The Locomotives of the Great Northern Railway

THE LOCOMOTIVES OF THE GREAT NORTHERN RAILWAY.

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The Locomotives of The Great Northern Railway,

1847-1910,

BY

GEO. FREDK. BIRD.

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PREFACE.

IN presenting a history of the various types of locomotives which have been constructed for the Great Northern Railway, the compiler is aware of many deficiencies in the work. So far from this being a history of the line, the following pages cannot claim to comprise anything more than a somewhat brief catalogue of locomotives, many of which have earned fame in the annals of railway development. To have dealt with them as fully as might be is not in the power of the compiler, and equally beyond the limits of space allowable in a publication of this character. The utmost that can be urged is that, principally owing to the disinterested assistance of many kind friends, the writer has been enabled to produce what is, so far as he is aware, the first approximately complete list of the locomotives built for the Great Northern Railway from its opening as a small branch line in Lincolnshire until the present date.

It is largely due to the same kindly help that the letterpress is so fully illustrated by outline drawings of engines, the particulars from which the drawings have been built up being obtained from a variety of sources, ranging from old note books to quite recent photographs. As

regards the earlier engines, the main groundwork of fact was derived indirectly from that *doyen* of locomotive superintendents, the late Mr. Archibald Sturrock, but much valuable assistance has also been given by friends who have freely placed their storehouses of information at the writer's disposal. Notable among these must be mentioned Mr. E. L. Ahrons, to whom the writer is indebted for a number of items of information, especially as regards the engines of twenty and thirty years ago, and whose first-hand knowledge of many of the engines extends back to 1876.

The writer is indebted to the late Mr. Patrick Stirling for some details as to the period covered by his efficient control of the G.N.R. locomotive department, but as regards details of dimensions and not a few photographs of that and the present time, thanks are especially due to Mr. H. A. Ivatt, the present chief of the Locomotive Department, who has most courteously acceded to every most iresome appeal for information.

It does not fall within the scope of the historical sketch to which this is a preface to dwell at length on the influence exercised on the Great Northern Railway by its three superintendents of the locomotive department. The somewhat heterogeneous collection of locomotive stock introduced by Mr. Sturrock was in accordance with then existing conditions, and admirably fulfilled the requirements of the time. Mr. Stirling took over the command at a period when a change of policy was eminently desirable, and his complete scheme of standardisation, which was, moreover, capable of constant adjustment to more strenuous conditions of service, had a marked effect on the efficiency of the

locomotive department. Towards the close of his career, however, the remarkable and sudden increase in speed and weight of express trains became so exacting as to require a thorough departure from conservative traditions, and when Mr. Ivatt took charge in 1896 he was at once confronted with a serious problem in the task of bringing the locomotive department into closer touch with traffic requirements. How he has grappled with the difficulty, by introducing from time to time new locomotives of quite modern capacity, which have shown him to be instinct with resource and originality, this history may serve to indicate. It is safe to prophesy that the future of the locomotive department of this line is assured so long as it remains under the control of one who has proved himself so eminently capable of adapting his methods to new and decidedly exacting circumstances.

It is to be recorded with regret that since the publication of the first edition of this little book Mr. Archibald Sturrock, the first locomotive superintendent of the Great Northern Railway, has passed away at the ripe age of 92. Though, with his retirement from that important position, Mr. Sturrock's engineering career may be said to have ended, he took a great interest still in locomotive matters, and he was good enough to express kindly appreciation of the writer's work in compiling this history.

G. F. B.

ILLUSTRATIONS.

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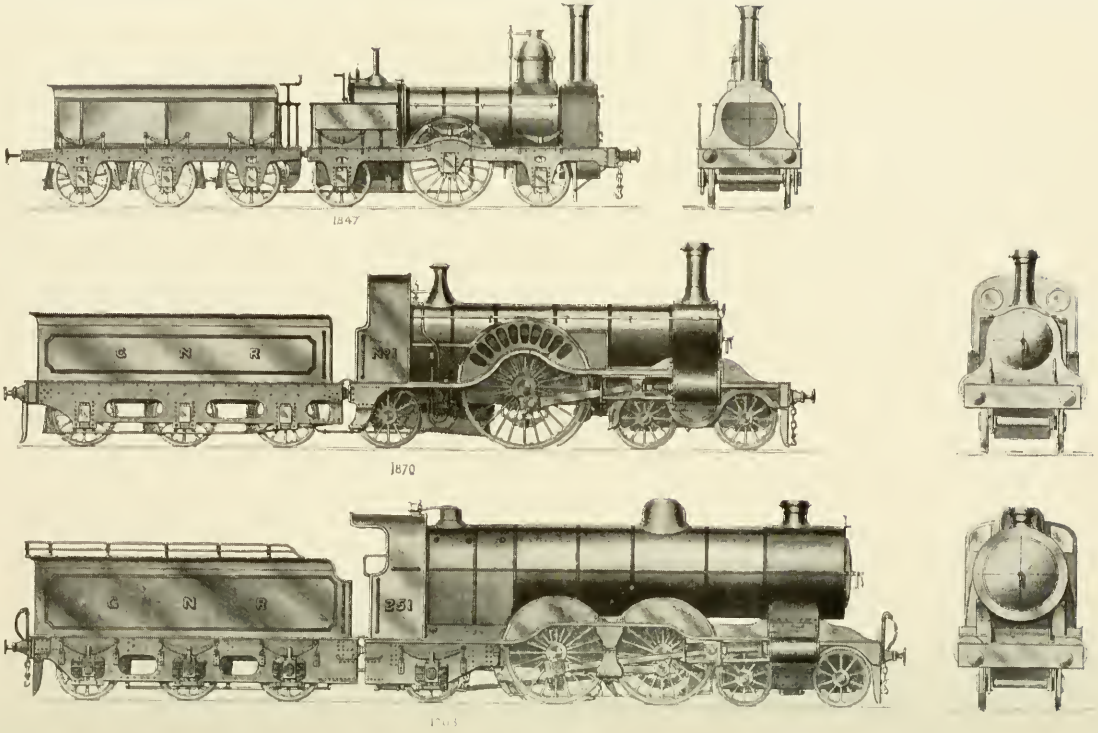


The Development of Great Northern Railway Locomotives, 1847—1903.

THE LOCOMOTIVES OF THE GREAT NORTHERN RAILWAY.

PART I.

INTRODUCTION, 1847-1850.

THERE is no intention to give here a history of the rise and growth of the Great Northern Railway. That has already been done, and were it not so, the telling of so romantic a story as the elevation of what was, at its origin, a small local line in Lincolnshire into one of the great trunk lines of the United Kingdom, with the battles that were waged around it, and the legislation that had to be encountered in the process, could not well be compassed in the limited space here available. For the present purpose all that need be said of the beginning of this important through system of communication between

London and the North can be of the briefest character. The first portion of what is now the Great Northern Railway was opened on March 1st, 1848, and extended from Grimsby to Louth. Then followed other sections, forming piece after piece of a fairly homogeneous whole, but it was not until October 14th, 1852, that the first train ran from King's Cross Terminus northwards along the present East Coast route.

So far for the history of the line. From the very beginning it happened that the Great Northern had to do that which it has so notably accomplished ever since—to show uncommon qualities of speed, for from the outset of its career it entered into active competition with established alternative routes for the main prize constituted in the through traffic to Scotland. As a consequence, the locomotives placed upon the line have always represented first-class practice, the passenger engines being of the speediest types possible, while the equally important mineral traffic passing over the line has also made a demand for exceptionally powerful goods locomotives.

The first of the Company's engines to be put to work were fifty built by the firm of Sharp Brothers & Co., of Manchester, who were formerly known under the style of Sharp, Roberts & Co., subsequently becoming Sharp, Stewart & Co., Ltd., of Atlas Works, Glasgow, and now one of the three component firms comprised in the North British Locomotive Co., Ltd. These engines, which were numbered in the company's books from 1 to 50, were delivered to the G.N.R. during the years 1847, 1848 and 1849, and, as can be gathered from the accompanying

illustration, Fig. 1, were of the builders' well-known design of the period. They had cylinders 15-in. in diameter, with a 20-in. stroke, and a pair of single driving wheels 5-ft. 6-in. in diameter, with leading and trailing wheels each 3-ft. 6-in. in diameter, the wheel-base being 12-ft. 8-in., of which 5-ft. 9-in. separated the leading and driving wheel centres, and 6-ft. 11-in. separated the driving and trailing wheel centres. The boiler barrel was 10-ft. in length, with a diameter of 3-ft. 6¾-in., and contained 147 tubes 10-ft. 5-in. long and 1¾-in. in diameter. The inside firebox measured 3-ft.

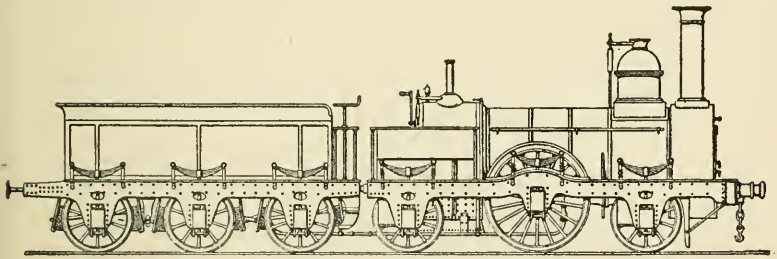


Fig. 1.

in length by 3-ft. 6½-in. in breadth, and the heating surface was distributed as follows: firebox 57·9 sq. ft.; tubes 690·3 sq. ft.; total, 748·2 sq. ft. The weight of these "Little Sharps" was 18 tons 8½ cwt. At a subsequent date equalising levers connected the springs of the leading and driving wheels. These levers were not, however, introduced until some time after 1850, in which year the device was patented by Messrs. Hawthorn. A number of the "Little Sharps" were converted into tank locomotives in the year 1852, as will be shown more particularly in due course.

Following the engines already mentioned came a class which were always known on the line as the "Small Hawthorns," so named after their builders, Messrs. R. and W. Hawthorn, of Newcastle-on-Tyne. There were twenty of these engines, numbered consecutively with the first lot, of which Nos. 51 to 62 were delivered during the years 1848 and 1849, and Nos. 63 to 70 during 1850. The illustration, Fig. 2, showing No. 51 of this class, indicates the chief features, and points the fact that except in matters of detail

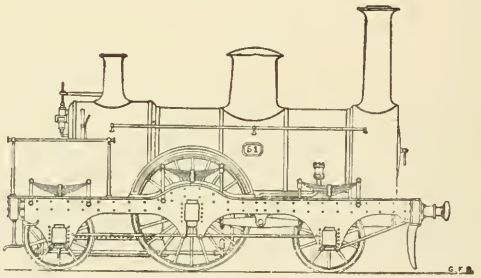


Fig. 2.

these engines were of the firm's standard pattern. Nos. 61 to 70 differed from the others in having no domes, but they all had cylinders measuring 15-in. by 21-in. and driving wheels 6-ft. in diameter, the leading and trailing wheels being 3-ft. 6-in. in diameter, and at distances of 7-ft. and 6-ft. 9-in. respectively from the driving wheel centre, the total wheel-base thus being 13-ft. 9-in. The boiler barrel was 10-ft. in length and 3-ft. 10-in. in diameter, containing 173 tubes each of $1\frac{3}{4}$-in. diameter, and the internal firebox measured 3-ft. 10-in. in length by 3-ft. 6-in. in breadth.

Heating surface formed a total of 907 sq. ft. of which 68 were apportioned to the firebox, and 839 to the tubes. The weight of these engines was 27 tons 1 cwt. Nos. 52 to 57 were for a time lent to the East Kent Railway, afterwards a portion of the London, Chatham & Dover Railway, and were the first engines at work on that particular line.

Passenger traffic on the infant line being provided for to the extent shown, orders were given to supply some engines for the goods department. Accordingly, two classes of four-coupled engines were soon put to work, the one set

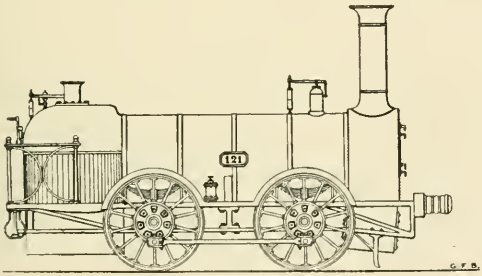


Fig. 3.

having four wheels only, all coupled, while the others ran on six wheels, the leading and driving wheels being coupled. Of the former, six were built by Messrs. Bury, Curtis and Kennedy, and were all at work in 1848, receiving the railway Company's Nos. 121 to 126, and, as can be seen from the accompanying illustration of No. 121, Fig. 3, were of the well-known "Bury" type of the period, having inside cylinders measuring 15-in. by 24-in., four-coupled wheels 5-ft. in diameter, the bar-frame, which was an integral factor of the type, and the modified circular, dome-topped

firebox casing. Six other engines of almost the same pattern, numbered from Nos. 127 to 132, were built in 1848 and 1849 by Messrs. William Fairbairn & Sons, of Manchester, probably under contract with Messrs. Bury, who frequently sub-let part of their orders. The accompanying drawing of No. 127, Fig. 4, with its tender, shows the main features of these engines, which had 15-in. by 24-in. cylinders, and 5-ft. 1-in. coupled wheels standing on a wheel-base of 7-ft. 8-in. The tender had four 3-ft. wheels on a 7-ft. 5-in. wheel-base, the total wheel-base of engine

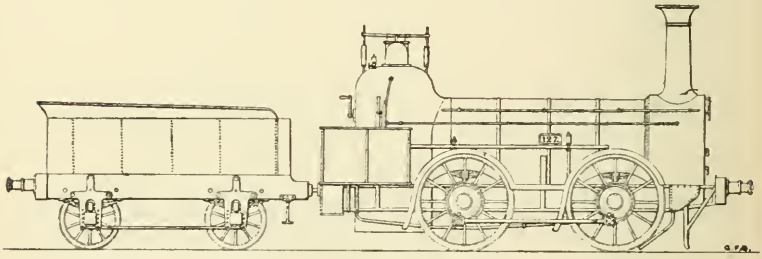


Fig. 4.

and tender being 27-ft. 11-in., with a length over buffers of 39-ft. 5-ins.

As can readily be understood, these twelve engines did not distinguish themselves to any praiseworthy degree by their capability for dealing with main-line traffic, which on this particular line, at all events, was of a heavier character than they were competent to work. Mr. Sturrock, therefore, afterwards converted them into six-wheeled, front-coupled engines, by the simple process of extending the framing rearwards, and adding a pair of 3-ft. trailing wheels under the footplate. At the same time, he further

dispensed with the tenders, providing Nos. 121 to 126 with saddle tanks carried over the barrel of the boiler, in the manner shown in the accompanying illustration, Fig. 5,

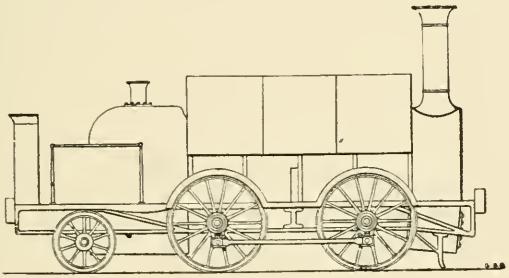


Fig. 5.

and by this addition giving them a total weight of 29 tons 6 cwt., while Nos. 127 to 132 had side tanks.

The six-wheeled goods engines already mentioned were Nos. 101 to 115, and were built by Messrs. R. & W. Hawthorn in 1848. The illustration, Fig. 6, here given of No. 101 shows the leading features of this class, which had

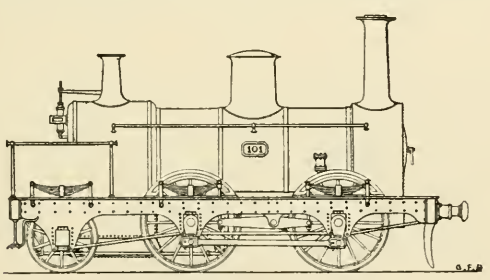


Fig. 6.

four wheels coupled in front, with equalizing levers connecting the springs, and a pair of smaller trailing wheels. These wheels were respectively 5-ft. and 3-ft. 6-in. in diameter,

the driving-wheel centres being 7-ft. 6-in. apart and the total wheel-base 14-ft.; the cylinders measured 15-in. by 24-in. With a boiler barrel 10-ft. long and 3-ft. 10-in. in diameter, containing 166 tubes of 2-in. diameter, and an internal firebox 3-ft. 6-in. long by 3-ft. 5-in. broad, there was a total heating surface of 970 sq. ft., of which the firebox contributed 75 and the tubes 895 sq. ft. The weight of these engines was about 26 tons.

In the first week of January, 1849, Messrs. Bury, Curtis & Kennedy delivered to the company a passenger

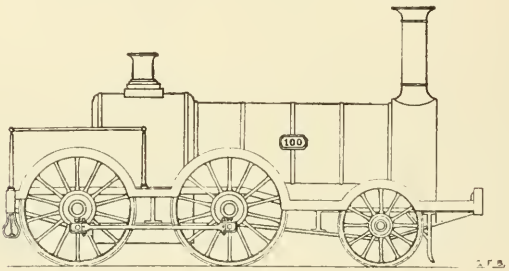


Fig. 7.

engine, No. 100, which claims some attention. As can be seen from the illustration, Fig. 7, it was not of the standard pattern of the firm, being carried on six wheels, while the shape of the firebox also differed from that almost invariably associated with the "Bury" engines. The maker's No. of this engine was 359, and it had inside cylinders 15-in. by 22-in., a pair of leading wheels 4-ft. 3-in., and four coupled wheels 5-ft. 9-in. in diameter respectively. During 1855 and 1856 this engine was rebuilt, having in the first-named year broken its crank-shaft and run off the rails, and as it

issued from the shops it presented quite a changed appearance, the inside bar frames being concealed by the provision of a new plate framing outside the wheels, the external aspect of the engine as thus converted closely approximating to that of the coupled passenger engines subsequently built with the Nos. 71 to 75, which will be referred to later. At the same time the cylinders had their diameter increased to 16-in. Some years later, in 1871, this No. 100 was again renewed with wheels of the same diameter as those originally placed under her, and still later, in 1875, she was

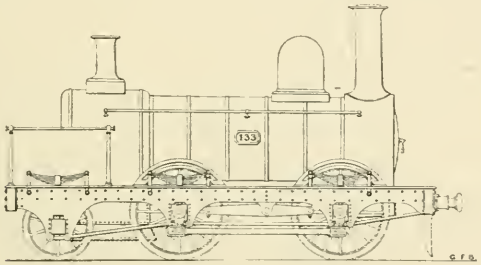


Fig. 8.

provided with a new set of wheels, the leaders being 4-ft. 6-in., and the drivers 6 ft. in diameter, respectively, thus raising the whole engine by about 3 inches.

Four locomotives were purchased from Messrs. Peto, Brassey & Betts in 1849 and 1850, to which were given the G. N. R. Nos. 133 and 159 to 161. When at work on the G. N. R. No. 133 presented the general appearance shown in the accompanying illustration, Fig. 8, having four driving wheels of 5-ft. diameter, coupled in front, and a pair of 3-ft. 6-in. trailing wheels. The wheel-base was 14-ft. 6-in., of which 8-ft. 3-in. divided the driving wheel centres. Inside

cylinders measuring 15-in. by 24-in., outside bearings throughout, a raised firebox and a dome placed well forward on the boiler barrel, and equalizing levers between the driving springs, were features of this engine, and Nos. 159 to 161 were apparently of much the same general design and dimensions. All these engines were built by Messrs. C. Tayleur & Co.

Five engines which received the G. N. R. Nos. 162 to 166 were also purchased a year or two later. Engine No. 162 was purchased from a Yorkshire line, and was originally built by Messrs. Kitson. No. 163 was a standard Hawthorn double-framed goods, with 5-ft. driving wheels and 16-in. by 24-in. cylinders, built in 1850. Nos. 164 and 165 were standard Wilson goods engines of similar dimensions to No. 168, described and illustrated on p. 19, and were built in 1852. No. 166 was a single-framed goods engine, built by Messrs. Shepherd & Todd, of Leeds, in 1850, with 16-in. by 24-in. cylinders and 5-ft. driving wheels, each of which was built up of a solid disc instead of with spokes. It had single inside frames, the coupling rods being connected directly with the wheels with crank pins. All these engines came from the Yorkshire railway already referred to, and did good service. No. 165 was lately running at Bradford, and more recently still was stationed at Ardsley, and is the oldest goods engine on the G. N. R.

So far, the goods engines built for the Great Northern had consisted of four-coupled types, but in 1850 a notable movement was made in the putting to work of a six-coupled engine, which was followed during that and the following year by a number of similar locomotives. These had inside cylinders, outside frames and axle bearings, and

equalizing levers between the leading and driving springs. Other leading details in their construction may be seen from the accompanying illustration, Fig. 9, of No. 116. In all there were 31 engines built of this class, 15 being built by Messrs. R. & W. Hawthorn and 16 by Messrs. E. B. Wilson & Co. Of these the former firm built Nos. 116 to 120 in the year 1850, and Nos. 134 to 143 (makers' Nos. 739 to 748) in 1850 and 1851, while Messrs. Wilson's engines, of the same dimensions, but differing in details of fittings, as was customary at the time, bore the Nos. 144 to 158 and 167, and were built and delivered in 1850 and 1851.

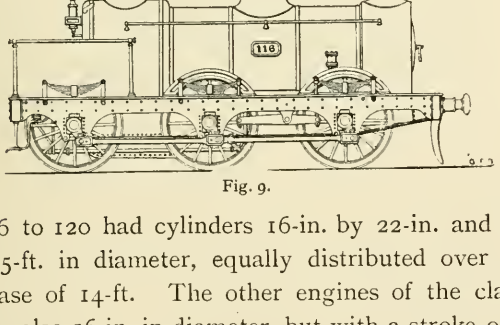


Fig. 9.

Nos. 116 to 120 had cylinders 16-in. by 22-in. and driving wheels 5-ft. in diameter, equally distributed over a total wheel-base of 14-ft. The other engines of the class had cylinders also 16-in. in diameter, but with a stroke of 24-in. The boiler barrel was 10-ft. in length, with a diameter of 3-ft. 10-in., and contained 158 tubes of 2-in. diameter. The internal firebox measured 3-ft. $10\frac{1}{2}$-in. in length by 3-ft. $3\frac{1}{2}$-in., and the heating surface was—firebox 78, tubes 815, total 893 sq. ft.

In 1850 and 1851 two passenger engines which had been ordered from Messrs. E. B. Wilson & Co. were

put to work, bearing Nos. 201 and 202. They were built in accordance with the firm's speciality in single driving engines, with inside bearings to the driving wheels and outside bearings to the leading and trailing wheels, this conjunction of details, together with others less conspicuous, constituting what was known as the "Jenny Lind" pattern, over which some heated discussions have at times been centred. These two engines for the G. N. R. had driving

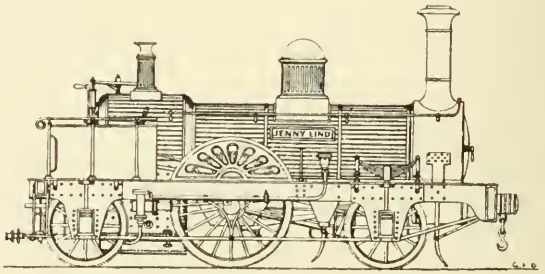


Fig. 10.

and carrying wheels of 6-ft. and 4-ft. respectively, and had cylinders 16-in. in diameter, with an original stroke of 20-in., which was subsequently lengthened to 22-in., when they were rebuilt some years later by Mr. Stirling. The accompanying illustration of the original "Jenny Lind," Fig. 10, may be taken as representing Nos. 201 and 202 on the G. N. R. when built. Neither of these engines, however, bore the name-plate shown here on their prototype, and they also probably presented a few minor differences in matters of detail.

PART II.

ARCHIBALD STURROCK, 1850-1866.

UP to this period in its history the Great Northern Railway can scarcely be said to have had an actual locomotive superintendent. At the outset Mr. Cubitt, brother to the well-known contractor, did indeed virtually occupy that position for a few months, and on his death Mr. Bury, whose engagement on the London and Birmingham Railway had terminated at the close of the year 1846, also for a brief space took over the locomotive department of the Great Northern. But it was soon felt that Mr. Bury's position could not fail to be one of considerable delicacy, in view of his dual capacities as an official of a railway company and a member of a firm of locomotive builders; and in 1850 a new arrangement was suggested, whereby the services of Mr. Archibald Sturrock were secured, and that gentleman was definitely installed as locomotive engineer. Mr. Sturrock had previously gained upwards of ten years' experience in the Great Western Works at Swindon under Mr. Daniel Gooch, and there can be no doubt that the excellent training thus acquired fitted Mr. Sturrock in a most eminent degree to undertake the duties of his new appointment on a railway to which the qualities of speed and power in its locomotive stock were absolutely necessary for a continued and prosperous existence. From the start the new locomotive

engineer kept two main ideas strongly to the front in providing engine-power for the railway, those two ideas being the vital influence of the firebox in determining the capability of an engine, and the need of a high boiler pressure to develop the full capacities of the machine. Accordingly we find that in all the engines built to his specifications there was an unusually large provision of heating surface, especially as regards the firebox, which, as Mr. Gooch had always maintained, is the true measure of the power of a locomotive; while from the outset he adopted

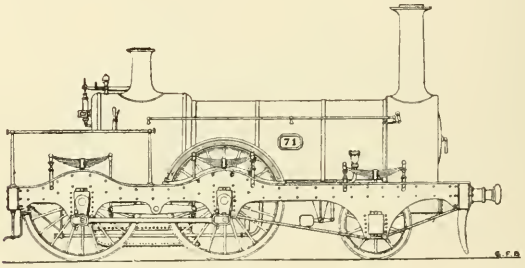


Fig. 11.

what, at that time, was the comparatively high pressure of 150 lbs. to the square inch, as the standard working pressure of all the locomotives turned out to his orders.

The first passenger locomotive built for the G. N. R. Company to Mr. Sturrock's instructions was No. 71, which began work in 1851, and was one of twenty constructed to the same leading dimensions. Of these Nos. 71 to 75 were built by Messrs. R. & W. Hawthorn, and Nos. 76 to 90 by Messrs. E. B. Wilson & Co., and the two accompanying illustrations, Figs. 11 and 12, showing respectively Nos. 71 and 76, indicate that, while in details

each firm still continued to follow its own practice, the general dimensions of the railway company's locomotive engineer were closely adhered to. These twenty engines were all built to the following chief particulars:—cylinders 16-in. by 22-in.; leading wheels 3-ft. 6-in., four-coupled driving wheels 6-ft. in diameter; wheel-base 15-ft., of which 7-ft. 3-in. divided the centres of the coupled axles; boiler barrel 10-ft. in length, with a diameter of 3-ft. 9½-in., containing 157 tubes of 2-in. diameter; internal firebox, length 4-ft. 6-in., width, 3 ft. 3½-in.; heating surface: firebox

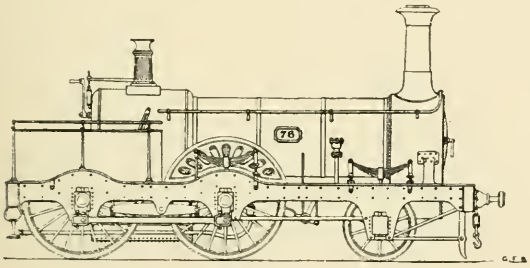


Fig. 12.

102 sq. ft., tubes 904 sq. ft., total 1006 sq. ft.; boiler pressure 150 lbs.; weight 27 tons 18 cwt.

Ten engines of unusual design were built by Messrs. Longridge & Co., and delivered to the railway company during the years 1851 and 1852, though it appears that they were actually ordered prior to Mr. Sturrock's assumption of office on the line. They were of practically the same type as the well-known "Folkestone" of the South-Eastern Railway, and were built in accordance with one of Mr. T. R. Crampton's patents, a principal feature of the design consisting "in the boiler resting upon three points: one on

the centre of a cross-spring, which bears upon the axleboxes of the driving wheels at the back of the firebox, and one on each side in the front, on compensating springs, each of which springs bears upon the two axleboxes of the small supporting wheels." In the case of the G. N. R. engines, the large reversed springs at each side, which, in the original specification spanned the interval between the two sets of leading wheels, were not employed, each of the four leading axleboxes having its own spring, with equalizing levers between the two on each side, this method of

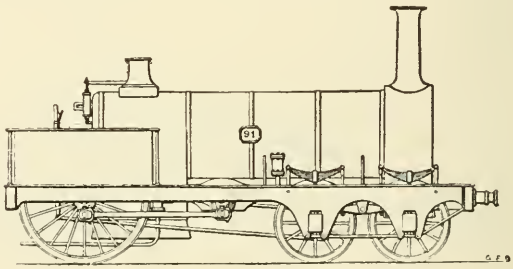


Fig. 13.

suspension being, for all practical purposes, the same as that above quoted. An important feature of the design consisted in the use of inside cylinders, which necessitated the employment of a "dummy" crank axle in front of the firebox, with outside cranks coupling it to the driving wheels at the extreme rear of the engine. These engines bore the G. N. R. Nos. 91 to 99 and 200, and one of them had the honour, at seven o'clock on the morning of October 14th, 1852, to draw the first train out of King's Cross terminus on its way to York. The illustration of No. 91 as here given, Fig, 13, shows the general external appearance of

these engines as originally built. They were speedily found, however, to be wholly unsuitable for the service they were intended to work, one very vital reason undoubtedly being the small proportion of weight available for purposes of adhesion, consequent on the position of the driving wheels. Mr. Sturrock, therefore, undertook the task of altering the arrangement of wheels to a more usual design, and in course of time they were all modified to the condition shown in our second illustration of No. 91, Fig. 14, in which the driving wheels are shown in the normal

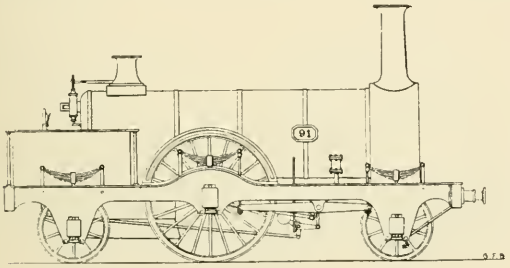


Fig. 14.

position, with the crank axle in front of the firebox casing, one pair of the carrying wheels being removed from the front of the engine to a more suitable place immediately behind the firebox. In this form the engines had outside bearings to all the wheels, and the driving axle had inside bearings as well. One of the engines, No. 200, passed through an intermediate stage, which is shown in the accompanying illustration, Fig. 15, being for a short period a four-coupled engine, having in its outside appearance a strong resemblance to the handsome coupled engines afterwards put upon the line by Mr. Patrick Stirling; but

this form only existed for a comparatively short period, and the engine was subsequently reconstructed in the single-driving form to which the others had been transformed. In their new condition these ten engines became known as the "converted Cramptons," and did excellent service for many years. The dimensions of the converted engines were:—cylinders 15-in. by 21-in.; driving wheels 6-ft. 6-in.; carrying wheels 3-ft. 6-in. in diameter; wheel-base: leading to driving wheels, 9-ft. 6-in., driving to trailing wheels 7-ft., total 16-ft. 6-in.; boiler barrel 10-ft. in length by 4-ft.

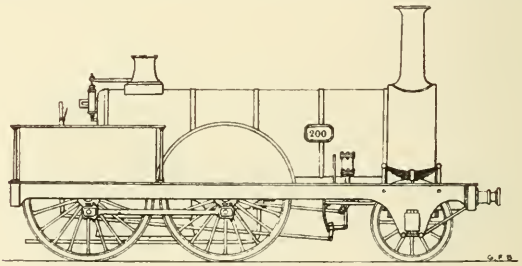


Fig. 15.

diameter, containing 168 tubes 2-in. in diameter, inside firebox 4-ft. 2-in. by 3-ft. 5-in.; heating surface: firebox 97 sq. ft., tubes 875 sq. ft., total 972 sq. ft.; weight in working order 28 tons 7 cwt.

The next engines put upon the line were a number of six-coupled goods locomotives of considerable size and power. Thirty of these were delivered in the years 1851 and 1852 by Messrs. E. B. Wilson & Co., with the G. N. R. Nos. 168 to 197, and ten during 1852 and 1853 by Messrs. W. Fairbairn & Sons, with the Nos. 198, 199 and 300 to 307. The accompanying illustration, Fig. 16, which shows

No. 168, will give an idea of the leading external characteristics of Messrs. Wilson's engines, which were, indeed, of a type that was subsequently adopted to a large extent by different railway companies. With six-coupled wheels having a diameter of 5-ft., cylinders measuring 16-in. in diameter with a stroke of 24-in., and a total adhesive weight of 29½ tons, it will be seen that this class of goods locomotive was exceptionally powerful for the period at which it first made its appearance. The three pairs of wheels were equally divided over a total wheel-base of 15-ft. 6-in., and all had

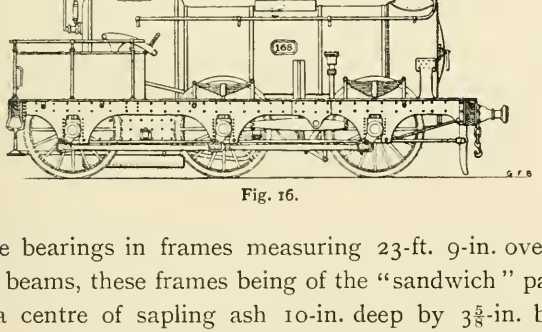


Fig. 16.

outside bearings in frames measuring 23-ft. 9-in. over the buffer beams, these frames being of the "sandwich" pattern with a centre of sapling ash 10-in. deep by $3\frac{5}{8}$-in. broad, having on each side an iron plate $\frac{7}{16}$-in. thick. In addition, the crank axle had two inside bearings between the wheels, in two iron frame-plates which extended from the cylinders to the firebox. A peculiarity about the boiler consisted in the adoption of a slightly oval section, the barrel having a vertical diameter of 4-ft. 3-in., while the horizontal diameter was only 4-ft. 1-in. Inside this barrel were 187 tubes of 2-in. diameter and 10-ft. $9\frac{3}{16}$-in. in length between

the tube plates. The firebox casing, which was of the raised pattern, had an outside length of 5-ft. 2-in., and a width of 4-ft. 3-in., while the copper firebox itself, which was provided with a transverse mid-feather, measured in its two divisions respectively a length of 2-ft. 0¼-in. each, with a common width of 3-ft. 7-in., and a uniform height of 5-ft. 2-in. above the grate bars, all inside measurements. This firebox had a grate area of 14·5 sq. ft. The engines of this class weighed 26½ tons empty, and 29½ tons in working order, the weight being distributed as follows: leading

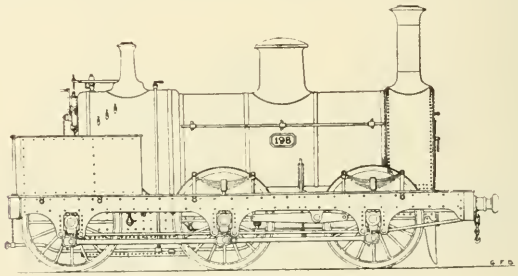


Fig. 17.

wheels 10½ tons, driving wheels 11½ tons, and trailing wheels 7½ tons.

In Fig. 17 is shown the general design of No. 198, which was one of the ten locomotives of the class built by Messrs. Wm. Fairbairn & Sons. Apparently these differed slightly from the earlier engines of the type, not only in general appearance, but also in some dimensions. For example, the boiler barrel seems to have been of a circular section 10-ft. 7-in. in length, with a diameter of 4-ft. 4-in., and contained only 184 tubes. The firebox had internal measurements of 4-ft. 6-in. in length by 3-ft. 10½-in. in

8 feet Bogie Express Locomotive, designed by Mr. Patrick Stirling. No. 548.

breadth, with a grate area of 15 sq. ft., and the heating surface formed a total of 1,109·3 sq. ft., of which the firebox accounted for 116·3 sq. ft., and the tubes for the remaining 993 sq. ft. While the total wheel-base remained the same as in the Wilson engines, it was unequally divided, the driving axle being 1-in. in advance of the central position, thus giving divisions of 7-ft. 8-in. and 7-ft. 10-in. between the leading and driving, and driving and trailing wheels respectively. The total weight of the engine is given as 30 tons 11 cwt., and the capacity of the tender tank 1,400 gallons of water.

Within a very short space of time orders were given for a further twenty goods locomotives of the same general design, but with wheels 5-ft. 3-in. in diameter, and cylinders measuring 16½-in. by 24-in., and slightly larger dimensions throughout. Of these, Nos. 308 to 317 were built by Messrs. R. Stephenson & Co. in 1851 and 1852, and Nos. 318 to 327 by Messrs. Nasmyth & Co. in 1852 and 1853 (builders' Nos. 100 to 109).

During the years 1852 and 1853 twelve fine engines were delivered to the railway company by Messrs. R. and W. Hawthorn, which became known as the "Large Hawthorns." They received the company's Nos. 203 to 214. In external appearance, as can be seen from the illustration here given, Fig. 18, which shows No. 203, they greatly resembled the No. 51 class, but were of larger dimensions throughout. Nos. 203, 213 and 214 were domeless, as shown in the accompanying illustration, while others had domes of the shape shown in preceding drawings of Hawthorn engines. Leading dimensions of these twelve locomotives were as follows: diameter of driving wheels

6-ft. 6-in., and of leading and trailing wheels 4-ft.; wheel-base: leading to driving wheels 7-ft. 9-in., driving to trailing wheels 7-ft. 3-in., total 15-ft.; cylinders 16-in. diameter with 22-in. stroke; steam ports 14-in. by $1\frac{1}{2}$-in.; exhaust ports 14-in. by $3\frac{1}{2}$-in.; diameter of blast pipe $4\frac{3}{4}$-in.; boiler barrel, consisting of $\frac{1}{2}$-in. plates, length 10-ft., diameter 4-ft., containing 171 tubes each 10-ft. 5-in. in length, with an outside diameter of 2-in.; firebox casing 5-ft. $1\frac{1}{4}$-in. long and 4-ft. wide; inside firebox, which was provided with a transverse midfeather, 4-ft. 6-in. long and 3-ft. 5-in. wide;

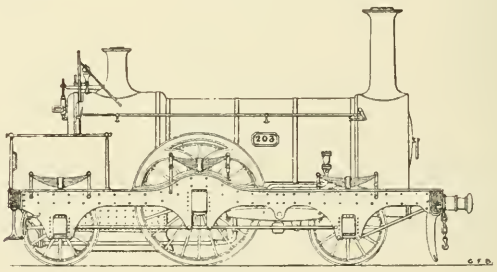


Fig. 18.

heating surface: firebox 114 sq. ft., tubes 874·4 sq. ft., total 988·4 sq. ft.; grate area 13·64 sq. ft. The total weight of each engine of the class in full working order was 27 tons 16 cwt., and the capacity of the water tank in the tender was 1,500 gallons. No. 210 of this class subsequently earned considerable distinction on one memorable occasion by charging right through a M. S. & L. R. goods train on the dangerous level crossing just south of Retford Station, thus carrying the "Flying Scotsman" of the period safely through an obstacle which it could not avoid. Mr. Michael

Reynolds describes this incident thus: "The down Scotch express was going down Retford bank, signals all clear, when Oliver Hindley saw a train going east from Sheffield to Lincoln, which would meet him on the level crossing. He could not stop, and with that clear mind which is so marked in Englishmen in time of danger, he put on full steam, and sent Mr. Sturrock's beautiful express engine clean through the goods train, scattering the trucks like match splinters, and carrying all safe. When asked about the matter Hindley said he could not keep clear, so he would clear away his obstruction. There is no doubt that, had he hesitated or feared, many lives would have been sacrificed. No. 210 engine carried the dents and scars like an old warrior, and looked handsomer than ever for this brush with the enemy of express trains."

Closely following the fine engines just mentioned came one still finer, which enjoyed the distinction of being the only specimen of its class. This noteworthy engine was No. 215, an illustration of which, with its original tender, is here given in Fig. 19, and concerning which Mr. Sturrock wrote a brief description some ten years ago to the following effect: "An engine with 7-ft. 6-in. driving wheels, a four-wheeled bogie in front, and a pair of carrying wheels in rear, was delivered to the Great Northern Railway on August 6th, 1853, and having a large tender, could and did run 100-mile lengths at the highest present speeds. This engine was constructed to prove to the directors of the Great Northern Railway that it was quite practicable to reach Edinburgh from King's Cross in eight hours by only stopping at Grantham, York, Newcastle and Berwick. This service was not carried out,

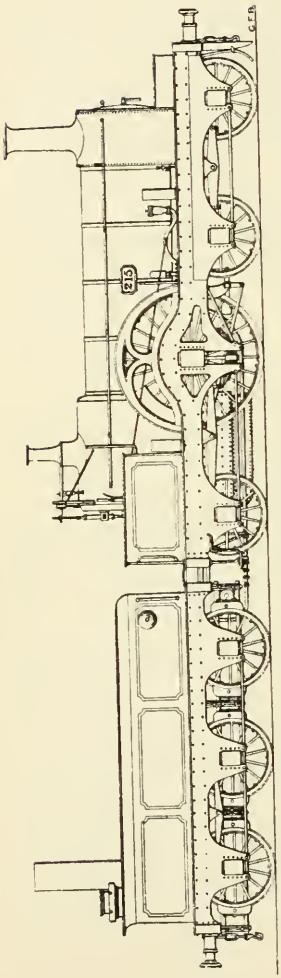


Fig. 19.

because there was no demand by travellers for nor competition amongst the railways to give the public such accommodation." No. 215 was built by Messrs. R. and W. Hawthorn, and was an eight-wheeled engine having outside bearings to all the wheels, including those of the bogie, a large raised firebox with a mid-feather, and no steam dome. The driving wheels had no flanges. It had a six-wheeled tender of large capacity which, as is shown in the illustration here given, had originally a hooded seat provided at the rear in a similar manner to the old broad gauge tenders on the Great Western Railway. The leading dimensions of the engine were: diameter of driving wheels 7-ft. 6-in., and of bogie and trailing wheels 4-ft. 3-in.; wheel-base: bogie wheels 7-ft. 2-in.; hind bogie wheels to driving wheels 6-ft. 4½-in.; driving to trailing wheels 8-ft. 2-in., total wheel-base 21-ft. 8½-in.; cylinders 17-in. by 24-in.; boiler barrel

12-ft. long by 4-ft. 4-in. diameter, containing 240 tubes 12-ft. $5\frac{1}{2}$-in. long by 2-in. diameter; internal firebox 5-ft. 5-in. by 3-ft. 9-in.; heating surface: firebox 155·2 sq. ft., tubes 1,564·0 sq. ft., total 1,719·2 sq. ft.; weight of engine empty 32 tons 11 cwt. 3 qrs., in working order 37 tons 9 cwt. 2 qrs. The tender was on six wheels of 4-ft. 3-in. diameter, and carried 2,505 gallons of water, its weight in working order being 33 tons.

As originally built, this engine does not appear to have been an unqualified success. Its blast-pipe orifice was only $3\frac{3}{4}$-in. in diameter, which was subsequently increased to $4\frac{1}{2}$-in. At first it caused great trouble by the ease with which it left the metals in going round sharp curves. This tendency was undoubtedly due to the design of the bogie, the sandwich frame of which made a very close fit with the main frame of the engine, and in damp weather the wood on both frames swelled to such an extent as to bind them together, thus neutralizing the effect of the bogie. Eventually the wood was cut well away, and iron plates were provided to give the necessary sliding surfaces, and with this increased freedom of action to the bogie, the engine seems to have given no further trouble in the way of derailments. No. 215 ran upon the G. N. R. until the year 1870, when it was broken up, and the driving wheels were utilized for a new engine, No. 92, which was then built, and to which further reference will be made in due course.

During 1853 and the two or three years immediately following, Mr. Sturrock provided no fewer than 63 six-coupled goods engines with cylinders 16-in. by 24-in. and 5-ft. 3-in. driving wheels. These were supplied by different makers, as follows:—Nos. 328 to 332 by Messrs. R. & W. Hawthorn

(makers' Nos. 858 to 862), in 1853 and 1854; Nos. 333 to 337 by Messrs. Kitson & Co., in 1853; Nos. 338 to 347 by Messrs. E. B. Wilson & Co., in 1854; Nos. 348 to 353 by Messrs. Sharp, Stewart & Co. (makers' Nos. 811 to 816); Nos. 354 to 356 by Messrs. Sharp, Stewart & Co. (makers' Nos. 820 to 822), and Nos. 357 to 362 by Messrs. Sharp, Stewart & Co. (makers' Nos. 826 to 831), all in 1854; Nos. 363 to 367 by the Vulcan Foundry Co. (makers' Nos. 367 to 371), in 1854; Nos. 368 and 369 by Messrs. E. B. Wilson & Co. in 1853; Nos. 370 to 380 by the same firm

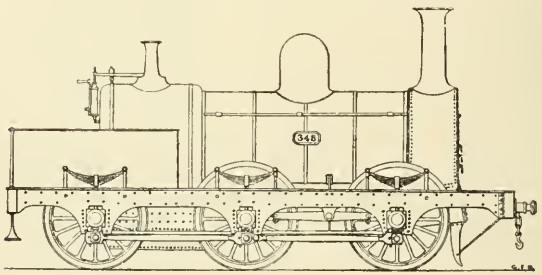


Fig. 20.

in 1854; Nos. 381 to 385 by Messrs. Kitson & Co. in 1855; Nos. 385 to 389 by Messrs. Sharp, Stewart & Co. (makers' Nos. 910 to 913) in 1855; and No. 390, by the same firm (makers' No. 914) in 1856. The accompanying illustration, Fig. 20, shows No. 348 of this class, the leading dimensions throughout being practically the same as follow: diameter of coupled wheels 5-ft. 3-in., the axles being equally divided over a wheel-base of 15-ft. 6-in.; cylinders 16-in. by 24-in.; boiler barrel 10-ft. 7-in. in length with a diameter of 4-ft. 3-in., containing 209 tubes of 2-in. diameter; heating surface: firebox 122·75 sq. ft., tubes 1,176·45, total

1,299·20 sq. ft.; capacity of tender tank 1,400 gallons; weight of engine 33 tons 10 cwt.

The company also acquired five locomotives which were originally built for the Leeds, Bradford and Halifax Junction Railway, which were given the G. N. R. running numbers 395 to 399. Nos. 395 and 396 were Kitson's standard double-framed goods-engines, with 5-ft. wheels, and Nos. 397 was also a Kitson goods engine, but with 5-ft. 3-in. wheels. No. 397 was employed on shunting work at Bradford, in its converted form as a

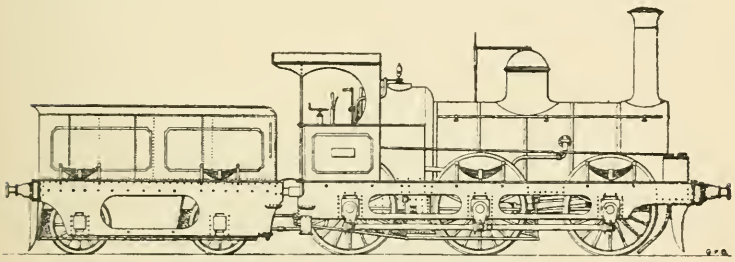


Fig. 21.

saddle-tank, until 1890, when it was scrapped. At that time its cylinders had been enlarged to 17¼-in. by 24-in. Nos. 398 and 399 were built by Messrs. Hudswell & Clarke, in 1863, and were standard, six-coupled, double-framed goods engines, with 5-ft. wheels and 15-in. by 23-in. cylinders. No. 399 (builders' No. 14) is illustrated by Fig. 21.

