 40	9. 76218	6	10. 23782	9. 85059	9	10. 14941	10. 08842	3	9. 91158	40
21	17 12	42 43	76236	6	23764	85086	9	14914	08851	3	91149	39
22	17 4	42 56	76253	6	23747	85113	10	14887	08859	3	91141	38
23	16 56	43 4	76271	7	23729	85140	10	14860	08868	3	91132	37
24	16 48	43 12	76289	7	23711	85166	11	14834	08877	4	91123	36
25	7 16 40	4 43 20	9. 76307	7	10. 23693	9. 85193	11	10. 14807	10. 08886	4	9. 91114	35
26	16 32	43 28	76324	8	23676	85220	12	14780	08895	4	91105	34
27	16 24	43 36	76342	8	23658	85247	12	14753	08904	4	91096	33
28	16 16	43 44	76360	8	23640	85273	12	14727	08913	4	91087	32
29	16 8	43 52	76378	9	23622	85300	13	14700	08922	4	91078	31
30	7 16 0	4 44 0	9. 76395	9	10. 23605	9. 85327	13	10. 14673	10. 08931	5	9. 91069	30
31	15 52	44 8	76413	9	23587	85354	14	14646	08940	5	91060	29
32	15 44	44 16	76431	9	23569	85380	14	14620	08949	5	91051	28
33	15 36	44 24	76448	10	23552	85407	15	14593	08958	5	91042	27
34	15 28	44 32	76466	10	23534	85434	15	14566	08967	5	91033	26
35	7 15 20	4 44 40	9. 76484	10	10. 23516	9. 85460	16	10. 14540	10. 08977	5	9. 91023	25
36	15 12	44 48	76501	11	23499	85487	16	14513	08986	5	91014	24
37	15 4	44 56	76519	11	23481	85514	16	14486	08995	6	91005	23
38	14 56	45 4	76537	11	23463	85540	17	14460	09004	6	90996	22
39	14 48	45 12	76554	12	23446	85567	17	14433	09013	6	90987	21
40	7 14 40	4 45 20	9. 76572	12	10. 23428	9. 85594	18	10. 14406	10. 09022	6	9. 90978	20
41	14 32	45 28	76590	12	23410	85620	18	14380	09031	6	90969	19
42	14 24	45 36	76607	12	23393	85647	19	14353	09040	6	90960	18
43	14 16	45 44	76625	13	23375	85674	19	14326	09049	6	90951	17
44	14 8	45 52	76642	13	23358	85700	20	14300	09058	7	90942	16
45	7 14 0	4 46 0	9. 76660	13	10. 23340	9. 85727	20	10. 14273	10. 09067	7	9. 90933	15
46	13 52	46 8	76677	14	23323	85754	20	14246	09076	7	90924	14
47	13 44	46 16	76695	14	23305	85780	21	14220	09085	7	90915	13
48	13 36	46 24	76712	14	23288	85807	21	14193	09094	7	90906	12
49	13 28	46 32	76730	14	23270	85834	22	14166	09104	7	90896	11
50	7 13 20	4 46 40	9. 76747	15	10. 23253	9. 85860	22	10. 14140	10. 09113	8	9. 90887	10
51	13 12	46 48	76765	15	23235	85887	23	14113	09122	8	90878	9
52	13 4	46 56	76782	15	23218	85913	23	14087	09131	8	90869	8
53	12 56	47 4	76800	16	23200	85940	24	14060	09140	8	90860	7
54	12 48	47 12	76817	16	23183	85967	24	14033	09149	8	90851	6
55	7 12 40	4 47 20	9. 76835	16	10. 23165	9. 85993	24	10. 14007	10. 09158	8	9. 90842	5
56	12 32	47 28	76852	17	23148	86020	25	13980	09168	8	90832	4
57	12 24	47 36	76870	17	23130	86046	25	13954	09177	9	90823	3
58	12 16	47 44	76887	17	23113	86073	26	13927	09186	9	90814	2
59	12 8	47 52	76904	17	23096	86100	26	13900	09195	9	90805	1
60	12 0	48 0	76922	18	23078	86126	27	13874	09204	9	90796	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
125°			A		A	B		B	C		C	54°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	4	7	9	11	13	16
	B	3	7	10	13	17	20	23
	C	1	2	3	5	6	7	8

TABLE XI

Log. Sines, Tangents, and Secants.

36° | 143°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	7 12 0	4 48 0	9. 76922	0	10. 23078	9. 86126	0	10. 13874	10. 09204	0	9. 90796	60
1	11 52	48 8	76939	0	23061	86153	0	13847	09213	0	90787	59
2	11 44	48 16	76957	1	23043	86179	1	13821	09223	0	90777	58
3	11 36	48 24	76974	1	23026	86206	1	13794	09232	0	90768	57
4	11 28	48 32	76991	1	23009	86232	2	13768	09241	1	90759	56
5	7 11 20	4 48 40	9. 77009	1	10. 22991	9. 86259	2	10. 13741	10. 09250	1	9. 90750	55
6	11 12	48 48	77026	2	22974	86285	3	13715	09259	1	90741	54
7	11 4	48 56	77043	2	22957	86312	3	13688	09269	1	90731	53
8	10 56	49 4	77061	2	22939	86338	4	13662	09278	1	90722	52
9	10 48	49 12	77078	3	22922	86365	4	13635	09287	1	90713	51
10	7 10 40	4 49 20	9. 77095	3	10. 22905	9. 86392	4	10. 13608	10. 09296	2	9. 90704	50
11	10 32	49 28	77112	3	22888	86418	5	13582	09306	2	90694	49
12	10 24	49 36	77130	3	22870	86445	5	13555	09315	2	90685	48
13	10 16	49 44	77147	4	22853	86471	6	13529	09324	2	90676	47
14	10 8	49 52	77164	4	22836	86498	6	13502	09333	2	90667	46
15	7 10 0	4 50 0	9. 77181	4	10. 22819	9. 86524	7	10. 13476	10. 09343	2	9. 90657	45
16	9 52	50 8	77199	5	22801	86551	7	13449	09352	2	90648	44
17	9 44	50 16	77216	5	22784	86577	7	13423	09361	3	90639	43
18	9 36	50 24	77233	5	22767	86603	8	13397	09370	3	90630	42
19	9 28	50 32	77250	5	22750	86630	8	13370	09380	3	90620	41
20	7 9 20	4 50 40	9. 77268	6	10. 22732	9. 86656	9	10. 13344	10. 09389	3	9. 90611	40
21	9 12	50 48	77285	6	22715	86683	9	13317	09398	3	90602	39
22	9 4	50 56	77302	6	22698	86709	10	13291	09408	3	90592	38
23	8 56	51 4	77319	7	22681	86736	10	13264	09417	4	90583	37
24	8 48	51 12	77336	7	22664	86762	11	13238	09426	4	90574	36
25	7 8 40	4 51 20	9. 77353	7	10. 22647	9. 86789	11	10. 13211	10. 09435	4	9. 90565	35
26	8 32	51 28	77370	7	22630	86815	11	13185	09445	4	90555	34
27	8 24	51 36	77387	8	22613	86842	12	13158	09454	4	90546	33
28	8 16	51 44	77405	8	22595	86868	12	13132	09463	4	90537	32
29	8 8	51 52	77422	8	22578	86894	13	13106	09473	5	90527	31
30	7 8 0	4 52 0	9. 77439	9	10. 22561	9. 86921	13	10. 13079	10. 09482	5	9. 90518	30
31	7 52	52 8	77456	9	22544	86947	14	13053	09491	5	90509	29
32	7 44	52 16	77473	9	22527	86974	14	13026	09501	5	90499	28
33	7 36	52 24	77490	9	22510	87000	15	13000	09510	5	90490	27
34	7 28	52 32	77507	10	22493	87027	15	12973	09520	5	90480	26
35	7 7 20	4 52 40	9. 77524	10	10. 22476	9. 87053	15	10. 12947	10. 09529	5	9. 90471	25
36	7 12	52 48	77541	10	22459	87079	16	12921	09538	6	90462	24
37	7 4	52 56	77558	11	22442	87106	16	12894	09548	6	90452	23
38	6 56	53 4	77575	11	22425	87132	17	12868	09557	6	90443	22
39	6 48	53 12	77592	11	22408	87158	17	12842	09566	6	90434	21
40	7 6 40	4 53 20	9. 77609	11	10. 22391	9. 87185	18	10. 12815	10. 09576	6	9. 90424	20
41	6 32	53 28	77626	12	22374	87211	18	12789	09585	6	90415	19
42	6 24	53 36	77643	12	22357	87238	18	12762	09595	7	90405	18
43	6 16	53 44	77660	12	22340	87264	19	12736	09604	7	90396	17
44	6 8	53 52	77677	13	22323	87290	19	12710	09614	7	90386	16
45	7 6 0	4 54 0	9. 77694	13	10. 22306	9. 87317	20	10. 12683	10. 09623	7	9. 90377	15
46	5 52	54 8	77711	13	22289	87343	20	12657	09632	7	90368	14
47	5 44	54 16	77728	13	22272	87369	21	12631	09642	7	90358	13
48	5 36	54 24	77744	14	22256	87396	21	12604	09651	7	90349	12
49	5 28	54 32	77761	14	22239	87422	22	12578	09661	8	90339	11
50	7 5 20	4 54 40	9. 77778	14	10. 22222	9. 87448	22	10. 12552	10. 09670	8	9. 90330	10
51	5 12	54 48	77795	15	22205	87475	22	12525	09680	8	90320	9
52	5 4	54 56	77812	15	22188	87501	23	12499	09689	8	90311	8
53	4 56	55 4	77829	15	22171	87527	23	12473	09699	8	90301	7
54	4 48	55 12	77846	15	22154	87554	24	12446	09708	8	90292	6
55	7 4 40	4 55 20	9. 77862	16	10. 22138	9. 87580	24	10. 12420	10. 09718	9	9. 90282	5
56	4 32	55 28	77879	16	22121	87606	25	12394	09727	9	90273	4
57	4 24	55 36	77896	16	22104	87633	25	12367	09737	9	90263	3
58	4 16	55 44	77913	16	22087	87659	26	12341	09746	9	90254	2
59	4 8	55 52	77930	17	22070	87685	26	12315	09756	9	90244	1
60	4 0	56 0	77946	17	22054	87711	26	12289	09765	9	90235	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
126°			A		A	B		B	C		C	53°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	4	6	9	11	13	15
	B	3	7	10	13	17	20	23
	C	1	2	4	5	6	7	8

TABLE XI

Log. Sines, Tangents, and Secants.

37° | | | | | | | | | | | | 142°

M.	Hour A.M.	Hour P.M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	7 4 0	4 56 0	9.77946	0	10.22054	9.87711	0	10.12289	10.09765	0	9.90235	60
1	3 52	56 8	77963	0	22037	87738	0	12262	09775	0	90225	59
2	3 44	56 16	77980	1	22020	87764	1	12236	09784	0	90216	58
3	3 36	56 24	77997	1	22003	87790	1	12210	09794	0	90206	57
4	3 28	56 32	78013	1	21987	87817	2	12183	09803	1	90197	56
5	7 3 20	4 56 40	9.78030	1	10.21970	9.87843	2	10.12157	10.09813	1	9.90187	55
6	3 12	56 48	78047	2	21953	87869	3	12131	09822	1	90178	54
7	3 4	56 56	78063	2	21937	87895	3	12105	09832	1	90168	53
8	2 56	57 4	78080	2	21920	87922	3	12078	09841	1	90159	52
9	2 48	57 12	78097	2	21903	87948	4	12052	09851	1	90149	51
10	7 2 40	4 57 20	9.78113	3	10.21887	9.87974	4	10.12026	10.09861	2	9.90139	50
11	2 32	57 28	78130	3	21870	88000	5	12000	09870	2	90130	49
12	2 24	57 36	78147	3	21853	88027	5	11973	09880	2	90120	48
13	2 16	57 44	78163	4	21837	88053	6	11947	09889	2	90111	47
14	2 8	57 52	78180	4	21820	88079	6	11921	09899	2	90101	46
15	7 2 0	4 58 0	9.78197	4	10.21803	9.88105	7	10.11895	10.09909	2	9.90091	45
16	1 52	58 8	78213	4	21787	88131	7	11869	09918	3	90082	44
17	1 44	58 16	78230	5	21770	88158	7	11842	09928	3	90072	43
18	1 36	58 24	78246	5	21754	88184	8	11816	09937	3	90063	42
19	1 28	58 32	78263	5	21737	88210	8	11790	09947	3	90053	41
20	7 1 20	4 58 40	9.78280	5	10.21720	9.88236	9	10.11764	10.09957	3	9.90043	40
21	1 12	58 48	78296	6	21704	88262	9	11738	09966	3	90034	39
22	1 4	58 56	78313	6	21687	88289	10	11711	09976	4	90024	38
23	0 56	59 4	78329	6	21671	88315	10	11685	09986	4	90014	37
24	0 48	59 12	78346	7	21654	88341	10	11659	09995	4	90005	36
25	7 0 40	4 59 20	9.78362	7	10.21638	9.88367	11	10.11633	10.10005	4	9.89995	35
26	0 32	59 28	78379	7	21621	88393	11	11607	10015	4	89985	34
27	0 24	59 36	78395	7	21605	88420	12	11580	10024	4	89976	33
28	0 16	59 44	78412	8	21588	88446	12	11554	10034	5	89966	32
29	0 8	59 52	78428	8	21572	88472	13	11528	10044	5	89956	31
30	7 0 0	5 0 0	9.78445	8	10.21555	9.88498	13	10.11502	10.10053	5	9.89947	30
31	6 59 52	0 8	78461	9	21539	88524	14	11476	10063	5	89937	29
32	59 44	0 16	78478	9	21522	88550	14	11450	10073	5	89927	28
33	59 36	0 24	78494	9	21506	88577	14	11423	10082	5	89918	27
34	59 28	0 32	78510	9	21490	88603	15	11397	10092	5	89908	26
35	6 59 20	5 0 40	9.78527	10	10.21473	9.88629	15	10.11371	10.10102	6	9.89898	25
36	59 12	0 48	78543	10	21457	88655	16	11345	10112	6	89888	24
37	59 4	0 56	78560	10	21440	88681	16	11319	10121	6	89879	23
38	58 56	1 4	78576	10	21424	88707	17	11293	10131	6	89869	22
39	58 48	1 12	78592	11	21408	88733	17	11267	10141	6	89859	21
40	6 58 40	5 1 20	9.78609	11	10.21391	9.88759	17	10.11241	10.10151	6	9.89849	20
41	58 32	1 28	78625	11	21375	88786	18	11214	10160	7	89840	19
42	58 24	1 36	78642	12	21358	88812	18	11188	10170	7	89830	18
43	58 16	1 44	78658	12	21342	88838	19	11162	10180	7	89820	17
44	58 8	1 52	78674	12	21326	88864	19	11136	10190	7	89810	16
45	6 58 0	5 2 0	9.78691	12	10.21309	9.88890	20	10.11110	10.10199	7	9.89801	15
46	57 52	2 8	78707	13	21293	88916	20	11084	10209	7	89791	14
47	57 44	2 16	78723	13	21277	88942	20	11058	10219	8	89781	13
48	57 36	2 24	78739	13	21261	88968	21	11032	10229	8	89771	12
49	57 28	2 32	78756	13	21244	88994	21	11006	10239	8	89761	11
50	6 57 20	5 2 40	9.78772	14	10.21228	9.89020	22	10.10980	10.10248	8	9.89752	10
51	57 12	2 48	78788	14	21212	89046	22	10954	10258	8	89742	9
52	57 4	2 56	78805	14	21195	89073	23	10927	10268	8	89732	8
53	56 56	3 4	78821	15	21179	89099	23	10901	10278	9	89722	7
54	56 48	3 12	78837	15	21163	89125	24	10875	10288	9	89712	6
55	6 56 40	5 3 20	9.78853	15	10.21147	9.89151	24	10.10849	10.10298	9	9.89702	5
56	56 32	3 28	78869	15	21131	89177	24	10823	10307	9	89693	4
57	56 24	3 36	78886	16	21114	89203	25	10797	10317	9	89683	3
58	56 16	3 44	78902	16	21098	89229	25	10771	10327	9	89673	2
59	56 8	3 52	78918	16	21082	89255	26	10745	10337	10	89663	1
60	56 0	4 0	78934	16	21066	89281	26	10719	10347	10	89653	0
M.	Hour P.M.	Hour A.M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
127°			A		A	B		B	C		C	52°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols	A	2	4	6	8	10	12	14
	B	3	7	10	13	16	20	23
	C	1	2	4	5	6	7	8

TABLE XI

Log. Sines, Tangents, and Secants.

38° | 141°

M	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine.	M.
0	6 56 0	5 4 0	9.78934	0	10.21066	9.89281	0	10.10719	10.10347	0	9.89653	60
1	55 52	4 8	78950	0	21050	89307	0	10693	10357	0	89643	59
2	55 44	4 16	78967	1	21033	89333	1	10667	10367	0	89633	58
3	55 36	4 24	78983	1	21017	89359	1	10641	10376	1	89624	57
4	55 28	4 32	78999	1	21001	89385	2	10615	10386	1	89614	56
5	6 55 20	5 4 40	9.79015	1	10.20985	9.89411	2	10.10589	10.10396	1	9.89604	55
6	55 12	4 48	79031	2	20969	89437	3	10563	10406	1	89594	54
7	55 4	4 56	79047	2	20953	89463	3	10537	10416	1	89584	53
8	54 56	5 4	79063	2	20937	89489	3	10511	10426	1	89574	52
9	54 48	5 12	79079	2	20921	89515	4	10485	10436	2	89564	51
10	6 54 40	5 5 20	9.79095	3	10.20905	9.89541	4	10.10459	10.10446	2	9.89554	50
11	54 32	5 28	79111	3	20889	89567	5	10433	10456	2	89544	49
12	54 24	5 36	79128	3	20872	89593	5	10407	10466	2	89534	48
13	54 16	5 44	79144	3	20856	89619	6	10381	10476	2	89524	47
14	54 8	5 52	79160	4	20840	89645	6	10355	10486	2	89514	46
15	6 54 0	5 6 0	9.79176	4	10.20824	9.89671	6	10.10329	10.10496	3	9.89504	45
16	53 52	6 8	79192	4	20808	89697	7	10303	10505	3	89495	44
17	53 44	6 16	79208	5	20792	89723	7	10277	10515	3	89485	43
18	53 36	6 24	79224	5	20776	89749	8	10251	10525	3	89475	42
19	53 28	6 32	79240	5	20760	89775	8	10225	10535	3	89465	41
20	6 53 20	5 6 40	9.79256	5	10.20744	9.89801	9	10.10199	10.10545	3	9.89455	40
21	53 12	6 48	79272	6	20728	89827	9	10173	10555	4	89445	39
22	53 4	6 56	79288	6	20712	89853	10	10147	10565	4	89435	38
23	52 56	7 4	79304	6	20696	89879	10	10121	10575	4	89425	37
24	52 48	7 12	79319	6	20681	89905	10	10095	10585	4	89415	36
25	6 52 40	5 7 20	9.79335	7	10.20665	9.89931	11	10.10069	10.10595	4	9.89405	35
26	52 32	7 28	79351	7	20649	89957	11	10043	10605	4	89395	34
27	52 24	7 36	79367	7	20633	89983	12	10017	10615	5	89385	33
28	52 16	7 44	79383	7	20617	90009	12	09991	10625	5	89375	32
29	52 8	7 52	79399	8	20601	90035	13	09965	10636	5	89364	31
30	6 52 0	5 8 0	9.79415	8	10.20585	9.90061	13	10.09939	10.10646	5	9.89354	30
31	51 52	8 8	79431	8	20569	90086	13	09914	10656	5	89344	29
32	51 44	8 16	79447	8	20553	90112	14	09888	10666	5	89334	28
33	51 36	8 24	79463	9	20537	90138	14	09862	10676	6	89324	27
34	51 28	8 32	79478	9	20522	90164	15	09836	10686	6	89314	26
35	6 51 20	5 8 40	9.79494	9	10.20506	9.90190	15	10.09810	10.10696	6	9.89304	25
36	51 12	8 48	79510	10	20490	90216	16	09784	10706	6	89294	24
37	51 4	8 56	79526	10	20474	90242	16	09758	10716	6	89284	23
38	50 56	9 4	79542	10	20458	90268	16	09732	10726	6	89274	22
39	50 48	9 12	79558	10	20442	90294	17	09706	10736	7	89264	21
40	6 50 40	5 9 20	9.79573	11	10.20427	9.90320	17	10.09680	10.10746	7	9.89254	20
41	50 32	9 28	79589	11	20411	90346	18	09654	10756	7	89244	19
42	50 24	9 36	79605	11	20395	90371	18	09629	10767	7	89233	18
43	50 16	9 44	79621	11	20379	90397	19	09603	10777	7	89223	17
44	50 8	9 52	79636	12	20364	90423	19	09577	10787	7	89213	16
45	6 50 0	5 10 0	9.79652	12	10.20348	9.90449	19	10.09551	10.10797	8	9.89203	15
46	49 52	10 8	79668	12	20332	90475	20	09525	10807	8	89193	14
47	49 44	10 16	79684	12	20316	90501	20	09499	10817	8	89183	13
48	49 36	10 24	79699	13	20301	90527	21	09473	10827	8	89173	12
49	49 28	10 32	79715	13	20285	90553	21	09447	10838	8	89162	11
50	6 49 20	5 10 40	9.79731	13	10.20269	9.90578	22	10.09422	10.10848	8	9.89152	10
51	49 12	10 48	79746	14	20254	90604	22	09396	10858	9	89142	9
52	49 4	10 56	79762	14	20238	90630	22	09370	10868	9	89132	8
53	48 56	11 4	79778	14	20222	90656	23	09344	10878	9	89122	7
54	48 48	11 12	79793	14	20207	90682	23	09318	10888	9	89112	6
55	6 48 40	5 11 20	9.79809	15	10.20191	9.90708	24	10.09292	10.10899	9	9.89101	5
56	48 32	11 28	79825	15	20175	90734	24	09266	10909	9	89091	4
57	48 24	11 36	79840	15	20160	90759	25	09241	10919	10	89081	3
58	48 16	11 44	79856	15	20144	90785	25	09215	10929	10	89071	2
59	48 8	11 52	79872	16	20128	90811	26	09189	10940	10	89060	1
60	48 0	12 0	79887	16	20113	90837	26	09163	10950	10	89050	0
M.	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
128°			A		A	B		B	C		C	51°

Seconds of time......		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	4	6	8	10	12	14
	B	3	6	10	13	16	19	23
	C	1	3	4	5	6	8	9

TABLE XI

Log. Sines, Tangents, and Secants.

39° | 140°

M.	Hour A. M.	Hour P. M.	Sine.	Diff	Cosecant.	Tangent.	Diff.	Cotangent.	Secant.	Diff.	Cosine	M.
0	6 48 0	5 12 0	9.79887	0	10.20113	9.90837	0	10.09163	10.10950	0	9.89050	60
1	47 52	12 8	79903	0	20097	90863	0	09137	10960	0	89040	59
2	47 44	12 16	79918	1	20082	90889	1	09111	10970	0	89030	58
3	47 36	12 24	79934	1	20066	90914	1	09086	10980	1	89020	57
4	47 28	12 32	79950	1	20050	90940	2	09060	10991	1	89009	56
5	6 47 20	5 12 40	9.79965	1	10.20035	9.90966	2	10.09034	10.11001	1	9.88999	55
6	47 12	12 48	79981	2	20019	90992	3	09008	11011	1	88989	54
7	47 4	12 56	79996	2	20004	91018	3	08982	11022	1	88978	53
8	46 56	13 4	80012	2	19988	91043	3	08957	11032	1	88968	52
9	46 48	13 12	80027	2	19973	91069	4	08931	11042	2	88958	51
10	6 46 40	5 13 20	9.80043	3	10.19957	9.91095	4	10.08905	10.11052	2	9.88948	50
11	46 32	13 28	80058	3	19942	91121	5	08879	11063	2	88937	49
12	46 24	13 36	80074	3	19926	91147	5	08853	11073	2	88927	48
13	46 16	13 44	80089	3	19911	91172	6	08828	11083	2	88917	47
14	46 8	13 52	80105	4	19895	91198	6	08802	11094	2	88906	46
15	6 46 0	5 14 0	9.80120	4	10.19880	9.91224	6	10.08776	10.11104	3	9.88896	45
16	45 52	14 8	80136	4	19864	91250	7	08750	11114	3	88886	44
17	45 44	14 16	80151	4	19849	91276	7	08724	11125	3	88875	43
18	45 36	14 24	80166	5	19834	91301	8	08699	11135	3	88865	42
19	45 28	14 32	80182	5	19818	91327	8	08673	11145	3	88855	41
20	6 45 20	5 14 40	9.80197	5	10.19803	9.91353	9	10.08647	10.11156	3	9.88844	40
21	45 12	14 48	80213	5	19787	91379	9	08621	11166	4	88834	39
22	45 4	14 56	80228	6	19772	91404	9	08596	11176	4	88824	38
23	44 56	15 4	80244	6	19756	91430	10	08570	11187	4	88813	37
24	44 48	15 12	80259	6	19741	91456	10	08544	11197	4	88803	36
25	6 44 40	5 15 20	9.80274	6	10.19726	9.91482	11	10.08518	10.11207	4	9.88793	35
26	44 32	15 28	80290	7	19710	91507	11	08493	11218	5	88782	34
27	44 24	15 36	80305	7	19695	91533	12	08467	11228	5	88772	33
28	44 16	15 44	80320	7	19680	91559	12	08441	11239	5	88761	32
29	44 8	15 52	80336	7	19664	91585	12	08415	11249	5	88751	31
30	6 44 0	5 16 0	9.80351	8	10.19649	9.91610	13	10.08390	10.11259	5	9.88741	30
31	43 52	16 8	80366	8	19634	91636	13	08364	11270	5	88730	29
32	43 44	16 16	80382	8	19618	91662	14	08338	11280	6	88720	28
33	43 36	16 24	80397	8	19603	91688	14	08312	11291	6	88709	27
34	43 28	16 32	80412	9	19588	91713	15	08287	11301	6	88699	26
35	6 43 20	5 16 40	9.80428	9	10.19572	9.91739	15	10.08261	10.11312	6	9.88688	25
36	43 12	16 48	80443	9	19557	91765	15	08235	11322	6	88678	24
37	43 4	16 56	80458	9	19542	91791	16	08209	11332	6	88668	23
38	42 56	17 4	80473	10	19527	91816	16	08184	11343	7	88657	22
39	42 48	17 12	80489	10	19511	91842	17	08158	11353	7	88647	21
40	6 42 40	5 17 20	9.80504	10	10.19496	9.91868	17	10.08132	10.11364	7	9.88636	20
41	42 32	17 28	80519	10	19481	91893	18	08107	11374	7	88626	19
42	42 24	17 36	80534	11	19466	91919	18	08081	11385	7	88615	18
43	42 16	17 44	80550	11	19450	91945	18	08055	11395	7	88605	17
44	42 8	17 52	80565	11	19435	91971	19	08029	11406	8	88594	16
45	6 42 0	5 18 0	9.80580	12	10.19420	9.91996	19	10.08004	10.11416	8	9.88584	15
46	41 52	18 8	80595	12	19405	92022	20	07978	11427	8	88573	14
47	41 44	18 16	80610	12	19390	92048	20	07952	11437	8	88563	13
48	41 36	18 24	80625	12	19375	92073	21	07927	11448	8	88552	12
49	41 28	18 32	80641	13	19359	92099	21	07901	11458	9	88542	11
50	6 41 20	5 18 40	9.80656	13	10.19344	9.92125	21	10.07875	10.11469	9	9.88531	10
51	41 12	18 48	80671	13	19329	92150	22	07850	11479	9	88521	9
52	41 4	18 56	80686	13	19314	92176	22	07824	11490	9	88510	8
53	40 56	19 4	80701	14	19299	92202	23	07798	11501	9	88499	7
54	40 48	19 12	80716	14	19284	92227	23	07773	11511	9	88489	6
55	6 40 40	5 19 20	9.80731	14	10.19269	9.92253	24	10.07747	10.11522	10	9.88478	5
56	40 32	19 28	80746	14	19254	92279	24	07721	11532	10	88468	4
57	40 24	19 36	80762	15	19238	92304	24	07696	11543	10	88457	3
58	40 16	19 44	80777	15	19223	92330	25	07670	11553	10	88447	2
59	40 8	19 52	80792	15	19208	92356	25	07644	11564	10	88436	1
60	40 0	20 0	80807	15	19193	92381	26	07619	11575	10	88425	0
M	Hour P. M.	Hour A. M.	Cosine.	Diff.	Secant.	Cotangent.	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.
129°			A		A	B		B	C		C	50°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	4	6	8	10	12	13
	B	3	6	10	13	16	19	23
	C	1	3	4	5	7	8	9

TABLE XI

Log. Sines, Tangents, and Secants.

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M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent	Diff.	Cotangent.	Secant.	Diff.	Cosine	M
0	6 40 0	5 20 0	9.80807	0	10.19193	9.92381	0	10.07619	10.11575	0	9.88425	60
1	39 52	20 8	80822	0	19178	92407	0	07593	11585	0	88415	59
2	39 44	20 16	80837	0	19163	92433	1	07567	11596	0	88404	58
3	39 36	20 24	80852	1	19148	92458	1	07542	11606	1	88394	57
4	39 28	20 32	80867	1	19133	92484	2	07516	11617	1	88383	56
5	6 39 20	5 20 40	9.80882	1	10.19118	9.92510	2	10.07490	10.11628	1	9.88372	55
6	39 12	20 48	80897	1	19103	92535	3	07465	11638	1	88362	54
7	39 4	20 56	80912	2	19088	92561	3	07439	11649	1	88351	53
8	38 56	21 4	80927	2	19073	92587	3	07413	11660	1	88340	52
9	38 48	21 12	80942	2	19058	92012	4	07388	11670	2	88330	51
10	6 38 40	5 21 20	9.80957	2	10.19043	9.92638	4	10.07362	10.11681	2	9.88319	50
11	38 32	21 28	80972	3	19028	92663	5	07337	11692	2	88308	49
12	38 24	21 36	80987	3	19013	92689	5	07311	11702	2	88298	48
13	38 16	21 44	81002	3	18998	92715	6	07285	11713	2	88287	47
14	38 8	21 52	81017	3	18983	92740	6	07260	11724	3	88276	46
15	6 38 0	5 22 0	9.81032	4	10.18968	9.92766	6	10.07234	10.11734	3	9.88266	45
16	37 52	22 8	81047	4	18953	92792	7	07208	11745	3	88255	44
17	37 44	22 16	81061	4	18939	92817	7	07183	11756	3	88244	43
18	37 36	22 24	81076	4	18924	92843	8	07157	11766	3	88234	42
19	37 28	22 32	81091	5	18909	92868	8	07132	11777	3	88223	41
20	6 37 20	5 22 40	9.81106	5	10.18894	9.92894	9	10.07106	10.11788	4	9.88212	40
21	37 12	22 48	81121	5	18879	92920	9	07080	11799	4	88201	39
22	37 4	22 56	81136	5	18864	92945	9	07055	11809	4	88191	38
23	36 56	23 4	81151	6	18849	92971	10	07029	11820	4	88180	37
24	36 48	23 12	81166	6	18834	92996	10	07004	11831	4	88169	36
25	6 36 40	5 23 20	9.81180	6	10.18820	9.93022	11	10.06978	10.11842	4	9.88158	35
26	36 32	23 28	81195	6	18805	93048	11	06952	11852	5	88148	34
27	36 24	23 36	81210	7	18790	93073	12	06927	11863	5	88137	33
28	36 16	23 44	81225	7	18775	93099	12	06901	11874	5	88126	32
29	36 8	23 52	81240	7	18760	93124	12	06876	11885	5	88115	31
30	6 36 0	5 24 0	9.81254	7	10.18746	9.93150	13	10.06850	10.11895	5	9.88105	30
31	35 52	24 8	81269	8	18731	93175	13	06825	11906	6	88094	29
32	35 44	24 16	81284	8	18716	93201	14	06799	11917	6	88083	28
33	35 36	24 24	81299	8	18701	93227	14	06773	11928	6	88072	27
34	35 28	24 32	81314	8	18686	93252	14	06748	11939	6	88061	26
35	6 35 20	5 24 40	9.81328	9	10.18672	9.93278	15	10.06722	10.11949	6	9.88051	25
36	35 12	24 48	81343	9	18657	93303	15	06697	11960	6	88040	24
37	35 4	24 56	81358	9	18642	93329	16	06671	11971	7	88029	23
38	34 56	25 4	81372	9	18628	93354	16	06646	11982	7	88018	22
39	34 48	25 12	81387	10	18613	93380	17	06620	11993	7	88007	21
40	6 34 40	5 25 20	9.81402	10	10.18598	9.93406	17	10.06594	10.12004	7	9.87996	20
41	34 32	25 28	81417	10	18583	93431	17	06569	12015	7	87985	19
42	34 24	25 36	81431	10	18569	93457	18	06543	12025	8	87975	18
43	34 16	25 44	81446	11	18554	93482	18	06518	12036	8	87964	17
44	34 8	25 52	81461	11	18539	93508	19	06492	12047	8	87953	16
45	6 34 0	5 26 0	9.81475	11	10.18525	9.93533	19	10.06467	10.12058	8	9.87942	15
46	33 52	26 8	81490	11	18510	93559	20	06441	12069	8	87931	14
47	33 44	26 16	81505	12	18495	93584	20	06416	12080	8	87920	13
48	33 36	26 24	81519	12	18481	93610	20	06390	12091	9	87909	12
49	33 28	26 32	81534	12	18466	93636	21	06364	12102	9	87898	11
50	6 33 20	5 26 40	9.81549	12	10.18451	9.93661	21	10.06339	10.12113	9	9.87887	10
51	33 12	26 48	81563	13	18437	93687	22	06313	12123	9	87877	9
52	33 4	26 56	81578	13	18422	93712	22	06288	12134	9	87866	8
53	32 56	27 4	81592	13	18408	93738	23	06262	12145	10	87855	7
54	32 48	27 12	81607	13	18393	93763	23	06237	12156	10	87844	6
55	6 32 40	5 27 20	9.81622	14	10.18378	9.93789	23	10.06211	10.12167	10	9.87833	5
56	32 32	27 28	81636	14	18364	93814	24	06186	12178	10	87822	4
57	32 24	27 36	81651	14	18349	93840	24	06160	12189	10	87811	3
58	32 16	27 44	81665	14	18335	93865	25	06135	12200	10	87800	2
59	32 8	27 52	81680	15	18320	93891	25	06109	12211	11	87789	1
60	32 0	28 0	81694	15	18306	93916	26	06084	12222	11	87778	0
M	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant	Cotangent.	Diff.	Tangent	Cosecant.	Diff.	Sine	M
130°			A		A	B		B	C		C	49°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	4	6	7	9	11	13
	B	3	6	10	13	16	19	22
	C	1	3	4	5	7	8	9

