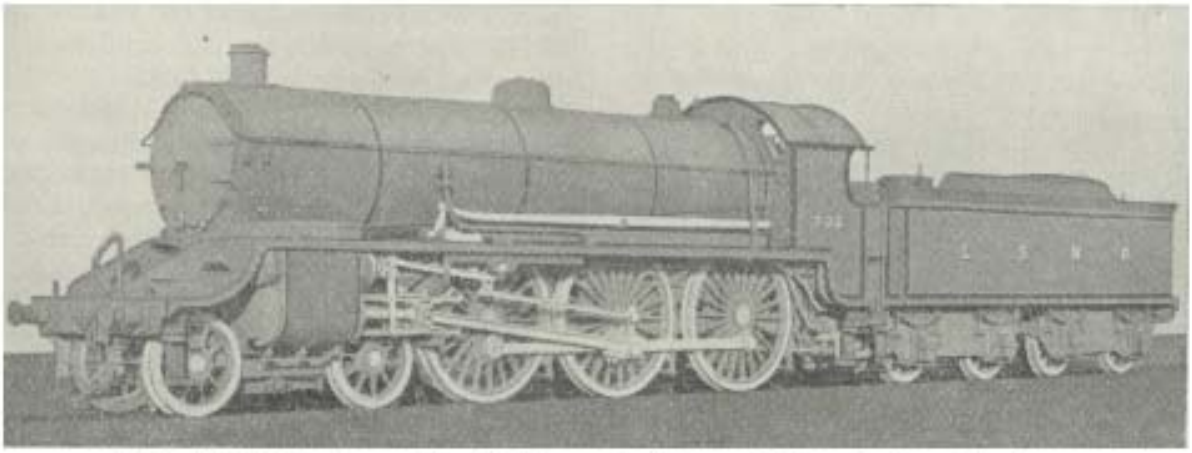
Locomotive Design on the Southern Railway*—1



Urie " N15 " class 4-6-0, later rebuilt to " King Arthur " class

AT the 1923 grouping, the Southern Railway took over 2,285 locomotives, 915 of which were from the L.S.W.R. Urie became Chief Mechanical Engineer of the L.S.W.R. in 1912 and subsequently produced five locomotive types as well as modernising many Drummond engines by superheating. He relied on the 4-6-0 type for top-link working and used the existing four-coupled engines for all other classes of trains, with the exception of the " D15 " class, which continued to be used on the Waterloo-Bournemouth service. Urie's aim seems to have been to standardise parts as far as possible and Walschaerts valve gear, though not of the long travel type, was adopted as standard, with high platforms which exposed the running gear and gave greater accessibility.

At the time the " N15 " locomotives were constructed for the L.S.W.R., they ranked as the heaviest of their type in the United Kingdom, though this mainly was due to the type and size of tender used, and was dictated by the prevailing conditions on this particular railway. The engine was of the same general type and main proportions as many other contemporary 4-6-0s. About the time when this class was introduced, there was on British railways, a tendency to increase the number of cylinders on the more powerful locomotives to three or four, but Urie felt that he could obtain from two cylinders of ample dimensions, the tractive effort required, that is, 26,200 lb. The cylinders were 22 in. diam. by 28 in. stroke and probably had the largest diameter that could be accommodated by the loading gauge. Drummond had built 26 engines of the 4-6-0 type with four cylinders, which were of the following classes :—

" E14 "	1	Engine No.	335
" F13 "	5	,,	,, 330 to 334
" G14 "	5	,,	,, 453 to 457
" P14 "	5	,,	,, 448 to 452
" T14 "	10	,,	,, 443 to 447, 458 to 462

However, Urie, as Works Manager, was called on to carry out repairs to these engines and due to his experience of broken frames, a contributory cause of which was a very bad system of cross staying, he set his face resolutely against any multi-cylinder locomotives. In connection with this particular point, Urie planned to rebuild the Drummond four-cylinder locomotives as two-cylinder engines similar to the " H15 " class, with the exception of the " T14 " type.

The preponderance of tank engines on the L.B.S.C.R. gives a good idea of the type of traffic and the service conditions required of locomotives on this line, for there were approximately three times as many tank engines as tender engines on passenger services. The L.B.S.C.R. had a considerable volume of goods traffic

*Abstract of a paper " History of Southern Railway Locomotives to 1938," by Mr. C. S. Cocks, read before the Institution of Locomotive Engineers, on November 17, 1948

which necessarily had to be worked at relatively high speeds, so as not to restrict the passenger train service, and the " K " class 2-6-0 tender engine, built by Billinton in 1913, was designed to meet these special circumstances and to haul trains up to 1,000 tons.

