A Century of Permanent Way

by

FRED BLAND, M.I. MECH. E. F.S.A.

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SECTION 1.

Paper prepared for the Annual Convention of the Permanent Way Institution, held in Sheffield and given as a Lantern Lecture on July 8th, 1925.

PRIOR PARK, BATH, 1754, WITH VIEW OF WAGON WAY. *(Earliest Illustration known).*

OLD PRINT, "HETTON COLLIERY" SHOWING ~~BLENKINSOPP'S~~ STEPHENSON'S ENGINE.

A Century of Permanent Way

By FRED BLAND.

Introduction.

THE IDEA of this paper came to me as a result of researches that I was making into the origin of Tramways, researches for use elsewhere, in the course of which I discovered so much interesting information that I thought it would perhaps interest many Permanent Way men if I gave a resumé, as brief as possible, of the progress of railways. While, no doubt, during the Centenary Celebrations a wealth of matter will be published, you will nevertheless like to know, I think, that your section has attempted to compile an historic record of its own. I have endeavoured to be accurate, and have made many searches for proofs, in which I have been greatly helped by an old friend, Mr. Isaac Briggs, of Sandal Magna, Wakefield, who is the son of Mr. Briggs, Engineer for the Leeds to Manchester Railways. Mr. Briggs has, as will be imagined, a mine of information, and I was therefore privileged to see many original documents, and to revel in original letters from Geo. Stephenson, Edward Pease, and I. K. Brunel. (These were all " strong men," and their letters breathe strength. They were never afraid of saying what they thought, and some letters, it must be confessed, are more forcible than polite). Others to whom my thanks are due are mentioned at the conclusion of this paper.

Early Engineering Feats.

The history of engineering dates back, if one is to accept the earliest biblical reference as authentic, from the Tower of Babel. The temple of Solomon probably carried with it some engineering problems, but the greatest civil engineering feats of ancient times lie to the credit of the Egyptians, some of whose works have lasted thousands of years, are not yet understood and cannot be repeated to-day. Speculation still rages, for example, as to the exact manner in which the Pyramids were built, and many ingenious theories have been put forward to account for the lifting and transport of the great blocks of stone of which they are composed. The Chinese, from the earliest times, had a great knowledge of engineering, but although they discovered many principles, they seldom applied them.

Probably the Romans were the first who applied engineering knowledge to the requirements of civilised life on anything like a considerable scale. The remains of Roman roads indicate how well they understood engineering. They spared no expense in making their roads, and they also built splendid aqueducts and bridges. It must be remembered, when considering the survival of so many of their roads, that there was a vast difference between the weight of the vehicles that passed along them, and that of those which go up and down the roads of to-day. The volume of traffic was also considerably smaller. Both these points must be borne in mind before any invidious comparison is made between the roads built by the Romans and those of our own time. The materials they used : for example their cement ; were often superior to ours ; though it must not be forgotten that they also possessed the art of building without cement, which they replaced by iron bolts that, together with the weight of the stones themselves, served to hold some of their buildings firmly together.

Civil engineering is a comparatively recent development of engineering science, owing its progress to the demands of the community, the advance of civilisation, and the increase of national wealth in time of peace. In early times the word " Engineering " was confined chiefly to military works, and the science was little understood or practised for civil purposes. Engineering was usually included with architecture, drainage, and river navigation, but after 1758, when canals were first introduced in this country by Brindley, engineering proper made rapid progress. The steam engine was by this time in general use for mining, etc., and in due course what is now known as civil engineering became a branch to itself. To-day the term covers a vast number of subjects, among which is railway engineering, some aspects of which form the substance of this paper. The early engineers were self-taught or were men born for the work, and it was their talents that gave civil engineering its original impetus.

The Origin of Permanent Way.

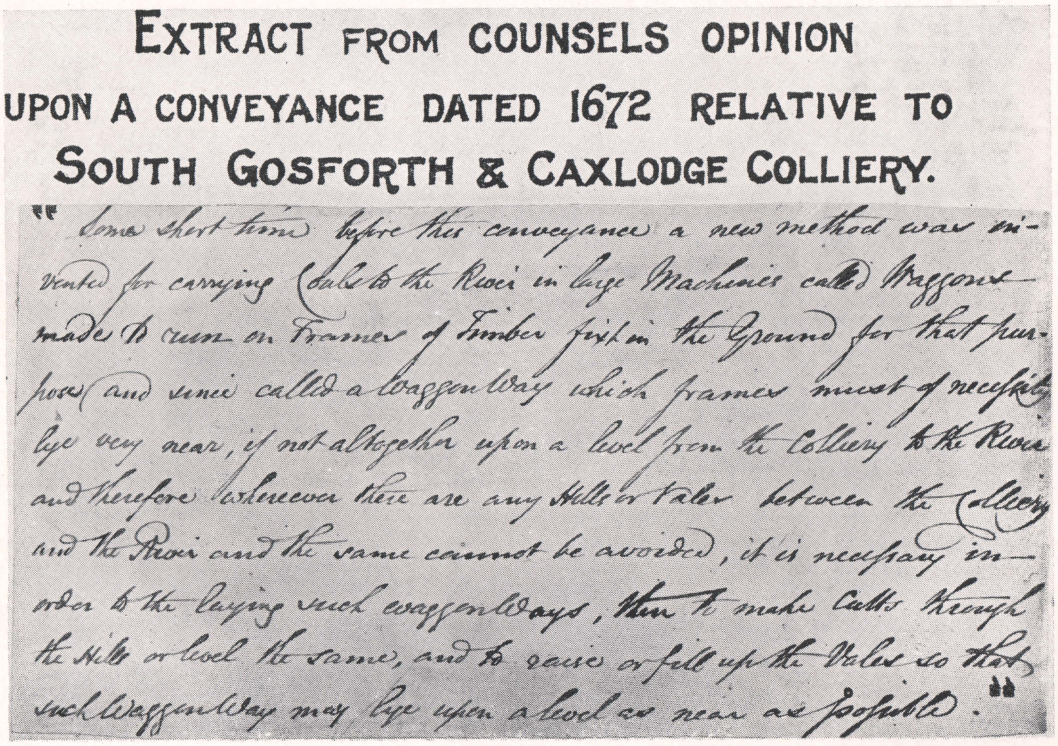
This brief introduction enables me to turn to the highly specialized branch of engineering which deals with permanent-way. It has been fully acknowledged by writers on railways, and by various works of reference, that railways had their origin in tram-ways or wagon ways, which were in use in very early days in the Newcastle quarries, and doubtless in other parts of the country as far back as the 16th century. The earliest reference to these ways that I have been able to find is in a will made by Ambrose Middleton, of Skirwith (County of Cumberland) and Barnard Castle, August 5th, 1555, by which a sum of money was left for the repair of a highway or tram. My friend Mr. T. Walter Hall, solicitor and antiquarian, of Sheffield, was good enough to make a search at York, but while he obtained extracts proving that such a will had existed, the original document, which I wished to photograph, was not in existence.

The next reference to these ways is as follows: Delavel, a London merchant, and Ambrose Dudley, obtained a Crown Lease for mines near Bedlington. In 1598 accounts were rendered at Wollaton for coals and rails, which proves that there was a wagon-way at Wollaton to the river Trent. This existed in 1597. A few years later, in 1602 to be precise, Mr. Huntingdon Beaumont, of Billbrough, near Nottingham, took to Middleton engines, wagons and boring tools. Possibly these were from Germany, since trams and trucks were used in the Tyrol before then. I ought to mention here, to keep my account strictly and chronologically accurate, that Germany possibly anticipated us in the use of rails. Their method was to put strips of iron on the wood timbers. These were nailed down on the wooden rails at curves.

The oldest *official* record of a wagon way that I could find was a Counsel's opinion (C. York 1763), which I photographed, and which is reproduced on this page in the form of an extract, in which the Counsel refers to the year 1672, when he mentions "an invention for carrying coals to the river in large machines called wagons made to run on frames of timber fixed in the ground for that purpose, and since called a wagon way, which frames must of necessity be very near, if not altogether upon a level from the colliery to the river, and therefore where there are any hills and vales from the colliery to the river, and the same cannot be avoided, it is necessary in order to the laying such wagon ways, then to make cutts through the hills or level the same, and to raise or fill up the vales so that such wagon way may lay upon a level as near as possible."

This is a very interesting document.

In South Wales and the Midlands these lines were known as tram roads, but in the north east they were given the name of wagon ways, and in 1676 Francis North (Lord Keeper of the Seal under Charles II. and James II.) called them way-leaves, timber rails being laid for the wagons. In 1758 the Middleton wagon-way, referred to in a preceding paragraph, was authorised by Parliament for supplying coals to Leeds. It ran from Middleton collieries (where Blenkinsop tried his locomotive in 1811) to the staithes in what is now Meadow Lane, Leeds.



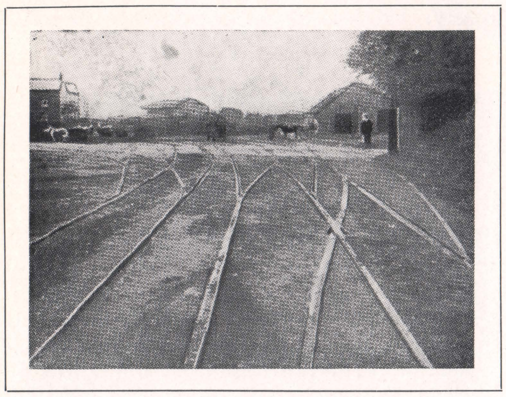
EXTRACT FROM COUNSELS OPINION UPON A CONVEYANCE DATED 1672 RELATIVE TO SOUTH GOSFORTH & CAXLODGE COLLIERY.

"Some short time before this conveyance a new method was invented for carrying Coals to the River in large Machines called Waggons made to run on Frames of Timber fixt in the Ground for that purpose and since called a Waggon Way which frames must of necessity lye very near, if not altogether upon a level from the Colliery to the River and therefore wherever there are any Hills or Vales between the Colliery and the River and the same cannot be avoided, it is necessary in order to the laying such WaggonWays, then to make Cutts through the Hills or level the same, and to raise or fill up the Vales so that such WaggonWay may lye upon a level as near as possible."

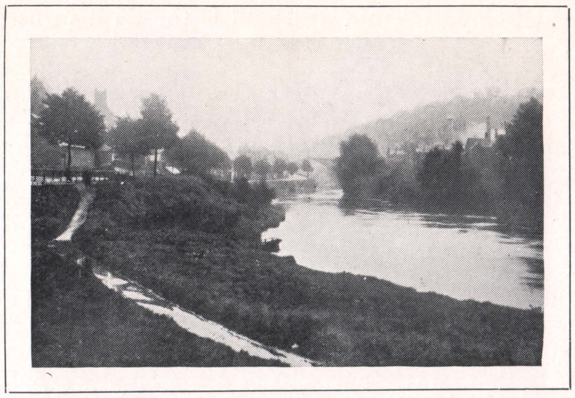
The First Cast Iron Rails.

Not until 1767 was cast iron used on a tram road, by the Coalbrookdale Iron Company; but there is no record of this, other than what has appeared in various journals from time to time. I wrote to the Company on this point and met with very courteous treatment. In fact, they sent me three plate-rails as made to-day, similar to the originals. Coalbrookdale can certainly be considered to have had the first rail road. It was followed by one at the Denby Collieries, near Alfreton, where I have seen some of the rails and blocks.

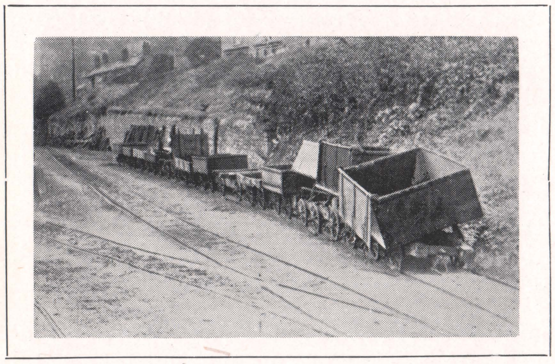
Old Cart Gear Tracks.



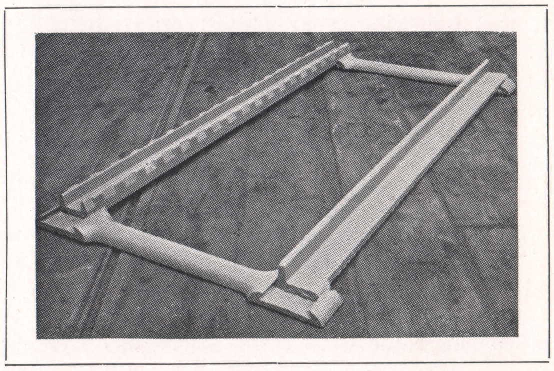
VIEW OF OLD CROSSINGS AT DENBY COLLIERY (1800).



ANCIENT TRAMROAD BY RIVER AT COALBROOKDALE.



OLD WAGONS USED AT COALBROOKDALE.



OLD TYPE OF PLATE-RAILS MADE AT COALBROOKDALE.

In 1768 Alloa, in Scotland, made a wagon way, which was relaid in 1785, using malleable iron bars $1.\frac{3}{4}'' \times \frac{3}{4}''$ on the top of the upper timber rail. Later, in 1805, this type of way was used at Walbottle Colliery, near Newcastle. The pieces were only 2ft. long and so narrow that they cut the wheel tyres and were replaced by wide cast iron rails.

The Outram Myth.

The next date of note is 1774, and it has a local interest because Mr. John Curr, the Duke of Norfolk's agent, laid cast iron plates of his own design upon sleepers at Sheffield, these plates being made by a man called Outram. They were 6ft. by $3''$ by $\frac{1}{2}''$ with a lug at the ends for bolting them on to the sleepers, the gauge being 2ft. There is no doubt that Outram made the first plate-rails at Butterley, and from this fact arose the popular fallacy that the word "tramways" was derived from the man "Outram." This is beyond question a myth, but the belief will probably never be destroyed.

Outram's partner, William Jessop, invented the "edge-rail" because of his experience with the plates, a trouble more precisely explained in a later section of this paper. Jessop also suggested flanged wheels, but was not their inventor, because they had been used before on wooden sleepers. The illustrations show various types of these edge-rails, of which all were laid on stone blocks so as to gain a rigid structure. Outram and Jessop were partners, and one of their contracts was the putting down of a track at Belvoir Castle in 1790—91. This track consisted of cast iron rails 3ft. by $1\frac{1}{4}$in. with raised head, each rail having a flat base at one end and a dovetail piece at the other. Flange-wheels were used, and these were the first to be employed on iron rails.

Plate-Rails v. Edge Rails.

The two partners quarrelled over this job. When Outram saw that Jessop had persuaded the Duke to have edge-rails, he went over to see the Duke himself, urging him to cancel the order for them, and to take instead his own plates, which were three feet long with a side flange. The Duke sent for Jessop, and heard both partners together at a very stormy meeting, the result of which was that the Duke decided to try both, and then make up his mind. In the end he retained the edge-rails and flange-wheels, with Outram's stone blocks. The wagons used were 4ft. 6in. high, and the Duke declared that the gauge must be the same. He took a centre measure of the rails, 4ft. 6in., which, with rails $1\frac{1}{2}$in. wide, gave 4ft. $4\frac{1}{2}$in. inside and 4ft. $7\frac{1}{2}$in. outside. Outram and Jessop both sent their own men over to lay the job, and the consequence was a refusal to lay each other's material. This strike occurred in 1793. Jessop's men were called "rail-layers," but the term "plate-layers" prevailed and is the term in use to-day.