In 1855 the Great Northern acquired by lease the small local line rejoicing in the extensive title of the Ambergate, Nottingham and Boston and Eastern Junction Railway, and at the same time took over the entire loco-

motive stock of that railway, which consisted of no fewer than nine engines. These, numbered consecutively from 1 to 9 on the A. N. and B. and E. J. R., became Nos. 218 to 222 and 391 to 394 in the books of the G. N. Company. Nos. 218 to 220 (Ambergate, etc., Nos. 1 to 3) were three small tank engines each running on four wheels, and had been built by Messrs. E. B. Wilson & Co. under Crampton's patents. The general design of these singular little engines is shown in the illustration herewith, Fig. 22, being that, in fact, of a number of similar machines that were supplied to various railways at about this period. They had inside

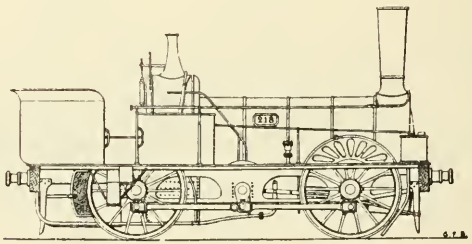


Fig. 22.

cylinders 11-in. in diameter with a 17-in. stroke, driving a "dummy" crank axle which was connected by means of outside cranks and coupling rods with the four 5-ft. driving wheels which carried the engine. The tanks had a capacity for 400 gallons, but the limited power and small weight, 16 tons, rendered these engines possibly some of the few "bad bargains" made by the G. N. Company. No. 221 (Ambergate No. 4) was a "Large Hawthorn," with 6-ft. 6-in. driving wheels, and 16-in. by 22-in. cylinders, and was therefore practically identical with the previously acquired

G. N. engines, Nos. 203 to 214. No. 222 (Ambergate No. 5) again had its prototypes on the line, since it was one of Messrs. E. B. Wilson & Co.'s "Jenny Lind" pattern, but with 6-ft. 3-in. driving wheels, and cylinders only 15-in. by 20-in. The remaining engines acquired, Nos. 391 to 394 (Ambergate Nos. 6 to 9), also were by the Wilson firm; Nos. 391, 393 and 394 being six-coupled engines, having 5-ft. driving wheels and 16-in. by 24-in. cylinders, and standing on a wheel-base of 15-ft. 4-in. equally divided. They were almost identical in external appearance with Nos. 168 to 197, which have already been illustrated and

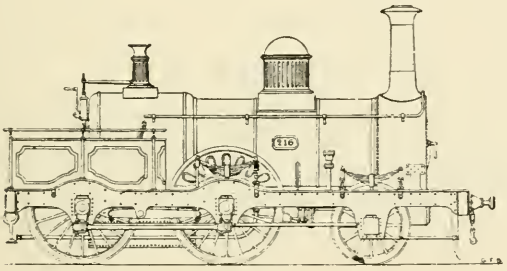


Fig. 23.

described. Their dates were respectively 1850, 1855 and 1854. No. 392 was also built by Wilson, in 1855, but had a small pair of leading wheels and only four-coupled 5-ft. driving wheels, with 16-in. cylinders.

Two locomotives were added to the company's stock in 1854 by purchase from Mr. C. C. Williams, and they received Nos. 216 and 217. They were four-coupled passenger engines of the type shown in the accompanying illustration, Fig. 23, having leading wheels 3-ft. 9-in. and driving wheels 5-ft. 9-in. diameter respectively, and cylinders 16-in. diameter with a 22-in. stroke. These engines, as can be

gathered from the drawing, were built by Messrs. E. B. Wilson & Co.

This same year, 1855, saw the first appearance of six handsome four-coupled passenger engines built to Mr. Sturrock's design by Messrs. R. & W. Hawthorn, which bore Nos. 223 to 228. They were, as usual, constructed with double frames and outside bearings to all the axles, and it will be noticed in the appended illustration, Fig. 24, showing No. 223, that equalizing levers were applied to the springs of the coupled wheels, as was Messrs. Hawthorn's

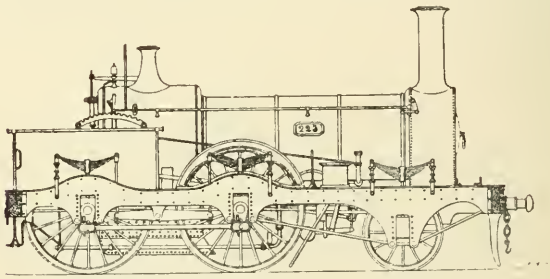


Fig. 24.

general practice in four-coupled engines. The leading dimensions were as follows: leading wheels 4-ft. and coupled wheels 6-ft. 6-in. in diameter respectively; wheel-base, from leading to driving wheels 8-ft. 3-in., from driving to trailing wheels 7-ft. 6-in., total 15-ft. 9-in.; cylinders 16½-in. by 22-in.; boiler barrel 10-ft. long with a diameter of 4-ft., containing 160 tubes 10-ft. 5-in. long with 2-in. diameter; internal firebox 4-ft. 8-in. by 3-ft. 5-in.; heating surface: firebox 110 sq. ft., tubes 872 sq. ft., total heating surface 982 sq. ft.; grate area 14·92 sq. ft.; weight in working order about 33 tons.

Following these in numerical order came a set of twelve passenger engines which might almost be regarded as Mr. Sturrock's masterpiece in designing. These were single driving engines of generous dimensions and fine proportions, which must strike the observer as being well in the front rank of locomotives so far as grace of appearance is concerned, while their performances abundantly proved that in no way were workmanlike qualities of speed and power sacrificed to obtain a satisfactory outline. These twelve engines bore the Nos. 229 to 240,

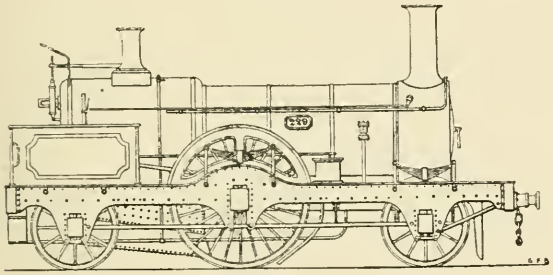


Fig. 25.

Nos. 229 to 232 being delivered by Messrs. Kitson & Co. in 1860, Nos. 233 to 236 by Messrs. Sharp, Stewart & Co. (makers' Nos. 1159 to 1161 and 1215) in 1860 and 1861, and Nos. 237 to 240 by Messrs. R. Stephenson & Co. in 1860, the whole being charged in the company's books at a total of £35,000. The accompanying illustration, Fig. 25, of No. 229 shows several interesting features, one being the great length of the firebox, which was provided with a longitudinal mid-feather, while the position of the leading wheels right forward under the centre line of the smoke-box and chimney is also noteworthy, as it is a practice that

has since been adopted without any exception in all G. N. R. six-wheeled passenger engines. A further detail, not apparent in the drawing, was the employment of hoops on the jaws of the cranks, which at the time was a somewhat unusual precaution. The leading dimensions of these splendid engines were: diameter of driving wheels 7-ft., and of leading and trailing wheels 4-ft. 3-in.; wheel-base: leading to driving wheel centres 9-ft. 6-in., driving to trailing wheel centres 8-ft. 6-in., total 18-ft.; cylinders 17-in. by 22-in.; length of boiler barrel 10-ft., diameter 4-ft., containing 164 tubes of 2-in. diameter; length of firebox casing 7-ft. 4-in.; heating surface: firebox 177 sq. ft., tubes 883·6 sq. ft., total 1,060·6 sq. ft.; capacity of tender tank 2,400 gallons; weight of engine only, 34 tons 12 cwt., of which 13 tons 6 cwt. 3 qrs. rested on the driving wheels.

In 1863 the Great Northern Railway were suddenly called upon to provide locomotive power for the working of their trains through the portion of the Metropolitan Railway over which they possessed running powers, and this necessity being unexpectedly brought forward, found the company in some difficulty, as at the time they had no tank engines which were specially fitted for the purpose. There were, however, a certain number of the "Little Sharps" which had already been converted into passenger tank locomotives by Mr. Sturrock, in 1852-3, which were utilized as makeshifts pending the provision of engines suitable for "underground" traffic. The main features in the conversion thus effected consisted in the lengthening of the frames to the rear of the driving wheels, and placing the trailing wheels further back to the extent of 3-ft. 1-in., thus increasing the normal wheel-base of 12-ft. 8-in. to

15-ft. 9-in. This extra length of framing allowed of the addition of a water tank and coal bunker, and, as is above stated, a number of the "Little Sharps" were converted in this manner, so as to present the external appearance

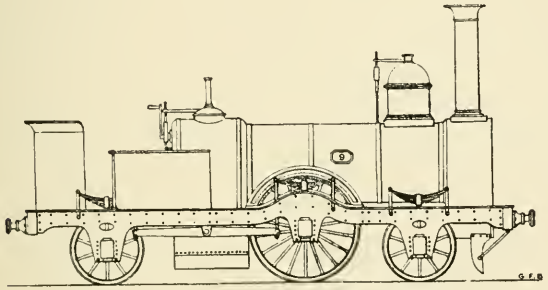


Fig. 26.

indicated in the accompanying illustration, Fig. 26, showing No. 9, which was one of those so treated. The following are the numbers of the engines thus converted, with the dates of conversion :—

Engine No.	Date.
19	January, 1852
40	March, ,,
46	,, ,,
45	April, ,,
10	,, ,,
1	May, ,,

Engine No.	Date.
2	May, 1852
6	,, ,,
9	,, ,,
18	June, ,,
39	July, ,,

Two others, Nos. 23 and 12, were also converted, the former into a front-coupled tender engine, and the latter into a front-coupled tank. In the earlier conversions a certain degree of end play was allowed to the trailing axles to permit of the easier negotiation of sharp curves such as are necessitated in underground work; but subsequent rebuilds were provided with radial axleboxes to the rear wheels,

which gave so much satisfaction as to result in the construction of a new type of locomotive embodying that as a principal feature.

These new engines were specially designed by Mr. Sturrock for the working of underground traffic, and were built in 1865 by the Avonside Engine Co., of Bristol (makers' Nos. 607 to 616). They bore the G. N. R. Nos. 241 to 250, and were of the type shown in the accompanying illustration, Fig. 27, of No. 241, having four-coupled wheels in front, a single pair of trailing wheels with radial axleboxes

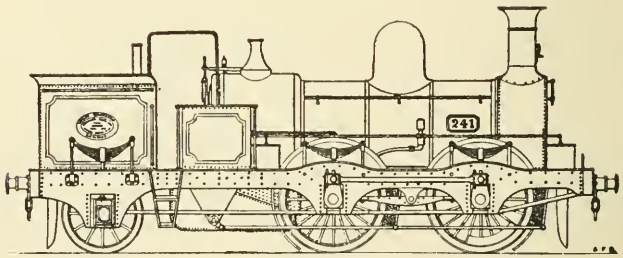


Fig. 27.

at the rear, and a large tank and coal bunker directly over the trailing wheels. Condensing was provided for by means of a long pipe running below the footplate into the tank. The leading dimensions of the engines were: diameter of coupled wheels 5-ft. 6-in., and of trailing wheels 4-ft.; wheel-base: leading to driving wheel centres 7-ft. 6-in., driving to trailing wheel centres 11-ft. 9-in., total 19-ft. 3-in.; cylinders 16½-in. by 22-in.; boiler barrel, length 10-ft., diameter 4-ft.; length of firebox casing 4-ft. 6-in.; total heating surface 867·1 sq. ft.; total weight in working order, 39 tons 12 cwt. 2 qrs.

So successful did the engines last mentioned prove that others to the number of ten were supplied in 1866, Nos. 270 to 274 by Messrs. Neilson & Co., of Glasgow (makers' Nos. 1311 to 1315), and Nos. 275 to 279 by the Avonside Engine Co. Those built by Messrs. Neilson had a 12-in. longer wheel-base, and weighed about 30 cwt. more than the first lot put on the rails, and were of the general design shown in the accompanying illustration of No. 270, Fig. 28.

During his successful career at the head of the locomotive department of the G. N. R., Mr. Sturrock

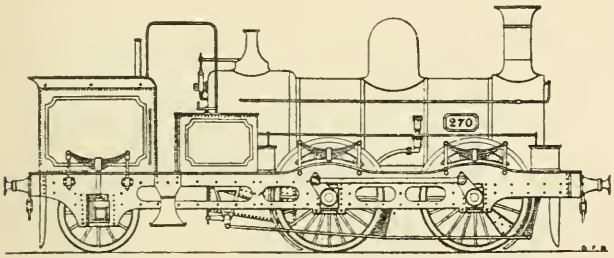


Fig. 28.

attempted to solve a problem that was at the time exercising many minds—the procuring of more adhesive and tractive force by the utilization of the dead weight of the tender. While many inventors coupled the tender to the engine in such a manner as to distribute part of its weight upon the trailing wheels of the engine, Mr. Sturrock proceeded on much bolder lines, and patented an arrangement whereby the tender itself constituted a separate locomotive, deriving its steam from the same boiler as supplied the engine cylinders. In effect, his "steam tender" ran on six wheels connected by means of outside cranks and coupling rods, the

axle of the middle pair of wheels being cranked instead of straight, and rotated by means of two 12-in. by 17-in. cylinders which were fitted under the framing, between the leading and middle pair of wheels. Fig. 29 shows the external appearance of one of these tenders. Steam was received by means of suitable pipes direct from the engine boiler, and after serving its purpose was condensed, the operation being described in Mr. Zerah Colburn's "Locomotive Engineering" in the following terms:—"The exhaust steam from the cylinders is delivered into a tubular condenser,

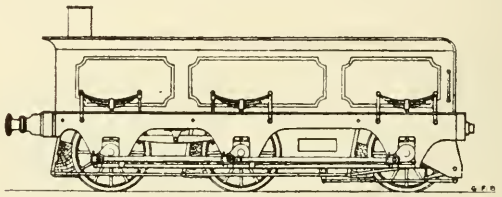


Fig. 29.

surrounded by the water in the tank, consisting of fifteen tubes 2-in. in outside diameter, about 12-ft. 8-in. in length, fixed into a reception box at each end. The first box receives the exhaust steam and delivers it through the tubes; the second is fitted with a waste pipe to carry off the uncondensed steam." Apparently there were two distinct sizes of steam tenders built, one having 4-ft. 6-in. wheels, and weighing 29 tons 8 cwt. with the tanks full, and the others having 4-ft. wheels, and weighing 27 tons 15 cwt. in running condition. The wheel-base of both was the same, leading to driving wheel centres 8-ft. 5-in., driving to trailing wheel centres 6-ft. 8-in., total 15-ft. 1-in., with a total length over the buffer beams of 21-ft. 7-in.

At the close of the year 1863 Mr. Sturrock made his first experiment in this direction by taking the tender of the old Sharp single No. 46, and converting it into a steam tender of the kind just described. In this form it was tried with a number of engines on the Great Northern Railway, and also appears to have been lent to the Manchester, Sheffield and Lincolnshire Railway Company, who subsequently, by the way, ordered six steam tenders from Messrs. Neilson & Co. in 1865. The first G. N. R. locomotive definitely provided with a steam tender was No. 391, and almost immediately afterwards Nos. 393 and 394 were also so fitted, certain alterations being made in them to allow for the additional tax put upon the boiler by the introduction of two new cylinders. These changes comprised the enlargement of the firebox, the provision of a second regulator in the steam dome, and a re-arrangement of the feed pumps to permit of the pumping of hot water. The engines were put to work on the London and Peterborough division, and at once showed themselves to be capable of hauling loads of from 40 to 45 loaded coal wagons over the ruling gradients of 1 in 200 on the main line, while on the level stretches of the Lincolnshire loop line they proved quite equal to 60 wagons, the ordinary loads hitherto worked on these two sections of the line being 30 and 35 wagons respectively.

Following the apparently successful result of these trials, it was resolved to extend the type, and a number of new goods engines being wanted at about this time to meet the growing requirements of the goods and mineral departments, the order was given that they were all to be built with steam tenders. No fewer than 70 engines were

comprised in this class, all of the standard six-coupled type, having driving wheels 5-ft. in diameter, cylinders 16-in. in diameter, with a stroke of 24-in., and in general dimensions were practically almost identical with the former engines of Mr. Sturrock's design, as can be seen from the accompanying illustration, Fig. 30, except for the provision of a firebox considerably larger than those formerly fitted, which extended well behind the trailing axle, and consequently had its grate sloping somewhat steeply from back to front. The grate area was in some as

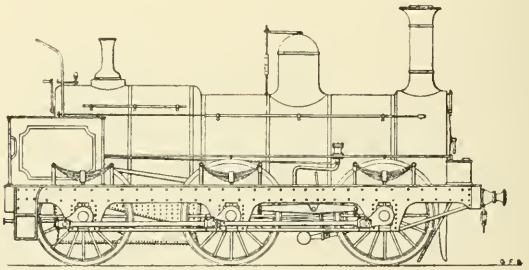


Fig. 30.

much as 26½ sq. ft. These engines, which weighed 35 tons apiece, and the contract price for which with tender was £3,750 each, were delivered to the railway company in the order and by the makers named: Nos. 400 to 409 by Messrs. Kitson & Co., Nos. 410 to 419 by Messrs. R. & W. Hawthorn (makers' Nos. 1248 to 1257), Nos. 420 to 429 by Messrs. Neilson & Co. (makers' Nos. 1151 to 1160), Nos. 430 to 439 by Messrs. R. & W. Hawthorn (makers' Nos. 1258 to 1267), all in the year 1865: and Nos. 440 to 449 by Messrs. Neilson & Co. (makers' Nos. 1171 to 1180), Nos. 450 to 455 by the Vulcan Foundry Co. (makers' Nos. 554

to 559), Nos. 456 to 460 by the Avonside Engine Co. (makers' Nos. 620 to 624), and Nos. 461 to 469 by Messrs. R. and W. Hawthorn (makers' Nos. 1325 to 1333), all in 1866. The leading dimensions of Nos. 450 to 455 were: cylinders 16-in. by 24-in.; coupled wheels 5-ft. diameter, distributed equally over a 15-ft. 6-in. wheel-base; boiler barrel 9-ft. 10-in. long, 4-ft. 2-in. diameter, containing 180 tubes of 2-in. diameter; heating surface: firebox 112·96 sq. ft., tubes 969·3 sq. ft.; total 1082·26 sq. ft.; grate area 23·58 sq. ft.

Before the whole of these goods engines were delivered, however, it was discovered that, while the steam tenders might be considered a mechanical success, they were scarcely so satisfactory from an economic point of view. It was found that engines provided with them could haul trains which were largely in excess of the requirements of the time, and which, moreover, were of such a length as to be extremely unwieldy in handling; and this was, naturally enough, a serious difficulty on a line on which there exists a frequent necessity to shunt goods trains in order to clear the way for express traffic. It was also found that the repairs bill for these engines and tenders reached an uncomfortably high figure, though there can be little doubt that this result was greatly contributed to by the carelessness of the men in charge, who viewed the question from their own standpoint, and could indeed hardly be expected to regard otherwise than with considerable disfavour an arrangement which gave them an additional "engine" to superintend. As a consequence of these disadvantageous experiences, it was decided to stop the output of steam tender engines, and orders were given to

the makers that those engines still building were to be stripped of the steam gear of the tenders prior to delivery. At the time of this decision 50 of these steam tenders were said to be in use on the line, but within a few years the entire lot were improved out of existence by Mr. Sturrock's successor, and the engines rebuilt with larger cylinders.

Early in 1866 a need arose for new engine power in order to deal with the growing goods traffic between the over-ground railway at King's Cross and the goods yards round about Farringdon Street and Blackfriars, which

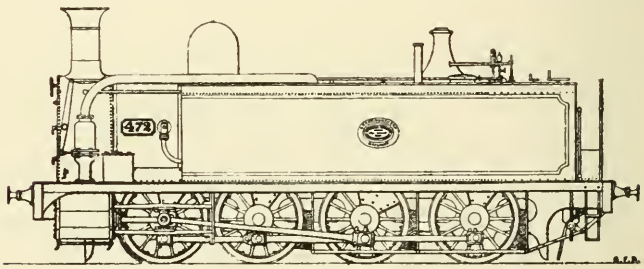


Fig. 31.

necessitates a large amount of tunnel work on a road having gradients of 1 in 35 and 1 in 39. Accordingly, two very powerful engines were obtained from the Avonside Engine Co., of Bristol, one of which was put to work early in the year 1866, and the other a few months later. They were numbered in the railway company's books as Nos. 472 and 473, and No. 472 bore upon it the maker's No. 633. These two engines were in general design and leading dimensions almost exactly similar to two previously supplied to the Vale of Neath Railway, and were, as can be seen from Fig. 31—which is an illustration of No. 472—side-tank

locomotives with eight-coupled wheels and outside cylinders. The wheels were 4-ft. 6-in. in diameter, and were distributed over a wheel-base of 15-ft. 10-in., the spacings being 4-ft. 10-in., 5-ft. 5-in., and 5-ft. 7-in. respectively, starting from the leading end. Both leading and trailing wheels were allowed a transverse play of $\frac{5}{8}$-in., subject to the control of an arrangement of check springs patented by Messrs. Slaughter & Caillet. The cylinders drove the third pair of wheels, as can be seen from the illustration, and they were of somewhat unusual size, having a diameter of $18\frac{1}{2}$-in. and a stroke of 24-in., thus allowing of the exertion of considerable tractive force — 152 lbs. for every lb. of effective steam pressure. A boiler of ample dimensions, the barrel measuring 13-ft. $8\frac{1}{8}$-in. in length and 4-ft. 4-in. in diameter, and containing 184 tubes each $2\frac{1}{8}$-in. in diameter, produced a total heating surface of 1550·1 sq. ft., of which 100 sq. ft. were contributed by the firebox and the remaining 1450·1 sq. ft. by the tubes. It will be noted that provision was made for the condensation of steam in working through the tunnels, and that the side-tanks were of unusual size. Each engine weighed a total of 56 tons in working order, which was so equally divided over the four pairs of wheels that the load on the rails under no one wheel greatly exceeded 7 tons. Both engines were broken up in 1880.

In 1866 ten powerful locomotives, of the four-coupled passenger class, were delivered to the railway by Messrs. Sharp, Stewart & Co., which received the Company's Nos., 251 to 260 (makers' Nos. 1667 to 1676). These were in many respects similar in detail to the large single-wheel engines built by the firm six years earlier, having "hoops" on the crank-axle webs, unusually large fireboxes, and

leading wheels placed well forward. They had one feature, however, distinct from their predecessors, in the form of a big steam dome on the centre of the boiler barrel. The illustration (Fig. 32), which shows No. 251, will afford a general idea of their appearance. The leading dimensions were: diameter of leading wheels 4-ft. and of four-coupled wheels 6-ft.; wheel-base: leading to driving wheel centres 9-ft. 7-in., driving to trailing wheel centres 7-ft. 6-in., total 17-ft. 1-in.; total length over buffer-beams 25-ft. 7-in.; cylinders 16½-in. by 22-in.; boiler barrel, length 10-ft.,

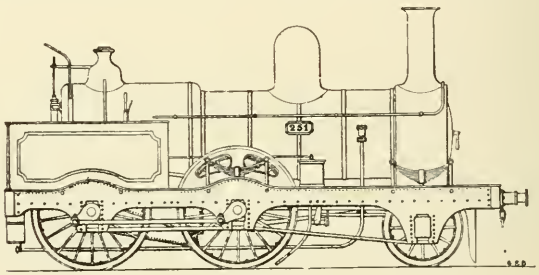


Fig. 32.

diameter 4-ft., containing 157 tubes of 2-in. diameter; length of firebox casing 7-ft. 2-in.; weight (empty) 33 tons 14 cwt., in working order 36 tons 4 cwt.; capacity of tender 2,400 gallons. All these engines were subsequently rebuilt by Mr. Stirling, and performed useful work for many years. They are now all broken up, with the exception of No. 258.

But the engines just mentioned, handsome though they were, and powerful too, were scarcely "out" before they were eclipsed by engines handsomer and more powerful. These later comers, six in number, were the last passenger engines

designed by Mr. Sturrock for the G. N. R., and, indeed, before they were put into actual service their designer had practically ceased his connection with the locomotive department of the line. They were numbered from 264 to 269, Nos. 264 to 266 being built by Messrs. John Fowler and Co. (makers' Nos. 747 to 749), in 1866; and Nos. 267 to 269 by the Yorkshire Engine Co. (makers' Nos. 1 to 3), in 1867. The accompanying illustration (Fig. 33) shows the leading features of the first three, the chief dimensions being: diameter of leading wheels 4-ft. 3-in., and of four-

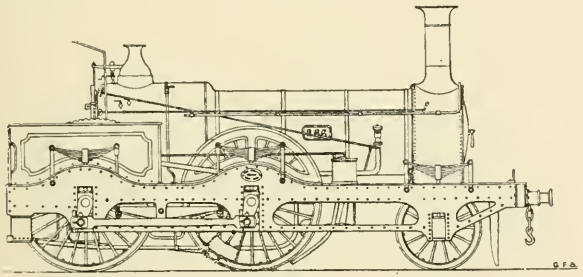


Fig. 33.

coupled wheels 7-ft.; wheel-base: from leading to driving wheel centres 9-ft. 7-in., and from driving to trailing wheel centres 8-ft. 6-in.; total wheel-base 18-ft. 1-in.; cylinders 17-in. by 24-in.; boiler barrel, length 10-ft. 1-in., diameter inside smallest ring 3-ft. 10-in., containing 167 tubes of 2-in. diameter; heating surface: firebox 121 sq. ft., tubes 907 sq. ft., total 1,028 sq. ft.; grate area 19·7 sq. ft.; capacity of tender 2,500 gallons. The other three engines, built by the Yorkshire Engine Co., differed slightly in external appearance from their predecessors, as can be seen from Fig. 34, which shows No. 268, and it is possible that

to some small degree the dimensions were also different, but in the main it may be taken that the figures already given apply to both sets of engines. These locomotives did not enjoy a very long career in their original form, however, for, as will be more particularly noted later on, Mr. Stirling took an early opportunity to rebuild them, and in the process converted them into single engines with flush-topped boilers. In this new form they entered on quite a new lease of life, and for many years they were ranked among the most useful engines on the line. They are now nearly all broken up.

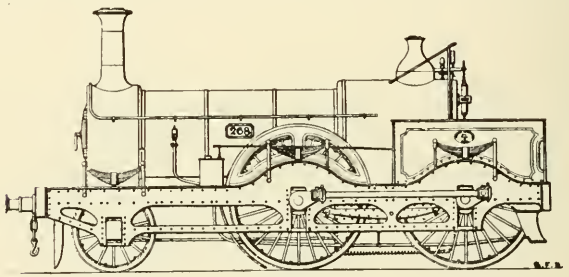


Fig. 34.

Two remarkably "pretty" little six-coupled tank engines were taken over by the G. N. Railway from the West Yorkshire Railway. These were built, in 1867, by Messrs. Manning, Wardle & Co., of Leeds. They received the company's Nos. 470 and 471 (makers' Nos. 250 and 251), and the former also bore on its side-tanks the name "Marquis," being apparently the only engine on the line which had the distinguishing feature of a name. This name had been conferred on it prior to its delivery to the railway. "Marquis" is shown in the accompanying illustration, Fig. 35. Though a set of large-scale drawings

which were published in Mr. Zerah Colburn's "Locomotive Engineering" give different measurements from those contained in the letter-press, the following are generally taken to be the correct dimensions of these engines: diameter of driving wheels 4-ft. 2-in.; total wheel-base 15-ft. 3-in.; cylinders 15-in. by 22-in.; total heating surface 782·5 sq. ft.; grate area 10·75 sq. ft.; total weight, empty 22½ tons; in working order 27 tons. In addition to the side-tanks there was a well-tank below the foot-plate, the three together containing a total of 831 gallons. These two

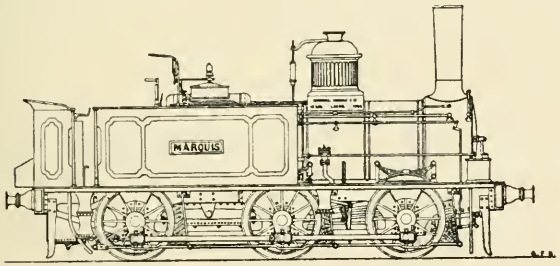


Fig. 35.

engines were generally typical of a considerable number brought out at about the same time by the makers, several of which were employed on Welsh railways, while others went to large ironworks, collieries and similar establishments, where their handiness and power would prove extremely desirable. No. 470 was stationed at Bradford, and No. 471 at Leeds, and in 1872 both were rebuilt as saddle tanks, though retaining the same frames, wheels, etc.

From the West Yorkshire Company were also obtained three engines, which were allotted G. N. R. Nos. 261 to 263. Of these, No. 261 was said to be a Sharp single,

List of G.N.R. Locomotives during Mr. Archibald Sturrock's Superintendence—Continued.

G.N.R. Numbers.	Date.	Builders.	Builders' Numbers.	Description.	Diameter of Driving Wheels. Ft. In.	Diameter and Stroke of Cylinders. Inches.	Remarks.
203-214	1852/3	R. & W. Hawthorn	795-806	6-wheel single ..	6 6	16 × 22	
215	1853	Ditto ..	821	8-wheel single ..	7 6	17 × 24	Leading bogie
216-217		E. B. Wilson & Co.		6-wheel 4-coupled ..	5 9	16 × 22	Purchased from C. C. Williams, 1854
218-220		Ditto ..		4-wheel Crampton	5 0	11 × 17	Purchased f'm Ambergate, Nottingham & Boston and E. Junction Ry.
221		R. & W. Hawthorn	834	6-wheel single ..	6 6	16 × 22	Ditto ditto
222		E. B. Wilson & Co.		Ditto ..	6 3	15 × 20	Ditto ditto
223-228	1855	R. & W. Hawthorn	915-920	6-wheel 4-coupled ..	6 6	16½ × 22	
229-232	1860/1	Kitson & Co. ..	645-648	6-wheel single ..	7 0	17 × 22	
233-236	1860/1	Sharp, Stewart & Co.	1159/61, 1215	Ditto ..	7 0	17 × 22	
237-240	1860	R Stephenson & Co.	1296-1299	Ditto ..	7 0	17 × 22	
241-250	1865	Avonside Engine Co.	607/16	Front-coupled tank	5 6	16½ × 22	For Metropolitan service
251-260	1866	Sharp, Stewart & Co.	1667/76	6-wheel 4-coupled ..	6 0	16½ × 22	
261		Sharp Bros & Co.		6-wheel single ..	5 6		P'chased f'm W. Yorks. Ry.
262-263		E. B. Wilson & Co.		6-wheel 4-coupled ..	5 6		Ditto ditto
264-266	1866	J. Fowler & Co ..	747/9	Ditto ..	7 0	17 × 24	Afterwards cvtd. to singles
267-269	1867	Yorks. Engine Co.	1/3	Ditto ..	7 0	17 × 24	Ditto ditto
270-274	1866	Neilson & Co ..	1311/15	Front-coupled tank	5 6	16½ × 22	For Metropolitan service
275-279	1866	Avonside Engine Co.	656/660	Ditto ..	5 6	16½ × 22	Ditto ditto
300-307	1853	W. Fairbairn & Sons		6-coupled goods ..	5 0	16 × 24	
308-317	1851/2	R. Stephenson & Co.	803/12	Ditto ..	5 3	16½ × 24	
318-327	1852/3	Nasmyth & Co. ..	100/9	Ditto ..	5 3	16½ × 24	
328-332	1853/4	R. & W. Hawthorn	858/62	Ditto ..	5 3	16 × 24	
333-337	1853	Kitson & Co. ..		Ditto ..	5 3	16 × 24	
338-347	1854	E. B. Wilson & Co.		Ditto ..	5 3	16 × 24	

List of G.N.R. Locomotives during Mr. Archibald Sturrock's Superintendence—Continued.

G.N.R. Numbers.	Date.	Builders.	Builders' Numbers.	Description.	Diameter of Driving Wheels.	Diameter and Stroke of Cylinders.	Remarks.
					Ft. In.	Inches.	
348-362	1854	Sharp, Stewart & Co.	811/16, 820/2, 826/31	6-coupled goods ..	5 3	16 × 24	
363-367	1854	Vulcan Foundry Co	367/71	Ditto ..	5 3	16 × 24	
368-380	1853/4	E. B. Wilson & Co.		Ditto ..	5 3	16 × 24	
381-385	1855	Kitson & Co... ..		Ditto ..	5 3	16 × 24	
386-390	1855/6	Sharp, Stewart & Co.	910/914	Ditto ..	5 3	16 × 24	
391	1850	E. B. Wilson & Co.		Ditto ..	5 0	16 × 24	Purchased f'm Ambergate, Nottingham & Boston and E. Junction Ry.
392	1855	Ditto ..		6-wheel 4-coupled ..	5 0	16 × 24	Ditto ditto
393	1855	Ditto ..		6-coupled goods ..	5 0	16 × 24	Ditto ditto
394	1854	Ditto ..		Ditto ..	5 0	16 × 24	Ditto ditto
395-396		Kitson & Co. ..		Ditto ..	5 0	16 × 24	Purchased from Leeds, Bradford & Halifax Ry.
397		Ditto ..		Ditto ..	5 3	16 × 24	Ditto ditto
398-399	1863	Hudswell & Clark ..	14	Ditto ..	5 0	15 × 23	
400-409	1865	Kitson & Co. ..	1265/70, 1294/7	Ditto ..	5 0	16 × 24	Steam Tenders
410-419	1865	R. & W. Hawthorn	1248/57	Ditto ..	5 0	16 × 24	Ditto
420-429	1865	Neilson & Co ..	1151/60	Ditto ..	5 0	16 × 24	
430-439	1865	R. & W. Hawthorn	1258/67	Ditto ..	5 0	16 × 24	
440-449	1866	Neilson & Co. ..	1171/80	Ditto ..	5 0	16 × 24	
450-455	1866	Vulcan Foundry Co	554/9	Ditto ..	5 0	16 × 24	
456-460	1866	Avonside Engine Co.	620/4	Ditto ..	5 0	16 × 24	
461-469	1866	R. & W Hawthorn	1325/33	Ditto ..	5 0	16 × 24	
470-471	1867	Manning, Wardle and Co.	250/251	6-coupled tank ..	4 2	15 × 22	Purchased from W. Yorks. Railway
472-473	1866	Avonside Engine Co.	633	8-coupled tank ..	4 6	18½ × 24	Outs. cylinders condensing

PART III.

PATRICK STIRLING: 1866—1872.

MR. STURROCK'S successor on the line was Mr. Patrick Stirling, at that time forty-six years of age. Mr. Stirling was born at Kilmarnock in 1820, and at the age of seventeen began a five years' apprenticeship at the Dundee Foundry. After serving his full period, he remained at the same works for a year as journeyman, and in 1843 left to enter into employment at the Vulcan Foundry, Warrington. From thence, after a short stay, he obtained the post of foreman at the works of Messrs. Neilson & Co., of Glasgow, where he undoubtedly received much valuable experience, which stood him in good stead in later years. Fresh from Messrs. Neilson's, he became locomotive superintendent of the Bowling and Balloch Railway—a small concern perhaps, but still another stepping-stone onwards and upwards. His next move was something in the nature of a divergence, for he quitted the railway to work with the shipbuilding firm of Laurance Hill, Port Glasgow; but subsequently he went as foreman to Messrs. R. & W. Hawthorn, thus returning by degrees to his proper sphere. After eighteen months' employment with the Newcastle firm, in 1853 he once more took over the duties of a locomotive superintendent, this time on no less important a line than the Glasgow and South-Western Railway; and now he was able to show a direct contradiction to the usual

application of the proverb anent a "rolling stone." He had, in fact, gathered sufficient "moss," in the shape of a varied experience and sound judgment arising therefrom, to occupy his new position with honour until 1866, when the vacancy on the G.N.R. was offered to him, and he transferred his services from the Glasgow and South-Western, on which he had controlled the locomotive department for thirteen years, to the English line. As successor to Mr. Sturrock he held this, his last appointment, for not quite twenty-nine years. On November 11th, 1895, he was, while still practically in "full harness," removed from the scene of his labours by death, being then in the 76th year of his age.

On assuming the reins of government in the locomotive department, in succession to Mr. Sturrock, Mr. Stirling at once set about the task of bringing the engine power of the line up to the requirements of the rapidly-increasing traffic. His first order was for twenty four-coupled passenger locomotives, which were delivered on the railway in the following order :—

Date.	Engine Nos.	Builders.	Builders' Nos.
1867	280-285	Avonside Engine Co.	 725-730
1868	286-289	,,	 731-734
1868	290-299	Yorkshire Engine Co.	 54-63

The leading dimensions were :—cylinders 17-in. in diameter by 24-in. stroke; diameter of leading wheels 4-ft. 1-in., and of coupled wheels 6-ft. 7-in.; wheel-base: leading to driving wheels 9-ft. 6-in., driving to trailing 8-ft. 3-in.; total 17-ft. 9-in.; boiler 3-ft. 10½-in. in diameter, with its centre 6-ft. 11-in. above the rails; inside firebox 4-ft. 8¾-in. long by 3-ft. 4½-in. wide by 4-ft. 10-in. deep; 206 tubes of

$1\frac{3}{4}$-in. diameter; heating surface: firebox 94 sq. ft., tubes $991\frac{1}{2}$ sq. ft., total $1085\frac{1}{2}$ sq. ft. The weight of No. 295 is given as—empty 32 tons 6 cwt.; in working order, 34 tons 9 cwt. 3 qrs., of which the distribution was as follows:—leading wheels 10 tons 11 cwt. 3 qrs.; driving wheels 11 tons 11 cwt.; trailing wheels 12 tons 7 cwt. Another set of weights, applying particularly to No. 289, giving a total of 37 tons 4 cwt., distributed as follows:—leading wheels 11 tons 3 cwt.; driving wheels 13 tons 5 cwt.; and trailing wheels 12 tons 16 cwt., probably denotes a later

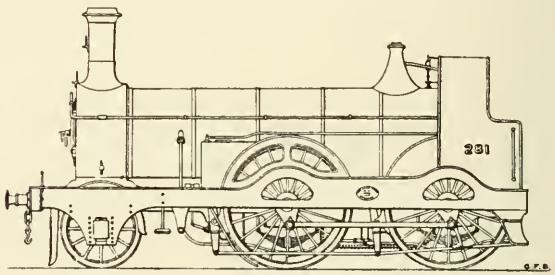


Fig. 36.

period of the engines' history, after they had been partially rebuilt and supplied with larger boilers; and to the same extent it must be understood that the accompanying illustration (Fig. 36) does not claim to depict No. 281 actually as she was when originally built, though it is sufficiently indicative of the general characteristics of the class. In rebuilding, Mr. Stirling modified sundry details to the standard patterns shown in the drawing, and effected minor alterations, which will be referred to in due course. These engines are noteworthy on more than one account. Not only were they Mr. Stirling's maiden production in his new sphere of office,

6 ft. 6 in. Coupled Passenger Locomotive, designed by Mr. Patrick Stirling. No. 708.

but they served also to mark the dividing line between the old and the new practice of the railway. Hitherto all passenger engines on the G.N.R. had been designed with double frames giving outside bearings to all the axles; many, if not all, had been fitted with boilers having raised firebox casings, many also had carried steam domes on the boiler-barrels, and, above all, there had been no marked uniformity of design, and certainly no attempt at reducing the stock to a few well-chosen types. This latter point is distinctly apparent in a glance at the illustrations, already given, of Mr. Sturrock's engines. Mr. Stirling, on the other hand, at once began to exercise a firm, controlling hand over the entire stock, and to impress the stamp of one fixed design on every engine that he placed upon the metals, so that, no matter by whom any locomotive was built, there was no longer occasion to pick out the lettering of the tender in order to determine to what line a Great Northern engine belonged. No great length of time elapsed therefore, after his taking command, before the locomotive stock assumed a vastly improved appearance as regards uniformity of style, and that style the neatest and least ostentatious of any in the United Kingdom or elsewhere.

The distinctive features which Mr. Stirling introduced upon the locomotives of which he had charge, and which appeared first upon all engines which he himself designed, and afterwards, so far as was possible, on all rebuilds or renewals of his predecessor's engines, were chiefly the following: — he decided that all six-wheeled express passenger locomotives should henceforth have inside bearings only for the driving or driving and coupled wheels, as the case might be, and outside bearings only for the

smaller carrying wheels. For goods, mixed traffic and tank engines he adopted inside frames and axle-bearings throughout, reinforcing the running and foot plates by means of a deep angle iron outside the wheels, extending from one buffer beam to the other. In place of the various types of boiler hitherto in use he adopted one distinctive pattern—with slightly varying dimensions to suit different classes of locomotives—having three telescopic rings, with the firebox casing fitting over the largest one. Externally the result was a flush-topped boiler having at the leading end a smoke-box of great neatness by reason of his system of providing it with a light covering with counter-sunk rivets. Once for all Mr. Stirling discarded a steam-dome, substituting for it a perforated pipe running the whole length of the boiler, and having the regulator fitted inside the smoke-box. A chimney of distinctive design, and a handsome brass casing for the safety-valves, placed rather to the rear of the centre-line of the firebox, were the only projections along the top of the boiler during the many years of Mr. Stirling's reign. Over the footplate he provided a much-needed cab for the engine-men, and this also, after a short tentative use of a trial pattern, soon became standardized. As time went on the locomotives to be built were still further brought to the pitch of economic perfection by the introduction of standard types designed on the interchangeable system. The same size of boiler was adopted for various classes, details of the cylinders and motion became common to several different types, and so on throughout the whole gamut of design. And with all these improvements came an almost painful degree of neatness of appearance. The open-work splashers, which Mr. Stirling affected in what may be termed his

youth, had their openings gradually blocked in, while newer engines simply had plain semi-circular sheets above the running plate, with a polished brass rim running round the outer edge. No rod communicating between the footplate and any of the mechanism in front of the cab was allowed to be in sight if it could possibly be concealed behind the frames, the bearing springs were generally placed quite out of sight, and the two sand-boxes on either side of the driving wheels, which were soon adopted, still further served to give an air of simplicity and neatness to the whole machine.

So far for the general lines of Mr. Stirling's practice. But, shortly after his succession to Mr. Sturrock, the making of a new epoch came about in another respect. As has been shown, all locomotives hitherto built for the Great Northern Railway had been obtained from "outside" firms. The new locomotive superintendent, however, speedily put matters into such a condition that the Company was able to build engines at its own works at Doncaster. Three locomotives were produced from these new shops towards the close of the year 1867, and since that date, while a certain number of engines have still from time to time been supplied by outside firms, the greater portion of the stock has been turned out from Doncaster Works, the number at the time of writing having attained nearly to the respectable total of 1,000.

Doncaster No. 1 engine was, as already mentioned, delivered on the rails at the latter end of 1867, and was fittingly enough the pioneer of a new type. It was specially designed by Mr. Stirling for working "mixed" traffic, ranging from heavy excursion to fast goods work, and for this the class has proved to be of such great utility that 153

locomotives of this type were eventually put to work. Engines of this type run most of the fast passenger train services in the West Riding division of the line. As can be seen from the accompanying illustration, which shows the first of the class, these "mixed" engines ran on six wheels, of which the leading and driving pairs were coupled, while a small pair of independent wheels under the cab bore the weight of the trailing end. Fig. 37, however, represents only the first three of the series in actual details, these being the three engines built at Doncaster in 1867.

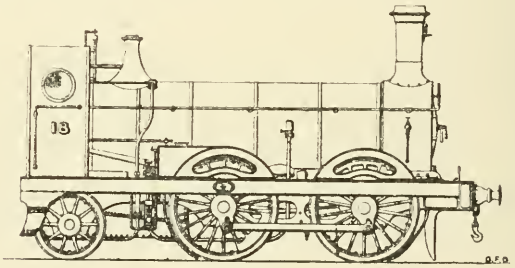


Fig. 37.

It will be noted that the square-sided cab with a circular window was the trial pattern first adopted by Mr. Stirling, which subsequently was replaced by the more familiar design already shown in the preceding figure. No. 18 and the two immediately following were distinguished from later editions by having only one large opening in each splasher. instead of two of the type shown in Fig. 36, and also by having a black beading round the splasher instead of the one of polished brass subsequently adopted. The leading dimensions of the first engines of this new class were: cylinders 17-in. in diameter with a 24-in. stroke; diameter

of coupled wheels 5-ft. 7-in., and of trailing wheels 3-ft. 7-in.; wheel-base: leading to driving axle 7-ft. 3-in., driving to trailing axle 7-ft. 11-in., total 15-ft. 2-in.; overhang of frame at leading end 4-ft. 10½-in.. and at trailing end 2-ft. 7-in.; boiler barrel: length 10-ft.; diameter outside smallest ring 3-ft. 10½-in.; height of centre above rails 7-ft.; firebox casing: length 5-ft. 6-in., depth at front 5-ft. 1-in., and at back 4-ft. 7-in.; heating surface: firebox 100 sq. ft., tubes 975 sq. ft., total 1,075 sq. ft.; grate area 16·25 sq. ft.; total weight in working order 31 tons. 18 cwt., distributed as follows: leading wheels 11 tons 14 cwt., driving wheels 14 tons, and trailing wheels 6 tons 4 cwt.

The first series of these useful engines consisted of 46, which were built in the years from 1867 to 1874 inclusive, with the following works and running numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1867	1	18	1870	54	65
,,	2	23	,,	57	200
,,	3	40	,,	58	35
1868	12	44	,,	59	64
,,	15	49	1871	63	85
,,	16	9	,,	67	32
,,	17	38	,,	70	30
,,	19	218	,,	72	203
,,	20	220	,,	73	68
1869	22	76	,,	76	83
,,	23	205	1872	81	46
,,	24	11	,,	85	13
,,	25	31	,,	87	52
,,	28	19	,,	90	71
,,	33	17	,,	91	75
,,	35	82	1873	98	16
,,	39	27	,,	99	50
1870	42	56	,,	106	508
,,	43	54	,,	109	509
,,	45	58	,,	112	77
,,	47	59	,,	114	81
,,	52	15	1874	124	73
,,	53	25	,,	126	219

Mr. Stirling's next design was for a six-coupled goods engine, and here again he at once fixed upon a standard pattern which, with a few trifling modifications of detail, and an increase in dimensions and power, was subsequently repeated without further revision, until at the present time nearly 300 of his goods engines are in use on the line. Those first delivered consisted of twenty locomotives built by outside firms in the following proportions :—

Date.	Engine Nos.	Builders.	Builders' Nos.
1867	474-478	John Fowler & Co.	871- 875
1868	479-483	,,	876- 880
1867	484-493	Neilson & Co.	1356-1365

In the accompanying illustration of No. 474, Fig. 38, are seen the leading features of this class of engine, including the inside cylinders, inside frames and axle bearings, and the deep angle iron running from buffer beam to buffer beam outside the wheels. The cab shown was the pattern first tried by Mr. Stirling, and was fitted to all the earlier engines of his design; but in 1869 or 1870 he modified it into the shape more generally associated with G.N.R. locomotives, which has already once been shown in Fig. 36, and is further abundantly illustrated in those drawings subsequently to be reproduced in dealing with Mr. Stirling's term of office. Of these early goods locomotives the chief dimensions are comprised as follows: cylinders 17-in. by 24-in.; diameter of six-coupled wheels 5-ft. 1-in.; wheel-base: leading to driving 7-ft. 3-in., driving to trailing 8-ft. 3-in., total 15-ft. 6-in.; boiler barrel 10-ft. in length, with a diameter outside the smallest ring of 3-ft. 10½-in., containing

206 tubes each $1\frac{3}{4}$-in. in diameter; heating surface: firebox 94·25 sq. ft., tubes 985·5 sq. ft., total 1,079·75 sq. ft.; total weight in working order 32 tons 11 cwt. The trailing springs consisted of six volute springs arranged in two wrought-iron troughs placed transversely, one of which was secured to the frames below the footplate, while the other took its seating at each end on the tops of the axleboxes.