TABLE XI

Log Sines, Tangents, and Secants

41° 138°

M	Hour A.M.	Hour P.M.	Sine	Diff.	Cosecant	Tangent	Diff.	Cotangent.	Secant	Diff	Cosine	M
0	6 32 0	5 28 0	9.81694	0	10 18306	9 93916	0	10.06084	10.12222	0	9.87778	60
1	31 52	28 8	81709	0	18291	93942	0	06058	12233	0	87767	59
2	31 44	28 16	81723	0	18277	93967	1	06033	12244	0	87756	58
3	31 36	28 24	81738	1	18262	93993	1	06007	12255	1	87745	57
4	31 28	28 32	81752	1	18248	94018	2	05982	12266	1	87734	56
5	6 31 20	5 28 40	9 81767	1	10 18233	9 94044	2	10 05956	10 12277	1	9.87723	55
6	31 12	28 48	81781	1	18219	94069	3	05931	12288	1	87712	54
7	31 4	28 56	81796	2	18204	94095	3	05905	12299	1	87701	53
8	30 56	29 4	81810	2	18190	94120	3	05880	12310	1	87690	52
9	30 48	29 12	81825	2	18175	94146	4	05854	12321	2	87679	51
10	6 30 40	5 29 20	9.81839	2	10 18161	9 94171	4	10 05829	10 12332	2	9 87668	50
11	30 32	29 28	81854	3	18146	94197	5	05803	12343	2	87657	49
12	30 24	29 36	81868	3	18132	94222	5	05778	12354	2	87646	48
13	30 16	29 44	81882	3	18118	94248	6	05752	12365	2	87635	47
14	30 8	29 52	81897	3	18103	94273	6	05727	12376	3	87624	46
15	6 30 0	5 30 0	9 81911	4	10 18089	9.94299	6	10 05701	10 12387	3	9.87613	45
16	29 52	30 8	81926	4	18074	94324	7	05676	12399	3	87601	44
17	29 44	30 16	81940	4	18060	94350	7	05650	12410	3	87590	43
18	29 36	30 24	81955	4	18045	94375	8	05625	12421	3	87579	42
19	29 28	30 32	81969	5	18031	94401	8	05599	12432	4	87568	41
20	6 20 20	5 30 40	9 81983	5	10 18017	9 94426	8	10.05574	10 12443	4	9.87557	40
21	29 12	30 48	81998	5	18002	94452	9	05548	12454	4	87546	39
22	29 4	30 56	82012	5	17988	94477	9	05523	12465	4	87535	38
23	28 56	31 4	82026	5	17974	94503	10	05497	12476	4	87524	37
24	28 48	31 12	82041	6	17959	94528	10	05472	12487	4	87513	36
25	6 28 40	5 31 20	9 82055	6	10.17945	9 94554	11	10 05446	10 12499	5	9.87501	35
26	28 32	31 28	82069	6	17931	94579	11	05421	12510	5	87490	34
27	28 24	31 36	82084	6	17916	94604	11	05396	12521	5	87479	33
28	28 16	31 44	82098	7	17902	94630	12	05370	12532	5	87468	32
29	28 8	31 52	82112	7	17888	94655	12	05345	12543	5	87457	31
30	6 28 0	5 32 0	9.82126	7	10.17874	9 94681	13	10 05319	10.12554	6	9.87446	30
31	27 52	32 8	82141	7	17859	94706	13	05294	12566	6	87434	29
32	27 44	32 16	82155	8	17845	94732	14	05268	12577	6	87423	28
33	27 36	32 24	82169	8	17831	94757	14	05243	12588	6	87412	27
34	27 28	32 32	82184	8	17816	94783	14	05217	12599	6	87401	26
35	6 27 20	5 32 40	9.82198	8	10 17802	9.94808	15	10 05192	10 12610	7	9.87390	25
36	27 12	32 48	82212	9	17788	94834	15	05166	12622	7	87378	24
37	27 4	32 56	82226	9	17774	94859	16	05141	12633	7	87367	23
38	26 56	33 4	82240	9	17760	94884	16	05116	12644	7	87356	22
39	26 48	33 12	82255	9	17745	94910	17	05090	12655	7	87345	21
40	6 26 40	5 33 20	9.82269	10	10.17731	9.94935	17	10.05065	10.12666	7	9.87334	20
41	26 32	33 28	82283	10	17717	94961	17	05039	12678	8	87322	19
42	26 24	33 36	82297	10	17703	94986	18	05014	12689	8	87311	18
43	26 16	33 44	82311	10	17689	95012	18	04988	12700	8	87300	17
44	26 8	33 52	82326	10	17674	95037	19	04963	12712	8	87288	16
45	6 26 0	5 34 0	9 82340	11	10.17660	9.95062	19	10.04938	10 12723	8	9.87277	15
46	25 52	34 8	82354	11	17646	95088	20	04912	12734	9	87266	14
47	25 44	34 16	82368	11	17632	95113	20	04887	12745	9	87255	13
48	25 36	34 24	82382	11	17618	95139	20	04861	12757	9	87243	12
49	25 28	34 32	82396	12	17604	95164	21	04836	12768	9	87232	11
50	6 25 20	5 34 40	9.82410	12	10 17590	9.95190	21	10 04810	10 12779	9	9.87221	10
51	25 12	34 48	82424	12	17576	95215	22	04785	12791	10	87209	9
52	25 4	34 56	82439	12	17561	95240	22	04760	12802	10	87198	8
53	24 56	35 4	82453	13	17547	95266	22	04734	12813	10	87187	7
54	24 48	35 12	82467	13	17533	95291	23	04709	12825	10	87175	6
55	6 24 40	5 35 20	9.82481	13	10.17519	9.95317	23	10 04683	10.12836	10	9.87164	5
56	24 32	35 28	82495	13	17505	95342	24	04658	12847	10	87153	4
57	24 24	35 36	82509	14	17491	95368	24	04632	12859	11	87141	3
58	24 16	35 44	82523	14	17477	95393	25	04607	12870	11	87130	2
59	24 8	35 52	82537	14	17463	95418	25	04582	12881	11	87119	1
60	24 0	36 0	82551	14	17449	95444	25	04556	12893	11	87107	0
M	Hour P.M.	Hour A.M.	Cosine.	Diff	Secant	Cotangent.	Diff.	Tangent	Cosecant	Diff	Sine	M
			A		A	B		B	C		C	

131° 48°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	4	5	7	9	11	12
	B	3	6	10	13	16	19	22
	C	1	3	4	6	7	8	10

TABLE XI

Log. Sines, Tangents, and Secants.

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M	Hour A. M.	Hour P. M.	Sine	Diff.	Cosecant	Tangent.	Diff.	Cotangent	Secant	Diff.	Cosine	M
0	6 24 0	5 36 0	9.82551	0	10.17449	9.95444	0	10.04556	10.12893	0	9.87107	60
1	23 52	36 8	82565	0	17435	95469	0	04531	12904	0	87096	59
2	23 44	36 16	82579	0	17421	95495	1	04505	12915	0	87085	58
3	23 36	36 24	82593	1	17407	95520	1	04480	12927	1	87073	57
4	23 28	36 32	82607	1	17393	95545	2	04455	12938	1	87062	56
5	6 23 20	5 36 40	9.82621	1	10.17379	9.95571	2	10.04429	10.12950	1	9.87050	55
6	23 12	36 48	82635	1	17365	95596	3	04404	12961	1	87039	54
7	23 4	36 56	82649	2	17351	95622	3	04378	12972	1	87028	53
8	22 56	37 4	82663	2	17337	95647	3	04353	12984	2	87016	52
9	22 48	37 12	82677	2	17323	95672	4	04328	12995	2	87005	51
10	6 22 40	5 37 20	9.82691	2	10.17309	9.95698	4	10.04302	10.13007	2	9.86993	50
11	22 32	37 28	82705	3	17295	95723	5	04277	13018	2	86982	49
12	22 24	37 36	82719	3	17281	95748	5	04252	13030	2	86970	48
13	22 16	37 44	82733	3	17267	95774	5	04226	13041	3	86959	47
14	22 8	37 52	82747	3	17253	95799	6	04201	13053	3	86947	46
15	6 22 0	5 38 0	9.82761	3	10.17239	9.95825	6	10.04175	10.13064	3	9.86936	45
16	21 52	38 8	82775	4	17225	95850	7	04150	13076	3	86924	44
17	21 44	38 16	82788	4	17212	95875	7	04125	13087	3	86913	43
18	21 36	38 24	82802	4	17198	95901	8	04099	13098	3	86902	42
19	21 28	38 32	82816	4	17184	95926	8	04074	13110	4	86890	41
20	6 21 20	5 38 40	9.82830	5	10.17170	9.95952	8	10.04048	10.13121	4	9.86879	40
21	21 12	38 48	82844	5	17156	95977	9	04023	13133	4	86867	39
22	21 4	38 56	82858	5	17142	96002	9	03998	13145	4	86855	38
23	20 56	39 4	82872	5	17128	96028	10	03972	13156	4	86844	37
24	20 48	39 12	82885	6	17115	96053	10	03947	13168	5	86832	36
25	6 20 40	5 39 20	9.82899	6	10.17101	9.96078	11	10.03922	10.13179	5	9.86821	35
26	20 32	39 28	82913	6	17087	96104	11	03896	13191	5	86809	34
27	20 24	39 36	82927	6	17073	96129	11	03871	13202	5	86798	33
28	20 16	39 44	82941	6	17059	96155	12	03845	13214	5	86786	32
29	20 8	39 52	82955	7	17045	96180	12	03820	13225	6	86775	31
30	6 20 0	5 40 0	9.82968	7	10.17032	9.96205	13	10.03795	10.13237	6	9.86763	30
31	19 52	40 8	82982	7	17018	96231	13	03769	13248	6	86752	29
32	19 44	40 16	82996	7	17004	96256	14	03744	13260	6	86740	28
33	19 36	40 24	83010	8	16990	96281	14	03719	13272	6	86728	27
34	19 28	40 32	83023	8	16977	96307	14	03693	13283	7	86717	26
35	6 19 20	5 40 40	9.83037	8	10.16963	9.96332	15	10.03668	10.13295	7	9.86705	25
36	19 12	40 48	83051	8	16949	96357	15	03643	13306	7	86694	24
37	19 4	40 56	83065	8	16935	96383	16	03617	13318	7	86682	23
38	18 56	41 4	83078	9	16922	96408	16	03592	13330	7	86670	22
39	18 48	41 12	83092	9	16908	96433	16	03567	13341	8	86659	21
40	6 18 40	5 41 20	9.83106	9	10.16894	9.96459	17	10.03541	10.13353	8	9.86647	20
41	18 32	41 28	83120	9	16880	96484	17	03516	13365	8	86635	19
42	18 24	41 36	83133	10	16867	96510	18	03490	13376	8	86624	18
43	18 16	41 44	83147	10	16853	96535	18	03465	13388	8	86612	17
44	18 8	41 52	83161	10	16839	96560	19	03440	13400	8	86600	16
45	6 18 0	5 42 0	9.83174	10	10.16826	9.96586	19	10.03414	10.13411	9	9.86589	15
46	17 52	42 8	83188	11	16812	96611	19	03389	13423	9	86577	14
47	17 44	42 16	83202	11	16798	96636	20	03364	13435	9	86565	13
48	17 36	42 24	83215	11	16785	96662	20	03338	13446	9	86554	12
49	17 28	42 32	83229	11	16771	96687	21	03313	13458	9	86542	11
50	6 17 20	5 42 40	9.83242	11	10.16758	9.96712	21	10.03288	10.13470	10	9.86530	10
51	17 12	42 48	83256	12	16744	96738	22	03262	13482	10	86518	9
52	17 4	42 56	83270	12	16730	96763	22	03237	13493	10	86507	8
53	16 56	43 4	83283	12	16717	96788	22	03212	13505	10	86495	7
54	16 48	43 12	83297	12	16703	96814	23	03186	13517	10	86483	6
55	6 16 40	5 43 20	9.83310	13	10.16690	9.96839	23	10.03161	10.13528	11	9.86472	5
56	16 32	43 28	83324	13	16676	96864	24	03136	13540	11	86460	4
57	16 24	43 36	83338	13	16662	96890	24	03110	13552	11	86448	3
58	16 16	43 44	83351	13	16649	96915	25	03085	13564	11	86436	2
59	16 8	43 52	83365	14	16635	96940	25	03060	13575	11	86425	1
60	16 0	44 0	83378	14	16622	96966	25	03034	13587	12	86413	0
M	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant	Cotangent	Diff.	Tangent	Cosecant.	Diff.	Sine	M
132°			A		A	B		B	C		C	47°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	3	5	7	9	10	12
	B	3	6	10	13	16	19	22
	C	1	3	4	6	7	9	10

TABLE XI

Log. Sines, Tangents, and Secants.

43° — 136°

M.	Hour A. M.	Hour P. M.	Sine.	Diff	Cosecant	Tangent	Diff.	Cotangent	Secant	Diff.	Cosine	M
0	6 16 0	5 44 0	9. 83378	0	10. 16622	9. 96966	0	10. 03034	10. 13587	0	9. 86413	60
1	15 52	44 8	83392	0	16608	96991	0	03009	13599	0	86401	59
2	15 44	44 16	83405	0	16595	97016	1	02984	13611	0	86389	58
3	15 36	44 24	83419	1	16581	97042	1	02958	13623	1	86377	57
4	15 28	44 32	83432	1	16568	97067	2	02933	13634	1	86366	56
5	6 15 20	5 44 40	9. 83446	1	10 16554	9. 97092	2	10. 02908	10. 13646	1	9. 86354	55
6	15 12	44 48	83459	1	16541	97118	3	02882	13658	1	86342	54
7	15 4	44 56	83473	2	16527	97143	3	02857	13670	1	86330	53
8	14 56	45 4	83486	2	16514	97168	3	02832	13682	2	86318	52
9	14 48	45 12	83500	2	16500	97193	4	02807	13694	2	86306	51
10	6 14 40	5 45 20	9. 83513	2	10. 16487	9. 97219	4	10. 02781	10. 13705	2	9. 86295	50
11	14 32	45 28	83527	2	16473	97244	5	02756	13717	2	86283	49
12	14 24	45 36	83540	3	16460	97269	5	02731	13729	2	86271	48
13	14 16	45 44	83554	3	16446	97295	5	02705	13741	3	86259	47
14	14 8	45 52	83567	3	16433	97320	6	02680	13753	3	86247	46
15	6 14 0	5 46 0	9. 83581	3	10. 16419	9. 97345	6	10. 02655	10. 13765	3	9. 86235	45
16	13 52	46 8	83594	4	16406	97371	7	02629	13777	3	86223	44
17	13 44	46 16	83608	4	16392	97396	7	02604	13789	3	86211	43
18	13 36	46 24	83621	4	16379	97421	8	02579	13800	4	86200	42
19	13 28	46 32	83634	4	16366	97447	8	02553	13812	4	86188	41
20	6 13 20	5 46 40	9. 83648	4	10. 16352	9. 97472	8	10. 02528	10. 13824	4	9. 86176	40
21	13 12	46 48	83661	5	16339	97497	9	02503	13836	4	86164	39
22	13 4	46 56	83674	5	16326	97523	9	02477	13848	4	86152	38
23	12 56	47 4	83688	5	16312	97548	10	02452	13860	5	86140	37
24	12 48	47 12	83701	5	16299	97573	10	02427	13872	5	86128	36
25	6 12 40	5 47 20	9. 83715	6	10. 16285	9. 97598	11	10. 02402	10. 13884	5	9. 86116	35
26	12 32	47 28	83728	6	16272	97624	11	02376	13896	5	86104	34
27	12 24	47 36	83741	6	16259	97649	11	02351	13908	5	86092	33
28	12 16	47 44	83755	6	16245	97674	12	02326	13920	6	86080	32
29	12 8	47 52	83768	6	16232	97700	12	02300	13932	6	86068	31
30	6 12 0	5 48 0	9. 83781	7	10. 16219	9 97725	13	10. 02275	10. 13944	6	9. 86056	30
31	11 52	48 8	83795	7	16205	97750	13	02250	13956	6	86044	29
32	11 44	48 16	83808	7	16192	97776	13	02224	13968	6	86032	28
33	11 36	48 24	83821	7	16179	97801	14	02199	13980	7	86020	27
34	11 28	48 32	83834	8	16166	97826	14	02174	13992	7	86008	26
35	0 11 20	5 48 40	9. 83848	8	10. 16152	9. 97851	15	10 02149	10. 14004	7	9. 85996	25
36	11 12	48 48	83861	8	16139	97877	15	02123	14016	7	85984	24
37	11 4	48 56	83874	8	16126	97902	16	02098	14028	7	85972	23
38	10 56	49 4	83887	8	16113	97927	16	02073	14040	8	85960	22
39	10 48	49 12	83901	9	16099	97953	16	02047	14052	8	85948	21
40	6 10 40	5 49 20	9 83914	9	10. 16086	9. 97978	17	10. 02022	10. 14064	8	9. 85936	20
41	10 32	49 28	83927	9	16073	98003	17	01997	14076	8	85924	19
42	10 24	49 36	83940	9	16060	98029	18	01971	14088	8	85912	18
43	10 16	49 44	83954	10	16046	98054	18	01946	14100	9	85900	17
44	10 8	49 52	83967	10	16033	98079	19	01921	14112	9	85888	16
45	6 10 0	5 50 0	9 83980	10	10. 16020	9. 98104	19	10. 01896	10. 14124	9	9. 85876	15
46	9 52	50 8	83993	10	16007	98130	19	01870	14136	9	85864	14
47	9 44	50 16	84006	10	15994	98155	20	01845	14149	9	85851	13
48	9 36	50 24	84020	11	15980	98180	20	01820	14161	10	85839	12
49	9 28	50 32	84033	11	15967	98206	21	01794	14173	10	85827	11
50	6 9 20	5 50 40	9. 84046	11	10. 15954	9. 98231	21	10. 01769	10. 14185	10	9. 85815	10
51	9 12	50 48	84059	11	15941	98256	22	01744	14197	10	85803	9
52	9 4	50 56	84072	12	15928	98281	22	01719	14209	10	85791	8
53	8 56	51 4	84085	12	15915	98307	22	01693	14221	11	85779	7
54	8 48	51 12	84098	12	15902	98332	23	01668	14234	11	85766	6
55	6 8 40	5 51 20	9. 84112	12	10. 15888	9. 98357	23	10. 01643	10 14246	11	9 85754	5
56	8 32	51 28	84125	12	15875	98383	24	01617	14258	11	85742	4
57	8 24	51 36	84138	13	15862	98408	24	01592	14270	11	85730	3
58	8 16	51 44	84151	13	15849	98433	24	01567	14282	12	85718	2
59	8 8	51 52	84164	13	15836	98458	25	01542	14294	12	85706	1
60	8 0	52 0	84177	13	15823	98484	25	01516	14307	12	85693	0
M	Hour P. M.	Hour A. M.	Cosine	Diff	Secant	Cotangent.	Diff.	Tangent	Cosecant	Diff	Sine	M.
133°			A		A	B		B	C		C	46°

Seconds of time		1s	2s	3s	4s	5s	6s	7s
Prop. parts of cols.	A	2	3	5	7	8	10	12
	B	3	6	9	13	16	19	22
	C	2	3	5	6	8	9	11

TABLE XI

Log. Sines, Tangents, and Secants.

44° | 135°

M.	Hour A. M.	Hour P. M.	Sine.	Diff.	Cosecant.	Tangent.	Diff.	Cotangent	Secant	Diff	Cosine.	M.
0	6 8 0	5 52 0	9.84177	0	10.15823	9.98484	0	10.01516	10.14307	0	9.85693	60
1	7 52	52 8	84190	0	15810	98509	0	01491	14319	0	85681	59
2	7 44	52 16	84203	0	15797	98534	1	01466	14331	0	85669	58
3	7 36	52 24	84216	1	15784	98560	1	01440	14343	1	85657	57
4	7 28	52 32	84229	1	15771	98585	2	01415	14355	1	85645	56
5	6 7 20	5 52 40	9.84242	1	10.15758	9.98610	2	10.01390	10.14368	1	9.85632	55
6	7 12	52 48	84255	1	15745	98635	3	01365	14380	1	85620	54
7	7 4	52 56	84269	2	15731	98661	3	01339	14392	1	85608	53
8	6 56	53 4	84282	2	15718	98686	3	01314	14404	2	85596	52
9	6 48	53 12	84295	2	15705	98711	4	01289	14417	2	85583	51
10	6 6 40	5 53 20	9.84308	2	10.15692	9.98737	4	10.01263	10.14429	2	9.85571	50
11	6 32	53 28	84321	2	15679	98762	5	01238	14441	2	85559	49
12	6 24	53 36	84334	3	15666	98787	5	01213	14453	2	85547	48
13	6 16	53 44	84347	3	15653	98812	5	01188	14466	3	85534	47
14	6 8	53 52	84360	3	15640	98838	6	01162	14478	3	85522	46
15	6 6 0	5 54 0	9.84373	3	10.15627	9.98863	6	10.01137	10.14490	3	9.85510	45
16	5 52	54 8	84385	3	15615	98888	7	01112	14503	3	85497	44
17	5 44	54 16	84398	4	15602	98913	7	01087	14515	4	85485	43
18	5 36	54 24	84411	4	15589	98939	8	01061	14527	4	85473	42
19	5 28	54 32	84424	4	15576	98964	8	01036	14540	4	85460	41
20	6 5 20	5 54 40	9.84437	4	10.15563	9.98989	8	10.01011	10.14552	4	9.85448	40
21	5 12	54 48	84450	5	15550	99015	9	00985	14564	4	85436	39
22	5 4	54 56	84463	5	15537	99040	9	00960	14577	5	85423	38
23	4 56	55 4	84476	5	15524	99065	10	00935	14589	5	85411	37
24	4 48	55 12	84489	5	15511	99090	10	00910	14601	5	85399	36
25	6 4 40	5 55 20	9.84502	5	10.15498	9.99116	11	10.00884	10.14614	5	9.85386	35
26	4 32	55 28	84515	6	15485	99141	11	00859	14626	5	85374	34
27	4 24	55 36	84528	6	15472	99166	11	00834	14639	6	85361	33
28	4 16	55 44	84540	6	15460	99191	12	00809	14651	6	85349	32
29	4 8	55 52	84553	6	15447	99217	12	00783	14663	6	85337	31
30	6 4 0	5 56 0	9.84566	6	10.15434	9.99242	13	10.00758	10.14676	6	9.85324	30
31	3 52	56 8	84579	7	15421	99267	13	00733	14688	6	85312	29
32	3 44	56 16	84592	7	15408	99293	13	00707	14701	7	85299	28
33	3 36	56 24	84605	7	15395	99318	14	00682	14713	7	85287	27
34	3 28	56 32	84618	7	15382	99343	14	00657	14726	7	85274	26
35	6 3 20	5 56 40	9.84630	8	10.15370	9.99368	15	10.00632	10.14738	7	9.85262	25
36	3 12	56 48	84643	8	15357	99394	15	00606	14750	7	85250	24
37	3 4	56 56	84656	8	15344	99419	16	00581	14763	8	85237	23
38	2 56	57 4	84669	8	15331	99444	16	00556	14775	8	85225	22
39	2 48	57 12	84682	8	15318	99469	16	00531	14788	8	85212	21
40	6 2 40	5 57 20	9.84694	9	10.15306	9.99495	17	10.00505	10.14800	8	9.85200	20
41	2 32	57 28	84707	9	15293	99520	17	00480	14813	8	85187	19
42	2 24	57 36	84720	9	15280	99545	18	00455	14825	9	85175	18
43	2 16	57 44	84733	9	15267	99570	18	00430	14838	9	85162	17
44	2 8	57 52	84745	9	15255	99596	19	00404	14850	9	85150	16
45	6 2 0	5 58 0	9.84758	10	10.15242	9.99621	19	10.00379	10.14863	9	9.85137	15
46	1 52	58 8	84771	10	15229	99646	19	00354	14875	10	85125	14
47	1 44	58 16	84784	10	15216	99672	20	00328	14888	10	85112	13
48	1 36	58 24	84796	10	15204	99697	20	00303	14900	10	85100	12
49	1 28	58 32	84809	11	15191	99722	21	00278	14913	10	85087	11
50	6 1 20	5 58 40	9.84822	11	10.15178	9.99747	21	10.00253	10.14926	10	9.85074	10
51	1 12	58 48	84835	11	15165	99773	21	00227	14938	11	85062	9
52	1 4	58 56	84847	11	15153	99798	22	00202	14951	11	85049	8
53	0 56	59 4	84860	11	15140	99823	22	00177	14963	11	85037	7
54	0 48	59 12	84873	12	15127	99848	23	00152	14976	11	85024	6
55	6 0 40	5 59 20	9.84885	12	10.15115	9.99874	23	10.00126	10.14988	11	9.85012	5
56	0 32	59 28	84898	12	15102	99899	24	00101	15001	12	84999	4
57	0 24	59 36	84911	12	15089	99924	24	00076	15014	12	84986	3
58	0 16	59 44	84923	12	15077	99949	24	00051	15026	12	84974	2
59	0 8	59 52	84936	13	15064	99975	25	00025	15039	12	84961	1
60	0 0	6 0 0	84949	13	15051	10.00000	25	00000	15051	12	84949	0
M.	Hour P. M.	Hour A. M.	Cosine	Diff.	Secant.	Cotangent	Diff.	Tangent.	Cosecant.	Diff.	Sine.	M.

134° | A | A | B | B | C | C | 45°

Seconds of time		1ˢ	2ˢ	3ˢ	4ˢ	5ˢ	6ˢ	7ˢ
Prop. parts of cols.	A	2	3	5	6	8	10	11
	B	3	6	9	13	16	19	22
	C	2	3	5	6	8	9	11

ROUTE SURVEYING IN OPEN COUNTRY.

BY ORIC BATES.

The purpose of this section is to enable the traveller to collect in the field data from which he may construct a map of the localities he has visited.

Instruments.

The following instruments are essential: (1) A scale of equal parts, preferably divided according to the metric system into centimeters and twentieths. Scales should have both edges bevelled and divided. A handy length is 15 cms. Leather slip-cases protect the edges. (2) A small, right-angled triangle of transparent celluloid, thickest procurable. The radius should be about 10 cm. long. (3) A semicircular protractor of metal (German silver or brass) about 8 to 10 cm. in radius, and divided to read 30′. (4) A pair of dividers, about 10 cm. long, with detachable or reversible pencil-holder and extension bar. Also, a key for loosening and tightening the pivot. (5) A steel tape, at least 20 meters long, in a leather case, to roll up by hand. (6) A compass, 6 to 10 cm. in diameter, fitted with a strong leather sling case. The best compasses are the prismatic ones of European make, but those fitted with open sight-vanes will serve for very rough work. In either case, the check-lever by which the needle is clamped must not admit sand or dust. (7) A night-marching compass (those designed by Captain Belfield are the best). (8) An aneroid barometer, of good make, fitted with an altitude scale. If possible, a pair of these instruments should be carried. (9) A pair of good thermometers reading to 0.5°, with a metal case. (10) An instrument for measuring angles — either a light traveller's sextant, a box sextant, or a light transit instrument. The last is strongly recommended. (11) A good lever-watch of known rate. (12) A pair of field glasses (preferably "day and night" glasses). The traveller should be thoroughly competent to use and adjust the above instruments before going into the field.

It is a mistake to buy any but the best instruments, or to obtain them second-hand without the advantage of an expert opinion. Angle-measuring instruments purchased from Swiss or other Continental makers should be graduated on the principle of 360° to the circle (not 400°). In hot climates pencils become several grades softer than standard; "4 H" is by no means too hard for field work in the Tropics, and in desert surveys, even harder pencils are found desirable. Note-books of tinted paper (green or blue) will be found less trying on the eyes than white in regions where the sun is very strong.

Definitions.

(1) "The course" is the angle made by a line of march (or by the track of a ship) with the meridian. This angle may be reckoned either in points (8 points to a quadrant) and fractional points of the mariner's compass (*e. g.*, SSE; NE½E, etc.), or in degrees. In the latter case, the degrees may be counted clockwise from the north point (*e. g.*, 90° = E; 180° = S; 270° = W; 315° = NW, etc.), or from north to east and north to west, and from south to east and south to west. The reckoning in a complete circle is by far the more convenient. Note that, as there are 32 points in the circle of the mariner's compass, 1 point = 11° 15′ of arc. Thus, NNE½E = 2½ points from north = 28° 7′ 30″. In practice, compass bearings are seldom read closer than 1°.

(2) Distance ("Dist.") is technically the length of a course in units of length (nautical miles, kilometers, versts, etc.) or, when the rate of travel is known and uniform, in hours and fractions, afterwards to be converted into units of length. In the problems given below, nautical miles are regularly to be understood when miles are mentioned.

(3) Difference of Latitude ("Diff. Lat.") is the distance on the meridian between the latitude of one point and

that of another. It may be reckoned in linear measure or arc, since 1′ of Diff. Lat. = 1 mile. When one point lies due east or west of another there is no Diff. Lat. between them.

(4) Departure ("Dep.") is the distance along a parallel of latitude between the meridians of two points. When one point is due north or south of another there is no Dep. between them.

(5) Difference of Longitude ("Diff. Long.") is the difference in arc between the meridian of one point and that of another. The length of 1° of longitude for every degree of latitude is exhibited in the following table.

Length of One Degree of Longitude in Different Latitudes.

Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles	Lat.	Miles
°		°		°		°		°	
1	59.99	19	56.73	37	47.92	55	34.41	73	17.54
2	59.96	20	56.38	38	47.28	56	33.55	74	16.54
3	59.92	21	56.01	39	46.63	57	32.68	75	15.53
4	59.85	22	55.63	40	45.96	58	31.80	76	14.52
5	59.77	23	55.23	41	45.28	59	30.90	77	13.50
6	59.67	24	54.81	42	44.59	60	30.00	78	12.47
7	59.55	25	54.38	43	43.88	61	29.09	79	11.45
8	59.42	26	53.93	44	43.16	62	28.17	80	10.42
9	59.26	27	53.46	45	42.43	63	27.24	81	9.39
10	59.09	28	52.98	46	41.68	64	26.30	82	8.35
11	58.90	29	52.48	47	40.92	65	25.36	83	7.31
12	58.69	30	51.96	48	40.15	66	24.40	84	6.27
13	58.46	31	51.43	49	39.36	67	23.44	85	5.23
14	58.22	32	50.88	50	38.57	68	22.48	86	4.19
15	57.96	33	50.32	51	37.76	69	21.50	87	3.14
16	57.68	34	49.74	52	36.94	70	20.52	88	2.09
17	57.38	35	49.15	53	36.11	71	19.53	89	1.05
18	57.06	36	48.54	54	35.27	72	18.54	90	0.00

The conversion of Dep. to Diff. Long. and *vice versa* can be readily effected by use of the above table, or by the factors in Table I (p. 329).

Problem 1.— Given the Course and Dist., to Find the Diff. Lat. and Dep.

EXAMPLE.— An expedition marches from a point in Lat. 12° 36′ N on a course of 123° 45′ (= SE by E) for 27 miles, and then halts. What is the Lat. reached, and what Dep. has been made?

Draw the meridian line NS (Fig. 22), and at A, lay off the angle $NAB = 123° 45'$. With the graduated scale, lay off 27 equal parts (one part for each mile) from A to D. From D drop a vertical to the meridian NS at C. Then AC = the Diff. Lat. = 15.1, and CD = the Dep. = 22.4 miles.

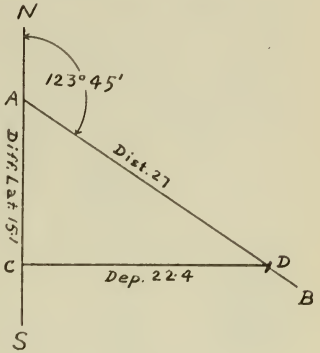


Fig. 22

By Table I (p. 329). The course 123° 45′ being larger than 90° and less than 180°, subtract it from the latter, thus obtaining the supplement, 56° 15′. Enter Table I with the nearest whole degree of this supplement, 56°, against which will be found the factors 0.559 for the Diff. Lat. and 0.829 for the Dep. Multiply Dist. 27 by the first of these factors: $27 \times 0.559 = 15.09$ as the Diff. Lat.; multiply Dist. 27 by the second factor: $27 \times 0.829 = 22.38$ as the Dep. (In determining the Diff. Lat. and Dep. "by inspection," note clearly in what quadrant the course falls; if between 0° and 90° it will lie between north and east; if between 90° and 180° it will lie between east and south, etc. Table I (p. 329) gives courses only up to 90°; hence continuous readings must be reduced to quadrant readings.)

Problem 2. — Given the Course and Diff. Lat., to Find the Dist. and Dep.

Example. — A caravan leaves a town in Lat. 12° 18′ N and follows a course of 326° 15′ (NW by N). At noon, by an observation of the sun, the Lat. is 12° 31′ N. What is the Dist. travelled, and the Dep. made?

The Diff. Lat. = 12° 31′ − 12° 18′ = 13′. Draw AB (Fig. 23) = 13 miles = Diff. Lat. The course being over 270°, subtract it from 360°, which gives 33° 45′. Lay off at this angle the line AC from A. At B erect a perpendicular to AB, and prolong it to cut AC. Then, the distance BC gives the Dep. = 8.6 miles, and the distance AC gives the Dist. travelled = 15.6 miles.

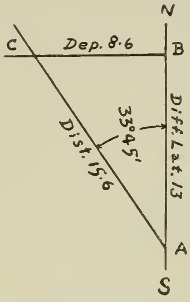


FIG. 23

By Table I. The nearest number of degrees to 33° 45′ to be found in the table is 34°. With this as a course enter Table I (p. 329), and take out the Diff. Lat. factor, 0.829, by which divide 13, the Diff. Lat. This gives 13 ÷ 0.829 = 15.6 = Dist. Take out the Dep. factor, 0.559, multiply the Dist. 15.6 just obtained. This gives 15.6 × 0.559 = 8.7 = Dep.

Problem 3. — Given the Dist. and Diff. Lat., to Find the Course and Dep.

EXAMPLE. — From Zaghawah Oasis, in Lat. 18° 1′ N. an expedition covers 147 miles in a direction south and west, when, by observation, the Lat. is found to be 15° 52′ N. What is the Course and Dep. from Zaghawah?

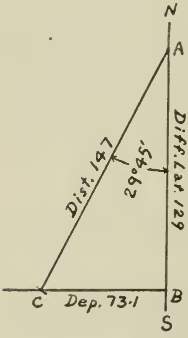


FIG. 24

Diff. Lat. = 18° 1′ − 15° 52′ = 2° 9′ = (60 × 2) + 9 = 129 miles. Draw AB (Fig. 24) = 129 miles. At B erect the vertical BC, of indefinite length. With radius = 147 miles, the Dist., and A as a center, cut the line BC. Then, BC = Dep. = 73.1 miles, and the angle BAC = the Course = S 29° 45′ W = 209° 45′ (= about SSW ¾ W).