A few years later (Nov., 1800) Dr. James Anderson, father-in-law of Outram, wrote a paper entitled "Cast Iron Rails" for an agricultural journal, suggesting that rail-ways should be laid alongside existing roads, and that a trial of this new invention should be laid from London to Bath. There is no doubt that Outram suggested this paper to Dr. Anderson.

William Thomson, of Denton, Northumberland, at a meeting of the Literary and Philosophical Society, Newcastle-on-Tyne, proposed railways for passengers and goods, these ways to consist of cast iron plates 5in. wide, with a flange 3in. high. In 1801 the Surrey Iron Railway was opened; the first public rail-way to work.

In the following year (1802) an Irish engineer, Richard Lowell Edgeworth, put forward a project for laying rails on the great roads of England, but he was advised to let the matter alone, and so he missed the opportunity that George Stephenson was to take later on. It has been truly said that "there is a tide in the affairs of men, which taken at the flood, leads on to fortune." George Stephenson was a great example of this, and although he was not quite so great an engineer as popular legend would have us believe, he knew "men and things" and above all knew when to grasp the opportunity and use the men. It was in this way that he came by his fame.

The Surrey Iron Railway.

Reference has been made above to the Surrey Iron Railway which ran from Wandsworth to Croydon. This was an instance of a plate-railway, and as remarked, it was the first rail-way available to the public on payment of tolls, previous lines having all been private and reserved exclusively for the use of their owners. Perhaps this will be the best place in which to complete the history of this track. When the new railway was first proposed, it was necessary to buy up this Surrey railway, known as Merstham Tramway, and also the Croydon, Merstham and Godstone Iron Railway claimed to be the first of its kind (possibly in the south), running from Croydon to Merstham Chalkpits, and also from Wandsworth.

The plate-rails were laid on stone sleepers, many of which have been used as kerbstones in Croydon. It is said that remains of the old line can still be seen. It was opened in July, 1805, and the new railway used part of their site, Croydon West standing on the site of the old Croydon Canal which the London, Brighton and South Coast Railway Co. had to buy up as well. The new railway also used up part of the tracks.

Those who are Masons will be interested to learn that the foundation stone of the New England Viaduct (Surrey Iron Railway) was laid on May 27th, 1837, and on the eve of Masonry 5839, laid by the U.M., assisted by his brethren and under the auspices of the Directors of the Company.

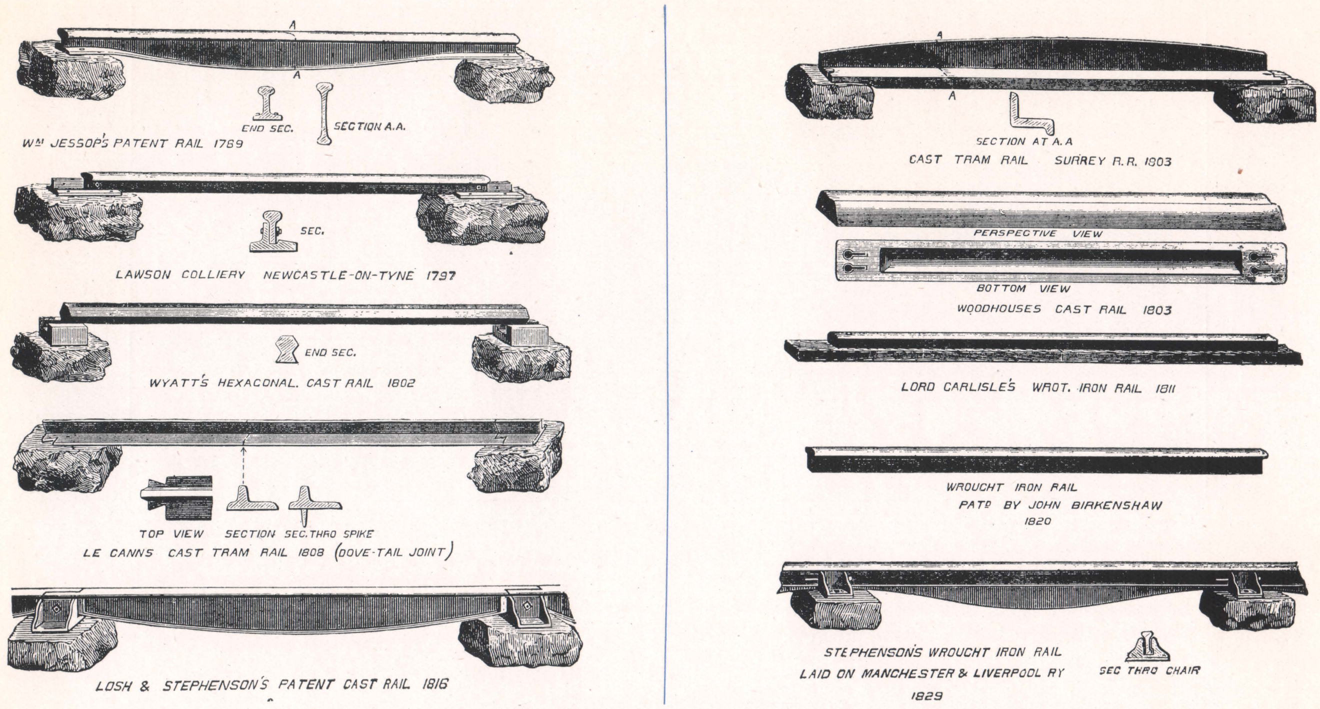
The Coming of Wrought Iron and Edge Rails.

Next came the Oystermouth Railway which carried passengers, without powers, in 1804. In 1805 began the use of wrought iron rails, which were made in lengths of 15 feet. These replaced the cast iron rails, which were liable to fracture, and which could not exceed 3ft. 11in. in length. In 1808 another railway without powers began to carry passengers, namely the Kilmarnock and Troon. In the same year a select committee considered the rail-road question, and Adam Walker proposed that railways should be gradually tried, but, first, with one wheel on a rail 12in. wide, and the other wheel on the road, so as to get people accustomed to their use. A year later (1809) a wagon-way was opened from Berwick Main to the Tyne, and it is said that by 10 o'clock 10,000 people were assembled. Four wagons were drawn up by a fixed engine, the British flag was hoisted, and 6 guns were fired; these were answered by a man-of-war in the Tyne, after which 400 people sat down to dinner to celebrate the event.

Later that day, six men without horses easily pulled four loaded wagons, each of which carried 10 men, to show the advantage of the rail-way.

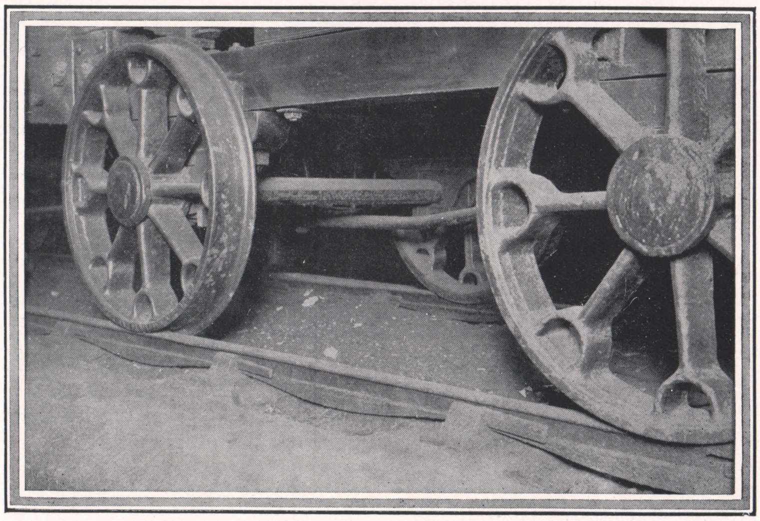
Plate-rails were at first used, but these soon gave way to edge-rails, the forerunners of our present rails; both systems ran well into the 19th century. Plate-rails had projecting flanges to keep the wheels on the track. Edge-rails had no such projection, and consequently wheels were made with a flange on the inner side, as is the case to-day, in order to keep them on the track. The advantage of this method was that there was no accumulation of dust and dirt on the rail. In South Wales it was estimated that there were 150 miles of plates for local purposes, but in the North, edge-rails were in greater favour and were adopted by George Stephenson, as is seen by a perusal of his letters. The plate-rails became objectionable owing to the deep side-flange, which led to dust and dirt collecting in the plate, and the pins, in consequence, were continually coming out, so that many horses were lamed. Their gradual supercession by edge-rails was, therefore, not surprising.

In 1810 a Frenchman records a visit to Wales, during which he had seen there, rail-ways (or wagon-ways or tramways). Low cast iron wheels ran in an iron groove lying in the road. He adds: "now the grooves are placed on the circumference of the wheel running upon a rail, which is an edge of iron upon which nothing can lodge. Five or six wagons are drawn by three horses or four tons per horse besides the wagons, which would be impossible on a common road."



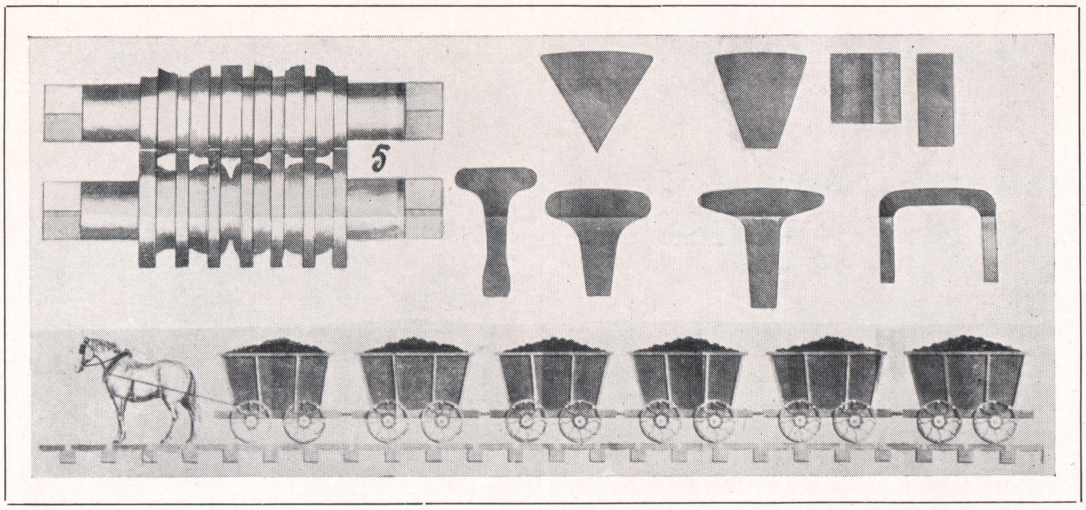
Types of Early Rails-Cast and Wrought.

In 1811 the third of the three companies that, without powers, carried passengers, began to function. This was the Stratford and Moreton, but the first railway actually authorized for passengers was the Berwick and Kelso, on May 31st, 1811. It was never made, and the present line, which was opened in 1846, has a different route. Between this authorization and the opening of the Stockton and Darlington Railway in 1825, twenty-one other public railways were authorized, but the Stockton and Darlington was the first to obtain powers for working trains by locomotives.



THE FIRST RAILWAY TRACK WITH STONE SLEEPERS AND PECULIARLY SHAPED RAILS AND WHEELS.

In 1812 the proposal of Adam Walker in 1808 was echoed by Robert Stevenson, of Edinburgh, grandfather of Robert Louis Stevenson, who made similar proposals. Tentative suggestions of this kind were made continually until the time of William James, who has been called the "Father of Railways." He was agent to several Warwickshire estates and had been interested in railways since 1802, particularly in the Surrey Iron Railway referred to previously. Mr. James was strongly in favour of using Jessop's edge-rails.



FIRST ROLLED RAILS, BIRKENSHAW'S PATENT, SHOWING SECTIONS AND ROLLS.

Malleable Iron Rails.

This chronological account of the history of Permanent-way is now gradually drawing near to the memorable date represented by the opening of the Stockton and Darlington Railway, but before coming to this point, the account must be completed by the insertion of certain other interesting details. A little before 1820, Robert Stephenson saw some malleable iron rails at Tindale Fell. These had then been in use eight years. He showed them to Michael Longridge, of Bedlington, whose agent was John Birkenshaw, with the result that the first malleable or wrought iron rails were rolled in 1820 at the Bedlington Iron Works under John Birkenshaw's Patent, the original of which I have seen and copied.

It ought to be explained here that Michael Longridge was the proprietor of the Bedlington Ironworks and was a very great friend and helper of both George and Robert Stephenson. His letters to them were characterized by great affection.

It is interesting to note that in 1821, William James, the Father of Railways, said that the Bedlington rail was the best he had seen.

The above illustration is from Birkenshaw's patent showing both rails and the rolls. His claim was that rolled rails would be better, cheaper, and last longer than the cast iron rails then in use. He says : " The advantages derived from this method of constructing railway bars may be summed up as follows :—

1st. The original cost of a malleable iron railway is less than that of a cast iron railway of great strength.

2nd. As the rails can be made in lengths of 9, 12, 15 or 18 feet each, and even longer when required, the number of joints is thereby reduced ; and thus is removed, in a great measure, the liability to which the short rails now in use are exposed, of receiving blows and shocks from the carriages which move over them.

3rd. In order to remedy the evil arising from the rails being imperfectly joined, the plan of *welding* the ends of the rails together has been adopted ; by this means, making one continued rail the whole length of the road without any joint whatever.

4th. It hence follows that on the iron railways, the loss of coals occasioned by the jolting of the wagons at the joints of the rails, and the injury done to the wheels, the carriages, and engines from the same cause, are, if not entirely prevented, at least considerably diminished.

The Coming of the Stockton and Darlington Line.

Meanwhile, things were on foot for the inauguration of the Stockton and Darlington railway. In 1820 a meeting was held to promote a meeting for this line, which described it as a rail or tramroad. It was decided to apply to Parliament for powers to construct a tramway on Overton's plan, and a discussion took place as to whether it should be the South Wales type of tramroad or an improved rail-road as used in the North. Royal assent was given on April 19th, 1821, for a railway or tramway, which term was also used in the Act of 1823. In 1821 we find George Stephenson urging the use of wrought iron rails as against cast iron for the Stockton and Darlington railway. This advocacy caused him to suffer material loss, and for a time he forfeited his friendship with Mr. Losh, a well-known man of those days.

Another interesting event in the same year was the publication, by Thomas Gray, of Nottingham, of a book on railways, in which he proposed three pairs of rails for each direction, on roads to be made for them (thus anticipating our modern arterial roads), with traversers and turntables to cross from line to line. Like many other pioneers he was laughed at, and although he anticipated the future, he died in poverty.