From the first Mr. Stirling held very pronounced opinions in respect to the peculiar suitability of single driving wheels

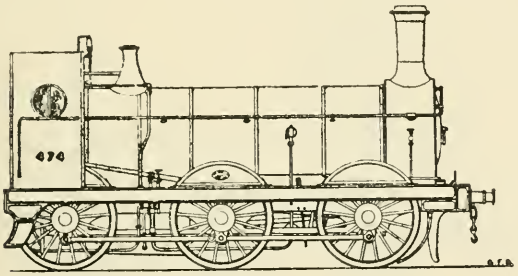


Fig. 38.

for the conduct of express passenger traffic, holding that while a single pair of driving wheels could be made to furnish ample adhesion, there could be no doubt as to the superiority in freedom and economy which would result from the abolition of the usual coupling with a second pair of wheels. Accordingly it is not surprising to find that he had been but a few months at the head of the locomotive department before he designed a new type of engine embodying his favourite theory. This type consisted originally of twelve engines, all turned out at the Doncaster works of the G.N.R. during the years 1868 to 1870, with

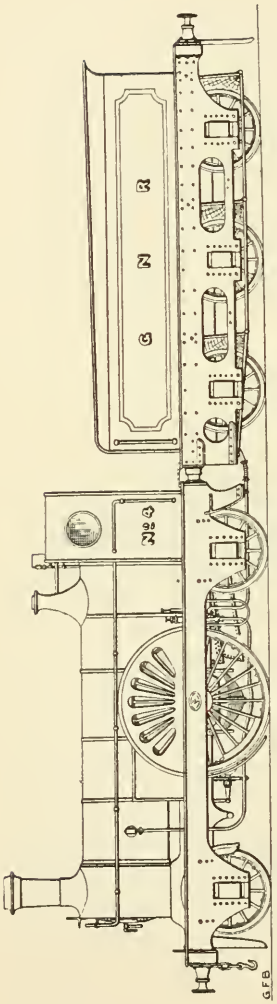


Fig. 39.

odd numbers, the full list being given below:—

Date.	Doncaster No.	Engine No.
1868 ..	4 ..	6
,, ..	5 ..	222
,, ..	6 ..	41
,, ..	8 ..	4
,, ..	9 ..	21
,, ..	11 ..	14
1869 ..	26 ..	55
,, ..	27 ..	61
,, ..	32 ..	63
,, ..	34 ..	215
1870 ..	48 ..	37
,, ..	51 ..	39

As can be seen from the accompanying illustration, Fig. 39, which shows them as originally built, these engines were in their main design virtually enlarged copies of the famous "Jenny Lind," having inside bearings only to the driving wheels and outside bearings only to the leading and trailing wheels. The earlier engines of the class had the square cab first employed by Mr. Stirling, and ordinary spring lever safety valves; but these, together with the later

ones, were subsequently modified in this respect, receiving the standard G.N.R. cab and Ramsbottom's valves inside a brass valve casing, as is shown in the second illustration, Fig. 40, which shows No. 4 as supplied with a new boiler and brake fittings, with other alterations in external appearance that need no special reference. According to official statements of the period, the leading dimensions of these fine engines were: cylinders 17-in. by 24-in.; diameter of driving wheels 7-ft. 1-in., and of leading and trailing wheels 4-ft. 1-in.; wheel-base: from leading to

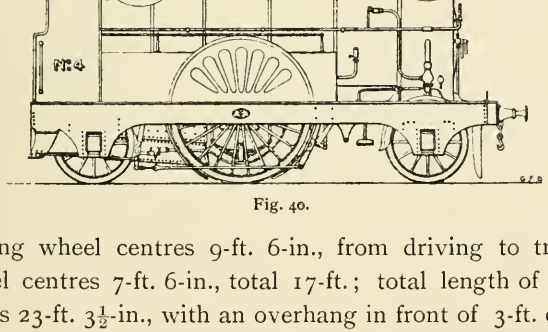


Fig. 40.

driving wheel centres 9-ft. 6-in., from driving to trailing wheel centres 7-ft. 6-in., total 17-ft.; total length of frame plates 23-ft. $3\frac{1}{2}$-in., with an overhang in front of 3-ft. $0\frac{1}{2}$-in., and at back of 3-ft. 3-in.; height of top of frame above rail level 4-ft. 2-in.; boiler barrel: length 10-ft. 2-in., diameter outside smallest ring 3-ft. $10\frac{1}{2}$-in., height of centre above rails 7-ft. 2-in., containing 192 tubes each measuring 10-ft. $5\frac{7}{8}$-in. between tube plates, with a diameter of $1\frac{3}{4}$-in.; length of firebox casing 5-ft. 6-in., distant from driving wheel centre 1-ft. $10\frac{5}{8}$-in.; inside fire-box 4-ft. 10-in. long at bottom and 3-ft. $4\frac{1}{2}$-in. wide at bottom, with an average

height above the grate of 4-ft. 6¼-in.; boiler pressure 130 lbs. per sq. in.; heating surface: firebox 89·5 sq. ft., tubes 922·25 sq. ft., total 1,011·75 sq. ft., grate area 16·4 sq. ft. Total weight in working order 33 tons, distributed as follows: Leading wheels 10 tons 8 cwt., driving wheels 14 tons, trailing wheels 8 tons, 12 cwt.; weight empty 30 tons 5 cwt. The capacity of the tender was 2,500 gallons of water. It should be noted that the cylinders, which originally provided a tractive force of only 82·57 lbs. per lb. of effective steam pressure, were subsequently replaced by new ones of 17½-in. diameter. One engine differed from the rest by being fitted with 192 tubes of the small diameter of 1 $\frac{9}{16}$-in. still placed at the same pitch, from centre to centre, as the larger ones. Mr. Stirling found this boiler quite as efficient as the others, and the innovation bore fruit ultimately in designing the boilers of the 8-ft. bogie engines, of which an extended mention will be made in due course.

The next new type introduced by Mr. Stirling consisted of a class of six-coupled saddle tank locomotives similar in general appearance to his tender goods engines, but of slightly smaller dimensions throughout. These engines were eight in number, and were built in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1868	7	392	1871	64	395
,,	10	124	,,	65	398
,,	13	162	1872	95	166
1869	37	396	1873	96	167

No. 392 had inside cylinders 17-in. in diameter with a stroke of 24-in., and six-coupled wheels 5-ft. 1-in. in diameter, the distance apart of the centres being: leading and driving 7-ft. 3-in., and driving and trailing 7-ft. 6-in.

respectively, thus giving a total wheel-base of 14-ft. 9-in. The frame plates measured 23-ft. 9½-in. from end to end, giving an overhang at the leading end of 4-ft. 7½-in., and at the trailing end of 4-ft. 5-in. With a length of 10-ft. 2-in., and a diameter outside the largest ring of 3-ft. 9-in., the boiler barrel contained only 90 tubes, each of 2-in. diameter outside. The firebox shell was 4-ft. 7-in. in length, and the centre of the boiler was pitched 6-ft. 10½-in. above the rail level. Extending over the length of boiler and firebox was a saddle tank having a capacity of 975 gallons of water,

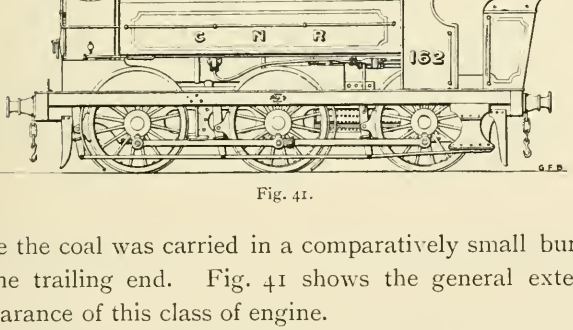


Fig. 41.

while the coal was carried in a comparatively small bunker at the trailing end. Fig. 41 shows the general external appearance of this class of engine.

For working the underground traffic it was soon found necessary to provide further engine power, but at first Mr. Stirling did not make any considerable change on the approved designs of his predecessor. Indeed, his earlier engines built for that service were of the same general type as those introduced by Mr. Sturrock in 1865 and 1866, being six-wheeled well-tank engines having four-coupled driving wheels under the barrel of the boiler, and an

independent pair of trailing wheels, placed well back and fitted with radial axleboxes, to carry the tank and bunker. As can be seen from the accompanying illustration, Fig. 42, which shows No. 119, the latest of the type, the principal change of design consisted in placing the main frames, and consequently the bearings of all four driving wheels, inside the wheels, this arrangement giving greater compactness to the appearance. The cylinders were 17½-in. in diameter with a stroke 24-in., and drove two pairs of wheels coupled in front, each 5-ft. 7-in. in diameter, and placed with the

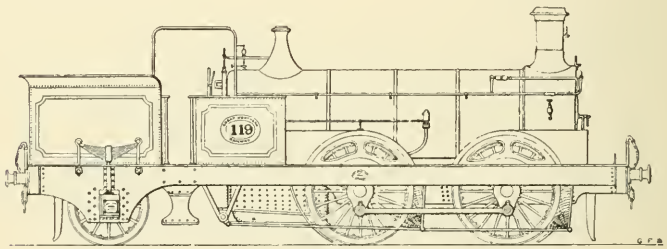


Fig. 42.

axle centres 7-ft. 3-in. apart. The total wheel-base measured 20-ft. 3-in., the trailing wheels, 4-ft. 1-in. in diameter, being placed 13-ft. in rear of the driving axle. Over all, the frame plates were 28-ft. 11-in. in length, with an overhang of 5-ft. 3½ in. at the leading end, and 3-ft. 4½-in. at the trailing end. The boiler barrel was pitched at a height of 7-ft. above the rails, and measured 10-ft. in length, with a diameter outside the smallest ring of 3-ft. 10½-in., and the fire-box shell was 4 ft. 10-in. long, with a depth below the centre line of the boiler of 5-ft. 1-in. in front, and 4-ft. 7 in. at back. A total heating surface of 917·5 sq. ft. was

provided in the following proportions: firebox 100 sq. ft., tubes 817·5 sq. ft., while the grate area was 14 sq. ft. At the trailing end was situated a well-tank having a capacity of 1,000 gallons, and a bunker to hold 30 cwt. of coal. In working order, engines of this class weighed a total of 41 tons 13 cwt., distributed as follows: leading wheels 11 tons 16 cwt., driving wheels 14 tons 12 cwt., and trailing wheels 15 tons 5 cwt. To work through the tunnels an arrangement was provided for condensing on all engines of this class except the two first built, and to the same end the chimney was reduced in height, so that it had a clear height above the rail level of only 12-ft. 7-in. The class consisted altogether of thirteen engines built at Doncaster in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1868	14	126	1870	55	122
,,	18	127	,,	60	132
1869	21	125	1871	68	116
,,	30	123	,,	69	118
,,	31	131	,,	75	117
,,	40	129	,,	78	119
1870	46	121			

As is mentioned above, Nos. 126 and 127 were not supplied with condensing apparatus, and these two engines were put to work in the West Riding division.

Next in order of issue from the Doncaster works came seventeen goods engines of practically identical dimensions with the No. 474 class already described and illustrated, with 17-in. by 24-in. cylinders, and six-coupled wheels of 5-ft. 1-in. diameter. These were delivered in the following series:—

Date.	Doncaster No.	Engine No.
1869	29	369
,,	36	377
,,	38	184
1870	41	169
,,	44	380
,,	56	190
,,	62	366
1872	80	148
,,	84	311
1872	86	333
,,	88	197
1873	100	151
,,	104	152
,,	111	186
,,	113	171
,,	115	335
,,	116	193

Without repeating the detailed dimensions of this class of goods, it may be mentioned that the boiler barrel of the Doncaster-built engines was pitched with its centre 6-ft. 10-in. above the rails, and that the angle of inclination of the cylinders in this type and in all front-coupled engines designed by Mr. Stirling was 1 in $8\frac{3}{4}$. Furthermore, it may be remarked for those that take interest in such matters, that in addition to the first three engines built at the company's works, all these early goods engines and the coupled passenger engines built "outside," of the 280 class, originally had black beading round the splasher rims, which was in most cases afterwards changed to the standard brass beading subsequently adopted on all Mr. Stirling's engines.

At the period now reached by this history Mr. Sturrock's fine bogie engine, No. 215, was withdrawn from service after a long and distinctly honourable career, and was for the most part condemned to the scrap heap. The driving wheels, however, were too good to break up, and with these in hand Mr. Stirling built a new engine, also the only one of its class, the date and Doncaster number being:

Date.	Doncaster No.	Engine No.
1870	49	92

The accompanying illustration, Fig. 43, shows No. 92 to have been simply an enlarged example of the single-

wheel engine already introduced by Mr. Stirling, the leading dimensions being: diameter of driving wheels with new tyres 7-ft. 7-in., and of leading and trailing wheels 4-ft. 1-in.; wheel-base: from leading to driving wheel centres 9-ft. 9-in., from driving to trailing wheel centres 7-ft. 9in., total wheel-base 17-ft. 6-in.; total length of frame-plate 23-ft. 9½-in., of which 3-ft. 0½-in. overhung at the leading end, and 3-ft. 3-in. at the trailing end; height of top of frame above rail level 4-ft. 2-in.; cylinders 17½-in. by 24-in.; boiler barrel: length 10-ft. 6-in., diameter outside

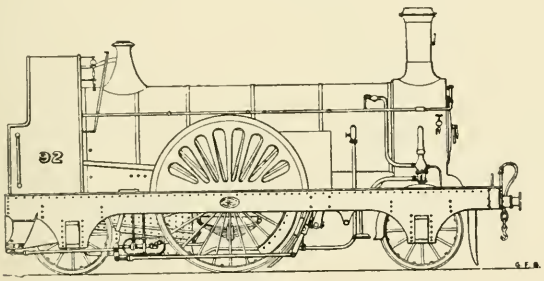


Fig. 43.

smallest ring 3-ft. 10½-in., height of centre above rails 7-ft. 4-in., containing 192 tubes of 1¾-in. diameter; length of firebox casing 5-ft. 6-in., distance from centre of driving axle 1-ft. 11⅝-in.; working pressure of boiler 130 lbs.; grate area 16·4 sq. ft.; total weight in working order 33 tons 12 cwt., distributed as follows: leading wheels 10 tons 1 cwt., driving wheels 14 tons 16 cwt., and trailing wheels 8 tons 15 cwt. The success attending the introduction of this large engine led eventually to the building of a number of still more powerful engines of a similar general design, some sixteen years later, as will be seen in due

course. No. 92 is now in the "A" class, a new engine bearing the same number having been built recently by Mr Ivatt.

There now came a period in the history of the Great Northern Railway when the rapid increase in speed and in the weight of the trains required to maintain express service began to constitute a serious problem for the locomotive engineer. The coupled and single-wheel engines so far in existence were being taxed practically to the utmost limits of their power, and with still a steady increase of traffic it became necessary to design not only more engines, but more powerful engines than any hitherto put into service. As has already been mentioned, Mr. Stirling was ever a consistent advocate of no more than a single pair of driving wheels being employed for really fast work, the only apparent drawback being, of course, a relatively small adhesive power. This drawback, however, he considered to be largely exaggerated in importance, and for some little time he kept careful observation of the comparative working of the 7-ft. single and 6½-ft. coupled engines which he had already placed on the line, both classes having 17-in. by 24-in. cylinders, and being for all practical purposes of equal boiler power. The result confirmed his theories in a convincing manner, for he found that with trains of equal weight the single-wheel engine had "the best of it." In fact, the 7-ft. singles generally beat the smaller coupled engines, in point of time, over such an exceptional test road as that from King's Cross to Potter's Bar, a distance of 12¾ miles, nearly all uphill, with gradients varying from 1 in 105 for two miles to 1 in 200.

Finding that sufficient adhesion could be obtained from a single pair of driving wheels, Mr. Stirling accordingly set to work to design a larger and more powerful engine than the 7-ft. class, and selected as the basis of his calculations driving wheels having the unusual diameter of 8-ft., being satisfied, as he subsequently explained, that "the larger the wheels the greater the adhesion to the rails." Without pitching the boiler at a height which at that time would have been considered excessive, he found it impossible to clear the 14-in. cranks which were contemplated, so he had no alternative but to place the cylinders outside the frames. Again, he decided to lay them in a horizontal line with the driving wheel centres, to obviate the disadvantages of inclined outside cylinders, and this position, with the great overhang that it caused, and the considerable disturbance of weight resulting therefrom, which would have unduly loaded a single axle at the leading end, caused him to adopt a bogie with the axles sufficiently spread apart to allow the cylinders to be placed between the two sets of wheels. Considerable prominence is given to this chain of reasoning, which seems to have been that followed out by Mr. Stirling, in order to combat the theory sometimes put forward that Mr. Sturrock's No. 215 was the direct inspiration from which Mr. Stirling's No. 1 was derived. When it is remembered that Mr. Stirling never adopted the bogie for any class of express engine but this, preferring rather a rigid wheel-base of 19-ft. 1-in. on his later single-wheeled locomotives, it is only reasonable to assume that his employment of the bogie was actuated by force of circumstances rather than by imitation of any previous design, to the same degree that he found it necessary in this case also to make

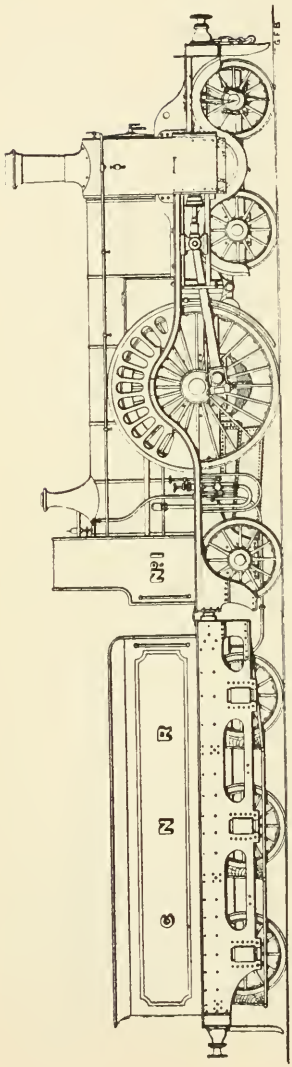


Fig. 44.

a radical departure from his otherwise invariable practice of placing the cylinders between the frameplates.

These engines, 53 in number altogether, were all built at Doncaster, the first to be turned out being appropriately enough allotted No. 1, thus displacing the "Little Sharp" of 1847. No. 1 is shown in the accompanying illustration, Fig. 44, as originally built in the early part of 1870, being, as can be seen, an eight-wheeled locomotive having outside cylinders, inside frames and axle bearings, a leading four-wheeled bogie, a single pair of driving wheels, and a smaller pair of independent trailing wheels. With regard to the bogie, it may be noted here that Mr. Stirling did not place the pivot on which it turned equi-distant from the two axles; but, on the contrary, the pivot was placed 3-ft. 6-in. in rear of the leading axle centre, and

only 3-ft. in advance of the hind axle centre. The result of this unequal spacing was twofold. Not only was the weight on the bogie wheels so distributed as to lead up by gradations to the greater weight on the driving wheels, but another effect was produced in the easing of the bogie in negotiating curves, the leading wheels making a greater transverse movement, and the hind wheels a correspondingly less transverse movement than would have ensued from a more equal spacing. In addition to the central pivot, the bogie had side bearings under each cylinder. At the rear end the engine was carried on five volute springs arranged much in the manner described as being adopted in the goods engines built a year or two earlier. The cylinders were each held in an opening formed in the corresponding frame, which was here deepened considerably for the purpose, and the opening was secured beneath the cylinder by means of a stay made to clip the frame like a hornplate stay. As regards the boiler feed, this was delivered, as shown in the illustration, at the side of the firebox casing in all the earlier engines of the class. The internal firebox had its crown slightly rounded and was secured to the outer casing by a number of round stays, each $\frac{7}{8}$-in. in diameter, screwed into both firebox and casing, and then riveted over on the outside. An inclined copper mid-feather was adopted in place of the customary brick arch, and to this extent enhanced the direct heating surface of the firebox.

The leading dimensions of No. 1 were as follows:—diameter of bogie wheels 3-ft. 11-in., of driving wheels 8-ft. 1-in., and of trailing wheels 4-ft. 1-in.; wheel-base, bogie wheel centres 6-ft. 6-in., from hind bogie wheel to driving wheel centres 7-ft. 9-in., from driving to trailing wheel

centres 8-ft. 8-in., from centre of bogie pin to centre of trailing wheels 19-ft. 5-in., total wheel-base 22-ft. 11-in.; total length of frame-plates 27-ft. 7-in., the overhang being 2-ft. 2-in. in front and 2-ft. 6-in. at back; length outside buffer beams 28-ft. 1-in., over all 29-ft. 9-in. Cylinders 18-in. diameter, 28-in. stroke; throw of eccentrics $3\frac{1}{4}$-in., length of eccentric rods 5-ft. 10-in., length of expansion links (curved Stephenson pattern) 1-ft. 4-in., length of connecting rods 6-ft. 10-in.; diameter of blast pipe $4\frac{3}{4}$-in. Boiler barrel (in three rings) 11-ft. 5-in. long, with a diameter outside the smallest ring of 3-ft. $10\frac{1}{2}$-in., height of centre-line above the rails 7-ft. 1-in., containing 217 brass tubes 11-ft. 8-in. long between plates, and with an outside diameter of $1\frac{9}{16}$-in.; boiler pressure 140 lbs. per sq. in.; thickness of plates (Yorkshire iron) $\frac{1}{2}$-in., lap-jointed, double riveted longitudinally, single riveted vertically and circularly; the firebox casing measured 6-ft. 2-in. long outside, with a width at the bottom of 3-ft. $11\frac{1}{2}$-in., increasing to 4-ft. $1\frac{1}{2}$-in. at the centre-line of the boiler; depth below centre-line of boiler at front 5-ft. 1-in., at back 4-ft. 7-in. The internal firebox of copper had its side and crown plates $\frac{1}{2}$-in. thick, the back plate being increased to $\frac{5}{8}$-in., and the tube plate to $\frac{3}{4}$-in.; at the bottom its length was 5-ft. 5-in., diminishing to 5-ft. $4\frac{1}{2}$-in. at the top; the mean width was 3-ft. 3-in., and the height 5-ft. $10\frac{1}{2}$-in. and 5-ft. $4\frac{1}{2}$-in. at front and back respectively. Distance of firebox casing from driving axle centre 1-ft. 9-in, length of smokebox inside 2-ft. $8\frac{3}{4}$-in., diameter across centre-line inside 4-ft. 9-in.; heating surface: firebox 122 sq. ft., tubes 1,043 sq. ft., total 1,165 sq. ft.; grate area 17·6 sq. ft. The weight of No. 1 in working order was 38 tons 9 cwt., distributed as follows:—leading

bogie wheels 7 tons, hind bogie wheels 8 tons, driving wheels 15 tons, and trailing wheels 8 tons 9 cwt. A tender to carry 3½ tons of coal and 2,700 gallons of water, and weighing in full condition 26 tons 10 cwt., was originally supplied, the total length of engine and tender over buffers being 50-ft. 2-in.; but in course of time nearly all the class were provided with larger tenders having enhanced capacities for fuel and water.

In all, as has already been mentioned, a total of 53 engines were built of this type between the years 1870 and 1895. But while they were all practically of the one type, and while in general design the first and last of the class, separated by an interval of more than a quarter of a century, showed no difference save in the matter of details and a certain increase in weight and power, it will be more convenient, and perhaps more correct, to divide them into three batches, the dividing line in one case being marked by a distinct increase in dimensions, while in the other the division is of a somewhat arbitrary character. This arbitrary line may be drawn at the close of the year 1882. Up to that period, and possibly a few years later still, the leading dimensions already given will apply to all the 8-feet engines, with a proviso that in respect to some few details such alterations or modifications were effected as were necessary to bring these engines into line with the practice prevailing at any given date in respect to the locomotive stock built at Doncaster. These changes will generally be noted more particularly when the remainder of the engines of this class come under notice, and for the present it is sufficient to mention one item affecting the external appearance of the engine. Up to 1881 the driving-wheel splashers were all of

the perforated type shown in the illustration of No. 1. In the course of time, however, the openings were blocked in with thin plates, and No. 664, built in the year just mentioned, was turned out with perfectly plain splashers, and with a handsome brass oval date-plate on each splasher in place of the inconspicuous one so far adopted on these engines, which had been carried on the curved running plate immediately over the driving axle. This engine was sent by the railway company to take part in the memorable Stephenson Centenary Festival of that year.

The following is a list of the dates and numbers of the 8-feet bogie engines built up to the close of 1882, 37 in all, to which the description and dimensions already given more particularly apply:—

Date.	Doncaster No.	Engine No.
1870	50	1
,,	61	8
1871	66	33
,,	77	2
1872	82	3
1873	105	5
,,	107	7
1874	120	22
,,	150	48
1875	165	34
,,	170	47
,,	185	53
1876	195	62
,,	212	221
,,	215	94
1877	219	69
,,	220	98
,,	230	544
,,	231	545
1877	232	546
,,	233	547
1878	240	548
,,	245	549
,,	247	60
,,	248	550
1879	281	93
1880	285	95
,,	303	662
1881	312	663
,,	320	664
,,	321	665
,,	323	666
,,	324	667
1882	341	668
,,	342	669
,,	349	670
,,	350	671

It is to be recorded with regret that, of the above, Nos. 2, 8, 33, 48, 60, 62, 69, 98, 546, 549, 550 and 662 have recently been condemned, as is further noted in due course.

In addition to the set of twenty coupled passenger locomotives built by "outside" firms, which have already been described as Mr. Stirling's "maiden" design on the G.N.R., two were put in hand at Doncaster in the following order:—

Date.	Doncaster No.	Engine No.
1871	71	261
,,	74	262

These were the only two of the class built at Doncaster, for almost immediately afterwards, as will be seen later on,

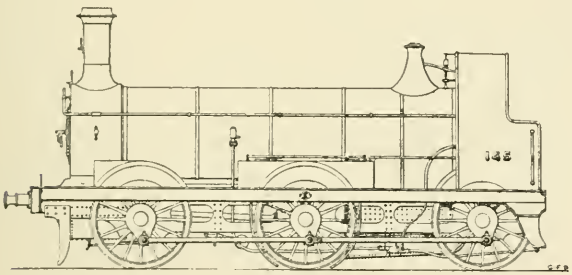


Fig. 45.

a newer type with greater cylinder power was brought out, which became the standard pattern for the future.

In 1871 Mr. Stirling designed and built at the Doncaster works six six-coupled engines of exceptional dimensions and power, the object he had in view in departing from his normal practice of the period being the conveyance of mineral trains between Doncaster and Peterborough by way of the loop-line through Lincoln and Boston, the distance being 100 miles and the contemplated gross load 687 tons. These engines were, in external appearance, as can be seen from Fig. 45, which shows one

of the class, of Mr. Stirling's standard pattern, and they were built in the following order :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1871	79	174	1873	102	145
1872	83	376	1874	118	146
1873	97	158	,,	125	164

The cylinders were of large size, 19-in. in diameter, with a stroke of 28-in., and were made in one casting with the valves underneath, as there was no room for them between the cylinders, and as a consequence motion was transmitted to the valve spindles by means of rocking-shafts. In order to avoid excessive inclination of the cylinders, single guide-bars were employed, placed above, so that the piston rods could be brought down as close as possible to the leading axle. Reversing was effected by means of a screw gear instead of the ordinary hand lever. The leading dimensions of these fine engines were as follows :—diameter of six-coupled wheels 5-ft. 1-in.; wheel-base: from leading to driving wheel centres 8-ft. 5-in., from driving to trailing wheel centres 9-ft. 2-ft., total wheel-base 17-ft. 7-in. Total length of engine over buffers 28-ft. 1-in., distance between frames 4-ft. 1½-in., width outside frames 7-ft., width over footplate 7-ft. 3-in. Cylinders: 19-in. in diameter with a 28-in. stroke; distance apart of centres 2-ft. 2½-in.; angle of inclination 1 in 11½; diameter of piston rods 3¼-in.; length of connecting rods 6-ft. 9-in. Boiler barrel 11-ft. 4-in. in length, with a diameter outside the smallest ring of 4-ft. 3-in.; height of centre-line above rails 7-ft.; length of firebox casing 6-ft. 2-in.; width, 4-ft. 0½-in.; length of internal firebox at top 5-ft. 4½-in., and at bottom 5-ft. 5½-in.; width, 3-ft. 4½-in. The boiler barrel contained 232 tubes 11-ft. 8-in. long, with

an outside diameter of $1\frac{3}{4}$-in., spaced at $2\frac{3}{8}$-in. centres; heating surface: firebox 112 sq. ft., tubes 1,240 sq. ft., total 1,352 sq. ft.; grate area 18·7 sq. ft. The total weight of the engines, in road-worthy condition, was 40 tons, distributed as follows: leading wheels 14 tons; driving wheels 14 tons 15 cwt.: and trailing wheels 11 tons 5 cwt.

These engines appear to have admirably fulfilled the purpose for which they were designed, taking loads of the figure already mentioned and running to time with great regularity on a relatively small coal consumption of about 46-47-lbs. per mile. But, strange to say, Mr. Stirling had committed practically the same fault that his predecessor was guilty of when he introduced his "steam tenders." He had apparently overlooked the fact that there was no accommodation on the line for the shunting of a train of 55 wagons with an engine and tender attached, the sidings not being long enough. Accordingly, the average load had on this account to be reduced to 50 wagons or less, with an average gross load of 625 tons, and for this reduced weight a less powerful engine could be employed. Had it not been, more especially, for the double level crossing at Lincoln, which would not accommodate the extra length of train which these engines were built to work, the type would no doubt have been largely adopted; for many years they were stationed at Doncaster, but latterly Mr. Ivatt has transferred the majority of them to Ardsley, in order to work coal trains in the West Riding, where there are several severe banks of 1 in 50 to be negotiated. No. 164 was broken up in 1901, but the other five are still at work.

As was mentioned on p. 45 of the present volume, the two small tank engines built by Messrs. Manning, Wardle

and Co. for the West Yorkshire Railway, and subsequently taken over by the Great Northern Railway, were, in 1872, passed through the Doncaster shops, and emerged rebuilt into saddle tanks while still retaining the original frames, wheels and motion.

Date.	Doncaster No.	Engine No.
1872	89	471
,,	92	470

It is probable that the results of their working in this rebuilt form were instrumental in introducing a new and handy type of small-wheel saddle tank engine, which was first brought out about two years later, and will be referred to at length in due course.

The next class to make its appearance was a marked development of Mr. Stirling's early design of locomotive for working the underground suburban traffic to Moorgate Street and the South of London. While retaining the four 5-ft. 7-in. driving wheels, coupled in front, this new class of engine had the trailing end carried on a four-wheeled bogie, thus constituting a much easier riding engine. At the same time the gross weight of the locomotive in full working order was actually less than that of the earlier six-wheeled type. The leading dimensions of these locomotives were as follows: cylinders 17½-in. in diameter with a stroke of 24-in.; diameter of driving wheels 5-ft. 7-in., and of bogie wheels 3-ft. 1-in.; wheel-base: coupled wheels 7-ft. 3-in., driving wheels to leading bogie wheels 10-ft. 3-in., leading bogie wheels to centre of bogie pin 2-ft. 3-in., bogie pin to trailing bogie wheels 2-ft. 9-in., total wheel-base 22-ft. 6-in.; overhang of frame plates at leading end 5-ft. 3-in., and at trailing end 4-ft. 3-in. from bogie pin, total length of frame plates, 27-ft. The boiler was pitched with its centre 7-ft.

above the rail level, having a length of barrel of 9-ft. 10-in., and a diameter inside the smallest ring of 3-ft. 9½-in., and the firebox casing measured 4-ft. 6-in. in length, with a depth below the centre line of the boiler of 5-ft. 1-in. at the leading end, and 4-ft. 7-in. at the back. The heating surface was: tubes 806 sq. ft., firebox 81 sq. ft., thus giving a total of 887 sq. ft. Over the bogie was a large tank and bunker having a capacity for 1000 gallons of water and 30 cwt. of coal. The total weight in working order was 40 tons 14 cwt. 3 qrs., distributed as follows:—leading wheels 11 tons 10 cwt. 3 qrs., driving wheels 14 tons 14 cwt., and bogie wheels, 14 tons 10 cwt.

In all, 48 engines of this type were built at Doncaster between the years 1872 and 1881, their dates, works numbers and running numbers being as follows:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1872	93	120	1878	236	623
,,	94	128	,,	238	624
1873	108	504	,,	243	625
,,	110	505	,,	246	626
,,	117	506	,,	250	244
1874	119	510	,,	253	246
,,	123	507	1879	259	241
,,	129	511	,,	261	243
,,	131	512	,,	265	250
,,	140	513	,,	266	245
,,	144	514	,,	272	627
,,	147	515	,,	275	628
,,	152	516	,,	277	247
,,	153	517	,,	279	249
1875	173	528	1880	283	629
,,	178	529	,,	284	630
,,	184	530	,,	289	242
,,	189	531	,,	290	248
1876	194	532	,,	297	652
,,	198	533	,,	298	653
,,	203	130	1881	306	654
,,	206	159	,,	307	655
1877	234	621	,,	313	656
1878	235	622	,,	314	657

Of the list given above, however, more than one-half, from No. 621 onwards, were provided with larger tanks and bunkers at the trailing end, which also caused a corresponding increase of the total weight of the engines. The accompanying illustrations of Nos. 517 and 246, Figs. 46 and 47 respectively, show the leading external characteristics of these two classes of engine. It will be noticed that the earlier class had the number plates on the side sheets, while the later ones had them on the sides of the bunkers. Some of the earlier engines, however, among which

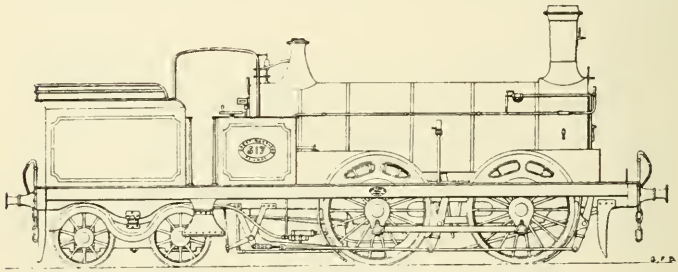


Fig. 46.

were Nos. 241, 245, 248, 507, 513, 515 and 516, were afterwards fitted with larger bunkers, and then had the number plates removed to the position shown in Fig. 47. These engines, and those of the 126 class, together with rebuilds of Mr. Sturrock's Metropolitan engines, are the only types on the G.N.R. with brass number plates. Nos. 510, 511, 513, 515, 528, 529, 531, 241 to 250, 621 to 628, 654 and 655 were fitted with condensing apparatus for working through the "underground," and were also provided with shorter chimneys, so as to pass the Metropolitan Railway loading gauge. The two engines, Nos. 629 and 630, which re

included in the foregoing list, should really be considered as a separate type, as they were of smaller dimensions than the rest, the driving wheels being only 5-ft. 1-in. in diameter, and the cylinders 16-in. by 22-in. They and the four engines built in 1881 had the closed type of splasher which subsequently replaced the perforated

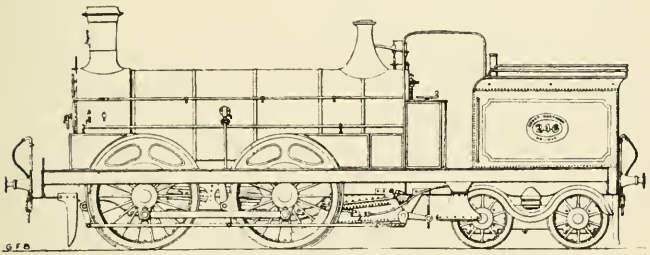


Fig. 47.

open pattern on all new classes of engine. It will be noticed that from 1878 these engines began to appropriate the numbers originally given to Mr. Sturrock's earlier Metropolitan passenger engines, which at about that period, or earlier, underwent a course of rebuilding and were relegated to the "A" class, as will be seen almost directly.

PART IV.

MR. STIRLING'S REBUILDS.

REFERENCE has already been made in this history to a certain adaptation of some of the earlier engines introduced by Mr. Sturrock in order to meet the more exacting requirements of a development of traffic. For the most part it is impossible to give any very detailed information on this subject, as the changes in question were made in no fixed order and in no definite degree capable of exact classification. For example, the "little Sharps," the first passenger engines on the line, underwent several different kinds of transformation with a view to their adaptation to varying needs. A few, of which No. 9 has already been quoted and illustrated as an example, were adapted by Mr. Sturrock to work the underground traffic during a temporary stress of circumstances. Others, of which No. 23 was a well-known representative, underwent conversion, also under Mr. Sturrock's *régime*, into front coupled engines with the addition of a second pair of driving-wheels in front of the drivers. Engines of this type were employed, amongst other services, on the Leeds and Wakefield branch, when it was opened. A further process of development even, took place with yet another series of these useful little engines, as can be seen from the accompanying illustration, Fig. 48, which shows No. 12 converted into a front coupled engine having its wheel-base

extended at the trailing end, with the addition of a tank and coal bunker. This transformation was probably not brought about until the early years of Mr. Stirling's reign, as is indicated by the chimney, but it is noteworthy that No. 12 retained its old boiler and cylinders. Four others were very similarly altered, though they required such additional work to be put upon them in the shape of new leading wheels, frames and boilers, together with new cylinders of the increased dimensions of 16-in. diameter and 24-in. stroke, as to justify them in emerging from the shops in all the

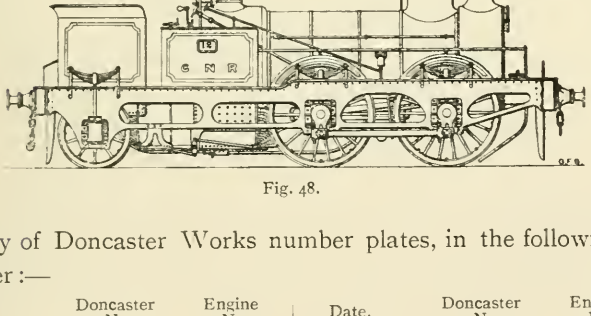


Fig. 48.

glory of Doncaster Works number plates, in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1873	101	43	1874	139	20
,,	103	10	,,	142	42

Unfortunately no illustration is to hand to depict these rebuilds, which subsequently performed much useful service on local branch traffic, even long after they were relegated to the "A" class by the appropriation of their numbers to more modern engines in 1887 and 1888.

Two at least of the "small Hawthorns" also underwent

a complete transformation under Mr. Stirling's rule, to a degree that left little of the original design apparent. These were Nos. 67 and 70, and the accompanying illustration, Fig. 49, shows No. 67 as a front coupled passenger engine having two pairs of 6-ft. driving wheels, with cylinders $17\frac{3}{4}$-in. in diameter and 24-in. in stroke. A distinctly interesting feature of the "re-build" is the adoption of outside bearings to all the wheels, with underhung springs, this being thoroughly at variance with Mr. Stirling's usual practice, as was also, indeed, the employment of outside

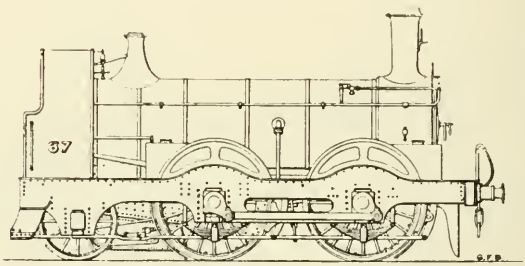


Fig. 49.

frames of the type shown. Certainly, this fine powerful-looking engine seems to have little, save its number, to connect it with the 6-ft. singles of 1848. No. 70 subsequently paid another visit to the shops, and emerged with 18-in. by 24-in. cylinders. As rebuilt, No. 67 was supplied with a six-wheeled tender, but No. 70 had a four-wheeled tender, as also had several other engines, including even some of Mr. Stirling's earlier "mixed traffic" engines of the No. 18 class. Nos. 67 and 70 were both broken up about two years ago.

The Wilson passenger engines of 1851 also contributed

6 ft. 6 in. Coupled Bogie Locomotive, designed by Mr. H. A. Ivatt. No. 1312.

their share of survivals to come under the hands of the late locomotive superintendent. Nos. 78, 79, 87 and 88 were of this number, of which four, Nos. 79 and 87 were supplied with new frames in re-building. Fig. 50 shows No. 79 as thus altered. Some of these engines retained their six-ft. coupled wheels, with 16½-in. by 22-in. cylinders, while Nos. 79 and 87 had their wheels enlarged to 6-ft. 6-in., with correspondingly larger cylinders, 17½-in. by 24-in.

No. 263A, a Wilson four-coupled engine, was also rebuilt so as to greatly resemble the smaller engines of this

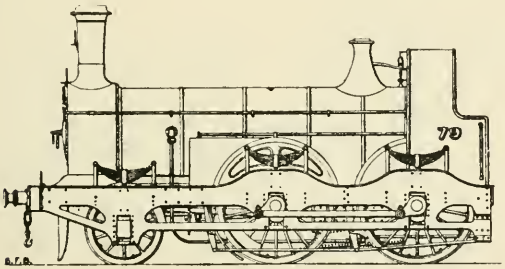


Fig. 50.

series, viz., Nos. 78 and 88.

As details are not to hand of the date at which Mr. Stirling undertook these various rebuilds, and it would be difficult if not impossible to arrange them in absolute chronological order at this late period, it will perhaps be best to follow as nearly as can be the numerical order in dealing with them. Therefore, the next class to be mentioned is that known throughout their career as the "converted Cramptons," Nos. 91 to 99. The illustration, Fig. 51, shows these pretty little engines during the later days of their existence, together with the pattern of tender

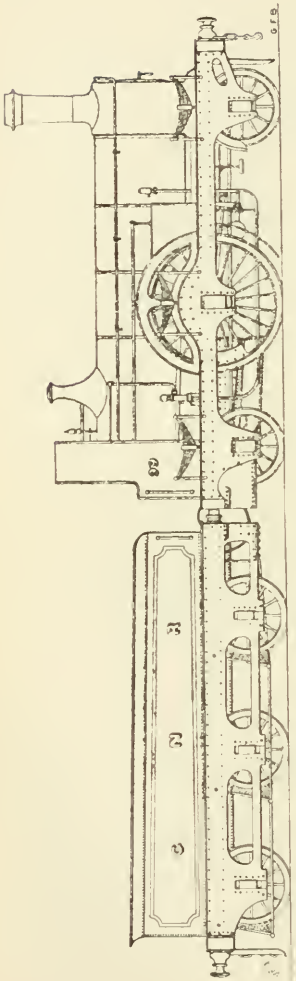


Fig. 51.

then in vogue. It may be mentioned that the "converted Cramptons" took their share in the working of the Great Northern Manchester express during the 'fifties and early 'sixties, and with the light trains then usual they were accounted excellent performers.

The old Bury coupled engine, No. 100, had been rebuilt, with outside plate frames, as far back as 1855. It was again rebuilt in 1871 with the same sized wheels, and again in 1875 with 4-ft. 6-in. leading and 6-ft. coupled wheels. The engine was supplied with a new boiler as recently as 1891, and has only been broken up within the last year or two. Latterly, it had cylinders 17½-in. by 24-in.

Reverting to a lower order of service, the following of a numerical scheme leads to Fig. 52, in which can be seen Mr. Stirling's transformation of the early

Hawthorn goods engines into a more powerful type better adapted to the requirements of his time. In No. 139A the tender was dispensed with, and in its place a saddle tank and a coal bunker at the trailing end added considerably to the adhesive weight, while the boiler and cylinder power were also enhanced to bring this engine and others of the same class up to date. The list of these converted engines was as follows: Nos. 134, 139, 140, 144, 149, 155 and 397. They were all rebuilt with cylinders 17-in. by 24-in., which were

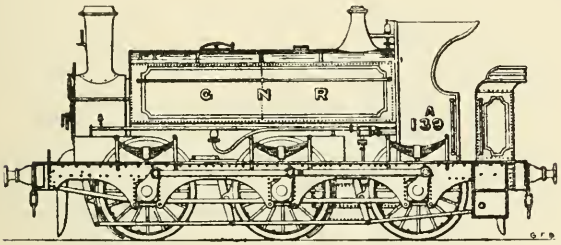


Fig. 52.

subsequently bored out to 17½-in. diameter, except No. 397, which was 17¼-in. only.

Nos. 101 to 110, and 112 to 115, four-coupled goods engines, were rebuilt with 16-in. by 24-in. cylinders, and still retained their tenders. Some of them as rebuilt were fitted for working the Westinghouse brake, being employed at Doncaster for trial trips of the E. C. J. S. coaches. No. 111, however, was completely rebuilt as a saddle tank locomotive with new frames and six-coupled wheels, and was conspicuous as being the only six-coupled engine on the line in which the frames and running plate rose in a curve

above the outside cranks. No. 112A is still employed at Doncaster in shunting at the carriage works, and is fitted with the Westinghouse brake.

Less drastic measures served to adapt No. 160 and some other engines of a similar type into fairly efficient "mixed traffic" engines, as is shown in Fig. 53, for the chief change appears to have been the provision of a standard Stirling boiler and cab, with a slight increase in cylinder power. Nos. 133 and 160 were so rebuilt with 16-in. by 24-in. cylinders, and were fitted with the Westinghouse brake, as

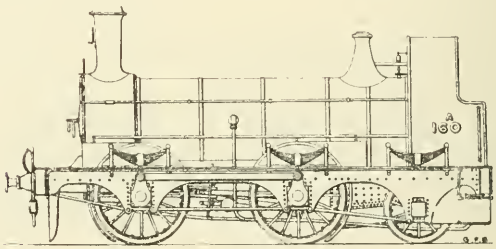


Fig. 53.

in the case of the No. 101 class.

Most of the goods engines numbered up to No. 199 were rebuilt with 17-in. cylinders, and some of these, as Nos. 177, 180, 165 and 192, are, or were quite recently, still at work under their old numbers. No. 180 had 18½-in. by 24-in. cylinders for many years.

Two very famous little engines, the two "Jenny Linds," Nos. 201 and 202, survived to come under Mr. Stirling's care, but unfortunately no illustration is forthcoming to show them at this period. The framing was slightly altered, and the tie-rods connecting the leading and trailing horn-plates

were removed, so that as rebuilt these engines bore a somewhat close resemblance to Mr. Stirling's own six-wheel single-drivers of the No. 4 class. They still retained the old dimensions of cylinders, 16-in. by 22-in., though the diameter was subsequently enlarged to the extent of ½-in. No. 222, which was practically of the same class, appears to have dropped out of use comparatively early, and was broken up.

Unfortunately, also, an equally noteworthy class, Nos. 203 to 214, must be passed over without any illustration or

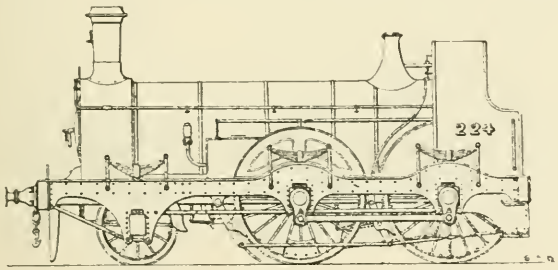


Fig. 54.

extended mention as regards their later years of service. This is a fate of which they are scarcely deserving, since they shared with the "converted Cramptons" and the "Jenny Linds" in establishing the Great Northern Company's reputation for speed at a very early date. In Mr. Stirling's time all these types were undoubtedly "out-classed" as regards the best express services, but they were still able to work their way with fast local traffic, and so to justify their prolonged existence.

The Hawthorn coupled passenger engines, Nos. 223 to 228, underwent due revision, being supplied with new

boilers and 17-in. by 22-in. cylinders. In 1884 No. 224, which is shown in accompanying Fig. 54, was again overhauled. Some time prior to that overhauling it had been supplied with cylinders 17¼-in. by 24-in. It was finally scrapped two or three years later.

Mr. Sturrock's fine 7-ft. singles, Nos. 229 to 240, in due course received new boilers as they became necessary, and some had their cylinders enlarged to 17-in. by 24-in., this timely augmentation of weight and power serving to

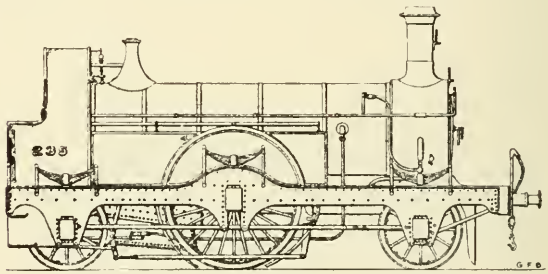


Fig. 55.

bring them well in line even with Mr. Stirling's earlier single engines. Fig. 55 shows No. 235 as thus transformed. From 1885 onwards, however, they suffered a partial eclipse, being transferred into the "A" class as the numbers gradually fell to the new 7-ft. 6-in. single engines which Mr. Stirling introduced at that period. These engines have now all been scrapped, No. 231A being the last to undergo that fate.

Still preserving the numerical precedence, irrespective of class, the next change to be noted was in the earlier type of Metropolitan engines brought into being by Mr. Sturrock in 1865. As can be seen from the accompanying illustra-

tion of No. 246A, shown in Fig. 56, these engines underwent some considerable change since, in addition to the provision of new boilers, new frames also apparently became neces-

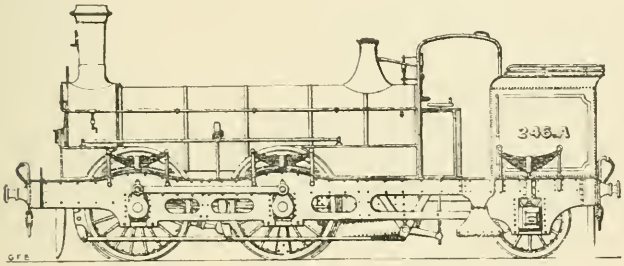


Fig. 56.

sary. The design adopted for these was practically identical with that of the No. 270 class, already illustrated in its proper place. While on this subject, it may be mentioned that the No. 270 class also was rebuilt by Mr.

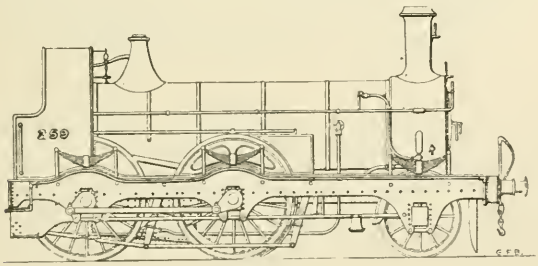


Fig. 57.

Stirling with new boilers in 1879-81, and only underwent dissolution at the scrap heap after 33 years of honourable service.

The 6-ft. coupled passenger engines, Nos. 251 to 260, which throughout their career escaped the fatal brand of

the "A" to their running numbers, underwent the inevitable overhauling as regards their boilers, and made their appearance in the style shown as regards No. 259, illustrated by Fig. 57. With the exception of No. 255, which retained her 16½-in. by 22-in. cylinders, bored out to the extent of another ½-in., these engines as rebuilt were fitted with cylinders varying from 17-in. to 17½-in. in diameter with 24-in. stroke. It is regrettable to learn that these engines are now broken up, with the sole exception of No. 258.

But their immediate successors, the famous 7-ft.