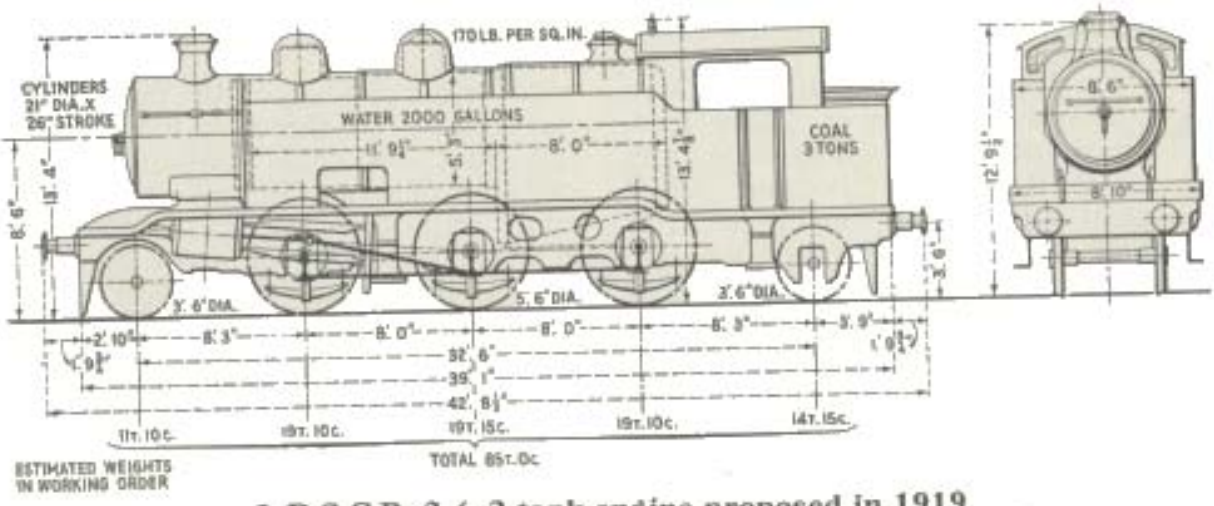
In 1919, it was proposed to build a new tank engine of the 2-6-2 type shown in the accompanying diagram. This engine was to be similar to the " K " class in nearly every respect, except that tanks were to be fitted and the wheel spacing was to be lengthened, to meet the demands of the civil engineer. Eventually, further " K " class engines were built, and the tank engine design was not pursued.

For passenger train working on the S.E.C.R., there were almost as many tank engines as tender engines, and, as in the case of the L.S.W.R., they were well dispersed over the whole system, typifying the suburban type of train service with frequent journeys to and from terminal stations. Passenger tender locomotives were of the four-coupled type, and the six-coupled type was used on passenger tank engines only, of which there were five of the 0-6-4 wheel arrangement.

On his appointment to Chief Mechanical Engineer in 1913, Maunsell found a complete set of drawings of a new 4-4-0 type engine, later known as the " L " class, and he immediately placed orders for a number of these engines to be built. Beyer, Peacock & Co. Ltd. undertook the contract but could supply only 10 engines in the stipulated time, and as no other maker in this country was in a position to give the necessary delivery, Maunsell placed an order for 12 engines with the Borsig locomotive works, Berlin.

Before the drawings were passed out, alteration was made to accord with Maunsell's experience in Inchicore. The $1\frac{1}{16}$ in. lap was reduced to $\frac{7}{8}$ in. and, in consequence, reduced the valve travel. These engines were to replace an Ashford 4-6-0 type designed by Wainwright, which was refused by the civil engineer on account of the bridge loading.

Between 1913 and 1923, Maunsell was responsible for the introduction of three new types of locomotive; this period covers the first world war, when he was actively engaged on government work in this country and France. These new engines were: the " N " class 2-6-0 tender engine, with taper boiler, 200 lb. per sq. in. steam pressure, 5 ft. 6 in. diam. wheels and 19 in. by 28 in. stroke cylinders; the " K " class 2-6-4 tank engine, in many respects identical with the " N " class, but with 6 ft. wheels; and the " N1 " class similar to the " N " class, though having three cylinders. It was Maunsell's practice to construct only one of the new type, until he was satisfied with the design.



L.B.S.C.R. 2-6-2 tank engine proposed in 1919

The " N " class locomotive was built in 1917, from designs begun early in 1914, but, due to the war, it was considerably delayed. This probably was the first engine in this country to have a combination of high superheat with long travel valves.

