The Great Western Railway and Its Personnel

By H. HOLCROFT

No. 1

The scheme for a railway from London to Bristol received assent 125 years ago. In the article which follows the author deals with the broad gauge period of the Great Western Railway and the later acquisition of standard gauge lines which made it necessary to introduce a mixed gauge. The years from 1863 to 1892 saw the spread of standard gauge to all parts of the system, and the first step towards the Paddington to South Wales main line as it is known to-day by the building of the Severn Tunnel. In this period the G.W.R. took on the construction of all its own locomotives and rolling stock at Swindon and Stafford Road.

OF all the railway companies in Great Britain, the Great Western was the most distinctive; this was due to those amongst its personnel who laid its foundations, guided its destiny, and developed and expanded its system. The rank and file ever gave loyal and devoted service to the one company that retained its identity, its name and traditions for well over a century. Even after some twelve years, the old Great Western is still recognisable in the Western Region of British Railways, retaining such features as its own form of the automatic vacuum brake, its own automatic train control, the position of the driver on the right-hand side of the footplate, and its own method of testing locomotives in service. The old traditions and loyalties linger not far below the surface; the former Great Western may be dead, but it won't lie down!

Although a proposal for a railway worked

Charles Saunders, secretary of the London Committee which promoted the Great Western Railway, and later secretary of the company and superintendent of the line

by steam locomotives was put forward as early as 1825, it was the success of the newly opened railway between Liverpool and Manchester in 1830 that brought matters to a head and led the enterprising citizens of London and Bristol to think that a railway between their cities would be equally successful. Committees were formed at each to initiate a scheme, and the services of the eminent engineer, I. K. Brunel, were engaged.

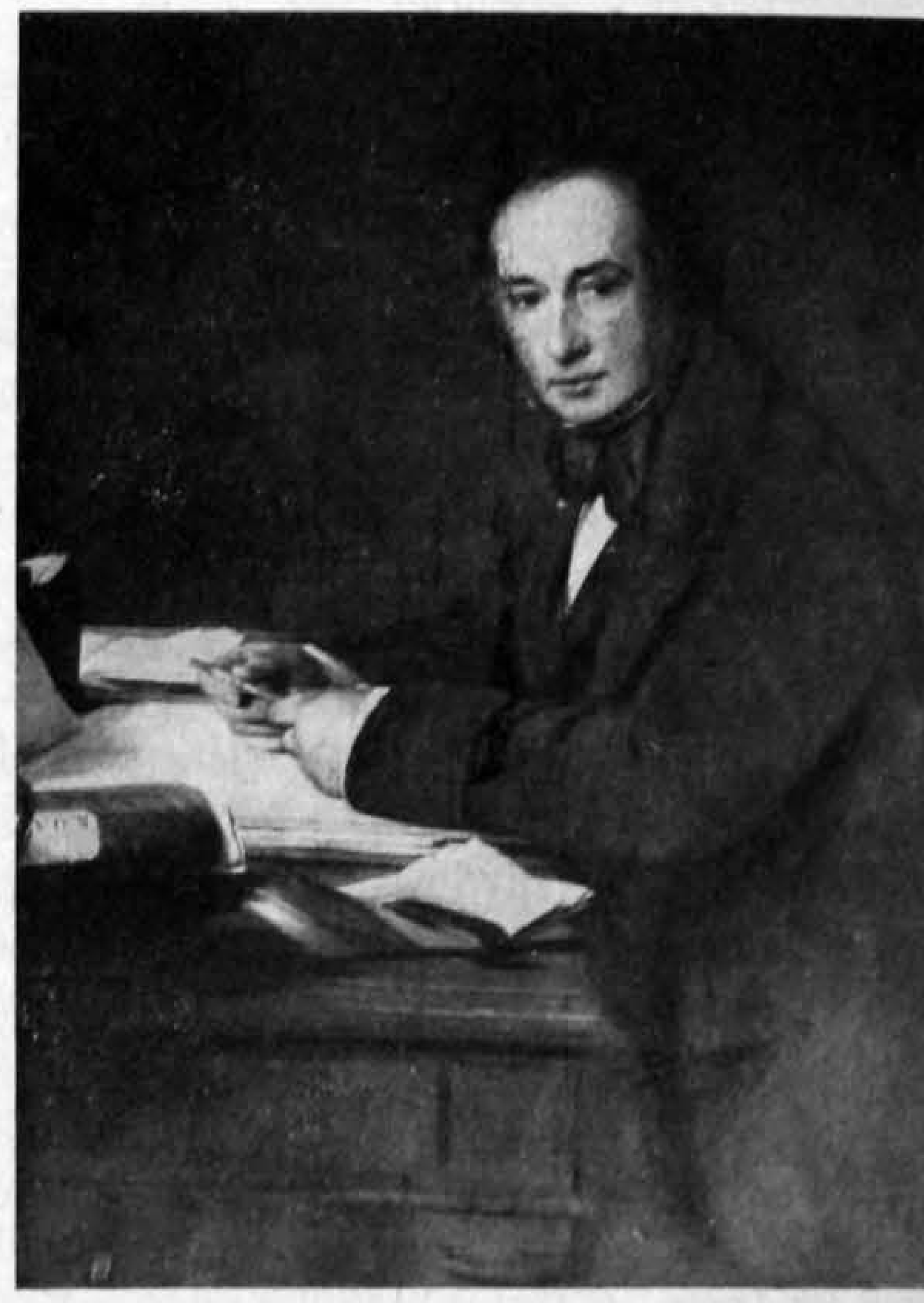
Money was subscribed towards shares in the proposed company, but not to the amount necessary before the authority of Parliament could be obtained. Here entered upon the scene a notable character in Charles Saunders, secretary of the London Committee, who traversed the intervening country, and by his energy and powers of persuasion induced a sufficient number of new subscribers to contribute and so allow of a Bill being presented to Parliament in 1834. This scheme, which involved a terminus near Vauxhall Bridge in London, was rejected, but another, in which a joint station at Euston was planned, received assent in 1835; it was modified later to make the terminus near the canal basin at Paddington instead.

In making the preliminary survey over the route selected, Brunel was struck by the almost level character of the line for the greater part of the mileage and the fact that such curves as were necessary could be set out to a very large radius. He grasped the opportunity presented here for high-speed running, due to the low tractive resistance of trains, but he did not think this could be done on the 4ft 8½in gauge so far adopted on the earlier railways, and he considered a wider gauge to be desirable for stability. He thought that the wheels of the rolling stock should be as large as possible in relation to the diameter of the journals and the lower part of the bodies of the vehicles carried between the wheels instead of above them, so lowering the centre of gravity.

The question of gauge had been purposely omitted from the Bill, and Brunel afterwards put forward his recommendations for a gauge of 7ft, which was accepted. At that period the London and Birmingham and the Grand Junction Railways formed a continuous 4ft 8½in line north-westwards from London, and further developments were all to the north of that line. South-westwards was the 4ft 8½in gauge London and Southampton Railway. Thus, with London as origin, there was a large sector of England and Wales open for broad gauge development. From the Great Western main line branches were visualised to the north and south, while infilling of the region would be started by the Cheltenham and Great Western Union Railway and the Bristol and Exeter Railway, both to be built to the 7ft gauge. The question of interchange of traffic with the narrower-gauge railways had not so far arisen and seemed of small importance compared with the speed and passenger comfort expected of the broad gauge. It will be noted that the emphasis was on passenger carrying and that freight was a secondary consideration, the reverse of things on railways in the industrial north country.

Construction of the line started at each end, and for the track Brunel adopted bridge rails laid on longitudinal sleepers, transoms being used to connect and support the sleepers at intervals. These in turn were fastened to piles driven into solid ground in order to hold the timber framework down so that gravel packing could be rammed hard under the sleepers.

In the case of rolling stock, Brunel made no attempt at design, but in ordering from



I. K. Brunel, who was engaged by the London and Bristol committees as their engineer

contractors he laid down certain stipulations which had to be met. In the case of the locomotives, the builders had great difficulty with their designs to meet these stipulations and, as a result, some of the locomotives delivered could only be described as freaks.

To take charge of the running and maintenance of the locomotives Brunel engaged in 1837 the services of a young engineer, Daniel Gooch, then but 21 years of age.