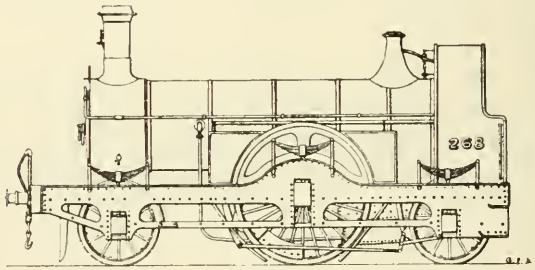


Fig. 58.

coupled engines which constituted Mr. Sturrock's latest design for the Great Northern Railway, were less easily dealt with. It has been said that in their original state they "could not keep their side-rods on." At all events, they seem to have come to grief frequently through either the breaking or the bending of the coupling-rods, and possibly this consideration weighed more in Mr. Stirling's dealing with them than even his well-known predilection for a single-driver. In 1873, Nos. 266 and 267 were converted into single-wheel engines, Nos. 265 and 269 followed suit in 1875, and Nos. 264 and 268 in 1878,

all having the original cylinder dimensions 17-in. by 24-in. They were all supplied with new boilers once again, in 1885-9. The alteration effected generally is indicated by the foregoing illustration, Fig. 58, which shows No. 268, an engine which is specially noteworthy as having been one of those involved in the fatal smash at Abbots Ripton. Nos. 265 and 266 ran for a long time fitted with the Westinghouse brake, and worked between Doncaster and Peterborough, *via* Lincoln.

A certain number of goods engines underwent consider-

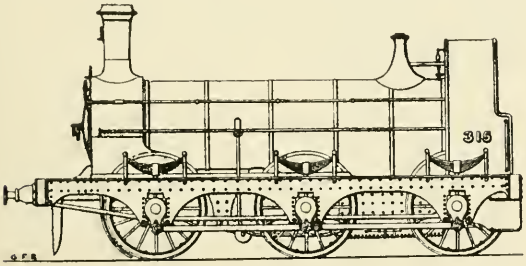


Fig. 59.

able rebuilding, which involved the supply of new plate frames amongst other details. These engines were the following: Nos. 179, 302, 303, 304, 305, 306, 329, 331, 332, 343, 360, 407, 408, 416 and 432. Others received new boilers and a general overhaul, as shown in Fig. 59, which illustrates No. 315 supplied with a standard Stirling boiler. In all cases, the diameter of the cylinders was consistently increased to 17½-in. in the process of rebuilding.

Having already illustrated the No. 400 class of goods engine and the "steam tender" devised by Mr. Sturrock, in the proper place as originally built, it may be interesting

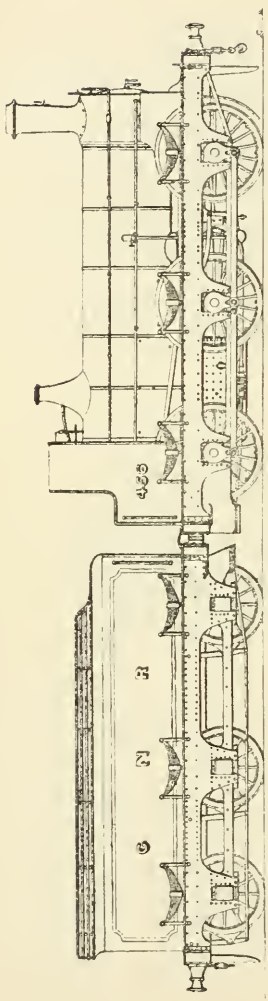


Fig. 60.

to show a later phase of their development. Accordingly, this somewhat inadequate account of the rebuilds instituted by Mr. Stirling contains an illustration of No. 456, illustrated in Fig. 60, showing it in its rebuilt form, with the original steam tender "improved out of existence," or at least almost out of recognition, by Mr. Stirling. A number of these engines were specially rebuilt by Mr. Stirling with 18-in. by 26-in. cylinders, such, for instance, as Nos. 401 to 405, 425, 429, 434, 440, 442, 446, 463 and 468, and possibly some others.

No. 456 was one of five locomotives built by the Avonside Engine Co. in 1866. Another engine of the same general type and dimensions, but differing in details, is shown in Fig. 61, No. 422, being one of twenty engines supplied to the Great Northern Railway in 1865-6 by Messrs. Neilson

and Co., and afterwards rebuilt in the form shown in the illustration during the early years of Mr. Stirling's *régime*.

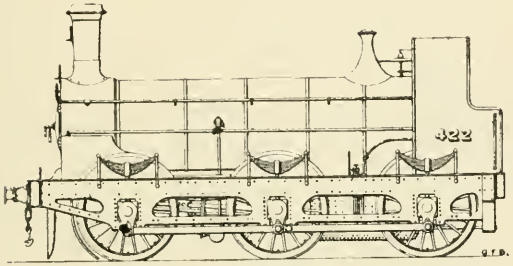


Fig. 61.

PART V.

PATRICK STIRLING. 1874-1895.

REVERTING after this digression into the subject of "rebuilds" to strict chronological order, the next design brought out by Mr. Stirling was embodied in half-a-dozen handy little tank engines which in general dimensions followed somewhat closely the pattern of the rebuilt Nos. 470 and 471, which have already been referred to. In external appearance, however, these new engines were essentially of Mr. Stirling's own design, as can be gathered from an inspection of the accompanying illustration, Fig. 62, which shows the first built, No. 136, all the details being in accordance with the standard fittings adopted at the period. The engines were all built at Doncaster Works in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1874	136	136	1874	149	399
,,	137	137	1875	175	605
,,	138	138	,,	176	604

It will be noticed that, oddly enough, the Doncaster and running numbers of the first three exactly agreed. These engines had inside cylinders 16-in. in diameter with a stroke of 22-in. and six-coupled driving wheels 4-ft. 1-in. in diameter. The wheel-base was 14-ft. 3-in., the leading and driving axles being 7-ft. 3-in. apart from centre to centre, and the frames measured 23-ft. $4\frac{1}{2}$-in. between the

buffer beams, there being an overhang in front of 4-ft. 8-in., and at the rear of 4-ft. 5½-in. The boiler barrel measured 10-ft. in length, with a diameter at the smallest ring of 3-ft. 10½-in., and it was pitched with its centre line 6-ft. 5-in. above the rail level, the top of the chimney being 12-ft. 9-in. above the rails. A comparatively small firebox was provided, the outer casing being only 4-ft. 2-in. in length. The water supply amounted to 1,000 gallons, and was situated in a saddle tank on top of the boiler, while a bunker at the rear of the footplate was provided to carry a

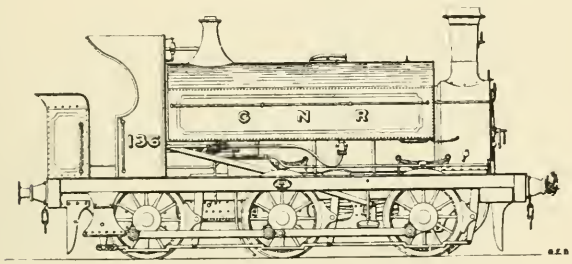


Fig. 62.

few cwt. of coal. At the start these little engines were apparently intended chiefly for shunting work, for which their small heating surface and bunker capacity peculiarly adapted them, but they seem to have proved equal to local goods traffic also, and subsequently Mr. Stirling built further engines, having the same size of driving wheel, for special classes of work, to which attention will be drawn in due course.

In the same year, 1874, Mr. Stirling introduced an important innovation by the adoption of a new size for cylinders, 17½-in. by 26-in., which subsequently became the

standard for the coupled passenger engines and the six-coupled tender and tank goods engines. The first class to receive the enlarged cylinders was a set of 36 six-coupled goods engines which were built at Doncaster during the next seven years, their dates being as follows:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1874	121	372	1878	242	641
,,	122	373	,,	249	642
,,	132	354	,,	252	643
,,	133	198	1879	258	644
,,	155	196	,,	264	645
1875	156	173	,,	267	160
,,	159	340	,,	269	646
,,	161	365	,,	270	133
,,	163	141	,,	273	168
,,	167	163	,,	278	154
,,	169	339	1880	287	640
,,	171	187	,,	292	647
,,	181	328	,,	295	648
,,	182	194	,,	301	649
1876	199	312	,,	304	650
,,	200	314	1881	308	651
1878	237	310	,,	329	102
,,	239	393	,,	330	101

With cylinders 17½-in. by 26-in. and six-coupled driving wheels 5-ft. 1-in. in diameter, these engines were in general

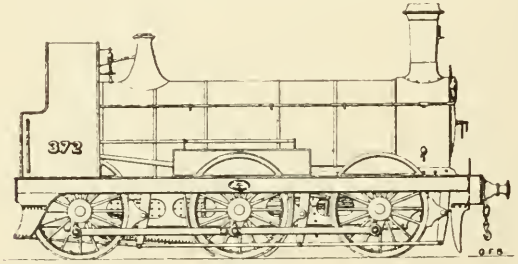


Fig. 63.

dimensions almost exactly similar to the earliest goods locomotives designed by Mr. Stirling, while in external

appearance also, as can be seen from the illustration herewith, Fig. 63, there was little change to be noted. It is possible that, while the boiler dimensions remained unchanged, some difference in the heating surface was effected by altering the numbers and diameters of the tubes. Thus, the 206 tubes of $1\frac{3}{4}$-in. diameter, originally favoured by Mr. Stirling, were afterwards reduced to 186, and in some cases to 169, while the diameter was also reduced to $1\frac{5}{8}$-in.

A demand for new engine power to deal with the

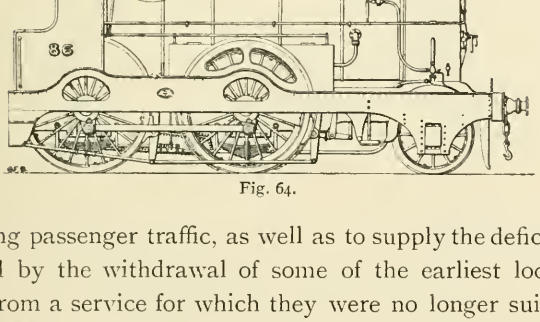


Fig. 64.

growing passenger traffic, as well as to supply the deficiency caused by the withdrawal of some of the earliest locomotives from a service for which they were no longer suitable, caused Mr. Stirling to build a further set of four-coupled passenger engines. The accompanying illustration of the first of these, No. 86, Fig. 64, indicates that the design was in all points very similar to that of Mr. Stirling's maiden effort in 1867. No. 86, however, led off the new departure with cylinders $17\frac{1}{2}$-in. in diameter and 26-in. in stroke, the four-coupled wheels being 6-ft. 7-in. in diameter, with their centres 8-ft. 3-in. apart. The leading wheels were

4-ft. 1-in. in diameter and 9-ft. 8-in. in advance of the driving wheels, centre to centre, thus giving the exceptionally long wheel-base of 17-ft. 11-in. A total heating surface of 992·8 sq. ft. was provided, the firebox yielding 95 sq. ft. and the tubes 897·8 sq. ft. respectively. The weight of the engine in working order was 38 tons 12 cwt., apportioned as follows: leading wheels 12 tons, driving wheels 13 tons 16 cwt., trailing wheels 12 tons 16 cwt. Altogether 19 engines were built to the same general design, the dates and numbers being as here given :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1874	127	86	1879	257	263
,,	128	89	,,	263	51
,,	141	84	,,	271	96
,,	146	90	,,	274	99
1875	186	540	1880	291	223
,,	188	541	,,	294	97
,,	192	542	,,	300	207
1876	193	543	1881	309	226
1877	224	72	,,	310	212
,,	225	80			

The year 1874 also saw the introduction of a new type

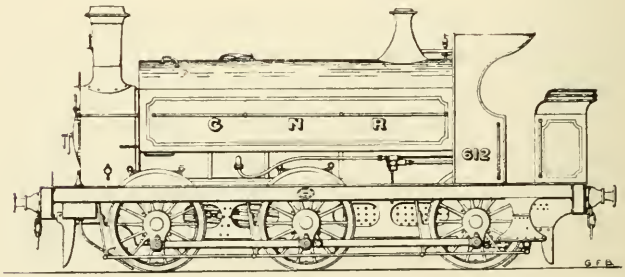


Fig. 65.

of goods engine, having its water supply provided in a

saddle tank above the boiler, and the class at once proved so successful, both for local goods and other traffic, that it has constantly been added to by Mr. Stirling and his successor, until now there are upwards of 200 of these engines on the Great Northern Railway, all practically of the same type, though differing somewhat in dimensions, as in course of time an increase in weight and power has been desirable. The first batch, 35 in all, were of the appearance shown in the illustration (Fig. 65) given herewith, and were of the following dimensions: — the cylinders were 17½-in. in diameter with a stroke of 26-in., inclined downwards towards the driving axle at a ratio of 1 in 8¾; the wheels, six-coupled, measured when new 4-ft. 7-in. in diameter, and occupied a total wheel-base of 15-ft. 6-in., of which 7-ft. 3-in. separated the leading and driving axles, and 8-ft. 3-in. the driving and trailing axles, centre to centre; the frame-plates had a total length between buffer beams of 25-ft. 4-in., the overhang being in front 5-ft. and at the rear end 4-ft. 10-in., and the footplate was at the standard height above the rails of 4-ft. 2-in. The firebox had its front-plate 1-ft. 10½-in. in rear of the driving axle centre, and measured 5-ft. 6-in. in length outside, with a depth below the centre-line of the boiler at either end of 4-ft. 9-in., and the boiler barrel was 10-ft. 1-in. in length, with a diameter at the front ring of 3-ft. 10½-in., its centre being pitched at a height of 6-ft. 7½-in. above the level of the rails. The saddle tank had a capacity for 1,200 gallons of water, and the engine weighed in full working order a trifle over 40 tons. The first engines, to which the above-recorded dimensions particularly apply, were all built at Doncaster at the dates and with the numbers here given:—

Date.	Doncaster No.	Engine No.
1874	130	494
,,	134	495
,,	135	496
,,	143	497
,,	145	498
,,	151	499
1875	177	500
,,	180	601
,,	183	602
,,	190	603
1876	213	606
,,	214	607
1877	217	608
,,	221	609
,,	222	610
,,	223	611
,,	226	612
,,	227	614
1877	228	613
,,	229	615
1878	254	616
1879	255	617
,,	260	618
,,	262	619
,,	268	620
,,	276	633
,,	280	634
1880	282	635
,,	286	636
,,	288	637
,,	293	638
,,	296	153
,,	299	472
,,	302	639
,,	305	473

The six engines of this class built in 1874 had bunkers with sloping backs, similar to those of the earlier engines illustrated in Fig. 41, while some of the class were fitted with short chimneys and safety valve casings for the London Dock traffic.

A demand also arose about this period for those most useful "mixed traffic" engines of which the "Doncaster No. 1" was the prototype, and during the next few years, up to 1879, no fewer than 75 engines of this class were constructed, one-third of the number being built at Doncaster, while the remainder were supplied from "outside." The Doncaster-built engines had the following leading dimensions:—cylinders 17½-in. in diameter with a stroke of 24-in.; driving wheels, coupled in front, 5-ft. 7-in., and trailing wheels 3-ft. 7-in. in diameter respectively. The boiler barrel measured 10-ft. in length with a diameter inside the front ring of 3-ft. 9½-in., and contained 169 tubes 1⅝-in. in diameter, the heating surface being: firebox 94·5

sq. ft. and tubes 743 sq. ft., the total being 837·5 sq. ft. The weight of the engine in working order was 32 tons 3 cwt., distributed as follows:—leading wheels 12 tons 7 cwt., driving wheels 13 tons 12 cwt., trailing wheels 6 tons 4 cwt. It is said that the wheel-base of these engines was only 14-ft. 7-in., of which 7-ft. 3-in. divided the centres of the coupled wheels: but, while a few of the class may have been built of smaller dimensions, the majority appear to have had a wheel-base of at least 15-ft. 2-in., as in the No. 18 class, or possibly of 15-ft. 3-in., as in later engines

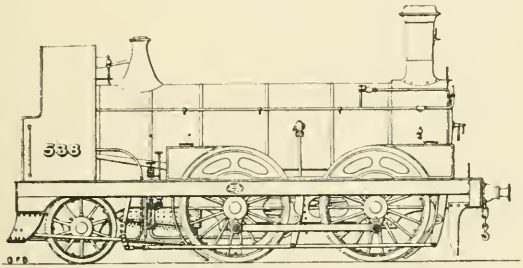


Fig. 66.

of the same general type. The 25 engines built at Doncaster, of which Fig. 66 shows the external appearance, bore the following dates and numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1874	148	74	1875	191	525
,,	154	36	1876	196	526
1875	157	519	,,	197	45
,,	158	518	,,	201	534
,,	160	520	,,	202	527
,,	162	521	,,	204	535
,,	164	26	,,	205	536
,,	166	28	,,	207	538
,,	168	522	,,	210	537
,,	172	523	,,	211	539
,,	174	24	1878	251	57
,,	179	29	1879	256	66
,,	187	524			

The 50 engines built "outside" were of the same general type, as can be seen from the accompanying illustration (Fig. 67), but no details are to hand save that the wheels and cylinders were identical with those of the Doncaster-built batch, and that the total heating surface was 843 sq. ft. as regards the more numerous set. They were delivered in the following order:—

Date.	Engine No.	Builders.	Builders' No.
1875 ..	551-556 ..	Sharp, Stewart & Co. ..	2564-9
1876 ..	557-562 ..	,, ,, ..	2570-5
,, ..	563-572 ..	,, ,, ..	2585-94
,, ..	573-580 ..	,, ,, ..	2646-53
,, ..	581-600 ..	Kitson & Co. ..	2059-78

Those readers who are interested in such matters should take note that the engines' and makers' numbers do not always run in strict agreement, as, for instance, engine

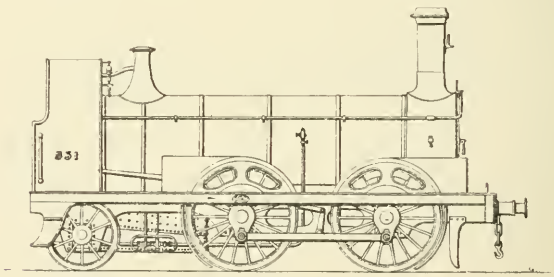


Fig. 67.

Nos. 563 and 564 bear makers' Nos. 2586 and 2585 respectively. The weight of the engines built by Messrs. Sharp, Stewart & Co. is given as 31 tons 13 cwt.

From 1876 onwards a few small passenger engines were built for local services, having four wheels coupled in front and a smaller pair of trailing wheels under the footplate, the water supply being carried in a saddle tank on

top of the boiler. Altogether six of these locomotives were built at Doncaster in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1876	208	501	1877	218	161
,,	209	502	1878	241	631
,,	216	503	,,	244	632

The accompanying illustration (Fig. 68) shows the chief features of the first four, whilst the following are their leading dimensions:—cylinders 17½-in. in diameter and 26-in. length of stroke, coupled wheels 5-ft. 1½-in. in diameter, trailing wheels 3-ft. 7½-in. in diameter. The wheel-base

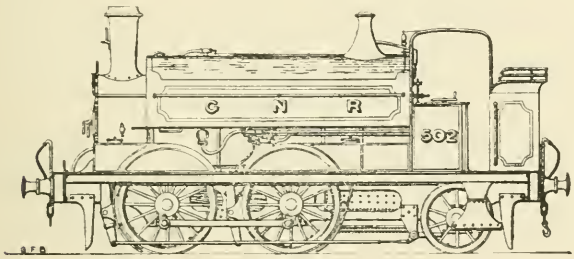


Fig. 68.

measured a total of 15-ft., the coupled wheels being 6-ft. 7-in. apart, centre to centre. Length of frame-plates between buffer beams 24-ft., the overhang being 5-ft. 3-in. in front and 3-ft. 9-in. at rear respectively. The boiler barrel was pitched with its centre-line 6-ft. 9-in. above the rail level, and measured 9-ft. 3-in. in length, with a diameter outside the smallest ring of 3-ft. 10½-in., while the outside firebox had a length of 4-ft. 6-in. The heating surface amounted to a total of 763 sq. ft., of which 74 sq. ft. were contributed by the firebox and 689 sq. ft. by the tubes, and the grate area measured 12¾ sq. ft. In the saddle tank there was a

capacity for 800 gallons of water, while a fair supply of coal was provided for in a bunker at the trailing end 4-ft. 6-in. high, 2-ft. 6-in. long, and extending the whole width of the footplate. The total weight of these engines in working order amounted to 37 tons 5 cwt., allotted as follows:—leading wheels 12 tons 13 cwt., driving wheels 14 tons 5 cwt., trailing wheels 10 tons 7 cwt. It should be noted that Nos. 501 to 503 took the numbers hitherto appropriated by three small tank engines taken over from the Stamford and Essendine Railway in 1875 and broken up after about

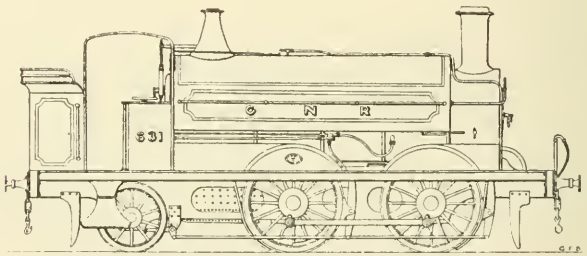


Fig. 69.

a year's service. No details are to hand respecting these original engines, except that they had cylinders 15-in. by 20-in., 13-in. by 18-in. and 11-in. by 22-in.

Nos. 631 and 632 differed from the other four of the class in having cylinders only 16-in. in diameter, with a 22-in. length of stroke. Otherwise, except for a slightly smaller bunker capacity, they were for all practical purposes of the same dimensions and type as No. 502, as can be seen from the accompanying illustration (Fig. 69) showing No. 631.

A further number of coupled passenger engines was

built during the years 1881-3, which differed from the preceding engines of the same type in no essential particular; and they are, for the purposes of this article, divided from the No. 86 class, already illustrated and described, for no other reason than that they were the first of the class to be

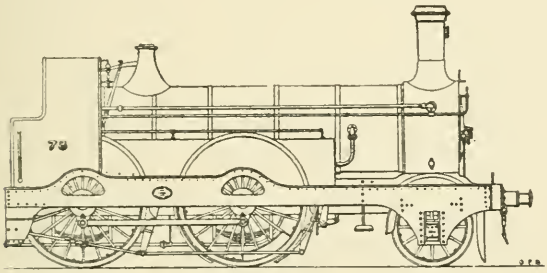


Fig. 70.

provided with plain splashers. As can be seen from the accompanying illustration of No. 78, shown in Fig 70, they were in other details almost precisely similar to the earlier class, and were of the same general dimensions. This order consisted of nine locomotives having the dates and numbers given below:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1881	311	208	1882	343	201
,,	317	227	,,	344	202
,,	322	91	1883	351	699
1882	338	78	,,	352	700
,,	339	88			

The success of the new type of saddle-tank goods engines (illustrated on a previous page) being now beyond question, Mr. Stirling proceeded in 1881 to build a considerable number of new locomotives of the same general type, but differing in a few dimensions, the tank capacity being smaller and the bunker larger than in the pioneers of the

class. The cylinders still retained the original dimensions, 17½-in. in diameter with a stroke of 26-in., and the six-coupled wheels were also of the same diameter, 4-ft. 7-in., and were spaced at intervals between centres of 7-ft. 3-in. and 8-ft. 3-in. from front to back. Over all, however, the new engines were longer than their predecessors, the frame-plate measuring 26-ft. 10-in. in length, with an overhang of 5-ft. 6-in. at front and 5-ft. 10-in. at back respectively. The boiler barrel, which was pitched with its centre-line 6-ft. 7½-in. above the rails, measured 10-ft. 1-in. long, with a

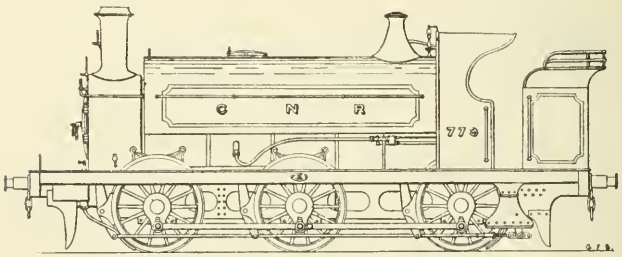


Fig. 71.

diameter outside the smallest ring of 3-ft. 10½-in., and the firebox casing was 5-ft. 6-in. long outside. A total heating surface of 798 sq. ft. was apportioned as follows:—firebox 83 sq. ft., tubes 715 sq. ft., and the grate area was 16 sq. ft. In full working order, with 1,000 gallons of water in the saddle tank, these engines weighed 42 tons 12 cwt., of which 14 tons 6 cwt. were allotted to the leading wheels, 15 tons 8 cwt. to the driving wheels, and the remaining 12 tons 18 cwt. to the trailing wheels. The accompanying illustration of No. 779 (Fig. 71) will afford an idea of the external appearance of these locomotives, which numbered 43, built at the

following dates and with the works and running numbers here given :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1881	315	672	1886	403	787
,,	316	673	,,	404	788
,,	319	674	1887	429	789
,,	325	675	,,	430	790
,,	326	676	,,	439	779
1882	332	677	,,	440	780
,,	333	678	1888	453	801
,,	334	679	,,	454	802
,,	335	680	,,	459	803
,,	340	681	,,	468	804
1883	353	688	1889	481	805
,,	354	689	,,	482	806
,,	355	690	1890	509	397
,,	358	691	,,	511	139
,,	359	692	,,	521	807
,,	360	693	,,	523	808
1885	387	781	1891	527	809
,,	388	782	,,	530	810
,,	399	783	,,	536	851
,,	400	784	,,	538	852
,,	401	785	,,	544	853
1886	402	786			

In 1881 Mr. Stirling brought out a new type of passenger tank engine for local and suburban services. These locomotives were eight-wheeled, having two pairs of driving wheels coupled in front and a trailing bogie, and they differed from the earlier design already illustrated in Figs. 46 and 47 by having the water supply provided in side tanks with the coal bunker distinct behind the footplate. From an inspection of the illustration here given of No. 761, Fig. 72, it will be seen that the general design was very neat and compact, the arrangement of the side tanks, cab and bunker in one piece conducing greatly to that effect, and producing an ample shelter for the men in charge. These engines, 16 in number, were built to the following

dimensions: cylinders 17½-in. by 24-in., diameter of driving wheels 5-ft. 1-in., and of bogie wheels 3-ft. The total wheel-base was 22-ft. 6-in., the coupled wheel centres being 7-ft. 3-in. apart, and the bogie wheel centres 5-ft. From the leading wheel centre to the centre of the bogie pin measured 19-ft. 9-in., the bogie pin being placed 3-in. in advance of the centre of the bogie. The frames measured over all 29-ft. 3-in., the overhang being 5-ft. 3-in. and 1-ft. 6-in. at front and back respectively. Pitched with its centre line 7-ft. 3-in. above the rails, the boiler barrel had a length of

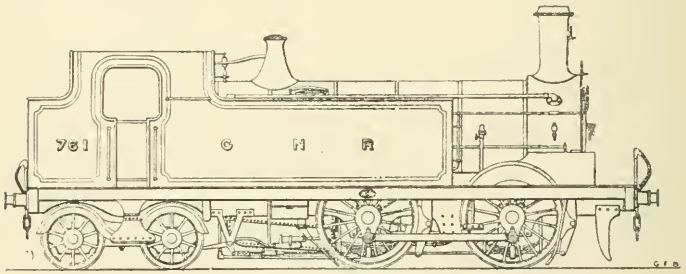


Fig. 72.

10-ft. 1-in., and a diameter outside the smallest ring of 4-ft. 0½-in., while the firebox casing was 5-ft. 6-in. long outside, with a depth below the centre line of 5-ft. 2-in. and 4-ft. 8-in. at front and back respectively. The heating surface of the tubes was 830 sq. ft. The two side tanks collectively had a capacity of 1,000 gallons of water and the bunker held 3 tons of coal, and with these supplies brought the total weight of the engines in working order up to the respectable total of 50 tons 4 cwt. Following is a list of the dates and numbers of the 16 engines comprised in this group:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1881	318	658	1884 ..	369 ..	696
.. ..	327 ..	659	,, ..	372 ..	697
,, ..	328 ..	660	,, ..	375 ..	698
,, ..	331 ..	661	,, ..	376 ..	761
1882 ..	336 ..	682	,, ..	381 ..	762
.. ..	337 ..	683	1885 ..	384 ..	763
1884 ..	363 ..	694	,, ..	385 ..	764
,, ..	365 ..	695	,, ..	386 ..	765

Nos. 694 to 698 and 761 were fitted with condensing apparatus and low chimneys for working on the Metropolitan service. The others were all stationed at Bradford.

As the demand for engine power to work goods traffic was in excess of the supply possible from Doncaster, the Company ordered 35 goods locomotives very similar to the type illustrated in Fig. 63, having cylinders 17½-in. by 26-in., and 5-ft. 1-in. wheels, from "outside" firms in the following order:—

Date	Makers.	Makers' Nos.	Engine Nos.
1882 ..	Vulcan Foundry ..	954-68 ..	716-30
1882 ..	Dübs & Co. ..	1607-26 ..	731-50

A new type of saddle-tank locomotives, substantially of the same general class as those described and illustrated by Fig. 71, but adapted in certain dimensions to suit the requirements of a special traffic, was brought out in 1882, four engines being built of the type in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1882 ..	347 ..	684	1884 ..	364 ..	686
,, ..	348 ..	685	,, ..	366 ..	687

While of the same general design as the previously mentioned class of goods tank-locomotives, these four engines were, apart from having wheels of 6-in. less diameter, slightly modified in detail, because, being intended to work trains over a portion of the Great Eastern and kindred railways in the east-end of London, in the direction

of Poplar, Royal Mint Street and Thames Wharf, it was necessary to reduce their vertical dimensions to suit the loading-gauges at that time in force between the last-named place and Stratford Low Level. With this end in view the boiler was pitched with its centre line no more than 6-ft. 2-in. above the level of the rails, and the chimney and safety valve casing were also reduced so as to keep within a clear height above the rails of 11-ft. 6-in. These engines had the following leading dimensions: the cylinders, which inclined downwards towards the driving axle at the standard slope of 1 in $8\frac{3}{4}$, measured $17\frac{1}{2}$-in. in diameter with a stroke of 24-in. The three pairs of driving wheels were each 4-ft. 1-in. in diameter, and were spaced over a total wheel-base of 15-ft. 6-in., with 7-ft. 3-in. separating the leading and driving axle centres, and 8-ft. 3-in. separating the driving and trailing axle centres. The two single frame plates each measured 26-ft. 10-in. long, the overhang being 5-ft. 6-in. and 5-ft. 10-in. at leading and trailing ends respectively, while the footplate was at the standard height above the rails of 4-ft. 2-in. As usual, the boiler barrel consisted of three telescopic rings, having diameters of 3-ft. $10\frac{1}{2}$-in., 3-ft. $11\frac{1}{2}$-in., and 4-ft. $0\frac{1}{2}$-in. respectively, outside measurement, with a length of barrel 10-ft., the height of the centre line above the rails being 6-ft. 2-in., as already mentioned. The outside firebox was 5-ft. 6-in. long, and was distant 1-ft. $10\frac{3}{4}$-in. from the centre of the driving axle. Over the boiler and firebox was a saddle tank containing 1,000 gallons of water, and the coal was carried in a capacious bunker at the trailing end. The weight of these engines was slightly over 40 tons in working order. It may be mentioned here that the loading gauge has been

raised at Stratford Bridge in recent years, and that these engines, and others to be referred to later, have since been fitted with standard chimneys as they required renewal.

A further supply of mixed traffic engines becoming necessary, in 1882 Mr. Stirling brought out a modified design, in which the severity of his later patterns became apparent. The perforated splashers of earlier days were

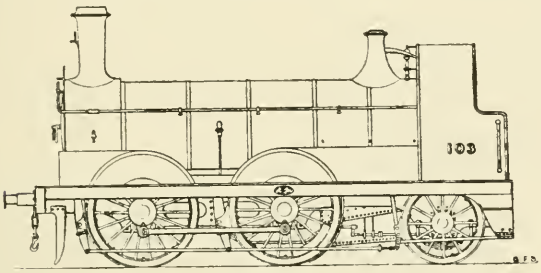


Fig. 73.

abandoned and more simplicity in outward appearance adopted. Fig. 73 shows No. 103, the pioneer of the new type of engines, of which 12 were built during the years 1882 to 1885 inclusive, in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1882	345	103	1884	373	105
,,	346	104	,,	374	106
1883	361	112	1885	391	107
,,	362	113	,,	392	108
1884	370	114	,,	397	109
,,	371	115	,,	398	110

In dimensions these engines differed slightly from those preceding them. The cylinders were still 17½-in. in diameter, with a stroke of 24-in., and the front coupled driving wheels measured, when new, 5-ft. 7½-in. in diameter the trailing wheels, however, being enlarged 6-in., to a

diameter of 4-ft. 1½-in. The wheel-base was 15-ft. 3-in., of which 7-ft. 3-in. separated the centres of the coupled axles, while the frame-plates measured 23-ft. 8-in. over ends, the overhang being 4-ft. 11-in. and 3-ft. 6-in. at leading and trailing ends respectively. The boiler barrel measured 10-ft. in length, with a diameter, outside the smallest ring, of 4-ft. 0½-in., and contained 186 tubes, each 1⅝-in. in diameter; while the firebox shell was 5-ft. 6-in. long outside, with a breadth at the frame-level of 4-ft. 1-in.

In 1883 Mr. Stirling designed a new class of six-coupled

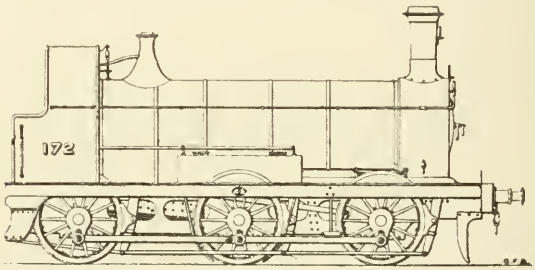


Fig. 74.

tender engines of unusual power, for working the mineral traffic in the West Riding, where the gradients to be surmounted are often as severe as 1 in 50, and the eight engines of this class were consequently known as the "West Riding" coal engines. Their order of building was as follows:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1883	356	374	1887	447	142
,,	357	172	,,	448	188
1885	395	185	1888	457	156
,,	396	189	,,	458	157

In general dimensions and in appearance, as can be seen from the accompanying illustration, Fig. 74, showing

No. 172, these engines were practically of the standard type of goods engine, having 17½-in. by 26-in. cylinders, but a large increase in tractive force was obtained by reducing the diameter of the driving wheels down to 4-ft. 7-in. The engines of this type stood on a total wheel-base of 15-ft. 6-in., divided as usual into sections of 7-ft. 3-in. between the leading and driving axles, and 8-ft. 3-in. between the driving and trailing axles, centre to centre. The frame-plates were unusually long, 24-ft. 5½-in., with an overhang forward of 5-ft. 2-in., and behind of 3-ft. 9½-in., and as usual the height to the footplate was 4-ft. 2-in. Pitched with its centre line 7-ft. 2-in. above the rails, the boiler barrel had a length of 10-ft. 1-in. and a diameter outside the smallest ring of 4-ft. 0½-in. while the firebox shell measured 5-ft. 6-in. in length outside, and was distant 1-ft. 10¼-in. from the driving axle centre. It will be seen that, like the large mineral engines designed by Mr. Stirling in 1872, these locomotives were built for a special traffic.

With the Doncaster works fully occupied, and a growing demand for further engine power for passenger traffic, the locomotive superintendent was compelled at about this date to order a number of standard coupled passenger locomotives from "outside." This order consisted in all of 15 engines, built by Messrs. Kitson & Co., of Leeds, with the following dates and numbers :—

Date.	Makers' No.	Engine No.	Date.	Makers' No.	Engine No.
1883 ..	2479-85 ..	701-7	1884 ..	2486-93 ..	708-15

These engines were, as already stated, practically of standard design, at all events as regards the first seven of them, but in No. 708 a modification of the outside frame-plate was adopted to the extent shown in the accompanying

illustration, Fig. 75, and apparently the change was considered so satisfactory that a very similar modification was introduced into all engines of the class subsequently built at Doncaster. The leading dimensions of these "outside" built engines were substantially in agreement with the standards then prevailing at the Company's own works, the cylinders being 17½-in. in diameter with a 26-in. stroke, the coupled wheels being 6-ft. 7½-in. in diameter, and the leading wheels 4-ft. 1½-in., while the distribution of the wheel-base was also in accordance with the figures already

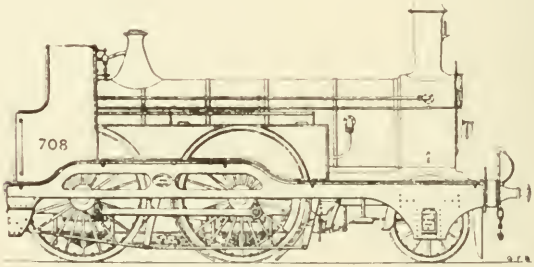
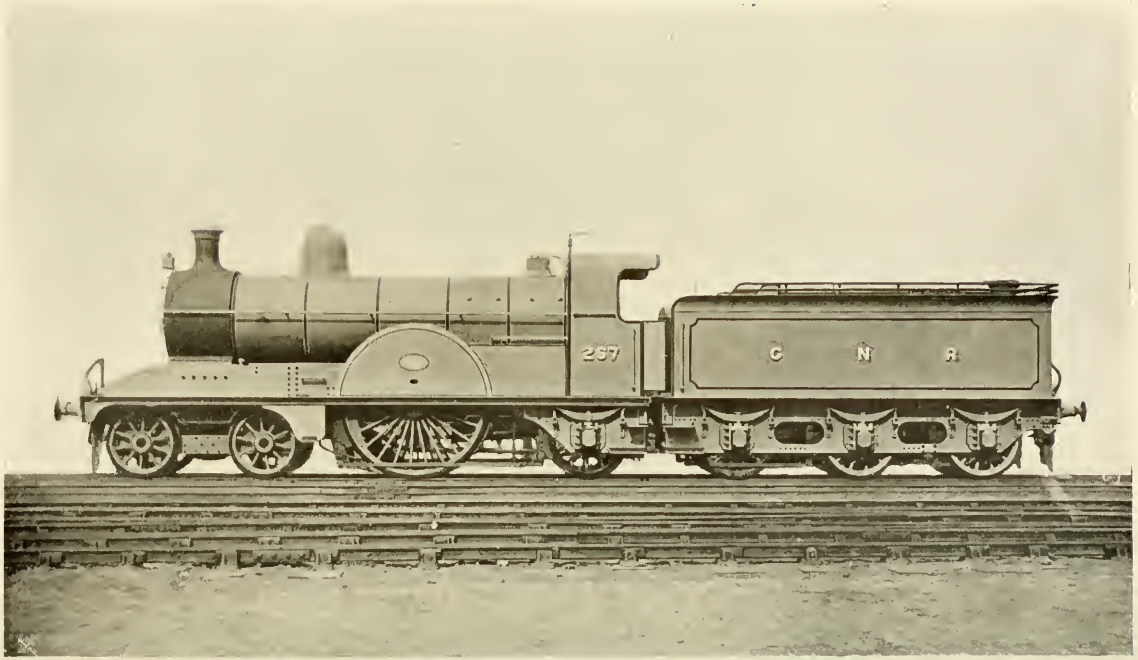


Fig. 75.

quoted. The boiler barrel measured 10-ft. 2-in. in length with a diameter outside the smallest ring of 4-ft. 0½-in., and contained 186 tubes of 1⅝-in. diameter. The internal firebox was 4-ft. 10½-inches long, by 3-ft. 6-in. wide, and afforded a grate area of 16¼ sq. ft. In full working order these engines weighed a total of 38 tons 4 cwt., apportioned as follows: leading wheels 12 tons 15 cwt.; driving wheels 13 tons 16 cwt.; and trailing wheels 11 tons 13 cwt.

In addition to these 15 engines, Mr. Stirling also put in hand at the Doncaster works further similar locomotives, with the newer pattern of frame, except for the



7 ft. 6 in. Bogie Express Locomotive, designed by Mr. H. A. Ivatt. No. 267.

fact that the perforations still retained the shape of the older Doncaster-built engines. These engines came out at intervals during the next three years, in the following order :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1884	367	751	1886	408	228
,,	368	752	,,	421	216
,,	377	206	,,	422	225
,,	378	209	,,	423	755
,,	382	753	,,	424	756
,,	383	754	,,	425	757
1886	405	211	,,	426	758
,,	406	217	1887	437	759
,,	407	224	,,	438	760

Up to this period (1884) 37 of the fine 8-ft. bogie express engines, designed by Mr. Stirling, had been built, all practically identical in details with the original No. 1 of 1870, and with fourteen years' experience in service their designer saw no reason for materially altering the type when a demand for more express engines arose. The construction of a continuation of the class was accordingly entered on at Doncaster, and in the course of the next seven years ten more 8-footers were produced, making in all 47 built to the same general dimensions. Such alterations or modifications as were introduced into this second series were those of detail rather than of principle, being indeed a mere bringing-up of these fine engines into line with the practice prevailing at a given time in respect to all other locomotive stock turned out from Doncaster works. So far as external appearance is concerned, it is sufficient to compare the accompanying illustration, Fig. 76, showing No. 778 as built in 1887, with the original No. 1 already given, to show how little modification became desirable in a space of seventeen years. Otherwise, dealing with changes that are

scarcely apparent in a drawing which shows only the external view of the locomotive, it may be well to refer more particularly to the slight character of the internal changes. Among the first of the alterations was an increase in the diameter of the trailing wheels to the extent of 6½-in., and the substitution of Ramsbottom valves for the original spring-balance safety valves. In the framing, a slight change was made at the trailing end by the replacing of the cast-iron footplate originally used there, by stays made of plates and angle irons. At the leading end also a

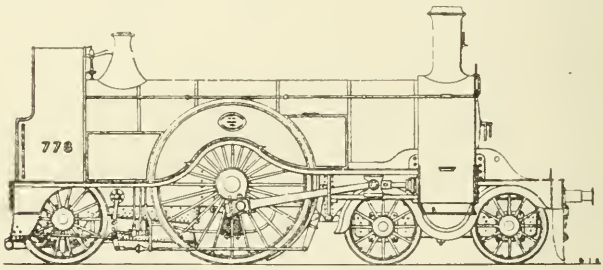


Fig. 76.

slight alteration was made to secure greater strength, and the framing of the bogie was modified in some details. For the later engines of the class a rather heavier driving axle was employed, no doubt in direct consequence of the gradual increase of weight on the driving wheels, the chief enlargement taking effect in the necks receiving the bearings, which were increased to 8½-in. in diameter, in place of the original 8-in. The ordinary plate springs at first used to transmit the weight to the driving wheels were in the very latest engines abandoned in favour of a pair of Timmis' helical springs under each axlebox, while, on the other hand,

the volute springs formerly adopted for the trailing wheels were replaced by plate springs slung under the axleboxes. So far as the boiler and firebox were concerned a few modifications were made and the later engines of the class were provided with the customary brick arch in the firebox in place of the sloping water mid-feather at first furnished for the same purpose, and the injectors were removed from the sides to the footplate end of the firebox, and thence delivered their feed to the middle of the boiler barrel by means of an internal tube which ran across the top of the inside firebox. The boiler barrel was slightly enlarged in diameter, but strangely enough, so it would seem, the heating surface was reduced by the reduction of the number of flue tubes to 174, of a diameter of $1\frac{3}{4}$-in. each, these figures henceforth constituting the standard throughout Mr. Stirling's continuance of office. These engines were built in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1884	379	771	1887	433	776
,,	380	772	,,	441	777
1885	393	773	,,	442	778
,,	394	774	1893	631	1001
1886	427	775	,,	632	1002

It may be interesting to note that Nos. 1001-2 were originally allotted Nos. 264-5, the idea then being to break up the old converted singles bearing those numbers. However, fortunately, for the two historic veterans, other counsels prevailed in the nick of time, and as a sign that they would be granted a further lease of life the two newer engines were in 1894 renumbered as is given above.

Having already dealt in some fulness with the original No. 1 of 1870, it may be instructive to notice closely the parallel dimensions here given of No. 776, built in 1887,

with a view to seeing how little change was effected after an experience of 17 years. The dimensions of No. 776 corresponding to those already given of No. 1 were as follows: diameter of bogie wheels 3-ft. 11½-in.; of driving wheels 8-ft. 1½-in.; and of trailing wheels 4-ft. 7½-in. Wheelbase: bogie wheel centres 6-ft. 6-in.; from hind bogie wheel to driving wheel centres 7-ft. 9-in.; from driving to trailing wheel centres 8-ft. 8-in.; from centre of bogie pin to centre of trailing wheels 19-ft. 5-in.; total wheel-base 22-ft. 11-in. Total length of frame plates 27-ft. 7-in., with an overhang of 2-ft. 2-in. in front, and 2-ft. 6-in. at back; outside buffer beams 28-ft. 1-in.; over buffers 29-ft. 9-in. Cylinders 18-in. in diameter, 28-in. stroke. Boiler barrel 11-ft. 5-in. long, with a diameter outside the smallest ring of 4-ft.; height of centre line above the rails 7-ft. 3½-in.; containing 174 copper tubes, each 11-ft. 9-in. long by 1¾-in. in diameter. Length of firebox casing 6-ft. 2-in.; distance from driving axle centre 1-ft. 9-in.; depth below centre line of boiler, in front 5-ft. 1¾-in., at back 4-ft. 7¾-in. Heating surface: firebox 109 sq. ft.; tubes 936 sq. ft.; total 1,045 sq. ft.; grate area 17·75 sq. ft.; boiler pressure 160 lbs. per sq. in. Total weight of engine, 45 tons 3 cwt., distributed as follows: leading bogie wheels 8 tons 2 cwt., hind bogie wheels, 9 tons 9 cwt., driving wheels 17 tons, and trailing wheels 10 tons 12 cwt. The tender in use for express work in 1887 contained 2,900 gallons of water and 5 tons of coal, and weighed when thus loaded 33 tons 7 cwt. 3 qrs.

Specimens of these 8-ft. engines have been exhibited on different occasions. No. 47 was at the Railway Jubilee Exhibition, held at Darlington in 1875; No. 664 took part in the Stephenson Centenary Exhibition at Newcastle in

1881; and No. 776 was shown, not only at the Newcastle Exhibition of 1887, but also at Edinburgh in 1890. No. 776, by the way, had the old "built-up" chimney, and not the plain cast-iron pattern shown in the drawing of No. 778. With regard to power and speed, these engines have reflected the highest credit on the foresight of their designer, since even at the present day the locomotives which were planned more than thirty years ago are still dealing with the fastest and some of the heaviest traffic on a far from easy road, with ruling gradients of 1 in 200. During Mr. Stirling's long term of office, the use of pilot engines, or double-engine running, as it may preferably be called, was strictly forbidden, and yet trains of from ten to sixteen heavy six-wheeled coaches, giving loads behind the tender of from 150 to 240 tons, were drawn to and from King's Cross at booked speeds ranging from 45 to 55 miles per hour, with regularity and success. The great increase in the weight of trains during the last few years, has, however, at last, begun to tell on locomotives never very superabundantly provided with boiler power, and "pilots" are now often to be seen assisting the eight-footers. Even a later and larger edition of the same engine, which will be dealt with in due course, is almost equally overloaded in meeting present-day requirements, the defect in either case being a want of sufficient boiler power to maintain the maximum efforts now required.

As regards extreme speed, the records published of the now "historic races" to Edinburgh in 1888, and to Aberdeen in 1895, give some remarkable instances. For example, on August 20th and 21st, 1895, respectively, engine No. 668 took a load, reckoned as 101 tons behind

the tender, from King's Cross to Grantham, 105¼ miles, in 104 min. 51 sec. and in 101 min. respectively; while another, No. 775, on August 19th, 20th and 21st, conveyed the same train from Grantham to York, 82¾ miles, in 79 min. 9 sec., 78 min. 9 sec. and 76 min. respectively. In 1888, the best performances of the bogie singles had been, from King's Cross to Grantham, in 111 min. 49 sec., by No. 22, and from Grantham to York in 88 min., by No. 775, the champion also of the later so-called "race." Apart from these special runs, it is worth noting that the ordinary service of the Great Northern Railway demands that on at least half-a-dozen occasions daily it is necessary for the engine to cover a distance of 60 miles in 60 minutes when running between the London terminus and Grantham, up or down, in order to keep time.

In dealing with the 8-ft. bogie engines as originally designed by Mr. Stirling and brought out in the year 1870, it was suggested that he adopted the two main features, of outside cylinders and a leading bogie, as a matter of necessity, not of choice, and there appears to be proof of this theory in the fact that in 1885 he brought out an engine which, though on an enlarged scale throughout, was practically a repetition of the six-wheeled single driving engine of 1868, and which was, nevertheless, intended to perform exactly the same duty as the large bogie engines. This new engine, of which an illustration is given in the accompanying Fig. 77, was immediately followed by another of the same dimensions :—

Date.	Doncaster No.	Engine No.
1885	389	238
,, ...	390	232

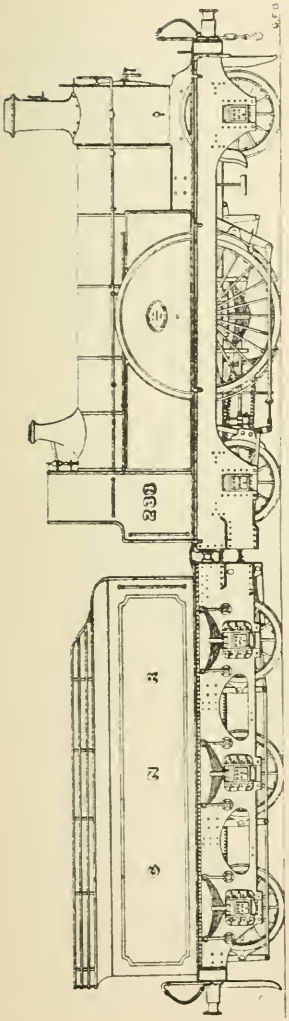


Fig. 77.