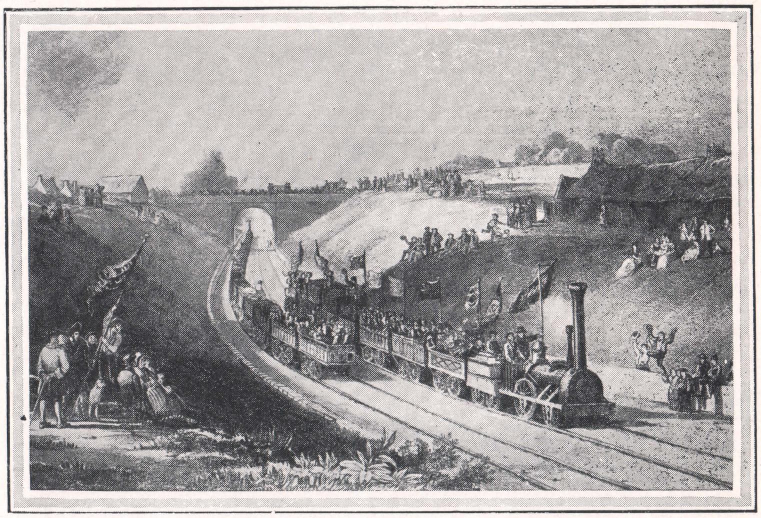
THE OPENING OF THE STOCKTON & DARLINGTON RAILWAY, THE FIRST RAILWAY IN THE WORLD.—THE FIRST TRAIN PASSING OVER SKERNE RAILWAY BRIDGE, DARLINGTON.

The Year 1825 and After.

We now come to the eventful year whose centenary is being celebrated at the present time, the year 1825, which saw the opening of the Stockton and Darlington Railway. Wylam's Colliery in Northumberland used in this year plate-rails with side-flanges as then in use, the wheels having no flanges; but these plate-rails were replaced by edge-rails after 1825, when flange-wheels were adopted. For some years the Stockton and Darlington line found passenger traffic irregular, and anyone could run coaches on the line on payment of tolls. It was not until 1834 and 1835 that the railway committee ran passenger trains as such. Meantime Robert Stephenson had returned to England, and in 1827 took charge at his father's engine-works. In the same year Prussian officials came over to see Stephenson's works, the fame of which had spread widely. They presented a voluminous report. About this time, to refer for a moment to continental development, we find the French using mushroom-head rails, called "champignon." Previously their rails had been rolled and welded together, but the French engineers eventually enlarged the upper surface, and added projections, which gave them the name indicated. The rails on the Lyons line weighed 28½lbs. per metre; these were followed by double mushrooms, or a rough double-head or bull-head. But in 1846 they reverted to the T rail, 74lbs. per yard.

French and American engineers followed the Prussians on a visit to Stephenson's works in 1828, and it is in this year that we find Robert Stephenson making improvements in the locomotive-engines which led up to the "Rocket." In 1830 he was appointed engineer-in-chief to the Warrington, Leicester and Swannington Railways, the duties of this post being additional to his engine-work. In the same year, 1830, the Leeds and Bradford line was proposed, but was thrown out until 1854. But this year witnessed the opening of the Canterbury and Whitstable line, amidst great rejoicings.

In 1825 a further interesting development was the use of cast iron sleepers by George Overton, whose name has already been mentioned in connection with the Stockton and Darlington Railway. These sleepers were put down at Sirhowy (Wales) upon the Lydney and Lidbrooke tramways, where in 1815 a locomotive had been tried, the inventor of which is unknown. In 1829 George Stephenson supplied another locomotive to this line, which was a big passenger line in 1822, but conducted by private individuals, the fare being 6d. per tram payable at each toll gate. This fare was raised later to 1/-.



THE OPENING OF THE FIRST SCOTTISH RAILWAY—THE GLASGOW TO GARNKIRK LINE—IN 1831.

If I may digress for a moment, I would like to mention here that there is an old stone rail-road still existing between Bugsworth and Chapel-en-le-Frith, which the London and North Western Railway have, I believe, given notice to move. This line was laid by Outram with plate-rails 3ft. long, weighing 56lbs. per yard. These rails were replaced in 1870 by steel rails from Gorton, measuring 9ft. and 12ft. long.

The First Passenger Line.

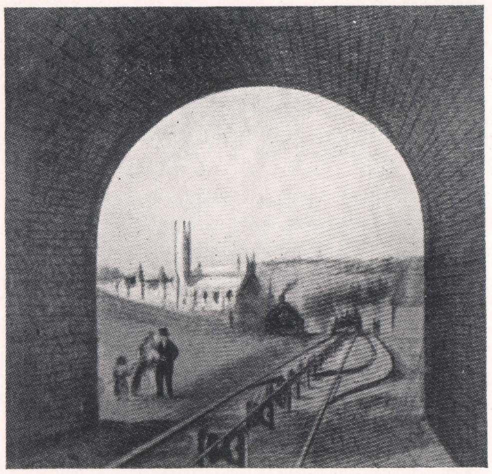
Ackerman's coloured print of the opening shows a great crowd of people on the banks, in holiday attire,

OPENING OF CANTERBURY AND WHITSTABLE PASSENGER RAILWAY, 1830.

and it is still more interesting to note that the print shows a passing-place. This railway was the first in the world to have a proper passenger service, with a locomotive, the "Invicta," which is now in Canterbury.

The illustration shows the opening of this railway, and another shows the tunnel which was specially built for the passengers to run through. The wagons were drawn through this tunnel by a stationary engine and ropes, as shown, because the locomotive only ran from Whitstable Bay to near the tunnel. The first railway to run through the tunnel with a locomotive was the Leicester and Swannington, a year or two later. The chimney of the locomotive was too long for the tunnel, and scared the dignitaries with the scattered smoke and flames.

I shall not enlarge upon the Stockton and



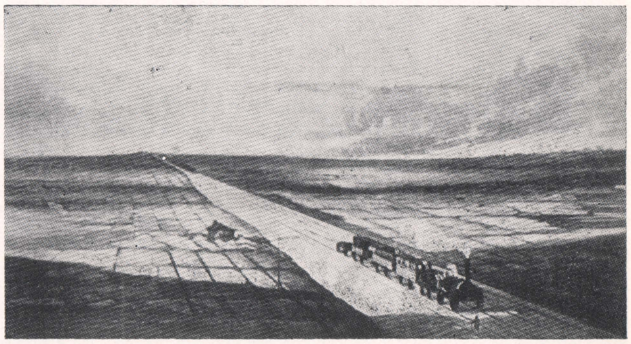
TUNNEL ON THE CANTERBURY WHITSTABLE RAILWAY.

Darlington Railways as more experienced writers have dealt at great length with that line.

The Liverpool-Manchester Railway.

In 1830 the greatest work of George Stephenson was opened. This was the Liverpool to Manchester railway. I give here an old estimate of costs for its material:

Stone blocks ..	..	1/4 each.
Chairs, 10lbs. each	..	£15/0/0 per ton.
Rails, 35lbs. yard	..	£16/10/0 per ton.
Laying 34 miles	..	5/- yard.
Total estimate	..	£400,000.

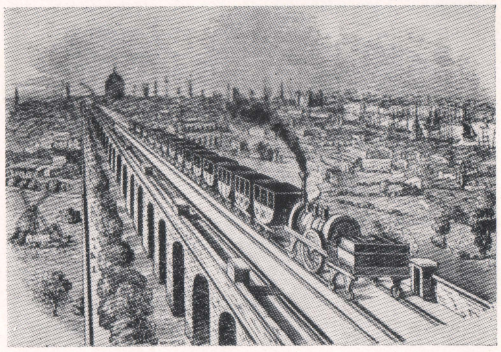


TRAIN CROSSING CHAT MOSS (LIVERPOOL & MANCHESTER).

The earliest steam line was from Leeds to Selby, 1831—4. In constructing this line the contractors opened many ancient coal-workings of the Beeston bed, crude timbering and wooden shovels being frequently found, and cutting into coal-works was a common occurrence.

The First London Line.

The first railway in London was the London and Greenwich, which was proposed in 1832, two years after the opening of the Liverpool and Manchester line. The first brick was laid in 1834, and by July, 1835, nearly 500 arches had been erected.



LONDON AND GREENWICH RAILWAY ON BRIDGES OR ARCHES.

The Times, September 24th, 1835, said: "The Arches sprang up like mushrooms." A trial trip was run on June 9th, when the "Royal William" ran 1 mile in 4 minutes in the presence of a great number of people. It is *said* that a glass of water filled to the brim was placed on a stone sleeper, and was unspilled as the engine went past. The engine could take 12 coaches and 288 passengers.

There seem to have been great rejoicings in connection with this railway, since we read that on the 14th December, 1836, the Lord Mayor opened the extension in state, and grand-stands were erected on both sides of the line to London Bridge. Church bells were rung, military bands attended, and one went in the train. Many travellers ventured into inns for refreshment, and could not get back owing to the crowds. In Easter week, 1838, it is said that 20,000 people were turned away.

On the 16th October, in the same year, "a distinguished company of foreigners and Quakers" were carried: why this description is given is unknown. In December a paper stated that one of the carriages ran off the rails, but "the party of noodles" who had ventured were not hurt, and added: "How lucky, no-one killed the first day!" The Chairman congratulated shareholders on the accident, showing how safe accidents were—a very different procedure from that of to-day.

Our illustration on page 9 shows the Greenwich railway in 1837. It was frequently called a "Roman aqueduct." The work was designed and carried out by Lt.-Col. Laidman, R.E., and Mr. George Walter was the leading spirit. A great feature was the roadway and gravel path planted with trees to extend 24ft. on each side of the viaduct from end to end. The arches were to be let and bring in a lot of money, but leakage stopped all this. It was claimed that invalids and children would use this promenade, but the widening for the Croydon railway in 1840 spoilt all this. A good deal of it still exists, and the arches are known by many. The viaduct and permanent-way were made in 1838 by Rennie. The rails weighed 50lbs. a yard (and in 1912, 91¼lbs. and 95lbs). When the Bricklayers' Arms branch was built, in 1849, all the arches were communicating, the height diminishing until one had to stoop. The engineer made two great mistakes: his arches were not water-tight; and his permanent-way was too rigid, so that frequent breakages of axles occurred. When the arches were being built, a sum of several thousands a year was offered for them, but declined, the directors anticipating that more would be gained by separate letting. In the end they got nothing. In 1835 the Half Way Tavern was built in the arches at Rotherhithe New Road. In July, 1838, the noise of the stone sleepers of this railway was found so great that it was decided to lay with wood in future. Very interesting details of this line can be obtained from the Locomotive Publishing Company, who issued a souvenir of it in 1912, from which the present particulars were gleaned:

OLD PRINT, "THE COLLIER" SHOWING BLENKINSOPP'S ENGINE.

The London & Birmingham Railway.

On September 17th, 1838, the London and Birmingham railway or London and North Western Railway (before the recent amalgamation) was opened. This line was laid through difficult country, the main endeavour being to procure good gradients and curves, the prevailing gradient being 16ft. per mile, or 1.330. The worst curve, of 600 yards radius, was on the Chalk Farm Lane. One or two interesting things in regard to this railway may be noticed. It was the first to carry the mail, a horse box being converted into a post office for the purpose. Passengers were allowed time for refreshments, which, it was said, would be served by "female" attendants. First-class trains had 1st class and mail carriages, some carrying four inside and some carrying six, one compartment being convertible into a bed-carriage if required, thus anticipating our sleeping-cars. The 2nd class carriages were open at the sides, there being no linings, cushions or other divisions. The night mail had the carriages closed. This line was laid to the standard gauge with intermediate spacing of 6ft. 5in. The costs of the original stations will also, perhaps, interest readers, and therefore, I reproduce them here.

	£	s.	d.
Euston Station cost	81,532	0	0
Camden Depot cost	114,385	0	0
Wolverton cost	109,454	0	0
	£305,371	0	0
Stations between London and Wolverton	25,386	0	0
Remaining stations about ..	29,243	0	0
Total cost of stations	£360,000	0	0

The cost per mile was £47,374 0s. 0d., including stations, land, carriages, wagons, engines, etc. In 1839 the cost of repairs was £333 0s. 0d. per mile.

George Stephenson on Rail-Wear.

I do not apologise for the insertion here of George Stephenson's opinion, copied from an original letter, as to the wear of rails. He considered that "in the north the rails should wear longer than the south, seeing that rails in the south dry quicker, being exposed to the sun's rays. It is well known that all metallic surfaces wear much more when they are dry than wet, therefore presuming a line is laid E. to W. and both rails wet, then the south side of the rails will evidently dry sooner than the north sides, the south side of the rail being immediately exposed to the sun, while the north is defended therefrom by the upright edge of the rails, and therefore the north wheel will outrun that of the south."

Sheffield and the Railway.

The railway came to Sheffield in a rather roundabout way, and one finds a certain amusement in recalling that Rotherham was opened up in 1838, two years before the line from Leeds to Sheffield and Chesterfield (planned by George Stephenson) began to work (June 30th, 1840). Sheffield thus came in via Rotherham. I remember going as a youngster to the present Midland Railway Goods Station to take a train to Rotherham, but in those days, I think, we walked as often as we rode, through pleasant country fields and canal banks—now, alas, no more. George Stephenson knew by instinct the counties of the future, but he preferred a roundabout track, easy to make, and avoiding inclines and tunnels. The present line was not opened until 1870.

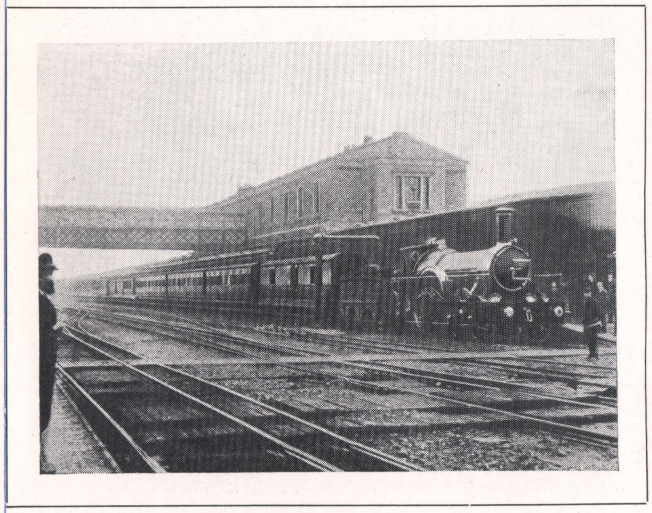
Railways Rejected.

It is a remarkable fact that many towns refused railways, and I enumerate a few of these. One was Stamford, which in 1840 was very important since it lay in the track of the Great North Road, whereas now it is only a sleepy county town. Progress was blocked by the Marquis of Exeter, Lord of the Manor. Peterborough saw its opportunity in the refusal of Stamford and offered assistance, with the result that it is now a very important centre. Of local interest in connection with this paragraph is the fact that one of the directors of Edgar Allen & Co., Ltd., the late Mr. F. A. Warlow, bought and lived at a place called the "Mere" at Deeping St. James, which I have visited. The "Mere" was created by the taking out of material to form the original railways and embankments.