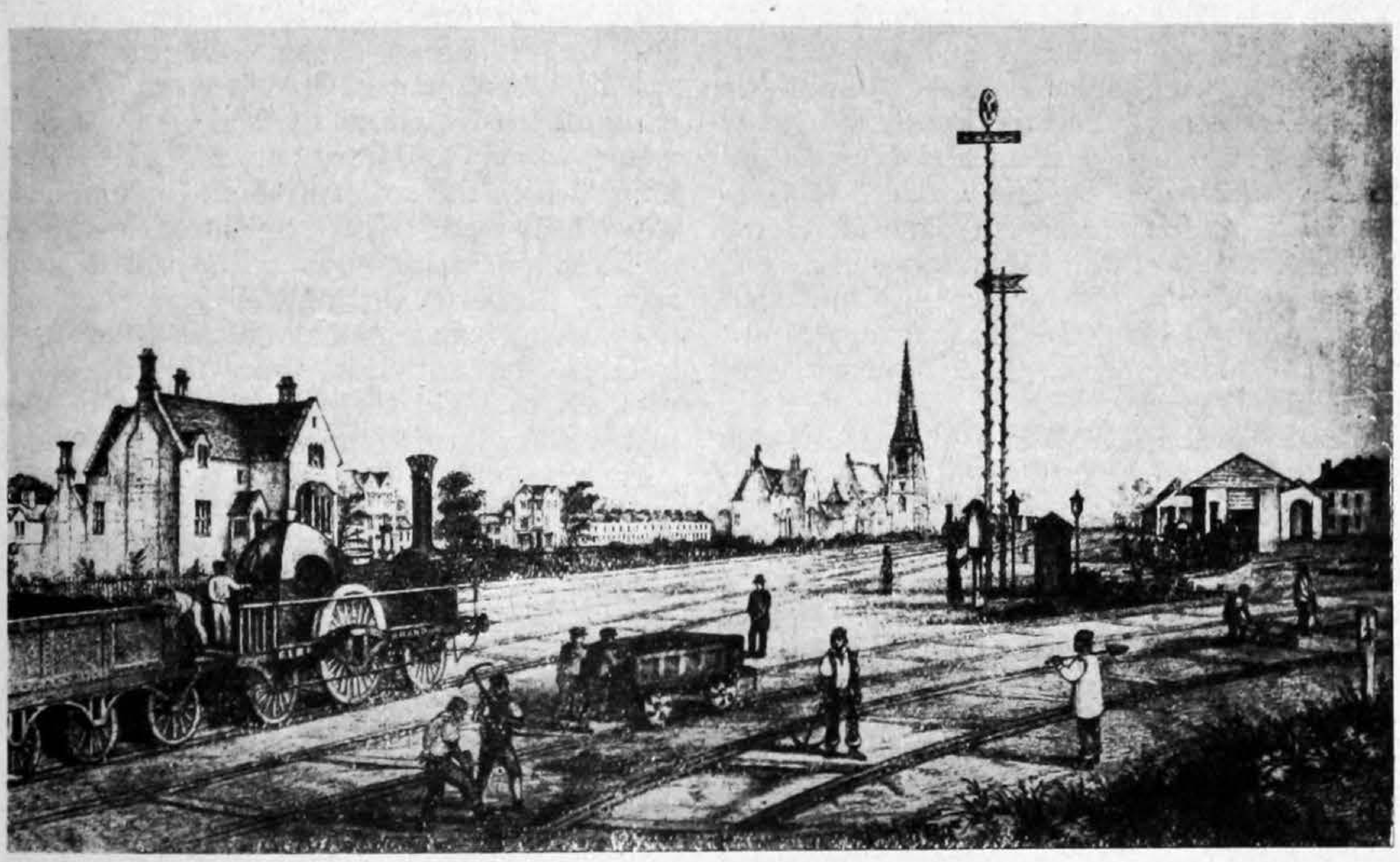
Trial running was made in stages as construction proceeded and the line gradually opened to the public as far as Maidenhead. After the novelty had worn off, disappointment was expressed by a section of the share-

Sir Daniel Gooch, who joined the G.W.R. at the age of twenty-one to take charge of locomotive running and maintenance

holders and opposition was raised against Brunel going any further with the broad gauge. The track was difficult to maintain due to the method of packing the ballast, and with unyielding support at the piles an undulating motion was given to the carriages, which reacted on the springs and gave most unpleasant riding. The performance of most of the locomotives was poor, breakdowns were frequent and service unreliable.

Brunel eventually overcame his critics, but in continuing the broad gauge westwards from Maidenhead he abandoned the pile attachment and adopted a heavier rail section and larger sleepers, which were laid on the ballast. Transoms and the tie bolts merely preserved the gauge.

As the line advanced westwards, the question of a locomotive establishment arose. Brunel in company with Gooch visited the site where the Cheltenham and Great Western Union Railway was to join the G.W.R. main line, a spot in open country near the old market town of Swindon. This junction was at the summit of the line, and to the east was an easy road with but slight gradients and suitable for fast running of trains by locomotives with large-diameter driving wheels; westwards there were gradients of 1 in 100 to be faced, for which smaller wheels would be more suitable. This, then, was the most suitable point for change of engines; adequate water was available and fuel could be brought in by canal. Also, an establishment was proposed which included a large running shed, repair shop for maintenance backed by a factory for the complete building of new locomotives and for their general repairs. As it was open country, it would be necessary to construct a large number of houses to accommodate footplate and shed staff, mechanics and labourers, besides the large station staff at the junction. The proposal was put forward to the board, who approved it, and a start was soon made on the town of New Swindon and its famous works.



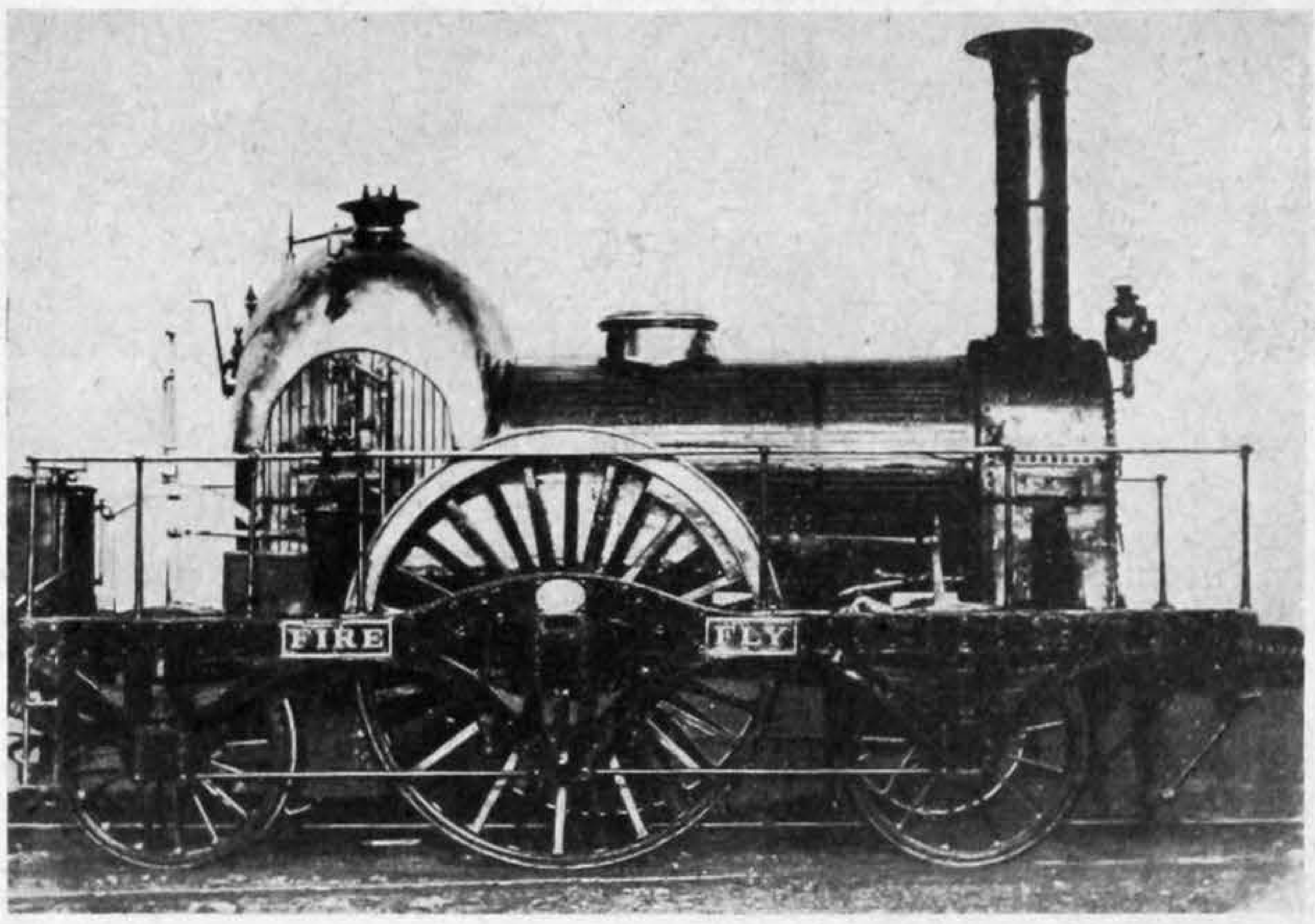
New Swindon in 1847, looking west, with Gloucester branch on right

Owing to the unsatisfactory position as regards locomotive power, Gooch was instructed to prepare his own designs and have locomotives built to them by contractors. There were four classes, a 2-2-2 with 7ft driving wheels for passenger service between Paddington and Swindon, a similar design with 6ft wheels for the Bristol and Swindon section, and for freight working a 2-4-0 and a 0-6-0, both with 5ft wheels, for the respective sections.