The leading particulars of both these fine six-wheeled locomotives were as follows:—diameter of driving wheels 7-ft. 7½-in.. and of leading and trailing wheels 4-ft. 1½-in.; wheel-base: leading to driving wheel centres 9-ft. 9-in., driving to trailing wheel centres 8-ft. 1-in., total 17-ft. 10-in.; cylinders 18½-in. in diameter, with a stroke of 26-in.; boiler, all steel: length of barrel, 10-ft. 6-in., working pressure 150 lbs. to the sq. in., total heating surface 967·8 sq. ft.; frames, of steel, 1¼-in. thick; total weight of engine in working order 39 tons 15 cwt., of which the driving wheels received 17 tons.

The two experimental engines fulfilling expectations, during the next few years more locomotives of the same type were turned out from Doncaster Works in quick succession, to the number of ten, in the following order:—

Date.	Doncaster. No.	Engine No.	Date.	Doncaster. No.	Engine No.
1886	409	234	1887	446	239
,,	410	229	1888	455	231
1887	428	237	,,	456	233
,,	434	230	,,	469	235
,,	445	236	,,	470	240

It will be noted with some regret that these 12 engines took the numbers of Mr. Sturrock's fine 7-ft. singles, which henceforth became relegated to the "A" class.

The second series of these express locomotives were larger throughout than their two prototypes, being built so as to

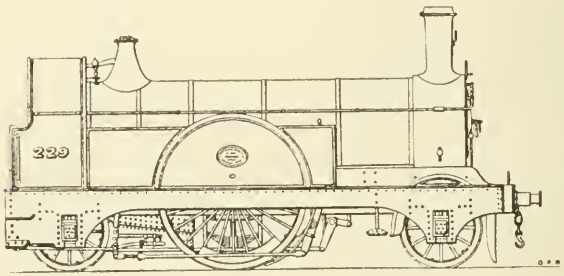


Fig. 78.

take boilers of the standard pattern supplied to the bogie engines of the same date, while their external appearance differed but slightly from that of No. 238, as can be seen from the accompanying illustration, Fig. 78, which shows No. 229. The leading dimensions were as follows: diameter of driving wheels 7-ft. $7\frac{1}{2}$-in., and of leading and trailing wheels 4-ft. $1\frac{1}{2}$-in.; wheel-base: leading to driving wheel centres 10-ft. 8-in., driving to trailing wheel centres 8-ft. 5-in., total 19-ft. 1-in.; length of frameplates 25-ft. 5-in., with an overhang in front of 3-ft. 1-in., and at back of 3-ft. 3-in. Cylinders $18\frac{1}{2}$-in. in diameter with 26-in.

length of stroke; boiler barrel 11-ft. 5-in. in length with a diameter outside the smallest ring of 4-ft.; centre line above rails 7-ft. 6-in., containing 186 tubes, each 11-ft. 9-in. long with a diameter of 1¾-in.; working pressure 160 lbs. per sq. in. Heating surface: firebox 109 sq. ft., tubes 1,001 sq. ft.; total 1,110 sq. ft., grate area 18·4 sq. ft. The firebox casing measured 6-ft. 2-in. long by 4-ft. 0½-in. wide at the bottom. The crank axle was forged of Siemens-Martin steel, with bearings 8¼-in. in diameter and 7-in. long, and with wheel seats of the large size of 9¾-in. The motion consisted of the ordinary open slot link and eccentrics invariably adopted by Mr. Stirling. In full working order engines of this class weighed a total of 39 tons 14 cwt., apportioned as follows: leading wheels 11 tons 18 cwt., driving wheels 17 tons, trailing wheels 10 tons 16 cwt. Empty the engine weighed exactly 3 tons less, the weights then being 11 tons, 15 tons 14 cwt., and 10 tons respectively. The tender carried 2,900 gallons of water and 4 tons of coal and weighed 38 tons 10 cwt.

While cheaper both in first cost and in up-keep than the bogie engines, these six-wheelers were found to be quite as efficient in the conduct of the express traffic. If anything they have proved themselves faster than the larger engines, both as regards the maximum speed for individual miles and the average speed throughout a long run. During the "races" to Edinburgh and Aberdeen respectively, in 1888 and 1895, these engines shared the running of the East Coast trains from King's Cross to York with the 8-ft. singles, and the record run of 1888 was obtained with No. 233, which on August 25th of that year covered the distance between London and Grantham, 105¼ miles, in 105

minutes, or at the average rate of 60·2 miles per hour. So far as coal consumption was concerned, there seemed to be little to choose between the two classes, and though sharing the running with the eight-footers the six-wheelers never superseded them. In fact, the two distinct classes were built, as it were, side by side, and more bogie engines were turned out from Doncaster, as will presently be seen, some time after the building of the six-wheeled engines had ceased.

In 1886, after an interval of nearly five years, Mr. Stirling again found it necessary to provide additional

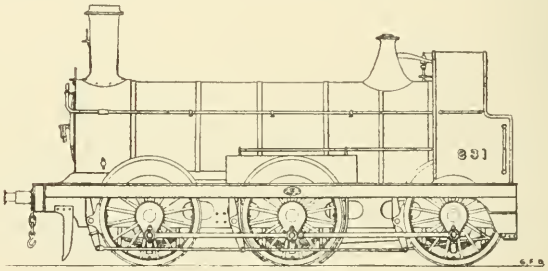


Fig. 79.

six-coupled goods engines, and during the next eight years no fewer than 72 locomotives of the class were built at the Doncaster works. They were generally of what might be termed Mr. Stirling's standard pattern as originally introduced in 1867, but brought up to date in external details and in some few dimensions. The accompanying illustration of No. 831, shown in Fig. 79, conveys an idea of the appearance of these useful engines, the leading dimensions being as here given: cylinders 17½-in. in diameter with a stroke of 26-in.; diameter of six-coupled driving wheels, 5-ft. 1½-in.; wheel-base: leading to

driving wheel centres 7-ft. 3-in., driving to trailing wheel centres 8-ft. 3-in., total 15-ft. 6-in.; length of frame plates 23-ft. 11-in., with an overhang of 5-ft. 2-in. and 3-ft. 3-in. at leading and trailing ends respectively. The boiler barrel was 10-ft. 1-in. in length, with a diameter outside the smallest ring of 4-ft. $0\frac{1}{2}$-in., and was pitched with its centre line 7-ft. 2-in. above the level of the rails. It contained 174 tubes of $1\frac{3}{4}$-in. diameter and the firebox casing measured 5-ft. 6-in. in length outside; the boiler pressure was 160 lbs. per sq. in. A total heating surface of 922·4 sq. ft. was provided in the following proportions: firebox 92·4 sq. ft., tubes 830 sq. ft.; and the grate area was 16·25 sq. ft. In full working order, engines of this class weighed 36 tons 10 cwt., divided as follows: leading wheels 12 tons 18 cwt., driving wheels 14 tons 8 cwt. and trailing wheels 9 tons 4 cwt. The standard tender provided had a total weight of 34 tons 18 cwt. 3 qrs., with its normal supply of 2,800 gallons of water and 5 tons of coal.

The dates, works and running numbers of the 72 engines comprised in this series of goods engines are given in the following table:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1886	411	791	1887	449	176
,,	412	792	,,	450	183
,,	413	793	,,	451	389
,,	414	794	,,	452	147
,,	415	795	1888	460	178
,,	416	796	,,	461	309
,,	417	797	,,	462	150
,,	418	798	,,	463	324
,,	419	799	,,	464	181
,,	420	800	,,	465	321
1887	431	322	1889	475	323
,,	432	307	,,	476	382
,,	443	199	,,	479	300
,,	444	320	,,	480	301

Date.	Doncaster No.	Engine. No.	Date.	Doncaster No.	Engine. No.
1889	487	330	1891	550	838
,,	488	135	,,	552	840
,,	493	170	,,	554	841
,,	494	195	,,	556	845
,,	495	191	,,	558	842
,,	496	383	,,	560	846
1890	501	342	,,	561	843
,,	502	347	1892	563	847
,,	503	175	,,	565	844
,,	505	391	,,	567	848
,,	514	378	,,	569	849
,,	515	370	,,	572	850
,,	522	831	,,	574	317
,,	524	832	,,	575	341
1891	529	833	,,	586	143
,,	533	834	,,	587	346
,,	537	835	,,	592	313
,,	539	385	,,	595	182
,,	541	836	1893	634	319
,,	543	379	,,	637	327
,,	545	837	1894	641	1011
,,	547	839	,,	645	1012

Nos. 1011 and 1012 were originally allotted Nos. 315 and 318 respectively, but subsequently received their numbers as given in the list, and the two old engines bearing the numbers 315 and 318 remained on the list of G.N.R. stock for a little while longer, until Mr. Stirling's successor replaced them by new engines in 1898, as will be seen later.

Several new mixed traffic engines were put in order from 1887 onwards, to the number of 21 in all, built at intervals during the next eight years. In external appearance they were practically identical with No. 103, already illustrated in Fig. 73, so that a separate representation of them is scarcely necessary. They had cylinders 17½-in. in diameter with a stroke of 24-in., with front coupled driving wheels each 5-ft. 7½-in. in diameter and a pair of trailing wheels 4-ft. 1½-in. in diameter. The total wheel-

base measured 15-ft. 3-in., of which 7-ft. 3-in. divided the centres of the coupled axles, and the frame plates had a length of 23-ft. 8-in., with an overhang of 4-ft. 11-in. and 3-ft. 6-in. at leading and trailing ends respectively. The boiler barrel was 10-ft. long, with a diameter outside the smallest ring of 4-ft. 0½-in., the centre line being pitched 7-ft. 2-in. above the rail level, and it contained 174 tubes each 1¾-in. in diameter. The firebox casing measured 5-ft. 6-in. long outside and the boiler pressure was adjusted to 160 lbs. per sq. in. Heating surface was provided as follows: firebox 92·4 sq. ft., tubes 823·6 sq. ft., total 916 sq. ft., and the grate area was 16·25 sq. ft. In working order the engines of this class weighed 35 tons 2 cwt., apportioned as follows: leading wheels 12 tons 16 cwt., driving wheels 14 tons, trailing wheels 8 tons 6 cwt. The tender was of the same weight and capacity as that allotted to the goods engines, previously described.

These mixed traffic engines bore the following dates and numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1887	435	10	1893	611	357
,,	436	12	,,	616	358
1888	466	20	,,	620	957
,,	467	326	,,	625	953
,,	473	42	,,	626	954
,,	474	43	1894	663	955
1891	546	951	,,	664	956
,,	557	952	1895	685	958
1893	602	325	,,	686	959
,,	604	355	,,	687	960
,,	609	356			

Nos. 951 and 952 ran for some months as Nos. 67 and 70, and were renumbered in 1892.

Towards the close of the year 1888 Mr. Stirling brought out the first of his latest class of standard four-coupled

passenger engines, which in all main essentials were almost identical with those which constituted his maiden design on the G. N. R. more than twenty years previously. These later engines, which are illustrated by No. 870, shown in accompanying Fig. 80, numbered 56 in all, and were of the general dimensions here given: cylinders 17½-in. in diameter with a stroke of 26-in.; diameter of leading wheels 4-ft. 1½-in., and of coupled wheels 6-ft. 7½-in.; wheel-base: leading to driving wheel centres 9-ft. 8-in., driving to trailing wheel centres 8-ft. 3-in., total 17-ft. 11-in.; length

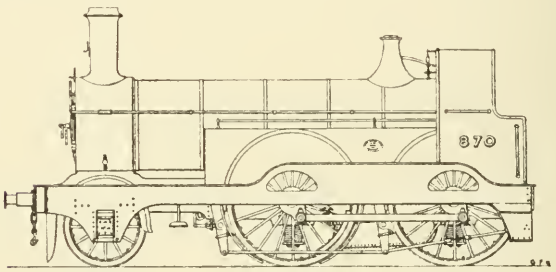


Fig. 80.

of frame plates 24-ft. 11-in., the overhang being 3-ft. and 4-ft. at leading and trailing ends respectively. The boiler barrel measured 10-ft. 2-in. long, with a diameter outside the smallest ring of 4-ft. 0½-in., and was pitched with its centre line 7-ft. 1-in. above the rail level. It contained 174 tubes each 10-ft. 6-in. long and 1¾-in. in diameter. The firebox casing was 5-ft. 6-in. long by 4-ft. 0½-in. wide outside measurement, while the inner firebox measured 4-ft. 9½-in. long by 3-ft. 4½-in. wide. The boiler pressure was 160 lbs. per sq. in., and heating surface was apportioned as follows: firebox 92·4 sq. ft., tubes 836·9 sq. ft., total 929·3 sq. ft., while

the grate area was 16·25 sq. ft. The total weight of engine in working order amounted to 39 tons, distributed as follows: leading wheels 11 tons 10 cwt., driving wheels 14 tons 4 cwt., and trailing wheels 13 tons 6 cwt. An unusually large tender was provided for these engines containing 3,500 gallons of water and 5 tons of coal, its weight as thus loaded amounting to no less than 40 tons 5 cwt. 3 qrs., or considerably over a ton greater than that of the engine to which it belonged.

The 56 engines of this class were built and numbered as follows:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1888	471	210	1892	590	883
,,	472	204	,,	593	884
1889	477	811	,,	596	885
,,	478	812	1893	606	886
,,	483	813	,,	621	887
,,	484	814	,,	622	888
,,	485	815	,,	624	889
,,	486	816	,,	628	890
,,	489	817	,,	633	891
,,	490	818	,,	635	892
,,	491	819	,,	638	893
,,	492	820	,,	639	894
,,	497	213	1894	642	895
,,	498	214	,,	644	896
1890	508	79	,,	646	897
,,	510	87	,,	648	898
1891	532	861	,,	649	899
,,	534	862	,,	650	900
,,	540	863	,,	665	991
,,	542	864	,,	666	992
,,	549	865	,,	667	993
,,	553	866	,,	668	994
1892	578	867	,,	669	995
,,	579	868	,,	670	996
,,	581	881	1895	677	997
,,	584	882	,,	678	998
,,	585	869	,,	679	999
,,	588	870	,,	680	1000

In all, Mr. Stirling built no fewer than 139 engines of this class, a point to which particular attention is drawn,

because, in general admiration of the several types of single-wheel express locomotives on the G. N. R., it is customary to lose sight of the fact that they were a minority as regards numerical importance, whatever may have been their influence in creating and maintaining the reputation of the line for speed.

A new type of front-coupled trailing bogie tank engine, specially fitted for working suburban traffic through the "Underground" to Moorgate Street, etc., was brought out at the close of 1889. Altogether, 25 engines were built of this class, together with four others of slightly different

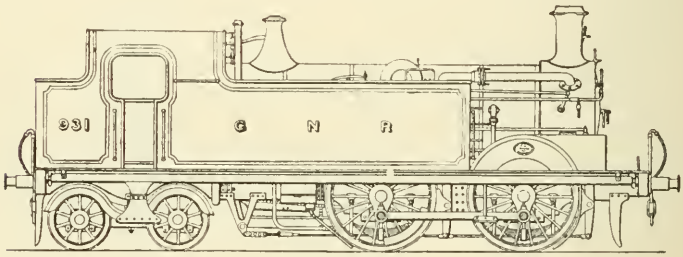


Fig. 81.

dimensions. and they were all provided with appliances for condensing steam in the tunnels, and were also built with shorter chimneys than usual, only 12-ft. 7-in. above the rail level, to meet the exigencies of the "Underground" loading gauge. The external appearance of the engines is shown in the accompanying illustration of No. 931, Fig. 81. The leading dimensions of the 25 engines first built were as follows: cylinders 18-in. in diameter with a stroke of 26-in., angle of inclination towards the driving axle 1 in $8\frac{3}{4}$, driving wheels (four-coupled in front) 5-ft. $7\frac{1}{2}$-in. in diameter, and

bogie wheels 3-ft. in diameter; wheel-base: coupled axles, centre to centre, 7-ft. 3-in., driving axle to leading bogie wheel axle, centre to centre, 10-ft. 3-in.; bogie wheel-base 5-ft., with the bogie pin 3-in. in advance of the centre, thus giving a wheel-base from the leading wheel centre to the centre of bogie pin of 19-ft. 9-in.; total wheel-base 22-ft. 6-in. Total length of frame plates 29-ft. 3-in., the overhang being 5-ft. 3-in. at the leading end and 4-ft. 3-in. at the trailing end, measured from the bogie pin; height of top of outer frame plates 4-ft. 2-in. The boiler barrel was 10-ft. 1-in. in length, with a diameter outside the smallest ring of 4-ft. 0½-in., and it was pitched with its centre line 7-ft. 3-in. above the rail level; length of firebox casing 5-ft. 6-in. Heating surface and grate area were practically identical with those of the latest standard goods engines already described. Capacity of side tanks 1,000 gallons. Empty, engines of this class weighed 45 tons 4 cwt., while in full working order the total was 53 tons 9 cwt., distributed as follows: leading wheels 17 tons 7 cwt. 2 qrs., driving wheels 17 tons 16 cwt., and bogie wheels 18 tons 5 cwt. 2 qrs.

These engines were built at Doncaster and numbered in the order given below :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1889	499	766	1891	531	829
1890	500	767	,,	535	830
,,	504	768	1892	582	931
,,	506	769	,,	583	932
,,	507	770	,,	589	933
,,	512	821	,,	594	934
,,	513	822	,,	598	935
,,	518	823	1893	601	936
,,	519	824	,,	607	937
,,	520	825	,,	610	938
,,	525	826	,,	614	939
1891	526	827	,,	617	940
,,	528	828			

Four more saddle tank locomotives, built specially for service on the line to Thames Wharf, with short chimneys, etc., were brought out at about this time, with the following numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1890	516	134	1892	577	144
,,	517	140	,,	580	149

The engines built in 1892, of which the accompanying illustration, Fig. 82, shows the leading external features, differed from their predecessors of the same type in having the cab and bunker at the trailing end completely closed

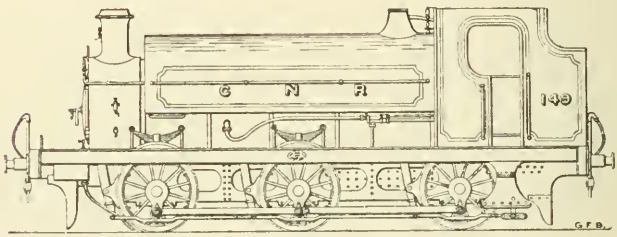


Fig. 82.

in, much after the style already adopted for the bogie tank locomotives dating from 1881 onwards, and to this extent afforded a much desired shelter for the men in charge. Their leading dimensions were as follows: — cylinders, inclining downwards towards the driving axle at the usual slope of 1 in $8\frac{3}{4}$, $17\frac{1}{2}$-in. in diameter with a stroke of 24-in. The six-coupled wheels were each 4-ft. 1-in. in diameter, and were distributed over a total wheel-base of 15-ft. 6-in., of which 7-ft. 3-in. separated the leading and driving, and 8-ft. 3-in. the driving and trailing wheel centres respectively. The two frame plates measured 26-ft. 10-in. in length

between buffer beams, the overhang being 5-ft. 6-in. at the leading end, and 5-ft. 10-in. at the trailing end. Pitched with its centre line 6-ft. 2-in. above the rail level, the boiler barrel measured 10-ft. in length, with a diameter outside the smallest ring of 3-ft. 10½-in., and the firebox casing had a length of 5-ft. 6-in. outside. The total heating surface was 798 sq. ft., the firebox contributing 83 sq. ft. and the tubes 715 sq. ft.; the grate area was 16 sq. ft. As in the previous engines of the same class, the saddle tank had a capacity of 1,000 gallons, and the engine in full working order weighed rather more than 40 tons.

The improved style of cab fitted to the class last dealt with was also adopted for the larger type of standard six-coupled goods tank engines from this time onwards; this was introduced in those built at Doncaster, the last to have an open cab being No. 853, as has already been mentioned, while the next running number, No. 854, started the new style. The completion of the series runs in the following order :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1891	548	854	1892	564	858
,,	551	855	,,	568	859
,,	555	856	,,	570	860
,,	559	857			

Others were delivered from "outside" firms, 20 in all, in the following proportions :—

Date.	Engine Nos.	Builders.	Builders' Nos.
1891	901-10	R. Stephenson & Co.	2751-60
,,	911-20	Neilson & Co.	4398-4407

All these saddle tank goods engines were built to the same general dimensions as were given in reference to the illustration of No. 779 (Fig. 71), preceding.

In 1892 Mr. Stirling brought out a third series of his

six-wheeled single express locomotives with 7½-ft. driving wheels, to the number of 11 in all, thus completing a total of 23 of the same general type. In appearance and dimensions there was no conspicuous difference between the earlier and later sets of the series, as can be gathered from an inspection of the accompanying illustration of No. 876 (Fig. 83), except for the fact that this particular engine and No. 873 were fitted with Davis & Metcalfe's patent exhaust steam injectors. No. 880 is supplied with Macallan's variable blast pipe. The engines were built in the following order :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1892	562	871	1894	652	877
,,	566	872	,,	653	878
,,	571	873	,,	654	879
,,	573	874	,,	655	880
,,	576	875	,,	656	981
1894	651	876			

All the above were built to the following leading dimensions: the cylinders were 18½-in. in diameter with a stroke of 26-in., except in Nos. 871 to 875, which originally had 18-in. cylinders, subsequently enlarged to 18¼, 18¾ or 18½-in. As in the earlier types, the driving wheels measured 7-ft. 7½-in. in diameter with new tyres, and the leading and trailing wheels 4-ft. 1½-in. in diameter, and the wheel-base consisted as before of two divisions, 10-ft. 8-in. and 8-ft. 5-in., making a total of 19-ft. 1-in. between the centre of the leading and trailing wheels. It should be noted, however, that this exceptionally long wheel-base was mitigated to some extent by special play in the leading axleboxes, which eased the engine on curved portions of the road, and the provision of side play has sometimes been understood to imply the use of radial axleboxes. As a matter of fact, the leading axleboxes had

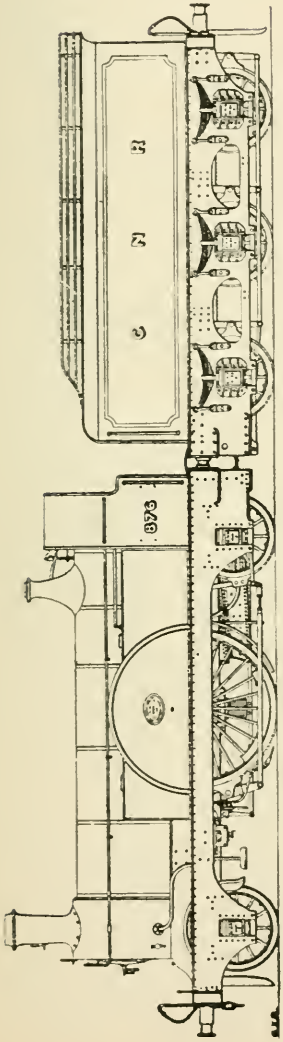


Fig. 83.

free play to the extent of $\frac{7}{16}$-in. on either side of the centre line, thus giving a total freedom of $\frac{7}{8}$-in., but the traverse was at right angles to the line of the engine's motion, and in no sense what is implied by the use of the word "radial." The boiler of this class of engine carried a working pressure of 160 lb. to the sq. in., and had a length of barrel of 11-ft. 5-in., and a diameter outside the smallest ring of 4-ft. It was pitched with its centre 7-ft. 6-in. above the rail level, and the top of the cast-iron chimney was 13-ft. 4-in. above the same datum line. The outside firebox had a length outside of 6-ft. 2-in., and a width at bottom of 4-ft. $\frac{1}{2}$-in., while the firebox itself measured internally 5-ft. $5\frac{1}{2}$-in. long and 3-ft. $4\frac{1}{2}$-in. wide, with a depth at the tube plate end of 5-ft. $8\frac{1}{2}$-in., and at the firehole end of 5-ft. $2\frac{1}{2}$-in. There were

174 tubes measuring 11-ft. 9-in. in length with a diameter of $1\frac{3}{4}$-in., giving a heating surface of 936 sq. ft., which, added to the 109 sq. ft. of the firebox, provided a total of 1,045 sq. ft. The grate area was 18·4 sq. ft. In full working order these engines weighed nearly a ton more than their predecessors, their distribution being: leading wheels 12 tons 4 cwt., driving wheels 17 tons 8 cwt., and trailing wheels 11 tons 1 cwt., or a total of 40 tons 13 cwt. The standard tender had a capacity for 3,500 gallons of water and 5 tons of coal, and weighed, when full, 40 tons 5 cwt. 3 qrs.; but some of the engines were subsequently provided with the largest tenders built for express traffic on the G. N. R., carrying 3,850 gallons of water and weighing 41 tons 14 cwt. 2 qrs. Nos. 875 and 876 were stationed at Doncaster, and earned the name of "trial trip engines," as part of their duties comprised making trial runs with new rolling stock. A splendid photograph of No. 875, which was specially painted in neutral colours for the purpose, was sent to the Chicago World's Fair in 1893.

In the meantime there was still a continued demand for the useful saddle tank engines with six-coupled wheels, and a further ten were built at Doncaster in the years 1892-3, of the prevailing standard dimensions, in the following order:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1892	591	921	1893	605	926
,,	597	922	,,	608	927
1893	599	923	,,	612	928
,,	600	924	,,	613	929
,,	603	925	,,	615	930

Of these, however, Nos. 921 to 926 were fitted with appliances for condensing, so as to be capable of working across London through the "Underground," and the

accompanying illustration, Fig. 84, shows No. 922 as so fitted, a noteworthy feature in the apparatus being the casing towards the front of the saddle tank, which for a

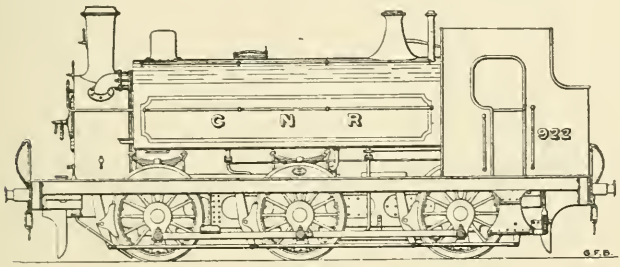


Fig. 84.

time led to the rumour that Mr. Stirling was introducing the steam dome on his later engines.

Hitherto all locomotives of this class had been built with cylinders of the standard dimensions, 17½-in. by 26-in., but at this period the diameter was enlarged to 18-in., and henceforth up to the present day all new engines of this type have been provided with 18-in. by 26-in. cylinders. Under Mr. Stirling's immediate superintendence 20 engines were built at Doncaster with this increase of tractive force, all other dimensions remaining as before, the dates and numbers being as follows:—

Date.	Doncaster No.	Engine No.
1893	618	961
,,	619	962
,,	623	963
,,	627	964
,,	629	965
,,	630	966
,,	636	967
1894	640	968
,,	643	969
,,	647	970
1894	657	971
,,	658	972
,,	659	973
,,	660	974
,,	661	975
,,	662	976
1895	681	977
,,	682	978
,,	683	979
,,	684	980

Of these engines, Nos. 971 to 976 were provided with condensing apparatus.

In 1893, two engines of the outside cylinder bogie type were built at Doncaster, which received originally the Nos. 264 and 265, but were afterwards renumbered 1001 and 1002. These have already been referred to in the list of 8-ft. engines given on page 119.

Mr. Stirling added in 1894 another six engines of the same general type, the only difference being a modification in some of the leading dimensions, and an increase in weight

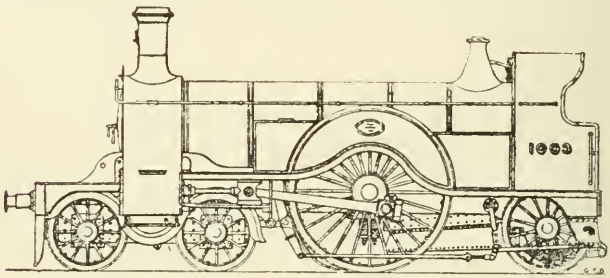


Fig. 85.

and tractive power. Strangely enough, with larger cylinders and more weight available for adhesion, Mr. Stirling provided boilers having less heating surface than in previous engines of the type. Indeed, it will be noted with some surprise that the heating surface of the several engines from the beginning of his career on the Great Northern Railway was on a descending scale, this being particularly noticeable in the large bogie engines. But at the same time, it must be remarked that the firebox and the grate area of the last, about to be mentioned in detail, were larger than before, and it is by these factors, rather than by a huge, but often

inefficient, aggregate of tube-surfaces, that the true evaporative power of a boiler is estimated.* These six engines, the last express locomotives designed by Mr. Stirling, were all built at Doncaster, with the following dates, and works' and running numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1894	671	1003	1895	674	1006
,,	672	1004	,,	675	1007
1895	673	1005	,,	676	1008

In external appearance, as can be seen from the accompanying illustration of No. 1,003, Fig. 85, these engines showed little modification when compared with their predecessors, except with regard, perhaps, to a look of greater compactness caused by an increase of weight and strength in some details, and a trifling alteration of the hitherto prevailing standard pattern of cab, which, in the case under notice, was made to curve backwards some little distance at the top in order to afford a better protection to the engine-men. As will be seen at a later stage, the present locomotive superintendent has still further modified the pattern in the same direction. It will be noticed, moreover, that as the boiler was pitched higher than in preceding engines of this type, Mr. Stirling found it necessary to revert to the built-up form of chimney. The leading dimensions of the new engines were as follows: diameter of bogie wheels 3-ft. 11½-in.; of the driving wheels 8-ft. 1½-in.; and of the trailing wheels 4-ft. 7½-in.; wheel-base: bogie-wheel centres 6-ft. 6-in. (unequally divided as in previous engines of the class), from hind bogie-wheel to driving wheel

* The apparently larger firebox of the No. 1 class, built in 1870, owed some of its heating surface of 122 sq. ft. to the water mid-feather, which was subsequently abandoned in favour of the customary brick arch.

centres 7-ft. 9-in., from driving wheel to trailing wheel centres 9-ft., from centre of bogie pin to centre of trailing wheels 19-ft. 9-in., total wheel-base 23-ft. 3-in. Cylinders, 19½-in. in diameter with a stroke of 28-in., except No. 1008, which was built with cylinders only 19-in. in diameter, a measurement she still retains. The boiler barrel had a length of 11-ft. 1-in. and a diameter outside the smallest ring of 4-ft., and was pitched with its centre-line 7-ft. 6-in. above the level of the rails. It contained 174 tubes, 11-ft. 5 in. long with a diameter of 1¾-in. The boiler-pressure was 170-lbs. per sq. in. An unusually large firebox was provided, the casing having an external length of 6-ft. 8-in., with a breadth at the bottom of 4-ft. 0½-in., while the inside firebox had a length of 5-ft. 11½-in. and a breadth of 3-ft. 4½-in., measured at the base. Heating surface: firebox 121·72 sq. ft., tubes 909·98 sq. ft., total 1,031·70 sq. ft.; and grate area, 20 sq. ft. When originally built, engines of this class weighed a total of 49 tons 11 cwt., which was distributed as follows: bogie wheels 19 tons 12 cwt., driving wheels 19 tons 4 cwt., and trailing wheels 10 tons 15 cwt. Two of these fine engines, however, achieved an unenviable notoriety, No. 1,006 being in the St. Neot's accident on November 10th, 1895, and No. 1,003 in the Little Bytham accident on March 7th of the following year, and the great weight on the driving wheels was thought to have contributed to one or both of these mishaps. Anyhow, a re-adjustment of the load seems to have been effected, for at a later date the weight of No. 1,007 was officially given as follows: bogie wheels 19 tons 15 cwt., driving wheels 18 tons, trailing wheels 11 tons, total, 48 tons 15 cwt. The tenders supplied to these engines

were of the large type, carrying 3,850 gallons of water and five tons of coal, and weighing, thus loaded, 41 tons 14 cwt. 2 qrs.

A modified pattern of the latest standard type of bogie tank engine, fitted for working through the "Underground," was brought out in 1895. Four engines were built to this new design in the following order :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1895	688	941	1895	690	943
,,	689	942	,,	691	944

In external appearance, as can be seen from the accompanying illustration, Fig. 86, these engines were very similar to their predecessors, the chief difference being that the side tanks were shorter. The supply of water was, in fact,

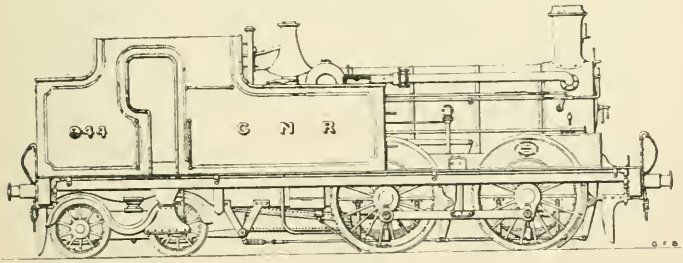


Fig. 86.

divided over the two side tanks and a well tank placed at the rear of the foot-plate, below the coal bunker. In general dimensions these latter engines were almost identical with their forerunners, as will be gathered from the accompanying list. Diameter of driving wheels 5-ft. 7½-in., and of bogie wheels 3-ft. Wheel-base: coupled wheels 7-ft. 3-in., from centre of driving axle to centre of leading bogie axle 10-ft. 9-in., centre to centre of bogie wheels

5-ft., total wheel-base 23-ft. Cylinders 18-in. by 26-in., inclined downwards, as usual, in the ratio of 1 in $8\frac{3}{4}$. Boiler barrel 10-ft. 1-in. long, with a diameter outside the smallest ring of 4-ft. $0\frac{1}{2}$-in.; height of centre above rails 7-ft. 3-in.; and of chimney top above rails 12-ft. 7-in. Firebox casing 5-ft. 6-in. long outside, with a depth below the centre line of the boiler of 5-ft. 2-in. and 4-ft. 8-in., at front and back ends respectively. The weight was approximately the same as in the earlier engines, but rather differently distributed.

With the introduction of this type of engine, Mr. Stirling's career may be said to have finished, for the illness which resulted in his death came about shortly afterwards, and terminated fatally on November 11th, 1895. So far as his reputation as a designer of new and successful types of locomotives is concerned, the foregoing brief historical notes will, it is to be hoped, assist in showing him to have been a man of strong convictions and with the courage to put his theories into practice. He deserves, indeed, to rank among the great locomotive superintendents of the age, not perhaps on account of any very startling originality of design or ingenious application of new principles, but certainly in consideration of the uniform excellence of his work and its peculiar aptness for the duty it was intended to perform. To so great an extent was his influence felt in the history of the railway company that to mention the G.N.R. at any time without coupling with consideration of it the name of Patrick Stirling is equivalent to that much-quoted hypothetical case of playing "Hamlet" with the title-rôle carefully omitted.

Table II.

List of G.N.R. Locomotives, Designed by Mr. Patrick Stirling, Built in the years 1867-1896.

Date.	Description.	Driving Wheels.	Cylinders.	First of Type.	Reference to Doncaster List.	Number of Engines built.	Where built.
		ft. in.	ft. in	No.			
1867	Coupled Passenger	6 7	17 × 24	280	—	20 built	Outside
1867	Front-coupled Mixed Traffic	5 7	17 × 24	18	**A**	46 ,,	Doncaster
1867	Six-coupled Goods.....	5 1	17 × 24	474	—	20 ,,	Outside
1868	Six-wheel Single.....	7 1	17 × 24	4	**B**	12 ,,	Doncaster
1868	Six-coupled Saddle Tank..	5 1	17 × 24	392	**C**	8 ,,	,,
1868	Six-wheel Radial Tank	5 7	17½ × 24	126	**D**	13 ,,	,,
1869	Six-coupled Goods.....	5 1	17 × 24	369	**E**	17 ,,	,,
1870	Six-wheel Single.....	7 7	17½ × 24	92	**F**	1 ,,	,,
1870	Bogie Single	8 1	18 × 28	1	**G**	37 ,,	,,
1871	Coupled Passenger.....	6 7	17 × 24	261	**H**	2 ,,	,,
1871	Six-coupled Mineral	5 1	19 × 28	174	**I**	6 ,,	,,
1872	Six-coupled Saddle Tank..	4 1	16 × 22	471	**J**	2 ,,	,,
1872	Bogie Well Tank	5 7	17½ × 24	120	**K**	22 ,,	,,
1873	Rebuilds of "Sharpies" ..	—	—	43	**L**	4 ,,	,,
1874	Six-coupled Saddle Tank ..	4 1	16 × 22	136	**J2**	6 ,,	,,
1874	Six-coupled Goods.....	5 1	17½ × 26	372	**E2**	36 ,,	,,
1874	Coupled Passenger.....	6 7	17½ × 26	86	**H2**	19 ,,	,,
1874	Six-coupled Goods Tank ..	4 7	17½ × 26	494	**M**	35 ,,	,,
1874	Front-coupled Mixed Traffic	5 7	17½ × 24	74	**A2**	25 ,,	,,
1875	Front-coupled Mixed Traffic	5 7	17½ × 24	551	—	50 ,,	Outside
1876	Front-coupled Saddle Tank	5 1	17½ × 26	501	**N**	4 ,,	Doncaster
1877	Bogie Well Tank	5 7	17½ × 24	621	**K2**	26 ,,	,,
1878	Front-coupled Saddle Tank	5 1	16 × 22	631	**N2**	2 ,,	,,
1881	Coupled Passenger.....	6 7	17½ × 26	208	**H3**	9 ,,	,,
1881	Six-coupled Goods Tank ..	4 7	17½ × 26	672	**M2**	43 ,,	,,
1881	Bogie Side Tank.....	5 1	17½ × 24	658	**O**	16 ,,	,,
1882	Six-coupled Goods.....	5 1	17½ × 26	716	—	35 ,,	Outside
1882	Six-coupled Saddle Tank ..	4 1	17½ × 24	684	**J3**	4 ,,	Doncaster
1882	Front-coupled Mixed Traffic	5 7	17½ × 24	103	**A3**	12 ,,	,,
1883	Six-coupled Mineral	4 7	17½ × 26	374	**P**	8 ,,	,,
1883	Coupled Passenger.....	6 7½	17½ × 26	701	—	15 ,,	Outside
1884	Coupled Passenger.....	6 7½	17½ × 26	751	**H4**	18 ,,	Doncaster
1884	Bogie Single	8 1½	18 × 28	771	**G2**	10 ,,	,,
1885	Six-wheel Single.....	7 7½	18½ × 26	238	**Q**	2 ,,	,,
1886	Six-wheel Single.....	7 7½	18½ × 26	234	**Q2**	10 ,,	,,
1886	Six-coupled Goods.....	5 1½	17½ × 26	791	**E3**	72 ,,	,,
1887	Front-coupled Mixed Traffic	5 7½	17½ × 24	10	**A4**	21 ,,	,,
1888	Coupled Passenger	6 7½	17½ × 26	210	**H5**	56 ,,	,,

List of G.N.R. Locomotives, designed by Mr. Patrick Stirling—*continued.*

Date.	Description.	Driving Wheels.	Cylinders.	First of Type.	Reference to Doncaster List.	Number of Engines built.	Where built.
		ft. in.	ft. in.	No			
1889	Bogie Side Tank.....	5 7½	18 × 26	766	**R**	25 built	Doncaster
1890	Six-coupled Saddle Tank..	4 1	17½ × 24	134	**J4**	4 ,,	,,
1891	Six-coupled Goods Tank ..	4 7½	17½ × 26	854	**M3**	7 ,,	,,
1891	Six-coupled Goods Tank ..	4 7½	17½ × 26	901	—	20 ,,	Outside
1892	Six-wheel Single.....	7 7½	18½ × 26	871	**Q3**	11 ,,	Doncaster
1892	Six-coupled Goods Tank	4 7½	17½ × 26	921	**M4**	10 ,,	,,
1893	Six-coupled Goods Tank ..	4 7½	18 × 26	961	**M5**	20 ,,	,,
1894	Bogie Single	8 1½	19½ × 28	1003	**G3**	6 ,,	,,
1895	Bogie Side and Well Tank	5 7½	18 × 26	941	**R2**	4 ,,	,,
1896	Six-coupled Mineral	4 7½	17½ × 26	1021	**P2**	10 ,,	,,
1896	Six-coupled Goods Tank ..	4 7½	18 × 26	1046	—	15 ,,	Outside
1896	Six-coupled Goods.....	5 1½	17½ × 26	1031	—	15 ,,	,,
1896	Six-coupled Goods.....	5 1½	17½ × 26	1081	**E4**	10 ,,	Doncaster

PART VI.

H. A. IVATT, 1896-1902.

ON the death of Mr. Patrick Stirling at the close of the year 1895, Mr. H. A. Ivatt was appointed locomotive engineer of the Great Northern Railway. At the time of accepting this new and distinctly honourable post of succeeding so distinguished a locomotive superintendent as Mr. Stirling, Mr. Ivatt held the same position on the G. S. and W. Railway of Ireland, and the new chief of the G. N. loco. department brought with him from across the Irish Sea a deservedly high reputation which has certainly suffered in no degree from his change of scene. As some time had necessarily to elapse, however, before he was able completely to relinquish his former duties to take up the newer, it was not until the close of 1896 that any engine exclusively of his design made its appearance on the Great Northern metals. In the interval a certain number of engines were, indeed, placed upon the line, but they were practically built to Mr. Stirling's standard patterns.

For example, during the interregnum fifteen engines of the six-coupled goods tank class were ordered from outside, to which were allotted the following numbers :—

Date.	Engine Nos.	Builders.	Builders' Nos.
1896	1046-60	Neilson & Co.	5017-31

Of these, Nos. 1056 to 1060 were built to condense their own steam.

Other engines in hand between the death of one and the succession of the other locomotive superintendent included ten goods engines similar in almost every respect to the powerful mineral engines introduced on the West Riding service in 1883, having six-coupled wheels 4-ft. 7½-in. in diameter, and 17½-in. by 26-in. cylinders. The outside appearance of these engines is shown in the accom-

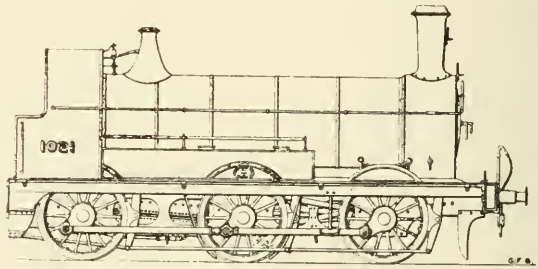


Fig. 87.

panying illustration of No. 1021, Fig. 87, and they were all built at the Doncaster Works of the company with the following running and shop numbers :—

Date.	Doncaster Nos.	Engine Nos.
1896	692-701	1021-1030

In addition a continuation of the series of standard six-coupled goods engines was in hand, these locomotives having 5-ft. 1½-in. driving wheels and 17½-in. by 26-in. cylinders. Twenty-five were built, partly at Doncaster and partly "outside," in the following proportions :—

Date.	Builders.	Builders' Nos.	Engine Nos.
1896 ..	G. N. R. Co. ..	702-711 ..	1081-1090
,, ..	Dübs & Co. ..	3370-3384 ..	1031-1045

Nearly at the close of the year 1896 Mr. Ivatt produced from the Doncaster Works his first passenger engine designed for the G. N. R., which was allotted the running

Ten-wheel Express Locomotive, with Vestibule Train. No. 984.

No. 400, and in its details marked a new departure so far as this particular line was concerned. In reality, however, this locomotive contained no startling novelties. It was not designed for express traffic, but was merely an improved development of the four-coupled passenger engines already in use, having the same size of driving wheels and cylinders as had been adopted by Mr. Stirling for many years. Apart from these main characteristics, nevertheless, there was abundant evidence of a change of *régime*, the principal external indications being the employment of a leading

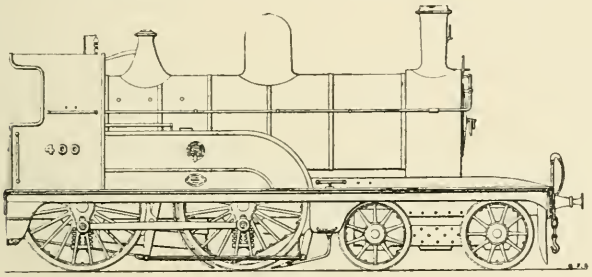


Fig. 88.

bogie and the presence of a steam dome on the boiler barrel. As can be seen from the accompanying Fig. 88, No. 400 differed also in external details of lesser importance, changes being made in the shape of the cab, in the driving-wheel splashers and in the position of the sandboxes. This engine had cylinders 17½-in. in diameter with a stroke of 26-in., their distance apart from centre to centre being 2-ft. 4½-in., thus allowing a fairly generous space for the valves to be placed between them. The steam ports measured 14-in. by 1½-in., and the exhaust ports 14-in. by 3½-in.; and the valves had a maximum travel of 4⅛-in., with

a lead in full gear of $\frac{5}{32}$-in. and an outside lap of $1\frac{1}{8}$-in. In nearly every respect this maiden design has constituted a standard for future reproduction. The bogie, of the swing link type, had four wheels each having a diameter on the tread, when new, of 3-ft. $7\frac{1}{2}$-in., the centres of the two axles being 6-ft. 3-in. apart, with the bogie pin $1\frac{1}{2}$-in. to the rear of the central position, thereby causing two unequal divisions of 3-ft. and 3-ft. 3-in. between the bogie pin and the trailing and leading bogie wheels respectively. The two pairs of coupled wheels, 6-ft. $7\frac{1}{2}$-in. in diameter, had their centres 8-ft. 3-in. apart, and from the driving wheels to the rear pair of bogie wheels there was a distance of 6-ft. 9-in., centre to centre, the total wheel-base of the engine being 21-ft. 3-in. Between buffer beams the frame plates measured 27-ft. 7-in., the overhang being 2-ft. 5-in. in front, or 5-ft. 8-in. reckoned from the bogie pin, and 3-ft. 11-in. at the trailing end. It will be noted that Mr. Ivatt substituted a steel plate buffer beam at the leading end in place of the "sandwich" beam adopted by his predecessor. Apart from the addition of a steam dome, Mr. Ivatt has modified the design of the boiler by the reduction of the three telescopic rings standardized by Mr. Stirling to two, and the employment of a thicker gauge of plate to stand the increased working pressure of 170 lbs. per sq. in., $\frac{9}{16}$-in. in place of $\frac{1}{2}$-in. The barrel of the boiler measured 10-ft. 1-in. long, with a diameter outside the smallest ring of 4-ft. $3\frac{7}{8}$-in., and it was pitched with its centre line 7-ft. $5\frac{1}{2}$-in. above the level of the rails. At the leading end was a smokebox having an external length of 2-ft. $10\frac{1}{4}$-in. and provided with a cast-iron chimney of standard G. N. pattern. The firebox casing had an outside length of 5-ft. 6-in., a maximum

external width of 4-ft. $6\frac{1}{8}$-in. at the centre line of the boiler and of 4-ft. $0\frac{1}{2}$-in. at the bottom, and was built throughout of $\frac{9}{16}$-in. plate. The firebox itself was of copper and had a length at the top of 4-ft. $9\frac{3}{4}$-in., and at the bottom of 5-ft. $0\frac{1}{4}$-in., a width at the top of 3-ft. 8-in. and at the bottom of 3-ft. $6\frac{3}{4}$-in., and a height in front of 5-ft. 11-in., and at back of 5-ft. $5\frac{3}{16}$-in., all inside measurements, while the side and back plates were $\frac{9}{16}$-in., and the tube plate was $\frac{3}{4}$-in. in thickness. Firebox and casing were held together by means of 665 copper stays $\frac{7}{8}$-in. in diameter. Within the barrel of the boiler were packed 215 copper tubes 10-ft. $4\frac{3}{8}$-in. long between plates, and $1\frac{3}{4}$-in. in outside diameter, with a thickness of 10 S. W. G. at the firebox end and 12 S. W. G. at the smokebox end. The steam dome had an inside diameter of 2-ft. In the matter of heating surface this engine showed a distinct increase on its predecessors, the total being 1,123·8 sq. ft., of which 103·1 sq. ft. were contributed by the firebox and 1,020·7 sq. ft. by the tubes; the grate area measured 17·8 sq. ft. A total weight in full working order of 44 tons 7 cwt. was distributed as follows: bogie wheels 16 tons 9 cwt., driving wheels 14 tons 9 cwt., and coupled wheels 13 tons 9 cwt. The tender was of a somewhat modified type, having the tank arranged in horseshoe fashion, and with gauge cocks fitted at the foot-plate end to show the amount of water at any time remaining in the tank. It was carried on six wheels, each 4-ft. $1\frac{1}{2}$-in. in diameter, equally spaced over a wheel-base of 13-ft. There was a capacity of 3,287 gallons of water and 200 cubic feet of coal, the weight of the tender empty being 18 tons 12 cwt. 2 qrs. and loaded 38 tons 6 cwt. In all, eleven engines were built at Doncaster to this initial

design in the following order :—

Date.	Doncaster Nos.	Engine Nos.
1896	712	400
1897	723-732	1071-1080

No. 1,080, however, differed from the rest in having a plain cast-iron safety valve cover of the ordinary Ramsbottom pattern in place of the polished brass column adopted throughout by Mr. Stirling.