The Association of Railway Locomotive Engineers (A.R.L.E.) was preparing a design of standard locomotives to be used by British railways as a whole, at this time. Two engines were designed, one of which was a 2-8-0 and the other a 2-6-0, largely based on the " N " class design. The work was undertaken at Ashford

drawing office to the recommendation of a select committee. The procedure was not followed, however, because of the impending railway grouping, and the Government, in the absence of the anticipated standard engines, used the "N" class drawings as approximating to the standard, to keep Woolwich Arsenal employed after the war. Fifty of these completed locomotives, built by the Woolwich Arsenal, were absorbed by the Southern Railway. The "N" class originally was designed largely for freight working, but has been used extensively for passenger services, especially over the difficult sections of the West of England line.

The "K" class 2-6-4 tank engine had all the characteristics of the "N" class and showed the trend for standardisation on the S.E.C.R. One of this type was built in 1917 and a further batch in 1925 for the Eastern Section and the Brighton main line. These engines came to be known as the "River" class, and, in all the main details, were as originally built.

Twenty sets of parts for the "River" class were prepared at Ashford, though, due to the urgent need for locomotive power and the commitments of the shops for repairs, it was not possible to erect the engines. Consequently, ten sets of parts were sent to Armstrong Whitworth (Nos. 800-809), and 9 sets were sent to Brighton (Nos. 791-799). The engines for use on the Brighton line had the Westinghouse pump. A further set of parts was built into the three-cylinder engine known as the "K1."

These engines ran until 1927, when they were converted to the "U" class as a result of the Sevenoaks accident. The design of the "U" class had been started before this event, as it was considered there were too many tank engines already and difficulty was experienced in finding suitable work for the class. The derailment of one engine was not enough to cause the withdrawal of the class, as engine, No. 790, had been running for some eight years before any further engines were built. Complete confidence in it clearly was established by its record during this period.

The point which largely influenced matters was the previous derailments of these engines, notably of No. 890, first at Wrotham and then at Bearsted, on the Maidstone East line. This probably was due to the type of track, but no difficulty was experienced until the number of engines running over this particular section was increased.

After Sevenoaks, heavy permanent-way reconstruction was decided on, and, as the work was spread over years, had these 2-6-4 tank engines not been rebuilt, it would have been necessary for them to be withdrawn and stored until the road was ready. In view of the decision to build the "U" class, rebuilding the tank engine to the 2-6-0 tender type was the obvious solution.

The Chatham line between Victoria and Chislehurst would not allow locomotives heavier than the "E" class, and although the civil engineer undertook to strengthen this portion of the road, the work could not be completed until 1925. To overcome this difficulty, Maunsell rebuilt 11 of the "E" class, as the "E1" class, the adhesive and total weight of which did not exceed the "E" class loading. The "E1" class locomotive could haul boat trains of up to 300 tons, which was in excess of that normally expected from the "E" class.

The "D" class was the result of a similar type of conversion for the Kent coast working, and was available for boat train service at holiday times to assist the "E1" locomotives.

The "N1" type, with conjugated valve gear as designed by Holcroft, was similar in many respects to the 2-6-0 two-cylinder engine, with the important difference that it was fitted with three cylinders. The cylinders were 16 in. diam. by 28 in. stroke, and arranged to drive the middle pair of coupled wheels, the outside cylinders being horizontal and the inside cylinders having an inclination of 1 in 8 to the horizontal. The piston valves, which were 8 in. dia. with 1¼ in. lap, were above on the outside cylinders and to the side of the inside cylinders.

The three-cylinder locomotive showed reduced wear, and coal consumption was 10 per cent. less than that of the two-cylinder engines, but the water consumption was 11 per cent. more for the same amount of work. It was stated that the reduced coal consumption was due to the better blast produced by six beats, as compared with four beats, and this result probably had some bearing on a decision taken at a later date, in connection with the design of the "Lord Nelson" engines.

Such was the position at the grouping, as concerns the engines in use on each of the constituent railways. The type of traffic on the Southern Railway was different from that on any of the other main-line companies, in that it was mainly a passenger line and a large percentage of its receipts was from that source. It had a very extensive suburban service in and around London, and the congestion of traffic at the termini had led to an early decision being taken to electrify certain sections of the three constituent companies, before the amalgamation.

At the time of the grouping, there were 77½ route miles and 240½ track miles of track electrified. By 1930, the electrification scheme had extended to 226½ route miles and 739½ track miles, and the increase was considerably assisted by colour-light signalling.

The policy of the Chief Mechanical Engineer was in large measure dictated by the growth of electrification, which, due to the suburban type of traffic, was making rapid strides towards the ultimate electrification of the whole Southern Railway system.