Delivery began in 1840 and the new locomotives proved to be thoroughly reliable, while the 7ft passenger engines, known as the "Firefly" class, soon established a reputation by their fast running.

Charles Russell became chairman in 1839 and held office for the next sixteen years, a period of continuous growth under his able guidance after the London-Bristol line was opened throughout in 1841. Charles Saunders was appointed Secretary to the company and Superintendent of the Line in 1840.

By 1846 Swindon works was in a position to build locomotives and Gooch designed another 2-2-2 engine considerably larger than the "Firefly." It had 8ft driving wheels, 18in by 24in cylinders, a large boiler and the link motion which Gooch had invented. After a short period the "Great Western," as it was named, was converted to a 4-2-2 and was followed by a batch of engines of an improved design known as the "Iron Duke" class.



The broad gauge locomotive "Firefly," one of the first four classes designed by Gooch and built by contractors

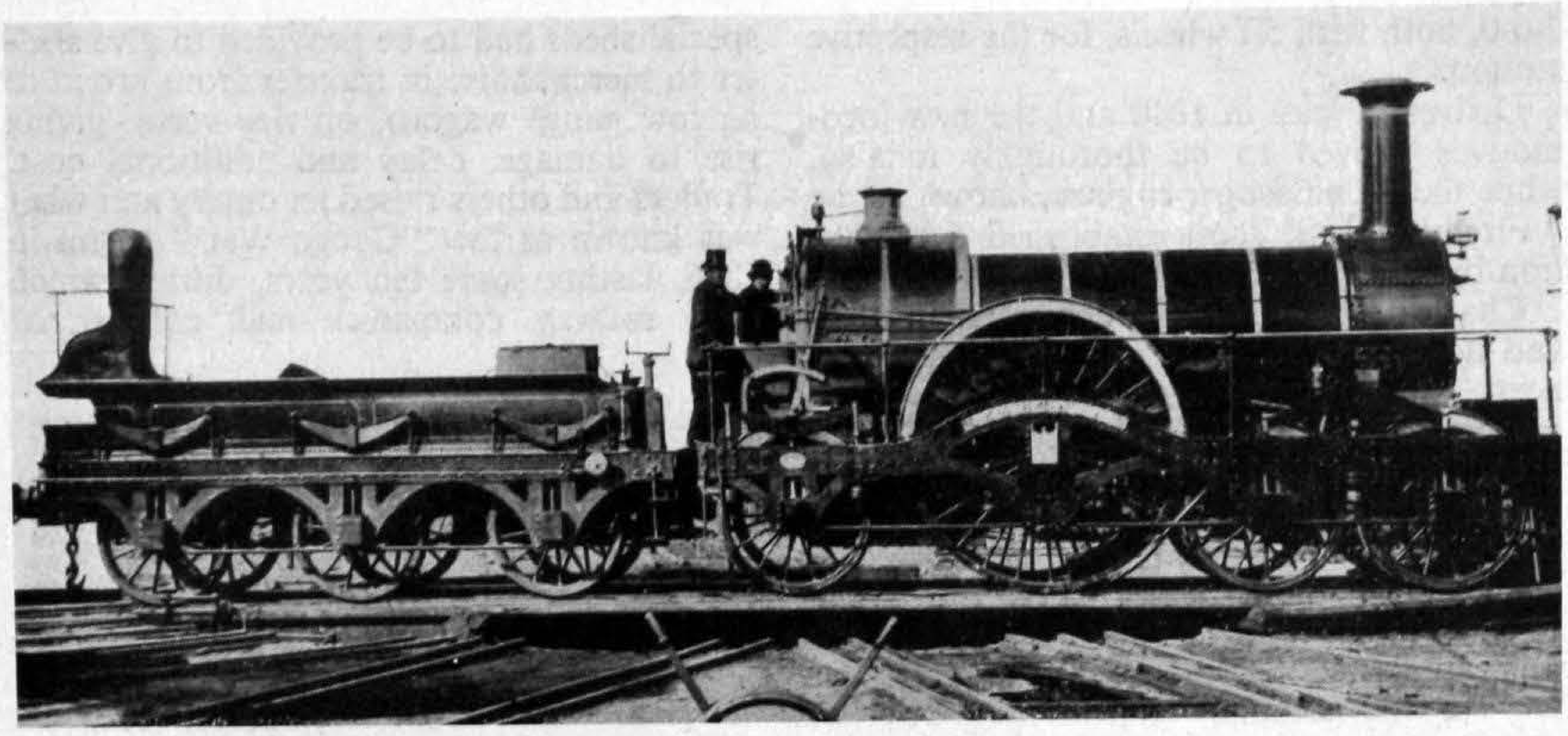
With these powerful engines the G.W.R. was far in advance of all other railways; in 1848 the 77 miles from Paddington to Swindon were run in 1 h 25 min with two intermediate stops, involving an overall speed of more than 54 m.p.h. and a running speed of over 61 m.p.h. The general public greatly favoured the broad gauge with its fast and punctual services and the smooth riding of its wide and comfortable coaching stock.

It was otherwise as regards the freight services and it was this side of the business which in time led to the abandonment of the broad gauge. Due to the expansion of the 4ft 8½in lines, termed narrow gauge at that period, these began to impinge upon and intersect the Great Western system, and at such points special sheds had to be provided to give shelter to merchandise in transfer from broad to narrow gauge wagons, or vice versa, giving rise to damage, delay and additional cost. Traders and others raised an outcry and what was known as the "Gauge War" began in 1846, lasting some ten years, during which rival railway companies and commercial interests put every possible obstruction in the way of further broad gauge expansion, which was hampered by the passing of the "Gauge Act" by Parliament. The Gauge Commission set up by the Government recommended that 4ft 8½in was to be the gauge to be used on all public railways, and so it is hereafter referred to as standard gauge.

Nevertheless, when Russell relinquished the chair in 1855, the broad gauge had pushed northwards as far as Wolverhampton and it was being extended southwards to Salisbury and Weymouth, while the South Wales Railway was operated by the G.W.R. broad gauge locomotives.

In 1854 the G.W.R. acquired the 4ft 8½in Shrewsbury and Chester and the Shrewsbury

Charles Russell, chairman of the Great Western Railway Company from 1839 to 1855



Broad gauge locomotive "Lightning," one of the "Iron Duke" class designed by Gooch and built at Swindon

and Birmingham Railways, but was not permitted to extend the broad gauge over them, so for the first time the G.W.R. had a standard gauge section. The repair shops for the two railways were at Stafford Road, Wolverhampton, under the charge of Joseph Armstrong, who was taken into the service of the Great Western and given superintendence over locomotive running on the section between Chester and Oxford, both broad and standard gauge; so was formed the Northern Division of the Locomotive Department.

As the works was laid out for maintenance only, extensions were planned for new shops to construct locomotives for the 4ft 8½in gauge. While this was being carried out, Gooch designed a number of new classes of locomotives having the same characteristics as those on the broad gauge. Some were built by contractors and others at Swindon, being conveyed over the broad gauge to Wolverhampton in special well wagons. They were to augment the northern locomotive stock and to replace some of the other and less satisfactory locomotives taken over.

When the new shops at the works were built and equipped, Armstrong began to construct locomotives to his own design. Although Gooch as Locomotive Superintendent was nominally responsible, he gave Armstrong a large measure of independence, for as a broad gauge upholder he had no liking for the narrower gauge.

The mixed gauge was completed between Wolverhampton and Oxford and then extended to Didcot, Reading and Basingstoke, so enabling traffic to reach Southampton and other places in the south without break of gauge. London was at a disadvantage as regards freight traffic, so the third rail was laid in to Paddington from Reading and accommodation was provided there for standard gauge stock in 1861. Upon this a passenger train service was inaugurated on standard gauge between Paddington and Birkenhead, while coal trains from South Wales could run to London on standard gauge via Hereford, Worcester and Oxford; meanwhile broad gauge services to Wolverhampton began to diminish.

The year 1863 saw the amalgamation of the Great Western with the West Midland Railway, which had itself been formed by a number of amalgamations. This was a standard gauge network extending over an area bounded on the east and south by Shrewsbury, Wolverhampton, Oxford, Worcester and Hereford, with an extension into Monmouthshire. The Act authorising this merger also included amalgamation with the broad gauge South Wales Railway, which had hitherto been worked by the G.W.R.

Brunel died in 1859 and his out-and-out supporter, Charles Saunders, chief executive officer with the title of General Superintendent, only remained in office long enough to see the Amalgamation Bills through Parliament before he resigned through ill health. He had largely contributed by his life's work to the creation and building up of the Great Western system as it then stood.