Immediately following the first of the above class came a set of ten engines of similar type and dimensions, except

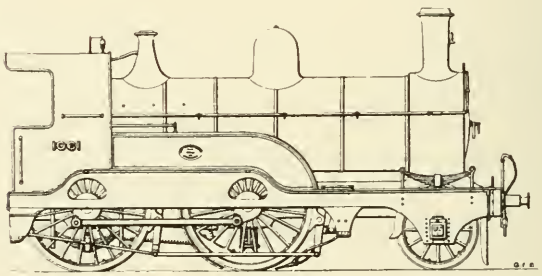


Fig. 89.

for the fact that they had only a single pair of leading wheels instead of a bogie, and heavy outside plate frames of the Stirling pattern. The leading wheels were 4-ft. 1½-in. in diameter and placed in advance of the driving wheels to the extent of 9-ft. 8-in., the total wheel-base being 17-ft. 11-in. The overhang of the frames was 3-ft. at the leading end and 3-ft. 11-in. at the trailing end. It will be noted from the accompanying illustration, Fig. 89, that the springs of the leading wheels were placed above the running plate, a position which renders them easier of access for inspection and repairs, though perhaps less neat than Mr.

Stirling's system of concealing them between the frames. In the same way the removal of the sandboxes from the front of the driving-wheel splashers to a situation below the running plate allows much-desired facilities for getting at the motion. The boilers of these six-wheeled engines were identical in every respect with that of No. 400, already described. In full working order the engines weighed a total of 41 tons 10 cwt., distributed as follows: leading wheels 13 tons, driving wheels 15 tons, trailing wheels 13 tons 10 cwt. and the new standard tender was supplied, weighing 38 tons 6 cwt. when fully loaded. The numbers of these locomotives are given below:—

Date	Doncaster Nos.	Engine Nos.
1897	713-722	1061-1070

It should be noted that the first three of these engines were built with a plain black beading round the driving splashers, while Nos. 1064-1070 had the outer edge finished off with a brass rim.

Mr. Ivatt's next contributions to the locomotive stock of the railway consisted of a further supply of the six-coupled

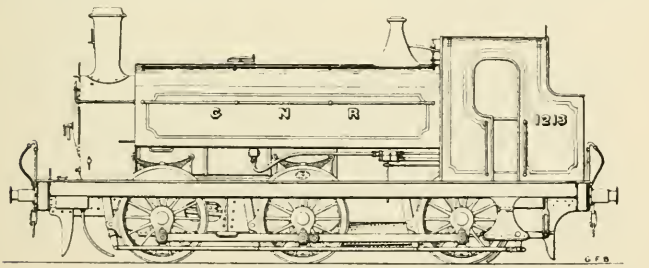


Fig. 90.

goods engines with saddle tanks which had originally been introduced by his predecessor. The new engines, however, presented certain modifications of details, and were heavier,

though the chief alterations visible to outside observation consisted in the introduction of a steam dome, and the abolition of the brass column surrounding the Ramsbottom safety valves. Comparatively few of these engines were put in hand at the Doncaster Works, the greater proportion of the total of 52 so built under Mr. Ivatt's directions being the product of outside firms, as the following list shows:—

Date.	Builders.	Builders' Nos.	Engine Nos.
1897 ..	G. N. R. Co. ..	733 ..	111
,, ..	,, ..	734 ..	155
,, ..	,, ..	735-744 ..	1201-1210
,, ..	Neilson & Co. ..	5095-5099 ..	1211-1215
1898-9 ..	R. Stephenson & Co. ..	2921-2930 ..	1216-1225
1899 ..	Sharp, Stewart & Co. ..	4471-4495 ..	1226-1250

A peculiar feature of the five engines built by Messrs. Neilson & Co. was that they had no domes, and still retained the safety valve brass column. These engines are shown in the accompanying illustration, Fig. 90, which represents No. 1213. The same features were also preserved in

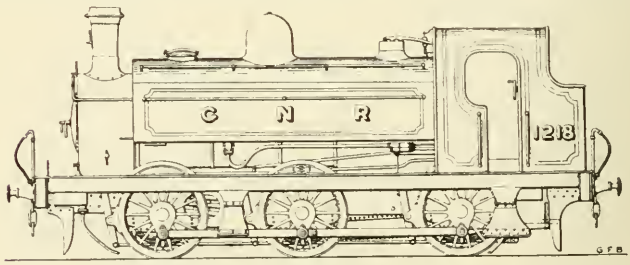


Fig. 91.

Nos. 111 and 155, built at Doncaster. It is possible that these particular engines were in reality built to the Stirling specifications, though dated so late as 1897. As regards the others, however, they bear unmistakable signs of a later design, as can be seen from Fig. 91, which shows No. 1218 of the Stephenson set, and is sufficiently indicative of the appear-

ance of all, except for very trifling differences of detail in such matters as the position and shape of the supplementary step on the running plate, etc. The leading dimensions of Nos. 1201-1210, 1216-1250 particularly, were as follows: cylinders 18-in. in diameter with a stroke of 26-in., diameter of driving wheels 4-ft. $7\frac{1}{2}$-in.; wheel-base: leading to driving wheels 7-ft. 3-in., driving to trailing wheels 8-ft. 3-in., total 15-ft. 6-in.; length of frame plates 27-ft. 6-in., with an overhang of 5-ft. 11-in. and 6-ft. 1-in. at leading and trailing ends respectively. The boiler was of Mr. Ivatt's standard pattern, consisting of two telescopic rings each of plate $\frac{9}{16}$-in. thick, the smaller of which had an outside diameter of 4-ft. $3\frac{7}{8}$-in., but forming a barrel measuring slightly more than usual, 10-ft. 6-in. The centre of the boiler was pitched at a height of 7-ft. 1-in. above the rail level, and the barrel contained 215 tubes each having an outside diameter of $1\frac{3}{4}$-in. The firebox was of the standard dimensions already given in detail in describing Mr. Ivatt's coupled bogie engine. A total heating surface was provided of 1,164·23 sq. ft., the tubes yielding 1,061·13 sq. ft., and the firebox 103·1 sq. ft., and the grate area measured 17·8 sq. ft. In full working order these engines weighed 51 tons 14 cwt., distributed as follows: leading wheels 16 tons 7 cwt., driving wheels 18 tons, and trailing wheels 17 tons 17 cwt.

Towards the close of 1897 and the beginning of 1898, a series of coupled passenger engines with leading bogies was brought out. As can be seen from the accompanying illustration, Fig. 92, which shows No. 1312, these were practically the same as No. 400, already described, except for the introduction of the ordinary iron casing to the Ramsbottom safety valves, which had already been adopted

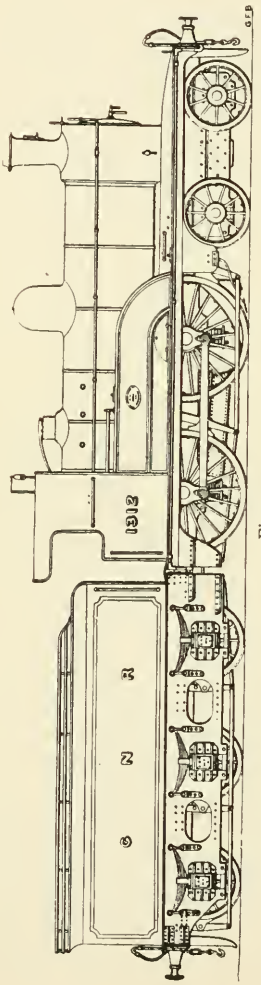


Fig. 92.

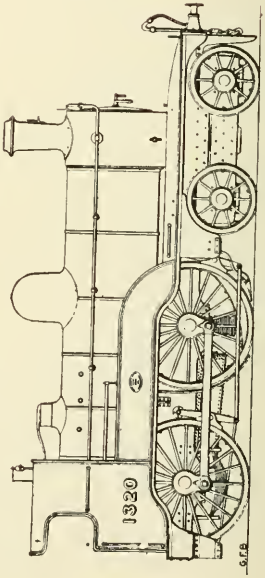


Fig. 93.

on No. 1080, as previously mentioned. In dimensions these engines were throughout identical with their prototype, so that a recapitulation of the figures already given is unnecessary here. The numbers of the engines in question were as follows :—

Date.	Doncaster Nos.	Engine Nos.
1897	745-754	1301-1310
1898	759-768	1311-1320

Of these the engines built in 1897 had a brass beading round the driving-wheel splashers, while Nos. 1311-20 had a black beading. No. 1320 differed from the rest by having the running plate raised at the driving wheels to clear the coupling rods, a detail which has since been adopted on other engines. This engine is illustrated separately in Fig. 93.

A tank engine of quite a new design, intended for local services, was introduced upon the G. N. R. in 1898, having ten wheels, inside cylinders, and side tanks, with a coal

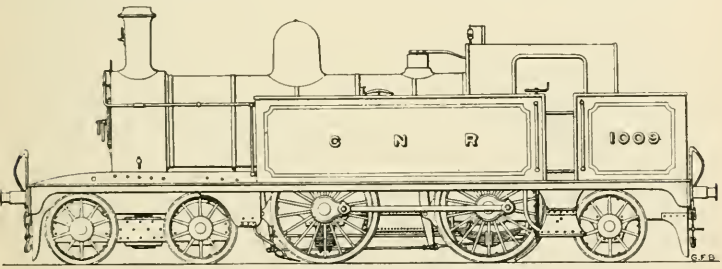


Fig. 94.

bunker at the trailing end. No. 1009, shown in the accompanying Fig. 94, was the first one of this class, which has so far comprised ten engines having the following dates and numbers :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1898	755	1009	1898	789	1016
,,	756	1010	,,	790	1017
,,	757	1013	,,	791	1018
,,	758	1014	,,	796	1019
,,	788	1015	,,	797	1020

As originally built, Nos. 1009 and 1010 had ordinary rigid axle boxes to the trailing wheels, whilst the rest were provided with radial axle boxes in order to secure greater flexibility of wheel-base. No. 1009 also differed from the others in having its Doncaster number plate at the front end of the tank instead of on the frame. In all other respects the engines of the class were identical, and they were built as nearly as possible to the standard dimensions introduced by Mr. Ivatt, according to the following official figures: the bogie and trailing wheels had a diameter of 3-ft. $7\frac{1}{2}$-in., and the coupled wheels had a diameter of 5-ft. $7\frac{1}{2}$-in. Wheel-base: bogie wheels, centre to centre 6-ft. 3-in., with the bogie pin only 3-ft. in advance of the hind bogie wheel axle; from hind bogie axle to driving axle, centre to centre 6-ft. 9-in.; coupled axles, centre to centre 8-ft. 3-in., and from centre of hind coupled axle to centre of trailing axle 6-ft. The frame plates had a total length of 33-ft. $3\frac{3}{4}$-in., with an overhang of 2-ft. 5-in. and 3-ft. $7\frac{3}{4}$-in. at the leading and trailing ends respectively. Cylinders $17\frac{1}{2}$-in. in diameter with a stroke of 26-in. The boiler was pitched with its centre line 7-ft. 6-in. above the rail level, and had a barrel measuring 10-ft. 1-in. long, and 4-ft. $3\frac{7}{8}$-in. in diameter outside the smallest ring. It contained 215 tubes of $1\frac{3}{4}$-in. outside diameter, and was provided with a smoke-box measuring 2-ft. $8\frac{7}{8}$-in. in length outside, and with a firebox casing having an outside length of 5-ft. 6-in. The working pressure of the boiler was

170 lbs. per sq. in., and the heating surface was made up to a total of 1123·8 sq. ft., of which the firebox contributed 103·1 sq. ft., and the tubes 1020·7 sq. ft., while the grate area measured 17·8 sq. ft. The capacity of the tanks was 1350 gallons, and of the coal bunker 50 cwt., and in full working order engines of this class weighed a total of 59 tons 15 cwt., distributed as follows: Bogie wheels 15 tons 10 cwt., driving wheels 16 tons 15 cwt., coupled wheels 17 tons, and trailing wheels 10 tons 10 cwt. These ten engines were not provided with appliances for condensing, and were fitted with cast-iron chimneys of the usual height, so that they were not adapted for Metropolitan traffic involving trips through the "Underground;" but subsequently other engines of the same general type and dimensions, but with special modifications fitting them for tunnel work, were built.

So far, Mr. Ivatt had not designed any locomotives for the express passenger traffic of the line, his coupled engines of the No. 400 class being intended for general work which might include express passenger service, but equally comprised express goods and special traffic. About the middle of 1898, however, he produced from the Doncaster Works a passenger express locomotive of a type novel in this country, and far exceeding in power and capacity any engine so far built for the G. N. R. This engine, No. 990, of which the accompanying illustration, Fig. 95, shows the external characteristics, had, as can be seen, outside cylinders and two pairs of coupled driving wheels, with a four-wheeled bogie at the leading end and small pair of trailing wheels under the back end of the firebox, thus embodying the general characteristics of what is now generally known

as the "Atlantic" type. The cylinders, which were placed at a slight inclination, were 18¾-in. in diameter, with a stroke of 24-in., with their centre lines distant transversely to the extent of 6-ft. 5½-in., and they drove the second pair of coupled wheels by means of connecting rods having the somewhat unusual length of 10-ft. between centres. The steam ports measured 1½-in. by 16-in., and the exhaust ports 3½-in. by 16-in., and the valves had an extreme range of travel of 4½-in. The coupled wheels had a diameter on the tread of 6-ft. 7½-in., and were placed with their centres

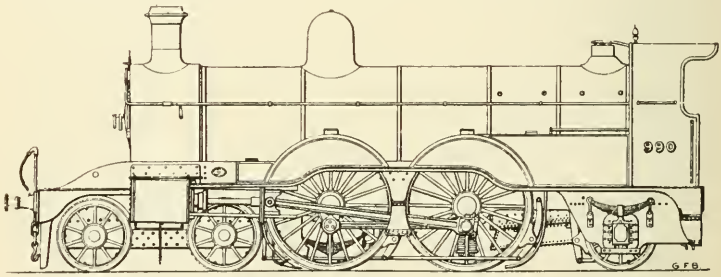


Fig. 95.

6-ft. 10-in. apart, and the distance of the centre of the trailing axle from the centre of the driving axle was 8-ft., thus giving a total rigid wheel-base of 14-ft. 10-in. In reality, however, the rigid wheel-base is restricted to the distance between the coupled axles, as there is allowance made for lateral play in the trailing-wheel axle-boxes. The bogie was of standard design, having four wheels each of 3-ft. 7½-in. diameter spread over a wheel-base of 6-ft. 3-in., with the bogie pin 1½-in. to the rear of the centre, and the second pair of bogie wheels was in advance of the leading pair of coupled wheels to the extent of 5-ft. 3-in. centre to centre,

the total wheel-base being 26-ft. 4-in. The single inside frame plates measured 33-ft. $0\frac{3}{4}$-in., having an overhang of 2-ft. 5-in. and 4-ft. $3\frac{3}{4}$-in. at leading and trailing ends respectively. It will be noted that the trailing axle has outside bearings in a supplementary outside frame plate, thereby ensuring a greater transverse space for the firebox. Apart from the foregoing, a large degree of interest was centred in the boiler, which was of exceptional pattern and dimensions. The barrel, which was pitched with its centre line 7-ft. 11-in. above the rail level, measured 14-ft. $8\frac{5}{8}$-in. in length, with a diameter outside the smallest ring of 4-ft. 8-in. This extreme length, however, was not utilized exclusively for tube heating surface, as the leading end of the barrel was recessed to the amount of 1-ft. $11\frac{1}{4}$-in., so as to provide an extension of the smokebox capacity, and this arrangement curtailed the length of the tubes to 13-ft. between the end plates. The tubes were 191 in number, and were of an outside diameter of 2-in. The firebox casing had a length of 8-ft. and a depth below the centre line of the boiler of 5-ft. 6-in. in front, and 5-ft. at back, and these ample measurements allowed of the use of a firebox having the very generous heating surface of 140 sq. ft., and with a grate area of 26·75 sq. ft. The total heating surface equalled 1,442 sq. ft., the tubes contributing 1,302 sq. ft., and a working pressure of 175 lbs. per sq. in. was provided. It is obvious that a still larger nominal heating surface could have been obtained by reducing the diameter of the tubes and increasing their number, but this would be in opposition to Mr. Ivatt's theory and practice. In full working order the engine weighed 58 tons, distributed as follows: bogie wheels 15 tons, first

pair of coupled wheels 15 tons, driving wheels 16 tons, and trailing wheels 12 tons. An unusually large tender was provided, having a capacity for 3,670 gallons of water and 5 tons of coal, and weighing 40 tons 18 cwt. when thus loaded, the total weight of engine and tender being 98 tons 18 cwt. This engine, which has recently been honored by receiving the name "Henry Oakley," was given the running No. 990, its works number being No. 769, and it has proved so successful that ten new engines have been built of practically similar design and dimensions. It may be interesting to note that in these big engines Mr. Ivatt has placed the regulator in the steam dome, and has reverted from the standard G. N. R. push and pull handle to the two-armed pattern moving across the back of the firebox in a sector plate.

Following the totally new departure in locomotive design just referred to, Mr. Ivatt brought out an enlarged pattern of the eight-wheeled bogie passenger locomotive, its principal features of difference from the No. 400 class being in respect to the use of a larger boiler and firebox, this latter causing a greater length of wheel-base between the coupled axles, while the larger boiler, pitched at a higher level from the rails, produced a return to the "built-up" form of chimney in place of the standard cast-iron pattern which had been in vogue during the later years of Mr. Stirling's rule at Doncaster. These features of resemblance and difference are indicated in the accompanying illustration, Fig. 96, which shows No. 1321, the first of the class. Five engines were built at Doncaster of this modified type with the following numbers :—

Date.	Doncaster Nos.	Engine Nos.
1898	770-774	1321-1325

The leading dimensions were: cylinders 17½-in. by 26-in.; diameter of bogie wheels 3-ft. 7½-in., and of coupled wheels 6-ft. 7½-in.; wheel-base: bogie 6-ft. 3-in., divided unequally; bogie pin to driving axle, centre to centre 9-ft. 9-in.; coupled axles, centre to centre 9-ft.; total wheel-base 22-ft.; length of frame plates 28-ft. 1-in., with an overhang of 2-ft. 5-in and 3-ft. 8-in. at leading and trailing ends respectively. The boiler had a length of barrel of 10-ft. 1-in., its centre line being pitched 7-ft. 11-in. above the rail level, and was formed of two rings, that nearest the smokebox having an

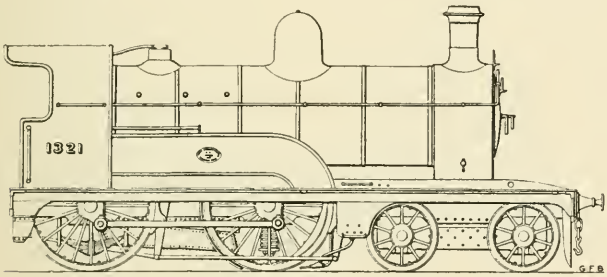


Fig. 96.

outside diameter of 4-ft. 9⅛-in., while the second ring, which lapped inside the first ring and the firebox covering, had an outside diameter of 4-ft. 8-in. The smokebox measured 2-ft. 10¼-in. long outside and the firebox casing was 6-ft. 4-in. long. Inside the boiler barrel were 238 tubes, each 10-ft. 4⅜-in. long, with an outside diameter of 1¾-in. The heating surface was: firebox 119·9 sq. ft., tubes 1,129·9 sq. ft., total 1,249·8 sq. ft., the grate area being 20·8 sq. ft. The safety valves were pressed to 170 lbs. per sq. in. In working order engines of this class weighed 47 tons 10 cwt., distributed as follows: bogie 16 tons 10 cwt., driving

wheels 17 tons, and trailing wheels 14 tons. A standard tender, weighing 40 tons 18 cwt., with its full complement of fuel and water, was provided.

At about this time ten new goods engines built by an "outside" firm were put to work, their numbers being :—

Date.	Engine Nos.	Builders.	Builders Nos.
1897 ..	1091-1095 ..	Dübs & Co. ..	3546-50
1898 ..	1096-1100 ..	,, .	3551-55

They occupied, in appearance, a half-way position between the Stirling and Ivatt *régimes*, having the late superintendent's pattern of cab and brass safety-valve casing in

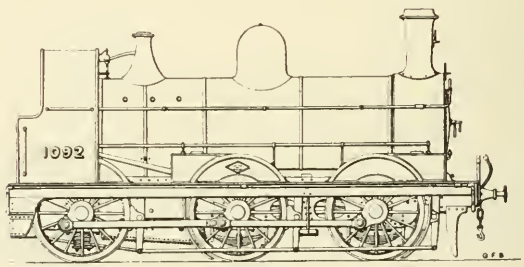


Fig. 97.

conjunction with his successor's new design of frame and standard type of boilers, as is shown in the accompanying illustration, Fig. 97. Their dimensions were as follows: cylinders 17½-in. by 26-in.; diameter of six-coupled wheels 5ft. 1½-in.; wheel-base: leading to driving wheel centre 7-ft. 3-in., driving to trailing wheel centre 8-ft. 3-in., total wheel-base 15-ft. 6-in., length of frames 24-ft. 5½-in., with an overhang of 5-ft. 2-in. and 3-ft. 9½-in. at leading and trailing ends respectively. The boiler was of exactly the same dimensions throughout as the standard pattern adopted in No. 400, and was pitched with its centre-line

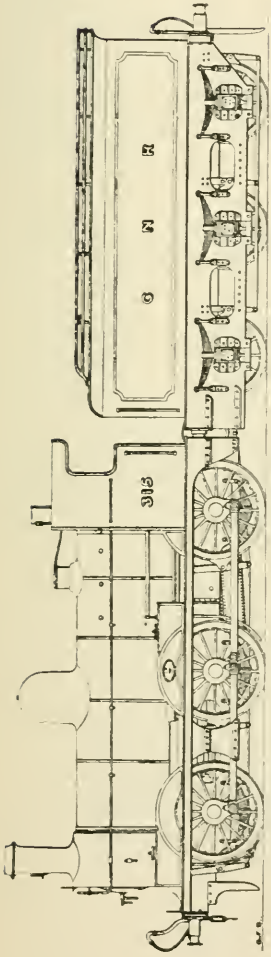


Fig. 98.

7-ft. 3½-in. above the rail level. In working order these engines weighed a total of 38 tons 8 cwt., distributed as follows: leading wheels 14 tons, driving wheels 15 tons 2 cwt., and trailing wheels 9 tons 6 cwt.

Immediately following these engines came ten built at Doncaster bearing odd numbers:—

Date.	Doncaster No.	Engine No.
1898 ..	775 ..	315
,, ..	776 ..	316
,, ..	777 ..	318
,, ..	778 .	329
,, ..	779 ..	331
,, ..	780 ..	332
,, ..	781 ..	334
,, ..	782 ..	336
,, ..	783 ..	337
,, ..	784 ..	338

As can be seen from the accompanying illustration, Fig. 98, which shows No. 315 with its tender, these engines had the new standard boiler throughout, even to the iron safety-valve casing and the new cab. The frame was also of the new and modified pattern and differed also in respect to having a cast-iron drag box

at the trailing end, which, in adding to the weight of the engine generally, caused a better distribution on the last pair of coupled wheels, the figures being: leading wheels 14 tons 11 cwt., driving wheels 15 tons 4 cwt., and trailing wheels 11 tons 10 cwt., or a total of 41 tons 5 cwt. In general dimensions they were precisely similar to the class last mentioned, so that it is unnecessary to recapitulate the various items.

Coincidently with these engines built at Doncaster, a further thirty-five exactly similar locomotives were under construction "outside," their numbers being:—

Date.	Builders.	Builders' Nos.	Engine Nos.
1898 ..	Dübs & Co. ..	3695-3699 ..	1101-1105
1899 ..	,, ..	3700-3729 ..	1106-1135

Having obtained satisfactory results from the new and enlarged bogie passenger engines recently described, Mr. Ivatt undertook the construction of a number embodying the same general features, but differing somewhat in external appearance, as can be gathered from Fig. 99, which illus-

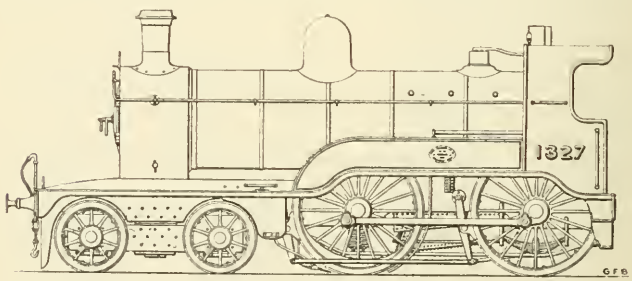


Fig. 99.

trates No. 1,327. It will be noted that, while in main dimensions these engines were exactly identical with Nos. 1321-5 as regards cylinders, boilers, wheels and frames, and

even weight, they had the outside running plate raised to clear the coupling rods, as is shown, this modification having been already tried on No. 1,320, one of the smaller bogie engines, as was mentioned at the time. These new locomotives also differed from their five predecessors in having a larger smokebox, measuring 3-ft. $5\frac{1}{2}$-in. in length outside. In all, 20 engines were built during 1898-9 (all at Doncaster) to the pattern shown in the accompanying illustration: their dates and numbers being as follows:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1898	785	1326	1899	852	1336
,,	786	1327	,,	853	1337
,,	792	1328	,,	854	1338
,,	793	1329	,,	855	1339
,,	794	1330	,,	856	1340
,,	795	1331	,,	857	1361
,,	798	1332	,,	858	1362
,,	799	1333	,,	859	1363
,,	800	1334	,,	860	1364
,,	801	1335	,,	861	1365

No. 1331 was fitted with Marshall's valve gear in order to test that device on passenger work.

Quite a new departure was made at this period by the production of an express locomotive with single driving wheels and a leading bogie, but with cylinders placed inside the frames. As can be seen from Fig. 100, this engine, which received the running No. 266 (Doncaster Works No. 787, 1898), was of exceptionally fine appearance. It was built on generous lines and in respect to the aggregate of dimensions seems almost to mark the extreme limits permissible by the English loading gauge to an engine of this type. The driving wheels were 7-ft. $7\frac{1}{2}$-in. in diameter and were driven by cylinders 18-in. in diameter with a stroke of 26-in., with steam and exhaust ports measuring 16-in. by $1\frac{1}{2}$-in., and

16-in. by 3½-in. respectively. The leading end of the engine was carried by a bogie of standard dimensions, having four wheels each 3-ft. 7½-in. in diameter, with their axles 6-ft. 3-in. apart centre to centre. At the trailing end were a pair of wheels 4-ft. 1½-in. in diameter, and it will be noted that the bearings and springs of these wheels were placed outside, the main frames being adapted at the rear of the driving wheels to secure this end, and thus giving greater stability to the engine as a carriage. The wheel-base was divided as follows: bogie wheels 6-ft. 3-in. (as already

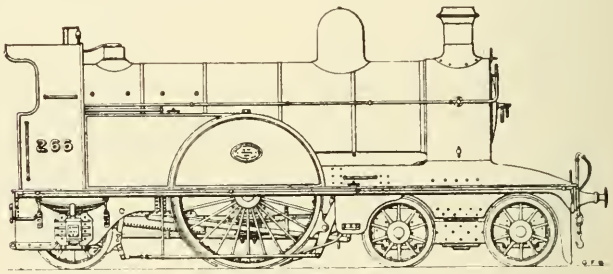


Fig. 100.

mentioned), from centre of trailing bogie wheels to centre of driving wheels 7-ft. 9-in., from centre of driving wheels to centre of trailing wheels 9-ft., thus giving a total of 23-ft. The frames measured 28-ft. 8-in. over all, with an overhang of 2-ft. 8in. and 3-ft. at the leading and trailing ends respectively, and they were of a very massive character, as can be judged in part from the appended illustration. In the matter of boiler power, Mr. Ivatt has throughout been more liberal than his predecessor, and No. 266 was no exception to the rule. Its boiler had a barrel formed of two telescopic rings, having a combined length of 11-ft. 4-in.,

and a diameter outside the two rings of 4-ft. $3\frac{7}{8}$-in. and 4-ft. 5-in. respectively, the plates being $\frac{9}{16}$-in. thick to withstand the working pressure of 170 lbs. per sq. in. In order to accommodate this diameter of barrel the boiler was pitched with its centre line 8-ft. 3-in. above the level of the rails. At the leading end was a capacious smokebox having an outside length of 3ft. $3\frac{7}{8}$-in. and the firebox casing measured 7-ft. in length. Inside the barrel of the boiler were 215 copper tubes, 11-ft. $7\frac{3}{8}$-in. long between the tube plates and with an outside diameter of $1\frac{3}{4}$-in. The heating surface reached a total of 1,269·6 sq. ft., of which 125·8 sq. ft. were contributed by the firebox, and 1,143·8 sq. ft. by the tubes, and the firegrate area was 23·2 sq. ft. In full working order the engine weighed 47 tons 10 cwt., apportioned as follows: bogie wheels 17 tons 10 cwt., driving wheels 18 tons, and trailing wheels 12 tons. The tender was of the large pattern, weighing 40 tons 18 cwt. with its complement of 3,670 gallons of water and 5 tons of coal.

Following this came a number of bogie passenger locomotives similar in all respects to the No. 1301 class already illustrated and described. These were built at Doncaster in the following order :—

Date.	Doncaster Nos.	Engine Nos.
1898	802-811	1341-1350

These retained the straight form of outside frame in contradistinction to the curved pattern tentatively adopted on No. 1320, definitely accepted for the No. 1326 class of large passenger engines, and subsequently also taken as the standard for future engines of the smaller type.

To meet the requirements for more engine power for trains in the Metropolitan district twenty new locomotives

were built. These were tank engines of the ten-wheel type introduced at the beginning of 1898, slightly modified to render them specially suitable for running through the tunnels of the "Underground." In general dimensions they were identical with their forerunners of the No. 1009 class, save that they were all fitted with condensing apparatus, and that all except the first were supplied with short chimneys of the built-up pattern, with a height above the rails of only 12-ft. $5\frac{5}{8}$-in., and a corresponding reduction in the height of the steam dome in order to clear the loading

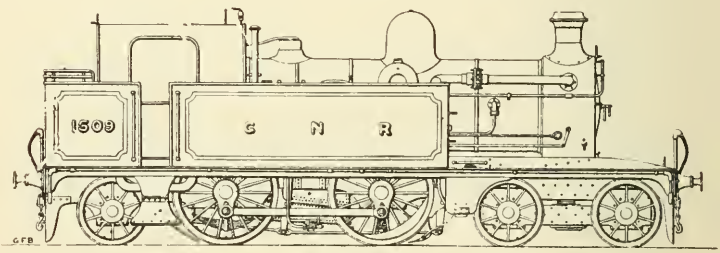


Fig. 101.

gauges of the Metropolitan Railway. These modifications give the engines the appearance of being larger, especially as regards the boiler barrel, than those without condensing arrangements, but the only differences between the two classes are those already stated, and an increase in weight in the condensing engines to a total of 62 tons 2 cwt. distributed as follows: bogie wheels 16 tons 10 cwt., driving wheels 18 tons, coupled wheels 16 tons 12 cwt., and trailing radial wheels 11 tons. The capacity of the tanks and bunkers was also the same in the two classes, namely, 1,350 gallons and $2\frac{1}{2}$ tons respectively. Fig. 101 shows the

external appearance of these locomotives, except so far as No. 1501 was concerned, this particular engine having the longer cast-iron chimney and larger steam dome of the earlier non-condensing class; as a consequence it is not employed on the London service. These engines were built at Doncaster in the following order:—

Date.	Doncaster Nos.	Engine Nos.
1899	812-821	1501-1510
1899	832-841	1511-1520

At this time a number of the older goods engines on the line were getting past work, and it became necessary to supply their places by new stock, besides making requisite additions to cope with increased traffic. The Doncaster Works being actively employed, it became necessary to give substantial orders to outside firms. It happened that at this time the locomotive builders in this country were fully engaged on orders to a degree that prohibited all idea of early delivery, and to meet the situation it was necessary to look to other sources of manufacture for supply, and accordingly twenty locomotives were ordered from the Baldwin Locomotive Works, Philadelphia, with a more or less free hand as regards general design. These engines were delivered ten at a time with most praiseworthy expedition, being shipped over in parts and put together ready for steam at Ardsley. They were all delivered to the railway company at a very early date in 1900 with one exception, the last of the set of twenty, No. 1200, being sent to Paris by its makers to form part of their noteworthy exhibit in the Exposition of that year. The numbers and dates of these were as follows:

Date.	Baldwin Works Nos.	Engine Nos.
July, 1899	16927-16936	1181-1190
January, 1900 ..	17321-17325	1191-1195
,, ..	17355-17359	1196-1200

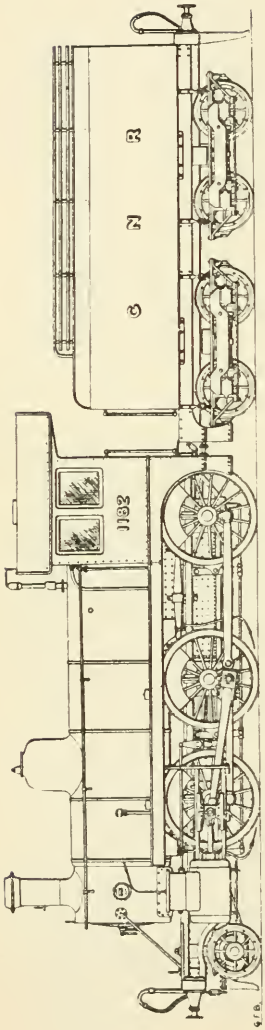


Fig. 102.

In outside appearance equally with constructive details, these American engines showed a marked difference as compared with the standard G.N.R. goods locomotives. From Fig. 102 it will be seen that they were of the "Mogul" type, having outside cylinders, six-coupled driving wheels, a leading pony truck, and a tender carried on two bogies. With the exception of the chimney, buffers and brake pipe fittings and sand boxes, which are below the footboard as in English practice, they were of American type throughout, merely modified to meet the restrictions of loading gauge, and designed to yield as nearly as possible the same efficiency of duty as the standard goods engines on the line. The leading dimensions were as follows: cylinders 18-in. in diameter with a stroke of 24-in.; driving wheels 5-ft. 1½-in. in diameter, truck and tender

wheels 3-ft. in diameter; wheel-base of engine 22-ft. 8-in., divided in the following proportion: centres of truck and leading coupled wheels 7-ft. 11-in., centres of leading coupled and driving wheels 6-ft. 3-in., centres of driving and trailing coupled wheels 8-ft. 6-in. The boiler, which was of the flush-topped pattern, was built of $\frac{5}{8}$-in. plates, with a diameter of 4-ft. $6\frac{3}{4}$-in., and contained 254 tubes measuring 10-ft. $11\frac{3}{4}$-in. long with a diameter of $1\frac{3}{4}$-in. The safety valves, of the "pop" pattern, were pressed to blow off at 175 lbs. per sq. in. The firebox was 6-ft. long by 2-ft. $9\frac{1}{4}$-in. broad by 6-ft. $3\frac{1}{2}$-in. deep, and there was a total heating surface of 1,380 sq. ft., the firebox contributing 120 sq. ft. and the tubes 1,260 sq. ft.; the grate area measured 16·7 sq. ft. In full working order these engines weighed 44 tons 19 cwt., of which 6 tons 15 cwt. 3 qrs. were on the truck, and 38 tons 3 cwt. 1 qr. on the six-coupled wheels. The double bogie tender carried 3,500 gallons of water and 5 tons of coal, and weighed, thus loaded, 37 tons 14 cwt. 2 qrs. It is interesting to note that for its capacity the American type of tender possesses less dead weight than the English six-wheeled pattern, a result which is mainly secured by the use of lighter and consequently thinner plates in the building of the tanks.

In the meantime orders for goods engines of Mr. Ivatt's standard pattern were being executed with the utmost despatch both at the Doncaster Works of the railway company, and by Messrs. Kitson & Co., of Leeds, and Messrs. Dübs & Co., of Glasgow, two orders of 20 each being in hand at Doncaster during the years 1899 and 1900 respectively, while the "outside" contingents consisted of 25 each. Of those built by Messrs. Dübs & Co., however, only thirteen were actually delivered to the G. N. R. Co.,

the other twelve being transferred to the Midland and Great Northern Joint Railway on completion, receiving that company's running Nos. 81-92. Those built by the G.N.R. bore the following numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1899	822	343	1900	882	165
,,	823	344	,,	883	177
,,	824	345	,,	884	179
,,	825	348	,,	885	180
,,	826	349	,,	886	192
,,	827	350	,,	887	302
,,	828	351	,,	888	303
,,	829	352	,,	889	304
,,	830	353	,,	890	306
,,	831	359	,,	891	308
,,	842	360	,,	892	384
,,	843	361	,,	893	386
,,	844	362	,,	894	387
,,	845	363	,,	895	388
,,	846	364	,,	896	390
,,	847	367	,,	897	392
,,	848	368	,,	898	394
,,	849	371	,,	899	396
,,	850	375	,,	900	398
,,	851	381	,,	901	399

The engines built "outside" bore the following numbers:—

Date.	Builders.	Builders' Nos.	Engine Nos.
1900	Kitson & Co.	3924-3948	1136-1160
1901	Dübs & Co.	3945-3957	1161-1173

In general dimensions all these goods engines were similar to the earlier Doncaster built engines of the No. 315 class. So far as external appearance is concerned, those locomotives built at the Company's works were also identical with No. 315, an illustration of which has already been given, except that the sand boxes used when running tender-first were removed from the middle pair of driving wheels to the trailing pair, and thus are concealed within the cab side plates. The same alteration was made with

respect to the engines built "outside," as can be seen from the accompanying illustration, Fig. 103, which shows No. 1138, and these were further distinguished by cast iron chimneys of the "built up" pattern, and brass beading round the splashers. In all other details they were practically of standard pattern.

Further engines of the smaller or No. 400 class of coupled passenger engines with a leading bogie were built during 1899. It has already been mentioned that of the preceding series No. 1320 differed from its companions in

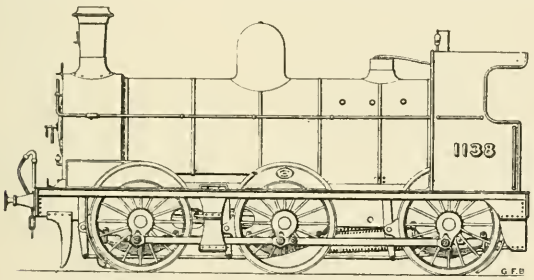


Fig. 103.

respect to having the running-plate raised to clear the coupling rods, and an illustration of this particular locomotive was given in Fig. 93. The latest engines of this class were precisely similar to that illustration, except for the one detail that their chimneys, though of cast iron, were moulded so as to give the appearance of the "built up" pattern. Their numbers were :—

Date.	Doncaster Nos.	Engine Nos.
1899	862-871	1351-1360

After exhaustive trials of the large ten-wheel passenger engine, No. 990, it was decided to place more locomotives of the same class upon the road. These later engines

were generally, in so far as their main dimensions were concerned, exactly similar to their prototype. The chief external points of difference lay in such details as an alteration of the framing at the leading end and a modification of the sanding arrangements. The steam sander delivered the sand under the driving or second pair of coupled wheels from boxes placed between the frames midway between the coupled axles, while the boxes and pipes used in running backwards were, in most cases, done away with. These engines also are fitted with a novel arrangement for locking the reversing gear in any desired position, consisting of a friction lock on the reversing shaft which is actuated by vacuum. The accompanying illustration, Fig. 104, showing No. 989 with its tender, also marks a slight modification adopted in the latter, the brake-blocks

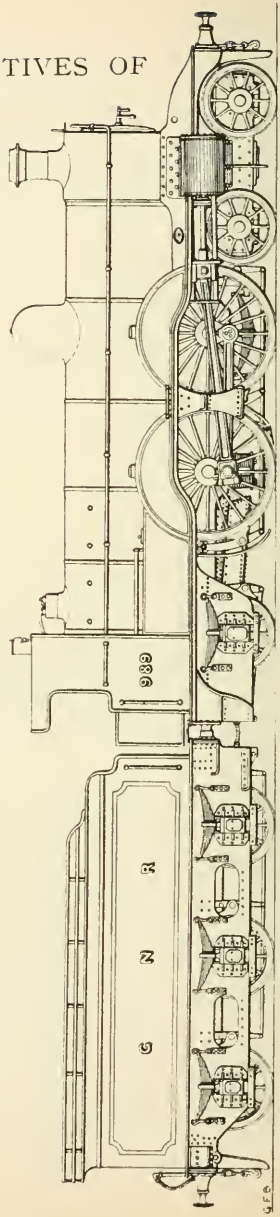


Fig. 104.

being applied at the front of the tender wheels instead of at the back, as had previously been the practice. Altogether, in addition to No. 990, ten engines of this class have so far been built, with the following numbers:—

Date.	Doncaster Nos.	Engine Nos.
1900	872-873	949-950
,,	874-881	982-989

In the meantime, Mr. Ivatt's new single-wheeler, No. 266, had already been running sufficiently long to prove its success in first-class express work, and another engine of a similar type was put in hand. It differed from its forerunner, however, in details of the motion, having cylinders 19-in. in diameter with balanced valves on top, the movement of the link motion being transmitted by means of a rocking shaft. The valves are balanced by strips on the Richardson system, and the exhaust takes place straight through the top. The leading dimensions were as follows:— cylinders 19-in. in diameter, with a stroke of 26-in.; diameter of bogie wheels with 3-in. tyres 3-ft. 8-in., of driving wheels 7-ft. 8-in., and of trailing wheels 4-ft. 2-in. Wheel-base: bogie 6-ft. 3-in., from trailing bogie wheel to driving wheel centres 7-ft. 9-in., and from driving to trailing wheel centres, 9-ft. Length of frames 27-ft. 8-in., with an overhang at leading and trailing ends of 2-ft. 8-in. and 3-ft. respectively. Boiler barrel: length 11-ft. 4-in., diameter outside smallest ring 4-ft. $3\frac{7}{8}$-in., thickness of plates $\frac{9}{16}$-in., height of centre above rails 8-ft. 3-in., length of smokebox 3-ft. $3\frac{7}{8}$-in., length of outside firebox 7-ft., width 4-ft. $\frac{1}{2}$-in. Heating surface: firebox 125·8 sq. ft., tubes 1143·8 sq. ft., total 1269·6 sq. ft., grate area 23·2 sq. ft., working pressure 175 lbs. per sq. in. Weight of engine in full working order 48 tons 11 cwt., of which 17

tons 15 cwt. was available for adhesion. Weight of tender with 3,670 gallons of water and 5 tons of coal 40 tons 18 cwt. The accompanying illustration, Fig. 105, also shows this engine to have had a deeper frame at the forward end, but with these exceptions it was practically a reproduction of No. 266. So far, eleven engines have been built to the design here shown, in the following order:—

Date.	Doncaster No.	Engine No.
1900	902	267
1901	934	92
,,	935	100
,,	936	261
,,	937	262
,,	938	263
,,	939	264
,,	940	265
,,	941	268
,,	942	269
,,	943	270

It will be noted with regret that these engines have displaced some historic veterans, which now drop into the fatal "A" list.

Continuing in chronological order, the next loco-

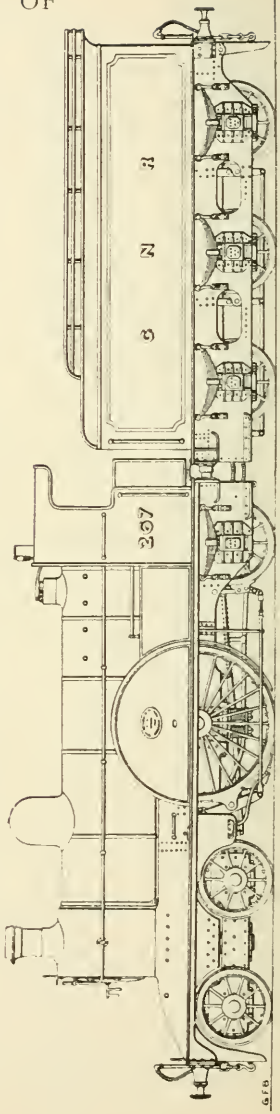


Fig. 105.

motives built at Doncaster were twenty of the large four-coupled bogie class, similar to Nos. 1321-1325, already described and illustrated. These twenty engines were turned out in the following order :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1900	903	1366	1900	913	1382
,,	904	1367	,,	914	1383
,,	905	1368	,,	915	1384
,,	906	1369	,,	916	1375
,,	907	1370	,,	917	1376
,,	908	1371	1901	918	1377
,,	909	1372	,,	919	1378
,,	910	1373	,,	920	1379
,,	911	1380	,,	921	1381
,,	912	1374	,,	922	1385

Immediately following the appearance of the engines last referred to, came a new type of goods locomotive which is deserving of extended mention. From time to time, as this brief history has sought to show, the locomotive superintendents of the Great Northern Railway have produced exceptionally powerful engines for the heavy mineral traffic of the line. Mr. Sturrock led off with his famous steam tender engines, and Mr. Stirling followed suit with the large mineral engines of 1872. In neither instance, however, was the general traffic management of the line quite ripe for the introduction of such power, and the two classes severally failed owing to their very success. Apparently, however, the time is now suitable for a considerable increase in the tractive capacity of mineral engines on the G. N. R., and Mr. Ivatt has responded by designing a type of locomotive for this work which bids fair to meet all requirements in that direction for some years to come. The accompanying illustration, Fig. 106, shows the pioneer of the type and presents the chief details of its outside

appearance. It will be seen at once that No. 401 is of immense tractive and adhesive power, having cylinders $19\frac{3}{4}$-in. by 26-in., eight-coupled wheels having, with 3-in. tyres, a diameter of only 4-ft. 8-in., and a total weight available for adhesion of more than $54\frac{1}{2}$ tons, while its capacity to raise sufficient steam to supply those big cylinders is evidenced by the ample size of the boiler, which is practically of the same type as that adopted already for the large ten-wheel express engines of the "990" class. The cylinders, whose dimensions as new are stated above, drive the second pair of wheels, towards which they incline downwards at an angle corresponding to a drop of 4-in. in 2-ft. $2\frac{3}{8}$-in., the distance from centre of cylinders to centre of driving axle being 9-ft. 9-in., and the connecting rods being 5-ft. $7\frac{3}{4}$-in. long between centres. The slide valves are of the

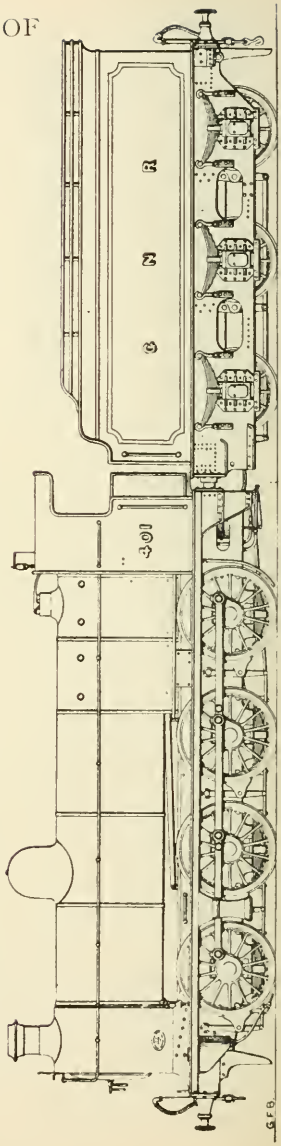


Fig. 106.