In 1924, a new express locomotive became necessary for the Western Section. Five engines of the "P14" class and five of the "G14" class had been authorised in Urie's time for rebuilding as two-cylinder engines. As no progress had been made in ordering the material, however, a decision was taken to build these engines with 6 ft. 7 in. wheels, based on the "N15" design, but modified to accord with the experience gained with the S.E.C.R. "N" class. This meant largely that only new boilers of the "N15" pattern would be needed, in addition to the necessary modifications already agreed. The amount of maintenance required by the "N15" locomotive also was examined, both in respect of shops and running sheds. It was said that the engine was sluggish and shy of steam and that drivers had to resort to the use of a razor, or jemmy, across the blast pipe, to maintain the steam pressure under heavy working.

A decision was made to build 10 engines, to be known as the "King Arthur" class. These engines retained the Drummond type tender with inside bearings at the axles, though the wear due to dust, ash, and so forth, was considerable, partly due to the large diameter journal required for inside bearings. A further order for 20 locomotives was placed with the North British Locomotive Co. Ltd., and as ten engines already were being built at Eastleigh, the patterns and drawings were immediately available for the contractors. Modification was made to the cab, which was similar in many respects to the "N" class with an extended roof, and the Urie tender was used instead of the Drummond type.

Certain of the Urie "N15" engines subsequently were fitted with double exhaust ported piston valves, in an endeavour to overcome some of the deficiencies of the valve gear and this has led to improved performance.

An interesting rebuild took place in 1927, due to certain branches of the West of England line being reconstructed, to take engines with a maximum axle load of 16 tons. The most powerful engines that could be used were two 0-6-2 tank engines and when additional power was required, the production of further engines of this type was contemplated. An alternative was put forward, however, for converting Stroudley "E1" tanks, some of which were redundant, to the 0-6-2 wheel arrangement. This was achieved by adding "N" class pony trucks taken over with the stock of spare parts from Woolwich Arsenal. A small extension of the frame plates, larger bunker and substitution of vacuum for air brake, were all that was then required. These rebuilds are used for both passenger and freight trains on such lines as Torrington-Halwill and Bere Alston-Callington, as well as for banking trains up the steep gradient from Exeter St. Davids to Exeter Central.

An engine of medium power was required for working on the Eastern Section and it was considered that a further batch of "L" class should be built. As a result, Maunsell built the "L1" in 1926, a design similar in many respects to the "L" class and which conformed to the general practice of that railway before the grouping, of relying on four-coupled tender engines for passenger working. By using the same design, most of the details were interchangeable. These locomotives could not be constructed at Ashford in the time allowed, and the order was placed with the North British Locomotive Co. Ltd.

Locomotive Design on the Southern Railway*—2

TO meet the traffic manager's demand for a locomotive capable of hauling 500-ton trains at an average speed of 55 m.p.h., the first of the "Lord Nelson" class four-cylinder 4-6-0s was built at Eastleigh works in 1926. The engine had a tractive effort of 33,500 lb. at 85 per cent. of the boiler pressure and the inside cylinders were arranged to drive the leading pair of coupled wheels, and the outside cylinders the middle pair of coupled wheels. Steam distribution was by a separate Walschaerts valve-gear to each cylinder, the middle gear having eccentrics on the leading axle and the usual return crank for the outside gear. The passages in the cylinders were arranged to give a free flow of live and exhaust steam.

The spacing of the cranks was arranged to give eight separate impulses to a revolution of the coupled wheels, so that the exhausts from each end of the cylinders occured separately, instead of the usual synchronisation to give four beats a revolution. Following a paper read before the Institution of Locomotive Engineers by Mr. Holcroft, in which attention had been drawn to the advantages gained by having cranks set at 45 deg., or 135 deg., to each other, an experiment was carried out on the Drummond four-cylinder engine, No. 449. The cranks of this 4-6-0 orginally had been set to give four impulses, though by turning the cranks of the inside engine through 45 deg. and re-balancing the wheels, eight impulses to a revolution were obtained.

The improvement made by the alteration to engine No. 449, particularly the saving in coal, was so marked that it was decided to incorporate the arrangement in the new "Lord Nelson" class. The arrangement provided a more uniform torque and more regular effect on the firebox draught than was customary, as well as allowing the engine to be worked more heavily without breaking-up the fire.

Whether the eight impulses of the "Lord Nelson" can be justified in the face of the fact that separate valve gears are required for each cylinder, always will give ground for debate, though the situation could have been met by the use of conjugated valve-gear. Nevertheless, the fact remains that these engines earned considerable revenue for the Southern Railway through their economical working.