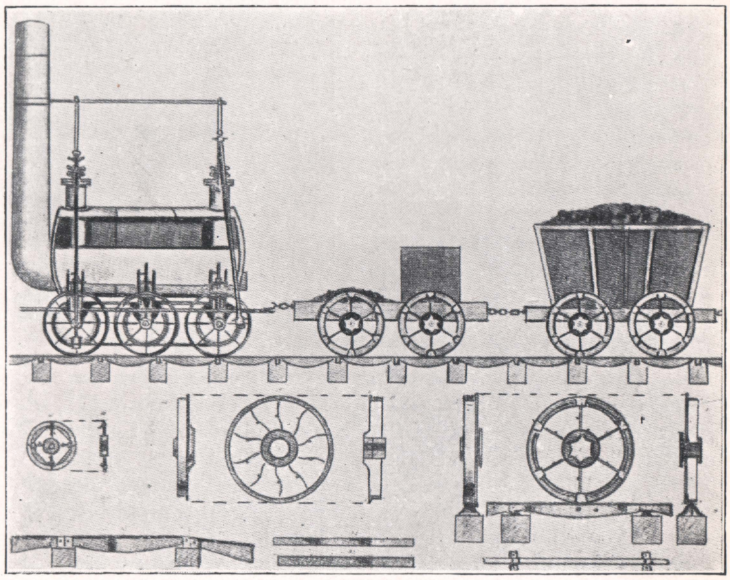
Another place to refuse the railway was Howden in Yorkshire, which was in 1840 the capital of Holderness. Its place was taken by Goole. Kingston-on-Thames was another, and the gap in this instance was filled by Surbiton. Ventnor refused, and so for a long time lagged behind Ryde and Cowes. Chertsey also refused, and gave Shepperton the chance to become an important junction. Going north to the Lake District, the isolation of Ambleside will be remembered by all who have visited that place. It is due to its rejection of the railway. No doubt there are many other instances that could be given, showing a similar lack of foresight on the part of English towns.

Further English Development.

Leeds possessed a line to London, and a railway via Harrogate to Thirsk was made and opened in 1849—50. In 1850 the Little North Western ran from Skipton to Lancaster and made Morecambe or the



LAST BROAD GAUGE TRAIN LEAVING SWINDON, MAY, 1892.



LOSH AND STEPHENSON'S ENGINE ON RAILS AND STONE BLOCKS; ALSO SHOWING WHEELS AND OTHER DETAILS.

old "Poulton le Sands." I remember travelling as a youngster on this line to Poulton le Sands. The line was afterwards extended to Carnforth and Ingleton to Tebay before the Settle and Carlisle was thought of. Originally the Scotch line was the Midland.

The Railway in America.

Beginning in the early thirties, America had to purchase her rails from England. In 1830 New Jersey sent its engineer, Mr. Robert Stevens, over to see Robert Stephenson, and on his voyage Mr. Stevens designed the present tee-rail with the base 3in. wide; he also designed the hook-headed spike used to-day, and the fishbolt. Unfortunately, he could find no English works ready to undertake the rolling of his rails, but ultimately he became acquainted with Mr. Guest, of the Dowlais works, and persuaded him to roll the rails, advancing a handsome sum to meet the expense of repairing the rolls in case of accident. As a matter of fact, there were several breakdowns. The rails came from the rolls twisted and as crooked as snakes. But at last they found the art of straightening the rails during the process of cooling. The first shipment of 550 rails, 18ft. long, weighing 36lbs. a yard, arrived in Philadelphia on May 16th, 1831. The weight was then increased to 42lbs. per yard, 3½in. wide, and more than 30 miles of this rail were used. A few years later rivets were discovered, and bolts and nuts as now used were adopted.

America was also experimenting. The first Tee rails were rolled at Danville in 1846. In 1848, Trenton Iron Works rolled a rail 7in. high, with a base 4⅝in. wide. 15 miles of this were laid, but the rails had to be taken up owing to the ends being hammered. The rolling of this rail resulted in the introduction of the "I" beam for building purposes. Inferior iron caused them to adopt a pear shaped head. Mr. Ashbel Welch was one of their foremost designers, and chairman of their rail committee.

The first steel rails were rolled in Chicago in 1865, as an experiment, but the first real contract for rails was rolled at Johnstown in 1867.

The Ride to York.

Somewhere about 1835, which was an eventful year in the history of railways, a great argument took place whether Leeds should be the centre for the Midland railway, or York. The argument was finally decided by George Hudson, who, after a meeting with George Stephenson at Whitby, said that "all trains must come through York," and made York what it is to-day. This decision brought in Thirsk and Darlington. (York from the days of the Romans and Vikings had always been a centre).

George Hudson, whose name appears in this connection, was a great figure in the development of railways, and in due course, some details of his adventurous career and its conclusion will be given. In 1836 the North Midland Railway was begun.

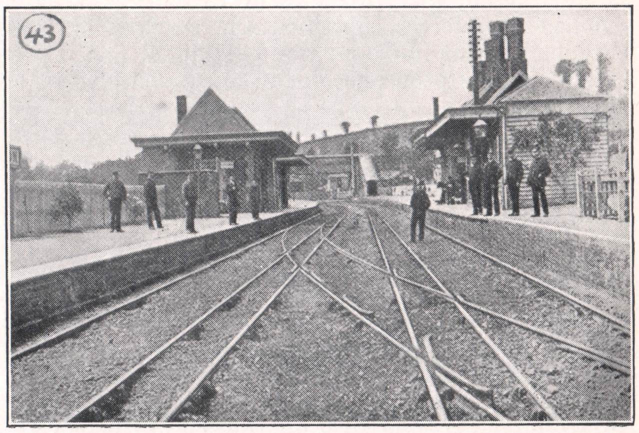
In 1854 York Station was designed by Thomas Prosser, engineer to the North Eastern Railway, 1854—74, but it was not opened until 1877. The station stands upon the site of a Roman cemetery, may tombs being disturbed in the course of its erection.

1835 also saw the first trial of wood keys or wedges by Mr. Locke, who also introduced the double head rail.

Fishplates had also been rolled with ribs to prevent bolts from turning round. Mr. C. May showed a specimen of a steel bridge-rail rolled under the "Uchatius" system by the Ebbw Vale Co., and prophesied steel rails in the future. (On December 7th of this year, George Stephenson built a locomotive for the first German Railway, Nurnberg to Furch.)

The Vicar of Bray Railway.

The Exeter and Crediton is worthy of mention in connection with this great battle. 5¾ miles long, it was opened in 1845, and was termed "the Vicar of Bray" railway because of its frequent changes to narrow and broad gauge. Perhaps, in order that this account of a very famous struggle may not lose its interest and attraction, it will be an advantage to abandon for a little space the strictly chronological order of this paper, and to give the history of the struggle from start to finish. In 1879 the Exeter and Crediton railway was finally converted to narrow gauge, when the South Western railway took it over. This last was a line working with the old North Devon broad gauge and London and South Western narrow gauge at Crediton. First opening with a broad gauge, it obtained in 1860 powers to work a narrow gauge to Exeter, and in 1862 it leased the line and paid 55% of the gross receipts. In 1874, the corporation obtained powers to widen this old line and to put in an extra track. It now forms part of the line from London to Devon and Cornwall. The illustration shows the two gauges.



CREDITON STATION—BROAD AND NARROW GAUGE KNOWN AS THE "THE VICAR OF BRAY."

Speculation Begins.

Reverting now to English history, it is well known that many railways were laid through pique and jealousy, money being freely obtained for them. In

CARTOON OF STEAM MOTORS IN WHITECHAPEL ROAD. (1830).

consequence mammoth speculation took place with disastrous results. Bradford, for instance, had begged for a track on the North Midland (1836—1840) but they were refused, and therefore in 1844 they raised the money themselves, obtained the services of George Stephenson as engineer, and built a line through Shipley to Skipton and on to Colne. The North Midland bought it up on a perpetual payment of 10%. This was the beginning of the fall of George Hudson from his height as " Railway King." He was chairman of both companies, bought one and sold the other. The North Western were the first to run from London to the North, then with various links. In 1844 there were four proposals to run an eastern route, followed by two others, and the fate of these I will mention in a few moments. The next important date is 1845 which represents the opening of the Manchester, Sheffield and Lincolnshire (Great Central) Woodhead Tunnel, the engineer of which was Joseph Locke. It represented a triumph of mind over matter and of perseverance over despair and ruin.

The Battle of the Gauges.

The year 1845 was one of the most important years with which I have to deal. It marked the temporary absence of George Stephenson from this country. He surveyed for railways in Spain, and later went to Egypt, where he considered the canal question and vetoed it, thus permitting Monsieur De Lesseps to take the glory. But the outstanding event was the beginning of the " battle of the gauges," in which the Stephensons and Isambard Kingdom Brunel both played a great part. The battle began with the appointing of a Royal Commission to consider the question of gauge. Captain Lane, R.N., said before this commission : " we owe our railways to the Northern Collieries, and their difficulties taught us to make railways."

Their report was to the following effect :—

1. That an increase in gauge would not present any advantages.

2 That greater speed may be attained with the wide gauge than with the narrow, but there would be some danger in exceeding the maximum velocity at present attained upon railways of the ordinary gauge, according to present construction.

3. That the narrow gauge is preferable for the transport of goods, and the most appropriate for the exigencies of trade.

4. That the wide gauge necessitates greater expense in the formation, and any reduction which might result in the cost of locomotive power does not appear to be of such a nature as to compensate for the increase in the first outlay.

5. It is very important that the gauge should be uniform throughout the same country.

6. The Commission see no reason for changing the narrow gauge which is 4ft. 8½ in. corresponding to 1m. 50 (4ft. 11in.) from the centre of the rail to the centre of the other in France.

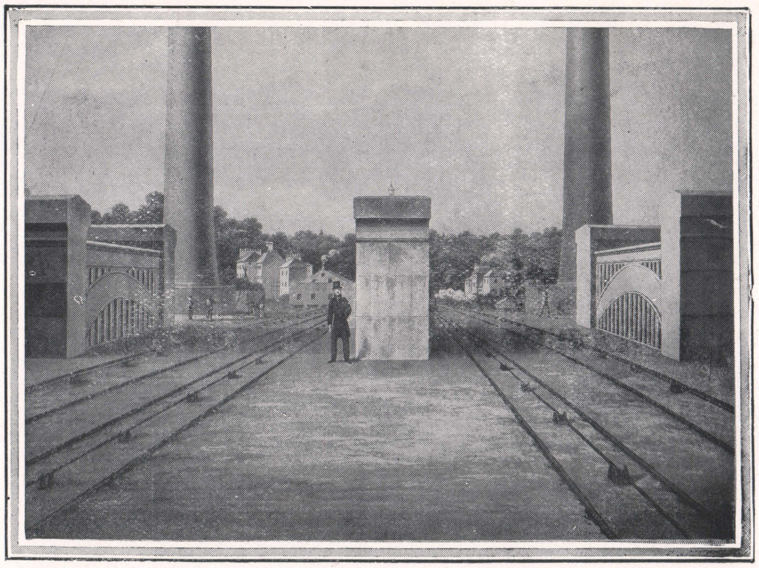
At this date 1901 miles of narrow gauge 4ft. 8½in. had been laid down, compared with 274 miles of broad gauge 7ft. 0in., and 122½ miles of Irish gauge 5ft. 3in. This is apart from local lines and foreign railways. There were many battles over this question between the north and south, and between Brunel and Stephenson, with the result that both kept their own. In later years the 4ft. 8½in. gauge became universal. It is said that Stephenson fixed 4ft. 8½in. because it was the tram-gauge of the quarries, etc., of the north, whereas Brunel fixed 7ft. 0in. because it was the gauge of Bristol stage coach. For the sake of speed he lowered the centre of gravity by placing the carriage (which was then in the form of two coaches joined together) between the wheels instead of over-hanging. Later on he increased the carriage-width to give more accommodation, and again overhung the wheels.

G.W.R. v. L. & N.W.R.

The Rugby and Oxford railway, in its Act of 1846, arranged for the Great Western to lease it ; then the London and North Western bought up the bulk of the Rugby and Oxford shares in order to block the Great Western. This dispute ran into 1848, but the Great Western won and laid the broad gauge to Birmingham.

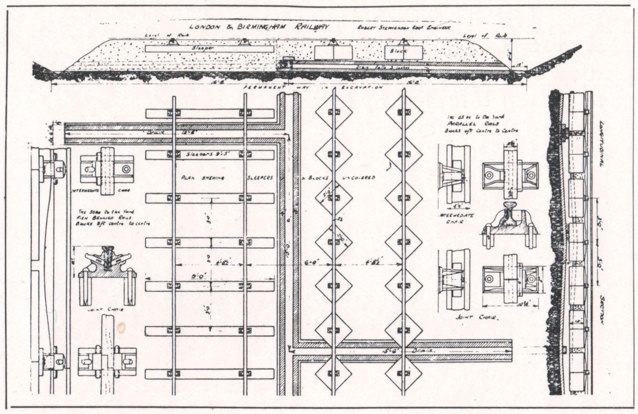
The narrow gauge won a moral victory, however, powers being obtained for both gauges to be laid from Birmingham to Oxford. The competition between these two railways did not extend to matters of gauge only, but also led to competition in speed. Thus the North Western increased their speed to London to 37½ miles an hour with light trains. In August, 1848, the North Western left Euston at 5 p.m. and arrived in Birmingham at 8.5. The fastest " up " train took 3 hours 10 minutes, whilst the Great Western maintained 44 miles an hour with double weight trains.

In 1850 the Great Western left Paddington for Birmingham with eight-wheel coaches, 38ft. long 9ft. 9in. wide; but a collision with a slow train occurred, and derailed the engine, "The Lord of the Isles." The passengers had to stop at Leamington, where they held a dinner, and drank success to the broad gauge. (Fancy having dinners to-day after collisions!) The battle went on, the Great Western doing 47 miles in $2\frac{3}{4}$ hours, and the North Western 41.2 miles in 3 hours. The track now cried out for attention, and the speed of the Great Western was reduced to 40 miles. In 1859 the broad gauge was abandoned at Birmingham. The Midlands and the North adopted 4ft. 8in. This was the year of Brunel's death. The Great Western had to alter the Birmingham and Oxford to 4ft. $8\frac{1}{2}$in. In 1869 the 7ft. gauge was abandoned north of Oxford, and on October 1st, 1861, the first narrow gauge train left Paddington for Birmingham, and did the journey in three hours 20 minutes. Another train went in 2 hours 50 minutes, or 53 miles an hour to Didcot, a speed quite equal to that of to-day. In the early seventies the North Western looked up, running a train each way in $2\frac{3}{4}$ hours as against the Great Western's 3 hours 18 minutes down, and 2 hours 55 minutes up, while others took 3 hours 40 minutes. But in the eighties the Great Western woke up again, running down in 2 hours 42 minutes and up in 2 hours 50 minutes. These two trains were called the "Afghans" because of Lord Roberts' march to Kandahar. The "Zulus" was the name given to the West of England expresses in 1879, after the Zulu war.



TRAINS WERE DRAWN FROM THE LONDON TERMINUS OF THE LONDON AND BIRMINGHAM RAILWAY BY CABLES WORKED BY STATIONARY ENGINES AT CAMDEN TOWN.