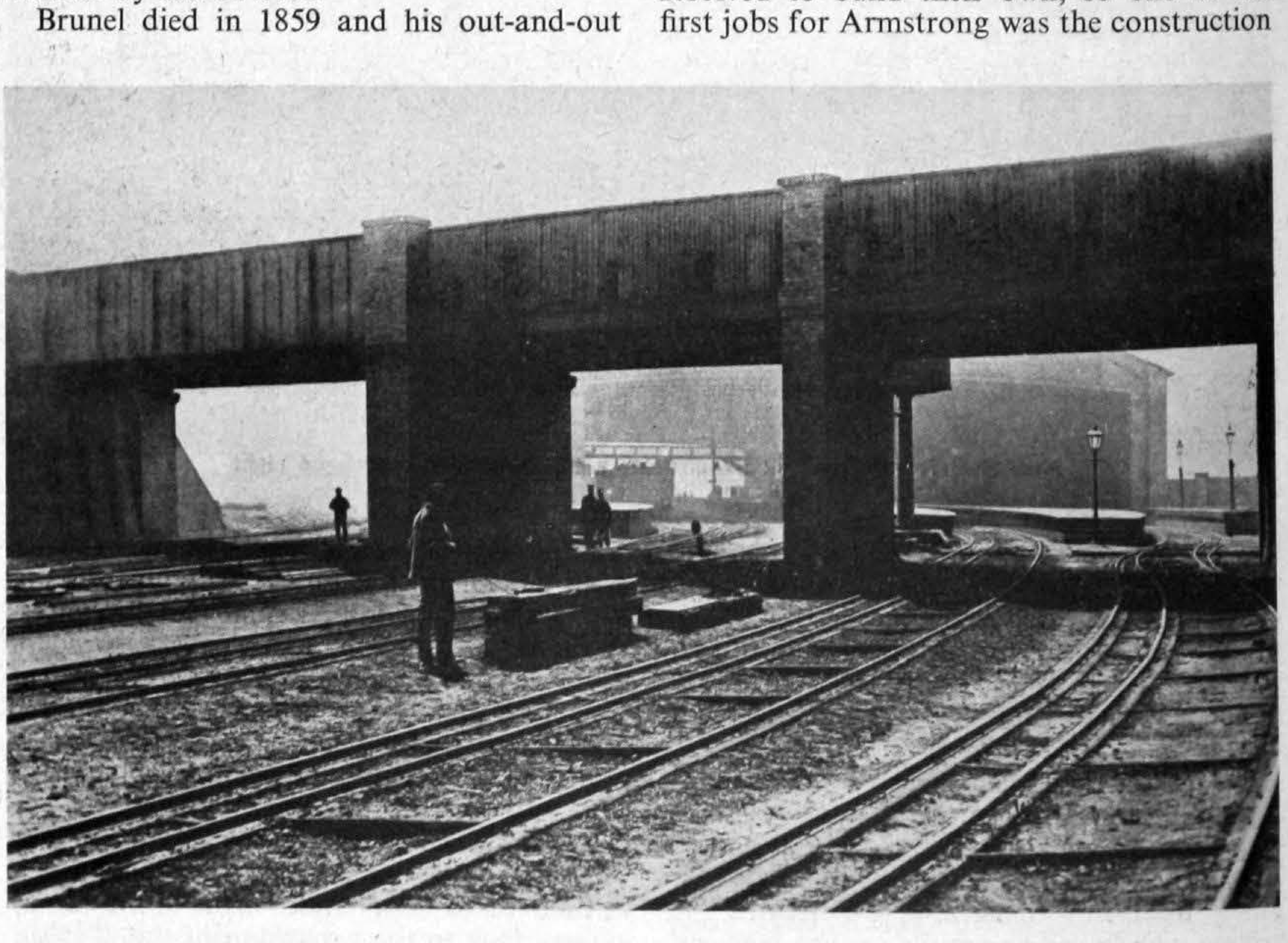
After the amalgamations shown in the accompanying map, the G.W.R. was no longer a predominantly broad gauge line ; the standard gauge constituted 50 per cent of the mileage, and a large proportion of the freight traffic was carried by it.

The dual office of secretary and general superintendent which Charles Saunders had held was divided, his nephew, F. G. Saunders, being appointed to the former, and James Grierson, the chief goods manager, was made general manager. As the policy of the board was to keep management in their own hands, they dealt directly with all the chief officers, in which case the general manager had control only of passenger and freight operation, and he looked after Parliamentary work.

In 1864 Daniel Gooch resigned ; the last of the "big four" who had built up the broad gauge, he saw that it had reached its zenith, and that it was only a matter of years before it would be replaced by the standard. Then but forty years of age, he went off to seek adventure anew in the laying of the first submarine cable across the Atlantic Ocean. With him also resigned John Gibson, carriage and wagon superintendent. He it was who gave his name to the Gibson ring fastening, so universally adopted for securing tyres to wheel centres.

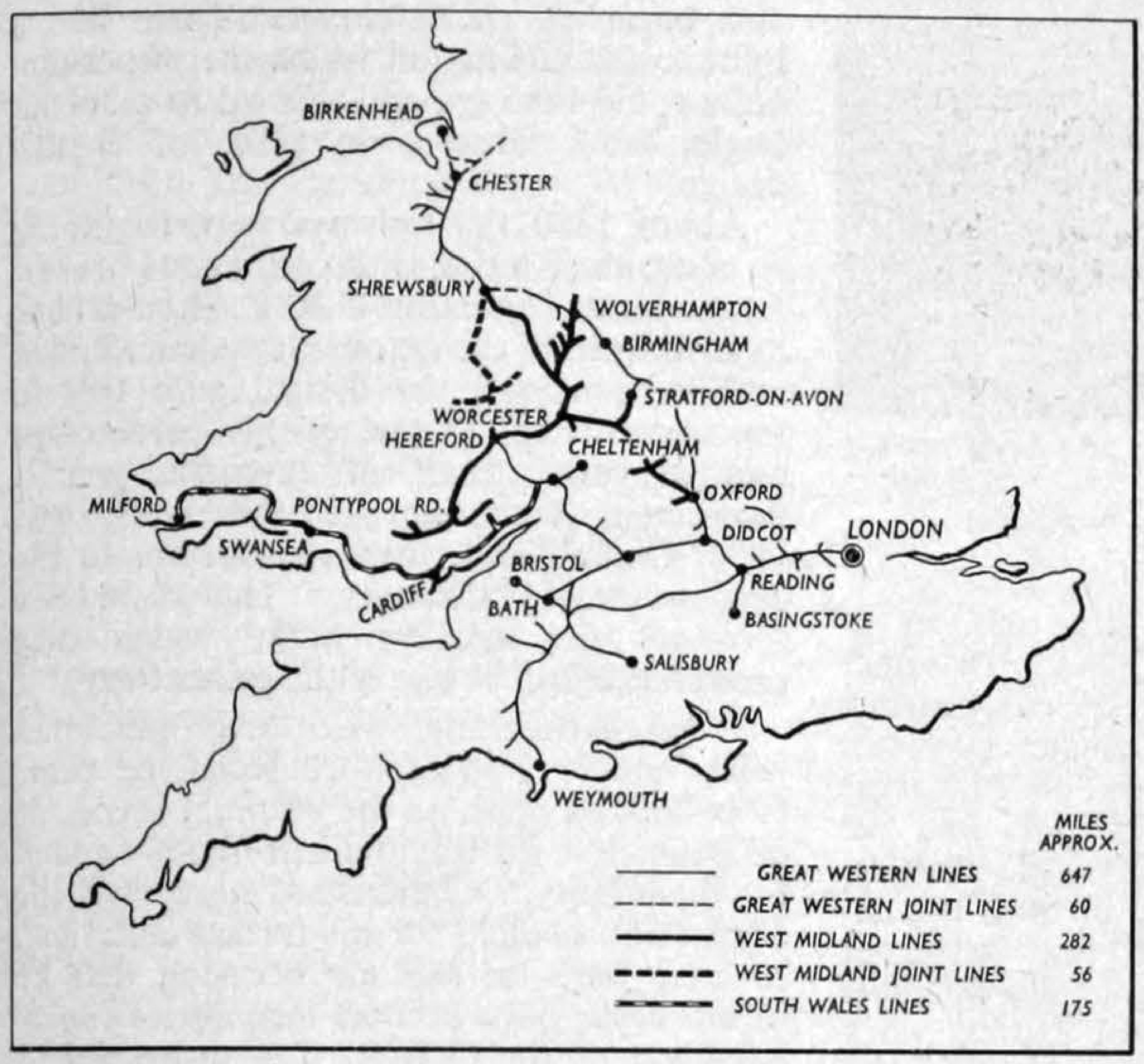
To fill these offices the directors appointed Joseph Armstrong to be locomotive, carriage and wagon superintendent for the whole system, whereupon he moved from Wolverhampton to Swindon, then a purely broad gauge works, and took up residence in a house which the company built for him and which he named "Newburn," after Newburn-on-Tyne where his boyhood days had been spent. Hitherto the railway had obtained its passenger and goods vehicles from contractors, but at this time the directors resolved to build their own, so one of the first jobs for Armstrong was the construction

George Armstrong, Northern locomotive divisional superintendent, 1864-1897. He was in charge of Stafford Road works for a period of 33 years



The north end of Wolverhampton low level station, G.W.R., in broad gauge days (about 1854), showing the third rail of the mixed gauge of new shops to the south of the main line, opposite the locomotive works.