In 1929, it was decided to increase the tractive effort of a "Lord Nelson" class engine by reducing the diameter of the driving wheels to 6 ft., before the batch of the class was complete. In fact, No. 859, *Lord Hood*, the subject of the experiment, was fitted with 6 ft. 3 in. wheels as this was found to be the biggest reduction in diameter that could be made without considerable alteration to the frames.

When put into traffic, No. 859 was used with the remainder of the class on the same link and though it has not been converted to standard again, no further engine of the class has been fitted with this size of wheel, so it must be concluded, due to the restricted alteration in the diameter of the wheel, that no very marked difference was observed.

The "Lord Nelson" boiler was never quite so free in steaming as that of the "King Arthur" and it was thought that the steaming of the later engines would improve if the length of tubes originally considered, had been used. As a result, No. 860, *Lord Hawke*, was provided with the increased boiler length and tried out before the last five engines of the class were built.

The increase in heating surface was 131 sq.ft., due to increased length of the tubes, though this probably acted only as a feed-water heater; the weight of the engine was increased by 1 ton 6 cwt. The difference between this engine and the remainder of the class, however, is not such as to warrant any particular attention, as there would appear to be no appreciable difference in its performance, except it is said that this engine is

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slightly more economical in fuel consumption.

About this time, Maunsell was considering the construction of a Pacific engine with nickel-steel boiler plates and a combustion chamber. Engine, No. 857, *Lord Howe*, was selected as the guinea-pig and built in all respects similar to the remainder of the class, with the exception that a special boiler was fitted. This boiler incorporated a large combustion chamber extending from the firebox for a distance of 3 ft. into the barrel and had a round-top firebox. It reduced the length between the tubeplates to 13 ft., so that the heating surface of the tubes decreased by 188 sq. ft., and the firebox heating surface was increased by 52 sq. ft.

Tests were carried out with No. 857, but did not carry any conviction and, in consequence, no further boiler of this type was fitted; a standard boiler was fitted to the rebuilt engine when renewal was required.

A theory was advanced to the Chief Mechanical Engineer from outside sources, that from an engine-hauling aspect it would be better to give a series of tugs than a steady pull, as the train would be accelerated much more quickly. Maunsell always was willing to try an experiment if there was a reasonable chance of success and, in 1934, the cranks of No. 865, *Sir John Hawkins*, were modified from the original 135 deg. set, to 180 deg., to ascertain if there would be any improvement at starting. As would be expected from these tests, no appreciable difference could be detected, but it is said by certain drivers, that, given rough weather and heavy trains, coal is fairly eaten by the engine and the tender is cleared. Nevertheless, the cranks of No. 865 have been left as altered.

In 1931, Maunsell looked into the question of converting a "Lord Nelson" class locomotive to a four-cylinder compound, with 6 ft. 7 in. diameter wheels, boiler pressure 250 lb. per sq. in., high pressure cylinders 15½ in. by 26 in., low pressure 22 in. by 26 in., which would have separate valve-gears and be fitted with poppet-type valves. At this time, Maunsell was influenced by reports of splendid French compound performances and drawings of the P.L.M. and Nord compound engines were studied. In January, 1932, authority was obtained to convert the engine and to build a new boiler, but, although the design reached an advanced stage, construction of the engine was not commenced.

In 1929, Maunsell produced the "Z" class 0-8-0 tank engine for service in the Southern Railway's principal goods yards and sorting sidings. The engine was designed for hump-shunting work and had sufficient sideplay at the leading and trailing wheels for negotiating a 4½ ch. curve.