Problem 4. — *To Find the Distance and Altitude of an Inaccessible Elevation.*

Measure with the tape a base-line (Fig. 25) of such length and direction that the angle ACB shall be as nearly a right angle as possible. From A measure the horizontal angle BAC, and from B measure the angle ABC. Measure also the vertical angles of the summit C at each station. Plot AB to scale, and lay off from each station the lines of sight. Their intersection gives the location of the point C.

To find the elevation of the point thus determined, erect at C the indefinite lines CD and CE, perpendicular to AC and to BC respectively. Construct the angles CAD and CBE equal to the vertical angles observed at A and B. Then CD = the altitude of C above Station A, while CE = the altitude above Station B.

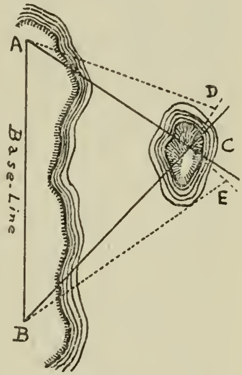


FIG. 25

A rougher method of finding the distance of an inaccessible object is by compass bearings taken from each end of a base on the point to be located, the bearing of the base-line itself being also noted, and the whole plotted to scale.

Problem 5. — *To Find a Distance very roughly by the Velocity of Sound.*

The velocity of sound is 1090 feet a second in calm weather with the thermometer at 32° F. For each additional degree of temperature add 0.96 feet to this velocity. Note by stop-watch the number of seconds between a visible explosion at a distant point and the sound of it. Multiply this number of seconds by the corrected velocity to obtain the approximate distance of the explosion.

Local Surveys.

For surveying limited areas the best instrument is the plane-table. This consists of (1) a drawing-board so mounted on a tripod as to be easily levelled, rotated to any desired alignment, and then clamped; (2) a level used to set the board in a horizontal position; and (3) an alidade. This last is a straight-edge fitted with sights (either open or telescopic), the axis of which is parallel with the straight-edge.

Topographic work of a rough sort may be done with an improvised plane-table made of any flat wooden surface, such as the cover of a camel-box; it is only essential that, when the paper is pinned on it, the surface of the latter should be flat. A stand for the board may be made of boxes or of stones. On this stand the board must rest firmly. A pocket level — at worst a medicine vial three-quarters full of water will serve — must be used in levelling the board. A straight-edge may be made out of an ordinary box-wood "ruler," by sticking a needle in each end of it at exactly the same distance from the edge of the scale, *i. e.*, so that an imaginary line through the needles would be exactly parallel to the edge of the scale. See that the needles are perpendicular to the flat plane of the scale; they may be set true with the help of a right-angled triangle. The straight-edge being thus fitted with sight-vanes, and the board prepared, the traveller is ready to begin his survey.

The first act should be the drawing of a north-and-south line on the paper by the help of a pocket compass. Having established this magnetic meridian, the observer has the choice of plotting his points either by direct measurement with a tape, or by "cutting in." The former method is only suitable for an area comprised within a radius of about 150 yards from the observer; it is, however, frequently combined with the latter.

By direct measurement. — The observer marks a point on his paper to represent his position, and determines the scale to which his plot is to be made. With the edge of his scale against the point representing his position, which we may call A, he sights on any point, p, that he wishes to locate, and rules an indefinite line from A toward p. The distance between A and p is then measured by the tape, after which the same distance is laid off to scale along the line from A, and the point p is thus plotted. This process is repeated until the observer has located on his map all the points within easy measuring distance. On the sheet he notes down any such details as will help him in constructing a finished map when he returns from the field.

By "cutting-in." — Suppose that the traveller, having mapped a small area by the method just described, wishes to locate various more distant points. He should sight on these points, p', p'', p''', etc., and then on another, B, within measurable distance, in all cases ruling out lines toward the points, and in the last case, plotting B to scale. Let him then remove his plane-table to B, and set it up over that point with the aid of a plumb-line. He first levels his board and then orients it, so that the north-and south line he drew on his sheet while at Station A is again true to the magnetic meridian. This puts the table in approximate adjustment. To make the adjustment perfect, the observer must take a "back-sight" on his first station. To do this he first places his straight-edge against B, and then sights back on A. If, when he does so, the edge of the scale does not coincide with the line AB, let him move the board little by little (keeping it level) until it does so. When this back-sight coincides with the original "fore-sight," and the board is level, with the point B on the paper directly over the point B on the ground, the board is in adjustment in its second "set-up." The observer now sights on p', p'', p''', etc., and rules out his lines from B. The intersections of these lines with those ruled toward the same points from A, give the desired positions. This process of "cutting-in," obviously, may be repeated until the sheet is filled, and a new one requisitioned. When this change is made, be sure the two sheets show two or more points in common, so that they may be correlated in constructing a map of the whole survey.

A good method is to put in a pin or needle at A or B (or whatever the set-up point is) against which the straight-edge may be swivelled in taking sights. Remember that the board must be kept level, and all taping must be "sighted in" to assure the measurements being taken in a straight line from the "set-up" to the point.

The Day's March.

Route-books. — A handy size for route-books is 13 × 20 cm. The book should be hinged along a short edge, and ought to contain about 100 pages of tough, smooth paper of greenish or bluish tint. The right-hand page should be blank, except for two fine black lines crossing at right angles in the middle of the page. The left-hand page should be cross-ruled in blue lines ("quadrille paper") spaced 0.5 cm. apart. On the inside of each cover should be a pocket for scale, triangle, and protractor, and the book should be fitted with pencil holders along the edges and with cloth bands to keep it shut when not in use.

Fig. 26 exhibits an imaginary day's march through desert country as entered in the route-book. Such a line of march, made up of various successive courses, is called a "traverse." In explanation of this figure: the recorder intended to follow a southerly line, and to make more Diff. Lat. than Dep., so that he naturally chose the longer of the cross-lines printed on the traverse-page as his meridian, naming the ends of the lines 0°, 90°, 180°, 270° (or N, E, S, W). At the top of the page are entered the date and the time of beginning and ending of the march. All entries are in hand-print for legibility. A scale of miles and corresponding marching-time is entered where most convenient (in Fig. 26 this rate is 2.5 miles an hour = 0.0416 per minute). As the traveller reckoned that the march would be east of south, he entered his point of departure, *A*, well up in the left-hand (NW) corner of the page, noting the dates and hours of his arrival at, and departure from, that station, together with its Long. and Lat. as calculated on the day he reached it (April 24), and its elevation above sea-level as found by an aneroid. Notes were entered on the quadrille page (left), while on the traverse-sheet (right) the sketch of the route was plotted as accurately as possible. (Do not put in the route-book descriptive material which ought to be in the journal.) The lines of march are plotted as solid lines, and the observed angles of distant points ("side-shots") are dotted. At each change of course the time is noted, the new direction is noted in degrees (or points), and all points

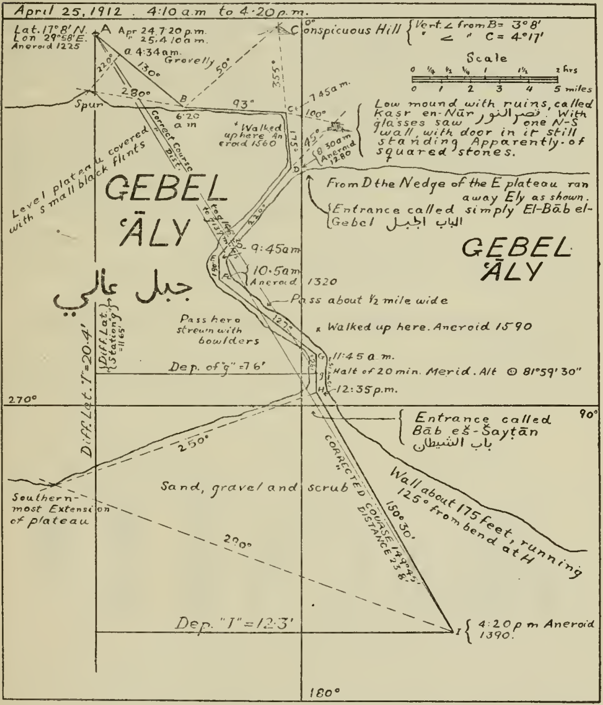


Fig. 26. Plotting of a Day's March

where the course is changed are lettered consecutively. In taking "side-shots" of distant elevations, vertical angles are also to be observed (as in "conspicuous hill," Fig. 26). Where possible, place-names are given in English transliteration and in the script of the country (*e. g.*, Gebel ʿĀly in Arabic and English in Fig. 26). When "side-shots" are taken at an intermediate point on any one line of march, the time must be noted (*e. g.*, at *a*). Aneroid readings are similarly fixed, or so plotted as to indicate their position. Notes as to soil, vegetation, etc., are entered as the character of the country changes. At noon a halt was made at *g* (between Stations *G* and *H*) to take a meridian altitude of the sun for latitude. (The observations are worked out in camp, and the results noted on the quadrille page.) The observer plotted the Diff. Lat. and Dep. of *g* from *A*, which gave him the Lat. and Long. of *g* by "Dead Reckoning." At Station *I* the traveller camped for the night, noting the time and elevation by aneroid, and taking a last "side-shot" on a point of the plateau west-northwesterly from his camp. By connecting *A* and *I* with a straight line the traveller obtained the Corrected Course (149° 45′) and Dist. (23.8); while a vertical from *I* to the meridian of *A* gave him the Dep. (12.3).

On the quadrille page the traverse in Fig. 26 would be entered thus:

Courses	Dist.	Diff. Lat.		Dep.	
		N	S	E	W
A – B 130°	3.9	0	2.50	3.00	0
B – C 93°	3.5	0	0.20	3.48	0
C – D 175°	1.9	0	1.88	0.20	0
D – E 220°	3.9	0	3.00	0	2.50
E – F 180°	0.8	0	0.80	0	0
F – G 127°	4.2	0	2.53	3.35	0
G – H 180°	1.3	0	1.30	0	0
H – I 150° 30′	9.4	0	8.20	4.75	0
		0	20.41	14.78	2.50
		20.41 S		12.28 E	

Rules for reducing a traverse (*i. e.*, to find the correct Diff. Lat. and Dep. of the place finally reached): Solve each course, either by projection or by inspection (see Problem 1). Note the Diff. Lat. and Dep. when obtained, in their appropriate columns, the former under north when the course has been northerly, and under south when the course has been southerly; the latter under east when the Dep. has been easterly, and under west when it has been westerly.

Having thus entered each course, add each of the four columns, N, S, E, and W. Take the difference between the northings and southings, and the result will be the desired Diff. Lat. north or south of the point of departure according as the larger sum was found in column N or (as in the example) in column S. Take the difference between the eastings and westings in the same manner, calling the resulting Dep. easterly or westerly according to which is the larger sum. The corrected course and direct distance between the point of departure and that reached can then be found as in the example.

Topographic Detail.

The traveller should aim at getting in as many natural features as possible in his route survey. Therefore, in a country where there is much relief, he should use several traverse-sheets for a single march, always being careful

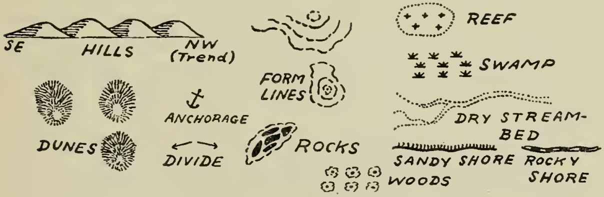


Fig. 27. Topographic Symbols

that on each new page are entered one or more points by which the page is "tied on" to the preceding sheet. Keep pencils sharp and book neat and clean; remember that a few carefully entered details are better than a host of ill recorded ones. A few conventional signs are shown in Fig. 27; others the traveller may employ if he pleases.

NOTES ON TRAVERSE SURVEYS IN TROPICAL SOUTH AMERICA.

BY A. HAMILTON RICE, M.D.

It is presumed that the reader has a practical working knowledge of taking astronomical observations with both transit theodolite and sextant, has some training in the field work of traverse surveys, and the cartographical ability to construct scales and do neat, correct topographical sketching and drawing.

In parts of South America, notably the Amazons Basin and regions contiguous to it, there is great difficulty, on account of dense forests, impenetrable swamps, and innumerable streams, in surveying any features other than the line of track or river followed. As both land routes and rivers are extremely winding, bearings have to be taken at frequent intervals. These bearings are entered in some sort of field-book and the route passed over is afterward plotted from the figures and notes by means of a protractor and time scale or several of the latter corresponding to the different rates of marching or rowing.

A convenient form of note-book is that having four lines ⅝ or ¾ of an inch apart ruled down the center of the left-hand pages. Such books of convenient size for the pocket can be obtained from Rees, Pall Mall S. W., London.

EXAMPLE. — Say the day's traverse for June 25 was commenced from Camp 33 where a latitude was obtained the night before (Fig. 28). Any heights of land to which back bearings (*B. B.*) or forward bearings (*F. B.*) can be read with a prismatic compass should be carefully noted and a sketch made of the hill's form with its bearing set beneath it, so that there can exist no confusion in its identification later. These physical features are sometimes useful in checking and correcting the direction of the traverse especially when they are near the route which has been passed over or points in advance near which it appears probable the route may pass.

The time of departure from camp in hours and minutes is set down in the first or left-hand column corresponding to times, and the compass is read to an imaginary central point of the most distant portion of the straightaway stretch of river visible to the observer; the bearing is entered in the center column and the estimated rate of travel entered in the third or right-hand column. On arrival at the point where the direction changes, a new bearing has to be taken, and the time noted as well as any change in the rate of progress.

This same method can be just as effectively employed in following any forest path or wilderness track. When it is impossible to get satisfactorily the forward direction of the track or river on account of the innumerable windings a convenient mean may be had by taking bearings every five minutes of time, or shortened or lengthened according as the result is desired to be more or less accurate. When any appreciable delay occurs, this is indicated by bracketing the times of arrival and departure, the lower or first corresponding with the former and the upper or second with the latter, respectively.

Often in tropical South America low, odd-shaped hills are discernible from long distances which, as one approaches, are obscured by the height and dense growth of the forests or the necessarily limited vision afforded from canoes. A high tree may then be utilized and an agile Indian pressed into service as most of the younger, light-built individuals will be found daring, skilful climbers as well as quite quick and intelligent in grasping what is wanted of them in identifying landmarks and orienting positions.

In canoe travel the following instruments are employed: a ship's compass supported on gimbals firmly secured in a strong box with brass-bound corners, a big, plainly marked automobile clock or watch with seconds hand, a range finder, aneroid, thermometer in a lined brass tube, field glasses, and a regulation ship's sounding line of 25 fathoms with a five-pound lead sinker. The top of one of the mess boxes is utilized as a table and the stern of the canoe just forward of the pilot or captain of the crew will be found the best place to work. All orders can be most easily given from here and information elicited, as the pilot is usually the most intelligent and best informed of

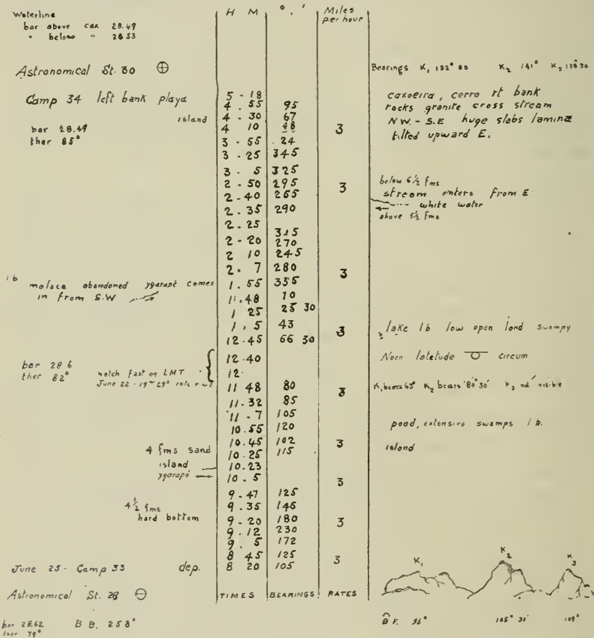
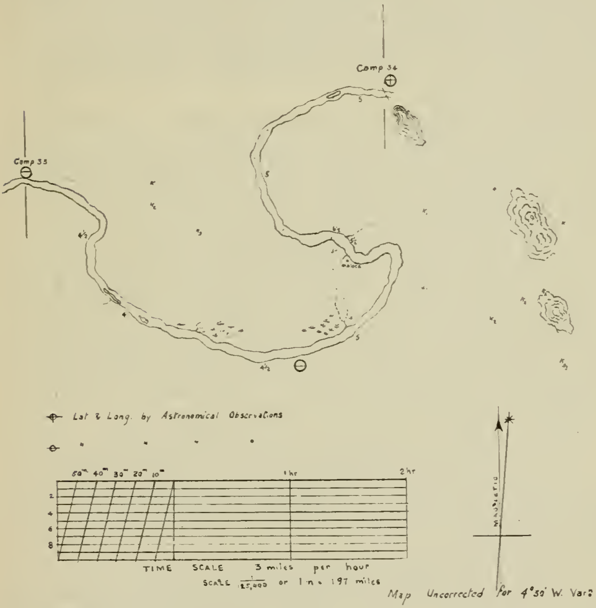


FIG. 28. SPECIMEN PAGES OF A NOTE-BOOK

the men. All firearms, axes, machetes, tools, etc., of the cargo should be placed sufficiently forward to eliminate any possibility of magnetic attraction upon the compass. During periods of rain or intense solar heat a large, strong umbrella such as can be obtained from Brigg, of London, will be found serviceable. When it is necessary to work at night a hurricane lantern so placed as to shed its light upon the compass face enables the topographer to continue uninterruptedly. The lantern should be of brass, copper, or some material not affecting the compass reading. In place of the note-book, paper ruled with dark lines into inch squares and again subdivided into five smaller squares, of the kind known to draughtsmen as profile paper, may be employed and the course of the river graphically plotted upon this. Sheets of it should be



TO SHOW PLOTTING OF A TRAVERSE

previously cut to a convenient size and held to a framed drawing board by artist's pins.

For plotting from the recorded notes it is convenient to construct scales showing the distances to be plotted in minutes of travelling at the different rates. These scales are easily worked by simple proportion and should be sufficiently deep to allow for reading to one minute of time (see Fig. 28).

In floating down a river, a fairly satisfactory measure of distance travelled can be obtained with currents of various velocities by timing floats over a measured distance in stretches of from slow to speedy velocities. Canoe crews are timed over measured distances by ascertaining the time necessary to paddle a canoe or row the heavier *batelão* in still water, or with currents of varying velocities, or pole up stream, and by maintaining upon such trials the uniform rate such as Indians and marineros commonly employ in working, a correct idea of rates can be deduced from which a very fair estimate of distances travelled is reached.

On land journeys the walking rate over different stretches, level, hilly, smooth, rough, etc., may be likewise determined; also the marching of mules, chosen always in preference to horses for this sort of work owing to their more uniform gait and general steadiness.

In cutting a track through forests the axemen and clearing party should be a day or more in advance of the instrumental portion of the party, and the compass man advancing with the sappers to indicate the chosen direction, should keep sufficiently behind them to preclude the possibility of magnetic attraction from axes and tools, and himself ought not of course to carry firearms.

Upon the broad and deep reaches encountered on the lower portions of South American rivers small patent sea-logs may be employed. These are trailed from launches and canoes and assist in the estimation of distances by dead reckoning.

It is of the greatest importance that compass traverses should be checked and adjusted by fixed points and that astronomical observations should be taken for latitudes, azimuths, and chronometric differences of longitudes.

When a position obtained by astronomical observations does not agree with that resulting from the compass plotting, the route up to that point must be corrected. If there is considerable detail on the map this is best done by the so-called "squaring-in" method, which is well known to draughtsmen, or the simpler graphic method of distributing errors can be employed.

Example. — Before leaving Station A (see Fig. 29) (Rio Blanco) observations were taken for latitude and time, and its longitude in relation with the preceding station was established. At Station B (Rio Negro) the position obtained by astronomical observations for latitude and time disagrees with that resulting from compass plotting as follows: Station B by compass plotting is 1.54 miles south of its latitude as determined by circummeridian altitudes of two pairs of north and south stars and 0.84 miles west of Station A, whereas its longitude determined by chronometric differences is shown to be 1.22 miles east.

A simple method of correction is the following: BB' is connected by a straight line. Through the other points where bearings were taken, draw lines parallel with BB' by means of parallel rulers. Draw the straight line AB in any convenient place and working back from Station B on the route, set off the distances of the stations or points of bearings with a pair of dividers. From B set off a line equal to BB' meeting another line, AB', drawn from A at a right angle. Drop perpendiculars to the line AB'. With dividers take measures of these perpendiculars and set them off on the lines of their respective stations drawn parallel to BB' and these will be the corrected positions of the various stations on the traverse which, connected by straight lines, will give the adjusted route.

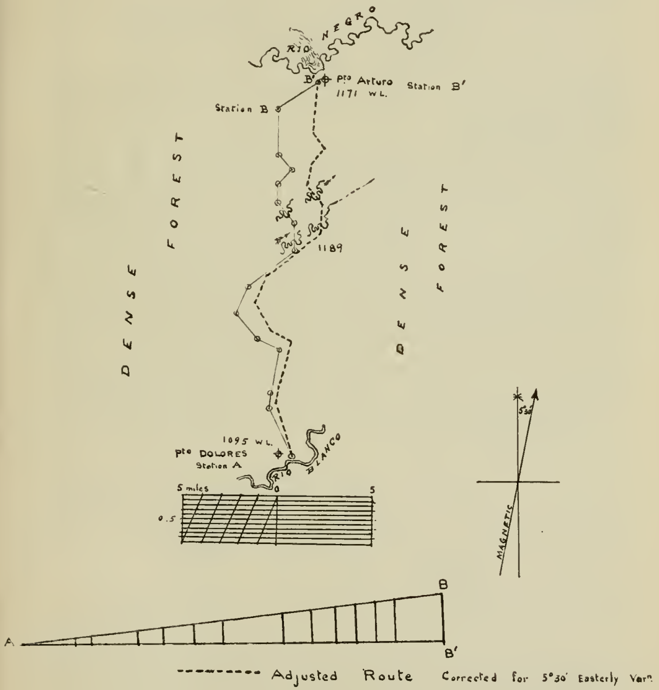
Latitudes had best be determined by circummeridian altitudes of balanced north and south stars, and the altitudes and chronometer times of transit of the stars must be worked out previous to observation by the formula, $\phi - \delta = \zeta$. For example, in latitude 40° north, on January 1, observations are required for latitude. The sidereal time at mean noon on that day is 18 h. 50 m., and supposing one wishes to begin at dark and complete the observations before 10.30 P. M., stars must be chosen for latitude which culminate between 0 h. and 5 h. 30 m. sidereal time.

The zenith distance of a star at culmination is found from the equation, $\zeta = \phi - \delta$, where the signs of the several quantities must be carefully attended to.

Then knowing that the latitude is approximately 40° 0′, and looking out the declination of α Cassiopeia from the

	h.	m.	°	′	Miles per hour.
	Pto	Arturo			
	4	45			$2\frac{1}{2}$
	3	43	355		$2\frac{1}{2}$
	3	17	317		$2\frac{1}{2}$
	2	53	33		$2\frac{1}{2}$
caño	2	29	355		
	2	3			$2\frac{1}{2}$
	1	27	306		$2\frac{1}{2}$
					$2\frac{1}{4}$
caño Potosi	12	50	355		
	11	28			
	10	03	46		$2\frac{3}{4}$
	9	27	17	30	$2\frac{3}{4}$
	8	50	315		$2\frac{1}{2}$
	8	20	290		$2\frac{1}{2}$
	7	25	3	30	
	7	10	355		$2\frac{1}{2}$
					$2\frac{1}{2}$
	6	0	325		
	Pto	Dolores			
	TIMES		MAGNETIC BEARINGS		RATES

FIG. 29. SPECIMEN NOTE-BOOK PAGES SHOWING



PLOTTING AND ADJUSTMENT OF A TRAVERSE

Nautical Almanac, the approximate zenith distance of this star is obtained thus:

$$\begin{aligned} \phi &= +40^\circ\ \ 0' \\ \delta &= +55\ \ 58 \end{aligned}$$

$$\phi - \delta = \zeta = -15^\circ 58' \text{ N of the zenith}$$

Similarly is found:

α Arietis $\zeta = +17^\circ\ \ 3'$ S of the zenith
ϵ Cassiopeiæ $\zeta = -23\ \ \ 9$ N " " "
α Tauri $\zeta = +23\ \ 42$ S " " "

forming two pairs of approximately equal north and south zenith distances.

As regards times of transit, if the watch is M. T., look out in the Nautical Almanac the G. S. T. of G. M. N., and correct this for longitude at the rate of 9.86 seconds per hour (W + E −). This will give the L. S. T. of L. M. N. Now the R. A. of the star is its L. S. T. of transit, hence the difference of the R. A. and the L. S. T. of L. M. N. gives the sidereal interval from L. M. T., which can then be reduced to a M. T. interval and used with a M. T. watch (corrected for any known error). If the watch shows S. T. no computation is necessary, except to apply any known error.

A list can then be drawn up entering altitudes instead of zenith distances:

Time	Star	Mag.	Aspect	Altitude	Remarks
h m				° ′	
5 44	α Cassiopeiæ	Var.	N	74 2	
6 56	ϵ Cassiopeiæ	3.6	N	66 51	
7 11	α Arietis	2.0	S	72 58	
9 39	α Tauri	1.0	S	66 18	

East and west stars suitably placed for time observations can be observed between the observations to α Cassiopeiæ and ϵ Cassiopeiæ or to α Arietis and α Tauri.

Commence observing altitudes about 15 minutes before transit and continue until sure some ten minutes have elapsed since transit. In case of the sun, altitudes are taken to upper and lower limbs alternately. It is not necessary to have an equal number of observations on either side of the meridian, but the better balanced and nearer to the meridian they are the better will be the results. For example, three observations on one side of the transit and five on the other may be said to be well balanced.

The chronometer error has to be applied to the true time of transit to obtain the chronometer time of transit.

The *rate* of chronometer is practically only required when the chronometer or watch used is unreliable, or when the interval between time of transit and time at which chronometer error was determined exceeds two hours, or the rate is unusually high. No good ordinary watch ought to gain or lose more than 12 seconds a day.

Only most experienced and expert observers can work quickly and accurately without the services of a booker, who should always be employed when possible. Native South Americans of the *cauchero* and trader classes are not adaptable as a rule for this sort of work. Good team play is essential between observer and booker and observations should be made in the following sequence:

(1) Observer sets up and adjusts theodolite, informs booker what observation is for, and name of star used, approximate watch correction, thermometer and barometer readings, value of one division of the vertical circle level, name of place, date, and referring object when required as in azimuths, all of which should be set down in angle-book under their respective headings.

(2) Observer gets star into field of telescope telling booker to "stand by." On making a contact observer says "up" or "top." Booker takes the time and records it.

(3) Observer reads out level readings, always giving eye-end of theodolite first, as "E, 5.5; O, 6.5."

(4) Observer reads out vertical angles, C and D verniers, and in case of azimuth observations horizontal angles, A and B verniers. Booker should always repeat the readings after he has written them down to show that he has them correctly. Booker should remind observer each time he is about to observe, what "face" should be used, and for sun observations what limb (upper, lower, left or right) he is to take. Limbs and faces ought always to be put down in the angle-book in their proper order for the

particular observation, before observing. After observing, everything required by the angle-book form should be inked in and the book signed. This ensures that no necessary data are omitted.

When on account of weather conditions, failure of lamps, or other cause, star work is impracticable, careful circummeridian altitudes of the sun should be taken, but more reliable and accurate results are to be expected from stars.

Never be satisfied with results from circummeridian altitudes of one star only, double altitudes of star or sun (Ivory's formula), or by employing the formula given in Bowditch's Navigation and Wilson's Topographic Surveying, of latitude determined from an observed altitude of a star or the sun regardless of its position.

Determination of time is done by observing sets of altitudes of east and west stars respectively, choosing those on or near the Prime Vertical having altitudes of more than 15° and less than 45°. Time may also be determined by equal altitudes of a star or the sun but it requires a clear sky for a considerable interval of time and is not to be recommended owing to the very uncertain weather conditions and almost inevitable gatherings of cumulus clouds which daily prevail over the Amazons region, and for this reason stars selected in the same way as for azimuths are preferred to trusting the sun for A. M. and P. M. sights.

In such a traverse as we are considering, longitude is determined by what is known as the "meridian-distance" method, effected by the transportation of chronometers and half-chronometer watches. By the comparison of their rates, and by determining their errors on Local Mean Time, the difference in time at any given second between any two stations can be ascertained. The difference between these two local times is the difference of longitude between the two stations.

It is always well to start and close traverses of this sort from and to points whose positions have been rigorously determined, as Bogota, Caracas, Manãos, and Porto Velho, for such stations serve as the standard to which the relative longitudes of succeeding places are referred.

Three, five, or seven half-chronometer watches (Herbert Blockley, London) should be carried and with work being done in a canoe or launch a good ship's chronometer can be usefully employed. This or one or several of the watches may be set to sidereal time.

Great care should be used in the transportation of the watches. They are best carried in sets of three or five in special tin boxes obtained from Blockley or in a webbing belt with pockets which close securely, the belt worn bandolier fashion, the watches further protected by chamois cases and wrapped in oiled silk; each watch known by some distinctive letter or number. One watch should be used for the time observations, and comparisons with all the others should be made before and after the observations.

Referring to Fig. 28 (pp. 400, 401), suppose that at Camp 31 from June 19 to June 22 observations were taken for time, and that rate was determined. The watch was found to be fast June 22 at 9 P. M. on Local Mean Time 19′ 29″ and to have a gaining rate of 4.2″ daily.

On arrival June 25 at Camp 34 where exists a *caxoeira* or falls and a line of hills crosses the terrane from NW to SE, a stay of three days is decided upon in order again to rate the watches and determine the difference of longitude between Camp 31 and Camp 34. The results of these observations show the watch on June 25, at 11 P. M., to be fast on Local Mean Time 17′ 52″, and its daily rate to have changed to 5.8″ gaining:

Camp 31, 9 P. M., June 22, chron.	19′ 29″ fast
3.08 days' mean rate	15.4
Camp 31, 11 P. M., June 25.	19′ 44.4″
Camp 34, 11 P. M., June 25.	17 52
Diff. of long.	1′ 52.4″
Camp 34 is east of Camp 31	0° 28′ 6″

That is, the time at the first station (Camp 31) where the last observations for error and rate were taken, must be reduced by the mean rate and interval of time to the same instant of time as when the first observations for error and rate were taken at the second station (Camp 34), and the difference of these two local times is the difference of longitude between Camp 31 and Camp 34.

The rate of a chronometer is determined by repeating the observation for time in the same spot after a few days, when the difference of the errors, divided by the time elapsed between the observations, will be the rate of the watch. Thus:

```
                                      h  m  s
June 19,  8 P. M., Camp 31, watch 0  19  16 fast
  "  22,  9 P. M.,    "     "    "    0  19  29  "
                                  ______________
                       interval, 3.04)1300(4.2
                                      1216
                                      ____
                                       840
                                       608
                                       ___

                                      h  m  s
June 25, 11 P. M., Camp 34, watch 0  17  52 fast
  "  28, 9.45 P. M.,  "     "    "    0  18  09  "
                                  ______________
                        interval, 2.9)17.00(5.8
                                      145
                                      ___
                                       250
                                       232
                                       ___
        Daily rate at Camp 31, 4.2s gaining
          "     "   "   "   34, 5.8s    "
                             _____
                             2)10.0
                             _____
        Mean daily rate......  5.0s    "
```

In case of return from Camp 34 to Camp 31, its error on L. M. T. should again be determined as well as its rate and a mean of the "to and from" journeys will give a very good value of the difference of longitude between the two points.

If no halt is made at Camp 34 beyond the ordinary night's rest, the travelling rate can be found by dividing the difference between the errors at Camp 31 (starting and returning) by the number of days which have elapsed.

Watch rates are variable and the only way to eliminate the effects of such variability is to carry a large number.

To be convinced of this the traveller has only to refer to his table of daily comparisons of three or more watches.

The foregoing method was employed in surveying the Inirida, Içana and Uaupés Rivers and in the overland journey to the northern sources of the Caqueta, some of the most difficult country to traverse in all South America (see Geographical Journal, August, 1914). Bogota (74° 5′ 45″ W) was the starting point and "reference meridian," and sixteen months later when the traverse was closed at Manãos (60° 3′ 15″ W, Port Ismail), there was an error of 6.2 miles short, necessitating a plus correction of 761 feet for each of the 43 stations at which time and rate were ascertained, making an almost unappreciable difference when reduced to a map of 1–1,000,000 or 1 inch = 15.7 miles scale.

For plotting work in the field either the 1–125,000 (*i. e.*, 1 inch = 1.97 miles) or 1–250,000 (*i. e.*, 1 inch = 3.95 miles) will be found convenient and advisable.

All astronomical readings should be noted down in a special angle-book carefully kept for that purpose. The one recommended by the Royal Geographical Society is excellent and can be obtained on application to the Map Curator as can also blank forms for working out computations which are furnished for the cost of printing.

A split-second stop-watch is often useful in taking observations, especially at night, and too much care and forethought cannot be expended in the matter of lighting up the field of the telescope for stellar observations. An excellent arrangement most ingeniously devised by Commander Edwards and Guy Wilson, Esq., used by them on the Bolivia-Brazil Boundary Commission, can be seen and obtained at Messrs. Troughton & Simms, Strand, W., London. A piece of thin, white cardboard or thick paper can also be utilized, fitted to the object end of the telescope by means of an elastic band and bent slightly over the object glass. The light from any small lamp, electric torch, bicycle or chromolyte is thrown on to the paper and is reflected to, and lights up the interior of the telescope.

Wireless telegraphy and its use in determining longitudes in this sort of work should be mentioned in connection with its employment by Commander H. A. Edwards, R. N. R., upon his last journey, September, 1913, to January, 1914, when Chief of the Bolivia-Brazil Northern Boundary Commission (see Geographical Journal, May, 1915). C. C. Chapman, an American and wireless expert formerly in our navy, now associated with the Marconi Co., accompanied Commander Edwards's party with a rough field set of receiving apparatus designed and made by himself for use in the field, and was most successful in receiving wireless time signals which by pre-arranged plan were sent nightly from the Porto Velho Station (Madeira River), its position having previously been determined by a series of time signals with the Manãos Station, whose position in regard to Para was determined by an exchange of telegraphic time signals.