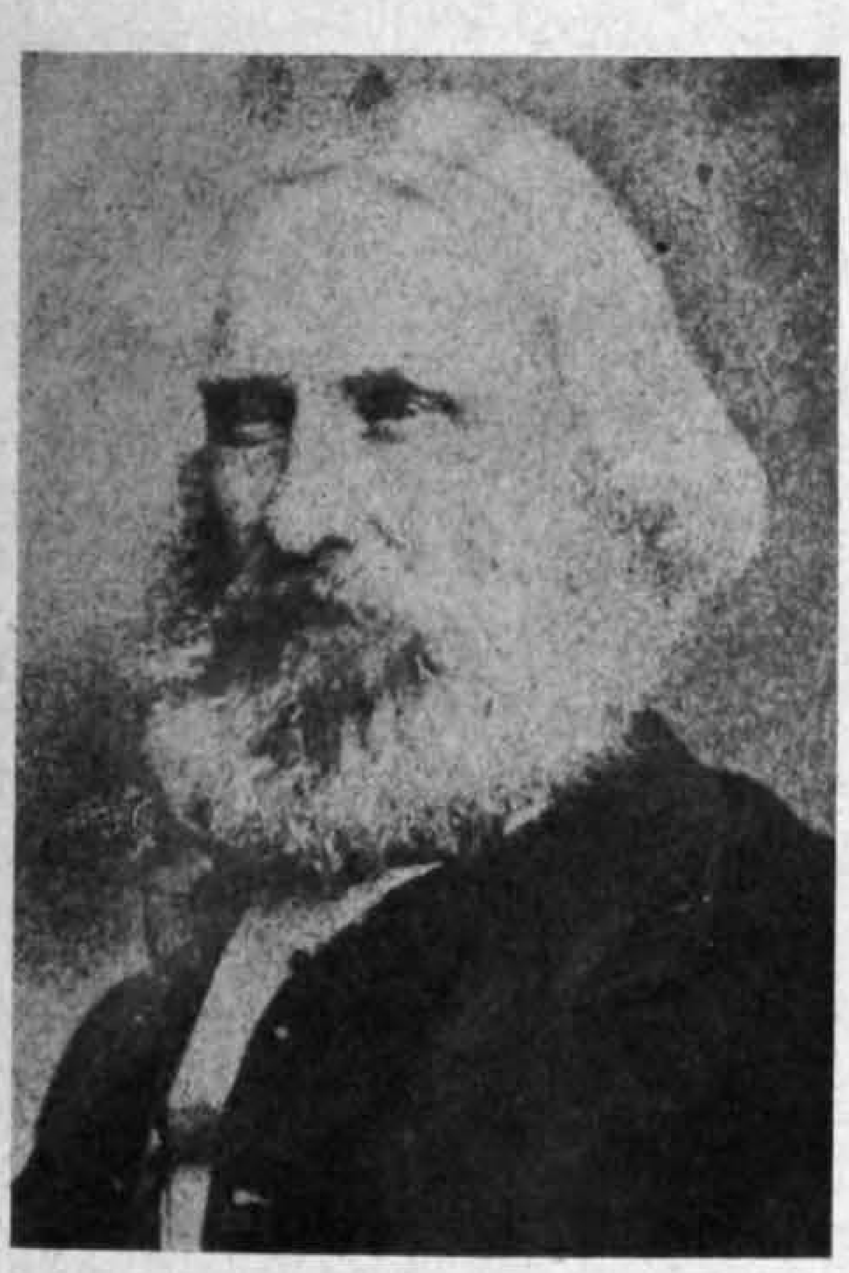
After designing and building the last of the broad gauge engines, construction of which ceased after 1866, Armstrong concentrated on building a number of standard gauge locomotives of various classes, and so satisfactory were they that they gave good service for the next forty to fifty years.



Extent of the G.W.R. after incorporation of the West Midland and South Wales Railways by the amalgamations of 1862–63

Owing to the difficulty in filling the chair, the directors prevailed upon Sir Daniel Gooch, as he had become, to return to the railway. He was elected Chairman in 1865 and continued in this position until his death in 1889, so giving a second period of service lasting twenty-four years. The broad gauge was, however, in recession, and, as its traffic dwindled, service ceased on the Northern Division and the broad gauge rail of the mixed gauge between Wolverhampton and Oxford was taken out in 1869, and the material used to extend mixed gauge from Didcot to Swindon, whereby the latter first established contact with the standard gauge system in 1872.

As soon as this had been done, the whole of the line from Swindon to Milford via Gloucester was converted from broad to standard gauge. Mixed gauge was then extended to Thingley Junction and Bristol, and in 1874 the whole of the branches to the south of the main line were similarly converted, so that nothing was left of the broad gauge except the original London to Bristol line, and that in mixed gauge, and nearly all trains were of standard gauge stock. The only broad gauge trains were the through passenger and freight for the Bristol and Exeter, South Devon and Cornwall Railways. In 1876 these railways were taken over, so that the G.W.R. broad gauge received a new lease of life, being extended from Bristol to Exeter and Penzance.



Joseph Armstrong, appointed locomotive, carriage and wagon superintendent for the whole system in 1864, with headquarters at Swindon

It is remarkable that Armstrong produced in the various works under his command the whole of the rolling stock needed to replace the broad gauge stock as the sections were converted, without having to go to contractors. To aid him in this great achievement he had called William Dean, Manager of Stafford Road Works at Wolverhampton, to be his Assistant.

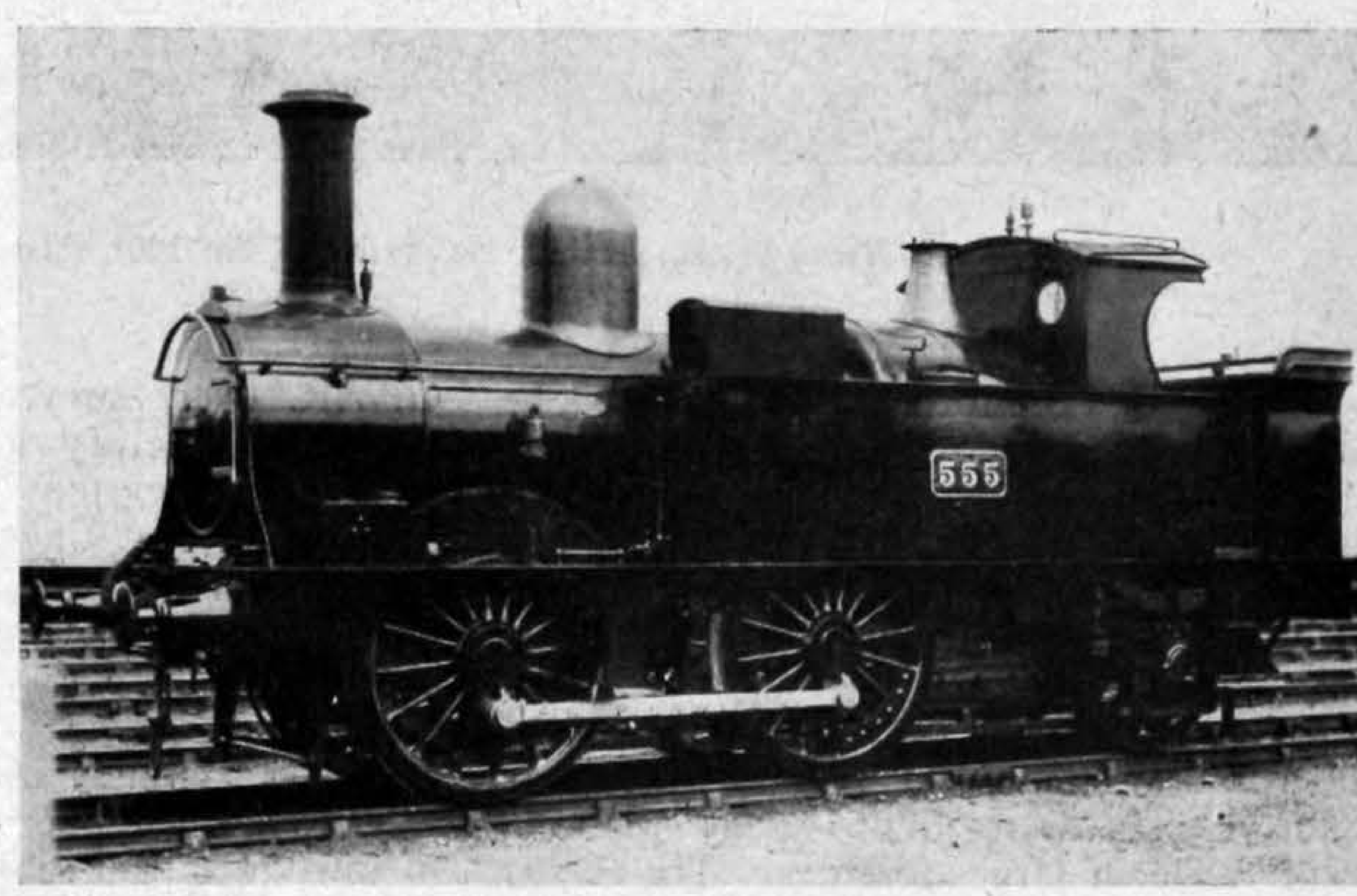
Worn out by his exertions, Armstrong died in 1877, and was deeply mourned by the entire population of New Swindon. The biographers of Timothy Hackworth lay as much stress upon his activities as a zealous Wesleyan in promoting the well-being of New Shildon, Durham, as they do upon his fame in locomotive engineering. Armstrong came under his influence at an impressionable age and it set the pattern for his conduct of life—firm in his dealings, yet with an underlying charity which guided all his actions. There is much in parallel in the lives of these two men.