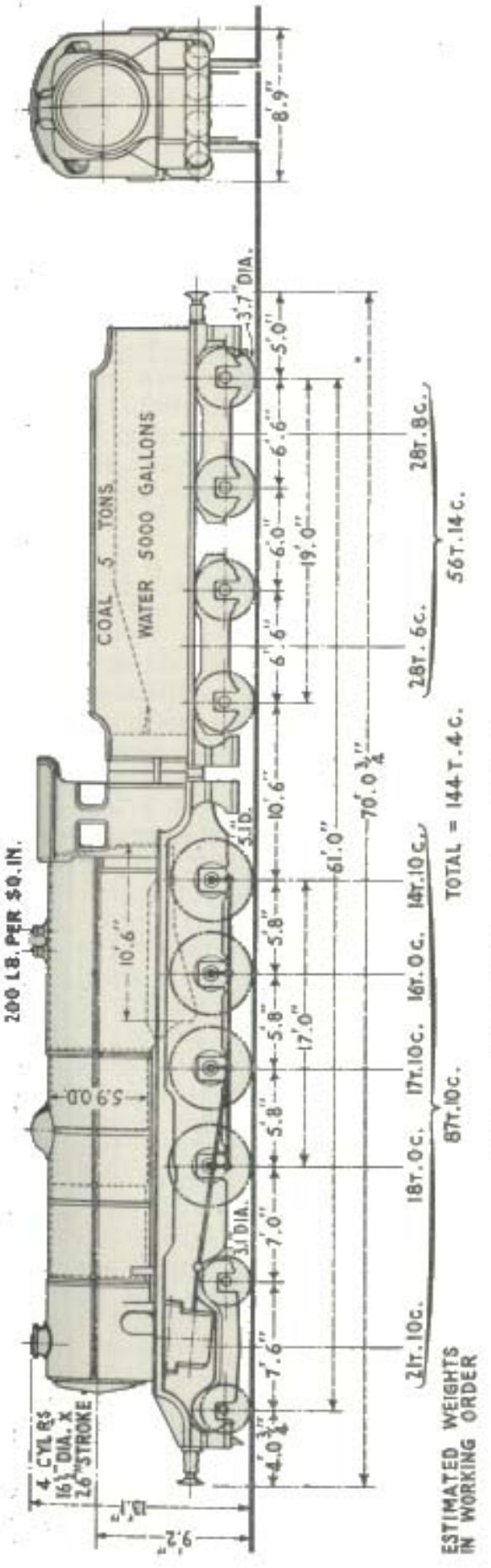
A standard central section boiler with large steam and water capacity, but small grate area, was fitted so that heat could be stored for periods of waiting, and blowing-off at the safety valves minimised. With the original scheme, it was intended to use conjugated valve gear, but the Civil Engineer raised objection to the distance between the buffer face and leading wheels. Subsequently a pony truck was proposed, though, as this led to the loss of a certain amount of adhesion, it was not pursued.

In an attempt to improve thermal efficiency, conserve the use of water, and reduce boiler maintenance between repairs, a heat conservation experiment was carried out in 1930. The engine chosen for modification was the "N" class 2-6-0 No. 1816, which is illustrated elsewhere in this issue.

The experiment was remarkable in that all the exhaust steam was returned to the boiler and draught was obtained by a fan at the smokebox.

When the "Lord Nelson" class locomotives had established themselves, the traffic manager decided he would like an equivalent type of engine for the secondary services, which would be capable of hauling loads up to 400 tons, with average speeds of 55 m.p.h. The Chief Mechanical Engineer, to conform with his standardisation policy, planned to produce a smaller edition of the "Lord Nelson" class. The idea was to substract one cylinder and one pair of wheels, which led to the shortening of the boiler, so producing a three-cylinder 4-4-0 type, that would be cheaper to build and maintain.

The first scheme was to use "Lord Nelson" flanged plates for the shortened boiler, but, as this boiler then would have been too large to keep within the prescribed weight, the engine was scaled down to allow use of the "King Arthur"



Maunsell 4-8-0 type intended for the Kent coal traffic

flanged plates instead. The new 4-4-0 therefore had the same firebox as the later "King Arthurs," which, it will be recalled, had a slightly smaller grate area than the original, due to the fact that a wider water-leg was used. By fitting the "King Arthur" round-top boiler, it was found the profile of the cab could be modified to allow the engine to pass through the Hastings gauge and the locomotive produced to these particulars ultimately was known as the "Schools" class.