These remarks represent a slight digression from the question of gauge, but one need only add, in order to round off this short history of an important point, that France and other countries followed our gauge for their main lines. Before the subject is left, a note must be made concerning the 6ft. centre-way, which was adopted after the death of Mr. Huskisson at the opening of the Liverpool and Manchester Railway, a death due to the narrowness of the centre-way, which was only 5ft. 1in. When the Manchester to Leeds line was laid, the contractor fixed 6ft. On the original Versailles line it was only 2ft. 9in. and 1ft. 6in., but it was afterwards altered to 6ft. without columns, officials having been killed as a result of its original narrowness. Instructions were given that the centre-way should be sufficient in width to allow two trains to pass without danger to a foot passenger between the tracks, and to allow passengers to put their heads outside without injury.



TRACK DETAILS, LONDON AND BIRMINGHAM RAILWAY.

George Hudson.

It has been mentioned that in 1844 there were four proposals to run an eastern route, which proposals were followed by two others. In 1846, one year after the report of the commission on gauges, only the Great Northern had survived and was authorised by Parliament; but this line was bitterly opposed by George Hudson, although at the last he played into their hands. Hudson was a linen draper in College St., York. He inherited £30,000 and plunged into railway work. He wanted to "get rich quick," but his desire was also to enrich his county by means of his railway schemes which enrichment he foresaw would be the result. He made a great name and was called a speculator. Able to grasp immense details, he was for a time the "superman" in the railway world. Thrice Lord Mayor of York and also M.P. for that city, he was ruined in 1847—8, when he was accused of paying dividends out of capital, which dividends he had to refund, and becoming bankrupt in consequence

Rail Sections.

In the early years great discussion took place as to the section of rails, and the merits of the double-head versus T rail (which still remains). The double-head was condemned as a reversible rail owing to wear and distortion, but if not reversed, it was preferable to the Tee rail. Outside Great Britain there is no doubt that the Tee rail is the more widely used throughout the world to-day. The weight per yard was a variable item. In 1846 a Dutch engineer mentioned seeing an 82lb. rail in England.

In 1845, by the way, an atmospheric railway was tried. Croydon laid a single line between Forest Hill and West Croydon. It was in use for 12 months only and a description of it is given in "Locomotives of the London, Brighton and South Coast Railway."

Turning now to fresh developments and experiments with rails, the year 1846 that marked the authorization of the Great Northern Railway saw some interesting tests. M. Paulin Talbot, a noted French engineer, came to England, worked in conjunction with George Stephenson, and was afterwards joined by Monsieur Segrin, who became himself a leading French engineer. An interesting test for deflection on various double-head and Tee rails was made in 1846. Six rails were tested with a weight of 8 to 24 tons, the rails being fixed on supports 2in. wide by 4ft. 1in. apart.

No. 1 rail was made of a mixture of fine metal and scrap iron.

No. 2 was made of pure fine metal.

No. 3 was made of a mixture of fine metals instead of scrap-iron.

The others were double-head section.

The test was only momentary, was confined to less than 3in. in the middle, and was not of much use. No. 1 broke at 22 tons, No. 2 at 19 tons, No. 3 at 18 tons. The others broke at from 18 to 22 tons. The question of *coning* was also then considered.

Specifications.

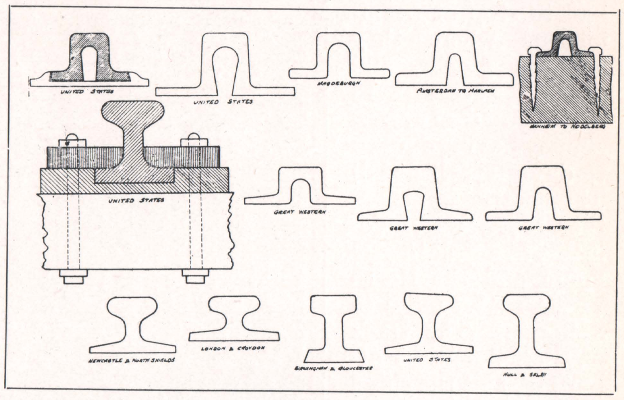
The original specifications were very quaint. A French specification advised that "a respectable "tradesman should be selected, one who could fulfil "his engagements, and then allow him a fair price for "his work. That Companies are often tempted by low "tenders and manufacturers can only be able to make "a profit by inferior material. When once made, "time often forbids their being replaced, and if "referred to arbitration, the judges being averse to "ruin the manufacturers generally use great indul-"gence."

"Always have a sample before rolling the rails. "This precaution had been neglected by a French "Railway Co., 400 tons being rolled before the En-"gineer had the sample. The rail was not correct "and yet not sufficiently defective to reject."

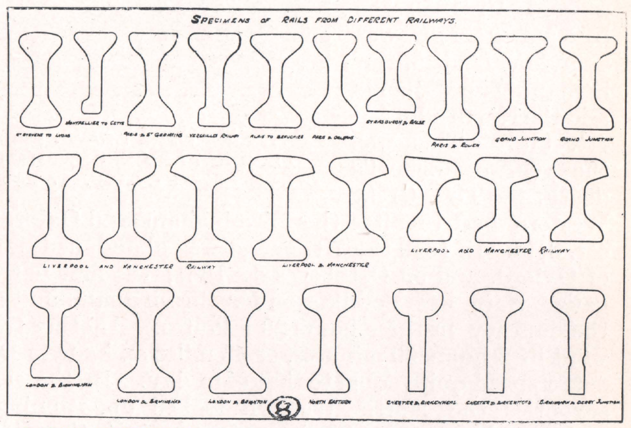
"These instructions should be given to manufacturers."

"Lengths were to be a m/m, but 1/20 less lengths could be taken."

Geo. Stephenson's specification drawn up for the London and Birmingham Railways, is too long to insert here. This specification is most complete, covering rails, chairs, bolts, keys, pins, a detailed specification being given for each, also for ballasting and laying the permanent way.



VARIOUS SECTIONS OF EARLY BRIDGE RAILS—ENGLISH AND FOREIGN.

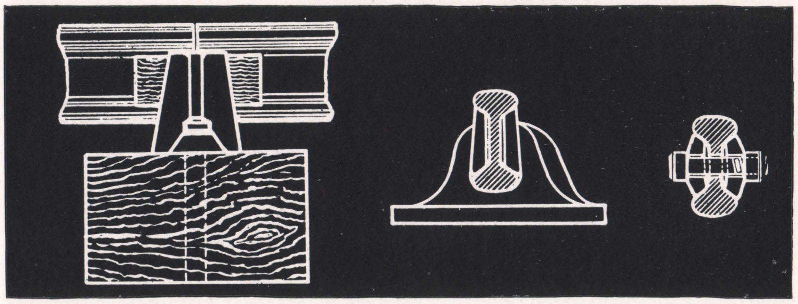


EARLY SECTIONS OF RAILS—ENGLISH AND FOREIGN.

English Bull-head Sections.

The only other remark I wish to make before concluding this address is to mention the bull-head sections, 1901, compiled by J. F. Conradi, the district engineer of the Great Central Railway, who wrote on permanent way. Mr. Conradi discussed the question of bull-head versus flat-bottom rails, and also whether keying should be inside or outside. He alluded next to cast iron chairs first introduced by Greaves, and known as pot or bowl sleepers, about 23" diameter at the base, 5½in. high, and about ¾in. thick, the ballast being made into little sleepers, sufficient to fill the inside of the bowl. The final packing was by ramming ballast into the interior of the bowl through holes left in the inner surface, and then gauged with tie-rods. Sir Bradford Leslie, in his paper published in the April 1925 issue of the *Permanent-way Journal*, alludes to these chairs in paragraph 35, stating that there are still some in use after 70 years wear. He also shows what I call a triple chair with semi-circular base, and I draw your attention to a similar chair, but with flat base, known as Fowler's joint in 1849.

ILLUSTRATIONS OF EARLY JOINTS.



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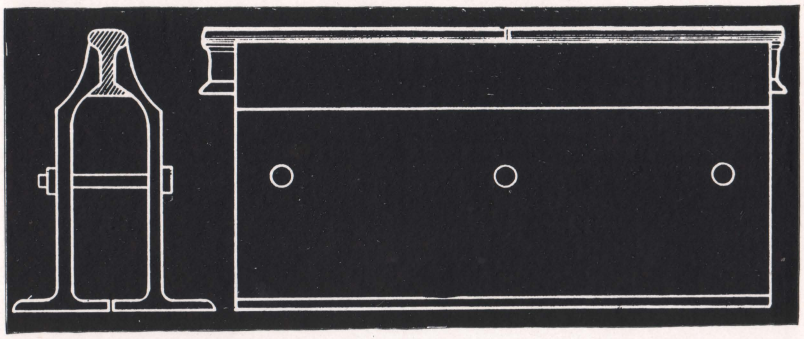

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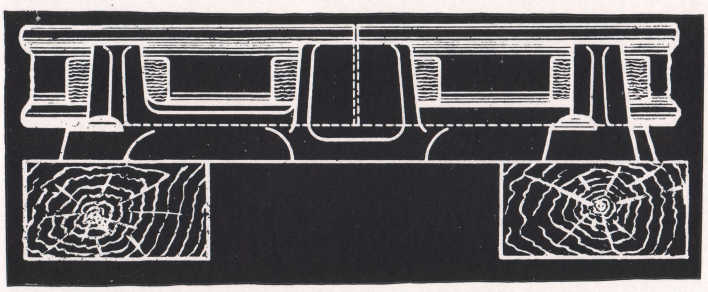

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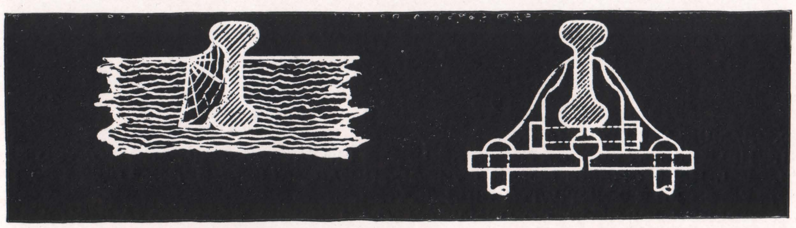
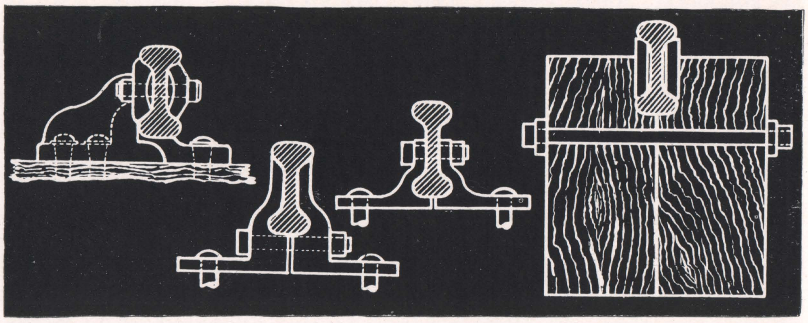


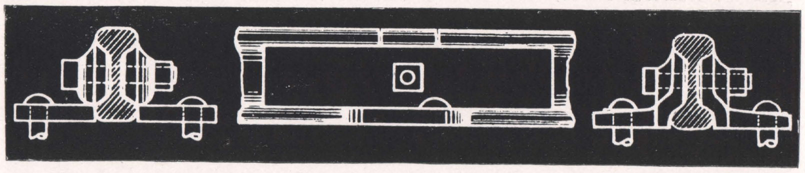
6. 7.

1. PRIOR TO 1835. JOINT CHAIR WITH WOODEN KEY.
2. JOHN DAY, 1835. CHAIRS IN 2 HALVES BOLTED BELOW THE RAILS AND USED ON BALLAST OR ON SLEEPERS.
3. ADAMS & RICHARDSON'S, 1847. FISH JOINT, FISHPLATES SUPPORTED IN IRON CHAIRS.
4. D.H. RAIL WITH 4 BOLTS AND FISHPLATES.
5. FOWLER, 1849. JOINT CHAIR WITH THREE WOODEN KEYS.
6. PARSON'S, FEB. 1849. RAIL FIXED IN CROSS SLEEPERS WITHOUT CHAIRS.
7. BARLOW, JUNE 1849. HALF CHAIRS BOLTED BELOW THE RAIL, AND CLIPPING THE WEB AND BASE OF THE RAIL.

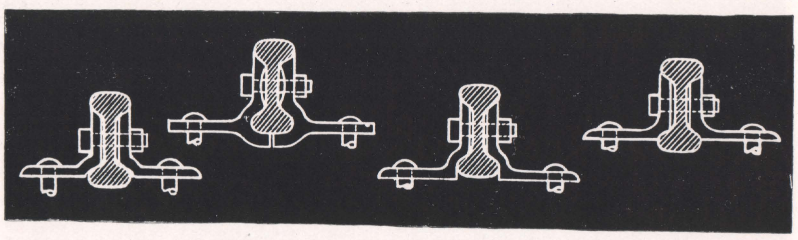
Illustrations of Early Joints—*continued.*



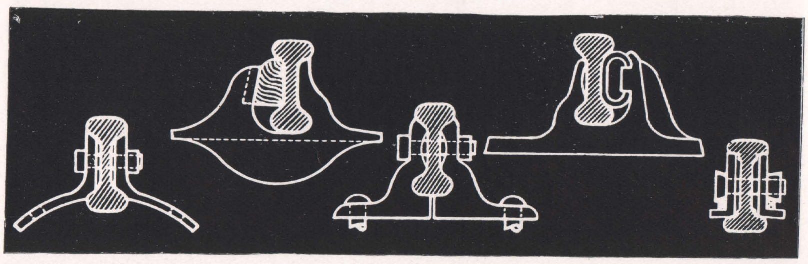
8. 9. 10. 11.



12. 13.



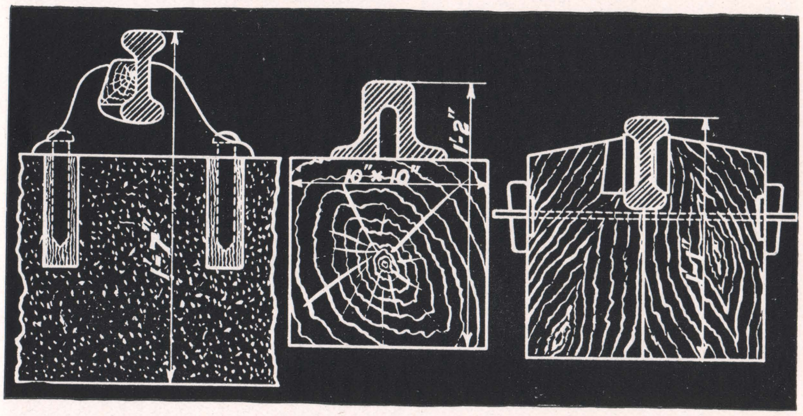
14. 15. 16. 17.



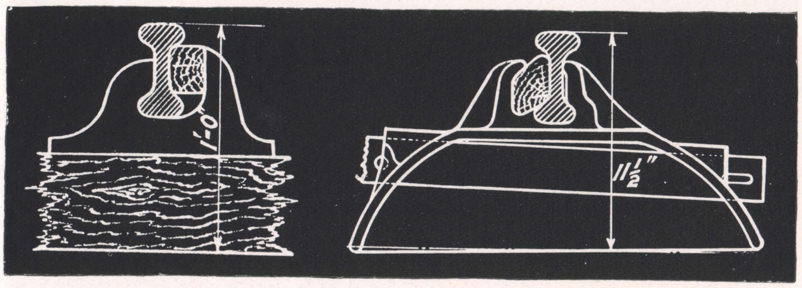
18. 19. 20. 21. 22.