Although the directors had provided New Swindon with various amenities in 1841, the town had by 1864 become drab and down-at-heel. Unlike Gooch, who lived in London and had his office there, Armstrong came to live among his workpeople and their families. He became chairman of the Swindon New Town local board and by the energy and zeal displayed in his thirteen years there, the civic life and moral tone of the community were stimulated.

When Joseph Armstrong departed from Wolverhampton for Swindon in 1864, he left his brother George in charge of the standard gauge works and the northern locomotive division, giving him a very large measure of independence, and permitting him to design and construct his own locomotives, though bearing responsibility as locomotive superintendent for what was done there in his name.

For a long period Wolverhampton was the largest running centre on the G.W.R. and Stafford Road Works the principal standard gauge locomotive building and repair depot. Men trained under George Armstrong filled most of the posts in the divisional offices of the running department, and the position of locomotive running superintendent was almost monopolised by a series of men who had served under him.

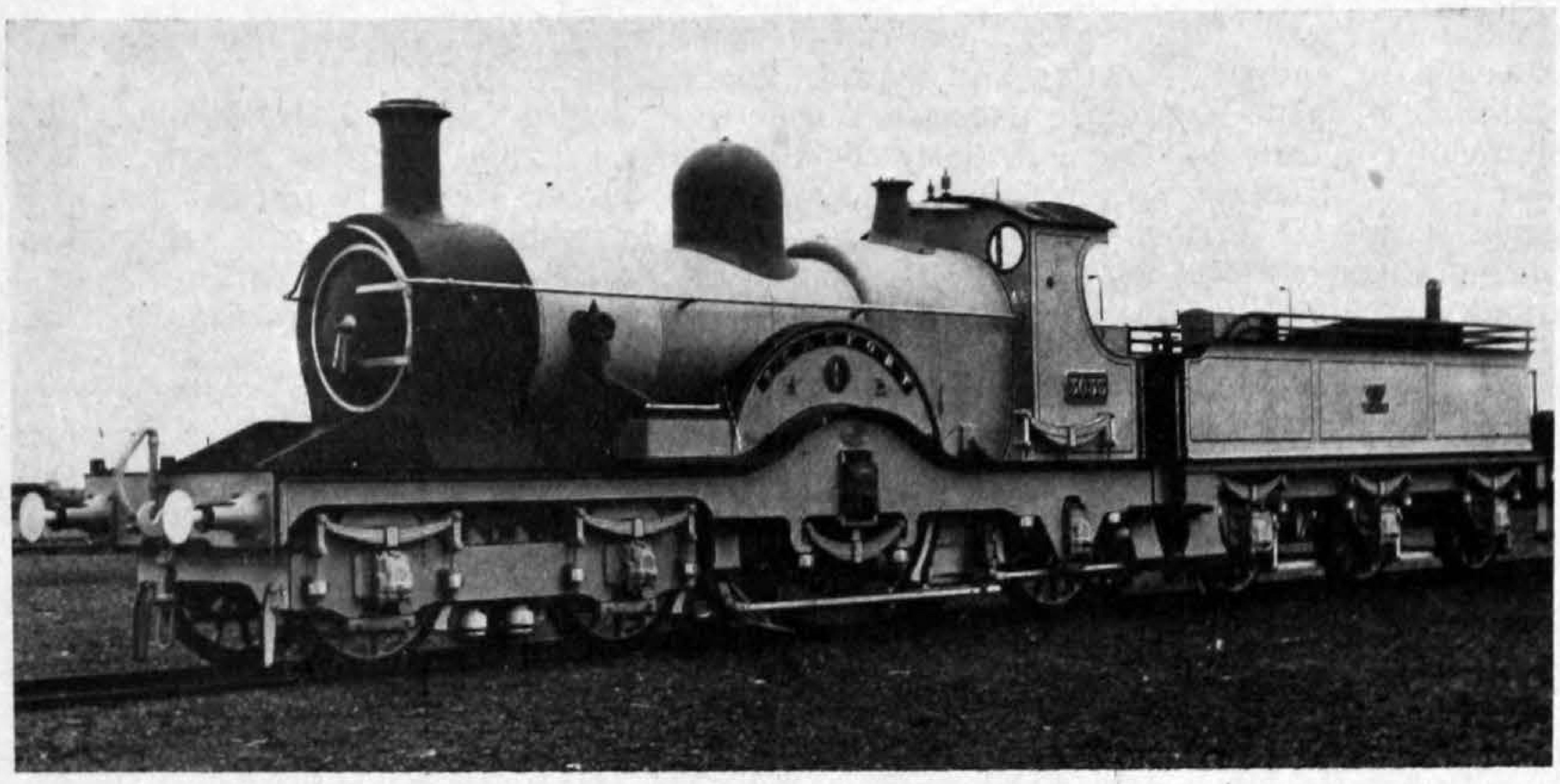
When Joseph Armstrong began building standard gauge locomotives at Swindon to replace broad gauge ones made redundant by the conversions of 1872 and 1874, they differed entirely in design from those being built by his brother at Stafford Road. This duplication of locomotive practice was a peculiar feature of the Great Western and extended over some thirty-five years or more. Even the style of painting was different, the Wolverhampton engines being distinguished by their dark blue-green colour.



Armstrong 0–4–2 tank locomotive built at Stafford Road

Unlike his brother, George Armstrong was a big and powerful man of strong will. As a descendant of one of the most turbulent and warlike of the border clans, he could be tough and uncompromising, though he was well liked and respected by his men and by the citizens of Wolverhampton. When William Dean was appointed to succeed George Armstrong's brother, Joseph, in 1877, something like a crisis arose, for Dean well knew the character of the man under whom