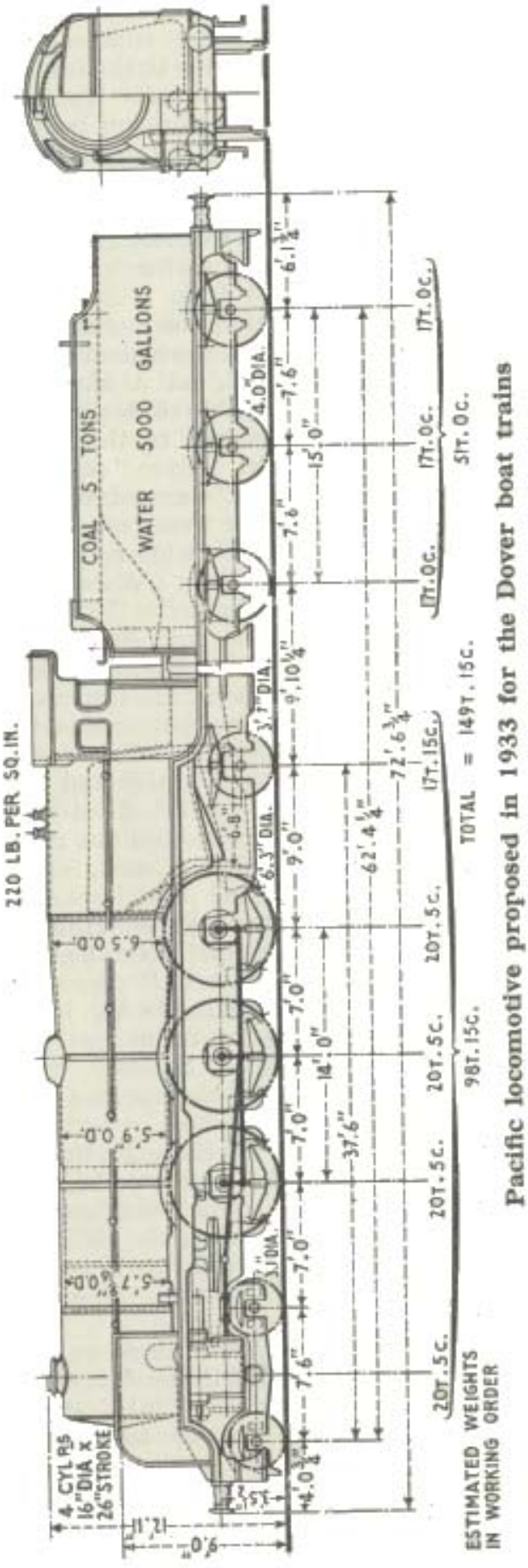
It will be noted that the engine had a tractive effort almost equivalent to the "King Arthur" and, as a class, the locomotives were capable of dealing with trains normally allocated to the "King Arthur" and "Lord Nelson" 4-6-0s.

When the "Schools" were submitted to the civil engineer, they were restricted to the following lines: Waterloo to Exeter; Waterloo to Portsmouth; Waterloo to Bournemouth; Victoria to Brighton; Victoria to Eastbourne and Newhaven; Victoria to Dover *via* Tonbridge, Maidstone East and Chatham, the latter only providing that certain civil engineering work could be undertaken. The first of the "U1" class engines, which had been converted from the "K1" 2-6-4 tank engine, was now in service, and due to the restrictions on the "Schools" class, further "U1s" were ordered. as they were permitted to work through the Hastings gauge, with the required axle loading. Both the "U1" and "N1" type locomotives now were available for heavy passenger and goods trains on the Hastings line and the "Schools" class was accepted only after the line had been made suitable.

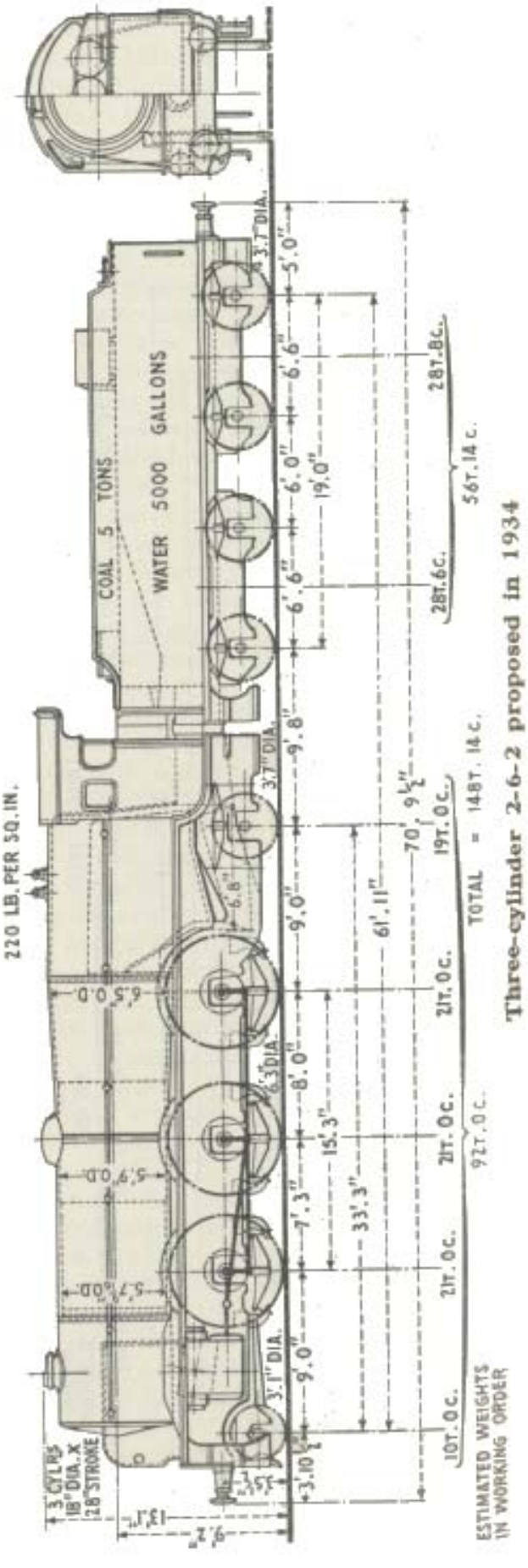
A number of "U1" class 2-6-0s also was built for working intermediate and semi-fast passenger trains over heavily-graded sections of the line, such as from Waterloo to Portsmouth, and in the West of England beyond Exmouth Junction.