Eight-coupled Goods Locomotive, with Train. No. 401.

balanced kind, on top of the cylinders, deriving their motion from the eccentrics and expansion gear through the medium of a rocking shaft. The driving wheels, 4-ft. 8-in. in diameter, occupy a total wheel-base of 17-ft. 8-in., of which 5-ft. 8-in. separate the middle pairs, with the leading and trailing axles respectively distant to the extent of 6-ft. Over all, the frame plates measure 30-ft., the overhang in front being 6-ft. 3-in., and at back 6-ft. 1-in., while the footplate is 4-ft. 2-in. above the rail level. The boiler barrel, pitched with its centre line 8-ft. 4-in. above the rails, is built up of three rings of $\frac{9}{16}$-in. steel, the middle ring having an outside diameter of 4-ft. $6\frac{7}{8}$-in., and the outer rings being 4-ft. 8-in. in diameter outside. The length of the barrel is 14-ft. $8\frac{5}{8}$-in., of which, however, 1-ft. $11\frac{1}{4}$-in. is occupied by the rearward extension of the smokebox. The smokebox proper has a length of 3-ft. $2\frac{3}{8}$-in. and a diameter of 5-ft. $6\frac{1}{2}$-in., inside measurements. The firebox casing is 8-ft. long outside and 4-ft. $0\frac{1}{2}$-in. wide at the bottom, its depths below the centre line of the boiler being 5-ft. 6-in. in front and 4-ft. 8-in. at back. Within the boiler barrel are 191 tubes 2-in. in diameter and 13-ft. long, the total heating surface being 1438·84 sq. ft., of which the firebox contributes 136·74 sq. ft., and the tubes the remaining 1302·1 sq. ft. The grate area is 24·5 sq. ft. It should be noted that though the Ramsbottom type of safety valve is retained in these big engines, it is duplicated, and the working pressure is fixed at 175 lb. per sq. in. In full working order this type of engine weighs a total of 54 tons 12 cwt. 1 qr., apportioned as follows:—Leading wheels 13 tons 3 cwt. 2 qrs., driving wheels 14 tons 18 cwt. 3 qrs., intermediate wheels 12 tons

18 cwt. 1 qr., and trailing wheels 13 tons 11 cwt. 3 qrs. The tender is of the standard large type, weighing, with 3,670 gallons of water and 5 tons of coal, 40 tons 18 cwt. 1 qr.; thus the total weight of engine and tender is 95 tons 10 cwt. 2 qrs.; and the total length over buffers is 54-ft. $7\frac{1}{2}$-in.

Following is a list of the eight-coupled mineral engines of the No. 400 class built up to 1906 :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1901	923	401	1903	1009	422
1902	964	402	,,	1010	424
,,	965	405	,,	1011	426
,,	966	406	,,	1012	427
,,	967	407	,,	1013	429
,,	968	403	,,	1014	430
,,	969	408	,,	1015	428
,,	970	409	,,	1016	431
,,	971	410	1904	1027	432
,,	972	404	,,	1028	433
,,	973	411	,,	1029	434
,,	976	412	,,	1050	435
,,	978	414	,,	1051	436
,,	982	413	,,	1052	437
,,	983	415	,,	1053	438
,,	984	417	,,	1054	439
,,	985	416	,,	1055	440
,,	986	418	1906	1139	441
,,	987	419	,,	1140	442
,,	988	420	,,	1141	443
,,	989	421	,,	1142	444
1903	1007	423	,,	1143	445
,,	1008	425			

No. 407 and several others were subsequently fitted with a variable blast pipe, which is automatically worked from the reversing rod, and No. 417 has been fitted with the Schmidt superheater and piston valves, in conjunction with which the Klinger forced system of lubricating the cylinders and valves was introduced.

In succession to the engine last illustrated came a

further series of ten-wheeled tank locomotives fitted with condensing apparatus, for working the London suburban traffic through the "underground" to Moorgate Street and elsewhere. These were of the type already described, and illustrated by Fig. 101, but it should be noted that they differed from their predecessors in having cylinders 18-in. in diameter, with a stroke of 26-in., and in the absence of rails round the bunker-top.

Their numbers were as follows :—

Date.	Doncaster Nos.	Engine Nos.
1901	924-933	1521-1530

Two further series of this class of engine have since been built as follows :—

Date.	Doncaster Nos.	Engine Nos.
1903	1017-1026	1531-1540
1907	1155-1164	1541-1550

No. 1533 was fitted with brake blocks to the wheels of the bogie, and No. 1514 of the earlier series was also so equipped, whilst No. 1520 of the earlier series was fitted with Marshall's valve gear.

In 1901 also there arose a need for a further supply of the useful goods locomotives with six-coupled wheels and a saddle tank over the boiler, of which Mr. Stirling had built upwards of 150, and Mr. Ivatt had already put 45 on the rails. Accordingly another 40, having six-coupled wheels 4-ft. 7½-in. in diameter and cylinders 18-in. by 26-in., were constructed at Doncaster in the following order :—

Date.	Doncaster Nos.	Engine Nos.
1901	944-954	1251-1261
1902	955-963	1262-1270
1905	1087-1096	1271-1280
1908	1216-1225	1281-1290

Nos. 1251-1270 differed from the other engines of the same type in having a raised deck to the cab-roof, about

6-in. high, which is fitted with ventilators, and the later engines of the class had fluted coupling rods.

A few years ago almost every locomotive superintendent of note designed a four-cylinder high-pressure engine for express traffic, more or less as a protest against the introduction of the compound system, and in 1902 Mr. Ivatt built an engine, No. 271 (Doncaster No. 974), which is shown in the accompanying illustration, Fig. 107. It will be seen that No. 271 bears a resemblance to No. 990, in that it has a leading bogie, four-coupled wheels and a small pair of trailing wheels. No. 271 is, however, provided with four cylinders, two outside the frames and two inside, placed in line. These cylinders are each 15-in. in diameter, with a stroke of 20-in., and drive direct on the first pair of coupled wheels, with

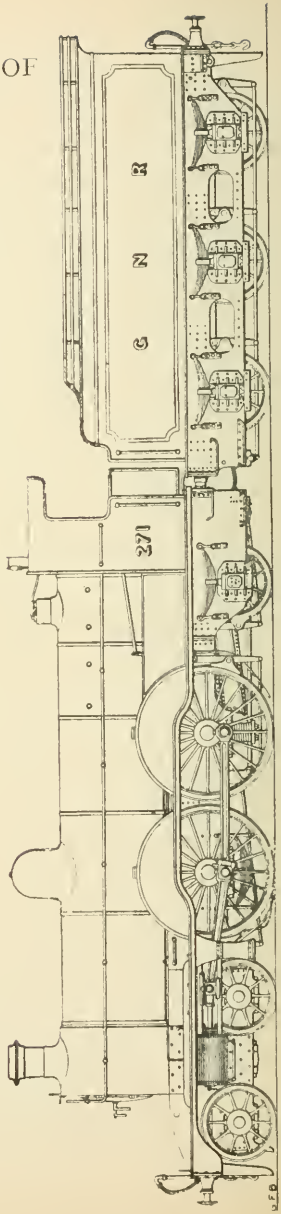


Fig. 107.

connecting rods 5-ft. 9¾-in. long, the distance from centre of cylinders to centre of driving axle being 9-ft. 3-in. The bogie and trailing wheels are each 3-ft. 7½-in. in diameter, while the four-coupled wheels are 6-ft. 7½-in. in diameter, and are placed with their centres 6-ft. 10½-in. apart, the total wheel-base being 26-ft. 9-in., of which the bogie-wheel centres account for 6-ft. 3-in., and the distance of the trailing wheels from the rearmost coupled axle accounts for 7-ft. 6-in. Over all, the frame-plates measure 33-ft. 7¼-in., the overhang being 2-ft. 5-in. and 4-ft. 5¼-in. at leading and trailing ends respectively. The original boiler, with its centre 8-ft. 1-in. above the rails, had a barrel 15-ft. 4¼-in. long, with a diameter outside the smallest, or middle ring, of 4-ft. 6⅞-in. The smokebox had a length externally of 3-ft. 3¼-in., and it was extended within the boiler barrel, but not to the same degree as in the "990" class, the distance between tube plates being 14-ft. The tubes were only 141 in number, 2¼-in. in diameter. The firebox casing measured 8-ft. in length, with a breadth at the bottom of 4-ft. 0½-in., giving a heating surface of 140¼ sq. ft., to which was to be added the tube surface of 1,162¾ sq. ft., making a total of 1,303 sq. ft. The grate area was 24½ sq. ft. Duplex safety valves were fitted, pressed to blow off at 175-lb. per sq. in. In its original state this engine weighed 58 tons 15 cwt., divided as follows: bogie 15 tons 10 cwt., driving wheels 17 tons, coupled wheels 15 tons 15 cwt., and trailing wheels 10 tons 10 cwt.; and the tender was of the smaller kind, fitted with water pick-up apparatus, weighing in working order only 38 tons 10 cwt.

In 1904, No. 271 was fitted with the Walschaerts valve gear, and towards the close of 1908 was again

overhauled and a boiler of the standard 990 class fitted, having a total heating surface of 1442 sq. ft.

The next engines constructed at Doncaster were a further series of bogie four-coupled passenger locomotives of the "1326" class, already described and illustrated, and these have been succeeded by two other series, as the following list shows :—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1902	975	1386	1907	1169	1399
,,	977	1388	,,	1170	1180
,,	979	1391	1908	1226	41
,,	980	1389	,,	1227	42
,,	981	1387	,,	1228	43
,,	990	1390	,,	1229	44
,,	992	1394	,,	1230	45
,,	993	1395	,,	1231	46
,,	994	1392	,,	1232	47
,,	995	1393	,,	1233	48
1907	1165	1396	,,	1234	49
,,	1167	1397	,,	1235	50
,,	1168	1398			

In Dec., 1902, appeared the first of a class of passenger express engine, which is to the modern Great Northern locomotive equipment what Mr. Stirling's famous 8-ft. singles were to the same railway's stock of 40 years ago. This noteworthy engine, No. 251, which is illustrated in Fig. 108, was the prototype of the standard G.N. express engine of to-day, and has so far justified its existence that there are now no fewer than 81 of the class.

So far as the general dimensions of cylinders, wheels and length are concerned, it was practically identical with the pioneer British "Atlantic," No. 990, already described and illustrated in this monograph, but it was fitted with a much larger boiler, with a total heating surface of 2,500 sq. ft., and this innovation, which also increased the adhesion

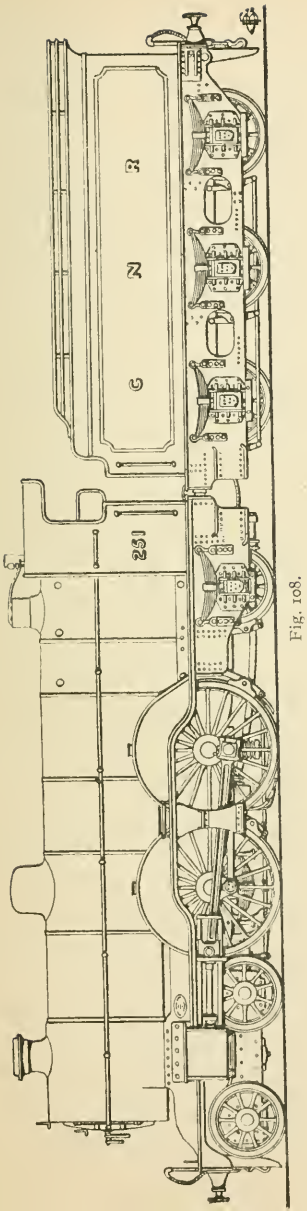


Fig. 108.

weight by several tons, has rendered it a far more powerful machine than the earlier engine.

A point not mentioned in connection with No. 990, though the feature is common to all the G.N.R. Atlantic engines, large and small, is the differential throw of the connecting and coupling rod pins. The coupling rod pins of the driving wheels are 6-in. in diameter, and have a throw of $11\frac{1}{2}$-in., whilst the connecting rod pins are 5-in. in diameter, turned eccentrically on the larger coupling rod pins, so as to give a throw of 12-in. Thus, whilst the stroke of the pistons is 24-in., the coupling rods travel in a circle of only 23-in. diameter, a reduction which at high speeds is of considerable importance in reducing the stress on those rods. Another point of interest is the reversing gear, which has a vacuum lock of Mr. Ivatt's invention fitted on the middle

of the reverse shaft, this holding the gear in any set position.

The boiler was naturally the chief feature of interest in this engine. The barrel consisted of two rings, each of $\frac{5}{8}$-in. steel plate, giving a total length of barrel of 16-ft. $3\frac{7}{8}$-in., the one nearest the smokebox being 8-ft. $6\frac{3}{4}$-in. long and 5-ft. $4\frac{3}{4}$-in. in diameter outside, and the other 8-ft. 1-in. long and 5-ft. 6-in. in diameter outside. The smokebox tube-plate was of the drumhead type, set inside the front ring, the actual length of the boiler between tube-plates being 16-ft., and the smokebox was also extended forward, its total internal length being about 5-ft. 9in., and its internal diameter 5-ft. $11\frac{1}{4}$-in. The centre of the boiler was 8-ft. $8\frac{1}{2}$-in. above the level of the rails, and this height, with the large diameter of the smokebox, reduced the effective outside height of the chimney to 1-ft. $7\frac{1}{2}$-in.; this, however, was partly obviated by continuing the inner lining of the chimney 2-ft. 1-in. downwards into the smokebox, when it terminated in a bell mouth of 2-ft. diameter slightly below the level of the upper row of tubes, and $10\frac{5}{8}$-in. above the top of the $5\frac{1}{4}$-in. blast pipe. The firebox was of a design not hitherto adopted in Great Britain, curving out from the shape of the boiler barrel at top to a wide base resting on the main engine frames. At the foundation ring it had an external length of 5-ft. 11-in., and a width of 6-ft. 9-in. In order to clear the driving wheels both the throat plate and the lower part of the firebox tube-plate were sloped backwards at an appreciable angle. The inside firebox had a length inside at the top of 5-ft. $5\frac{7}{16}$-in., a width inside at the bottom of 5-ft. $11\frac{5}{8}$-in., and a depth in front of 5-ft. $0\frac{1}{2}$-in., and at

back of 4-ft. 6½-in. below the centre line of the boiler. The crown plate was 1-ft. 2 3/16-in. and 1-ft. 0 1/16-in. above the centre line at front and back respectively. The heating surface of the firebox was 141 sq. ft., and of the 248 tubes, 16-ft. long by 2¼-in. diameter, 2,359 sq. ft., giving a total of 2,500 sq. ft.; the grate area was 30·9 sq. ft. Four safety valves of the Ramsbottom type, each 3-in. in diameter, were enclosed in a circular casing on the firebox, and were adjusted to blow off at a pressure of 175 lb. per sq. in. Owing chiefly to the increased size of the boiler, No. 251 weighed considerably more than No. 990, the total weight of the engine in working order being 68 tons 8 cwt., distributed as follows:—On bogie wheels 17 tons 6 cwt., on each pair of coupled wheels 18 tons, and on trailing wheels 15 tons. The tender was of the standard type, and weighed 40 tons 18 cwt. with 3,670 gallons of water and 5 tons of coal. It differed from its predecessors, however, in being fitted with Mr. Ivatt's patent water-pick-up apparatus, which has since been very largely adopted on the G.N.R. tenders.

As has already been mentioned, there are at present no fewer than 81 engines of the "251" class in service, their dates and numbers being as follows:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1902	991	251	1904	1040	283
1904	1030	272	,,	1041	285
,,	1031	273	,,	1042	282
,,	1032	274	,,	1043	286
,,	1033	275	,,	1044	284
,,	1034	276	,,	1045	287
,,	1035	277	,,	1046	289
,,	1036	278	,,	1047	288
,,	1037	279	,,	1048	290
,,	1038	280	,,	1049	291
,,	1039	281	1905	1067	293

Date.	Doncaster No.	Engine No.
1905	1068	297
,,	1069	296
,,	1070	294
,,	1071	295
,,	1072	298
,,	1073	299
,,	1074	301
,,	1075	300
,,	1076	1400
,,	1077	1401
,,	1078	1402
,,	1079	1403
,,	1080	1405
,,	1081	1404
,,	1082	1406
,,	1083	1407
,,	1084	1408
,,	1085	1409
,,	1086	1410
,,	1109	1411
,,	1110	1412
,,	1111	1413
,,	1112	1414
1906	1113	1415
,,	1114	1416
,,	1115	1417
,,	1116	1418
,,	1117	1419
,,	1118	1420
,,	1144	1422
1906	1146	1423
,,	1147	1424
,,	1148	1425
,,	1149	1427
,,	1150	1428
,,	1151	1426
,,	1152	1429
,,	1153	1430
,,	1154	1431
1907	1171	1432
,,	1172	1433
,,	1173	1434
,,	1174	1435
,,	1175	1436
1908	1186	1437
,,	1187	1438
,,	1188	1439
,,	1189	1440
,,	1190	1441
,,	1191	1443
,,	1192	1444
,,	1193	1442
,,	1194	1445
,,	1195	1446
,,	1196	1447
,,	1197	1448
,,	1199	1450
,,	1200	1449
,,	1201	1451

For the purpose of instituting comparative trials with No. 292, a four-cylinder compound "Atlantic," which will be described in due course, No. 294 was altered to carry a working pressure of 200 lb. per sq. in. The result of these trials was that the compound engine showed a slight superiority in efficiency and economy, though scarcely to so marked a degree as to compensate for the enhanced prime cost of construction.

One of the later engines of the class, No. 1442, after running for about 40,000 miles, which included hauling the

Royal train conveying the King and Queen to Leeds in the summer of 1908, was temporarily withdrawn from service in the spring of 1909, and was overhauled in the shops and given an "exhibition finish" prior to being shown in the Machinery Hall at the Imperial International Exhibition at Shepherd's Bush. It was shown standing on the present standard track of the G.N.R., with 100-lb. rails, and a portion of a water-trough in the four-foot, whilst alongside it was Mr. Stirling's pioneer 8-ft. single, No. 1, which had been withdrawn from service in August, 1907, after completing upwards of 1,400,000 miles. This veteran had then been partially dismantled, and much of its internal gear and fittings removed, but for the purposes of exhibition it was thoroughly overhauled, and not only so, but renovated as far as possible in its original condition, and supplied with an old tender with wooden brake-blocks, as in 1870. It was also shown standing on a specimen of the track of that period, with steel rails weighing 80 lb. per yard.

An interesting series of comparative trials was instituted between engines of this class and standard L. & N.W.R. express locomotives during the summer of 1909. No. 1449 was "lent" to the L. & N.W.R. and put to work on the traffic between Euston and Crewe. The engine was worked by its own driver and fireman, with a L. & N.W.R. driver as pilot-man. During the same period the L. & N.W.R. locomotive No. 412, "Marquis," a four-coupled bogie engine of the "Precursor" class, was at work on the G.N.R. main line, with its own driver and fireman and a G.N.R. pilot-man, running between King's Cross, Doncaster and Leeds on alternate days, in competition with the Atlantic No. 1451. No official figures are forth-

coming as to the results of these friendly trials, which naturally aroused considerable interest in the railway world. A somewhat similar test was made some time previously when a standard L. & Y. R. express engine was "lent" to and ran for some time on the Great Northern Railway, with one of that company's tenders.

The next new class of engine constructed at Doncaster was a large eight-coupled tank locomotive with a pair of trailing wheels. This engine, No. 116, which is illustrated in Fig. 109, was, as originally built, so far as boiler,

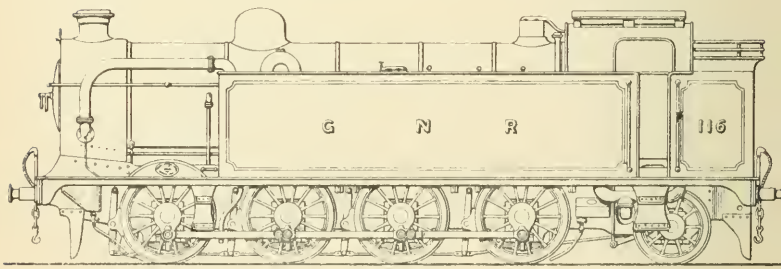


Fig. 109.

cylinders and wheels were concerned, practically identical in dimensions with the eight-coupled mineral engines of the "401" class, with the addition of side tanks and an end bunker, and condensing apparatus, this last being fitted with the intention that this locomotive should work passenger and goods traffic over the Metropolitan "underground" section of the G.N.R., and the chimney and steam dome were of a modified pattern in order to pass the Metropolitan loading gauge. The cylinders were 19¾-in. in diameter, with a stroke of 26-in. The diameter of the eight-coupled wheels was 4-ft. 7½-in., and of the radial trailing

wheels 3-ft. 7½-in. The total wheel-base was 25-ft. 2-in., the two middle pairs of coupled wheels being 5-ft. 8-in. apart, centre to centre, and the two extreme pairs being respectively distant from these to the extent of 6-ft., whilst the trailing axle was 7-ft. 6-in. to the rear of the last coupled axle, centre to centre. The engine measured 35-ft. 7¼-in. over the buffer beams, the overhang being 6-ft. 5-in. and 4-ft. 0¼-in. at leading and trailing ends respectively; the total length over all was 38-ft. 7¼-in. The boiler originally supplied was similar to that of the No. 401 class, and its centre line was 8-ft. 4-in. above the rails. As originally built, the side tanks and bunker were of exceptionally large capacity, being built to hold 2,000 gallons of water and 4 tons of coal respectively. In road-worthy condition, the engine weighed a total of 79 tons, the distribution being: on leading coupled wheels, 15 tons; on driving, intermediate and trailing coupled wheels, 17 tons per axle; and on trailing radial wheels, 13 tons.

Almost immediately after being put in service, this powerful and otherwise successful engine was found to be too heavy for the Metropolitan line, and in response to the requirements of the permanent way department, Mr. Ivatt undertook so to modify the design as materially to reduce the gross moving load. With this end in view, he removed the boiler originally provided, and replaced it by one having a length of barrel of 11-ft. 9-in., and a minimum diameter, inside, of 3-ft. 11¾-in.; the firebox was also reduced to 6-ft. 2-in. in length. This new boiler had a total heating surface of 1,043·7 sq. ft., of which the firebox contributed 107·7 sq. ft., and the tubes 936 sq. ft.; the grate area was 17·8 sq. ft. At the same time, the side tanks were reduced

in length, lessening their capacity to 1,500 gallons, and only 3 tons of coal were carried. As thus modified, the engine weighed 70 tons 5 cwt., distributed as follows: on leading wheels 13 tons 10 cwt., on driving wheels 15 tons 5 cwt., on intermediate coupled wheels 15 tons, on trailing coupled wheels 14 tons 10 cwt., and on trailing radial wheels 12 tons.

No. 116 ran for some time in its modified form, as shown in Fig. 110, before being followed by others of the same class, but eventually a series, built in accordance with

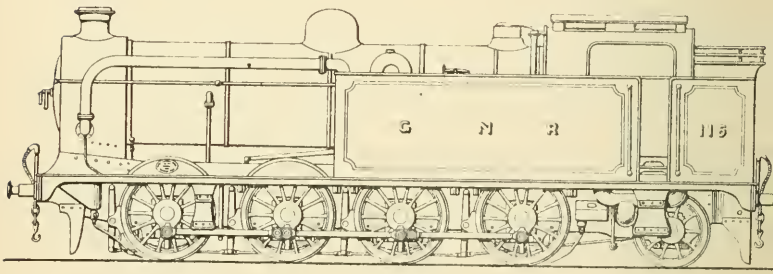


Fig. 110.

the revised dimensions, were built at Doncaster in the following order:—

Date.	Doncaster Nos.	Engine Nos.	Date.	Doncaster Nos.	Engine Nos.
1903 ..	1004 ..	116	1905 ..	1097-1106 ..	127-136
1904 ..	1056-1065 ..	117-126	1906 ..	1119-1138 ..	137-156

Nos. 127-136, which had 19¾-in. cylinders, on completion, instead of being sent to the Metropolitan district, were stationed at Colwick, to work coal trains over the Nottinghamshire branch lines, and these were followed to the same depôt by Nos. 137-141, which began work between Colwick sidings and Pinxton, and later by Nos. 142-151, all these having 18-in. cylinders. At the beginning of 1908,

Nos. 116-126 were removed from London to Colwick, and prior to getting to work there had their cylinders reduced from 19¾-in. to 18-in. diameter, and the condensing gear removed. Nos. 127-131 were similarly stripped of their condensing gear and sent to Ardsley (Leeds). Nos. 127-136 are the only engines of the class now running with 19¾-in. cylinders. In October, 1909, No. 133 of this class was rebuilt with a boiler similar to that originally fitted to No. 116, bringing the total weight, with tanks full and 2½ tons of coal in the bunker, up to 71 tons 7 cwt.

In the meantime there were completed at Doncaster a series of the new engines of the smaller Atlantic, or "990" class. They differed from their original in having the frames so shaped as to allow of them being fitted with the larger boilers if necessity arose, and they also had the duplicate (four-column) Ramsbottom safety valves which subsequently were fitted to all the Atlantic class, large and small. The dates and numbers of these new engines were:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1903	996	252	1903	1001	257
,,	997	253	,,	1002	259
,,	998	256	,,	1003	250
,,	999	255	,,	1005	260
,,	1000	254	,,	1006	258

At the beginning of 1905 Mr. Ivatt made a notable departure by the introduction of a four-cylinder compound locomotive of the Atlantic type. In general design it is of the "251" type, having the same dimensions of boiler and wheels as that class. The cylinders are placed in line across the engine, and are of proportions that have given rise to some argument. The high-pressure cylinders are outside, 13-in. in diameter with a stroke of 20-in., with balanced

slide valves of the open-backed type placed above them, while the low-pressure cylinders, inside the frames and connected to the leading pair of coupled wheels, are 16-in. in diameter with a stroke of 26-in., and have their valves placed back to back between them. As can be seen, the outside cylinders are actuated by Walschaerts valve-gear, the low-pressure cylinders being operated by Stephenson link motion. A change valve is fitted over the low-pressure steam chest, worked by a small auxiliary steam cylinder, whereby the low-pressure cylinders can be supplied at will, and for any length of time, with either live steam from the boiler or the exhaust steam from the high-pressure cylinders, thus being worked either as a "simple" or a compound, according to requirements. There are two reversing levers with sectors placed close together on the foot-plate, and the two sets of gear can be operated independently or together, as may be desired. Mr. Ivatt's vacuum locking device is fitted to the two reversing shafts, this device having the advantage of locking the gear close up to its work, thereby obviating any slackness in the fittings between the shaft and the foot-plate. Apart from the cylinder arrangement, and the construction of the boiler shell with slightly thicker plates to stand an enhanced working pressure of 200 lb. per sq. in., No. 292 was practically identical with the "simple" Atlantics of the "251" class. The modifications here chronicled, however, increased the total weight of the engine to 69 tons, which were distributed as follows: On bogie wheels 18 tons 10 cwt., on each pair of coupled wheels 18 tons 5 cwt., and on trailing wheels 14 tons. The tender is of the standard type, carrying 5 tons of coal and 3,670 gallons of water, and

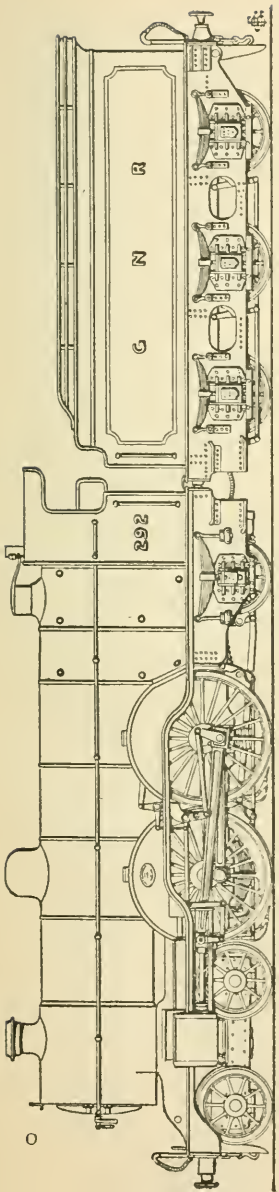


Fig. 111.

provided with Mr. Ivatt's pick-up apparatus for filling the tank *en route*. No. 292 bears Doncaster Works No. 1066, and is shown in Fig. 111. In a series of tests made with this engine and No. 294 "simple" Atlantic, already referred to, the advantage was slightly in favour of the compound engine.

Almost simultaneously with the advent of No. 292, a further trial of compounding was made on the Great Northern Railway. With the consent of his directors, Mr. Ivatt invited the leading firms of locomotive builders in the country to submit tenders for the building of locomotives of their own design, and an engine designed by the Vulcan Foundry, Ltd., of Newton-le-Willows, was accepted and built. No. 1300, which bears the makers' No. 2025 and the date 1905, is a four-cylinder compound, approximating in

arrangement with the well-known and successful system of M. de Glehn, but with certain specialities of the builders. For example, the engine is provided with the "Vulcan" patent starting valve, which admits steam at a reduced pressure to the receiver at starting, the supply being automatically cut off as soon as the steam has reached the low-pressure cylinders. Another feature is the "Vulcan" patent reversing gear, which allows one reversing screw to operate both high and low-pressure valve gear at the same time, giving a variable cut-off for the two sets of motion, which can be adjusted to suit requirements whilst the engine is running. Thus the high-pressure motion can, for instance, be notched up at will without interfering with the cut-off of the low-pressure cylinders, or *vice versâ*. These two devices were fully illustrated and described in *The*

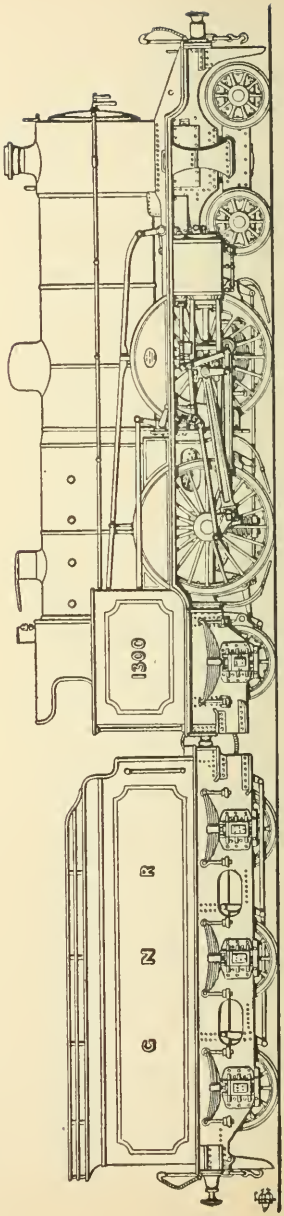


Fig. 112.

Locomotive Magazine of September 14th, 1907. As can be seen from the accompanying illustration, Fig. 112, this engine differed in external appearance from the general type of G.N.R. designs, though in certain details the practice of the railway was adhered to, notably in the framing and details of the leading bogie and the trailing wheels; and the tender was of the standard G.N.R. pattern, being, in fact, built at Doncaster.

No. 1300 differed from the Doncaster-built compound already described in most of its leading dimensions, and notably in the size and proportions of its cylinders, the discrepancy being, of course, all the more noticeable since both engines have the same diameter of coupled wheels, 6-ft. 8-in. No. 1300 has two high-pressure cylinders, 14-in. in diameter with a stroke of 26-in., placed outside the frames and driving direct on the trailing pair of coupled wheels, and actuated by Walschaerts valve gear and piston valves. The low-pressure cylinders are in the usual position below the smoke box, and are 23-in. in diameter with a stroke of 26-in.; they are also actuated by Walschaerts gear and piston valves. The bogie is of the standard G.N.R. swing-link pattern, with a wheel-base of 6-ft. 3-in., the leading axle being 3-ft. 3-in. in advance of the centre pivot, but it is fitted with wheels only 3-ft. 2-in. in diameter. The driving wheels are 6-ft. 8-in. in diameter, and the trailing wheels 3-ft. 8-in. The total wheel-base of the engine is 28-ft. 2-in., divided as follows :—Bogie, 6-ft. 3-in.; trailing bogie wheels to leading coupled wheels, 6-ft. 9-in.; coupled wheels, centre to centre, 8-ft. 6-in.; trailing coupled to trailing carrying wheels, 6-ft. 8-in. The boiler is of ample size; it has a barrel 11-ft. 11-in. long with an outside

diameter of 5-ft. 1⅝-in., and is pitched with its centre 8-ft. 10-in. above the rail level. It contains 149 "Serve" steel tubes, 12-ft. 4-in. long by 2¾-in. in diameter. The outside firebox measures 10-ft. in length, and is of the round-topped pattern, the restriction of the loading gauge preventing the Belpaire firebox originally intended from being adopted. The copper inside firebox measures 9-ft. long, 4-ft. 10½-in. wide at the centre line of the boiler, and 6-ft. 4½-in. and 4-ft. 9-in. high at front and back respectively. The total heating surface is 2,514 sq. ft., of which the firebox contributes 170 sq. ft., and the tubes 2,344 sq. ft.; the grate area is 31 sq. ft. The boiler carries a working pressure of 200 lb. per sq. in. The engine as originally designed would have weighed 72 tons, but this was subsequently reduced to 71 tons, the distribution of weights being as follows:— On bogie wheels 20 tons 5 cwt., on each pair of coupled wheels 18 tons 10 cwt., and on trailing wheels 13 tons 15 cwt. The tender is of G.N.R. standard dimensions, with capacities for 3,670 gallons of water and 5 tons of coal respectively, and weighs 40 tons 18 cwt. full. The total wheel-base of engine and tender is 49-ft. 6-in., and the total length over buffers 58-ft. 10½-in. This engine has worked the express services of the Great Northern Railway in conjunction with No. 292 (Doncaster compound) and the "simple" Atlantics of the "251" class without demonstrating any marked superiority in either efficiency or economy of operation, but the introduction of an engine so obtained, and built to the designs of a firm of locomotive builders in place of the Company's own locomotive engineer, was an experiment deserving of note.

In 1904 Mr. Ivatt began to turn his attention to the

provision of rail motor coaches suitable for local traffic, and designed some steam coaches which were built at Doncaster and elsewhere. Before these were completed, however, he made experiments with a petrol motor coach, which began work by making a series of trial trips between Hatfield and Hertford. Two other petrol coaches, Nos. 3 and 4, built by Messrs. Kerr, Stuart & Co., Ltd., worked the service until early in 1909, when they were withdrawn.

Early in 1905 orders were booked with the Avonside Engine Co., Ltd., and Messrs. Kitson & Co., Ltd., for two steam rail motor coaches from each firm. In the meantime Mr. Ivatt put two in order at the Doncaster works, as follows :—

Date.	Doncaster No.	Rail Motor No.
1905	1107	No. 2
,, ...	1108	No. 1

The design of these coaches consisted in making the locomotive and carriage body detachable, thus rendering it easy to withdraw either part for repairs, so that should the engine of one complete coach, and the body of another, be laid aside at one time, the other sections might be utilised together during the interval. The engine bogie was therefore made complete in itself as a small four-wheeled locomotive with a loco-type boiler 4-ft. 0½-in. in diameter, containing 178 tubes, and working at a pressure of 175 lb. per sq. in.; the firebox measures 3-ft. 6-in. long by 4-ft. 0½-in. wide. The total heating surface is 382 sq. ft., and the grate area 9½ sq. ft. The cylinders are placed outside the bogie frames, and are 10-in. in diameter by 16-in. stroke, actuated by Walschaerts valve gear, and the coupled driving wheels are 3-ft. 8-in. in diameter. The car body is 49-ft. long, and is carried at the other end on a standard

G.N.R. four-wheeled carriage bogie. It is divided into a luggage compartment next to the engine, third-class smoking and non-smoking compartments, a first-class saloon (the total seating accommodation being for 53 passengers), and a guard's compartment, which is fitted with duplicate controlling gear so that the car can be operated from that end when running carriage first.

Some of these engines were first put to work on the Louth-Grimsby section of the G.N.R., a section of 14 miles in all with four intermediate stations, to which were added six additional "haltes," at Fotherby, Utterby, Grainsby, Holton Village, Weelsby Road and Hainton Street. Others were intended for the local services between Finchley and Edgware, Hatfield and Hertford, Hatfield and St. Albans, Hitchin and Baldock, etc.

The coaches built by outside makers differed in some details from those built by the Railway Company itself. Thus, Nos. 5 and 6, the locomotive bogies of which were built by Messrs. Kitson & Co., Ltd., and the carriage bodies by the Birmingham Carriage & Wagon Co., Ltd., had the following leading dimensions:—Cylinders, 10-in. by 16-in.; heating surface of boiler, 505·64 sq. ft.; working pressure, 200 lb. per sq. in.; diameter of coupled wheels, 3-ft. 7-in.; length over buffers, 66-ft. $5\frac{1}{8}$-in.; extreme width over step boards, 8-ft. $10\frac{1}{2}$-in.; extreme height, 12-ft. 6-in.; seating accommodation for 57 passengers; total weight, 40 tons 2 cwt.

Nos. 7 and 8, built by the Avonside Engine Co., Ltd., have the following leading particulars:—Cylinders, 10-in. by 16-in.; diameter of coupled wheels, 3-ft. 8-in., with 3-in. by $5\frac{1}{2}$-in. tyres; wheel-base of engine bogie, 8-ft.; heating

surface: firebox 60 sq. ft., tubes 330 sq. ft., total 390 sq. ft.; grate area, 10·3 sq. ft.; working pressure, 200 lb. per sq. in.; total wheel-base of coach, 53-ft. 9-in.; total length over buffers, 66-ft. $1\frac{5}{8}$-in.; extreme width over carriage body, 8-ft. 6-in.; accommodation for 10 first-class and 40 third-class passengers; total weight, 40 tons $9\frac{3}{4}$ cwt. The water tanks are placed below the carriage body, and contain 650 gallons of water. These coaches are fitted with the automatic vacuum brake, having two 18-in. cylinders. The tractive effort with a 70 % cut-off is 5,500 lb., and a motor of this type and power is capable of taking a trailer car as well up gradients of 1 in 40, and of averaging a speed of 20 miles per hour up gradients of 1 in 50.

Having found that the large 0-8-2 tank engines of the No. 116 class, which were originally intended to deal with the heavy suburban passenger and goods traffic into and out of the Metropolitan Railway's underground lines, were even in their reduced dimensions still too much for the permanent way and works of that system, Mr. Ivatt transferred them elsewhere, as has already been noted, and proceeded to substitute for them a powerful type of tank engine, which should, however, be lighter on the track. Accordingly, in 1906, he built a locomotive with six-coupled wheels and a trailing radial pair, which had the following leading dimensions:—Cylinders, 18-in. by 26-in.; diameter of six-coupled wheels, 5-ft. 8-in., and of trailing wheels, 3-ft. 8-in.; wheel-base: leading to driving wheels 7-ft. 3-in., driving to trailing coupled wheels 9-ft., trailing coupled to trailing radial wheels 7-ft. 0-in., total 23-ft. 3-in.; boiler: length of barrel 10-ft. 1-in., diameter (outside) 4-ft. 8-in.; height of centre above rails,

8-ft. $0\frac{3}{8}$-in.; working pressure, 170 lb. per sq. in.; heating surface: firebox 120 sq. ft., tubes 1,130 sq. ft., total 1,250 sq. ft.; grate area, 19 sq. ft.; capacity of tanks 1,600 gallons, and of bunker 4 tons; weight of engine in working order, 64 tons 14 cwt., of which 51 tons 4 cwt. rested on the six-coupled wheels.

This engine, No. 190, was succeeded by ten others of the same general design, but slightly modified in one or two details, the chief object of the change being to effect a more equable distribution of weight over the four pairs of wheels

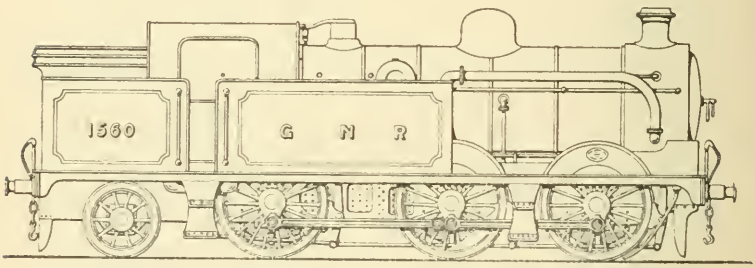


Fig. 113.

in view of the fact that some of the "foreign" lines South of London, on which these engines would be expected to run, did not allow the same maximum load per wheel as the G.N.R. itself. Accordingly, the side tanks were shortened, and the end tank enlarged, and the wheel-base slightly lengthened behind the coupled wheels. These modified engines, one of which is shown in Fig. 113, had the following dimensions:—Wheel-base: leading to driving wheels 7-ft. 3-in., driving to trailing coupled 9-ft., trailing coupled to trailing radial 7-ft. 6-in., total 23-ft. 9-in.; boiler: length of barrel, 10-ft. 1-in.; capacity of tanks

1,600 gallons, and of bunker 4 tons: weight of engine in working order, 65 tons 17 cwt., distributed as follows: on leading wheels, 16 tons 2 cwt.; on driving wheels, 18 tons; on trailing coupled wheels, 17 tons 5 cwt.; and on trailing radial wheels, 14 tons 10 cwt. All the engines of this class were, of course, fitted with condensing gear.

Below are given the dates, works numbers and running numbers of the series, including ten built this year:—

Date.	Doncaster No.	Engine No.
1906	1145	190
1907	1176-1185	1551-1560
1910	1256-1265	1561-1570

Interposed in the series of large Atlantic type locomotives already referred to, Mr. Ivatt allocated one of the numbers in the "1400's" to an engine which stood apart from the rest. No. 1421 (Doncaster No. 1166, 1907) was a four-cylinder compound, in general design resembling the earlier compound engine, No. 292, already described and illustrated, but differing in details. For example, whilst the high-pressure cylinders were of the same dimensions, 13-in. by 20-in., the low-pressure had 2-in. greater diameter, 18-in. by 26-in., and they were operated by Walschaerts valve gear instead of the ordinary Stephenson link-motion adopted in the earlier engine. The leading coupled axle was of a built-up, balanced type, patented by Mr. Ivatt. The boiler was also of a modified pattern, the smokebox being extended backwards instead of in advance of the chimney. Consequently the distance between the tube-plates was reduced from 16-ft. to 14-ft. 6-in., with a proportionate reduction in the heating surface, the total being 2,351·8 sq. ft., of which the firebox contributed 143·6 sq. ft., and the tubes 2,208·2 sq. ft.; the grate area was 31 sq. ft.

Otherwise the engine, which is illustrated by Fig. 114, was practically identical with No. 292, and in general dimensions with the "251" class. No. 1421 weighed in working order 69 tons 2 cwt., distributed as follows:—On bogie wheels 18 tons 2 cwt., on each pair of coupled wheels 18 tons, and on trailing wheels 15 tons. It was provided with the standard tender, fitted with Mr. Ivatt's patent water pick-up apparatus.

It may be interesting to note in this place that engine No. 265, 7-ft. 8-in. bogie single, was fitted with Mr. Ivatt's patent flexible balanced crank axle, and Joy's valve gear in place of the Stephenson link motion, in 1910, and that No. 866, a Stirling four-coupled passenger engine, has also been rebuilt with another form of balanced crank axle of Mr. Ivatt's design.

In 1908 Mr. Ivatt intro-

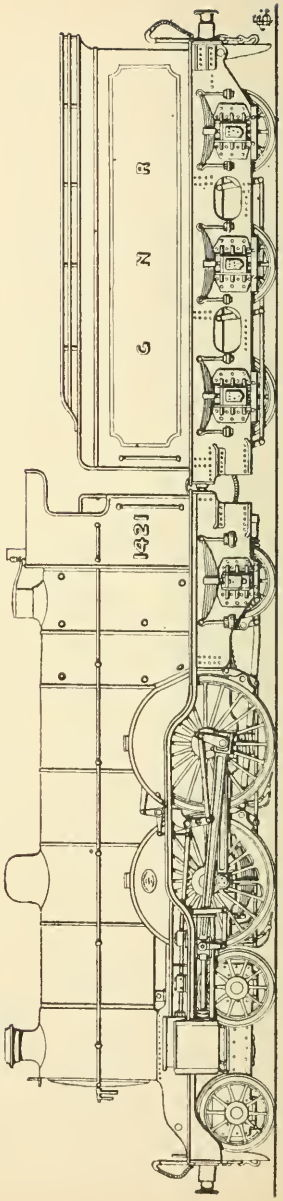


Fig. 114.

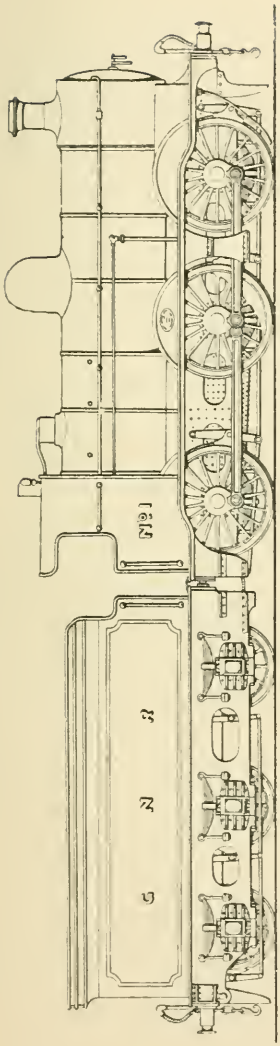


Fig. 115.

duced a new class of six-coupled goods tender engines, with wheels of exceptionally large diameter, 5-ft. 8-in. These engines are, in respect to their boilers, cylinders, motion and wheels, practically interchangeable with the 0-6-2 suburban tank locomotives of the "190" class, and were intended to work express goods and mixed traffic on the main line. They are illustrated in Fig. 115. Following are the leading dimensions :—Cylinders, 18-in. by 26-in.; diameter of coupled wheels, 5-ft. 8-in.; wheelbase: leading to driving 7-ft. 3-in., driving to trailing 9-ft., total 16-ft. 3-in.; boiler: length of barrel 10-ft. 5-in. between tube plates, diameter (outside) 4-ft. 8-in., height of centre above rails 8-ft. $0\frac{3}{8}$-in.; heating surface: firebox 120 sq. ft., tubes 1,130 sq. ft., total 1,250 sq. ft.; grate area, 19 sq. ft.; working pressure, 170 lb. per sq. in. The tender

was of a new pattern with unequally spaced wheel-base, 7-ft. between leading and middle, and 6-ft. between middle and trailing wheels respectively, this arrangement bringing more weight to bear on the leading wheels; the capacity of the tender was 3,500 gallons of water and 6½ tons of coal. In working order the engine weighed 46 tons 14 cwt., distributed as follows: on leading wheels, 16 tons; on driving wheels, 17 tons 4 cwt.; and on trailing wheels, 13 tons 10 cwt.; the tender weighed 43 tons 2 cwt. The total wheel-base of engine and tender was 37-ft. 8-in., and the extreme length over buffers 50-ft. 5½-in.

So far fifteen engines of this class have been built at Doncaster, in the following order:—

Date.	Doncaster No.	Engine No.
1908	1198	1
,,	1202-1215	2-15

A new series of eight-coupled mineral engines was put in order at Doncaster in 1909. They differed from their prototype, No. 401, in having fluted coupling rods and larger crank pins and were fitted with the exhaust steam injector on the left-hand side. They bear the following numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1909	1236	446	1909	1241	451
,,	1237	447	,,	1244	452
,,	1238	448	,,	1245	453
,,	1239	449	,,	1248	454
,,	1240	450	,,	1250	455

Nos. 451 to 455 were fitted with the Schmidt superheater, piston valves and 21-in. cylinders. They also had other features slightly different from those of their predecessors. In order to accommodate the tail rods of the piston valves, the overhang at the leading end was increased

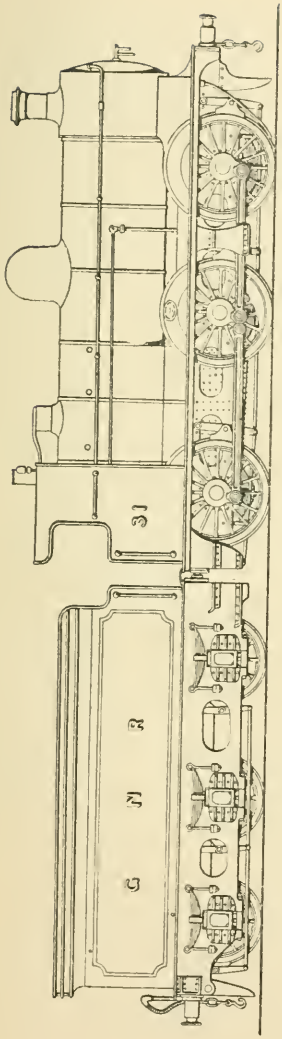


Fig. 116.

by about 9-in., and the centre of the boiler was raised 2-in., to 8-ft. 6-in. The heating surface was as follows: fire-box 137 sq. ft., tubes 1,027 sq. ft., total 1,164 sq. ft.; superheater surface 343 sq. ft.; grate area 24½ sq. ft. The working pressure in these superheater engines was reduced to 160 lb. per sq. in. The total weight of the engine in working order was increased by these various modifications to 58 tons 5 cwt., distributed as follows: On leading wheels 14 tons 6 cwt., on driving wheels 15 tons 9 cwt., on intermediate wheels 14 tons 4 cwt., and on trailing wheels 14 tons 6 cwt. The tender was of the new type, as adopted on the No. 1 class, weighing 43 tons 2 cwt.