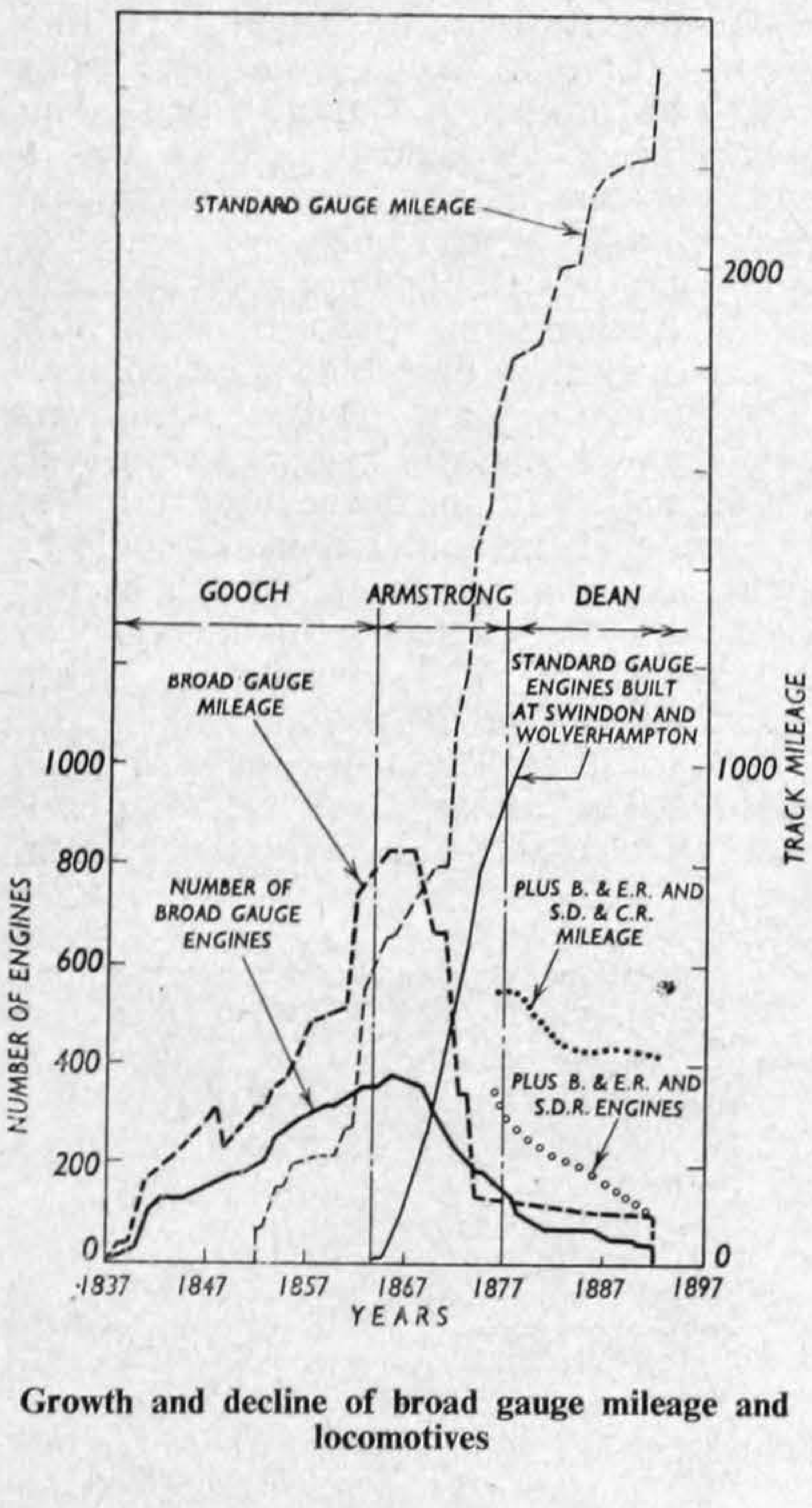
Joseph Armstrong, Jnr., designer, with G. J. Churchward, of the G.W.R. vacuum brake



Dean 7ft 8in express locomotive of the 3001 class

he had served at Stafford Road. Therefore, he left well alone in allowing him to carry on as he had done before, and this went on for another twenty years, for there was no retiring at sixty-five for George Armstrong ; he kept on until seventy-five years of age.

George Armstrong's designs produced sound and economical locomotives, and modernised versions of two of his tank engine classes were built at Swindon in recent times in large numbers. The writer has seen suggestions in technical publications that Armstrong did no more than superintend the building of engines at Wolverhampton to Swindon orders and designs, but, as he



Growth and decline of broad gauge mileage and locomotives

spent the earlier part of his career at Stafford Road, the writer can say at first-hand that this was not the case ; as far as he could see the only control was through the purse strings.

Locomotive practice during William Dean's term of office could be described as patchy. In the main he based much of his construction on that of his predecessor, making some modifications and enlargements from time to time, so giving the G.W.R. over the years a large number of highly satisfactory locomotives. In other cases he departed from the Armstrong features, and amongst his greater successes were the 7ft single-wheelers of 1878, the 2301 class goods engines of 1883 and the beautiful 3001 class 7ft 8in single-wheelers from 1891 onwards ; eighty of these dominated the running of main line passenger services for a number of years. His attempts to introduce tank engines for express work ended in failure, as also his trials of compounding, and his design of 0–4–2 passenger side tank rode badly and was no better when converted to 0–4–4.

Dean's suspension bogie for the coaching stock was a distinctive feature of G.W.R. trains for a number of years. It was the best riding bogie of its day and the coaches ran very smoothly, being exceedingly comfortable at the highest speeds. The four long suspension bolts which transmitted the weight of the body to the bogie through scroll irons and cross bars were normally vertical but took up an angular position on curves ; on the straight the bogie was self-aligning, being maintained parallel to the track. The pivot carried no weight, but it allowed of a small amount of side play. Dean's locomotives also had a modified version of this bogie.

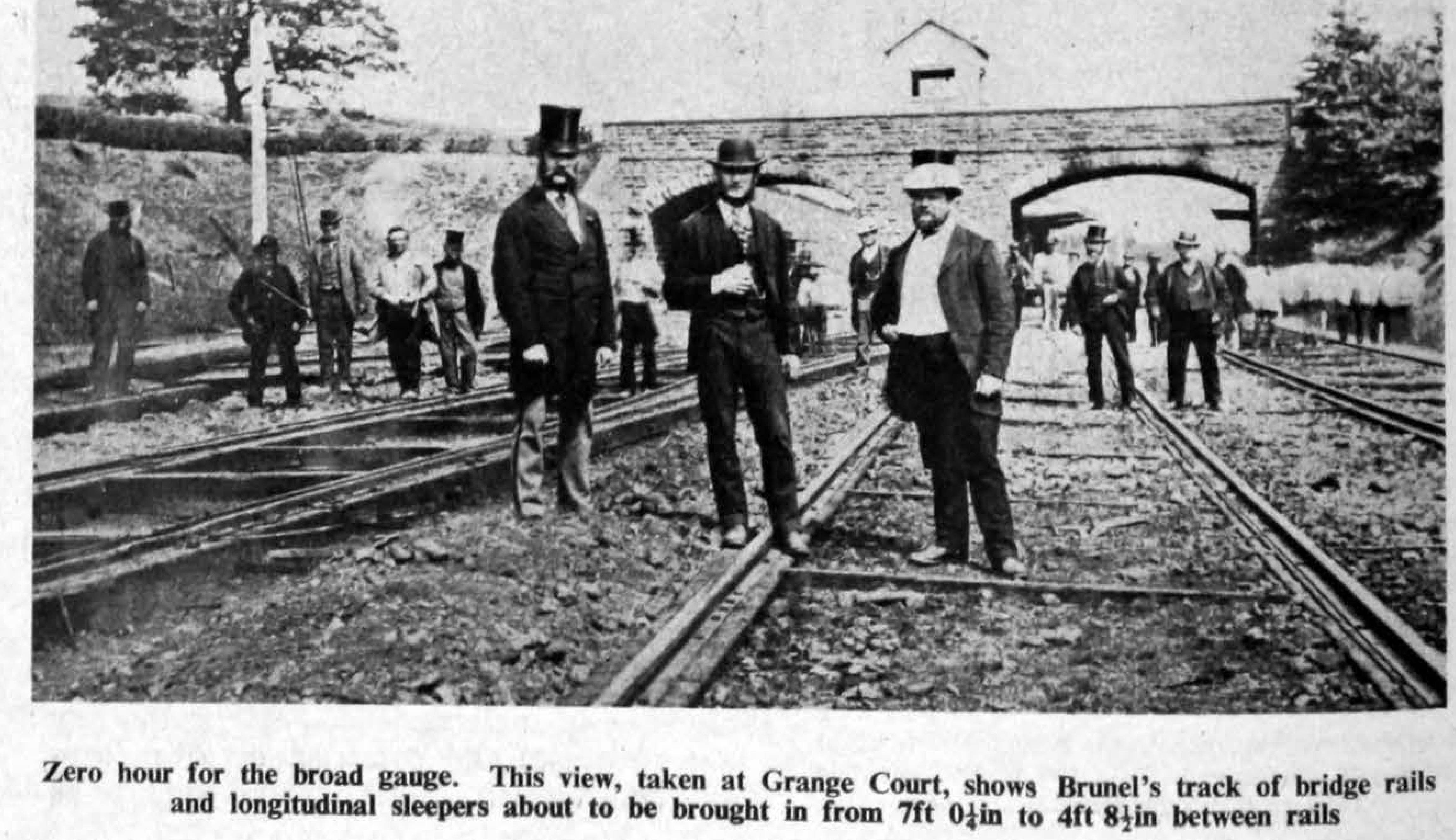
Originally the weight was taken on the four corners of the bogie of 6ft 4in wheelbase used on 48ft stock, but later, with longer coaches, the wheelbase was increased to 8ft 6in, and the suspension bolts located between the wheels. It was increased to 10ft for the longest stock and eight suspension bolts were used in pairs. When, in time, the traffic department pressed for even longer coaches, the distance between bogie centres had to be increased, and this resulted in greater angularity between underframe and bogie on sharp curves. There was a limit to the inclination which the suspension bolts could take up, and this led to a bolster bogie being adopted in place of Dean's design.

About 1880 the railways were beginning to equip their trains with continuous brakes. Dean decided that the G.W.R. should have its own form of the automatic vacuum brake, and he entrusted the designing of this to Joe Armstrong, a son of his predecessor and a young man of inventive genius. Associated with him in this work was G. J. Churchward, then an assistant to the carriage works manager. This distinctive form of the vacuum brake which they produced is still in use at the present day.