8.		APRIL,	1850.	SAMUEL'S FISH CHAIR.
9.	ADAMS,	JUNE,	1851.	HALF CHAIR SUPPORTING THE UPPER LIP OF THE RAIL AND BOLTED BELOW.
10.	DOULL,	OCT.,	1851.	W.I. HALF CHAIRS BOLTED THROUGH RAIL, CLIPPING THE LOWER PORTION.
11.	MANSELL,		1852.	WOOD PILE JOINT WITH SIDE PLATES.
12.	MANSELL,		1852.	SOCKET JOINT OR COMBINATION OF 3 PARTS FORMING A DOUBLE JOINT WITHOUT HOLES THROUGH RAILS.
13.	ADAMS,	FEB.,	1853.	BRACKET JOINT BOLTED THROUGH RAILS AND FIXED TO SLEEPERS.
14.	ADAMS,		1853.	RAILS RECESSED IN W.I. SLEEPERS.
15.	ADAMS.		1853.	BRACKET WITH UNDER LIPS FORMING A CHAIR.
16.	WILD,	MARCH,	1853.	D.H. RAIL WITH ANGLE PLATES: BOLTED THROUGH RAIL AND BASE.
17.	LIDDELL,		1854.	SIMILAR TO NO. 16, BUT WITH SHALLOWER PLATES.
18.			1854.	D.H. RAIL. BOLTED BY C.I. SLEEPERS.
19.			1854.	WOOD LINE CHAIR.
20.			1855.	BARNINGHAM.
21.			1855.	BURLEIGH ELASTIC KEY.
22.			1856.	RECESSED RAIL SECTION FOR FISHES OR BRACKETS.

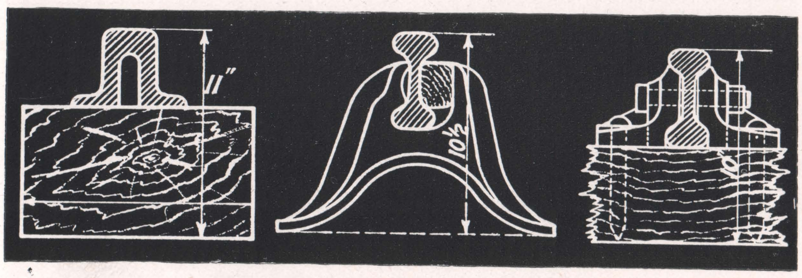
Illustrations of Early Joints—*continued.*



23. 24. 25.



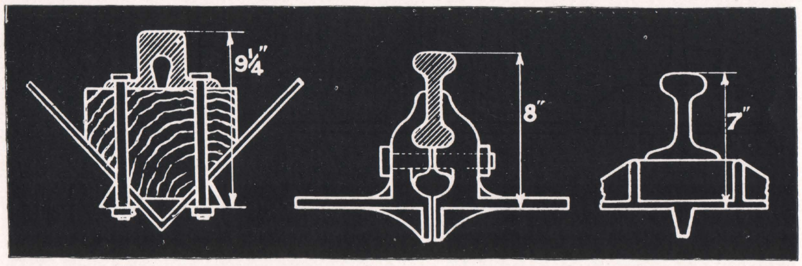
26. 27.



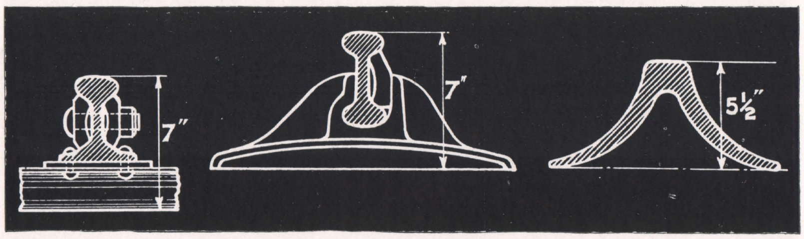
28. 29. 30.

23.		STONE BLOCK SYSTEM.
24.		BRIDGE RAIL.
25.		MANSELL'S WOOD PILE.
26.		CROSS SLEEPER AND CHAIR.
27.	GREAVES,	1846. SPHEROIDAL CAST SLEEPERS OR POT-BOWLS.
28.		BRIDGE RAIL.
29.	BARLOW,	1849. C.I. SLEEPER AND WOODEN KEYS.
30.	ADAMS,	C.I. BRACKETS ON CROSS SLEEPERS.

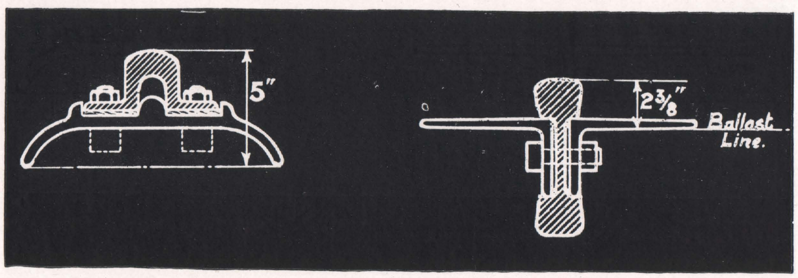
Illustrations of Early Joints—*continued.*



31. 32. 33.



34. 35. 36.



37. 38.

31.		REYNOLD'S LONGITUDINAL C.I. TROUGH, WOOD LINED.
32.	1850.	BARLOW'S C.I. SLEEPERS IN HALVES.
33.	1853.	DE BERGUES CAST IRON PLATES.
34.		SPENCER'S CORRUGATED C.I. SLEEPERS.
35.	1855.	BURLEIGH'S CAST IRON SLEEPERS.
36.	1849.	BARLOW'S SADDLE BACK RAIL.
37.	1852.	MACDONNELL'S W.I. TROUGH BEARER AND BRIDGE RAIL.
38.	1855.	ADAM'S SUSPENDED GIRDER RAIL.

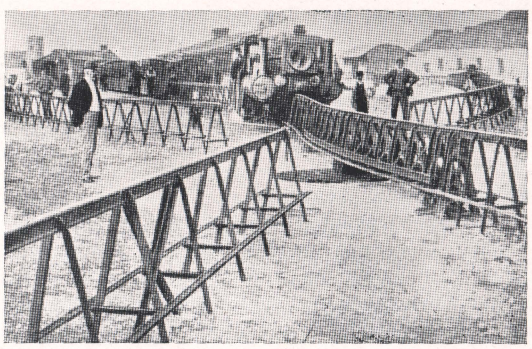
Fishplates.

About this time the question of fishplates came under discussion. In 1857 a paper was read by William Bridges Adams upon the varieties of permanent way. In the course of this he mentioned that it was anything but permanent, chiefly because the locomotives then used were double the weight of those for which the lines were designed. One wonders what Mr. Adams, could he have been present to-day, would have said of the modern locomotives and track, evolved during the past 70 years. He was strongly in favour of an elastic track, whereas Sir Bradford Leslie leans towards solid tracks or joints, and this was also the opinion of Robert Stephenson. Mr. Adams anticipated the present sorbitic treatment of rails, because he mentioned "hardening the surface." He was in favour of the double-head rail, as against the flat bottom rail. He also claimed to have introduced a fishplate joint as now used. Upon this point there was great discussion and some strong terms were employed.

Mr. Robert Richardson said that he had introduced the matter to Mr. Adams, who had patented the fishjoint under Adams and Richardson in 1847. Mr. Bruff, of the Eastern Counties Line, said that Mr. Richardson was his assistant, and they had tried a fish-joint to overcome a difficulty.. This was the first application of a fish-joint, and Mr. Richardson then patented it with Mr. Adams. Mr. Greaves said that they were not a novelty, as he had seen them 22 years ago used for the Camden and Amboy Railway in America. Mr. D. Stephenson mentioned the use in 1835 of a fish-joint on the Camden and Amboy railway in the United States of America. These were, however, link-plates for outside the joints, $5'' \times 2\frac{1}{2}'' \times \frac{5}{8}''$. They were not really fish-plates at all.

The Mono-rail.

The later developments of railways are pretty well known to most of you, and therefore, I do not intend to carry this chronological record further. I might point out, however, that in 1901 the mono-rail system was projected, but the "Railway Magazine" advised its readers to await results for a year after running. A track was laid on the Listowel and Ballybunion Railway, County Kerry, Ireland. It was built on the Lartique Mono-rail system, and was supposed to be the only one in the world, although it is said that one was to have been tried in Germany; of this, however, I have no report.



MONO RAILWAY TRACK (IRELAND) NOW ABANDONED.

The Listowel track ran regularly for many years, and did good service in this little corner of Ireland, but it has now been demolished by Messrs. T. W. Ward, Ltd., who seem to be the last home for curios of this kind. It will be noted from the illustration that there are double carriages, *i.e.*, half on each side of the rail. Pessengers had to cross a quaint bridge, which was part of the train, in order to get in or out of the far half.

Conclusion.

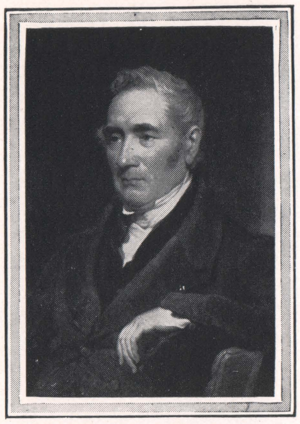
Many writers will deal with the centenary, but I venture to hope that your section will be found to have produced a paper worthy of preservation and dealing with the subject from your own point of view. There is no doubt that railways revolutionized the world during the past century, because previously the method of travelling differed very little from that of early days.

I would like here to express grateful thanks to friends who, although unknown to me personally, have been at great pains to help me, and I would mention particularly the Librarians of Sheffield, Newcastle and Aberdeen; Mr. Briggs and his brother in London for researches in the British Museum; Mr. J. H. Warren in his "Century of Locomotive Building"; and the Editor of the "Locomotive." I would like also to acknowledge extracts from Timothy Hackworth's "History of the Locomotive," Nicholas Wood's "Treatise on Railroads"; the "Geology of Yorkshire" by Professor P. F. Kendall, The Oxford Dictionary, the Encyclopedia Britannica, etc. I am also indebted to Brigadier General Campbell for illustrations and to "The Sphere" for plates. If there are others not included, it is an error of omission and not of commission.

"Lay down your rails ye nations near and far,
Yoke your full trains to steam's triumphant car,
Link town to town and in these iron bands,
Unite the estranged and oft embattled lands."

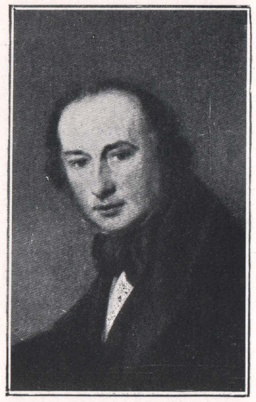
(*From a poem by Charles Mackay,*
"*Railway Examiner,*" *Nov.* 25, 1845).

Early Railway Engineers—Permanent Way.

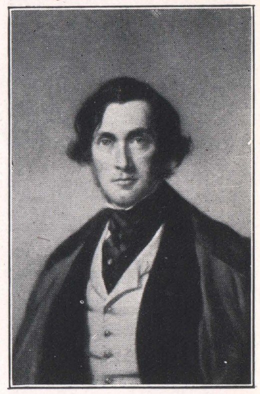


GEORGE STEPHENSON,
THE FIRST RAILWAY ENGINEER,
BORN 1781. DIED 1848.

ROBERT STEPHENSON,
BORN 1803.
DIED 1859.



ISAMBARD K. BRUNEL.
BORN 1806.
DIED 1859.



JOSEPH LOCKE,
BORN 1805.
DIED 1860.

George Stephenson.

Priority must be given to Geo. Stephenson. He began working at 8 years old in the fields, at 15 he was Assistant Fireman at Newburn Collieries, at 17 he improved a fixed engine, and got the post of Directing Engineer, although at this time he could not read or write. In 1821 he urged the use of wrought iron rails as against cast iron for the Stockton and Darlington Railway, by which he suffered material loss, and for a time, his friendship with Mr. Losh, a well known man at that time.

His greatest work was no doubt the Liverpool to Manchester Railway. *See page* 9.

In 1845 Geo. Stephenson surveyed for Railways in Spain.

In 1851 he went to Egypt, where he also considered the Canal question and vetoed it, thus permitting M. de Lesseps to take the glory.

George Stephenson was a great example of this, and while he was not so great an engineer as supposed, he knew "men and things" and when to grasp the opportunity and use the men, and so came his fame.

In 1802 an Irish Engineer—Richard Lowell Edgeworth said he had a project for laying Railways on the great roads of England, but he was advised to let it alone and so missed the chance that George Stephenson took.

"There is a tide in the affairs of men which taken at the flood leads on to fortune."

Robert Stephenson.

In 1823 he was appointed manager of an engine manufacturing business established by his father in Newcastle. In 1824 he was given command of a mining expedition to Columbia. In 1827 he took charge at the engine works. In 1830 he was appointed Engineer-in-Chief to the Warrington and Leicester and Swannington Railways, as well as his engine work, and in 1833 he was chief engineer to the London and Birmingham Railway, a difficult undertaking.

His fame was not only for locomotives, but for bridges, *i.e.*, the Menai Tubular Bridge, the St. Lawrence and High Level at Newcastle. Needless to say, he had a lot of opposition from Brunel and other Engineers.

In 1853 Robert Stephenson visited Belgium to meet King Leopold, who conferred the title of Chevalier.

The London and Birmingham Railway or London and North Western Railway as it came to be known (before the recent amalgamations), opened in 1837 and 1839. This line was laid through difficult country, the endeavour being to procure good gradients and curves, the prevailing gradient being 16 ft. per mile, or 1 in 330. The worst curve of 600 yards radius was at the Chalk Farm Lane.

Robert Stephenson excelled his father as an engineer, but died comparatively young, worn out through working night and day, as men of his type have the habit of doing.

Isambard Kingdom Brunel.

Brunel was undoubtedly a great man, who, when he undertook a task, took in hand everything, carriages, gauge and track. He adopted longitudinal sleepers because local colliery-tramroads had them.

There were few skilled engineers in those days, but the few fought continually. Their letters showed either great affection or equally great jealousy, and the terms in which these letters were written were scarcely restrained. Brunel designed everything for his own undertakings, and all drawings were worked out from his notes. Among other things, he designed the Clifton Suspension Bridge, which was not completed until 1864, by Barlow and Hawkshaw, Brunel having died in 1859. Portions of the work consisted of parts of the Hungerford Bridge (Charing Cross) designed by Brunel and taken down in 1863. The Great Western Railway also appointed Brunel as their engineer. It is interesting to note that a terminus for this railway was proposed to be laid at Acton to be reached over a viaduct 24ft. high with a parapet 6ft. 6in. high, so that the passengers could not look in at house windows. Brompton district tabooed it on account of the continuous stream of fire and smoke with stifling fumes so Paddington gained, and in 1836 that extension was authorized.