A new type of six-coupled goods engines with standard wheels was brought out in 1909, and is illustrated in Fig. 116. Following are the leading dimensions:—

Cylinders 18-in. in diameter by 26-in. stroke; diameter of six-coupled wheels 5-ft. 2-in.; wheelbase: leading to driving 7-ft. 3-in., driving to trailing 9-ft., total 16-ft. 3-in.; boiler: length of barrel 10-ft. 1-in., diameter (outside) 4-ft. 8-in.; height of centre above rails 7-ft. $9\frac{8}{8}$-in.; heating surface: firebox 120 sq. ft., tubes 1,130 sq. ft., total 1,250 sq. ft.; grate area 19 sq. ft.; working pressure 170 lb. per sq. in.; weight of engine in working order 47 tons 6 cwt., distributed as follows: on leading wheels 15 tons 14 cwt., on driving wheels 17 tons and on trailing wheels 14 tons 12 cwt. The tender is of the new type, weighing 43 tons 2 cwt. Twenty engines of this class have been built so far, bearing the following numbers:—

Date.	Doncaster No.	Engine No.	Date.	Doncaster No.	Engine No.
1909 ..	1242 ..	31	1910 ..	1266 ..	21
,, ..	1243 ..	32	,, ..	1267 ..	22
,, ..	1246 ..	33	,, ..	1268 ..	23
,, ..	1247 ..	34	,, ..	1269 ..	24
,, ..	1249 ..	35	,, ..	1270 ..	25
,, ..	1251 ..	37	,, ..	1271 ..	26
,, ..	1252 ..	36	,, ..	1272 ..	27
,, ..	1253 ..	38	,, ..	1273 ..	28
,, ..	1254 ..	39	,, ..	1274 ..	29
1910 ..	1255 ..	40	,, ..	1275 ..	30

In May, 1909, one of the smaller Atlantic engines, No. 988, was rebuilt with the Schmidt superheater, and fitted with new cylinders 20-in. in diameter by 24-in. stroke, with 8-in. piston valves. The working pressure of the boiler was reduced to 160 lb. per sq. in., and the distributon of heating surface was modified as follows: firebox 137 sq. ft., tubes 1,027 sq. ft., total 1,164 sq. ft.; superheater surface 343 sq. ft.; grate area $24\frac{1}{2}$ sq. ft. The weight of the engine was increased to 60 tons, as follows: on bogie wheels 16 tons, on leading coupled wheels 15 tons 12 cwt., on driving

wheels 16 tons 12 cwt., and on trailing wheels 11 tons 16 cwt. It received one of the new tenders.

Subsequently, in 1910, No. 1383, four-coupled bogie engine, was fitted with a Baldwin smokebox superheater, which necessitated the provision of an extended smokebox. The weight of the engine in working order was thereby increased to 50 tons 9 cwt.

Following on these trials of superheating, Mr. Ivatt has put in hand a new series of the large Atlantic type of express engine, fitted with the Schmidt superheater. This class is provided with 20-in. by 24-in. cylinders fitted with tail rods, and piston valves, lubricated by means of Wakefield's mechanical lubricator. Externally the boiler is of the same dimensions as in the 251 class, the only noticeable difference being that the chimney is placed further forward so that the blast should clear the "header" or steam collector on the smokebox tube plate. The working pressure is only 150 lb. per sq. in., and the heating surface is apportioned as follows: firebox 143½ sq. ft., tubes 1,909½ sq. ft., total 2,053 sq. ft.; superheater surface 343 sq. ft.; grate area, 31 sq. ft. There are at present ten of this series in course of construction at Doncaster bearing the following numbers:—

Date.	Doncaster No.	Engine No.
1910	1276-1285	1452-1461

PART VII.

MR. IVATT'S REBUILDS.

WHILE the foregoing pages have dealt with Mr. Ivatt's new locomotives, a small space may be devoted to the matter of rebuilds of older engines which have been carried out by the present capable locomotive superintendent. No practical end can be served by going into the matter in the closest detail, as in some cases the engines thus rebuilt have already completed their sphere of usefulness, but sufficient may be said to show the lines on which it was necessary to proceed in order to enhance for a brief period the capabilities of some of the stock that was becoming obsolete, though not at the time of rebuilding quite ready for the scrap-heap.

Mr. Stirling's bogie singles were the first engines of his predecessors on which Mr. Ivatt had to place his improving hand, and in these the most novel feature, judged from outside, was the introduction of the steam dome, which had been absent from all new designs on the G.N.R. for nearly 30 years. No. 93 was the first engine to undergo alteration, and it was almost immediately followed by the Exhibition veteran No. 776. Though differing in a few minor details, as for instance in the size of the dome and the steam pressure carried, the

accompanying Fig. 117, which shows No. 93, may be accepted as illustrating the transformed engines. They both received new boilers having larger fireboxes than formerly, and carrying a higher pressure of steam—170 lb. in No. 93 and 175 lb. in No. 776. The heating surface worked out to: Firebox 114 sq. ft., tubes 969 sq. ft., total 1,083 sq. ft.; grate area 23¼ sq. ft. According to figures given to the writer by Mr. Ivatt, these changes altered the weight of the engines, No. 776 being given with the following distribution: bogie 17 tons 6 cwt., driving wheels

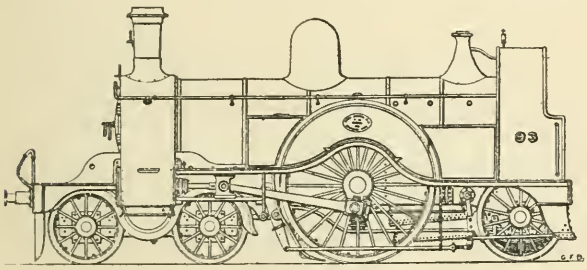


Fig. 117.

18 tons, trailing wheels 10 tons 14 cwt., total 46 tons. The tenders were altered, the tanks being converted to "horse-shoe" form. The driver's toolbox was brought to the front, so as to be within reach from the footplate, and gauge cocks were fitted to the tanks at the footplate end. As altered, the weight of the tender was officially given as 41 tons 14 cwt. 2 qrs.

Other engines of the class were also rebuilt and modified, with a view to extending their spheres of usefulness. But the traffic requirements of the G.N.R. have become so much more exacting within the last few years

that these fine single-wheelers have for some time been hopelessly outclassed in express work. It was inevitable, therefore, though regrettable, that the doom of the eight-footers should be pronounced, and they have been gradually withdrawn from service until in July, 1910, there were only nine left in service: Nos. 95, 1006 and 1007 stationed at Grantham, Nos. 668, 776, 1001, 1003 and 1004 at Peterborough, and No. 1008 at Lincoln. As has been mentioned on a previous page, No. 1 is still in existence, though not in service, and is now, after having been removed from the

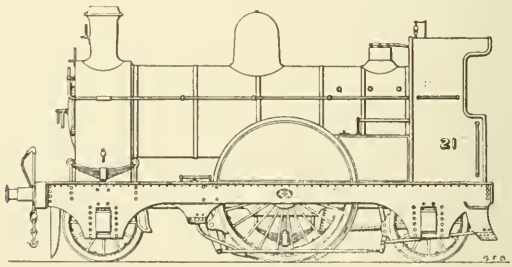


Fig. 118.

Imperial International Exhibition, standing in the erecting shop at King's Cross.

Next among the rebuilds came Mr. Stirling's old 7-ft. singles. No. 21 (as can be seen from the accompanying illustration, Fig. 118) was supplied with a new boiler, having 1,119 sq. ft. of heating surface and 16¼ sq. ft. of grate area. To adapt this larger boiler to the 7-ft. wheels it was necessary to pitch it with its centre line 7-ft. 10-in. above the rails. So far as the frames and wheels were concerned, the principal alteration consisted in placing the leading springs, of a longer span than formerly, outside and

above the frames instead of in the inaccessible position previously adopted. Another change welcomed by enginemen concerned the removal of the sandboxes from the front of the splashers, where they prevented ready access to the motion, to a position below the running plate. Other engines of the same class also underwent a process of rebuilding; but they have since been subjected to the same fate as the bogie engines, until now there are few, if any, remaining.

Several 7-ft. 6-in. engines were rebuilt with new boilers

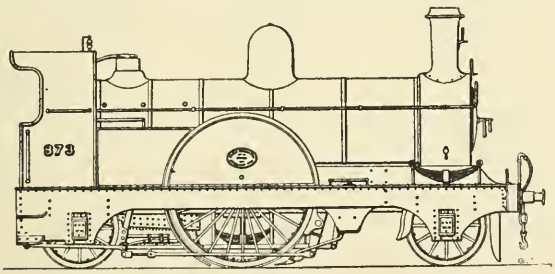


Fig. 119.

carrying 170 lb. pressure and possessing a heating surface of 1,083 sq. ft. apportioned as follows: firebox 114 sq. ft., tubes 969 sq. ft. As will be seen from Fig. 119, the nature of other alterations effected was practically identical with that already detailed in regard to No. 21. Others were also rebuilt, but with boilers of the domeless Stirling pattern.

Quite a number of Mr. Stirling's coupled passenger engines have been rebuilt. From Fig. 120 it will be seen that by the adoption of Mr. Ivatt's standard boiler and cab, and the effecting of sundry alterations to the leading

springs and sandboxes, these rebuilds closely resembled the coupled engines completed by Mr. Ivatt shortly after he took charge at Doncaster. Some, however, retained the old form of cab.

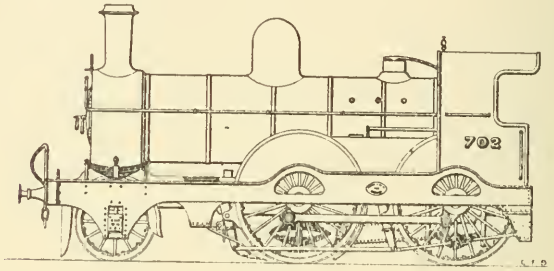


Fig. 120.

An interesting rebuild was effected with regard to No. 708, one of the coupled passenger engines built by Messrs. Kitson & Co., Ltd., in 1884. This engine was equipped in 1903 with the Druitt Halpin thermal storage apparatus.

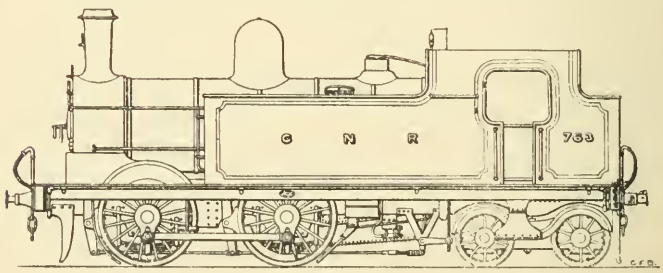


Fig. 121.

Several of the 5-ft. 1½-in. and 5-ft. 7-in. front-coupled bogie tank engines have been rebuilt in the manner shown in Fig. 121. They were supplied with Mr. Ivatt's standard boiler, which is of greater diameter than that originally fitted,

so that the wing tanks had to be placed rather wider apart during the process of reconstruction in order to accommodate this larger boiler. Otherwise the engines remain much as they were, except for slight alterations on the footplate.

One of Mr. Stirling's well-tank bogie engines, No. 533, was rebuilt as a crane engine for handling material at the Doncaster works. Various alterations were made to suit the new service. The well-tank underneath the coal bunker at the trailing end was removed, and two side tanks on either side of the smokebox substituted for it. Other modifications included new sand boxes to the leading driving wheels necessitated by the addition of the side tanks, steam sanding gear, and a new boiler and cab. The crane was adapted for dealing with a maximum load of 5 tons at a radius of about 11-ft. 6-in., and was so designed as to be able to make a complete revolution on its pivot. The engine retains its continuous brake gear, which is used for the testing of new rolling stock.

Several of Mr. Stirling's six-wheeled front-coupled radial passenger tank engines, notably Nos. 116, 120 and 122, and a number of Mr. Stirling's front-coupled tender engines for mixed traffic were rebuilt with new boilers, but on the other hand a number of these one-time useful engines have been removed from service.

Similarly, a large number of Stirling goods engines were rebuilt, and special mention may be made of one, No. 743, which was also fitted with Marshall's valve gear, concerning which the untechnical press predicted such phenomenal properties. The ten-wheeled passenger tank

engine No. 1520 was also so fitted, but the gear has in both cases been removed.

Various saddle-tank goods engines have been rebuilt, with new boilers of the domeless pattern, in order to avoid alteration to the tanks.

As regards the older goods engines on the line, built during Mr. Sturrock's *régime*, and rebuilt by Mr. Stirling, historians will perhaps be sorry to learn that these have now all disappeared.

Table III.

List of G.N.R. Locomotives, Designed by Mr. H. A. Ivatt, Built in the years 1896-1910.

Date.	Description.	Driving Wheels.	Cylinders.	First of Type.	Reference to Doncaster List.	Number of Engines built.	Where built.
		ft. in.	ft. in.	No.			
1896	Coupled Bogie Passenger..	6 7½	17½ × 26	400	**S**	11 built	Doncaster
1897	Coupled Passenger.....	6 7½	17½ × 26	1061	**H6**	10 ,,	,,
1897	Six-coupled Goods Tank ..	4 7½	18 × 26	111	**M6**	12 ,,	,,
1897	Six-coupled Goods Tank ..	4 7½	18 × 26	1201	—	40 ,,	Outside
1897	Coupled Bogie Passenger..	6 7½	17½ × 26	1301	**S2**	20 ,,	Doncaster
1897	Ten-wheel Bogie Tank	5 7½	17½ × 26	1009	**T**	10 ,,	,,
1898	Atlantic Passenger.....	6 7½	18½ × 24	990	**U**	1 ,,	,,
1898	Coupled Bogie Passenger..	6 7½	17½ × 26	1321	**V**	5 ,,	,,
1897	Six-coupled Goods	5 1½	17½ × 20	1091	—	10 ,,	Outside
1898	Six-coupled Goods	5 1½	17½ × 26	315	**E5**	10 ,,	Doncaster
1898	Six-coupled Goods	5 1½	17½ × 26	1101	—	35 ,,	Outside
1898	Coupled Bogie Passenger..	6 7½	17½ × 26	1326	**V2**	20 ,,	Doncaster
1898	Bogie Single	7 7½	18 × 26	266	**W**	1 ,,	,,
1898	Coupled Bogie Passenger..	6 7½	17½ × 26	1341	**S3**	10 ,,	,,
1898	Ten-wheel Bogie Tank	5 7½	17½ × 26	1501	**X**	20 ,,	,,
1899	Mogul Goods	5 1	18 × 24	1181	—	20 ,,	U.S.A.
1899	Six-coupled Goods	5 1½	17½ × 26	343	**E6**	20 ,,	Doncaster
1900	Six-coupled Goods	5 1½	17½ × 26	1136	—	38 ,,	Outside
1899	Coupled Bogie Passenger..	6 7½	17½ × 26	1351	**S4**	10 ,,	Doncaster
1900	Atlantic Passenger.....	6 7½	18¾ × 24	949	**U2**	10 ,,	,,
1900	Bogie Single.....	7 8	19 × 26	267	**W2**	11 ,,	,,
1900	Coupled Bogie Passenger..	6 7½	17½ × 26	1366	**V3**	20 ,,	,,
1901	Eight coupled Mineral	4 7½	19¾ × 26	401	**Y**	55 ,,	,,
1901	Ten-wheel Bogie Tank	5 7½	18 × 26	1521	**X2**	30 ,,	,,
1901	Six-coupled Goods Tank ..	4 7½	18 × 26	1251	**M7**	40 ,,	,,
1902	Ten-wheel 4-cylr. Passenger	6 7½	(4) 15 × 20	271	**Z**	1 ,,	,,
1902	Coupled Bogie Passenger..	6 7½	17½ × 26	1386	**V4**	10 ,,	,,
1902	Atlantic Passenger.....	6 8	18¾ × 24	251	**LU**	81 ,,	,,
1903	Atlantic Passenger.....	6 8	18¾ × 24	252	**U3**	10 ,,	,,
1903	Eight-coupled Radial Tank	4 8	19¾ × 26	116	**YT**	41 ,,	,,
1905	Atlantic Compound	6 8	(13 × 20) (16 × 26)	292	**ZZ**	1 ,,	,,
1905	Atlantic Compound	6 8	(14 × 26) (23 × 26)	1300	—	1 ,,	Outside
1905	Rail Motor Coach	3 7	10 × 16	2	**MC**	2 ,,	Doncaster
1905	Rail Motor Coach	3 7	10 × 16	5	—	4 ,,	Outside
1906	Six-coupled Radial Tank ..	5 8	17½ × 26	190	**MM**	21 ,,	Doncaster
1907	Coupled Bogie Passenger..	6 8	17½ × 26	1396	**V5**	15 ,,	,,
1907	Atlantic Compound	6 8	(13 × 20) (18 × 26)	1421	**ZZ2**	1 ,,	,,
1908	Six-coupled Goods.....	5 8	17½ × 26	1	**EE**	15 ,,	,,
1909	Six-coupled Goods.....	5 2	17½ × 26	31	**EE2**	20 ,,	,,
1910	Superheater Atlantic	6 8	20 × 24	1452	**LUS**	10 bldg.	,,

Table IV.

List of Locomotives built at Doncaster Works, 1867-1910.

Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
1	1867	18	A	49	1870	92	F	97	1873	158	I
2	,,	23	,,	50	,,	1	G	98	,,	16	A
3	,,	40	,,	51	,,	39	B	99	,,	50	,,
4	1868	6	B	52	,,	15	A	100	,,	151	E
5	,,	222	,,	53	,,	25	,,	101	,,	43	L
6	,,	41	,,	54	,,	65	,,	102	,,	145	I
7	,,	392	C	55	,,	122	D	103	,,	10	L
8	,,	4	B	56	,,	190	E	104	,,	152	E
9	,,	21	,,	57	,,	200	A	105	,,	5	G
10	,,	124	C	58	,,	35	,,	106	,,	508	A
11	,,	14	B	59	,,	64	,,	107	,,	7	G
12	,,	44	A	60	,,	132	D	108	,,	504	K
13	,,	162	C	61	,,	8	G	109	,,	509	A
14	,,	126	D	62	,,	366	E	110	,,	505	K
15	,,	49	A	63	1871	85	A	111	,,	186	E
16	,,	9	,,	64	,,	395	C	112	,,	77	A
17	,,	38	,,	65	,,	398	,,	113	,,	171	E
18	,,	127	D	66	,,	33	G	114	,,	81	A
19	,,	218	A	67	,,	32	A	115	,,	335	E
20	,,	220	,,	68	,,	116	D	116	,,	193	,,
21	1869	125	D	69	,,	118	,,	117	,,	506	K
22	,,	76	A	70	,,	30	A	118	1874	146	I
23	,,	205	,,	71	,,	261	H	119	,,	510	K
24	,,	11	,,	72	,,	203	A	120	,,	22	G
25	,,	31	,,	73	,,	68	A	121	,,	372	E2
26	,,	55	B	74	,,	262	H	122	,,	373	,,
27	,,	61	,,	75	,,	117	D	123	,,	507	K
28	,,	19	A	76	,,	83	A	124	,,	73	A
29	,,	369	E	77	,,	2	G	125	,,	164	I
30	,,	123	D	78	,,	119	D	126	,,	219	A
31	,,	131	,,	79	,,	174	I	127	,,	86	H2
32	,,	63	B	80	1872	148	E	128	,,	89	,,
33	,,	17	A	81	,,	46	A	129	,,	511	K
34	,,	215	B	82	,,	3	G	130	,,	494	M
35	,,	82	A	83	,,	376	I	131	,,	512	K
36	,,	377	E	84	,,	311	E	132	,,	354	E2
37	,,	396	C	85	,,	13	A	133	,,	198	,,
38	,,	184	E	86	,,	333	E	134	,,	495	M
39	,,	27	A	87	,,	52	A	135	,,	496	,,
40	,,	129	D	88	,,	197	E	136	,,	136	J2
41	1870	169	E	89	,,	471	J	137	,,	137	,,
42	,,	56	A	90	,,	71	A	138	,,	138	,,
43	,,	54	,,	91	,,	75	,,	139	,,	20	L
44	,,	380	E	92	,,	470	J	140	,,	513	K
45	,,	58	A	93	,,	120	K	141	,,	84	H2
46	,,	121	D	94	,,	128	,,	142	,,	42	L
47	,,	59	A	95	,,	166	C	143	,,	497	M
48	,,	37	B	96	1873	167	C	144	,,	514	K

List of Locomotives built at Doncaster Works, 1867-1910.

Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
145	1874	498	M	193	1876	543	H2	241	1878	631	N2
146	,,	90	H2	194	,,	552	K	242	,,	641	E2
147	,,	515	K	195	,,	62	G	243	,,	625	K2
148	,,	74	A2	196	,,	526	A2	244	,,	632	N2
149	,,	399	J2	197	,,	45	,,	245	,,	549	G
150	,,	48	G	198	,,	533	K	246	,,	626	K2
151	,,	499	M	199	,,	312	E2	247	,,	60	G
152	,,	516	K	200	,,	314	,,	248	,,	550	,,
153	,,	517	,,	201	,,	534	A2	249	,,	642	E2
154	,,	36	A2	202	,,	527	,,	250	,,	244	K2
155	,,	196	E2	203	,,	130	K	251	,,	57	A2
156	1875	173	,,	204	,,	535	A2	252	,,	643	E2
157	,,	519	A2	205	,,	536	,,	253	,,	246	K2
158	,,	518	,,	206	,,	159	K	254	,,	616	M
159	,,	340	E2	207	,,	538	A2	255	1879	617	,,
160	,,	520	A2	208	,,	501	N	256	,,	66	A2
161	,,	365	E2	209	,,	502	,,	257	,,	263	H2
162	,,	521	A2	210	,,	537	A2	258	,,	644	E2
163	,,	141	E2	211	,,	539	,,	259	,,	241	K2
164	,,	26	A2	212	,,	221	G	260	,,	618	M
165	,,	34	G	213	,,	606	M	261	,,	243	K2
166	,,	28	A2	214	,,	607	,,	262	,,	619	M
167	,,	163	E2	215	,,	94	G	263	,,	51	H2
168	,,	522	A2	216	,,	503	N	264	,,	645	E2
169	,,	339	E2	217	1877	608	M	265	,,	250	K2
170	,,	47	G	218	,,	161	N	266	,,	245	,,
171	,,	187	E2	219	,,	69	G	267	,,	160	E2
172	,,	523	A2	220	,,	98	,,	268	,,	620	M
173	,,	528	K	221	,,	609	M	269	,,	646	E2
174	,,	24	A2	222	,,	610	,,	270	,,	133	,,
175	,,	605	J2	223	,,	611	,,	271	,,	96	H2
176	,,	604	,,	224	,,	72	H2	272	,,	627	K2
177	,,	500	M	225	,,	80	,,	273	,,	168	E2
178	,,	529	K	226	,,	612	M	274	,,	99	H2
179	,,	29	A2	227	,,	614	,,	275	,,	628	K2
180	,,	601	M	228	,,	613	,,	276	,,	633	M
181	,,	328	E2	229	,,	615	,,	277	,,	247	K2
182	,,	194	,,	230	,,	544	G	278	,,	154	E2
183	,,	602	M	231	,,	545	,,	279	,,	249	K2
184	,,	530	K	232	,,	546	,,	280	,,	634	M
185	,,	53	G	233	,,	547	,,	281	,,	93	G
186	,,	540	H2	234	,,	621	K2	282	1880	635	M
187	,,	524	A2	235	1878	622	,,	283	,,	629	K2
188	,,	541	H2	236	,,	623	,,	284	,,	630	,,
189	,,	531	K	237	,,	310	E2	285	,,	95	G
190	,,	603	M	238	,,	624	K2	286	,,	636	M
191	,,	525	A2	239	,,	393	E2	287	,,	640	E2
192	,,	542	H2	240	,,	548	G	288	,,	637	M

List of Locomotives built at Doncaster Works, 1867-1910.

Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
289	1880	242	K2	337	1882	683	O	385	1885	764	O
290	,,	248	,,	338	,,	78	H3	386	,,	765	,,
291	,,	223	H2	339	,,	88	,,	387	,,	781	M2
292	,,	647	E2	340	,,	681	M2	388	,,	782	,,
293	,,	638	M	341	,,	668	G	389	,,	238	Q
294	,,	97	H2	342	,,	669	,,	390	,,	232	,,
295	,,	648	E2	343	,,	201	H3	391	,,	107	A3
296	,,	153	M	344	,,	202	,,	392	,,	108	,,
297	,,	652	K2	345	,,	103	A3	393	,,	773	G2
298	,,	653	,,	346	,,	104	,,	394	,,	774	,,
299	,,	472	M	347	,,	684	J3	395	,,	185	P
300	,,	207	H2	348	,,	685	,,	396	,,	189	,,
301	,,	649	E2	349	,,	670	G	397	,,	109	A3
302	,,	639	M	350	,,	671	,,	398	,,	110	,,
303	,,	662	G	351	1883	699	H3	399	,,	783	M2
304	,,	650	E2	352	,,	700	,,	400	,,	784	,,
305	,,	473	M	353	,,	688	M2	401	,,	785	,,
306	1881	654	K2	354	,,	689	,,	402	1886	786	,,
307	,,	655	,,	355	,,	690	,,	403	,,	787	,,
308	,,	651	E2	356	,,	374	P	404	,,	788	,,
309	,,	226	H2	357	,,	172	,,	405	,,	211	H4
310	,,	212	,,	358	,,	691	M2	406	,,	217	,,
311	,,	208	H3	359	,,	692	,,	407	,,	224	,,
312	,,	663	G	360	,,	693	,,	408	,,	228	,,
313	,,	656	K2	361	,,	112	A3	409	,,	234	Q2
314	,,	657	,,	362	,,	113	,,	410	,,	229	,,
315	,,	672	M2	363	1884	694	O	411	,,	791	E3
316	,,	673	,,	364	,,	686	J3	412	,,	792	,,
317	,,	227	H3	365	,,	695	O	413	,,	793	,,
318	,,	658	O	366	,,	687	J3	414	,,	794	,,
319	,,	674	M2	367	,,	751	H4	415	,,	795	,,
320	,,	664	G	368	,,	752	,,	416	,,	796	,,
321	,,	665	,,	369	,,	696	O	417	,,	797	,,
322	,,	91	H3	370	,,	114	A3	418	,,	798	,,
323	,,	666	G	371	,,	115	,,	419	,,	799	,,
324	,,	667	,,	372	,,	697	O	420	,,	800	,,
325	,,	675	M2	373	,,	105	A3	421	,,	216	H4
326	,,	676	,,	374	,,	106	,,	422	,,	225	,,
327	,,	659	O	375	,,	698	O	423	,,	755	,,
328	,,	660	,,	376	,,	761	,,	424	,,	756	,,
329	,,	102	E2	377	,,	206	H4	425	,,	757	,,
330	,,	101	,,	378	,,	209	,,	426	,,	758	,,
331	,,	661	O	379	,,	771	G2	427	,,	775	G2
332	1882	677	M2	380	,,	772	,,	428	1887	237	Q2
333	,,	678	,,	381	,,	762	O	429	,,	789	M2
334	,,	679	,,	382	,,	753	H4	430	,,	790	,,
335	,,	680	,,	383	,,	754	,,	431	,,	322	E3
336	,,	682	O	384	1885	763	O	432	,,	307	,,

List of Locomotives built at Doncaster Works, 1867-1910.

Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
433	1887	776	G2	481	1889	805	M2	529	1891	833	E3
434	,,	230	Q2	482	,,	806	,,	530	,,	810	M2
435	,,	10	A4	483	,,	813	H5	531	,,	829	R
436	,,	12	,,	484	,,	814	,,	532	,,	861	H5
437	,,	759	H4	485	,,	815	,,	533	,,	834	E3
438	,,	760	,,	486	,,	816	,,	534	,,	862	H5
439	,,	779	M2	487	,,	330	E3	535	,,	830	R
440	,,	780	,,	488	,,	135	,,	536	,,	851	M2
441	,,	777	G2	489	,,	817	H5	537	,,	835	E3
442	,,	778	,,	490	,,	818	,,	538	,,	852	M2
443	,,	199	E3	491	,,	819	,,	539	,,	385	E3
444	,,	320	,,	492	,,	820	,,	540	,,	863	H5
445	,,	236	Q2	493	,,	170	E3	541	,,	836	E3
446	,,	239	,,	494	,,	195	,,	542	,,	864	H5
447	,,	142	P	495	,,	191	,,	543	,,	379	E3
448	,,	188	,,	496	,,	383	,,	544	,,	853	M2
449	,,	176	E3	497	,,	213	H5	545	,,	837	E3
450	,,	183	,,	498	,,	214	,,	546	,,	951	A4
451	,,	389	,,	499	,,	766	R	547	,,	839	E3
452	,,	147	,,	500	1890	767	,,	548	,,	854	M3
453	1888	801	M2	501	,,	342	E3	549	,,	865	H5
454	,,	802	,,	502	,,	347	,,	550	,,	838	E3
455	,,	231	Q2	503	,,	175	,,	551	,,	855	M3
456	,,	233	,,	504	,,	768	R	552	,,	840	E3
457	,,	156	P	505	,,	391	E3	553	,,	866	H5
458	,,	157	,,	506	,,	769	R	554	,,	841	E3
459	,,	803	M2	507	,,	770	,,	555	,,	856	M3
460	,,	178	E3	508	,,	79	H5	556	,,	845	E3
461	,,	309	,,	509	,,	397	M2	557	,,	952	A4
462	,,	150	,,	510	,,	87	H5	558	,,	842	E3
463	,,	324	,,	511	,,	139	M2	559	,,	857	M3
464	,,	181	,,	512	,,	821	R	560	,,	846	E3
465	,,	321	,,	513	,,	822	,,	561	,,	843	,,
466	,,	20	A4	514	,,	378	E3	562	1892	871	Q3
467	,,	326	,,	515	,,	370	,,	563	,,	847	E3
468	,,	804	M2	516	,,	134	J4	564	,,	858	M3
469	,,	235	Q2	517	,,	140	,,	565	,,	844	E3
470	,,	240	,,	518	,,	823	R	566	,,	872	Q3
471	,,	210	H5	519	,,	824	,,	567	,,	848	E3
472	,,	204	,,	520	,,	825	,,	568	,,	859	M3
473	,,	42	A4	521	,,	807	M2	569	,,	849	E3
474	,,	43	,,	522	,,	831	E3	570	,,	860	M3
475	1889	323	E3	523	,,	808	M2	571	,,	873	Q3
476	,,	382	,,	524	,,	832	E3	572	,,	850	E3
477	,,	811	H5	525	,,	826	R	573	,,	874	Q3
478	,,	812	,,	526	1891	827	,,	574	,,	317	E3
479	,,	300	E3	527	,,	809	M2	575	,,	341	,,
480	,,	301	,,	528	,,	828	R	576	,,	875	Q3

List of Locomotives built at Doncaster Works, 1867-1910.

Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
577	1892	144	J4	625	1893	953	A4	673	1895	1005	G3
578	,,	867	H5	626	,,	954	,,	674	,,	1006	,,
579	,,	868	,,	627	,,	964	M5	675	,,	1007	,,
580	,,	149	J4	628	,,	890	H5	676	,,	1008	,,
581	,,	881	H5	629	,,	965	M5	677	,,	997	H5
582	,,	931	R	630	,,	966	,,	678	,,	998	,,
583	,,	932	,,	631	,,	1001	G2	679	,,	999	,,
584	,,	882	H5	632	,,	1002	,,	680	,,	1000	,,
585	,,	869	,,	633	,,	891	H5	681	,,	977	M5
586	,,	143	E3	634	,,	319	E3	682	,,	978	,,
587	,,	346	,,	635	,,	892	H5	683	,,	979	,,
588	,,	870	H5	636	,,	967	M5	684	,,	980	,,
589	,,	933	R	637	,,	327	E3	685	,,	958	A4
590	,,	883	H5	638	,,	893	H5	686	,,	959	,,
591	,,	921	M4	639	,,	894	,,	687	,,	960	,,
592	,,	313	E3	640	1894	968	M5	688	,,	941	R2
593	,,	884	H5	641	,,	1011	E3	689	,,	942	,,
594	,,	934	R	642	,,	895	H5	690	,,	943	,,
595	,,	182	E3	643	,,	969	M5	691	,,	944	,,
596	,,	885	H5	644	,,	896	H5	692	1896	1021	P2
597	,,	922	M4	645	,,	1012	E3	693	,,	1022	,,
598	,,	935	R	646	,,	897	H5	694	,,	1023	,,
599	1893	923	M4	647	,,	970	M5	695	,,	1024	,,
600	,,	924	,,	648	,,	898	H5	696	,,	1025	,,
601	,,	936	R	649	,,	899	,,	697	,,	1026	,,
602	,,	325	A4	650	,,	900	,,	698	,,	1027	,,
603	,,	925	M4	651	,,	876	Q3	699	,,	1028	,,
604	,,	355	A4	652	,,	877	,,	700	,,	1029	,,
605	,,	926	M4	653	,,	878	,,	701	,,	1030	,,
606	,,	886	H5	654	,,	879	,,	702	,,	1081	E4
607	,,	937	R	655	,,	880	,,	703	,,	1082	,,
608	,,	927	M4	656	,,	981	,,	704	,,	1083	,,
609	,,	356	A4	657	,,	971	M5	705	,,	1084	,,
610	,,	938	R	658	,,	972	,,	706	,,	1085	,,
611	,,	357	A4	659	,,	973	,,	707	,,	1086	,,
612	,,	928	M4	660	,,	974	,,	708	,,	1087	,,
613	,,	929	,,	661	,,	975	,,	709	,,	1088	,,
614	,,	939	R	662	,,	976	,,	710	,,	1089	,,
615	,,	930	M4	663	,,	955	A4	711	,,	1090	,,
616	,,	358	A4	664	,,	956	,,	712	,,	400	S
617	,,	940	R	665	,,	991	H5	713	1897	1061	H6
618	,,	961	M5	666	,,	992	,,	714	,,	1062	,,
619	,,	962	,,	667	,,	993	,,	715	,,	1063	,,
620	,,	957	A4	668	,,	994	,,	716	,,	1064	,,
621	,,	887	H5	669	,,	995	,,	717	,,	1065	,,
622	,,	888	,,	670	,,	996	,,	718	,,	1066	,,
623	,,	963	M5	671	,,	1003	G3	719	,,	1067	,,
624	,,	889	H5	672	,,	1004	,,	720	,,	1068	,,

List of Locomotives built at Doncaster Works, 1867-1910.

Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No	Date.	Engine No.	Class.
721	1897	1069	H6	769	1898	990	U	817	1899	1506	X
722	,,	1070	,,	770	,,	1321	V	818	,,	1507	,,
723	,,	1071	S	771	,,	1322	,,	819	,,	1508	,,
724	,,	1072	,,	772	,,	1323	,,	820	,,	1509	,,
725	,,	1073	,,	773	,,	1324	,,	821	,,	1510	,,
726	,,	1074	,,	774	,,	1325	,,	822	,,	343	E6
727	,,	1075	,,	775	,,	315	E5	823	,,	344	,,
728	,,	1076	,,	776	,,	316	,,	824	,,	345	,,
729	,,	1077	,,	777	,,	318	,,	825	,,	348	,,
730	,,	1078	,,	778	,,	329	,,	826	,,	349	,,
731	,,	1079	,,	779	,,	331	,,	827	,,	350	,,
732	,,	1080	,,	780	,,	332	,,	828	,,	351	,,
733	,,	111	M6	781	,,	334	,,	829	,,	352	,,
734	,,	155	,,	782	,,	336	,,	830	,,	353	,,
735	,,	1201	,,	783	,,	337	,,	831	,,	359	,,
736	,,	1202	,,	784	,,	338	,,	832	,,	1511	X
737	,,	1203	,,	785	,,	1326	V2	833	,,	1512	,,
738	,,	1204	,,	786	,,	1327	,,	834	,,	1513	,,
739	,,	1205	,,	787	,,	266	W	835	,,	1514	,,
740	,,	1206	,,	788	,,	1015	T	836	,,	1515	,,
741	,,	1207	,,	789	,,	1016	,,	837	,,	1516	,,
742	,,	1208	,,	790	,,	1017	,,	838	,,	1517	,,
743	,,	1209	,,	791	,,	1018	,,	839	,,	1518	,,
744	,,	1210	,,	792	,,	1328	V2	840	,,	1519	,,
745	,,	1301	S2	793	,,	1329	,,	841	,,	1520	,,
746	,,	1302	,,	794	,,	1330	,,	842	,,	360	E6
747	,,	1303	,,	795	,,	1331	,,	843	,,	361	,,
748	,,	1304	,,	796	,,	1019	T	844	,,	362	,,
749	,,	1305	,,	797	,,	1020	,,	845	,,	363	,,
750	,,	1306	,,	798	,,	1332	V2	846	,,	364	,,
751	,,	1307	,,	799	,,	1333	,,	847	,,	367	,,
752	,,	1308	,,	800	,,	1334	,,	848	,,	368	,,
753	,,	1309	,,	801	,,	1335	,,	849	,,	371	,,
754	,,	1310	,,	802	,,	1341	S3	850	,,	375	,,
755	1898	1009	T	803	,,	1342	,,	851	,,	381	,,
756	,,	1010	,,	804	,,	1343	,,	852	,,	1336	V2
757	,,	1013	,,	805	,,	1344	,,	853	,,	1337	,,
758	,,	1014	,,	806	,,	1345	,,	854	,,	1338	,,
759	,,	1311	S2	807	,,	1346	,,	855	,,	1339	,,
760	,,	1312	,,	808	,,	1347	,,	856	,,	1340	,,
761	,,	1313	,,	809	,,	1348	,,	857	,,	1361	,,
762	,,	1314	,,	810	,,	1349	,,	858	,,	1362	,,
763	,,	1315	,,	811	,,	1350	,,	859	,,	1363	,,
764	,,	1316	,,	812	1899	1501	X	860	,,	1364	,,
765	,,	1317	,,	813	,,	1502	,,	861	,,	1365	,,
766	,,	1318	,,	814	,,	1503	,,	862	,,	1351	S4
767	,,	1319	,,	815	,,	1504	,,	863	,,	1352	,,
768	,,	1320	,,	816	,,	1505	,,	864	,,	1353	,,

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Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
865	1899	1354	S4	913	1900	1382	V3	961	1902	1268	M7
866	,,	1355	,,	914	,,	1383	,,	962	,,	1269	,,
867	,,	1356	,,	915	,,	1384	,,	963	,,	1270	,,
868	,,	1357	,,	916	,,	1375	,,	964	,,	402	Y
869	,,	1358	,,	917	,,	1376	,,	965	,,	405	,,
870	,,	1359	,,	918	1901	1377	,,	966	,,	406	,,
871	,,	1360	,,	919	,,	1378	,,	967	,,	407	,,
872	1900	949	U2	920	,,	1379	,,	968	,,	403	,,
873	,,	950	,,	921	,,	1381	,,	969	,,	408	,,
874	,,	982	,,	922	,,	1385	,,	970	,,	409	,,
875	,,	983	,,	923	,,	401	Y	971	,,	410	,,
876	,,	984	,,	924	,,	1521	X2	972	,,	404	,,
877	,,	985	,,	925	,,	1522	,,	973	,,	411	,,
878	,,	986	,,	926	,,	1523	,,	974	,,	271	Z
879	,,	987	,,	927	,,	1524	,,	975	,,	1386	V4
880	,,	988	,,	928	,,	1525	,,	976	,,	412	Y
881	,,	989	,,	929	,,	1526	,,	977	,,	1388	V4
882	,,	165	E6	930	,,	1527	,,	978	,,	414	Y
883	,,	177	,,	931	,,	1528	,,	979	,,	1391	V4
884	,,	179	,,	932	,,	1529	,,	980	,,	1389	,,
885	,,	180	,,	933	,,	1530	,,	981	,,	1387	,,
886	,,	192	,,	934	,,	92	W2	982	,,	413	Y
887	,,	302	,,	935	,,	100	,,	983	,,	415	,,
888	,,	303	,,	936	,,	261	,,	984	,,	417	,,
889	,,	304	,,	937	,,	262	,,	985	,,	416	,,
890	,,	306	,,	938	,,	263	,,	986	,,	418	,,
891	,,	308	,,	939	,,	264	,,	987	,,	419	,,
892	,,	384	,,	940	,,	265	,,	988	,,	420	,,
893	,,	386	,,	941	,,	268	,,	989	,,	421	,,
894	,,	387	,,	942	,,	269	,,	990	,,	1390	V4
895	,,	388	,,	943	,,	270	,,	991	,,	251	LU
896	,,	390	,,	944	,,	1251	M7	992	,,	1394	V4
897	,,	392	,,	945	,,	1252	,,	993	,,	1395	,,
898	,,	394	,,	946	,,	1253	,,	994	,,	1392	,,
899	,,	396	,,	947	,,	1254	,,	995	,,	1393	,,
900	,,	398	,,	948	,,	1255	,,	996	1903	252	U3
901	,,	399	,,	949	,,	1256	,,	997	,,	253	,,
902	,,	267	W2	950	,,	1257	,,	998	,,	256	,,
903	,,	1366	V3	951	,,	1258	,,	999	,,	255	,,
904	,,	1367	,,	952	,,	1259	,,	1000	,,	254	,,
905	,,	1368	,,	953	,,	1260	,,	1001	,,	257	,,
906	,,	1369	,,	954	,,	1261	,,	1002	,,	259	,,
907	,,	1370	,,	955	1902	1262	,,	1003	,,	250	,,
908	,,	1371	,,	956	,,	1263	,,	1004	,,	116	YT
909	,,	1372	,,	957	,,	1264	,,	1005	,,	260	U3
910	,,	1373	,,	958	,,	1265	,,	1006	,,	258	,,
911	,,	1380	,,	959	,,	1266	,,	1007	,,	423	Y
912	,,	1374	,,	960	,,	1267	,,	1008	,,	425	,,

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Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
1009	1903	422	Y	1057	1904	118	YT	1105	1905	135	YT
1010	,,	424	,,	1058	,,	119	,,	1106	,,	136	,,
1011	,,	426	,,	1059	,,	120	,,	1107	,,	No. 2	MC
1012	,,	427	,,	1060	,,	121	,,	1108	,,	No. 1	,,
1013	,,	429	,,	1061	,,	122	,,	1109	,,	1411	LU
1014	,,	430	,,	1062	,,	123	,,	1110	,,	1412	,,
1015	,,	428	,,	1063	,,	124	,,	1111	,,	1413	,,
1016	,,	431	,,	1064	,,	125	,,	1112	,,	1414	,,
1017	,,	1531	X	1065	,,	126	,,	1113	1906	1415	,,
1018	,,	1532	,,	1066	1905	292	ZZ	1114	,,	1416	,,
1019	,,	1533	,,	1067	,,	293	LU	1115	,,	1417	,,
1020	,,	1534	,,	1068	,,	297	,,	1116	,,	1418	,,
1021	,,	1535	,,	1069	,,	296	,,	1117	,,	1419	,,
1022	,,	1536	,,	1070	,,	294	,,	1118	,,	1420	,,
1023	,,	1537	,,	1071	,,	295	,,	1119	,,	137	YT
1024	,,	1538	,,	1072	,,	298	,,	1120	,,	138	,,
1025	,,	1539	,,	1073	,,	299	,,	1121	,,	139	,,
1026	,,	1540	,,	1074	,,	301	,,	1122	,,	140	,,
1027	1904	432	Y	1075	,,	300	,,	1123	,,	141	,,
1028	,,	433	,,	1076	,,	1400	,,	1124	,,	142	,,
1029	,,	434	,,	1077	,,	1401	,,	1125	,,	143	,,
1030	,,	272	LU	1078	,,	1402	,,	1126	,,	144	,,
1031	,,	273	,,	1079	,,	1403	,,	1127	,,	145	,,
1032	,,	274	,,	1080	,,	1405	,,	1128	,,	146	,,
1033	,,	275	,,	1081	,,	1404	,,	1129	,,	147	,,
1034	,,	276	,,	1082	,,	1406	,,	1130	,,	148	,,
1035	,,	277	,,	1083	,,	1407	,,	1131	,,	149	,,
1036	,,	278	,,	1084	,,	1408	,,	1132	,,	150	,,
1037	,,	279	,,	1085	,,	1409	,,	1133	,,	151	,,
1038	,,	280	,,	1086	,,	1410	,,	1134	,,	152	,,
1039	,,	281	,,	1087	,,	1271	M8	1135	,,	153	,,
1040	,,	283	,,	1088	,,	1272	,,	1136	,,	154	,,
1041	,,	285	,,	1089	,,	1273	,,	1137	,,	155	,,
1042	,,	282	,,	1090	,,	1274	,,	1138	,,	156	,,
1043	,,	286	,,	1091	,,	1275	,,	1139	,,	441	Y
1044	,,	284	,,	1092	,,	1276	,,	1140	,,	442	,,
1045	,,	287	,,	1093	,,	1277	,,	1141	,,	443	,,
1046	,,	289	,,	1094	,,	1278	,,	1142	,,	444	,,
1047	,,	288	,,	1095	,,	1279	,,	1143	,,	445	,,
1048	,,	290	,,	1096	,,	1280	,,	1144	,,	1422	LU
1049	,,	291	,,	1097	,,	127	YT	1145	,,	190	MM
1050	,,	435	Y	1098	,,	128	,,	1146	,,	1423	LU
1051	,,	436	,,	1099	,,	129	,,	1147	,,	1424	,,
1052	,,	437	,,	1100	,,	130	,,	1148	,,	1425	,,
1053	,,	438	,,	1101	,,	131	,,	1149	1907	1427	,,
1054	,,	439	,,	1102	,,	132	,,	1150	,,	1428	,,
1055	,,	440	,,	1103	,,	133	,,	1151	,,	1426	,,
1056	,,	117	YT	1104	,,	134	,,	1152	,,	1429	,,

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Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.	Works No.	Date.	Engine No.	Class.
1153	1907	1430	LU	1199	1908	1450	LU	1245	1909	453	Y
1154	,,	1431	,,	1200	,,	1449	,,	1246	,,	33	EE2
1155	,,	1541	X	1201	,,	1451	,,	1247	,,	34	,,
1156	,,	1542	,,	1202	,,	2	EE	1248	,,	454	Y
1157	,,	1543	,,	1203	,,	3	,,	1249	,,	35	EE2
1158	,,	1544	,,	1204	,,	4	,,	1250	,,	455	Y
1159	,,	1545	,,	1205	,,	5	,,	1251	,,	37	EE2
1160	,,	1546	,,	1206	,,	6	,,	1252	,,	36	,,
1161	,,	1547	,,	1207	,,	7	,,	1253	,,	38	,,
1162	,,	1548	,,	1208	,,	8	,,	1254	,,	39	,,
1163	,,	1549	,,	1209	,,	9	,,	1255	1910	40	,,
1164	,,	1550	,,	1210	,,	10	,,	1256	,,	1561	MM
1165	,,	1396	V5	1211	,,	11	,,	1257	,,	1562	,,
1166	,,	1421	ZZ2	1212	,,	12	,,	1258	,,	1563	,,
1167	,,	1397	V5	1213	,,	13	,,	1259	,,	1564	,,
1168	,,	1398	,,	1214	,,	14	,,	1260	,,	1565	,,
1169	,,	1399	,,	1215	,,	15	,,	1261	,,	1566	,,
1170	,,	1180	,,	1216	,,	1281	M9	1262	,,	1567	,,
1171	,,	1432	LU	1217	,,	1282	,,	1263	,,	1568	,,
1172	,,	1433	,,	1218	,,	1283	,,	1264	,,	1569	,,
1173	,,	1434	,,	1219	,,	1284	,,	1265	,,	1570	,,
1174	,,	1435	,,	1220	1909	1285	,,	1266	,,	21	EE2
1175	,,	1436	,,	1221	,,	1286	,,	1267	,,	22	,,
1176	,,	1551	MM	1222	,,	1287	,,	1268	,,	23	,,
1177	,,	1552	,,	1223	,,	1288	,,	1269	,,	24	,,
1178	,,	1553	,,	1224	,,	1289	,,	1270	,,	25	,,
1179	,,	1554	,,	1225	,,	1290	,,	1271	,,	26	,,
1180	,,	1555	,,	1226	,,	41	V6	1272	,,	27	,,
1181	,,	1556	,,	1227	,,	42	,,	1273	,,	28	,,
1182	,,	1557	,,	1228	,,	43	,,	1274	,,	29	,,
1183	1908	1558	,,	1229	,,	44	,,	1275	,,	30	,,
1184	,,	1559	,,	1230	,,	45	,,	1276	,,	1452	LUS
1185	,,	1560	,,	1231	,,	46	,,	1277	,,	1453	,,
1186	,,	1437	LU	1232	,,	47	,,	1278	,,	1454	,,
1187	,,	1438	,,	1233	,,	48	,,	1279	,,	1455	,,
1188	,,	1439	,,	1234	,,	49	,,	1280	,,	1456	,,
1189	,,	1440	,,	1235	,,	50	,,	1281	,,	1457	,,
1190	,,	1441	,,	1236	,,	446	Y	1282	,,	1458	,,
1191	,,	1443	,,	1237	,,	447	,,	1283	,,	1459	,,
1192	,,	1444	,,	1238	,,	448	,,	1284	,,	1460	,,
1193	,,	1442	,,	1239	,,	449	,,	1285	,,	1461	,,
1194	,,	1445	,,	1240	,,	450	,,	1286	,,		
1195	,,	1446	,,	1241	,,	451	,,	1287	,,		
1196	,,	1447	,,	1242	,,	31	EE2	1288	,,		
1197	,,	1448	,,	1243	,,	32	,,	1289	,,		
1198	,,	1	EE	1244	,,	452	Y	1290	,,		