Every night the aerial wire was stretched between two or three convenient trees and the Commission was enabled to establish the longitudes of its camps and to use them as controlling points between which the river traverses were adjusted.

This pioneer work of Commander Edwards and Mr. Chapman is all the more remarkable when it is considered that it was carried out in the face of almost insurmountable dangers, difficulties, and discouragements, and the brilliant results of the expedition prove conclusively the utility and feasibility of wireless determinations of longitude over comparatively long distances under most unfavorable conditions.

The Geographical Journal for May, 1915, contains an appendix to Commander Edwards's report in which copious important notes are given of the wireless work and results and in the same magazine number is an interesting and instructive article on plane-table triangulation from one station only by E. A. Reeves, Esq., Instructor of the Royal Geographical Society's School of Surveying and Practical Astronomy, with examples and formulas, a method which might be of great practical value in surveying such country as abuts the eastern slopes of the Andes in Venezuela and Colombia.

PHOTOGRAPHY.

BY JOHN T. COOLIDGE, JR.

METHODS OF RECORDING TRAVEL.

THE traveller has at his disposal four methods of picturing scenes which he wishes to reproduce. Black and white photography, the simplest process, produces pictures which give at best an incomplete impression of a country. Stereoscopic photographs give a truer and far more complete record, but cannot be used in books or for lantern projection. A far more pleasing effect is secured by color photography; if this be combined with the stereoscopic principle it produces a startling combination of atmosphere, color, and distance. Colored stereoscopic transparencies are second only to motion pictures for the representation of reality.

CHOICE OF THE CAMERA.

Ordinary cameras will withstand the effects of most tropical climates, and a uniformly moist or dry condition is not likely to do damage, but for a climate of extreme changes of humidity and temperature it is safer to select a camera of the tropical models made of teakwood. The size of the camera selected depends entirely on how important a part of one's activities picture-making is to be, and for this reason no particular size or model can be definitely recommended. The writer makes it a practice to carry a small vest-pocket camera at all times in order to be prepared for unexpected opportunities when the larger instrument has been left in camp. Cameras of the reflex type produce the best results, as they are devised for exact focusing and for securing visibility of the entire field on the ground glass up to the moment of exposure. A small Graflex camera has recently been put on the market which can be used with a magazine plate-holder or films and which should be an ideal instrument for the traveller whose purpose is not sufficiently concerned with photography to warrant the encumbrance of a larger one.

Be thoroughly familiar with the use of the camera and development before leaving home. In camp there will be no expert to give instruction.

Stereoscopic cameras are made in several sizes. Those who contemplate taking pictures for the purpose of showing them to their friends rather than for publication will find the small stereoscopic Verascope, taking a picture 45 × 107 mm., quite satisfactory. It consists of two instruments, the camera and the stereoscope. The Ernemann Company makes a much less expensive stereoscopic camera which takes pictures to fit the Verascope. By having two Lumière screens fitted to this it can be used for colored transparencies.

In selecting a lens, it must be remembered that an inexpensive rapid-rectilinear lens used in bright light with a small diaphragm makes as good pictures as an anastigmat. But an anastigmat is necessary for sharp definition when the diaphragm is opened, as it must be when the lighting is not strong. The wider the aperture at which an anastigmat will work the "faster" it is, or in other words, the less light will be required. The wider the aperture, the more exact must be the focus.

Focal-plane shutters, such as are fitted to all cameras of the reflex type, are the only shutters which use 100 per cent of the light. All between-lens shutters waste at least 30 per cent.

Accessories.

It is only possible here to suggest articles of equipment which are required particularly for camp photography. Several London firms make portable dark-room tents, and a variety of changing bags, some of which have arrangements for inserting the head, while others have red windows, and holes for the arms. One of the most compact is the Westminster developing box which folds into a case 12½ inches square by 2 inches high. It is important to

Fig. 30. Developing Outfit for Portable Darkroom

Fig. 31. Portable Darkroom in Use

be provided with equipment for developing pictures in the field, because for the best results negatives should be developed within a week or two of the time of exposure. This is essential in hot, moist climates where a delay of two months is often sufficient to ruin them. Plate- or film-tanks are extremely useful. With a tank several negatives can be developed at once by exact methods of timing explained in the circular accompanying the tank developer, and the danger of fog due to imperfect dark-room facilities is decreased. Celluloid measures are preferable to glass. If trays are to be included, the least destructible are those of enamelled iron.

Suggestions for Meeting Tropical Conditions.

Dry plates withstand severe climates better than films, and when a magazine holder is used are not awkward to handle. Plates or films taken on a long journey should be sealed in tins supplied by the makers. When this precaution is observed, they retain their quality a long time, but they may become ruined during or after exposure, even when repacked in tins, if too long a time elapses before development. Some firms make a special brand of tropical plate, but ordinary plates are quite satisfactory if properly sealed until a reasonable time before exposure.

Hardeners. — Where no cool water is obtainable, negatives may be developed by the aid of a hardening solution. Wet gelatine melts at 90° F., but plates properly handled can be developed in solutions up to this temperature, and films in anything below 80° F. In cases of very high temperatures the negatives are immersed in the hardening bath first. In other cases the hardener may be used between development and fixing.

For a *hardening bath*, use formalin, 5 minims; water, 10 ounces. Immerse 5 minutes.

Other hardening solutions requiring 10 to 20 minutes are:

(1) Chrome alum, ½ oz.; water, 10 oz.

(2) Alum, 1 oz.; water, 20 oz.

Negatives must be washed well after hardening. Professor Harrison W. Smith recommends the following special directions supplied to him by the Eastman Company for tank development of Eastman N. C. film in tropical climates when the temperature of the water available is from 80° to 90° F.

Two regular solution cups of the Kodak film tank and one container one-half inch larger in diameter are required. This larger cup should correspond in depth to the embossed ring of the solution cups. In the following operations a thermometer must be employed and the directions strictly followed.

Place one pound of "hypo" in the large container and on top of this "hypo" set one of the solution cups containing water. It is assumed that the water does not exceed 90° F. in temperature.

Pour water between the two cups until it almost reaches the top of the outside or larger cup. With a stirring rod or stick, long enough to reach to the bottom of the larger cup, stir the "hypo." As the "hypo" dissolves the temperature of the water in the solution cup will be reduced.

Dissolve two pairs of the film-tank powders in the cooling water.

When the developer has reached 80° F. by actual test with thermometer, remove the solution cup from the larger cup, and place the film in same in accordance with regular instructions for Kodak tank development.

Use care to prevent the "hypo" or cooling solution contaminating the developer. With two powders and a temperature of 80°, development will require only five minutes. The tank should be repeatedly inverted during development.

Immediately upon removing the solution cup containing the prepared developer from the cooling solution, place the second solution cup, filled with water to the rim, in the cooling solution and while development is taking place in the other solution cup, dissolve one-half ounce of sodium bisulphite and one-half ounce of chrome alum (powdered) in this second solution cup, and at the same time stir the "hypo" between the two cups, as in the first instance, to cool the solution of bisulphite and alum as much as possible. This solution will probably reach 82°–84° F.

When development of film has been completed, drain developer from apron as *rapidly* as possible and place in the second solution cup containing the bisulphite and alum, moving the apron up and down to bring the solution in contact with every part of the film. This solution will arrest development and harden the film somewhat. Remove solution cup from larger container.

Allow the film to remain in this solution while 16 ounces of water are added to the "hypo" in the large container. Stir to dissolve balance of "hypo."

Remove apron from bisulphite-and-alum solution, draining as much as possible of this solution into the "hypo" solution in the large container. This solution acts as the hardener for the fixing solution and furnishes the proper dilution.

No time should be wasted in draining the apron, but the film should be removed from same as quickly as possible and placed in the fixing bath in the large container and moved continuously until completely fixed.

Leave the fixed film in this solution ten minutes *after* it appears to be fixed. This will harden it so that the film can be washed in water at a temperature of 100° F. if necessary.

Hypo eliminators. — When sufficient water for washing fixed negatives is not available, the following permanganate method may be used:

"Wash the negative for one minute and transfer to a shallow dish containing water with enough potassium permanganate in it to turn it light pink. Remove the negative as soon as the color goes, which will be in a second or two if hypo is present, and keep on treating in the very weak permanganate baths until the color is not discharged. The water itself will destroy the permanganate color, but not quickly as hypo does. This is a very cheap and satisfactory process which allows of a negative being ready for drying within three minutes of fixation" (from British Journal Photographic Almanac).

Drying. — In dry country where dust is blowing or in places of extreme humidity, drying presents serious difficulties. The best method is by grain alcohol. The higher the percent the better, using two or more baths in succession if there are enough negatives to dilute a single bath. In an emergency when no alcohol is at hand, immerse the negative for ten minutes in a hardening solution of one part formalin and fifty parts water; pour over it water just below the boiling point and place before a fire to dry. Six quick changes of nearly boiling water will take the place of ordinary cold washing.

General Hints.

In selecting a viewpoint, bear in mind the feature upon which interest is to be concentrated. If possible, leave out of the field superficial details which distract attention. To emphasize the size of large figures, lower the camera close to the ground, and for the opposite effect, raise it above the head.

The first thing which Kodak books teach is to stand with the back to the sun when taking photographs. This does away with possibilities of interesting light and shade effects, and is the first thing which must be forgotten before attractive pictures can be taken. The sun must not shine on the lens, but there is no harm, and usually much good, in pointing the camera obliquely toward it. To show the solidity of the object, cross light is the best.

It is doubtful whether the most skilful judges of light can estimate the proper exposure within 200 percent. Fortunately, an error of 500 percent, particularly if it be in the safe direction of over exposure, does no particular harm, except in color work. The correct exposure can be determined mechanically by the use of a Watkins or Wynne exposure-meter, small instruments containing sensitive paper, a small spot of which is exposed to the light until it reaches the same value as a standard gray strip alongside it. The time is recorded and from this the exposure can be computed. For Lumière color pictures it is almost essential.

Ordinary plates or films render colors in untrue values. Blue appears lighter than it does to the eye, and red and yellow appear too dark. This can be partly overcome by fitting an orange or yellow screen in front of the lens, known commercially as a ray filter. For a still truer rendering of colors, isochromatic or orthochromatic plates should be used as well as a screen. A special screen is necessary for Lumière color pictures.

Clouds. — The sky is so much lighter than the rest of the landscape that in giving it the proper exposure the foreground is underexposed. A screen graded from dark above to clear glass below, known to trade as a sky-filter, may be fastened in front of the lens to equalize the illumination. A better but more laborious way is to take two pictures with the camera on a tripod, one to expose the sky, the other the ground, and combine the two correctly exposed parts by double printing. Distant mountains, like clouds, require a very short exposure.

Waterfalls. — Falling water and foam reflect brilliant white light which should be enough for an exposure so short that the falling spray is caught by the camera. The surrounding rocks or foliage must be photographed with a longer exposure, and a double printing made.

Night Photographs.

Pleasing effects can be produced by combining firelight with flashlight. The camera is placed on a tripod, and the fire exposed first. If saltpeter is available, a little thrown on the fire will give the appearance of flame instead of a shapeless glow. The fire is then screened from the lens. A small quantity of flashlight powder wrapped in paper and thrown into the fire produces a flash which illuminates the surrounding figures. The lens must be screened from the direct glare of the flashlight. It is important to have the flashlight ignited in the fire, otherwise the position of the fire will not be consistent with the lighting in the picture. The illuminating power of undiffused light varies inversely as the square of the distance from the object, and the necessary quantity of powder can be estimated for any distance if experimental pictures have been taken at some given distance. Flashlight powder is useful for photographing caves and the depths of forest where the light is weak. The effect of daylight may be imitated by igniting the powder well above the objects to be illuminated, and arranging to have no sky in the picture, as this comes out black at night. Flash sheets are useful for quiet subjects, but powder is necessary for quicker exposures.

Wild-Animal Photography.

The most serious difficulty in this branch of photography is to approach wild animals within the extremely close range necessary to have an image of appreciable size on the plate. Telephoto lenses are useful when the light is bright, but fast lenses of long focal length are better. The Ross Telecentric, and the Dallmeyer Adon are two new departures in lens making so designed that the equivalent focus is twice the actual extension from lens to plate.

Thus a camera fitted with one of these needs only half the bellows extension required by an ordinary lens throwing an image of the same size. A large plate or film is not necessary, because even with the most successful approach or ambush it is almost impossible to cover more than a small part of the field with an image of an animal. The important feature is the focal length of the lens, upon which depends the size of the image. The longer the focus of a lens, the more necessary it becomes to focus accurately. For this reason, a camera of the reflex type is almost essential for game photography. When a locality is discovered where animals are expected to pass or to congregate it is best to build a blind a day or two before it is to be used, to allow the animals to become accustomed to it. It should be on the down-wind side of the animals' expected position. When there is no prevailing wind it is best to build several hiding places, and select the down-wind one on the occasion when the ambush is undertaken. Most animals are quick to discover a person whose body appears against the sky; but if there is an opaque screen behind, they will fail to see through a very imperfect screen in front of the intruder.

Nocturnal animals can be induced to take their own pictures by suspending across their path a thread connected with an automatic camera and an apparatus for igniting a flashlight. The best way to ignite the powder is by means of a blank revolver-cartridge fired by a pin or hammer, which can be released by an improvised hair trigger. Electricity is uncertain for this purpose, particularly in the Tropics. The writer has experimented with two systems: igniting the flash first, and having a rapid shutter open during combustion, or arranging a device which opened the shutter in advance of the flash and held it open to give the flash ample time to burn. Both methods worked successfully in the laboratory, the first having the advantage of a faster exposure with a waste of powder, and the second making use of all the powder with an exposure equal to the duration of combustion. In the field, however, the first system was unreliable owing to the difficulty of synchronizing the shutter and flash to a nicety in varying atmospheric conditions. The most finely pulverized brands of flash powder burn fastest, and combustion can be accelerated by confining it with a wad in the receptacle where it is ignited. Though animals jump when the flash goes off, they are not quick enough to react before the picture is made, and it is only when they happen to be in rapid motion at the moment when the trigger is released that the exposure is too slow. To insure ignition the flash powder must be packed down against the end of the cartridge, which should have its wad removed. It is best to have the camera shutter in front of the lens to prevent mist from condensing on the glass. When arranging threads, allow for shrinkage, otherwise rain or moisture may operate the camera. Fine black-silk thread is best. It is inconspicuous and shrinks less than cotton.

Motion-Picture Photography.

The taking of moving pictures does not require much more skill than ordinary photography, but the development and handling of the film is more laborious. One of the best cameras is the Newman-Sinclair, which is fitted with a reflex system of focusing, while another, the Aeroscope, is a hand cinematograph driven by a compressed-air motor. For the best results, a firm tripod is necessary, but this hand camera might be useful in circumstances where the use of a tripod is impossible.

Mr. Carl Akeley, of the American Museum of Natural History in New York, has designed an ingenious moving-picture camera now on the market. It is self-levelling, a feature which makes it possible to set up and start the camera almost instantaneously. It swings to the right or left and up or down automatically when such motion is desired for panoramas or to follow the action of the subject. For insect or aquatic pictures it can be swung readily into a vertical position with the lens over an aperture in the tripod head. It is the most compact of all moving-picture cameras and combines the best features of other designs with many improvements of its own.

Exposure. — By turning a crank, the film is passed behind the lens at the rate of a foot per second, during which time 16 pictures each 1 inch by ¾ inch are exposed. The speed of exposure is adjusted by a rotary shutter. The exposed film rolls up into a light-tight box which can be removed from the camera, and replaced by an empty one.

Development. — The most compact developing outfit consists of three large, flat trays nesting into each other, and a pin frame upon which the film is wound face out, in a spiral. A frame of 100-feet capacity is a convenient size for travelling. The film is left on the frame through the whole operation of development, fixing, and washing, and is wound on a larger square frame to dry. The whole cinematograph equipment and chemicals for 3000 feet of film ought to pack into two fiber cases totalling 120 pounds, to be carried by one donkey or two bearers.

Reference Books.

Abney, Sir W. deW.
1905. Instruction in Photography. Revised. London.

Brownell, L. W.
1904. Photography for the Sportsman-Naturalist. New York.

Dugmore, A. R.
1902. Nature and the Camera. New York.

Jones, B. E.
1912. Cassell's Cyclopaedia of Photography. London.

Snell, F. C.
1905. The Camera in the Fields. London.

GEOGRAPHY.

BY WILLIAM M. DAVIS.

The object of this chapter is to aid the traveller in observing the geographical features along his route. Nothing contributes so much to careful observation as careful record, with the intention of later preparing an accurate and intelligible account of the district or region traversed. It is therefore assumed in all that follows that the traveller proposes eventually to publish an article or a book concerning his travels.

Records.

The most important aid to geographical observation is a well kept daily record. A note-book should be carried with a pencil in an easily reached pocket; rubber bands strap the pages so that the book opens where desired and the leaves do not flap in the wind. During brief halts aids to memory should be written down in catch-words; these should be expanded to fuller form within a day as time offers. The more assiduous recorder will carry a small scratch-book in which he can, even while walking or when on horseback, jot down brief memoranda, to be enlarged in his note-book at the first opportunity. The more painstaking will place a slip of carbon paper between his note-book pages (note-books can be had especially prepared for this use), so that all records including letters are made in duplicate, one copy to be sent home for protection against loss, the other to be retained as an aid to memory. The more thoroughgoing will, on halting for noon or night, leave common duties about camp to his men, and at once devote himself to his journal which he alone can prepare.

The following suggestions regarding geographical records may be found of value. Write abundantly while the facts are in view if possible; do not trust to memory for more than a day; if time presses, make concise notes; if leisure is allowed, write in detail as if for a finished report; include all such details as will give life and color to description; do not trust alone to photographs for illustrations; make abundant simple sketches of landscapes and of local features; draw many outline maps.

If the traveller can determine beforehand the form in which his report is finally to be cast, he can from the outset phrase his record to suit his object; but the intention of making a brief report will not excuse scanty notes, for such a report is best made by selecting the most significant items from a full record. A traveller, inexperienced in writing for print, may feel diffident of his powers when making his first essay, not knowing how to begin and not seeing his way clearly to the end. Let him take his task piecemeal. When he is enjoying a local scene near his camp or a wide prospect from a commanding viewpoint, let him then and there write down what he sees, item after item, the larger features first, the smaller ones next, the details last; and if some inexperienced companion objects that analysis and record separate pleasure from contemplation, refute him by writing down the sensation of pleasure along with its cause, and thus deepen its impression while adding vivacity to the description of the view that inspires it; but it is not intended to recommend the habitual record of purely personal emotions.

The Causal Notion.

The independent record of separate geographical facts is better than no record at all; but a record is much improved if it includes a correlation of such facts as are supposed by the thoughtful observer to stand in the relation of cause and effect. Thus, in a valley where the enclosing hillsides are benched, this should be noted as due to outcrops of horizontal strata, provided the strata that make the hills are seen to lie horizontal; similarly it is well to note that waterfalls are related to the harder rocks; the detailed features of a linear ridge will be better described and understood, if a brief statement is made of the attitude of the slanting rock layers of which such ridges are usually composed; the location of a village will be better appreciated if the water supply, the river ford, or the harborage which has apparently determined its situation is briefly indicated; the habitual occupations of a tribe of savages ought to be recorded in view of the environment within which the occupations have become habitual. In many cases, cause and effect are so manifest that their relation may be at once announced; in uncertain cases, the supposed relation should be noted as an inference of the observer.

Errors to be Avoided.

Common mistakes in the geographical notes of an inexperienced recorder may be here indicated. Unconscious exaggeration is a frequent error, whereby distances, difficulties, and dangers are made to seem more formidable than they really are; but there is also the opposite mistake of the supercilious traveller, who intentionally understates real difficulties so that he may be thought to make light of them. Generalization must not be based on so few facts that temporary conditions are described as a prevalent, or that particular instances are said to be usual, or that individual characteristics are accepted as tribal or racial; it is better to make a list of occurrences and to set them forth separately than to generalize rashly. Information regarding distant matters should not be too readily accepted from "natives" who, however trustworthy they may be about their own district, are over-ready to accept and repeat vague, hearsay accounts of what they have not seen, and who are prone to give favorable replies, rather with the idea of pleasing than of deceiving their visitor; errors of this kind may be lessened if leading questions are avoided when making inquiries, and if individual testimony is mistrusted until it is independently confirmed. Care should be taken not to give a wrong impression by the use of inappropriate adjectives or of unnecessary superlatives; the careful choice of the best words for a description in the presence of the facts to be described is a fine art, like the choice of the true colors for a faithful picture.

Narratives.

The easiest form in which a geographical report can be cast is the narrative, which chronicles events in the order of their occurrence. All difficulty of rearrangement is thus avoided. This is also the most interesting form of report for the general reader, because it constantly introduces the personal experience of the writer. A geographical flavor can be preserved by setting every event in the landscape where it happened. The record should not be made too compact so that all freshness is crowded out of it, nor made too full by crowding every trifling detail into it. It should above all be truthful, and it should therefore be written on the ground that it describes. A final narrative may be hardly more than the transcript of a well kept note-book, condensed where the original records seem trivial, expanded where they seem insufficient. It is helpful to open a narrative with a general statement written at the end of the journey, so that the reader may better apprehend the relation of its parts to the whole.

Let no traveller hesitate to begin a record because he has not the skill that comes from training and practice; let him rather all the sooner begin to write down events as they happen, especially if he is on unfrequented ground; and above all let him persevere to the end. Two of the best narratives of exploration ever written — Darwin's "Journal of Researches" during his voyage round the world in the *Beagle* (1839) and Powell's "Exploration of the Colorado River of the West" (1875) — were the first works of earnest explorers, one only 23 to 25 years old, the other 33 or 34, who promptly wrote down what they saw from day to day, without any attempt to describe simple events in fine fashion. These famous books were published with little change from the form of the original records. A straightforward story, sincerely written, always commands respect.

Systematic Reports.

A report of more systematic form may be prepared by bringing together at the end of a journey all the records of various kinds of things, and arranging them in some well considered order; for example, mountains, hills, valleys, plains, rivers, lakes, coast; temperature, winds, clouds, rainfall, storms; forests, prairies, marshes, barrens; beasts, birds, fishes, insects; people, costumes, houses, paths, roads, farms, villages; products, industries, utensils, traffic; customs, ceremonies, and so on. Instead of reproducing a diary, one here tries to make up a card catalogue. The different examples of any class of things may be arranged according to their degree of perfection, or their size, or in any desired way. The personal experience of the traveller has small place here and as a result a report thus framed is likely to be "dry" reading; loss of vivacity may be lessened by introducing items of experience and adventure in connection with the things that give rise to them. This form of presentation is better adapted to the needs of the specialist in some particular field than to those of the general observer.

Regional Descriptions.

The most difficult but at the same time the most instructive form for a geographical report may be called the *regional*, in which the attempt is made to give a general account of the whole district or region under consideration. Here the many kinds of things that make up the region are not presented in narrative fashion, following the accidental sequence of their encounter by the traveller; nor in the disjointed arrangement of a classified system, which brings things of a kind together wherever they occur; but in their natural grouping, which sets down very unlike things close together, because they occur together in the region described, so that the reader is given a truthful and vivid impression of the complex reality. Hence a regional report demands more than a brief journey on one line of travel; the writer should dwell in a region for a time and cross it in all directions. The report cannot be finished on the ground, like a narrative; its parts must be frequently revised before their best form and arrangement can finally be reached. The evident difficulty in this form of presentation is that while geographical objects occur simultaneously in their natural grouping, they must be set forth in a linear order, one after the other, in readable succession. The sequence adopted should not be similar to the one suggested in the preceding paragraph for systematic presentation, for different classes of things are there treated independently; they should here be set forth in their actual association, so as to reveal their relations and their interdependence; for nothing can be truer than that the features, inorganic and organic, of any region have come to be what they are by the long interaction of many processes, which result in so close an enchainment of the parts that no report in which the elements of a region are presented as separate entities, assembled as if by chance, can give a faithful picture of the reality. Hence, a regional report involves deliberate reflection and composition afterward, as well as thoughtful observation and record during a journey.

A well advised order for regional presentation places a brief statement of the leading features at the beginning, so that the reader may immediately gain a general idea of the region described. It then proceeds with increasing detail, always indicating the relation of the smaller features described in later paragraphs to the larger features announced in the earlier paragraphs.

Use of Place-Names.

One of the most important matters in all forms of geographical presentation, regional and systematic as well as narrative, is to indicate the location of unknown features in terms of some previously described feature, and not in terms of some unknown feature. Familiar as place-names may be to the returning traveller, he should not expect his readers to be acquainted with them. It is not enough to say that all such place-names may be found on an accompanying map; the text should be self-explanatory, and it can easily be made so by always stepping from the known to the unknown. Thus in a narrative, the entire journey may be divided in an introductory paragraph or chapter into successive stages, each stage beginning at some point of importance which is then located in terms of the whole distance traversed; and thereafter, each less important place that is mentioned, be it mountain, river, or village, may be concisely located within its stage. Or in a regional description, small features mentioned in the course of the detailed statement should be located with respect to the larger areal divisions described in the brief introductory statement of the region as a whole; and still smaller places can afterward be located with respect to their less small neighbors. A place once introduced in this reasonable fashion may be used afterward as a known point of departure in locating another place. If the righteous ignorance of his readers is constantly borne in mind by the writer, his text will be more easily understood and hence more fully enjoyed.

Illustrations.

Local maps, diagrams, sketches, and photographs should be abundant. The interest and intelligibility of a record in after years, to its author as well as to others, is greatly increased by its illustrations, which are understood at a glance. Local outline maps may show a preferred route in a broken country, with indications of the course to be taken at valley branches or in the ascent to a pass. Such maps may be sketched on the road, improved by mounting a hill near halts, and drawn out in camp. The mere process of sketching a map impels closer observation of topographic features and suggests the addition, graphic or written, of many items that might otherwise be left unrecorded. Explanatory legends should be freely introduced in blank spaces of the map margin. Scale and north-mark (magnetic and true) should never be omitted.

Diagrams are of many kinds. Among the most helpful are the so-called "block diagrams" which give in bird's-eye perspective a simplified summary of the area treated, so that the reader may easily grasp the distribution of its larger features. A diagram-map, on which the chief subdivisions of an area are differently shaded, is also helpful, but it is less easily read than a bird's-eye diagram in which relief is drawn in perspective. Graphic aids of this kind greatly facilitate the understanding of a record and are well worth the moderate amount of labor that they cost.

In these modern days of universal photography, sketching is too much neglected. There are many views and many occasions which demand graphic record when the camera is not at hand; there are many small objects, such as utensils and ornaments, for which it is not worth while expending a film or a plate. At such times and for such things, outline sketches are serviceable; and there are few travellers who cannot learn to make such sketches fairly well.

Photographs of distant views seldom have much value; but for middle-distance and near-by scenes they are indispensable. They are now-a-days so easily taken that in many cases no sufficient care is given to the selection of a desirable point of view, of suitable illumination, and of a good foreground; yet without due attention to these details, the best geographical results cannot be reached. Views across plains or bodies of water should if possible be taken from a near-by hill, the slope or base of which should appear in the foreground. Every foot of height to which the camera can be raised in taking a view upon a broad plain will add to the value of the picture. The best photographs demand much labor in climbing to good view-points, much patience in waiting for good light effects, much skill in persuading unwilling subjects to group themselves effectively, and much tact in reconciling the other members of one's party to the delay thus caused; but the labor, patience, skill, and tact will be well expended, and good pictures thus secured will be well worth their cost.

The most important suggestion that can be made regarding illustrations of all kinds is that the traveller should frequently imagine himself an author or still better a lecturer, and as such make a list of the maps, diagrams, sketches, and photographs needed to illustrate his book or his story; then, as a traveller, he should make every effort to obtain them. The trouble of taking great numbers of pictures, many of them meaningless, would thus be avoided, and the patience of one's friends at home would not be so sorely tried as is now often the case.

Geographical Equipment.

A traveller's success in seeing the facts of the region that he crosses and in bringing home a good account of them depends in large measure on his mental equipment, which should include at least a moderate fund of geographical knowledge, an appropriate terminology, and a desire to do good work.

Geographical equipment may be treated as elementary and advanced. An advanced equipment may be obtained during a well chosen college course; an elementary equipment may be based on the memory of school studies and built up a little higher by general reading.

An elementary geographical equipment suffices for the empirical record of plainly visible facts in ordinary language. Hills may be described as high, low, steep, rocky, close-set, isolated; valleys, as narrow with steep, rocky walls or open with gently sloping soil-covered sides, as nearly straight, or pronouncedly serpentine; forests, as open or dense, with undergrowth, or of lofty trees beset with air-plants, and festooned with climbers; paths, as wandering, foot-worn, through the reeds and bushes of a marshy plain, or as ascending along the axis of a mountain spur.

The evident essential in descriptions of this kind is that they should be based on patient observation, accompanied or promptly followed by faithful record in carefully-framed phrases. A risky landing through the surf on a harborless coral reef should be recorded as soon as it is accomplished, if it be the voyager's intention to preserve the impression of the real event; for at no later time can the poise and plunge, the roar and the relief, be so well set down as when the nerves are still tingling with the excitement that the risk produces. The fatiguing experience of a hot ride over sand dunes between distant springs under a glaring sun can be best told if written out from notes taken in the saddle.

But on the other hand, the traveller should try to discriminate between what is significant and interesting, and what is trite and commonplace. To do this successfully will require much conscious thought and effort during his journey as well as afterward. However, success here is better ensured by crossing out whole paragraphs after they are written than by omitting them at the time; hence let records always be as abundant and detailed as possible.

An advanced geographical equipment enables the traveller to go beyond the immediately visible facts and infer something of the causes which have produced them and of the relations into which they enter. In contrast to the empirical records of a simple or elementary equipment, that include nothing that is not seen, the records made on the basis of an advanced equipment may be called explanatory or rational, because they include invisible causal relations by which visible facts are bound together. In so far as explanatory records are inferential, they are evidently less trustworthy than empirical records; but in so far as their inferences are well grounded, they are much more illuminating and profitable. Where explanatory inferences are not deemed secure, they should be cautiously introduced with "as if," or "it seems," or other phrase expressive of doubt; but, of all persons, the observer on the ground is the one who ought to risk making explanatory inferences, if geographical science is to advance.

Coastal Forms.

The characteristics of rational or explanatory description are best illustrated by specific examples. A coastwise voyage, with frequent landings, gives good opportunity for the explanatory treatment of the features of a shoreline. If the salients or headlands are cliffed, continue the landward profile out to sea and thus reconstruct roughly the amount of salient land that has been cut away; if a cove is closed by a beach, or if a bay-head is occupied by a delta, imagine these local accumulations removed and thus restore the original re-entrant of the shoreline. Then inquire whether the original shoreline was determined by the uplift and partial emergence of a smooth sea bottom, on which the uppermost layer of sediment occupies the surface, or whether it was determined by the subsidence and partial submergence of a dissected land surface, in which the surviving hills rose between the eroded valleys. In the first case, the original shoreline would be relatively simple, because the sea bottom usually has small inequalities; in the second case, the shoreline would be irregular, because half-submerged ridges and hills would stand forth in promontories and islands, while half-submerged valleys would be entered by branching bays.

When the features of a shoreline are thus analyzed, the shoreline as a whole can be easily and rationally described by stating the proportion in which its several elements compose it; and when thus rationally described, the position of landings, fishing stations, shell-heaps, and villages along its course can be most luminously set forth in terms of the elements to which they are locally related. It should be evident that records of this kind will be easy in proportion to the fullness of the observer's previous acquaintance with a rational scheme of shoreline evolution; that is, in proportion to the completeness of his mental equipment with facts and theories regarding shorelines. It is evident, too, that records of this kind go far beyond mere observation and call largely upon scientific imagination. So much the better! The pity is that observant eye-sight should not always be supplemented in this way by intelligent insight.

Glaciated Mountains.

A journey in a lofty mountainous region within temperate latitudes will lead the traveller over land-forms that have resulted from the former occupation of the valleys by glaciers; here a wide field for explanatory description is opened. The effort should be made to recognize three classes of forms: first, those summits and ridge crests which have not been acted on by ancient glaciers, but which during glacial as well as during preglacial and postglacial time have been worked upon only by the ordinary or "normal" agencies of weather and streams; second, those hollows and valleys which have been affected by either the destructive or the constructive work of ancient glaciers, acting upon preglacial forms of normal origin; third, those smaller forms which have been produced by normal agencies acting within the formerly glaciated area in postglacial time. A few days of active exploration will suffice to show that features produced by destructive glacial action, such as cirques and troughs, increase in size and strength toward the mountain crests, where they may indeed occupy the entire summit region; while the features produced by constructive glacial action, such as moraines, are found in the lower valleys or on the adjoining piedmont plains; and beyond the moraines will stretch the sheets of outwashed gravels. Small, rock-basin lakes are common in the cirques; much larger lakes often occur in the overdeepened troughs behind the terminal moraines. Midway between the cirques at the expanded head of a glacial system and the moraines of its dwindling termination, the main glacial trough will be joined by the less deep troughs or "hanging valleys" of lateral glaciers. Postglacial features are chiefly the talus or scree beneath the cliffs of the cirques and the trough walls; the gorges and gravel fans, cut and built where the streams of hanging side valleys cascade into the main trough or valley; deltas advancing into the trough-lakes; marshy meadows that represent aggraded lake basins in the cirque floors; and new-cut terraces in the outwashed gravels. The modernized description of a mountain ascent, in terms of the larger features thus briefly explained and of the many smaller features that go with them, would be to the competent reader like bright daylight, after the darkness of the empirical accounts of an earlier generation.

Notes on other classes of geographical features must be more concisely presented. The following paragraphs will suggest the nature of observations desired for physiographic features under the several headings. Organic factors are here omitted as they are treated in other chapters on plants, animals, and man.

Soils are best shown in cultivated fields or in ditches. The soil of stream banks is usually stream-laid and unlike the soil of neighboring higher ground. The soil of a slope is often more stony than that of plains above or below the slope. Soil composition may be described as stony, gravelly (rounded pebbles), sandy, loam, clay, muck, peat; depth and manner of passage (gradual, abrupt) from soil to underlying rock and depth of ground water, as found in wells, are important.

Plains. — Area, altitude, slope, boundary, manner of passage to adjoining forms; degree of approach to a level surface; form, height, and distribution of hills that surmount a plain; depth, breadth, and pattern of valleys that are incised beneath it; structure, as learned from rock outcrops on hillsides and valley sides, and from this, inferences as to origin, such as uplift from sea bottom (nearly horizontal strata of gravel, sand, clay, marl, limestone, with marine fossils); outspread river deposits, especially common in piedmont districts (irregular beds of gravel and sand), lava flows (see *Volcanoes*), plains or peneplains of subaerial degradation (surface usually undulating, transecting structure, often bearing scattered residual hills or mountains of hardest rocks — monadnocks — usually passing gradually and irregularly into rolling hills near stream sources); plains of marine abrasion (surface smooth, transecting structure, often overlaid with patches of marine gravels, limited on inland side by well defined margin of hilly or mountainous district). In all cases, note the present stage of dissection, as shown by proportion of original plain surface now remaining, to area of valleys.