When Armstrong was later appointed works manager at Stafford Road, he came to be looked upon as the eventual successor of Dean, but his tragic death in 1888 ended this possibility. Churchward never lost the admiration he held for his former colleague. In later years he said on occasion that he would never have become locomotive superintendent of the G.W.R. if Armstrong had lived : Joe was a far cleverer man !

After the 1863 amalgamation until the abolition of the broad gauge in 1892, there followed a long period of stagnation and lack of enterprise in the development of train services and improvements to the line, and what remained of the broad gauge after 1876 was obsolete and moribund. The exception to this state of *laissez faire* was the great work of constructing the Severn Tunnel, begun in 1873 and completed twelve years later.

South Wales traffic branched off at Swindon and had to go as far north as Gloucester before it could cross the River Severn. A plan to bridge the estuary lower down was abandoned in favour of a tunnel, for a study of the geological formations led to the conclusion that the scheme was practicable. The moving spirit in this enterprise was Charles Richardson, the



Zero hour for the broad gauge. This view, taken at Grange Court, shows Brunel's track of bridge rails and longitudinal sleepers about to be brought in from 7ft 0¼in to 4ft 8½in between rails company's resident engineer, and the directors adopted his layout. The railway to pass through the tunnel branched off from the South Wales line near Portskewet (Severn Tunnel Junction) and came up at Pilning on the English side, the Severn being 2¼ miles wide at this point.

Contractors were engaged and shafts were sunk on each bank of the river, from which headings were driven. Work went on slowly but steadily for seven years until a large underground spring of fresh water was struck which overwhelmed the pumps and filled the workings at the Welsh end up to river level.

Sir Daniel Gooch was not the man to be dismayed by such a disaster, for he had had his setbacks in the laying of the Atlantic cable. The directors decided to make a new start on the abandoned workings and engaged the services of the eminent engineer, Sir John Hawkshaw, to take charge, agreeing that he should employ contractors of his own choosing. In consequence, the experienced firm of T. A. Walker took over the job and arranged to speed up the construction, and planned to contain the spring.

More inundations followed, however. Sea water burst in through a hole in the tunnel roof before the brick lining had reached the point. Then the great spring flooded the workings once more, followed shortly after by sea water which had flooded the low-lying land by an abnormally high tidal wave ; this poured into the cuttings of the approach roads. High banks had to be raised to protect the tunnel from another such inundation. As completed, the works extended over some 7½ miles, with about 4½ in tunnel.

In 1886 the first trains began to use the tunnel and traffic between South Wales and the west and south of England was greatly facilitated. Its opening led to the development of a new north to south route from Crewe, by way of Shrewsbury, to the west.

Gooch died in 1889 ; in his second period of service as chairman he had saved the company from near bankruptcy by his measures of economy and in a few years had steered it back to prosperity, and the grateful shareholders voted him a gift of 5000 guineas in acknowledgment. It is remarkable that he never exploited the possibilities which the broad gauge offered for higher speeds and greater comfort in passenger services. Even the brilliant running of his 8ft single-wheelers in their early days was not continued, train speeds being cut down for reasons of economy, and never in general raised again to their old levels. He seemed to be content with the stock of locomotives which he had created during his time as locomotive superintendent. As these dwindled through scrapping as they wore out, they were replaced by double-framed standard gauge engines provided with long axles so that the wheels were outside the framing.

With the death of the chairman, the knell of the broad gauge was sounded ; it had lingered on through sentiment, out of respect for the last of its great upholders.

Mixed gauge extended from Paddington to Exeter and from Truro to Penzance. Exeter to Truro alone was broad gauge only, and rather than extend the mixed gauge and remove the third rail for the 7ft gauge later, it was decided to close the line for a few days and to convert the gauge. This was duly carried out in 1892 under the chief engineer, Louis Trench.

With the broad gauge out of the way, a new spirit of enterprise arose which swept away the lethargy which had prevailed since the amalgamation of 1863.

(To be continued)

Electrical Engineers Exhibition

No. I

The ninth Electrical Engineers (A.S.E.E.) Exhibition, Earls Court, London, will be opened on Tuesday, April 5, by Mr. Reginald Maudling, the President of the Board of Trade. It will remain open daily, 10 a.m. to 7 p.m., until Saturday, April 9. This year the main theme of the exhibition is " Marine Electrics." A preview of some of the exhibits is given here.

To focus attention on the theme of this exhibition—" Marine Electrics "—there will be a display devoted to electrical and electronic equipment from the British aircraft carriers H.M.S. " Victorious " and H.M.S. " Hermes." It will include a set-piece built to resemble part of H.M.S. " Hermes," which is the first aircraft carrier in the Royal Navy to be equipped with a.c. mains power generation throughout. H.M.S. " Hermes," it may be recalled, was built at Barrow-in-Furness by Vickers-Armstrongs, and was commissioned last November. The electrical services installation is a 440V, three-phase, 60 c/s system with a generating capacity of 5440kW.

For the Admiralty exhibit at Earls Court the shipbuilders will simulate a working passage bulkhead, of which there are many examples in the ship, showing the arrangement and wiring of equipment, such as transformers, power distribution panels, lighting distribution boxes, telephones, emergency connection boxes and emergency lighting fittings. A replica of part of the compass platform will also be built to show the wiring and installation of various navigational instruments and communications equipment.

Much of the Admiralty equipment to be seen in this section of the exhibition will be of considerable general interest. It will include arrangements for voltage stabilisation of power supplies, for providing emergency 440V three-phase supplies, with automatic changeover in the event of partial power failure. There will be two examples of main switchboards for modern ships (The Electric Construction Company, Ltd., and Whipp and Bourne, Ltd.). One of these boards carries a flow diagram which gives automatic indication of the state of all main generators and circuit breakers in the ship's power supply system. Both switchboards contain provision for full control of the generators. For voltage stabilisation automatic voltage regulators incorporating magnetic amplifiers made by Electro-methods, Ltd., and W. H. Saunders will be included. There will also be examples of control and communications switchboards for the special supplies required throughout the ship for radar weapon control, compasses, degaussing and to provide remote control of all rectifiers and conversion machinery (William White (Switchgear), Ltd., and Aish and Co., Ltd.). Modern developments in rectifiers will be exemplified by a 40kW silicon rectifier designed for installation in ships of the Royal Navy (Westinghouse Brake and Signal Company, Ltd.). There will be a full-scale model of a " Sea Cat " missile launcher (Short Brothers and Harland, Ltd.). Gyroscopic stabilisation of a rolling platform will be demonstrated (Ferranti, Ltd.).

This composite Admiralty exhibit will also include Decca navigational and radar equipment ; automatic boiler control by John Thompson (Boilers), Ltd. ; and refrigeration control panels by the Electrical Apparatus Company, Ltd. Plotting tables originally developed by the Admiralty Research Laboratory and made by Laurence Scott and Electromotors, Ltd., will be shown, together with Decca plotting equipment fitted in a typical ship's bridge. There will also be a display illustrating the system of planned maintenance which was introduced in the Fleet in 1957.

Although the emphasis of this year's exhibition is on marine electrical equipment, most of the exhibits at Earls Court are of general industrial interest and some of the newer items are briefly described below.

Electrical Research Association

The exhibits to be shown by The Electrical Research Association, Cleeve Road, Leatherhead, Surrey, can be divided into five groups (Stand B3) : radio interference ; flameproof and intrinsically safe electrical equipment ; dust-tight enclosures ; corrosion of condenser tubes and alloys; and research on cables.

Work on the measurement and suppression of radio interference has been one of the major interests of the E.R.A. for nearly thirty years. Initial studies were related to the protection of the broadcast radio and television services against interference caused by domestic appliances and motor vehicle ignition systems. The work included the development of measuring apparatus, methods of measurement, suppression techniques and the assessment of the degree of protection which could economically be achieved. The results of these studies have been embodied in a number of British Standards and Codes of Practice, and have contributed to the formulation of an International Standard for Radio Interference Measuring Apparatus (C.I.S.P.R.). Comprehensive reports on the behaviour and testing of screening enclosures have resulted from recent investigations and these studies may also prove valuable in the design of large reflectors for radar aerials and similar structures where a mesh type of construction would be advantageous in reducing wind resistance.

The problem of radio interference in ships is generally similar to that in broadcasting except that the signal-to-noise ratios for satisfactory reception are lower and the band-width of communications receivers is generally narrower than that used for the reception of broadcast programmes. Again, the signal levels to be protected are much lower for marine use than for broadcasting. The same general principles apply, however, and equipment development for measurement in the one field may equally well be used in the other. An example is the aerial tuning unit for a radio interference measuring set, developed for the Admiralty.

As exhibited (Fig. 1) the aerial tuning unit provides a small but sensitive aerial system of known effective height and low output impedance over the frequency range 0·15 to 30 Mc/s. With this unit a radio-frequency voltage measuring equipment such as the RMS 1 or 2 may be converted into a sensitive and accurate field