The works executed by Brunel will always be monuments of his skill, amongst which are notably the Gothic bridge over the Avon, Skew Bridge carrying G.W. over the Avon at Bath, bridge over the Thames at Maidenhead, five arches, two of 128 ft. span, which created a great sensation at that time.

Brunel and Stephenson were the two outstanding figures round which all others were revolving or were in opposition.

Joseph Locke.

His career was most interesting and forms the subject of another paper.* He was assistant to George Stephenson on the London and Birmingham line, as well as the one for Liverpool and Manchester, after which a time came when their partnership was dissolved.

Joseph Locke was no doubt quite equal to, if not greater, than the others. He earned a great reputation both in England and France, and the public always subscribed their money to any scheme with which he was connected. He was responsible for the construction of at least 2000 miles of track.

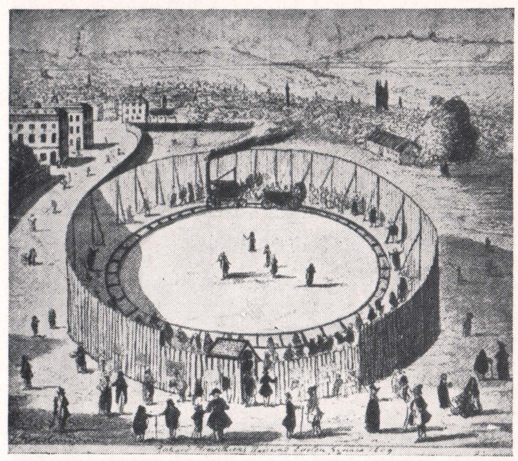
See reference pages 12—13.

**See Edgar Allen News," October,* 1926.

Richard Trevethick.

The steam locomotive is obviously more indebted to Trevethick for its discovery than to George Stephenson; but the latter saw its advantages and set to work to make use of them. It will probably be interesting and useful to give here the names of the inventors of the locomotive:

Trevethick	1771—1833	Experimental.
Murdock	1754—1839	
Blenkinsopp ..	1765—1836	
Mathew Murray ..		
Hedley	1779—1843	Practical.
George Stephenson	1781—1848	
Timothy Hackworth	1786—1850	



TREVETHICK'S CIRCULAR RAILWAY, EUSTON SQUARE, 1809.

From a "Rowlandson" Print.

In 1804 Richard Trevethick wrote that he had "lighted a fire in the tram-wagon and worked it without wheels and tested the engine, and then put it on the tramroad." In this instance, tram-wagon evidently meant locomotive. Later on he wrote, "the tram-wagon has been tried and is more manageable than horses. I believe we could draw 40 tons (but have not tried over 10 tons) for two miles and back. The engine, with water, weighs about five tons. It runs up the tramroad and the engine moves 9ft. at every stroke." He added that he intended "to meet the 'London Engineer,' take the horses out of the coach, and fasten the latter to the engine and draw them home for 9¾ miles. The coach axles being the same length as the engine axles the coach will run easily upon the tramroads." A bet of 500 guineas was made over this, and won. The illustration shows a view of Trevethick's circular railway.

Detailed Description of Lantern Slides.

No. 1.—Geo. Stephenson.

No. 2.—Robert Stephenson.

EARLY RAILS (see pages 6, 7, 15.)

No. 3.—The Jessop Rail, 1789, with deep centre and stone block.
The Lawson Rail, 1797. Of a T head type, bolted on.
The Wyatts Rail, 1802. Hex Bars in Cast Iron.
LeCanns Rail, 1808. Cast Flange and Dove Tail Joint.
Losh & Stephenson's, 1816. C.I. Rails in C.I. Chairs.

No. 4.—Surrey Railway Rail, 1803. C.I. Rail with *guide* flange and strengthening under rib.
Woodhouse Rail, 1803. A hollow C.I. Rail with ends recessed for fixing on to stone blocks.
Lord Carlisle's, 1811. W.I. Rail.
Birkenshaw Rail, 1820. Wrought Iron Rail, patented by John Birkenshaw.
Liverpool and Manchester, 1829. Geo. Stephenson's W.I. Rail on chairs and stone blocks.

No. 5.—First Rolled Rails, Birkenshaw's Patent, showing Rolls.)

No. 6.—John Birkenshaw's claim of advantages from original specification.

No. 7.—View of Bedlington Iron Works (Birkenshaw, Manager).

No. 8.—Various sections of early rolled Rails, English and Foreign

No. 9.—Various sections of early Bridge Rails, English and Foreign.

EARLY JOINTS.

No. 10.—All illustrated and described on pages 16-19.
No. 11.— do. do.
No. 12.— do. do.
No. 12.— do. do.
No. 13.— do. do.
No. 14.— do. do.

No. 15.—Foreign Rails. (p 15.)

No. 16.—Double Head Rails, 1901.

No. 17.—Present B.S. Bullhead Rail, 1925.

No. 18.—Present B.S. Flat Bottom Rail.

No. 19.—Built-up Diamond (Paris and Orleans).

No. 20.—Ancient Tramroad by River at Coalbrookdale. (p 4)

No. 21.—Old Wagons used at Coalbrookdale. (p 4)

No. 22.—End of Old Track at Coalbrook dale, 1780/1790.

No. 23.—Old Type Plate Rails—made at Coalbrookdale. (p 4)

No. 24.—View of old Trucks at Belvoir Castle.

No. 25.—View of Old Plate Rail Track, Denby Collieries. (p 4)

No. 26.—View of old Points and Crossings at Denby Collieries, 1800.

No. 27.—Cast Wheels, Axles, and Rails as first used—on Stone Sleepers. (p 6)

EARLY SWITCHES.

No. 28.—Stephenson's Switch Rails—early type. (p 25)

No. 29.—Three-way Switches with Lever Boxes. (p 25)

No. 30.—Stephenson's "Stub" Point with Eccentric Device, from an old Station View.

No. 31.—Stephenson's "Three-way" "Stub" Switches.

No. 31*a*.—Switch with Lifting Tongues, 1858 Thompson &
No. 31*b*.— do. Nicholson.

No. 31*c*.—Dodd's Patent Switch, 1839. No. 82197.

No. 31*d*.—Stockton and Darlington Cast Switches.

No. 32.—Early Platelayers' Tools.

EARLY VIEWS.

No. 33.—Boxmoor Embankment, showing method of excavation.

No. 34.—Opening of the Stockton and Darlington Railway, 1825. (p 8)

No. 35.—View of Train on the Newcastle and Carlisle Railway.

No. 35*a*.—Horse Drawn Loco No. 1. to Aycliffe.

No. 35*b*.—Run away Train showing Horse leaping off.

No. 36—Opening of Canterbury and Whitstable Passenger Railway, 1830. (p 9)

No. 37.—Tunnel on Canterbury and Whitstable Railway. (p 9)

No. 38.—Opening of First Scotch Railway. (Alloa.) (p 8)

No. 39.—Bristol to Bath—early train.

No. 40.—Last Broad Gauge Train leaving Swindon, May, 1892. (p 11)

No. 41.—Train crossing Chat Moss (Liverpool to Manchester). (p 9)

No. 42.—Combination View :—
Goods Train, Liverpool to Manchester.
Goods Train, G. W. Railway, Bath (Broad Gauge).

No. 43.—Crediton Station—Broad and narrow gauge. Known as "Vicar of Bray." (p 12)

No. 44.—Liverpool to Manchester Train, with Loco. "Planet," 1831.

No. 45.—Liverpool to Manchester Train, with 1st Class Passengers

No. 46.—French Railway, Lyon to Paris.

No. 47.—Prior Park, Bath, 1754, with view of Wagon Way (p 1) (earliest illustration known).

No 48.—Enlarged View of Wagon and Wagon Road.

No. 48*a*.—Tram Sled or Early Coal Conveyor.

No. 48*b*.—Chaldron Wagon used on the Tyne Tram-road.

No. 48*c*.—View of Tram-road, Berwick on Tweed, 1822.

No. 48*d*.—"Donovans" Neath Abbey, showing Winding ginn and Ancient Tram-road.

EARLY ENGINES.

No. 49.—Old Print "The Collier," showing Blenkinsopp's Engine. (p 10)

No. 50.—Old Print "Hetton Colliery," showing Blenkinsopp's Engine. (p 1)

No. 51.—Blenkinsopp's Loco. on early type of Rack rail.

No. 51*a*.—Rack Rail for Ditto.

No. 52.—Blenkinsopp's Loco. drawing Wagons.

No. 53.—Losh & Stephenson's Loco. and Rails. (p 11)

No. 54.—Early Chain Driven Loco., running on Rails laid on Stone Blocks.

No. 55.—From an old Print—Hexham Station.

No. 56.—Loading Coal in Newcastle Mines.

No. 57.—Cugnot's Steam Waggon, 1770.

No. 58.—Proposed Mechanical Carrier with Pedals.

No. 59.—Gurney's Improved Steam Coach.

No. 60.—First American Passenger Coach.

No. 61.—Cartoon of Steam Motors in Whitechapel Road (1830). (p 13)

No. 62.—Cartoon of Steam Motors in Regents Park Road.

No. 63.—Rainhill, where the various types of Engines were tested.

BRIDGES.

No. 64.—Bridge with London and Birmingham Express.

No. 65.—Train being drawn by Cable at Camden Town. (p 14)

No. 66.—Track Details, London & Birmingham Railway. (p 14)

No. 67.—Bridge at Maidenhead.

No. 68.—First Suspension Bridge over Tees (Stephenson).

No. 69.—Stephenson's "Locomotion" on Bridge.

No. 70.—Menai Tubular Bridge—Robert Stephenson & Council.

No. 71.—Menai Tubular Bridge—to-day.

No. 71*a*.—"Spital Hill" Tunnel, Sheffield (Stephenson).

Details of Slides—*Continued.*

FIRST LONDON RAILWAY.

No. 72.—London and Greenwich Railway on Bridges or Arches. (p 9)
No. 73.— do. Inside arches (taken in 1911).
No. 74.— do. Half Way House.
No. 75.— do. Line Drawing of Track and Arches.

AUSTRIAN CENTENARY.

No. 76.—First Railway in Vienna, 1825.
No. 77.—Early Second Class Austrian Coach. (p 24)
No. 78.—Austrian Railway before Locos. (p 24)

SUNDRIES.

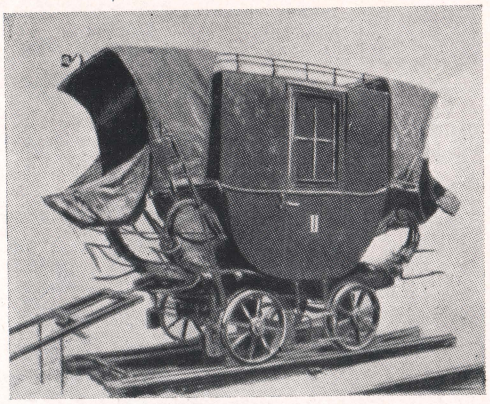
No. 79.—Modern Cable Track in China.
No. 80.—Wooden Tramway in Australia.
No. 81.—Trevethick's Circular Railway, Euston Square, 1809. (p 22)
No. 82.—Mono Railway Track (Ireland), now abandoned. (p 20)
No. 83.—Mono Rail Track Carriage.
No. 84.—Suspended Mono Rail in Prussia.
No. 85.—Facsimile of Counsels Opinion upon 1672 Tramroads. (p 3)

MODERN TRACKS.

No. 86.—Old Plan of Level Crossing, Grimsby, 1901. Now being renewed.
No. 87.—Baker Street Layout (Metro. Railway). Engineer, Mr. Wilson, President, 1925.
No. 88.—Buenos Ayres Grt. Southern Rly., Scissors Crossover.
No. 89.— do. Portion of Scissors Cross-over.
No. 90.— „ Triple Crossing of Scissors Crossover.
No. 91.— „ Star Crossings.
No. 92.—Great Northern Railway (Ireland), Star Crossings.
No. 93.—L. & S. W. Railway—Layout.
No. 94.— do.
No. 95.—Indian State Railway Slip-way.
No. 95*a*.—Indian State Railway—Acute Crossing.
No. 96.—Spring Frog—Buenos Ayres Western Railway.
No. 97.—Antofagasta Double Gauge Diamonds.
No. 98.—Level Crossing, North Eastern Railway.

No. 99.—Level Crossings—Tramway and Railway.
No. 100.—Complete Layout for New South Wales.
No. 101—Junction for North Eastern Railway in Solid Manganese Steel.
No. 102.—Group of Tested Rolled Manganese Steel Rails.

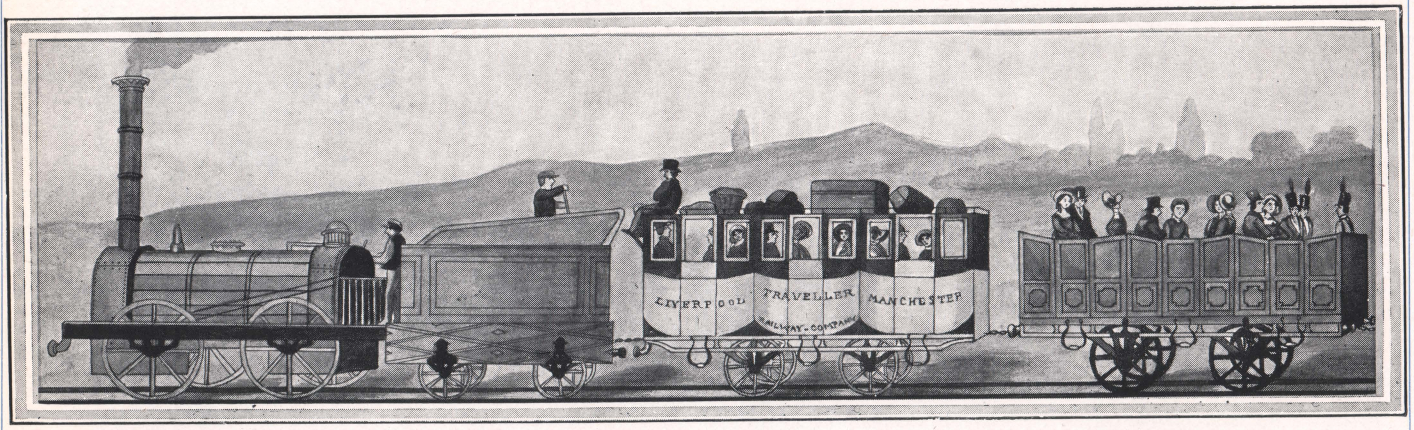
AUSTRIAN RAILWAYS.



ORIGINAL PASSENGER COACH—LINZ-BUDENWEIS RAILWAY.