Hills. — Altitude above sea level, height (relief) over neighboring plains or valleys; form, proportion of bare rock to soil-covered slopes; structure as inferred from rock outcrops; arrangement or grouping (close-set, open-spaced, isolated); relation to neighboring forms; of generally equal height (as if parts of a dissected upland), or of irregular height; in belts alternating with linear valleys determined by inclined beds of resistant and weak strata (note the composition and attitude of the strata); in belts along a mountain base, as foot-hills (note attitude and composition of determining rocks in relation to mountain mass).

Plateaus are of three kinds: (1) extensive highland areas of horizontal structure, bordered by higher mountains (see *Mountains*) or by descending escarpments; note height of descending scarp, its pattern as seen in plan, relation to structure as shown by benches, cliffs, and slopes, amount of dissection by gorges and valleys; if traversed by cliff-faced benches, note height, pattern, course, relation to structure; if trenched by canyons or valleys, note depth, breadth, course; (2) highland areas of deformed structure but of even surface, like uplifted peneplains, often surmounted by scattered monadnocks and more or less dissected by valleys; (3) intermont basins, floored with inwashed detritus from surrounding mountain, of stony surface and of steeper slope near the mountain base, but sandy or clayey or saline in central depressions. In all plateaus note altitude, area, boundary, degree of approach to a level surface, manner of departure from level, height of surmounting hills, depth of incised valleys, proportion of plateau surface to valley surface.

Uplands (under 1000 feet) and highlands (over 1000 feet). — Hilly or submountainous districts, of horizontal or disordered rock structure, often showing a rough equality of summit heights; note pattern of hills or ridges, and of valleys; trend of ridges in relation to rock structure; sketch sky-line and describe its inequalities; slopes, rocky or soil-covered; location of important river divides, their average height, and height of passes.

Mountains. — Trend of main range and of subordinate ranges, ridges, and spurs; altitude and form of chief and secondary summits (sharp or rounded), of ridges (even, serrate), of important passes (narrow, open, high, low), and of main valley floors; extent and boundary of mountainous area and transition to adjoining areas; composition and attitude of rocks; frequency of outcropping rock ledges, their form and distribution; amount and distribution of soil-covered slopes; relation of ridges to belts of resistant rocks and of valleys to belts of weak rocks. Subdivision of mountain slopes by ravines and side valleys, which head in peaks or in saddles and which separate buttressing spurs or ridges; short spurs often end at high levels in a valley fork; long spurs often spread at the mountain base, subdivided by short ravines; snow-line, timber-line.

Volcanoes. — Well preserved cones, altitude, dimensions of base, form; craters (formed by constructive eruption) and calderas (formed by destructive explosion or engulfment), their diameter, depth, and form of inner walls; crater lakes, solfataras; eruptions, dates; nature, course, and length of lava flows, distance of ash-falls; lakes barred by recent flows, course and features of outlets; amount of dissection of old cones by radial ravines, resulting mountainous form; ancient lava flows now surviving as caps of table mountains; volcanic necks and dikes laid bare by erosion of their former enclosure.

Glaciers. — Snow-fields, position, altitude, and area in late summer; glacier-head reservoirs, altitude, dimensions, area, relation to enclosing mountains, to adjoining snow-fields, and to discharging valleys; glaciers, total length, breadth at various points, slope, branches, termination; moraines, medial, lateral (on edge of ice), bank (on enclosing rocky slope), and terminal; their composition, dimensions, form; slope of enclosing mountains and estimated depth of ice at various points. The end of a glacier should be mapped in detail, measured from recognizable points a few hundred feet in front of it, sketched and photographed from described or marked points on one side, with reference to recognizable points on the other side. Similarly, the height of its surface at various points along its length should be recorded by sketching from a described or marked point on one side-wall, with respect to a recognizable point on the opposite wall; the dates of such maps, sketches, and photographs should be recorded. Velocity of ice motion may be measured by determining displacement of staffs or targets in mid-stream with respect to a line across glacier from wall to wall. (For land forms of glacial origin, see p. 434.)

Streams and rivers. — Divides between river systems, subdivides between branches of one system; their altitude and pattern. Springs, relation to pervious and impervious strata, position in valley heads, on hill or escarpment slopes, etc.; temperature, volume of discharge. Streams, breadth, depth, fall per mile, velocity, volume, variation with season; nature of ordinary flow (as in falls, cascades, rapids, torrent, moderate or sluggish current), and its change with varying nature of channel (bed and banks); course (direct, irregular, serpentine or meandering); navigability of rivers; mouth, with or without delta; distance of head of tide from mouth, effect of tides on river current; tide range at mouth.

Lakes. — Altitude, depth, area; temperature at surface and below; date of usual freezing and thawing; nature of bottom; color of water, transparency (depth at which a white china plate is visible in clear noon-day); inflowing streams, deltas, outlet; nature of enclosing slopes; origin of basin; features of shoreline.

Valleys. — Pattern with respect to enclosing hills (longitudinal, transverse, irregularly branching or wandering, rectangular branching or trellis-pattern, meandering); depth, form of valley sides, "valley-in-valley" (a narrow, young valley, incised in floor of a wider mature valley; depth and breadth of each); breadth of valley floor; relation of stream course to valley floor; flood plain, marks of former channels; valley-side terraces; relation of valley-side rock ledges to rapids and falls in stream.

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GEOLOGY.

BY WILLIAM M. DAVIS.

Field notes on geology may be graded as elementary, medium, and advanced. Elementary notes include records of the localities where rocks or minerals of certain kinds are seen. Notes of medium grade include inferences regarding underground structure as well as observations of surface outcrops. Advanced records add interpretations of past earth-history to observations of visible outcrops and inferences regarding existing structures.

Notes of Occurrence.

In little-known regions, the simplest notes concerning the occurrence of rocks, minerals, and fossils may prove to be of value, if reported briefly in a geological journal. The observer should be able to distinguish the ordinary minerals (quartz, feldspar, mica, hornblende, pyrite, calcite, gypsum, etc.) and rocks (sandstone, conglomerate, shale, slate, limestone, mica-schist, gneiss, granite, basalt, diorite, etc.), and should note their localities. Brief notes of this kind are made more valuable if they are accompanied by specimens (see below). In well known regions records of this kind are not worth making, apart from the satisfaction they may give the observer; yet even in well known regions interesting discoveries are occasionally made by untrained travellers, as when a party in the Alps discovered a cavity in a mountain-side containing an extraordinary number of unusually fine quartz crystals.

Structural Notes.

A more serviceable record includes, with the names of minerals and rocks observed in surface outcrops, some description of their manner of occurrence, and inferences as to their underground structure and mutual relations. Inferences as well as observations should be written in detail on the ground; memory should not replace record. Brief notes of occurrence would be greatly increased in value if expanded. Thus, in place of "Limestone occurs in the valley of —— River," write: "Beds of limestone, dipping about 30° SW, strike (trend) along the floor of —— valley, and are underlaid and overlaid by sandstones of similar dip, which form ridges on either side; as the valley floor averages 1000 feet in width, the limestones must be about 500 feet in thickness."

Notes of this kind are further improved if they are accompanied by outline maps and sections (see below) on which the areas and boundaries of rocks of different kinds are noted; observed outcrops can then be located with colored crayons and supposed areas indicated in lighter tints. The "wild game" here pursued is of a passive kind, but there is much sport in tracking it if the observer has time enough in a district to allow traverses in many directions. Such work is easy in arid regions, in which the scanty vegetation leaves abundant outcrops plainly visible. Here the observer may, with the aid of a field glass instead of a hammer, rapidly sketch in formation boundaries for several miles around a good point of view, and afterward make more detailed notes on composition, thickness, etc., at localities then selected as most promising. On the other hand, in heavily forested regions of low relief, geological work is slow and difficult, for outcrops are few and cannot be seen more than 50 or 100 feet away. In such regions, ridge crests and stream beds usually give the best opportunity for discovering the nature of the underlying rocks.

Field notes of the grade here considered should include, besides rock composition, details concerning nature of stratification (thick- or thin-bedded, even-bedded, cross-bedded, ripple-marked, mud-cracked, etc.); attitude of strata (horizontal, gently or steeply inclined — give angle and direction of dip — folded, irregularly deformed — give trend or strike of outcrops, or of ridges and valleys that follow resistant and weak strata); fossils (see below);

special structures (joints, veins and their minerals, slaty cleavage and its relation to original stratification, schistosity with detail of even or wrinkled arrangement and texture of constituent minerals and, if possible, relation to original structure); relation of rocks to land forms, as suggested in the chapter on *Geography*. Lines of contact and boundaries, showing unconformity, intrusion, or faulting, must be considered in more detail.

Unconformity.

When successive strata lie evenly, one on the other, they are said to be conformable. When the surface of contact between two structural masses truncates the structure of the lower mass, while the lower layers of the upper mass are adjusted to the contact surface, the two formations are said to be separated by an unconformity, and the upper mass is said to be unconformable to, or to lie unconformably on the lower mass. Thus the slanting beds, *S*, in Fig. 32, lie unconformably on the irregularly

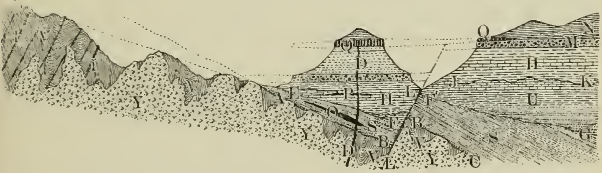

Fig. 32. Diagram of Geological Structures

truncated edges of the vertical schists, *V*, and granitic masses, *Y*; the surface of unconformity between them is seen in section in the line *AB–B′C*. Again, the horizontal strata, *H*, lie unconformably on the obliquely truncated slanting strata, *S*, as seen in the section line *EF–F′G;* finally the higher horizontal strata, *H*, are separated from the under strata, *U*, by an undulating line of unconformity, *JK*. An unconformity of this kind is difficult to detect; the difficulty is increased if the under surface is worn smooth, almost coincident with a single stratum, before the later strata are deposited (an instance of this kind is included in the figure and may be detected if the history there recorded is worked out). Fragments of the lower formation are often found in the basal members of unconformably overlying strata. The form and attitude of a surface of unconformity and all details regarding the adjoining rocks should be carefully noted.

Intrusions.

Crystalline rocks, such as granites and diorites, *Y*, are often found to penetrate rocks of other kinds, the penetrating rock usually lying beneath the other. The boundary between the two often suggests a branching penetration or intrusion from below, when the intrusive rock was mobile (molten) and the enclosing rock was rigid. The intrusive rock is usually finer-grained near its contact with the enclosing rock (effect of rapid cooling); fragments of the enclosing rock are often found in the intrusive rock near their contact. A simpler form of intrusion is shown at *DD*, where a fine-grained crystalline rock appears as a dike, occupying a fissure that traverses several other rock masses; the dike gives forth lateral sheets at *O*, *P*, and *Q*. If one of these sheets, as *O* or *P*, is found to be of dense texture throughout, and especially if it is seen to step by small breaks from bed to bed, it would be classed as an intrusive sill; if another, as *Q*, is found to be dense through its middle, somewhat scoriaceous at its base, and very scoriaceous at its surface, and if its fragments, more or less rounded (water-worn), are found in the next overlying beds, it would be interpreted as an extrusive or contemporaneous flow. Composition, attitude, and dimensions of intrusions and extrusions, with details of their relations to the adjoining rocks, should be carefully recorded.

Faults.

When corresponding series of rocks are found to be repeated on the two sides of a separating fracture, *LL*, they are said to be faulted. The separating fracture is often complicated; its side surfaces often have scorings or striations, more or less polished, called slickensides, which indicate relative motion. The faulted masses may have been drawn apart a few feet as well as vertically or laterally displaced; the space between them is then filled with angular fragments of the adjoining rocks, more or less cemented by various minerals; such cemented fragments constitute a fault breccia. Crystalline minerals are often found in the unfilled cavities. As fault breccias are usually more easily weathered than the adjoining rocks, ravines or valleys are often worn down on them, and hence faults are more generally inferred than seen. The course of a fault — the fault line — across the country, the attitude of the fault surface (vertical or slanting), the displacement of corresponding structures, as BB' or FF', and details regarding slickensides, breccia, etc., deserve careful attention.

Geological Processes.

The processes that have brought about changes in the geological past are best understood by a study of the processes now going on in the geographical present. They are chiefly as follows. (1) Ordinary or normal erosion, including the fracturing and disintegration of surface rocks by weathering, the slow down-hill "wash" and "creep" of rock waste or soil, and the more rapid transportation of rock waste by streams, with which are to be associated the corrasion of the stream channels by attrition of transported detritus; glacial erosion, including the scoring and plucking of subglacial surfaces, together with corrasion by subglacial streams and transportation of detritus beneath, within, and upon the ice; wind erosion and transportation, accomplished by the natural sandblast of wind-swept grains in arid regions; marine erosion or abrasion, including the attack of waves and wave-swept detritus on a shallow sea bottom and its shoreline, associated with which is the formation of sea-cliffs by sapping and weathering, and the transportation of abraded waste, chiefly into deeper water. (2) Deposition, chiefly the deposition of land-waste in the sea in the form of nearly horizontal stratified deposits (gravels, sands, muds) including many or few organisms as fossils; and the accumulation of calcareous deposits as limestones; also the deposition of stream-carried waste in lakes, on piedmont plains (where the mountain torrents, losing velocity, cannot carry along all the waste they have washed down their steeper courses, and hence deposit part of it in irregular beds), and in arid basins (where streams dwindle by evaporation and must therefore progressively deposit their load of waste); further, the deposition of glacier-borne waste beneath the ice (ground moraine or till), where the weight and velocity of the ice and hence its dragging power decrease, and at the ice margin (terminal moraine); the deposition of wind-borne waste in dunes and loess (fine dust deposits). (3) Diastrophism or deformation of the earth's crust, including slow or sudden uplifts, depressions, warpings, and fractures, often accompanied by earthquakes. Thus low land areas may be depressed beneath the sea, and shallow sea bottoms uplifted as land, but few if any instances are known in which the deep-sea bottom has been laid bare; horizontal strata along with their foundation of older rocks may be tilted, faulted, or otherwise deformed. (4) Vulcanism, including all the phenomena of intrusion and extrusion, deep-seated or superficial, in continents or in oceans. In so far as any of these processes are recognizable as now in progress, or in so far as ancient processes are recognized by their existing effects, they should be studied and interpreted. One example of such interpretation is offered below.

Specimens.

Decayed fragments, found loose, or broken from a weathered rock surface, are seldom worth carrying away. Fresh, unweathered specimens, broken with a large hammer from a surface of recent fracture, and trimmed neatly to shape with a small hammer, are of more value. A preferred shape for museum collections is like a cake of soap, about 1 × 2 × 3 inches; half-size samples weigh only one-eighth as much, and are recommended for travellers' collections. Thin chips, the size of a nickel or quarter, are useful for microscopic study, especially of igneous rocks. Specimens of crystalline minerals should not be trimmed to a specified size; the more handsome the crystals and the larger the specimen, the more valuable it is. All specimens should be promptly and carefully labelled, wrapped, and packed. It is useless to go to the labor of carrying a heavy load of specimens, if their localities cannot be certified.

Fossils. — Almost any fossil is worth bringing home from little-known regions; but the real interest and value of fossil collecting are not reached by random gathering. If the traveller who is at all interested in geology has the fortune to come upon a well exposed series of fossiliferous strata, several days may be profitably spent, laboriously hammering in layer after layer, with the most persistent work where fossils are most abundant. The fossils gathered in an hour or more on a rich bed or "horizon" should be sorted out and the best specimens of each kind labelled and wrapped; then the next rich horizon should be similarly worked, and so on through the series. Fossils found in loose "slide rock" or talus should be searched for in place higher up the slope. The composition, attitude, and thickness of the exposed strata should be carefully noted and illustrated in a cross-section (see below). Collections thus made may have high scientific value.

Prospecting.

The search for valuable minerals, or "prospecting," has special attractions; but the amateur must not expect often to discover anything new, so industriously has the world been ransacked by professionals. Preparatory study of mineralogy for a month or two, with special reference to the useful minerals, will be repaid by bringing to sight many things, otherwise invisible. A small case containing a blow-pipe and reagents for testing minerals is helpful in the field. Pick and shovel are needed for rough work; hammer and lens for fine work. A day's preparatory practice under instruction with a pan or shovel in "washing" stream gravel for gold or platinum should not be forgotten. Veins, fault-breccias, and contact zones, especially where intrusive rocks enter limestones and other bedded rocks, should be examined as well as the residual soil on broad uplands of deeply weathered rocks. From such soils all the soluble constituents have been leached out, leaving a concentrate of the insoluble minerals, in which the less common metals sometimes occur. Mineral fragments, or "float," in stream gravels should be followed up to their source, the approach to which is indicated by the fragments becoming larger, more numerous, and more angular. The famous graphite deposit of the Alibert mine in Siberia was discovered in this way. The most important rule in prospecting is not to waste time in unlikely ground; the next is, if likely ground is discovered, to persevere through disappointment: keep on looking for the needle, provided there is reason to think it is in the haystack. Third, if anything good is found in a wilderness, take careful note of its locality and of the route leading to it, so that it can be readily found again. Finally, do not talk about your find to chance wayfarers.

Geological Maps.

A topographical map (see p. 395), showing the general lay of the land, is needed as the basis of a geological map. In a treeless region the rough outlines of contrasted formations, such as are usually expressed in differences of surface form, may be quickly sketched in from good viewpoints; special excursions should then be directed to points where uncertainty remains. In a forested region, progress is slow because it must be made step by step instead of in broad sweeps. Generalization is easy in one case, difficult in the other. Care should be taken to distinguish observed outcrops and boundaries from the inferred but hidden extension of the same rocks under a soil cover; for this purpose inferences may be represented by different crayon tints, on which pen or pencil marks indicate observations.

Detailed plans on a larger scale than the general map serve to show local complications of structure, such as folded strata and different kinds of contacts. Even a rough outline map is a helpful supplement to verbal description.

Geological Sections.

Inferences as to underground structures are easily shown on imagined vertical sections, such as are naturally exposed in the wall of a deep canyon, or such as would be laid bare on the side of a railroad cut 100 feet deep. Structures observed in surface outcrops are to be reasonably prolonged underground, as shown in Fig. 32. In the most careful work, observation and inference should be differently represented, as on maps. The relative position of successive strata, their thickness, their supposed connection underground between different outcrops (as in trough-folds), the displacement of faults, the penetration of intrusive rocks, are all shown to best advantage in this way. The line of a section should be indicated on the map of its district. Admirably prepared maps and sections, with explanatory text, may be found in the folios of the Geologic Atlas published by the United States Geological Survey, now accessible in most scientific libraries. Sample folios can be had at small cost on addressing the Director of the Survey in Washington.

Interpretation of Geological History.

Geography culminates in regional descriptions based on abundantly visible surface features; hence geography is largely an observational science. The highest aim of geology is the interpretation of the earth's history, based on such fragmentary records of the past as are imperfectly disclosed in surface structures; hence geology is largely a speculative science. The essence of geological history is the exposition of inferred conditions and events in the order of their occurrence, with description of successive "populations" indicated by fossils, and explanation of the processes by which the succession of events was brought about.

Certain general principles of interpretation may be briefly stated. The lower members of a series of strata must have been deposited before the overlying members; but care must be taken in regions of disturbed structure not to be deceived by overturned strata in which the underlying members are the youngest. Conglomerates must be younger than the rocks from which the conglomerate pebbles are derived. Bedded rocks of rather even and continuous stratification, containing fossils resembling in some degree marine organisms of to-day, are believed to have been deposited in ancient seas; bedded rocks of uneven stratification, with frequent cross-bedding and mud-cracks, may have been deposited in seashore lagoons; but if they contain fossils of land plants and land animals only, they are presumably "continental deposits," formed by streams and rivers in basins or on piedmont lowlands; fine-bedded strata, containing fossils of land and freshwater forms, were presumably deposited in lakes or on flood plains of large rivers. Intrusive rocks must be younger (in the sense of having taken their present position later) than the rocks into which they intrude; a vein, a dike, or a fault must be younger than the rocks that it transects. An unconformity indicates the lapse of time locally occupied by erosion and hence unrecorded by deposition thereabouts, though presumably recorded by deposition elsewhere; for after the under rocks were formed, they must have been (1) uplifted with more or less deformation and (2) thus subjected to erosion, which must have been long continued if the deformed rocks are deeply truncated, and then (3) depressed to receive the covering strata. A fault indicates a displacement of the mass on one side with respect to the mass on the other.

It should be carefully borne in mind that error is more likely in inference than in observation. If an observer reports the existence of a slanting bed of limestone, his observation may as a rule be trusted, though it is possible that joint planes might be carelessly mistaken for bedding planes; if he reports that a slanting bed of limestone has been tilted from its (supposed) original horizontal position, he is evidently going back of the observable present into the invisible past, and his inference may be wrong, for some limestones are formed by incrustation, in which the original attitude of the deposits may have been slanting. Complicated inferences must be carefully thought out to all their reasonable consequences, and then tested by renewed observation at points where the expected consequences can be proved or disproved. For this reason inference as well as observation must be carried as far as possible in the field; inferences that are made after return from the field cannot be tested by renewed observation. Alternative explanations must be considered on the ground, and choice between them must be made by means of some crucial test, which it is the duty of the thoughtful and ingenious observer to devise and apply. The solution of most geological problems is best reached in their own field; hence problems should not be carried home for solution, and above all, the expert who has not seen the ground should not be expected to solve them if they remain unsolved by the observer to whom the ground is familiar.

Many a traveller in a region of great structural interest hesitates to attempt speculation about its geological history for fear of making mistakes. It has been well said by an able geologist that the only men who make no mistakes are those who do nothing. Let the beginner take courage; let him walk and look and hammer and think and sketch and write; let him begin with simple notes of mere occurrence; let him go on with notes on visible and inferred structures, and thus gradually open the way to speculations on past conditions and processes. Discussion with a companion aids progress. When first venturing on speculation, begin with simple structures, keep observations and inferences carefully apart, and write explicit statement of the principles on which inferences are based. As an example for practice, the structures shown in Fig. 32 may be interpreted as recording over twenty successive events, some longer, some shorter, such as (1) the deposition of the strata, *V*, (2) their tilting and folding, (3) intrusion of the black dikes, *II* (later than folding, because they are not folded), (4) intrusion of granite, *Y* (later than dikes, because the dikes are cut by the granite), (5) uplift of compound mass, (6) long-continued erosion, reducing the uplifted mass to a lowland of small relief, AB–$B'C$ (later than granite intrusion, because part of it is truncated), (7) subsidence of eroded lowland, (8) deposition of strata, SS, (9) uplift and slight tilting, (10) erosion, obliquely truncating compound mass, EF–$F'G$, (11) increased tilting, whereby part of region (to left) is elevated and part (to right) is depressed; and so on. There are only two problems of less evident interpretation: the relative dates of the fault, LL (17), and the volcanic features, DQ (19), and correlated therewith, the unconformity (18) between the parallel strata, M, N.

METEOROLOGICAL OBSERVATIONS.

BY ROBERT DE C. WARD.

Introduction.

Weather conditions are such ever-present and obvious controls of all outdoor activities that no one, least of all a traveller, can be unconscious of them. By devoting a few minutes a day to recording simple observations, every traveller, whether skilled in meteorological work or not, may not only make his own journey more worth while, but also add something definite and valuable to our knowledge of the meteorology of little-known regions. The traveller who has never made a study of meteorology, and who wishes to gain some general knowledge of the subject before he starts on his journey, may well read over one of the newer American meteorological text-books. If he desires to acquaint himself with the climatic conditions of the region which he plans to visit, he will do well to consult the standard work on local climate. In this he will find mention of important local phenomena which may be especially worthy of attention and further observation.

The present subject may be considered under two heads: (1) non-instrumental, and (2) instrumental observations.

Non-Instrumental Observations.

General. — Many travellers feel that unless they can keep up a complete series of standard meteorological records, with a considerable and superior instrumental equipment, it is not worth while to attempt any observations whatever. This is by no means the case. Even such irregular notes as may be made by a traveller on a train, on horseback, on foot, or on ship-board, are often of real interest. A few careful non-instrumental observations, especially if made regularly, are often of more value, even to meteorologists, than any number of careless and inaccurate instrumental records. Even in the most elaborate meteorological records, many weather elements are always observed non-instrumentally.

Hours of observation. — The time of an observation should always be recorded. So far as possible, all observations should be made at regular times, but irregular observations of the ordinary weather elements, and of other phenomena noted later (p. 456), should also be made when opportunity offers. It is advisable, when possible, to take three regular daily observations, because, by so doing, the diurnal variation as well as the extreme values of the different weather elements may usually be approximately determined. Preferred groups of hours, which serve equally well for instrumental records, are 6 A.M., 2 P.M., and 8 or 9 or 10 P.M; or 7 A. M., 2 P. M., and 9 P. M. The morning observation is best taken not later than 7 A. M., even earlier in summer. When an occasional day is spent in camp, hourly or two-hourly observations may be made if any especially noteworthy conditions prevail.

Temperature. — Thermometer readings often fail to indicate the temperature that we actually feel. It is, therefore, well worth while to note our sensations of heat or cold in some such terms as *chilly*, *muggy*, *exhilarating*, *depressing*, *mild*, *excessively hot*, etc. Such non-instrumental records of temperature are recommended, even when thermometer readings are also made. They give an idea of the general feeling which the weather produces, and this is an important part of the climatic picture. The occurrence of frost, or of a thin skim of ice in the early morning, gives evidence of nocturnal temperatures below freezing. Frost of varying stages of severity, and ice of different thicknesses, give general indication of the amount of cold below the freezing point. A rise of temperature above freezing may be noted when thawing is observed, especially in cloudy weather.

Wind. — Wind greatly affects our sensations of heat and cold. High winds may make travel uncomfortable, or even dangerous. A knowledge of local winds in mountainous regions may be put to practical use in locating camp sites. In boat or canoe trips, wind direction and velocity, and their changes, deserve careful attention.

Wind direction is to be recorded to eight points of the compass. The direction is that *from* which the wind blows. Regular changes in direction, seasonal and diurnal, should be noted, as well as the irregular changes referred to in a later paragraph. The prevailing wind direction may often be determined by observing the slant of wind-blown trees, which in many places serve as excellent wind-vanes; by noting the relative effects of wave-action on different sides of a lake or pond; or by observation of sand dunes. If high mountains are ascended, especially in the Tropics, changes in wind direction during the ascent should be noted. Wind direction and its changes are often of practical importance as indications of coming weather changes.

Wind velocity may be roughly estimated by noting the effect of the wind in blowing trees, or in producing waves of different sizes on lakes or rivers. The Beaufort scale, with the equivalents in miles an hour, as given by the United States Weather Bureau, is a convenient one for the use of travellers.

Beaufort Wind Scale.

No.	Terms	Miles per hour
0	Calm	0 to 3
1	Light air	3 to 8
2	Light breeze	8 to 13
3	Gentle breeze	13 to 18
4	Moderate breeze	18 to 23
5	Fresh breeze	23 to 28
6	Strong breeze	28 to 34
7	Moderate gale	34 to 40
8	Fresh gale	40 to 48
9	Strong gale	48 to 56
10	Whole gale	56 to 65
11	Storm	65 to 75
12	Hurricane	75 or over

The general tendency is to overestimate wind velocity, especially toward the higher numbers of the wind scale. The hours of calm, of change from calm to wind, of increasing and decreasing velocity, are important facts in the description of any climate. Note should be made of the occurrence of special winds, such as land and sea breezes and lake breezes; of the up-slope ("valley") wind by day and the down-slope ("mountain") wind by night in mountain regions; of exceptional warm and dry winds along the leeward base of a mountain range ("foehn" or "chinook"); of hot and dusty winds in deserts ("chamsin," "simoom," etc.), with record of time and duration of occurrence, topographic surroundings, relation to general weather conditions, to vegetation, and the like. If tornadoes, or whirlwinds, or waterspouts are met with, the width and length of their path should be observed, as well as their duration, direction of travel, clouds, wind changes, and preceding and accompanying weather. Tornadoes and gales may be detected many years after their occurrence by the damage which they did in forests.

Clouds. — Cloud amounts are ordinarily recorded in the words *clear, fair, cloudy,* and *overcast.* A *clear* sky is less than 3/10 cloudy; a *fair* sky is from 3/10 to 7/10 cloudy; a *cloudy* sky is over 7/10 cloudy; an *overcast* sky is covered with clouds, 10/10. In estimating the number of tenths of the sky which are cloudy, the lower portion of the sky, nearest the horizon, should be disregarded, owing to error by foreshortening. While single estimates of the amount of cloudiness by individual observers are often likely to be somewhat in error, the means are generally reasonably reliable. A note as to whether or not the sun was shining brightly at the time of each observation may well be made.

The thickness of clouds may be conveniently indicated by three or more exponents, as 10^1 for a thin cloud sheet completely covering the sky; 5^3 for a fair sky, with heavy clouds.

The kind of cloud should be recorded, by those who wish to pay attention to further details, in accordance with the International Cloud Classification. The United States Hydrographic Office (Washington, D. C.) publishes an excellent little book of colored cloud views, with names and descriptive text, which will enable every traveller, before starting on his journey, to familiarize himself with the standard cloud types. Changes in the kind, amount, and thickness of clouds are valuable indications of coming weather changes.

Cloud movements are also important in weather forecasting, as well as in showing the general drift of the upper air currents. These directions may be determined non-instrumentally for clouds near the zenith by holding the head steady near some tall object, like the corner of a building, or a tree, and noting the point of the compass from which the cloud moves across the sky within the field of vision. Observation of cloud movements near the horizon is difficult because of errors due to perspective.

Cloud heights may be judged very roughly by the brightness of the clouds. The high clouds, which best reflect sunshine, are the brighter. The altitude may also often be determined by noting the position of clouds over mountain tops of known elevation. When the observer is on his way up or down a mountain he may frequently ascertain the height of clouds whose base happens to be on a level with his own position.

Fog, which is merely the lowest form of cloud, should be noted, as well as its duration and density.

Rainfall. — Under the term *rainfall* meteorologists include, besides rain itself, snow, hail, sleet, frozen rain, etc. Non-instrumental observations of precipitation include the kind (rain, snow, hail, etc.), the amount (trace, light, moderate, heavy, very heavy), and the time of beginning and ending of the storm or shower. Such simple records soon furnish information concerning the diurnal periodicity of rainfall, the occurrence of rainy or dry seasons, and the character of the rainfalls, whether heavy or light, whether coming in brief local showers or in long stormy spells. All this has immediate personal interest, and is also a contribution of importance to the economic climatology of any little-known region. In connection with snow, the dates of first and last snow, the depth in each fall, and the character of the snow are to be recorded.

Numerous other observations are easily made, even on a hurried trip. Vegetation furnishes a general criterion regarding temperature, and especially regarding rainfall. When trees shed their leaves we infer a season of cold or of drought. The direction of rainy or snow-bearing winds may be discovered by seeing on which side trees or buildings are wet. Vegetation on slopes often indicates the direction of the damper winds. Whether or not hail, or snow, or sleet, or frozen rain occurs at all in the regions traversed is an important point which may be settled by any traveller, so far as the period of his own journey in a country is concerned. The occurrence of hail, especially on tropical lowlands and at sea, and of snow at or near sea-level in the Tropics, is of exceptional interest. Careful observations of the height of the snow-line on mountains in all parts of the world are still needed. Special note should be made of the locality and exposure, as well as of the date and altitude.

Forest and prairie fires indicate droughts or dry seasons. Whether a river is subject to floods may usually be determined by such hurried observations as any traveller may make from a car window, on horseback, or on foot, by noting the mud deposited by former floods on the trunks of trees; or by seeing the banks and neighboring fields actually under water. The condition of roads, whether dusty or muddy, indicates in a general way the occurrence or lack of recent rainfalls.

Thunderstorm observations should include the following: times of first, last, and loudest thunder, and of the beginning and ending of the rain; the direction from which the storm came; whether mild or severe; whether distant or near; the duration, velocity, and changes of the winds; the extent of the storm; the forms of the clouds, with note of their position in the storm; the size, form, and structure of hail-stones. Photographs or drawings of hail-stones are always interesting. Distant thunderstorms, lightning without thunder, and the direction in which these phenomena were observed, should also be recorded. The occurrence of "ball lightning" is interesting and, if opportunity offers, deserves special attention.

Miscellaneous phenomena. — There should be a generous space in every traveller's note-book for miscellaneous meteorological phenomena. Here may be included notes on the occurrence and amount of dew. The occurrence of frost may be detected both by seeing it and by noting its effects. The height reached by killing frosts may be determined by an examination of the vegetation on hill slopes. Haze is a phenomenon of interest, as are its cause, in dust, smoke, or water vapor, and the accompanying weather conditions. Optical phenomena deserve attention, such as auroras, especially in low latitudes, rainbows, haloes, St. Elmo's fire, etc. Mirages are worthy of note, with observations of the accompanying weather conditions. Travellers may often gather information concerning the seasons by noting the times of planting and of harvesting, and by observing periodic phenomena in animals and plants. The dates of freezing and of opening of rivers and lakes are climatic facts worthy of attention.

The general character of each day's weather ought to be summarized briefly in a special column of the meteorological note-book. It is the daily weather types which, averaged and in their sum total, give us climate. A brief statement as to each day's weather gives a vivid picture which is often of great service to other persons.

Form for non-instrumental record. — The form on the following page will be found convenient for such simple non-instrumental observations as have here been suggested. A note-book ruled and ready for use before starting on a journey is an aid. Otherwise meteorological records may be kept in a general note-book.

Instrumental Observations.

General. — The extent of his instrumental equipment will be determined by the interest, time, and means of each traveller. In the following sections reference is made only to the simple equipment which the average man will probably be able to take. Those who wish to give more time to this subject should consult the standard scientific guides for travellers, and the instructions in the use of the various instruments, published by the United States Weather Bureau. Whatever be the equipment, care should be taken to secure good instruments. It is essential that the traveller should familiarize himself with their use before he starts on his journey.

Thermometers and psychrometers. — The simplest and

Form for Non-Instrumental Record.

Month and Day	Hour	Temperature	Wind		State of Sky	Precipitation				General Character of Day	Miscellaneous Phenomena [1]	Remarks [1]
			Direction	Velocity		Time of Beginning	Time of Ending	Kind	Amount			

[1] The spaces for "Miscellaneous Phenomena" and for "Remarks" should run across a full page. Narrow columns will result in the omission of many interesting details.

most convenient method of taking air temperatures on travels is by means of the sling psychrometer. If a more expensive and more accurate instrument is desired, the Assmann aspiration psychrometer may be used. These instruments give data for the determination of the dew point and relative humidity, as well as the air temperature. Further, the difference between the wet- and dry-bulb readings furnishes some indication of the amount of evaporation and also of the "sensible temperature," *i. e.*, the temperature which we actually feel as distinguished from that registered by the ordinary thermometer.