The "W" class 2-6-4 tank engine, which was built at Eastleigh Works in 1931, was based on the "N1" three-cylinder locomotive, with the addition of side tanks, bunker, and trailing bogie.

In 1936, authority was received to proceed with the building of 20 goods locomotives to replace the "700" class and the Eastern "C" class. These locomotives were known as the "Q"



Pacific locomotive proposed in 1933 for the Dover boat trains



Three-cylinder 2-6-2 proposed in 1934

Locomotive Design on the Southern Railway

(See article on page 153)

Photo] [H. C. Casserley

Left : "Schools" class 4-4-0 No, 904, "Lancing," as originally built without smoke deflector plates

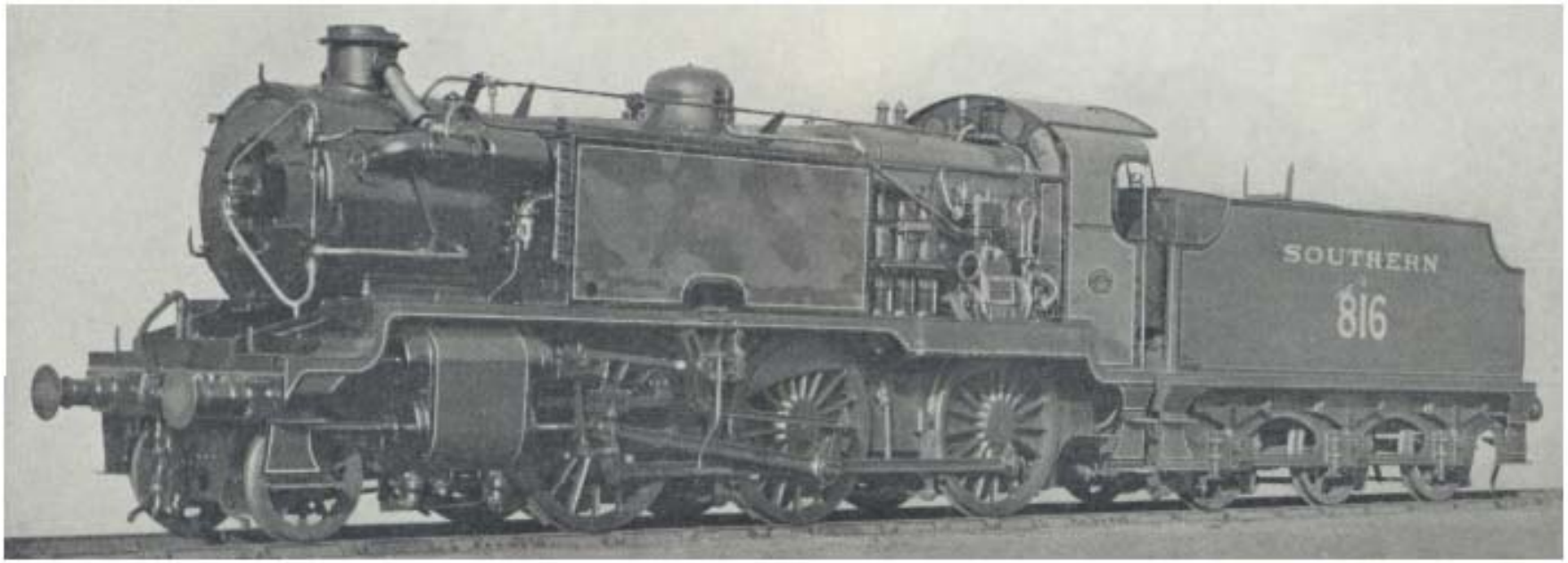


Photo courtesy] [Institution of Mechanical Engineers

2-6-0 locomotive No. A816 (later 1816) as modified in 1930, for the heat-conservation experiment