The sling psychrometer consists of a pair of thermometers (wet and dry bulb) fastened together on a metal back, to the upper part of which a cord with a loop at the end is attached. The muslin cover over the bulb of the wet-bulb thermometer must be thoroughly moistened with clean water just before each observation. The instrument is then whirled around the hand in a vertical circle a dozen or more times; the readings of both thermometers are noted, and the whirling is continued until two consecutive readings of the wet-bulb instrument are practically identical. This reading of the wet bulb, and the simultaneous reading of the dry bulb, should then be recorded. See that the muslin remains wet throughout the time of observation. In rainy or snowy weather stand sufficiently under shelter to keep the dry-bulb thermometer from becoming damp. It makes little difference whether the readings are made in the sun or shade. True readings may usually be secured in two or three minutes, or even less.

At least two sling psychrometers should always be taken on a journey, as they are likely to be broken; also in the careful barometric determination of altitudes simultaneous observations of the air temperature at two stations are essential. An extra supply of muslin coverings for the wet bulb is necessary, as they must always be clean. At temperatures below freezing, the readings of the wet bulb are rather unreliable. Nevertheless, evaporation takes place from ice as well as from water, and if time is allowed for the water in the muslin cover to freeze, the sling psychrometer gives reasonably good results if the temperatures are not too far below freezing. Care must be taken in whirling the instrument not to hit the ground or any neighboring object; the degrees should be read to tenths, and special attention should be paid to making a correct entry when the readings are below zero Fahr.

The Assmann aspiration psychrometer is a very ingenious and extraordinarily accurate form of the same instrument. This is made in two sizes, one of which is a pocket instrument suitable for a traveller's use. It is "ventilated" by a fan driven by clockwork so that no whirling is necessary. Moreover, the thermometers are protected against sun and rain by being enclosed in double nickel-plated tubes, open at the top and bottom to give passage to the current of air. The Assmann aspiration psychrometer may be held in the hand or hung upon a branch or a hook. The scale is Centigrade. Full instructions for use, and a certificate of corrections accompany each instrument.

Thermometers should be read systematically three times a day, if possible, at the hours suggested in a previous paragraph (p. 452). Maximum and minimum thermometers are very useful for determining the highest and lowest temperatures reached during each 24-hour interval, but their proper exposure on travels, especially in the case of the maximum, is difficult, and they are likely to get out of order. Frequent observations of the air temperature during the hours from noon to 2 P. M. will usually give approximately the highest temperature of the day. The lowest temperature usually occurs shortly before sunrise, and is therefore less conveniently observed. Both highest and lowest daily temperatures are interesting and important climatic data.

Dew point and relative humidity table. — The condensed table opposite gives the dew point and relative humidity for air temperatures from −10° to 100°, and for differences between dry- and wet-bulb readings from 1° to 24°, for 2° intervals. The figures in the left-hand vertical column are the differences in degrees between dry- and wet-bulb readings; the figures in the upper horizontal line are air temperatures. As an example, for air temperature 50°, and a difference between dry and wet bulbs of 8°, the dew

Table of Dew Point and Relative Humidity.

Difference of readings of dry and wet bulbs	Temperature of Air — Fahrenheit											
	—10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
1 D. P.	—22	— 7	5	16	27	38	48	58	69	79	89	99
R. H.	55	71	80	86	90	92	93	94	95	96	96	97
2 D. P.	—76	—18	— 1	12	24	35	46	57	67	77	87	98
R. H.	10	42	60	72	79	84	87	89	90	92	92	93
3 D. P.	..	—39	— 9	7	21	33	44	55	66	76	86	96
R. H.	..	13	41	58	68	76	80	84	86	87	88	90
4 D. P.	..	..	—22	1	17	30	42	53	64	74	85	95
R. H.	..	..	21	44	58	68	74	78	81	83	85	86
6 D. P.	..	..	..	—18	7	24	37	49	61	72	82	93
R. H.	..	..	..	16	38	52	61	68	72	75	78	80
8 D. P.	..	..	..	..	— 8	16	31	45	57	68	79	90
R. H.	..	..	..	..	18	37	49	58	64	68	71	74
10 D. P.	..	..	..	..	..	4	25	40	53	65	77	87
R. H.	..	..	..	..	..	22	37	48	55	61	65	68
12 D. P.	..	..	..	..	..	—16	17	35	49	62	74	85
R. H.	..	..	..	..	..	8	26	39	48	54	59	62
14 D. P.	..	..	..	..	..	..	5	28	45	58	70	82
R. H.	..	..	..	..	..	..	16	30	40	47	53	57
16 D. P.	..	..	..	..	..	..	—20	20	39	54	67	79
R. H.	..	..	..	..	..	..	5	21	33	41	47	51
18 D. P.	..	..	..	..	..	..	..	8	33	50	63	76
R. H.	..	..	..	..	..	..	..	13	26	35	41	47
20 D. P.	..	..	..	..	..	..	..	—13	25	45	60	73
R. H.	..	..	..	..	..	..	..	5	19	29	36	42
22 D. P.	..	..	..	..	..	..	..	..	15	39	56	69
R. H.	..	..	..	..	..	..	..	..	12	23	32	37
24 D. P.	..	..	..	..	..	..	..	..	0	32	51	66
R. H.	..	..	..	..	..	..	..	..	6	18	26	33

point (D. P.) is 31° and the relative humidity (R. H.) 49 percent. This table is taken from Professor W. M. Davis's "Elementary Meteorology," p. 150. Fuller tables should be used when possible.

Aneroid barometers. — The aneroid barometer has the great advantage of being more easily carried than the mercurial, of requiring fewer regular corrections, and of being more serviceable to the average traveller. It must be realized at the outset that pressures and altitudes measured by means of aneroids are not regarded as having the accuracy of those which are determined by means of mercurial barometers, or of a boiling-point apparatus. This fact granted, the traveller who has a first-class aneroid, knows its corrections, takes good care of it, and is skilled in its use, may use it with satisfaction and with profit, both to himself and to others.

Aneroid barometers are made in various sizes, from the so-called "watch" size, through "pocket" size, and up to 5 inches or even more in diameter. The watch and pocket sizes are more convenient to carry, but their scale divisions are so small that accurate readings are often difficult or impossible to make. The larger sizes have more open scales, but are heavier and more clumsy. To save weight, many aneroids are now made of aluminum. A medium-sized aluminum instrument will probably prove the most useful. It should be carried in a leather case slung by a strap over the shoulder. Aneroid barometers may be purchased of all dealers in standard meteorological instruments. None but the best, sold by makers of recognized standing, should be selected. For mountain work, the instruments must, of course, be adapted for use at the greatest elevations which are to be reached. At least two barometers ought to be taken, to provide for accident, for purposes of comparison, and because, in careful altitude work, two are necessary.

Within a few years two new forms of aneroid barometers have been designed which have been highly spoken of by those who have used them. One of these, the Watkin's Mountain Aneroid, is so constructed that it may be thrown out of action when not in use and thus protected from the disturbing effects of the diminished pressures during the ascent or descent of a mountain. The instrument may be kept constantly in action, and thus serve for ordinary weather observation. In the other, the Watkin's Three-Circle Aneroid, the difficulty arising from the small divisions on the scale of the ordinary aneroid, above referred to, is obviated in an ingenious way. The pressure and altitude readings are engraved around the margins of three concentric circles, the needle being long enough to extend across them all. A figure (1, 2, or 3), which appears in an opening through the face of the instrument, indicates on which of the three circles the readings are to be made. By thus distributing the pressure readings around three circles, instead of around the circumference of one circle, as in the ordinary pattern, it becomes possible easily to detect differences of altitude as small as five feet.

Aneroids are delicate instruments and require careful handling. They must be guarded against violent knocks and excessive jarring. They should be kept from the direct rays of the sun, held level, and tapped gently before each reading. The observer's eye ought to be directly over the pointer, or the reading may be made by sighting along the pointer. After a rapid ascent or descent a few minutes should be allowed to elapse before an observation is made. Aneroids must frequently be compared with mercurial barometers whose readings have previously been "corrected for temperature," and the corrections should be noted. Aneroids are particularly liable to error after they have been taken to considerable altitudes, and comparison with a mercurial barometer ought therefore to be made at the end of a trip as well as at the beginning. In fact, the error of an aneroid may be about the same at both of these times, and yet may have been different during the journey. For ordinary purposes it is best, however, not to keep adjusting an aneroid so as to bring it into agreement with a mercurial, but rather to note the corrections and then be careful to apply them whenever a reading is made.

For purposes of the ordinary weather record, pressure readings may be made thrice daily. When thus used as a "weather glass" there is no need of extreme accuracy. It is the kind and rate of change that is here of more consequence than the exact pressure reading. The cautious traveller will watch his barometer with critical eye. Pressure readings and changes vary so much with latitude and season that it is not practicable to give here any rules for local weather forecasting. In general, however, the more rapid and the greater the rise or fall, the more emphatic are the weather changes. The traveller who wishes to make his own weather forecasts will need to study the local prognostics, such as clouds, wind directions, changes in humidity, etc. Few good aneroids have the words "fair," "change," "rain," etc., engraved upon their dials. These words have only the most general significance, and then only if properly placed and adapted for use in one special locality.

Form for instrumental meteorological record. — The more nearly complete record which may be kept when psychrometer, barometer, and rain-gauge (see page 467) are used may be entered in a table like that on the opposite page, which also includes the non-instrumental observations described above.

Simple methods of determining altitudes by aneroid barometers. — The simplest method of determining altitudes, and the one which will therefore probably be employed by most travellers, is to disregard the effects of temperature and of moisture and to make direct use of the altitude scale which is usually provided on aneroids designed for mountain work, and is in most cases movable. This method gives relatively crude and often rather inaccurate results, especially if only one barometer is available. The plan of procedure with one instrument is as follows. Just before starting from the base station turn the movable altitude scale until the known elevation of the base station is brought opposite the end of the pointer. On reaching the upper station, the approximate altitude will be indicated by the pointer if there has meanwhile been no change in pressure at the starting point, and if the altitude scale has not been displaced during the ascent. If the elevation of the base station is unknown, differences of altitude can alone be determined. Obviously, the shorter the time required for the ascent, the less likeli-

Form for Instrumental Meteorological Record.

Date Month and Day	Hour	Pressure (in inches and hundredths)	Temperature		Humidity		Wind		Clouds			Precipitation			General Character of Day	Miscellaneous Phenomena [1]	Remarks [1]
			Dry Bulb	Wet Bulb	Dew Point	Relative Humidity	Direction	Velocity (miles per hour)	Kind	Amount (in tenths)	Direction of Movement	Time of Beginning and Ending	Kind	Amount			

[1] See footnote under previous table on p. 458.

hood there is of the pressure having changed at the base. This source of error may be eliminated, at least partially, in two ways: (1) the observer may return to his starting point and there take another observation of pressure. If there has been a change, it is assumed that the change has been gradual, and the resulting "correction" is distributed uniformly throughout the period of absence; or, the lower reading is taken as being the mean of the two readings made at the base before and after the ascent. (2) If the observer cannot return to his point of departure, he may learn something of the general pressure changes which are taking place by watching his barometer during an interval of an hour or two at some fixed elevation. Having thus an indication of the rate of any observed change of pressure, he may apply the necessary correction. Sometimes the mean sea-level pressure over the district may be learned from isobaric maps, or otherwise, and this mean may, if necessary, be used instead of observations at the lower station, but the results are obviously less accurate.

If two barometers are available, and the traveller returns to his starting point, one instrument should be left at the base station. This may be read there at frequent intervals by an observer who does not take part in the ascent, or its reading may be noted by the traveller on his return, in preference to that of the instrument which was taken up. A self-recording barometer, left at the base, gives a very convenient means of knowing the pressure there without the assistance of a second observer. Greater accuracy in the determination of altitudes can always be attained if several series of observations are made, as on different days, and the average is then determined. Varying errors thus tend to neutralize one another.

In the careful determination of altitudes it is better to dispense with the altitude scale altogether, and to calculate the heights from the pressures alone, correcting for the temperature of the air. In the best work, simultaneous observations of pressure and temperature, one at the top and one at the bottom, requiring two observers, are necessary. The elevation of the base station must, of course, be known. The simplest rule for such a calculation is the following: the difference in pressure between base and upper stations, expressed in hundredths of inches, multiplied by 9, gives the approximate altitude of the upper station over the lower in feet. This is reasonably accurate for relatively slight differences of altitude and for ordinary temperatures. A more accurate result may be obtained by using the multipliers given in the accompanying condensed table, for pressures from 31 to 22 inches, and mean temperatures for 30° to 80° F.

Table for Use in Determining Altitudes.

Pressure	30° F.	40° F.	50° F.	60° F.	70° F.	80° F.
22 inches	11.9	12.2	12.4	12.7	13.0	13.2
24	10.9	11.1	11.4	11.6	11.9	12.1
26	10.1	10.3	10.5	10.7	11.0	11.2
28	9.3	9.5	9.8	10.0	10.2	10.4
29	9.0	9.2	9.4	9.6	9.8	10.0
29.5	8.9	9.1	9.3	9.5	9.7	9.9
30.0	8.7	8.9	9.1	9.3	9.5	9.7
30.5	8.6	8.8	9.0	9.2	9.4	9.6
31.0	8.4	8.6	8.8	9.0	9.2	9.4

If barometric tables are not at hand, the difference in elevation may be calculated by means of the following formula, in which B_0 and T_0 are the pressure and the temperature respectively at the base station, of known altitude, and B_1 and T_1 are the pressure and the temperature respectively at the upper station.

$$\text{Difference in elevation} = \frac{B_0 - B_1}{B_0 + B_1}\left\{55{,}761 + 117\left(\frac{T_0 + T_1}{2} - 60\right)\right\}$$

Those who wish to attain greater accuracy than aneroid readings can give, must use mercurial barometers or a boiling-point apparatus. Details regarding the use of these instruments and the necessary tables, must be sought in the more exhaustive scientific guides or in other special publications.

Rain gauge. — Instrumental record of rainfall is impossible while the traveller is on the move, but there are usually so many opportunities when a rain gauge can be used that one should be carried if possible. During the night's rest, throughout a stay of several days at one camp, or during a heavy rain which necessitates the interruption of the journey, it is often perfectly feasible to expose a gauge and thus to ensure accurate measurements of the amount of rainfall.

A rain gauge of 3-inch diameter is only 13 inches high and is easily carried. It consists of a copper top, the receiver, with a hole in the bottom, a small copper measuring tube, a larger overflow attachment, and a measuring stick. The receiver fits closely over the top of the measuring tube, and the latter is placed inside the larger overflow attachment. The rain falling into the receiver runs into the measuring tube, and fills it to a depth greater than the actual rainfall in proportion as the area of the receiver is greater than the area of the measuring tube. In the gauge here considered, this ratio is such that the depth of rainfall is magnified ten times. The object of magnifying the amount is to enable the observer to measure a small rainfall more accurately. In the 3-inch gauge, the measuring tube holds just 1 inch of rainfall. An opening in this tube, near the top, serves as an escape for the water into the larger cylinder in case the rainfall is so heavy as to fill the tube to overflowing.

The rain gauge should be set up firmly, as, for example, between three wooden pegs driven securely into the ground, in an open space unobstructed by large trees, buildings, or other obstructions. Fences, walls, or trees should be at a distance not less than their own height. The measuring stick — more than one should be taken — is graduated to hundredths of an inch. Since the total depth of water which may be contained in the measuring tube, *viz.*, 1 inch, is magnified ten times, the measuring stick shows 1 inch of actual rainfall when the magnified depth is 10 inches. The "inches" on the measuring stick are a little over long, to allow for the rise of water when the stick is inserted in the tube. Rainfall is recorded in inches and hundredths. Observations should be made once a day when at a fixed station, preferably at the last observation of the day, unless the rainfall is so heavy that more frequent observations are necessary. A record at the end of every storm is also desirable.

In measuring the depth of rain, the stick is lowered through the bottom of the receiver into the measuring tube, and, on being withdrawn, the wet portion of the stick shows the depth of water. After each observation the gauge should be emptied and drained, and then put back in place. When the total rainfall more than fills the measuring tube (*i. e.*, exceeds 1 inch) the receiver should first be lifted off and the measuring tube carefully removed so that no water is spilled into the overflow attachment. After emptying the tube, the surplus water in the overflow attachment must be poured into the measuring tube and measured. The amount of rainfall thus found is added to the 1 inch previously thrown out. In cases of very heavy downpours, the gauge may have to be emptied several times. On such occasions, special care must be taken to record the amounts noted in successive observations.

The 3-inch gauge does not give the depth of snowfall accurately by reason of its small size, which prevents a good catch of snow-flakes. It is customary to measure the depth of snow in inches, by means of an ordinary foot-rule or yard-stick, at some level place where there has been no drifting. The depth of melted snow is also commonly given as so many inches and hundredths of rain. The overflow attachment of the 3-inch gauge may be used, inverted, to cut out a section of snow at some place where the conditions seem typical. A thin board, or a piece of tin, may then be slipped underneath the open mouth of the gauge, and thus the cylindrical section of snow is taken up in the gauge. The depth of snow when melted is then measured in inches and hundredths, as if it were rain.

The amounts of rainfall are to be entered in the record book, with a statement whether they refer to rain or to melted snow. When there has been no precipitation since the last observation an entry of 0.00 inches should be made. When the amount is too small to measure, the entry "T" (for *trace*) is made.

Additional instrumental equipment. — The traveller who so desires may easily enlarge his instrumental equipment, with the result that his record will gain greatly in interest and value. If a sea voyage is to be taken, a small-size self-recording barometer (barograph) is a most interesting travelling companion. This instrument should be hung from the ceiling of the stateroom by a spiral spring, and may be prevented from swinging too violently by means of two or three strings fastened to the sides of the room. The writer took his Richard barograph on a voyage around South America in 1897–98, and secured a continuous and most interesting record of pressure from New York back to New York again. A pocket nephoscope of a modified Fornioni pattern may be made to order by any instrument maker.[1] A convenient size is 5½ inches in diameter and has an adjustable eye-piece, in two sections. The Dines portable anemometer is an excellent instrument for determining wind velocities, although it is somewhat troublesome to carry. Other forms of portable or pocket anemometers are also made. The late Professor A. L. Rotch's instrument for obtaining the true direction and velocity of the wind at sea will be found both interesting and useful on an ocean voyage (see A. L. Rotch, "An Instrument for Determining the True Direction and Velocity of the Wind at Sea," Quart. Journ. Roy. Met. Soc., 1904, vol. 30, pp. 313–316.

Instruments.

(The prices are approximate.)

Sling psychrometer	$5.00
Rain gauge (3-inch)	1.50
Assmann aspiration psychrometer, pocket size (R. Fuess, Steglitz bei Berlin, without duty) . .	30.00
Aneroid barometer . . . . upwards	20.00
Watkin's mountain aneroid, for altitudes of 5000 to 20,000 ft. (without duty)	30.00 to 35.00
Watkin's three-circle aneroid, for altitudes of 5000 to 20,000 ft., made by J. J. Hicks, 8–10 Hatton Garden, London (without duty) . . .	25.00 to 30.00
Richard barograph, small size (without duty) . .	30.00
Dines' patent pressure portable anemometer (Casella & Co., 11–15 Rochester Row, London, S. W., without duty)	17.50

[1] See C. Abbe, Report of the Chief Signal Officer for 1887, pt. 2, pp. 330–331, pl. 32, fig. 86. Washington, D. C.

Pocket nephoscope, made to order	$5.00
Rotch's instrument for determining the true direction and velocity of the wind at sea (Casella & Co., London, without duty)	20.00

Reference Books.

Text-books.

Davis, W. M.
1894. Elementary Meteorology. Boston, 8vo, Ginn & Co.

Hann, J. von.
1908–11. Handbuch der Klimatologie. 3d ed. Stuttgart, 3 vols., 8vo, Engelhorn.

Milham, W. I.
1912. Meteorology. New York, 8vo, Macmillan Co.

Ward, R. De C.
1908. Climate, considered especially in Relation to Man. New York, 8vo, G. P. Putnam's Sons.

Scientific Guide-books.

Royal Geographical Society.
1906. Hints to Travellers. London, ed. 9, vol. 2.

Neumayer, G. von.
1906. Anleitung zu wissenschaftlichen Beobachtungen auf Reisen. 3d ed., vol. 1, pp. 595–640. Hanover, 8vo, Max Jänecke.

Special Instructions in the Use of Instruments.

The following pamphlets are published by the U. S. Weather Bureau and may be obtained from the Chief of the Weather Bureau, Washington, D. C.

Instructions for Coöperative Observers.

Barometers and the Measurement of Atmospheric Pressure.

Measurement of Precipitation.

Instructions for Obtaining and Tabulating Records from Recording Instruments.

Anemometry.
Whymper, Edward.
1891. How to use the Aneroid Barometer. London, 8vo, Murray.

Meteorological Tables.

Smithsonian Meteorological Tables. 3d revised ed. Washington, D. C., 8vo, 1907.
Psychrometric Tables. U. S. Weather Bureau, 8vo.
Barometers and the Measurement of Atmospheric Pressure. U. S. Weather Bureau, 8vo. (Contains barometric tables sufficiently complete for ordinary use.)

NATURAL HISTORY COLLECTING.

BY GLOVER M. ALLEN AND THOMAS BARBOUR.

INTRODUCTION.

TRAVELLERS frequently have unusual opportunity for obtaining specimens of plants or animals which, though often common enough where they occur, are of rarity and value in the museum at home. The great number of living species is a matter hardly appreciated by the ordinary traveller, but to the specialist who wishes to make detailed comparisons, a large series of individuals showing geographical, sexual, and individual variation from many parts of a species' range is of great importance. Opportunities should therefore not be neglected for gathering and preserving any specimens which may be met with and sending them to a museum of natural history, more especially to one that is universal in its scope. Harvard men in particular owe to the Agassiz Museum and the Gray Herbarium a debt not to be forgotten, and it should be a point of pride to carry forward the great work begun by Louis and Alexander Agassiz and by Asa Gray.

In general, it may be said that the large and conspicuous species of any sort are the least worth bringing back, as they are usually well known. The value and interest of specimens are often inversely as their size. Some species can easily be obtained during short periods only or in certain circumscribed localities, so that it may chance that a species usually considered rare, will be found abundantly under the right combination of circumstances. The small, the dull-colored, the inconspicuous and elusive, the nocturnal and the burrowing species should be sought after; the large and showy species are of secondary importance.

A complete record of the sex, place, date, altitude on land or depth in water, and measurements should be added where possible (see below) for these data are absolutely essential. With intensive study of the various groups, the modern demand for well prepared specimens increases, and highly specialized methods of collecting have come into use for many different groups of plants and animals. The novice may, none the less, frequently render efficient service by collecting and temporarily labeling and preserving his specimens, leaving it for the expert preparator or specialist at the museum to effect their final preparation.

The Collecting of Botanical Specimens.

It is seldom worth while to press a few blossoms or to waste time and space over miscellaneous specimens without record as to date, locality, altitude, and soil conditions. Plants under three feet high should be preserved entire including the roots. For uprooting and extricating the latter, a heavy knife is useful or a short-handled pick with a 7-inch point, carried in a belt sheath. With these the earth is loosened and the root shaken free or the clinging soil washed out.

The standard herbarium sheet adopted by botanists the world over is about 16 by 11 inches; all specimens should be bent so as to come within this compass. Plants collected in the field may be carried in a tin box (vasculum) which prevents evaporation and preserves their freshness. For short excursions, however, such a box is not needed. Plants rolled in well moistened papers so that little evaporation takes place will keep fresh two or three days; when so packed they may be sent to a permanent camp or possibly even to the herbarium for which they are intended.

Plants to be pressed as specimens must be dried quickly in order to keep their colors. To accomplish this the collector should provide himself with a number of sheets of thin blotting paper 16 by 22 inches, folded to 16 by 11 inches; and sheets of corrugated paper 16 by 11 inches. Place the plant inside the blotting-paper folder, its leaves arranged as smoothly as possible, some with lower surface uppermost. Lay the folder on a sheet of corrugated paper; lay a second sheet of corrugated paper on this, then a second folder with plants, and so on. The data for the specimens may be written on separate bits of paper and laid inside each folder. After a pile of folders has been made, light board or lattice frames, 16 by 11 inches, are placed at top and bottom, and the whole is tightly strapped together. About the package bind a strip of stout paper or enamel cloth long enough to hang down below the package and prevent escape of warm air when it is suspended by one end. Hang the bundle over a safety lantern or low fire, so that heat passing through the corrugations will dry the blotters and the plants contained in them. An ordinary safety lantern gives about the proper amount of heat and can be left all night. By morning the specimens are in condition to be packed, either in their folders or between dry sheets of newspaper, without the corrugated paper. The folders may be tied into bundles with a stiff cardboard to protect them and packed with naphthaline flakes to keep out insects.

Plants over three feet high cannot be preserved entire. In preserving large fleshy plants, it is sometimes necessary to split them and remove some of the interior. Fruits may be dried and kept separately in a small bag or envelope marked with sufficient data to identify them with the portion pressed. In case of trees, a twig with characteristic leaves, flowers, or fruit is all that can be easily preserved.

Small plants may be placed between the leaves of a cheap book or magazine of porous paper with notes written on the page margin. When the book is sufficiently filled, tie it up and put it under slight pressure. Mosses and lichens should not be much pressed, but may be kept in paper bags or envelopes.

Collecting Zoölogical Specimens.

Mammals.

Materials. — The same tools and materials are necessary as for birds (see p. 483), and in addition a millimeter rule (a small steel one is best), a pair of fine-pointed dividers for measuring, galvanized iron wire, small and large (sizes 15 to 23) for wiring feet and tails, a combined pliers and cutter for the wire, and a paper of ordinary pins for pinning out specimens.

For purposes of anatomical study, specimens may be preserved in alcohol, but it is seldom that such material hastily prepared in the field is of value. Bats, however, are about as well kept as alcoholics as in skins, but where possible two series of bats should be preserved, alcoholics and skins of each species, for the many delicate membranous structures dry and shrivel outside of spirit. Use alcohol of 75 percent, and make a slight incision into the abdomen of the specimen before putting it in alcohol. Formalin should not be used if alcohol is obtainable as it injures teeth and bones. Small tags with serial numbers stamped on them are best to label alcoholic specimens and a record is kept in a book, corresponding to these numbers, giving locality and date. Or the specimens may be wrapped in cheesecloth and the data written with pencil on strong paper enclosed with each packet. Bats are thus easily preserved and because of their great variety are perhaps the most interesting of mammals.

Collecting. — For large game the hunter has usually his own preference as to guns. A 12-gauge shot-gun with light loads of dust shot (2½ drachms of powder) is serviceable in bat collecting. Bats may in warmer countries, particularly, be found in caves or hollow trees or dark places of any sort, and if out of reach with a net, can be brought down with a .22-caliber pistol using a shot cartridge.

Traps. — Most small mammals are adepts at hiding, are largely active at night, and hence must be trapped. Two styles of traps are recommended: (1) the Schuyler mouse trap (sold by J. P. Schuyler Co., Bloomsburg, Pa., at $9 per gross) is excellent and consists of a metal skeleton base upon which a wire loop snaps down when the bait wire is loosened. This wire may be bent out straight and its hook turned at right angles to engage the bail wire, in order to make it spring more easily; (2) a second type is now commonly found on the market consisting of a wooden base with a treadle, the pushing down of which releases a wire loop that snaps and breaks the animal's neck, and often, unfortunately, its skull.

For bait, rolled oats are good, also nuts, English walnuts and peanuts particularly. With Schuyler traps a little pinch of oats is put on the ground and the skeleton base of the trap set over it; with the other trap the bait is scattered on the treadle. In tropical countries a little naphthaline flakes mixed with oats will prevent ants from stealing the bait. Dried dates have been found very attractive in desert regions where oatmeal proved ineffectual, or blew away.

Trap-setting requires judgment; it is well to put out as many as can be readily tended — from 50 to 100 or more. Traps should be placed among rock piles, along bottoms of banks, in runways, or among roots where holes are found. Larger sizes of both the above traps are made for rats, weasels, etc. For larger mammals steel traps of two or three sizes are needed. The large traps must be fastened to a drag; the small sizes may be spiked to a log or staked to the ground. Steel traps are either set at the entrance to a small pen of sticks at the opposite end of which the bait is placed, or they may be placed against a tree and the bait hung over them. Special methods are used to trap the more wary species, and long practice is necessary before success can be hoped for.

The following directions are largely condensed from Bulletin 39, part N, of the United States National Museum, a copy of which will prove useful.

Measurements. — Four measurements are taken before skinning: (1) total length from tip of nose to tip of tail vertebrae (for small mammals set up a pin at the nose and a second at the end of the tail bone on a straight line and measure the distance); (2) length of tail vertebrae measured by dividers, from root to tip of tail, when held at right angles to the body; (3) length of foot from heel to end of longest claw; (4) length of ear from lower edge of orifice to tip. These measurements are recorded on the label together with sex, date, locality, and a serial number corresponding to one to be attached, after skinning, to the skull.

Skinning small mammals. — In skinning, an incision is first made from the end of the breast-bone to the vent, care being taken not to cut through the thin abdominal wall. Work the skin gently away from the body on each side till the knee joint is exposed. This is forced up and the entire leg severed at the knee. Cut through the anus close to the skin and work the skin free all around at the base of the tail. This done, seize the bared portion of the tail between thumb and forefinger nail of the left hand, just in front of the point where the skin of the tail is turned back on itself. With the forceps in the right hand, grasp the root of the tail vertebrae and with a steady pull the entire tail will slip forth from its skin like a sword from its scabbard. After a little practice this is easily done. Do not pinch the tail with the left hand but merely hold back the skin with the fingernails.

After this the skin is free all around and is worked forward over the shoulders, as one would strip off a shirt, but care must be used not to stretch it by too much pulling. Any force applied should be exerted at the point where the skin and body meet. The fore limbs are now to be severed at the elbows, and as the skin is pulled over the head the bases of the ears are exposed. Cut these through close to the head on each side and continue peeling forward to the eyes. Care must be taken to cut through the eye-lids close to the skull; it is very easy to slit the skin here and make a bad gash. Continue with scissors cutting the skin away close to the skull and around the teeth. Finally a clip through the cartilaginous tip of the nose, between the end of the nasal bones and the skin itself, severs the skin completely from the body. With needle and thread catch the lips together from the inside by one stitch at the middle of the mouth. Now finish skinning the legs down to the foot joint, remove the flesh, and leave the leg bones (cleaned) to give firmness. Remove the sheets of cutaneous tissue lying on the inner surface of the skin, taking care not to use such force as to tear it, and dust it freely with preservative. Then turn it back, right side out. Five wires are now needed, four shorter ones for the legs and one for the tail. Fill out the skin with cotton to its natural proportions, using a single large piece of proper size and if necessary a few small pieces to fill in depressions. Be careful not to pack the skin too full or to wad in the cotton so as to cause lumps. A little shaping may be done by passing the skin, held by the nose, through the ring made by touching thumb and forefinger together. Wrap the leg wires with cotton and push their free ends deep into the palmar pads. The tail wire must be wrapped with cotton to the proper size, by taking a long fiber and twirling it with thumb and forefinger about the wire, building it up gradually in thickness at the base. This is inserted to the tip of the tail and made straight. Now sew up the cut in the belly and tie the label securely to the right hind leg. The skin is next pinned to the bottom of a box or the tray of the collecting chest or to a slab of wood by forcing a pin through each foot, thus stretching the fore feet out in front and the hind feet out behind, soles down. The feet should be brought close in to the sides of the head and tail; the tail itself must be pinned straight out behind in the axis of the body. Bats should be pinned with the wings folded along the sides. A few days are required for drying in ordinary climates. When the skins are dry so that they crackle upon pressure they may be rolled in stiff paper and packed away in a trunk or chest.

Skull. — The skull and teeth of a mammal are more important as an index to classification than any other part. It is therefore very necessary to preserve the skull or as much of it as is possible. After skinning, the skull must be severed from the body without injuring it in any way; the brain must be removed through the large foramen at the back by using a loop of wire, or by forcing in bits of cotton and then removing them with forceps. The eyes and larger masses of muscles may be roughly cut away, but great care must be taken not to injure any bone. A stout tag with a serial number corresponding to that borne by the label of the skin should be tied through the lower jaw. Skulls may be strung on a wire to dry, the wire passing through the loop of the label string. Be careful not to leave skulls where vultures, kites, dogs, or rats can get at them, and never leave them over night outside the collecting chest. Final cleaning is to be done in the museum at home.

Skinning large mammals. — For skinning large mammals the same general directions apply as for small ones, except in case of antelope, deer, or other horned species, and some others in which the head is of greater diameter than the neck. With such the neck is severed at the base of the skull, the skin then turned right side out. A cut about the base of each horn separates the horns from the skin. A V-shaped cut is then made at the back of the head, the arms of the V joining the cuts about the horns, and through this opening the skull is skinned out. The ears must be skinned from within by carefully cutting the large cartilage free from the skin except at its edges. The inverted ear is then in two parts, the cartilage on one side, its skin on the opposite side. The tail, if large, must be split on the under side and salt rubbed in.

After removing what flesh can be cut from the hide, plain salt should be thoroughly rubbed into every part of the inner surface, especially about the hoofs and mouth, and into the ears after skinning out as above described. Unless this is done the hair will slip when later the hide is softened for mounting. Finally, fold the skin up hair side out, and lay it in a shady place for twenty-four hours. It must then be unfolded, and more salt rubbed in, especially on places that seem softer than the rest. Fold it up again and allow it to remain a few hours more, then drain off the water that will have accumulated and spread out the hide *in the shade* to dry. Before it is quite dry, fold it together in convenient shape for packing and it will dry quite stiff. Do not dry a hide in the sun or by artificial heat, except in wet climates, as too great heat melts the fat in the skin and spoils its texture. It is often easier to skin the legs of large mammals by cutting them on the inner side to the hoofs, but in thin-haired species this renders them very difficult to mount handsomely on account of the seams necessarily made in sewing the skin together afterward. Never stretch a skin by pegging out or tying in a frame; for it is useless as a specimen after such treatment. Sportsmen's trophies, consisting of head-skin and horns are of relatively small scientific value. If the skull can be preserved entire it is better to do so, as such specimens are worth the trouble. Brain tissue is most offensive in decay, and the cavity itself is difficult to dry out. Unless it is well cleaned and dried, maggots are very apt to invade the decaying tissue and increase its offensiveness. Stout tags of linen or block tin with numbers corresponding to those of the skins must be attached to all skulls. Lower jaws are best packed separately, and numbered to correspond with their crania. Always wrap the lower front teeth very carefully in moss, grass, leaves, and a bit of cloth over all, otherwise they are invariably broken.

For animals with very thick hides, as rhinoceros or eland, it is necessary to pare off as much tissue from inside as possible for otherwise the salt will not penetrate. Such thinning also makes the specimen easier to transport. Sportsmen often make the mistake, in taking head-skins, of cutting the neck too far forward. Cut well back on the fore shoulder, and record the girth at the base of the neck.

Packing. — Small mammal skins, when dry, are best rolled in strips of newspaper, with the ends of the rolls folded together and pinched in. The packages are then placed side by side in shallow trays or in shallow layers in a box, with a partition supported on pins or nails between each layer to prevent crushing. The skulls are best carried in boxes, well wrapped. Large hides, rolled into as small compass as possible, should be securely boxed, preferably in tin-lined cases such as are obtainable in most countries frequented by English sportsmen. These prevent ingress of damp or insects. Large skulls and smaller hides should be first wrapped in newspaper if obtainable, and packed with plenty of straw in boxes of a size easily handled. These same boxes may be used in the field to transport the specimens. A free sprinkling of naphthaline flakes is absolutely necessary to prevent damage from vermin.

Birds.

The preparation of the very finest bird skins is a matter requiring much skill, but with a little practice, a novice can make passable specimens. For study purposes these are best kept as "skins," that is, the skin of the bird is filled out to its natural proportions with cotton or tow, its wings folded against the sides, the neck in its natural position. In this form the specimen can be easily handled, packed, or examined, and if desired, it can be at any time relaxed and mounted for exhibition.

Large or brilliantly colored birds are of less importance to bring home than the small, inconspicuous, or dull-colored types. The former are usually the best represented in collections, so that if transportation facilities are limited the available space is best utilized by bringing back the small or dull-plumaged varieties.

Collecting. — A 12-gauge double-barrel shot-gun is the best all-round gun; in one barrel — open bore — may be inserted an auxiliary barrel, the size of a 12-gauge shell, but fitted for a .32-caliber cartridge, taking a light charge of smokeless powder and "dust" or No. 12 shot. A supply of dust shot should always be secured at home since it is practically impossible to buy any but large shot in the wilds. A .410-caliber shot-gun is now made which is a powerful weapon. It shoots a regular shot-gun shell, the pattern of which is much more even than that of the .45-caliber shell with a shot capsule. A .22-gauge pistol with shot cartridges using smokeless powder is very effective for small birds at close range. Another excellent little collecting gun is the "Marble Game Getter." This has two barrels one above the other. The lower shoots either ball or shot cartridge of .44 or .410 caliber and the upper a .22 long, which may be loaded with dust shot and used where small birds are very tame or for small reptiles.

When a specimen is obtained, drops of blood should be absorbed with cotton or meal so as to soil the plumage as little as possible. Shot holes should be plugged with cotton and a wad of absorbent cotton forced well down the gullet with a small stick. Especial attention should be paid to absorbing all moisture from a rupture of the eye. Plenty of newspaper should be carried, from which a cornucopia of suitable size is made for each specimen. The bird, after smoothing, is dropped in beak first, and the open end then folded together. Many specimens can be carried without injury if thus wrapped. A loose bag or fish creel is best for carrying specimens, as they become jammed or ruffled in the pockets of a shooting jacket. Large, heavy birds should be at the bottom of the basket, the smaller ones on top. In hot countries or where it is impossible to attend to the specimens for some hours, a drop of formalin injected with a pipette up the anus will prevent decay for a considerable period.

Tools and material. — Scissors are the most convenient tool for skinning: a large, heavy pair, and a small, light one, with curved points if preferred. Some find a scalpel better suited to their need, and convenient as well for cleaning the bones of large birds. Two pair of forceps, one small (3-inch), the other large (6 to 10 inches), long enough to be used in stuffing, are necessary. Absorbent cotton is the best filling for small and medium-sized skins. One-pound packages are put up under compression and when unwrapped a small amount of the cotton fluffs out sufficiently to fill a number of skins. For large birds, tow, excelsior, or even well dried grass or paper may be used as a basis around which to wrap the softer cotton, for the artificial body. For a preservative, powdered arsenic or arsenic mixed with alum in the proportion of two to one is preferred by many, but the danger from poisoning through inevitable cuts and bruises is a serious drawback. A mixture of saltpeter and alum in the proportion of 16 to 1 is a harmless preservative though when using it the specimen must be more carefully guarded against depredations of insects. Corn meal as an absorbent while skinning is invaluable; a small heap on the table, box, or board used for a skinning table in which the specimen may be rolled during the process, will prevent damage of the plumage through contact with the body or its juices.

Labels, $\frac{3}{8}$ inches wide by $2\frac{1}{2}$ inches long, may be cut as desired from good white paper, and threaded securely by sewing twice through a narrow fold at the end; or a supply may be ordered with eyelets for the thread (the Dennison Co. of Boston makes them to order). Labels should be tied closely up to the bird's legs as those hanging from long dangling threads catch and pull off. Large labels take up unnecessary space and are easily torn off. On the label should be entered the locality as precisely as possible (for example: "British East Africa, Mt. Kenia, east side, 5000 feet"), the date, sex (♂ for male, and ♀ for female), color of iris, bill, feet or any bare patches, and the name of the collector. It is very important that the labels be made out and attached *at the time.* If completed from memory or attached subsequently many errors may arise.

Preparation of specimens. — A small folding table and chair are convenient if they can be carried; but a board resting upon the knees will serve in emergency. A heap of corn meal is placed in readiness on the table. With the scissors or scalpel, make an incision through the skin near the upper part of the breast-bone; lift the skin gently and extend the incision to the anus. Take care on reaching the abdomen not to cut into it but by lifting the skin slightly and carefully it may be cut without piercing the thin abdominal wall and freeing the body juices which stain the feathers. Dust the corn meal freely into the incision and elsewhere as the flesh is exposed. If meal is not to be had, keep the feathers from contact with the body by inserting bits of absorbent cotton. Separate the skin on each side of the body till the knee is reached. Then seizing the leg with the right hand, thrust the knee up and forward; separate the skin by pushing it gently at the point of contact, insert the large scissors wholly under the leg, and cut the entire leg through. Repeat on the other side, separating skin from body as far toward the back as possible, and all around the anus. Insert one blade of the scissors under the anus and sever it; then cut through the bone at the base of the tail in like manner, being careful not to cut through the bases of the tail feathers, or they will fall out. Hold the body in the left hand, and with the right push the skin forward over the base of the wings. Force should be applied only at the point of contact between skin and body. Pulling will stretch the skin irretrievably. Sever the wings completely through close to the body and continue stripping the skin off toward the head. The skin is thus turned inside out. Care is necessary in slipping the skull out through the neck, but with gentle pressure by the thumb nails on both sides it will slip through; the skin should be thus inverted to the base of the bill. The thin skin over the ears may be pulled out with forceps, and that over the eye cut through inside the lids. In case of birds such as woodpeckers and ducks, in which the head is much thicker than the neck, the latter must be severed as near the base of the skull as possible after the body is skinned, and an incision, to be sewed up afterward, is then made from the base of the skull down the back of the neck, large enough for the skull to pass through. The skull is then cleaned. Remove the eyes with forceps. Make a lengthwise cut with scissors on each side of the skull from the base forward along each side of the lower mandible. A third cut through the bottom of the skull connecting the first two, will permit the detachment of a considerable mass of muscle, brain, and tongue. Remove the brain with a looped wire and clear away as much flesh as possible.

After cleaning the skin of fat or flesh apply the preservative thoroughly to the inside. Place a little ball of cotton in each eye socket and then turn the skin right side out. This must be done as quickly as possible in hot countries or the skin will dry and then it cannot be turned again without moistening and using much care. Care is necessary in inverting the skin not to stretch or tear the neck while gently working the skull through it. Do not pull the skin; *push* it back into place. The wings and legs are now to be cleaned. In warm countries, the skin may stiffen and dry if this is done first. Pull the leg out and skin down as far as the heel; sever the tendons there and remove the flesh, leaving the bone for support. Strip the wing to the elbow and remove flesh in the same way. In small birds expose the forearm by pushing aside the skin along the inner side and cut away the flesh and tendons. In large birds it is necessary to loosen the quill bases of the large feathers inside and strip them down to the wrist joint, and the leg tendons must be removed by cutting through at the back of the foot and drawing them out. Preservative should be introduced or the scales will blister off.

Filling. — A tapering piece of absorbent cotton a bit larger than the body and neck is seized in one end of the forceps, worked through the neck and skull and out at the bill. A little practice will show how large a piece to take. The sides of the piece of cotton are tucked into the breast and abdomen, so as to fill the skin to its normal proportions, and the cut is then sewed together. The breast should be full and plump. Some collectors of experience use two pieces of cotton, one to fill the neck and throat, leaving a thin end to cover the breast, under which is inserted a second piece, nearly the shape of the body. The end of the neck cotton should be cut off at the bill or tucked into the upper throat and the bill closed by passing a thread and needle through the nostrils and tying the ends of the thread together over the lower mandible. The legs are to be crossed and the label tied close up to them, firmly.

Shaping and wrapping. — A very important and difficult part of the process is the final shaping and wrapping of the skin. Lay a thin, square sheet of absorbent or other long-fibered cotton on the table and place the bird in the middle on one of the diagonals of the sheet. The neck should be made rather short in most birds, which may be accomplished by pulling the cotton neck forward through the bill. The head and neck should be straight in front of the body, the wings brought into natural position by folding them together, then pinching the body with finger and thumb under the wings. Thrust the bend of the wing forward *under* the feathers of the lower neck and allow the ends of the wings to meet over the back as in their natural posture. Roll the skin thus shaped on its side and draw one corner of the sheet of cotton wool over the breast; then smooth the wing- and back-feathers of one side. The other wing is similarly arranged and the opposite corner of the sheet folded over the first. The plumage is thus held in position while the skin dries.

Determining the sex. — This should always be done by dissection. Taking up the skinned body, make a cut on its left side with the scissors from in front of the leg forward across the ribs, thereby laying open the body cavity. At the small of the back will be seen, if a male (♂) two oval white (or sometimes dark) bodies, the testes, which according to age or season may be very small or as large as a pea in small birds. In the female (♀) there is instead a somewhat three-cornered mass of small roundish bodies, the ovaries. In young or non-breeding birds the sexual glands are small and not always readily seen. If there is doubt as to the sex, *omit the sex mark from the label.*

Packing. — Skins must be dry before they are finally packed; otherwise they may mold. If on the march they may, on making camp, be laid out in a tray out of reach of dogs or kites, and smoothed if necessary. In damp climates or at sea artificial heat may be needed, particularly with large birds. Naphthaline flakes are useful in drying. When dry place each specimen bill foremost in a paper cone and fold the ends together. The paper should be stiff enough to prevent crushing except under considerable pressure. The skins thus prepared should be placed in layers, preferably one deep, and the layers separated by thin boards or cards, each independently fastened. In this way crushing is avoided in large measure. Scatter plenty of naphthaline flakes among the dry specimens. This is best taken from home, but in some countries can be obtained at smaller centers. It keeps out insects and mold.

A type of collecting chest made of fiber, like a small trunk, provided with a trunk lock, and containing a complement of shallow trays of several depths, is the best sort of case for packing and transporting specimens of this nature. They are made by James S. Topham, Washington, D. C.

Reptiles and Amphibians.

Collecting. — With reptiles, as with other creatures, it is the small and insignificant forms which are likely to be of the highest zoölogic interest. Such animals occur in almost all situations. Systematic reptile collecting is primarily a specialist's work since many of the species have peculiar habits and are extremely difficult to find. Nevertheless a great many forms are of such irregular appearance that they may be missed for years by the trained observer working in a locality where they certainly occur, while the veriest tyro may find them in abundance the month after. No broad rules can be laid down as to where or how to hunt reptiles. The subterranean species, which may often be obtained by turning over stones or following a native while he is plowing, are extremely interesting and well worth the trouble of preservation, as are also a host of the smaller and inconspicuous arboreal types.

Large snakes and lizards are well preserved by removing the skin, leaving in the head and legs, and then immersing the whole in the preserving fluid.

Most small reptiles may best be killed with the usual collecting gun of either .22 or .38 caliber, using fine shot. Long forceps (12-inch) are useful in pulling lizards out from crannies in rocks, or in the bark of trees. Many of the larger species of lizards and snakes may be caught by using a long stick of bamboo, or other light material, having at the end a noose of cord or fine wire. The captive may be dropped into a cloth sack, in which it will quickly disengage itself from the noose.

Preserving. — Small reptiles carried to the base camp, should be preserved in either formalin of 4 percent or alcohol of 75 to 80 percent, the latter by far the better fluid. Amphibians, newts, frogs, toads, etc., may be handled with impunity in most cases, and should be preserved in formalin as above, or in alcohol of about 70 percent. More specimens of frogs and toads are spoiled by putting them into too strong alcohol, which shrivels and hardens them, than by immersion in too weak spirits. Specimens preserved in liquid should be watched, and if decay sets in they should be transferred to a stronger solution of fresh preservative. When decay is arrested they should be returned to the weaker solution for preservation. Large specimens (those with *bodies* over 6 or 8 inches), or very fat specimens, should be slit along the belly before they are immersed.

Formalin of good quality is a useful preservative if the specimens are to be sent to a museum in less than two months' time; otherwise alcohol should be used. Any of the various commercial alcohols preserves equally well; many high-proof liquors such as arrack, aguadiente, mescal, tequila, pisco, etc., make an effective substitute for alcohol.

Shipment. — For shipment, the specimens which have been immersed long enough for the liquor to have penetrated the tissues thoroughly, may be packed in layers in a tin can, Standard Oil tin, cracker-box, or similar receptacle, the layers separated by cotton, fiber, or moss, a little alcohol put in to keep the whole moist, and the tin soldered up and packed in a crate for shipment. Specimens from the same locality should be tagged either with tin numbers or strong paper labels and a record kept of their data; or they should be, perhaps best, tied up in bundles with cheese-cloth and the full data inside, written with a soft pencil on good quality paper.

Fishes.

Collecting. — The smaller species of fish, and those which occur in isolated, rarely visited lakes and rivers, are sure to be of the greatest interest. It is important, if possible, to collect fully adult or both young and adult specimens; snakes change but little during growth, and young specimens can usually be identified, but fishes vary greatly between the young and adult conditions.

Fishes can be preserved and shipped to a museum in the same way as reptiles. Many of the rules for collecting the latter apply to both.

Systematic fish collecting often involves the use of some poison, such as copper sulphate, a few crystals of which thrown into a tide pool will produce astonishing results. In many regions the natives use any one of several widely known vegetable poisons for stupefying the fish in dammed-up brooks and streams, and the collector may often obtain excellent results by using the same methods. Fish traps, built on the principle of a lobster-pot, are very serviceable, while for species which swim near the surface or travel in schools, the seine and cast-net may be used. Dynamiting is a productive but dangerous pursuit. An ingenious substitute has been devised by using a detonating cap in a bait at the end of a fish line. This can be set off by an electric wire and battery (dry cell) by the fisher when the bait is touched or when the fish comes reasonably near it.

Preserving. — In the Tropics fishes spoil very quickly, and it is well to inject the soft-bodied forms with formalin, as well as to open the abdominal cavity. Generally speaking, with fish, as with reptiles, alcohol is greatly preferable to formalin as a preserving agent. It should be used whenever possible, unless the specimens are to remain immersed for a very short time, a month or less, and unless the additional bulk precludes the carrying of a considerable quantity on an expedition.

Crustaceans, Spiders, Insects.

In tropical countries opportunities are many for collecting multitudes of spiders, large and small, centipedes, and scorpions. Most small species of spiders are quite harmless and may readily be seized in the fingers and put into small vials of alcohol, not too strong (75 to 80 percent), with a small label bearing the data in lead pencil. Or a number may be put in each vial corresponding with a certain date and locality, and a record of these facts kept in a note-book. For handling centipedes, large spiders, or other doubtful-looking creatures, a pair of long forceps, 12-inch, is very convenient. These cost $1 at Codman & Shurtleff, 120 Boylston Street, Boston. If a number of specimens are put in a large bottle or jar, the free space should be filled with absorbent cotton to prevent them washing about and breaking during transportation. Crustaceans are best kept in alcohol, never in formalin, which dissolves their limy shells. Most insects, flies, bugs, beetles, are almost as usable in alcohol as dry, and are most easily preserved in this way.

Collecting. — If the traveller has a little time to expend, he may easily do much more than merely preserve specimens that chance to come under his observation. The sportsman often has opportunities for obtaining parasitic insects and ticks from game animals; these should be dropped in a small vial of alcohol with a slip of paper stating the place, date, and host. Traps for insects may be made by scraping together a small pile of rubbish and placing in it a bit of decaying meat, fungus, or other substance, which will attract a quantity of beetles, small flies or ants. On visiting the trap, the pile of rubbish is laid on a white cloth or paper, loosened and shaken, then after removing it, the insects that may have sought refuge in it are easily seen on the white surface. Net-sweeping is a very easy and productive method of obtaining small species of flies, bugs, or beetles. A strong net is swept quickly back and forth through and over grass, flowers, leaves, or other places where insects may hide and the contents of the net gathered at its extreme end are dropped into the killing-bottle. For catching butterflies or swiftly flying insects a collapsible net that can be affixed to the end of a stick used in connection with a jointed handle is very convenient and may be had from dealers in natural history supplies, *e. g.*, M. A. Frazar Co., 89 Sudbury Street, Boston. Insects are often attracted by lights and an electric torch or even an oil lamp placed upon a white sheet in the forest will add very many species to one's collection. A mixture of beer and molasses painted upon the trunks of forest trees, upon fences and even lamp posts, where they exist, will be found useful in attracting and stupefying many moths and other insects. "Sugar" the trees in the evening and collect the resting insects the following morning.

A killing-bottle is very necessary and one with a large open mouth will be found best. In the bottom, place a few crystals of cyanide of potassium, cover with a little sawdust, and run in a little plaster of Paris over the top to hold it in. Care should be taken to obtain the cyanide that gives off fumes, since a new kind is now largely used that has no fumes. The fumes rise into the bottle and quickly kill any insects contained in it. Beetles require a much longer exposure to the fumes than most other insects. For butterflies a square cocoa-tin is best, the part above the cyanide filled with strips of paper between which the insects with closed wings are dropped. A long strip of paper folded in zigzag fashion affords pockets which prevent the insect reaching the bottom of the box. Dragon-flies or other large insects may be killed by a drop of benzine or gasoline on the body. This instantly spreads a film over the body, suffocates the insect, and then evaporates completely.

Special methods are needed in case of so many groups of insects that it hardly pays the novice to attempt to gather these unless he intends to do serious work. For such, further directions will be found in Part F, of Bulletin 39 of the U. S. National Museum.

Packing. — Butterflies and moths are covered with minute scales which easily rub off and the specimen is ruined. With these it is necessary to enclose each specimen separately in a paper triangle. To make this, take a piece of paper of rectangular shape, and fold it over on a line parallel with a diagonal but falling short of the corner. The killed insect with closed wings is placed inside this and the ends folded down and creased to shut the case thus formed. The date corresponding with each should first be written on the outside. Dragon-flies and other fragile, large-winged insects should be prepared in the same way and the paper folders are then easily packed in a box in small compass. Small flies, beetles, grasshoppers, and other hard-bodied insects usually do not need individual care. For the traveller, the best way to preserve these in numbers is to have a cigar box containing a number of sheets of thin plush or if that is unobtainable, smooth-surfaced "cotton-wadding" (never cotton-wool), or even thin paper. These sheets should fit the inner dimensions of the box. A number of insects from a single locality are laid on the bottommost sheet and the other sheets placed lightly back in the box. When the first layer is filled, place with it a bit of paper giving locality and approximate or exact date, and so continue till the box is filled. A long strip of paper folded entirely about the unused sheets at the top of the box is convenient for lifting these out in order to reach the last layer. A little powdered camphor or better, naphthaline flakes, sprinkled among the layers is necessary to keep out insect pests. A large collection may be easily transported in this way and the specimens can be relaxed and spread by the specialist on returning home. Beetles and similar insects may be shipped in vials of alcohol or in boxes of carbolated sawdust. To about one-half bushel of sifted sawdust (using the coarser portion) add about four ounces of crude carbolic acid. The sawdust is placed in a bag, the acid is then added, and the whole well shaken and allowed to dry. The sawdust and insects may then be placed in layers in a wooden box for shipment.

Mollusks.

Mollusks are found in almost every sort of locality. Certain species frequent tall forest trees in tropical climates, others spend their lives in low bushes or on the ground in damp places. They especially abound in country containing much limestone or a limy soil. Many species live in freshwater ponds or streams, partly buried in the soft bottom or crawling about in the mud or on water plants. Marine species are found from tide marks to great depths. Many of the deep-water mollusks are obtainable by opening the stomachs of bottom-feeding fishes that swallow them as food. It is seldom of use to bring home a miscellaneous lot of shells without locality since these are of no value for scientific study. Not only the shell of the mollusk but its soft body is of interest for study. If possible both should be preserved, especially in case of snails since many of the differential characters are found in the radula or rasping organ of the mouth. For small species it is enough to drop them into weak alcohol (50 per cent) for a few hours and then dry them. The alcohol removes the body water in large measure so that they dry without the offensive odor that comes when they are merely allowed to die, often in a bottle or tin box, which holds in the moisture. Bivalve species (clams, mussels, etc.) may be laid in the sun a short time, which causes them to open, when the soft part may be removed with a knife. The two valves should be separated, but the hinge at point of union kept intact. After cleaning, close the valves in their natural position and wrap up, so that they shall not be separated in packing. If it is impracticable to use alcohol for preserving the mollusks, place the specimens in clean cold water, and bring to a boil; then remove the bodies with a bent pin. To put them in boiling water at first would crack the delicate outer layer of the shell. In snails the attachment of the body is usually along the inner central pillar well within the shell. Large shells with a delicate outer layer may often be prevented from cracking by a thin coating of vaseline. All specimens or lots of specimens from one locality should be accompanied by a label giving at least the place and date.

For collecting minute species, a pair of small forceps is necessary, the spring of which is weak enough to allow it to close with very slight pressure, so as not to tire the fingers with prolonged work. Glass vials are convenient in which to put the specimens; the mouth of the vial may be stopped with cotton or cork.

Marine collecting at small depths may be conducted with a dredge towed from a rowboat or sailboat. It must not be dragged faster than a few feet per minute. A weight should be attached a few feet above the dredge itself. In lieu of a dredge, good results have been obtained with a tin pail.

Packing. — In transporting specimens, the chief care should be to see that they are properly protected and that there is no chance for them to shake about. Alcoholic material is best put in glass preserve ("Mason") jars and any space filled with soft crushed paper. Dry specimens may be packed in boxes of convenient size, care being taken to wrap the larger shells in soft paper. Sawdust is to be avoided. Small species are to be packed in pill boxes or phials with a bit of soft cotton to keep them from shaking about. The locality and other data can be written on the outside of the box, or on a slip of paper in the vial. In case of alcoholics, the data should be written on stout paper with lead pencil and enclosed with the specimens; or numbers stamped on strips of block-tin corresponding to entries in a note-book may be used. Large species may have the data written on the inside of the shell with a lead pencil.

The preservation of slugs or other shell-less mollusks is difficult. Some land species may be drowned in water and then preserved in alcohol.

Other Marine Invertebrates.

Worms, and creatures of similar nature, can be easily preserved in either formalin or alcohol; echinoderms, such as starfishes, sea-urchins, brittle-stars, sea-lilies, may be well preserved by drying them in the sun, although it is best to immerse them for a short time in weak alcohol, or in fresh water, as they will then dry more quickly and be less offensive while they are drying. Coelenterates, such as jelly-fishes and sea-anemones, can be preserved in formalin. Jelly-fishes should be allowed to stand quietly for a while after they have been immersed until they have time to harden, as otherwise they disintegrate entirely; sea-anemones and similar creatures should first be stupefied by putting them in water to which magnesium sulphate has been added, so that they will not contract, withdraw their tentacles, etc., when they are immersed in the preserving fluid.

Reference Works.

Bulletin 39 of the United States National Museum consists of a series of short pamphlets, each dealing with the methods of collecting and preserving specimens of some group of animals, plants, or minerals. The titles of these follow with the letter designating each part, prefixed. They may be had from the National Museum by applying to its Secretary, at Washington, D. C.

G. Instructions for collecting mollusks, and other useful hints for the conchologist. By William H. Dall. 1893.

F. Directions for collecting and preserving insects. By C. V. Riley. 1892.

M. The methods employed at the Naples Zoölogical Station for the preservation of marine animals. By Salvatore Lo Bianco. 1899.

L. Directions for collecting and preserving scale insects (Coccidae). By T. D. A. Cockerell. 1897.

O. Directions for collecting and rearing dragon-flies, stone-flies and may-flies. By J. G. Needham. 1899.

C. Notes on the preparation of rough skeletons. By F. A. Lucas. 1891.

E. Directions for collecting reptiles and batrachians. By Leonhard Stejneger. 1891.

A. Directions for collecting birds. By Robert Ridgway. 1891.

D. Directions for collecting, preparing, and preserving birds' eggs and nests. By Charles Bendire. 1891.

N. Directions for preparing study specimens of small mammals. By G. S. Miller, Jr. 1899. Also second edition, revised, 1901.

Other excellent general works are Taxidermy and Zoölogical Collecting by W. T. Hornaday, New York (Scribners), 1902, and Rowley's Art of Taxidermy.

ANTHROPOLOGY.

BY ROLAND B. DIXON AND ALFRED M. TOZZER.

General Instructions.

For the traveller who intends to study, even superficially, the peoples with whom he comes in contact, some preliminary preparation is desirable. This should include (a) familiarization with the work done previously by other observers, (b) securing the necessary instruments, forms for record, (c) training in field-methods, etc. A brief survey of what has already been done, prevents useless duplication of effort, calls attention to the character of information needed, and saves time in various ways in the field. Brief notes made during such preliminary reading are often of great aid later.

For the amateur, the best results usually come from a concentration of effort in a particular field. Thus the traveller may pay especial attention to the physical type, to the ethnology, or to the archaeology of the peoples he meets; he may be a collector of specimens or a gatherer of information in regard to customs and beliefs.

For the separate aspects of the subject special instructions are given farther on under the respective headings. A few suggestions of general application, may, however, be made here. In anthropological investigations, the personal attitude of the observer is of prime importance. Unless he can secure the confidence of the people whom he is studying, he cannot hope for useful results. To adopt an attitude of ridicule toward their customs and beliefs, to laugh at them as "funny," or to denounce them as "wicked," is to defeat one's purpose in advance. Rather assume a serious interest and appear at least sympathetic with the point of view of the native.

Next in importance is avoidance of leading questions and care in trying to understand exactly what informants mean. Nothing is easier than to misunderstand or be misunderstood, or to read into a statement far more than it was intended to mean. Leading questions are an especial danger, for most savage and barbarous peoples have both an uncanny ability to divine what their questioner wishes to have them say, and a remarkable ingenuity in inventing offhand just the answers that will please. All important statements should be checked by independent witnesses.

Seemingly trivial matters must be carefully noted. Savage custom is extraordinarily rigid and persistent, and dominates trifling actions which in higher stages of civilization are left wholly unregulated. The minor elements of custom and belief often outlast the major, and important clews as to relationships and cultural association may be revealed by them.

The choice of informants is also of much importance. As a rule older persons are best, for they know more of old customs and beliefs than the younger generation, who, as a result of changed conditions, have often grown up with only an imperfect knowledge, or even an actual shame of the old traditions. The medicine-man, shaman, or priest is often an excellent informant, provided he can be induced to talk. Do not begin interrogations too soon. First establish friendly relations; then develop confidence; finally, ask questions.

In making payments for objects or information, the following points should be kept in mind. (a) Trade goods, presents, etc., will often be effective when money or other ordinary forms of payment are unavailing. (b) The character of such trade goods and presents best adapted to the peoples to be dealt with, should be learned before starting; red beads and tin watches may be regarded with indifference when blue beads or tobacco-pipes would be eagerly accepted. (c) Bargaining of a very tedious character is often necessary to secure what one wants. Persistence, patience, and assumed indifference usually win the day. (d) A purely fictitious value may be placed on objects or information regarded by the people as sacred or mysterious, and one cannot expect to obtain such things for their actual value.

For material equipment, a good camera is perhaps the first requisite (see *Photography*). For anthropological purposes a focussing camera of reasonable size is best; excellent work may be done with small pocket cameras if they are provided with a special lens and a portrait attachment. A tripod should be used and time exposures made when practicable. Flashlights are desirable for use in dark interiors or to secure pictures of night ceremonials. Never trust to memory; but record the exposures as made, giving date, place, and subject.

Note-books should be of such size as to fit the pocket conveniently. If possible they should be made with duplicate leaves arranged to be torn out, so that carbon copies of one's notes may be made as they are written and kept separate from the original, minimizing the danger of loss. This copy may, to good advantage, be mailed home whenever opportunity offers. A medium pencil is best for notes, as it will neither blur nor blot. In making notes, it is better to err on the side of fullness, rather than to try for brevity — the time for elimination and condensation comes after one has returned. Do not overlook things which in the field seem obvious, or are so familiar that one feels it impossible to forget them. It is surprising how uncertain the memory is on one's return. Lastly, it is impossible to be too careful in the labeling and packing of collections. Nothing is more aggravating than an unlabeled or inadequately labeled specimen. A broken object can usually be repaired, but missing information is difficult to replace.

Physical Anthropology.

The traveller who proposes to obtain information in regard to the physical characters of the peoples with whom he comes in contact, may do so in two ways: (a) he may himself make observations and measurements on the living, or (b) he may gather and bring back with him skeletal material, the study of which can be made either by himself or by experts on his return.

For making physical measurements, some instrumental equipment is needed. This may be reduced to the following. (a) A pair of calipers (folding if possible) of simple, strong construction, for measuring the length and breadth of the head. The points should not be too rounded, else they cannot easily pass through the thick hair of savage peoples. The calipers should have a maximum reach of 250 millimeters. (b) A pair of sliding calipers, for measurements of the face, nose, etc. These should have a maximum reach of 200 millimeters. (c) A folding, jointed, or telescoping measuring rod, two meters in length, graduated in decimeters and centimeters, and provided, if possible, with a sliding arm. (d) A 25-centimeter rule, graduated in millimeters, for reading the measurements taken with the calipers. (e) A one-meter measuring-tape. To these, a color-chart for determining the color of skin and eyes may be added, and also a supply of printed blanks for recording measurements made. The latter are not absolutely essential, but where many individuals are measured, the prepared blank saves much time and tedious copying of headings. Various forms of such blanks have been devised, but the minimum requirements should include the following items: series number, date, place, tribe, personal name, sex, age, parentage and relationship, stature, height sitting, span or reach, length of head, breadth of head, length of face, breadth of face, length of nose, breadth of nose, circumference of head, circumference of chest, color of skin, color of eyes, color and character of hair, pilosity, mutilations, deformations, abnormalities, pathology, descriptive characters. The first items require little explanation. Parentage and relationship include statements as to the tribal or blood affiliation of the person's parents, *i. e.*, whether of different tribes, races, etc., and indication that the individual measured is or is not related to some other individual measured, and if so how; thus the record might read "brother of No. 28," or "mother of No. 64."

The prospective traveller should, if possible, have some little instruction in taking measurements before leaving. If this is impossible, the following brief directions, if carefully carried out, will usually secure results of value.

Stature. — Be sure that the subject removes all foot coverings. He should stand with heels together, on a level piece of board or other smooth, hard surface, never on soft earth, grass, or sand. Instruct the subject to stand as erect as possible, and to hold the head erect, but without raising the chin. See that the heels touch the ground. The height should be read to a plane touching the top of the head (not the hair). Read to half-centimeters.

Height sitting. — Seat the subject erect on a level stool or box, not over a foot and a half high, with his legs stretched straight out, and the arms folded. Measure the distance from the upper surface of the seat to the top of the head, as in taking the stature.

Span. — Have the subject extend the arms horizontally in a straight line, with the middle finger of one hand touching a vertical wall or post. Place one end of the measuring rod at this point and, holding the rod parallel to the arms and close to the subject's neck and chin, ask him to reach with the greatest possible effort. Read to the tip of the middle finger of the other hand. The rod must not be bent and the finger at the wall must not be allowed to slip.

Length of head. — Place one point of the folding calipers on the most prominent part of the forehead between the eyebrows. Hold the instrument in a vertical plane and pass the other point down the middle line of the back of the head to the position of greatest length.

Breadth of head. — Using the same calipers, measure the greatest width over the ears. The calipers must be held horizontally and symmetrically.

Length of face. — Measure with the sliding calipers from the deepest depression on the nose between the eyes, to the under edge of the chin. The subject should press the teeth together, and the chin measurement should be to the bone, not merely the flesh.

Breadth of face. — Measure with the folding calipers the greatest width of the face across the cheek-bones, or the bones running from them toward the ear. The calipers must be held horizontally and symmetrically.

Length of nose. — With the sliding calipers, measure from the deepest depression on the nose between the eyes, to the point where the septum of the nose joins the upper lip.

Breadth of nose. — Measure with the same calipers the greatest breadth at the nostrils. Take care that the subject does not smile or otherwise spread the nostrils. Do not press the nostrils together with the calipers.

Circumference of head. — Measure around the head with the tape, on a horizontal plane passing just above the eyebrows. If the hair is long or heavy, pass the tape under it.

Circumference of chest. — Measure with the tape, on a horizontal plane passing through the nipples. The subject should stand, with arms hanging loosely at the side. Take the measure when chest is normal and again when fully inflated.

Color of skin, eyes, and hair. — Compare with the color-chart, and record by number. If no color-chart is carried, describe the colors as accurately as possible. Skin color should be given for exposed and unexposed parts. It is sometimes necessary to wash the skin to determine the true color. Hair is sometimes bleached with lime, or dyed, and inquiry should be made on this point if the color seems abnormal.

Character of hair. — The four main classes are: (1) straight, (2) wavy, (3) curly, (4) frizzly. Specimens of hair should be obtained when possible, although this may be difficult owing to superstitious fears that the stranger will make use of the hair in witchcraft.

Pilosity. — Record the amount and character of the hair on face and body. Note that its absence is often due to plucking the hair out.

Mutilations and deformities. — Note whether the teeth, ears, or nose are cut or mutilated in any way; whether circumcision is practiced, etc. Deformation of the head is the most common. If it exists, endeavor to discover how it is produced.

Abnormalities. — Under this head would come such features as albinism, supernumerary digits, hare-lip, etc.

Pathology. — Note any diseases or their effects that may be apparent.

Descriptive characters. — Note the character of the teeth, mouth, lips, fatness or leanness of body, muscular development, expression.

While the foregoing are the most important measurements and items, there are many others, which, if the observer has the time and knowledge, he may make to advantage. A small number of measurements on a large number of subjects is of greater value than a large number of measurements of a few subjects. Care should be taken to avoid all persons under twenty-one years of age; to make no attempt to select for measurement what appear to be "types," but to take all as they come; to secure, if possible, a reasonable number of female subjects, although this is often difficult or impossible, especially in Mohammedan countries.

In addition to measurements, photographs are of primary importance. Excellent portraits may be taken with a pocket camera if it has a good lens and a portrait attachment. The following points should be observed. (1) Portraits should include only the upper half of the body, so that the face will be large enough to be studied in detail; no head-covering should be allowed. (2) Of each subject at least two portraits should be taken: (a) full front, and (b) exact profile; the other profile and a three-quarters face may be added to advantage. (3) So far as possible all portraits should be made so that the figures or faces are of the same size, *i. e.*, the photographs should all be of uniform scale. (4) Focus for the face; if a portrait attachment is used, measure from the lens to the cheek-bone for full front, or to the tip of the nose, for profile. (5) Number and record your exposures and correlate them with the measurement records. Half the value of a portrait is lost if it is not certain to which of a series of measured individuals it pertains. A few full-length nude portraits, front and profile, may, if opportunity offers, be taken to advantage.

Difficulties experienced in getting subjects to allow themselves to be measured or photographed have to be overcome by tact, small payments, presents, etc. Sometimes people will allow in the seclusion of a tent or house what they would refuse in the open, subject to the ridicule and jests of their friends. Demonstration of the measurements on one's self or one's servants; simulated admiration of the people's strength or cleverness, as shown by tallness, size of head, etc., sometimes afford aid. Many peoples object to being photographed and some may become violent if their photographs are taken without their permission. This is usually due to the fact that they believe that the photographer, in taking away their likeness, takes also their souls. Often a promise to send each individual a copy of his or her picture will aid matters; and if such a promise is made, see that it is kept. Those who come after you may suffer for your failure to keep your word.

Observations may be made in regard to mental qualities, acuteness of vision or hearing, etc., but to be of real value, these as a rule require more special training and equipment than the ordinary traveller is likely to have.

In addition to the observations on the living, skeletal material may sometimes be secured, but is usually more difficult to obtain, as people naturally object to having the graves of their ancestors disturbed and plundered (see *Archaeology*). As a rule, excavation of skeletal material must be done in areas far from settlement, or carried on secretly. In any case, such work is likely to lead to trouble, and very serious consequences may result. Sometimes skulls are kept as trophies, and it may be possible to purchase some of these. Care should be taken in such cases to find whether the heads are from the same tribe or from an enemy. The transport of skeletal material is often troublesome, owing to the fear or dislike of the bones by carriers or servants. Concealment in packages of other materials is often the only way out of the difficulty. In packing, pains should be taken not to lose teeth or the smaller bones.

Material Culture.

Collection of Data.

The details of the domestic life of a people are perhaps the most easily obtained of all anthropological data. It is important to collect full notes upon this subject.

Division of labor. — One should note what things are done by the women (married and unmarried), what by the men, and what by the boys and girls. Native names for the various objects should be obtained as far as possible.

Food supply. — The names of the different kinds of food, the composition and manner of obtaining food, its preservation and preparation, and the utensils used in the various operations should be noted together with names of the plants employed for medicine and for making drinks and narcotics. Obtain specimens of all of these as far as possible. Some foods may not be eaten at certain times and by certain people. Investigate the utensils used in making fire and the use of fire in the arts and in connection with religion.

Hunting and fishing customs. — A list should be made of the animals and fish used by the people together with the implements employed in their capture. The rights of the hunter and fisherman are sometimes important. Often there is a prohibition against killing certain animals and, again, an animal must be captured and killed in a certain way.

Agriculture. — The time and method of preparing the ground, sowing, and harvesting, and the religious rites in connection with these operations should be investigated. Make a list of the foods cultivated, and domestic animals.

Habitations. — The selection of a site, materials, and methods of house-building, the forms, sizes, and plans are all important subjects. Note the names of the different parts of a house. There is often a sharp distinction between the domestic and the religious structure. The rites carried on in connection with their erection are often important. Inquire for the customs in regard to houses for the newly married and whether there are houses for the unmarried men and for the unmarried women. It is well to know whether the man or the woman owns the house and its contents. Describe and sketch the household utensils.

Dress. — Photograph and describe the male and the female dress, that used by the married and the unmarried. A distinction should be made between secular and religious dress, and dress showing rank and station. Changes of dress at different seasons should be noted, together with the names of the different parts of the dress, materials, and method of manufacture. Do not overlook foot coverings and snow-shoes. Ornaments: see under *Decorative Arts.*

Industrial arts. — The following subjects are suggested under the various headings. Basketry: materials, preparation of materials, methods of manufacture, with special attention to the weave, forms, use, and designs. Textiles: materials, preparation of materials, the names of the different parts of the loom and various implements for spinning and weaving, the operation of the loom, matting of various sorts. Substitutes for cloth: tapa, and the methods of its manufacture and decoration. Curing and uses of skin. Dyeing. Pottery: materials and methods of manufacture, forms, uses, and design such as painted, incised, and molded figures; substitutes such as stone, horn, bone, and wooden vessels. Stone, wood, bone, horn, shell, metal, and other objects: their names, methods of manufacture, and use. Tools for the various trades; mechanical devices. Means of transportation: sleds, boats, etc.

Decorative arts. — All phases of decoration should be investigated including the decoration of the person by painting, tattooing, and scarification; mutilations for the attachment of objects; blackening, filing, inlaying, and knocking out of teeth. Temporary attachment of objects to the body should be described, such as necklaces, bracelets, garters, etc. The dressing of the hair at special times and for special purposes should not be overlooked. The following points are suggested for investigation: decoration of implements, utensils, etc.; painted, incised, and relief decoration on pottery; designs on basketry, textiles, and pottery; carving on wood, bone, ivory; sculpture and bas-relief on stone and other materials. Interpretations of the designs should be carefully noted. It is important to confirm these interpretations from several different persons to avoid mistakes. It is a good plan to make sketches of the designs from as many objects as possible in order to give a good idea of the decorative art of the people. Any form of writing or means of communication should be carefully noted together with property marks upon utensils and weapons. Marks and pictures representing totems are of special importance.

Music and music instruments. — The phonograph is most useful for recording music, but transcriptions in the field are usually not to be recommended. Instruments and the methods of manufacture, with the names of the various parts are to be noted. Dance: see under *Religion.*

Games. — These are important and also their relation to religion.

Collection of Objects.

Almost all travellers collect objects from foreign countries. Buying an object is only a small part of such an operation if one is alive to the opportunities of the proper kind of collecting. Not only should the native name of the object be recorded as carefully as possible but the names of the different parts, the materials, and samples of these raw materials. The methods used in manufacture should be described and, if possible, a series of photographs made illustrating the various steps, starting with the raw products and ending with the completed specimen. The part played by the object in the domestic and religious life, when and how used, should be described in detail. Commonplace objects of every-day life should not be overlooked. The objects most valued are often those obtained from other peoples. Photographs should be obtained of important objects which are not purchased and which illustrate the life of the people. Distinction should be noted between the objects made by the people and those which are introduced from another tribe or from the "white man." It is especially important to obtain articles used in the religious rites of a people. This is usually difficult. There is often an elaborate ritual in connection with the manufacture of religious and sometimes of the secular objects. The raw materials may have to be collected at some special time and in some special way. The manufacture may proceed in a certain order and in connection with special prayers. The utensils used in games should not be overlooked. Many tribes have string figures like our "cat's cradle," which are especially important. Series of strings illustrating the various steps in making these figures should be taken when the visitor is not able to learn the process. The strings illustrating each step should be attached to card-board backs with the names of the fingers holding the different parts indicated.

Sociology.

Genealogical Method.

There is a wide variety in the data which may be collected upon the sociology of a people. If the traveller has but a short time at his disposal, perhaps the best way to begin is to use the Rivers genealogical method. This gives most valuable data on the social and vital statistics of a people. Select several well informed persons who have large family connections and write down with great care their genealogies, noting the name, relationships, and the village from which each has come, together with the totemic division, if any, to which each belongs. The age of marriage should be noted when this is possible. Remember that native systems of classifying relationships differ as a rule from ours and that the names "brother" and "sister" may be applied to other members of the same generation of the family group, for example, to cousins. In a similar way the same terms may be used for father and mother and uncle and aunt respectively, or similar terms for son and daughter and nephew and niece. It is usually possible, however, by employing the terms "proper" or "real father" to make the distinction between father in our sense of the term and father in the large sense where the "classificatory system" is used. Corroborate the data by consulting several members of the same family. From a study of several of these lists one may usually obtain the following information. (1) *System of kinship:* Does the child take the name and the totem from the mother or the father? On this is based the law of descent and inheritance. (2) *Names of relationships:* Do these conform to our terms or are they based on the "classificatory system" as described above? It may be shown that the terms of relationship used by men differ from terms used by women to denote the same grade of relationship. (3)

Marriage customs: Is marriage prohibited between people of the same village or of the same totem? Must a man marry a woman from a special village or with a special totem? (4) *Form of marriage:* Is monogamy, polygamy (more properly called polygyny), or polyandry the practice? Must a man marry his deceased wife's sister (the system of lévirate)? (5) *Customs in regard to naming:* Are names of the dead re-employed for the living? Kinds of names used. (6) *Vital statistics:* Size of the family, the relative number of each sex, the age of marriage, and its relation to fecundity; the proportion of individuals who grow up and marry.

The Individual.

Birth. — The genealogical method cannot bring out all points of interest in the sociology of a people. For an exhaustive study the data shown by the tables should be used as a point of departure for further investigation. A second point of departure may be the individual and the crises in his life. His birth and the natal ceremonies and associations should be investigated, together with the treatment of the mother, the father, and the child. "Couvade," the lying-in of the father, is a common practice at this time. Note the rite of naming the child and how the name is obtained. If there is more than one name, the real name may be known only to a few. Divination may be practiced at birth. The etiquette of the youth toward the older members of the community should be determined.

Education and puberty customs. — The education of the child should be investigated. Of special importance are the initiation rites on coming to the age of puberty or adolescence for the boy and the girl. Note whether there are ordeals, changes of dress, and mutilation at this time. The boy may receive a guardian spirit. The status of the boys is changed and they are usually separated from the opposite sex.

Marriage and the forms of marriage. — These have been touched upon in the genealogical method. The selection of the bride and the division of the tribe or totemic group to which she belongs, are all important. If there is a dowry note by whom it is paid. The marriage rite and the ceremonies at this time often show the relative position of the man and woman. The place where the couple resides after marriage and the rule of inheritance should be noted. The respective duties of husband and wife should not be overlooked. How may a man repudiate his wife or the wife her husband? Punishments are usually severe for sex crimes. It is important to note the status of the widow and the treatment of the aged.

Death. — The ideas of illness and death and their relation to magic are brought out under religion. The treatment of the sick, the temporary and permanent disposal of the dead, and the burial rites often show the ideas of the people in regard to a future life. The objects destroyed and buried with the dead should be noted together with the mourning ceremonies and the mourning dress.

Social Organization.

This is brought out to some extent by the genealogical tables. The grouping of a people may be geographical or it may be along kinship lines. The tribe and its subdivisions should be determined. There may be a primary division into two or more phratries and these, in turn, subdivided into clans or gentes. The functions and the government in each subdivision should be examined. Each section of the tribe may have a particular totem and the totem may descend through the mother or through the father. The totem is usually a special kind of animal or plant "between which and the individual there exists a special relationship." It is seldom an individual animal or plant. The rites undertaken in regard to the totem and the tabus in connection with it are important. It should be noted that this totem of the clan or of some other division of the tribe is distinct from the personal and individual totem or guardian spirit. There may be other forms of association, according to age grouping. Some tribes have slaves. Note their status and that of their children. Secret societies may be present in the tribe. The requisites for membership and the part these societies play in the government of the people should be investigated.

Rank and Government.

These features can usually be studied in connection with the various subdivisions of the tribe. The choice of a chief or headman, the tenure of office, and his powers are important.

Property.

This should be carefully investigated. Note what a man or a woman calls his or her own and what is held in communal ownership. The system of land tenure should be studied.

Crime, Punishment, and Morality.

The first two features may usually be determined by direct questioning. There is usually a distinction made between crimes against persons within and those without the tribe or division of the tribe, against property, and against religion. The rules of vengeance, retaliation, and exemptions by payment, if any, should be investigated. Ethical standards are difficult to understand unless one has a fair idea of the code of morals of the people. This may sometimes be ascertained from the mythology. What crimes are frowned upon and punished by the gods? There is a right and a wrong way of doing everything. It must be remembered that there is usually one standard for fellow tribesmen and another for enemies. Tribal etiquette and the laws of hospitality should be determined.

External Relations.

Intercourse with other tribes would indicate the extent of commerce. What articles are exported and what imported? The standard and media of exchange would show the kind of money used.

War.

The method of declaring, and preparing for war, and the tactics of war are important considerations. Defensive and offensive weapons should be studied. Note the treatment of prisoners.

Religion.

All peoples, however low their culture, have some form of religion. Often their every action is controlled rigidly by their religious beliefs. These beliefs and practices are of great importance for study, and every endeavor should be made to gather information and specimens bearing on this subject. Vital to success in this field more than any other are: (a) a sympathetic attitude on the part of the enquirer, and (b) the attainment of at least the partial confidence of the people. One's inmost and most sacred beliefs and feelings are not revealed to a scoffer or a total stranger.

For the anthropologist, religion has three main aspects: (a) its outward expression in forms and paraphernalia, (b) its inward basis of beliefs, and (c) its representatives, custodians, and interpreters. The first of these aspects would include all religious or superstitious ceremonials and practices such as those connected with birth, puberty, marriage, and death; agriculture; fishing and hunting; housebuilding, metal-working, etc.; those having to do with war, weather, seasons, animals (totems), witchcraft, magic, and divination, and the whole multitude of superstitious practices found among peoples of all grades of culture. Sometimes these ceremonials are of an almost incredible complexity and elaborateness, often lasting continuously for days or weeks. They may comprise complicated rituals, dances, sacrifices, and prayers, and may employ a great variety of regalia, ornaments, and accessories, so that a complete description and study of a single such ceremony is a difficult and exacting task, and might require many months of work on the part of the observer. Many on the other hand are brief, simple, and easily described.

Try to obtain, as far as possible, descriptions, photographs, and explanations of these ceremonials, and the ornaments and paraphernalia used. The last, if unobtainable, may be photographed, or models of them made. When open purchase is impossible, persons may be found who will part with their sacred things secretly. Apart from ceremonials there are many other ways in which religion expresses itself outwardly, such as in the tabus or prohibitions to which individuals or communities are subject; the use of amulets and charms, etc.

Beliefs, including mythology and folklore, are hard to investigate without a really competent interpreter, or some knowledge of the language. Every endeavor, however, should be made to enquire into the beliefs held in regard to deities, spirits, a future life, natural phenomena, etc. Myths, folk-tales, riddles, songs, should also be gathered. They should be written down at the time accurately and fully, in the words of the narrator, and as large a series obtained as possible. It is well to have the same tale told independently by different informants, in order to check the material.

Information in regard to the official representatives and exponents of religion, the shaman or medicine-man, priests, etc., their character, selection and training, duties and powers, together with their standing in the community — all are to be carefully noted. As these persons are usually the repositories of myths and religious knowledge, it is from such men that this sort of information can generally be best secured. Their position is so important in the tribe, that their friendship will often aid the traveller as greatly as their enmity or opposition (derived perhaps from the latter's attitude toward them) will serve to impede his work or progress.

Language.

Of all the branches of anthropological investigation which the traveller may be called upon to take up, the study of the languages spoken by the peoples met with requires for its successful prosecution the greatest amount of natural aptitude and special training. The difficulties of the task should not, however, deter one from making an attempt to obtain material.

The recording of an unknown or little-known language involves four main factors: (a) the securing of a satisfactory informant or interpreter, (b) the correct hearing of the sounds spoken, (c) the exact recording of these by means of alphabetic characters, and (d) the selection of the proper material, so that not only the vocabulary but the essential elements of the grammar may be worked out.

The informant or interpreter should speak the language studied as his mother-tongue, and should be able to understand and speak enough of some language known to the observer, for ordinary purposes. He should also be a person having a clear enunciation, reasonably slow diction, and some patience. This sort of work is wholly unfamiliar to most people, and the mental effort involved quickly tires them. Working through an intermediate interpreter or even two is possible, but difficult, and very likely to lead to misunderstandings and untrustworthy results. As a rule one or two hours of continuous work is all that will be done well.

The ability to hear correctly the spoken sounds of a foreign language is a rare gift, as many persons lack entirely the power of distinguishing the finer shades of difference in sound. Different languages present various grades of difficulty in this respect. Very close attention should be paid, and the recorder should have words and sounds repeated again and again until he feels sure of the exact sound. The more unfamiliar the sound, the greater care should be taken. Slurred or whispered sounds, aspirations, faint catches or clicks, nasalization, accent, tones and inflections of the voice — all must be listened for and recorded. A slight catch or aspiration may be all that serves to differentiate two words of quite different meaning. Difficult and unusual sounds may require a lengthy description. Watch the speaker's mouth, lips, and tongue to discover, if possible, how the sounds are made.

All hitherto unwritten languages should be recorded phonetically. The ideal phonetic alphabet would have a character for every possible sound, and such alphabets have been devised, but they are too complicated for any but the trained linguist and phonetician to use. In practice a compromise is usually adopted, and each sound of a language is represented by one *and only one* letter, usually that whose sound in the mother-tongue of the recorder is closest to the new sound. In English the same sound is often represented by several different letters; thus, the initial sounds of *c-ar*, *k-ing*, *q-ueer*, and *ch-aracter* are similar. Such methods should be avoided, and one and the same letter should always be used for a particular sound. On the other hand, in English several quite different sounds are represented by the same letter; for example, the several sounds all indicated by an "a" in the words, *fate*, *sat*, *arm*, *law*. In recording a language phonetically each of these four sounds should be represented by a different character, or by one character with different diacritical marks. It may be found that the language possesses two sounds that are closely similar, as two "t's" or two "b's," etc. In such case, they should be distinguished by an underline, a dot, or some other mark. A list should be made of the letters employed, and of the sounds for which they stand, with examples of words in English, French, or German which come nearest to illustrating the sound in question. In general write exactly what you hear. If the same word sounds differently on different occasions, write it just as heard, and do not try to "standardize" the spelling. Important grammatical elements may be indicated by these differences in form, slight as they are.

There are three sorts of material which may be gathered in studying a language: (a) vocabularies, (b) grammatical material, and (c) texts. These are valuable in the order given, the last being of the greatest value, but also the most difficult to obtain. In securing vocabularies, if possible point at the thing the name of which is wanted, or show a specimen of it to your informant; illustrate the action, etc. Care should be taken, however, to be sure the informant understands, *i. e.*, that when pointing to your head, he does not tell you the word for hair; when starting to run, that he does not give you the word for "afraid." Lists should be checked by independent witnesses. Many peoples have different words for animals at different ages, or with differently marked skins, for eating different sorts of food, or for eating in different positions, etc., therefore try to get the *exact* meaning of the words collected.

Grammatical material consists in the main of the replies to a planned series of questions, in which the enquirer seeks to obtain exact equivalents for various grammatical forms. Thus the informant is asked to tell how he would say "One dog, many dogs, two dogs"; "My bow, your bow, his bow," etc.; "I am hungry, you are hungry, etc." By preparing a series of questions of this sort, one may obtain in comparatively short time from an intelligent informant, material which will enable the essentials of the grammar of the language to be worked out. A long list of such questions, planned to bring out every side of grammatical form, with abundant examples of each type, will be of value in saving time.

Although valuable material may be obtained in this way to illustrate the grammar, the best grammatical material is that obtained from a series of texts or stories, written down word for word in the language, and of which a literal and exact translation is secured. Misunderstandings, ungrammatical forms, and other errors are in this way largely eliminated, and it is only from a mass of such texts that a real understanding of the language can be obtained. To get such material usually requires some training and practice, but if a favorable informant or interpreter is available, the experiment may be tried. Direct narrative of personal experiences, or better still, myths or folk-tales may be thus written down, and interlinear translations obtained.

Archaeology.

Outfit.

In addition to the general type of note-book already described, the traveller who desires to do serious archaeological work should have note-books ruled in millimeter squares, tracing paper, measuring tape, prismatic compass, twine, box of water colors, and a complete camera outfit. For work upon sculptured stones, in addition to the above, rubbing paper, molding paper, brushes, and glue should be carried in order to obtain molds. For full directions for taking paper molds, see Hints to Travellers, 9th ed., pp. 150–154 (published by Royal Geographical Society, London, 1906). A plane-table or theodolite is necessary when careful orientation is desired. Brushes, case knives or spatulae, bellows, and small, flat trowels are useful, especially in grave exploration. Shovels, picks, and crow-bars are the usual tools for excavation. In general, however, the tools used by the workmen should be obtained in the country where the work is to be carried on. Natives will use their own kind of tools to much better advantage than those foreign to them. Thus baskets, if the people are accustomed to them, are often more serviceable than wheel-barrows for removing earth. For packing the specimens cloth or bags of tough paper, boxes, among them nests of pill boxes, bottles with screw tops, and some light material should be provided. Labels are essential; small paper blocks are useful in this connection. Too much care cannot be expended in marking specimens for purposes of identification and in the packing of fragile objects.

Note-Taking.

One cannot have too many notes. Most careful notes of position are necessary; it is well to measure from two fixed points. Rough drawings of objects with their numbers help in identifying specimens which may have lost their labels.

Selection of Site by Explorer.

Local traditions should be consulted and the general topography should be examined in reference to water supply and centers of population. A guide familiar with the country is indispensable where it is impossible to cover any large territory by personal investigation.

Permits.

A written permission to excavate should be obtained from the owner of the land when the site belongs to an individual, or from the government when it is public land. Permits to explore on government land may usually be obtained by properly accredited persons through the American Minister or Consul.

Labor.

Native workmen are usually better than imported laborers. Wages should correspond to the native scale as far as possible. Time rather than "piece-work" is the basis of pay. The *bakshîsh* method is usually employed with success, a small sum of money being given to the workman who finds an object of importance or to the "gang" to which the workman belongs. This encourages the work and lessens the likelihood that the object will be sequestered in the pocket of the laborer. Strict discipline is necessary. It is usually better to give to each man a certain piece of work to do with a native foreman in charge of each gang.

Plan.

A plan drawn to scale should be made as the work progresses. Nothing should appear in the field plan except what is actually seen. Measurements should be precise and the points of the compass accurately noted.

Photographing.

The greatest aid to archaeology is the camera. In the selection of cameras, those with extension bellows for taking near-by objects are preferable. Photographs should be taken before the site is touched and at frequent intervals during excavation. The place where the picture is taken, together with the angle included in the picture should be indicated on the plan. It is generally better to develop plates in the field in order to avoid failures.

Lay-out of Site.

When the site is small it may be laid out in meter or three- or five-foot squares by means of a prismatic compass and twine. The squares are numbered so that the detailed position of walls, objects, etc., is readily recorded on the plan. When the site is large the plane-table or the theodolite is recommended.

Methods.

Trial pits or trenches may be dug to determine the extent of the site. Care should be taken, however, not to destroy walls and graves in this kind of work. There are three general methods of excavation. (1) The vertical-wall method in which a trench is run and this trench is constantly widened on one side by removing with great care the face of the wall. Any stratification is seen in this way. As objects appear in this wall they should be photographed *in situ* and their position as regards depth and general location noted. Care must be taken to prevent the wall of earth from falling. Sometimes where the depth of excavation is great, a series of steps, each with a vertical face, is made. (2) In the "onion" method the site is stripped horizontally in layers. The thickness of the layers depends upon the stratification; usually a few inches only should be taken off at one time. Great care is necessary in order to avoid breaking through important strata. This method is useful in excavating house- or temple-sites where there are distinct floor and wall levels. (3) The pit method is principally serviceable for preliminary examination but it should generally be avoided as there is always a danger of destroying valuable data. A series of unrelated pits should not be made.

Disposal and Identification of Débris.

The débris should not cover places to be excavated later for this makes a second removal necessary. Débris should be carefully examined and, where small objects occur, it should be sifted. Distinguish between the débris caused by time, the débris dating back to the construction of the building, that caused by the filling in on a former site, the débris of occupation or camp refuse, and that of decay.

Nothing should be overlooked in excavation; the geological formation, the relation to water supply, the objects of minor importance as shards of pottery, ash deposits, chips of stone, rough stone construction, bones of animals as well as those of man, and, as already pointed out, the general débris. If there are large masses of shards and only a small number can be taken, remember that the undecorated pieces are quite as important as the decorated. A mistake often made is that of selecting the unusual and the most striking. This gives a false idea of the pottery as a whole. It is a good plan to count or, sometimes, to weigh the pieces and make a calculation of the per cent of each class or each type occurring in a given area. Do not try to mend broken pottery in the field. The pieces supposed to belong to the same vessel may be indicated by a number or they may be packed together.

Every endeavor should be made to determine the history of the wanderings of the people found still living near the site in question. Myths of the present population may serve to indicate the history of the site. One should use some thought and care as to the way the site should finally be left when the work is ended. The owner of the site, first of all, should be satisfied. Pits and graves should be filled in as far as possible and the traveller should uncover only as much of the site as can be properly explored in the time at his disposal. Pot-hunting and relic-hunting should be frowned upon. Never attempt to excavate an important site unless with scientific intentions. Careless work for a single day may destroy important data which can never be replaced.

Types of Finds.

Remains in geological deposits. — Here the geological age of the formation is of primary importance. The vertical-wall method should be followed and any stratification noted. Samples of the earth of each stratum should be taken. Great care should be observed to determine the possibility of intrusions belonging to a later time and whether the objects found were laid down at the time of the deposition of the strata. The position of the objects may show this together with the fact that the strata are continuous over the object. All animal bones are especially important and any remains of fire should be noted. Photographs of objects *in situ* before removal from the wall of earth are especially important in this type of site, together with careful drawings of the stratification, faults, etc.

Cave deposits. — The relation of the cave to the surrounding country and the different levels of occupation should be carefully observed. The original floor of the cave should be found in each case. Care is needed in removing stalagmitic deposit so as not to break bones and other objects occurring in it. One should excavate in front of the entrance to caves. The vertical-wall method should be followed from the entrance to the end of the cave.

Surface finds. — It is often possible to make good collections of flint and other stone objects together with potsherds from the surface of freshly plowed fields or in an open country where there is little vegetation. They usually appear more clearly after a rain. If it is not possible to take away every object the average types should be selected, not the most striking pieces. Rejects, broken and unfinished pieces are important as well as perfect specimens.

Shell-heaps. — An artificial shell-heap is in most cases easily distinguished from a natural deposit by the presence of ash, broken pottery, animal bones, etc. The stratification should be examined and specimens of shells, bones, implements, and shards collected. The relation of the heap to the present shore-line and to the former shorelines should be determined. Neighboring sites still occupied may give an indication of the authorship of the shell-heap.

Village sites. — The recognition of these is often difficult. The change in the character of the vegetation may indicate the presence of a former village or camping site. Remains of rings of earth or mounds of earth sometimes indicate former houses. Post holes may occur. Caches of objects in pits should be carefully examined and the entire contents of the pit removed. A study of the type of houses of the present aboriginal inhabitants of the region is useful in many cases. A plan should be made showing the outline of the house, the position of the fireplace, and of all objects found. Always excavate beneath the living surface of the hut for possible presence of burials, pits, and caches.

Mounds and tumuli. — Mounds are of several types: domiciliary, burial, ceremonial; or they may be foundations for buildings that have disappeared. A trial trench or pit may be advisable to determine the character of the mound. If a thorough excavation is to be made the vertical-wall method should be followed. Foundation and domiciliary mounds are not usually fertile places for excavation. A ceremonial mound may have interesting wall and interior constructions which are important. In burial mounds cremation as well as inhumation should be looked for. It is essential to excavate beneath hard pan or to hunt for disturbed places in it. The age of trees growing on the mound should be calculated and the depth of the accumulated vegetable mold on the surface of the mound should be measured. A hill on top of which there is a grave should not be mistaken for an artificial mound.

Burials. — There is no phase of archaeological work where more care is needed than in excavating graves. The recognition of burial deposits is often difficult and sometimes only possible after an examination of the burial customs of the people investigated. A distinction should be made between cemeteries and single graves, and between burials of persons of importance and those of the common people. Graves of the latter often show more truly the life of the people than the graves of persons of authority. Cremation and inhumation are both practiced and, in some cases, the two methods of disposing of the dead are found in the same place. The aversion of living people to the investigation of graves of their ancestors is one of the difficulties often encountered. Greatest care should be taken not to offend public opinion. A single ruthless investigator may destroy for years any further opportunities for excavation in the locality. In opening a grave, the earth should be removed from the sides of the grave and then carefully from above the skeleton. The flat trowel or spatula, the brush, and bellows only should be used and one should take as much time as necessary. The grave should be photographed with the bones undisturbed together with the objects found in it. Numbers or letters are sometimes placed near the objects which are to appear in the photograph. A tilting table for the camera is useful here. A plan of the grave to scale should be made showing the points of the compass and the exact position of all the objects and parts of the skeleton. Bones are often in a very perishable condition and, if moist, they should be exposed to the air and dried before removal from the grave. The sun should never be allowed to strike them. If the bones are very dry and crumbling they should not be disturbed until they have been saturated with water and allowed to dry under the shade of paper or boards. They can then be removed and immediately wrapped in paper and cotton or other soft material and packed, but cotton or tow should not be put in direct contact with the bones. In taking up a fragile skull it is best not to try to remove it with the earth in it but to take the separate pieces and wrap each one so that the edges will not be broken. The skull can then be easily restored at home. Some investigators spray fragile bones with water-glass (silicate of sodium) or paraffin before removal. All the bones should be taken as well as the cranium. The teeth which are likely to fall out should be taken from the sockets, wrapped, and packed with the skull. Great care should be used to keep the bones of one skeleton together. Burials may occur in connection with any of the types of sites here mentioned; for example, under the floors of houses, in the center of ceremonial mounds, in caves, shell-heaps, etc. The greatest care should be observed when fragile objects such as those of ivory or wood are found. When removing them from the ground it is well to take them with the earth about them. Wrap them tightly in soft paper and do not try to clean them in any way until at home. A spray of melted paraffin over a very fragile object before removal is sometimes employed with success.

Megalithic monuments. — In this type of site, extensive excavation is usually impossible. Investigation should be made around the base of the stones, and burials in connection with the monuments should be looked for. In the alignments and stone circles, careful orientation to the true north is important. The character of the stone and the place of its quarrying should be investigated. Any markings on the stones should be noted. The superstitions and legends of the present population in regard to the monuments should not be overlooked.

Ruined buildings. — A carefully oriented plan together with photographs of the site as a whole is the first requisite. The alignments of the inner as well as the outer walls of the buildings in relation to the true north are important. A detailed plan of each building with all dimensions is necessary, together with a minute description of the details of the construction, the walls, roof, ceilings, lintels, doorways, etc. In the plan, a distinction should be made between the walls actually seen in place and those which are conjectured. It is well not to try to make a reconstruction of the plan unless there is ample evidence. Changes of plan in building and alterations in buildings should be noted. Make photographs and drawings of unusual features and of all forms of decoration. When possible, take rubbings and molds of all sculptures and bas-reliefs. Remains of color and of fresco painting should be noted and copied in color or the colors indicated on sketches made. Incised drawings, sometimes found on the plaster of the walls, may be copied by means of rubbings in addition to copies made in the note-book. Floors and walls should not be destroyed. The destruction of these features is justified only when there are several successive strata of occupation. Even then it is often possible by means of tunnels to obtain the data required and yet preserve the floors and walls above. Shoring tunnels with timber supports is often necessary. Where floors are found broken or partly destroyed, one is justified in removing the remains of the floor in search of rooms, burials, and lower floor levels.

Inscriptions, carvings, pictographs. — These are of great importance. Make drawings in addition to photographs wherever an actual mold or rubbing is not possible. It is often necessary that inscriptions and carvings should first be cleaned of vegetable or animal matter. This should be done with brushes and water unless the material is very friable. In pictographs the design may, under certain conditions, be brought out in the photographs by chalking the figures but this is not desirable unless other methods fail. In inscriptions and bas-reliefs the greatest patience should be used in getting the proper light from the side in order to bring out the design. Wetting the stone will generally help in emphasizing the details. A careful drawing of the inscription in addition to the photograph is always desirable.

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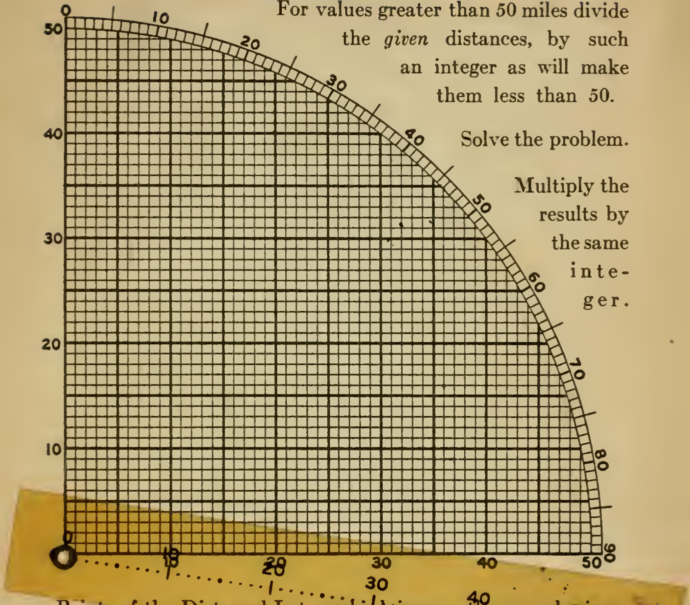
GRAPHI(

For values greater than 50 miles divide the *given* distances, by such an integer as will make them less than 50.

Solve the problem.

Multiply the results by the same integer.



Points of the Dist. and Lat. scales lying on the same horizontal line are "corresponding points."

Points of the Dist. and Dep. scales lying on the same vertical line are "corresponding points."

To change Course and Dist. to Lat. and Dep.; Set the movable radius to the given course. Note the given distance on the Dist. scale. The Lat. and Dep. are the corresponding points on the Lat. and Dep. scales respectively.

To change Lat. and Dep. to Course and Dist.: Find a point, *p*, corresponding to the given Lat. and Dep. Bring the movable radius to the point, *p*. The reading of the radius on the divided arc is the required course and the reading of the point *p* on the Dist. scale is the required Dist.

To change Dep. to Diff. Long.: Set the radius to the Mid. Lat. Seek the given Dep. on the *Lat.* scale. The reading of the corresponding point on the Dist. scale is the required Diff. Long.

To change Diff. Long to Dep.: Set the radius to the Mid. Lat. Seek the given Diff. Long. on the Dist. scale. The corresponding point on the *Lat.* scale is the required Dep.