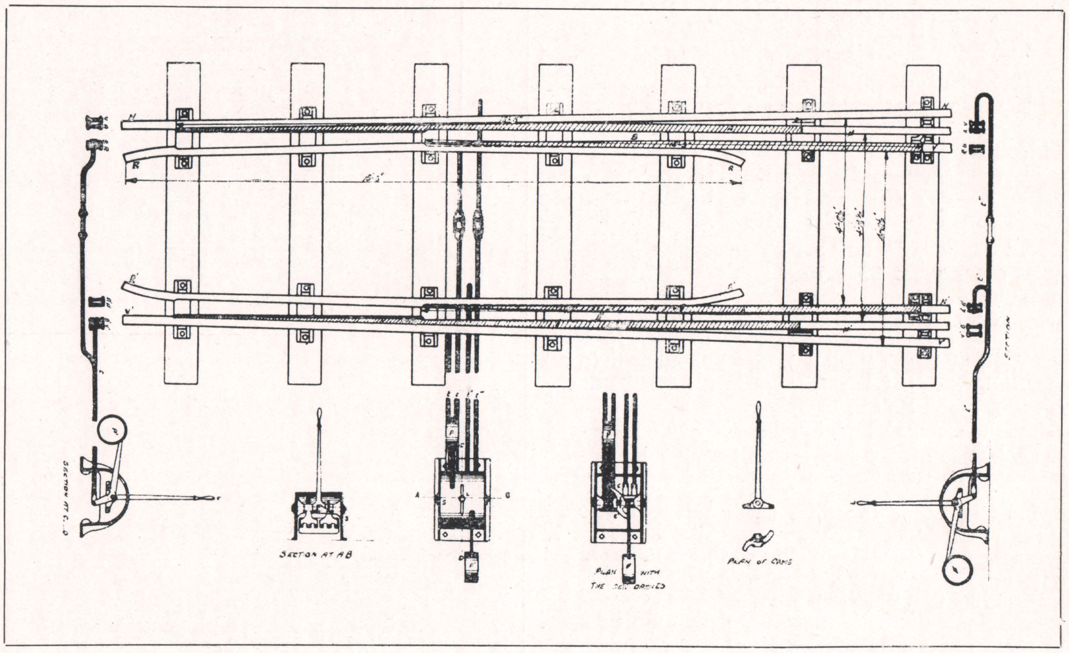
AUSTRIAN RAILWAY BEFORE LOCOS.

(1926 being also the Centenary of Austrian Railways the above two views are included.)

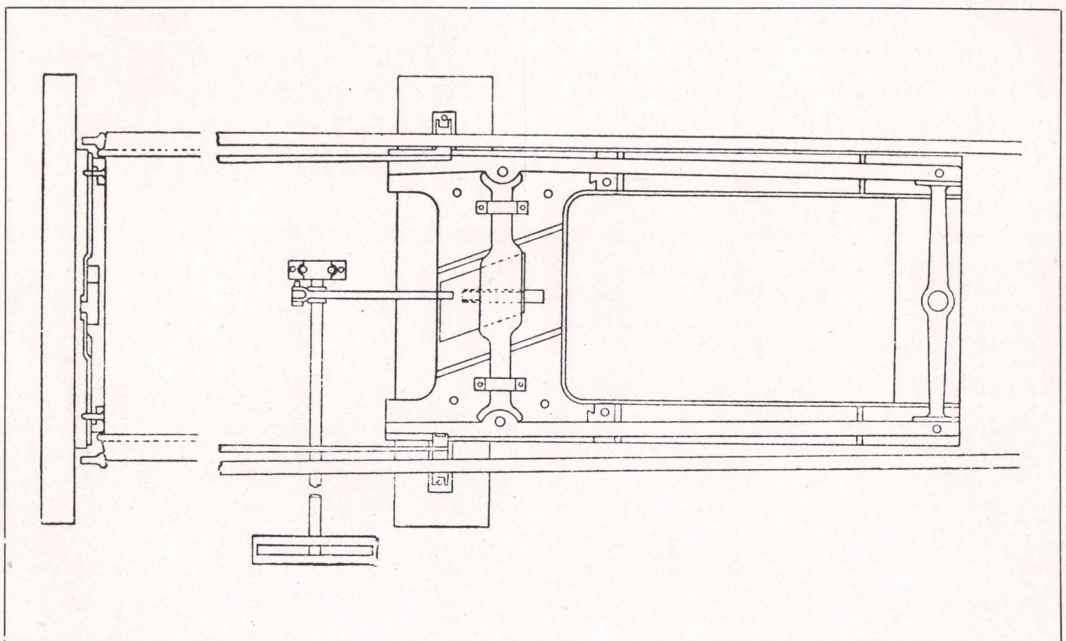


THE RAILWAY TRAIN OF THE EARLY PART OF THE LAST CENTURY.—THE FIRST-CLASS PASSENGERS WERE ACCOMMODATED IN A SORT OF TRIPLE COACH, AND THE OTHER PASSENGERS STOOD IN OPEN TRUCKS.

Early Switches.

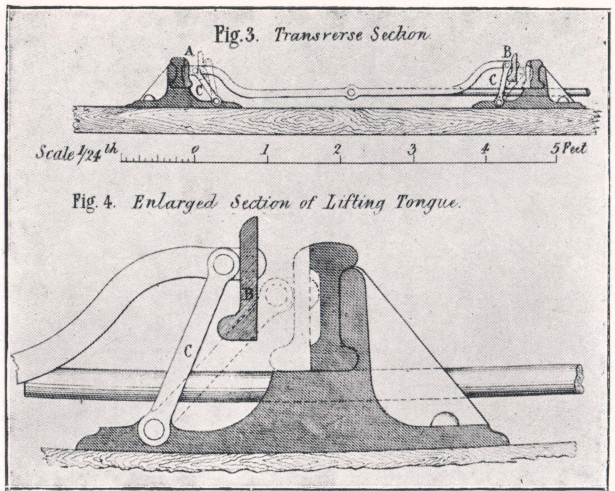


STEPHENSON'S THREE-WAY SWITCHES WITH LEVER BOXES.

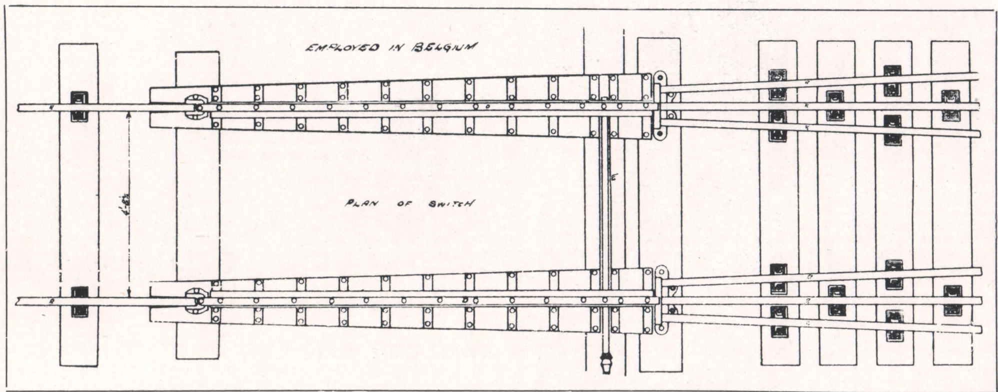


"ISAAC DODDS" SELF-ACTING SWITCHES (1839).

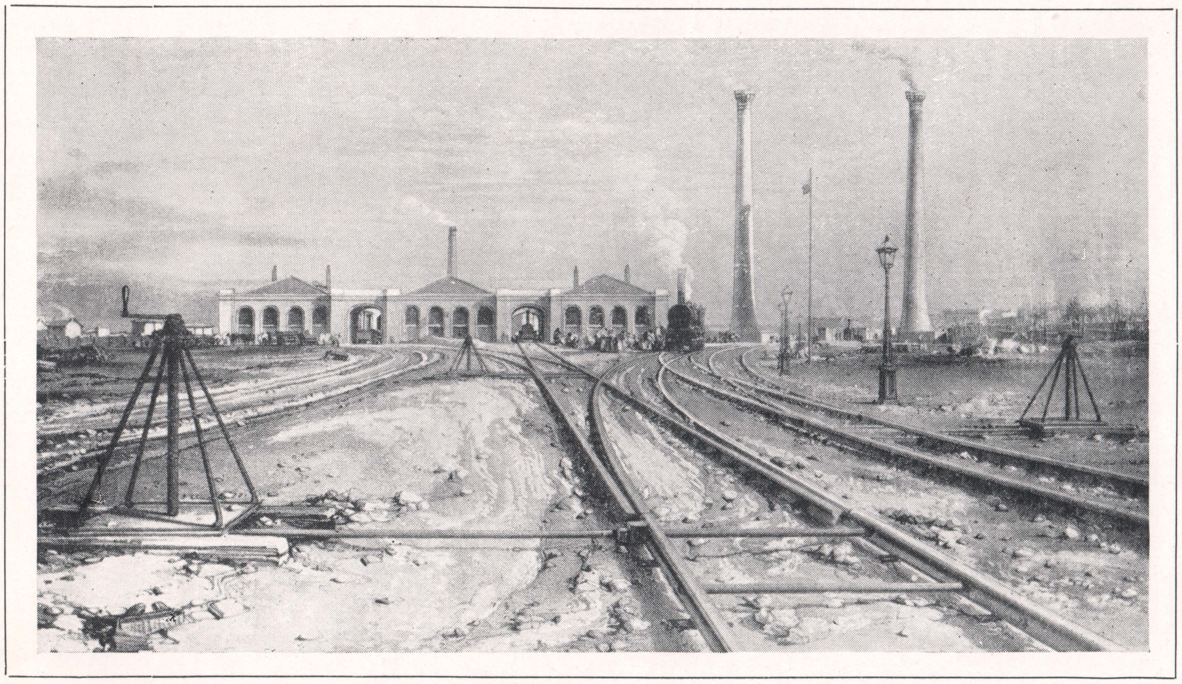
Early Switches.



SECTION OF "LIFTING" SWITCH, THOMPSON AND NICHOLSON, 1858.

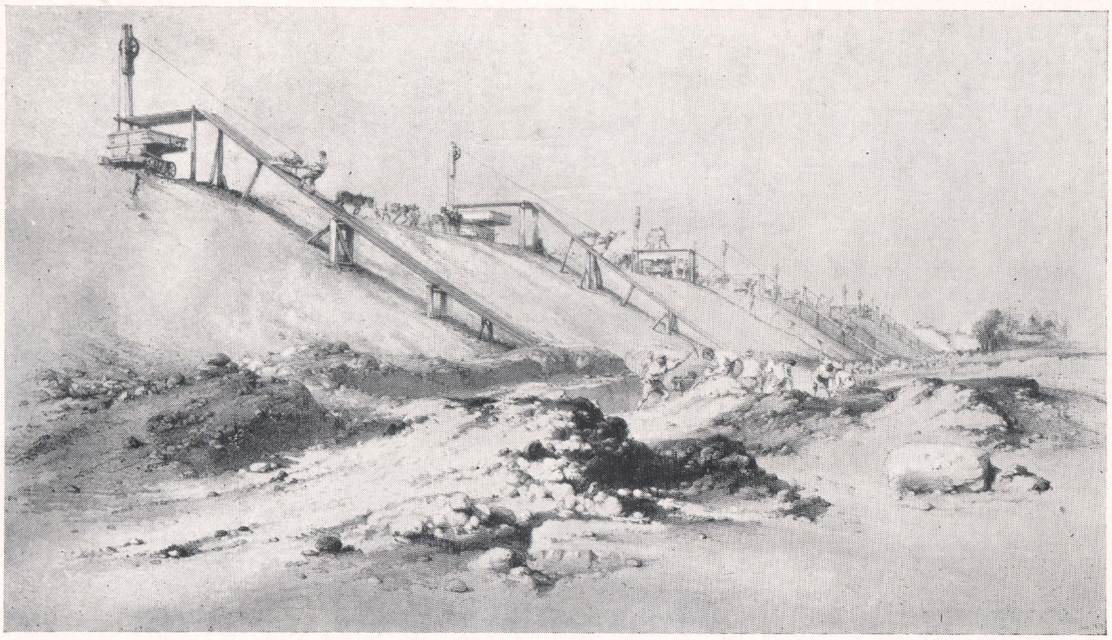


THREE-WAY "STUB" SWITCHES WITH PIVOTTED CHANGING PIECE.



STEPHENSON'S "STUB" SWITCH, WITH ECCENTRIC LEVER, LAID OUTSIDE CAMDEN TOWN STATION.

VIEW OF TRAM-ROAD, BERWICK-ON-TWEED, 1822.



BOXMOOR EMBANKMENT, SHOWING METHOD OF EXCAVATION.

Visit of Delegates of the Permanent Way Institute to the Imperial Steel Works.

On Monday, July 6th, 1925, a party of 100 delegates of the Permanent Way Institute visited the Imperial Steel Works.

The delegates first visited the tramway shops, where they saw points and crossings in Edgar Allen's Imperial Manganese Steel, in all the various stages, grinding, pressing, fitting, and the construction of complete layouts. They inspected a large manganese steel layout for Auckland, and also work in hand for the tramways of Amsterdam, Gothenburg, Stockholm and Turin. They also saw in different stages of construction various English orders including one from the Manchester Corporation Tramways.

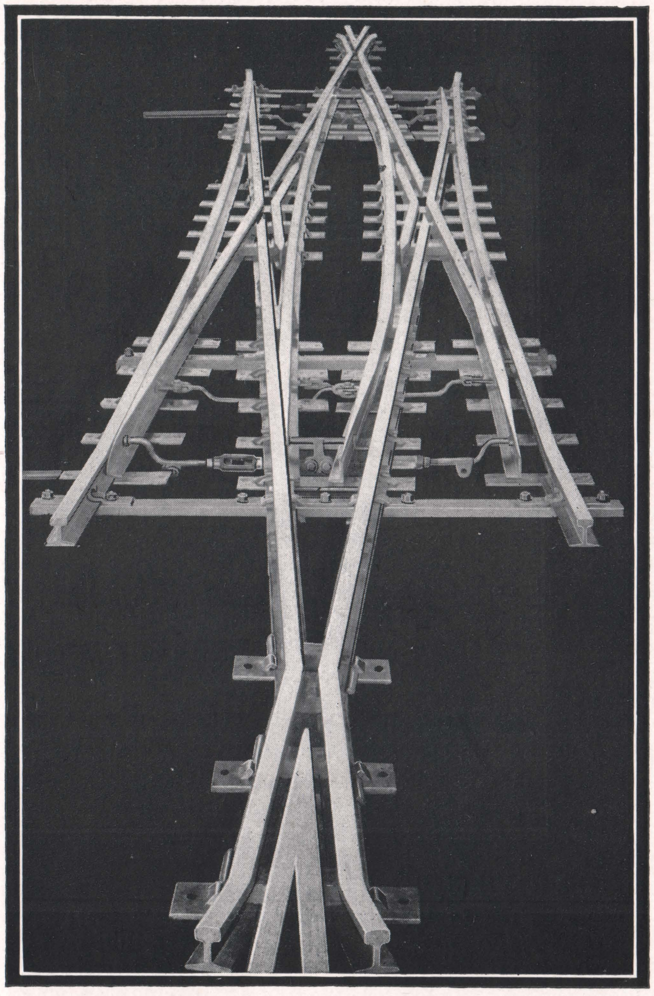
DELEGATES ARRIVING AT THE IMPERIAL STEEL WORKS.

After this department the railway fitting shop was visited. Here were seen the machine grinding of patent rolled Imperial Manganese Steel rails; the vertical grinding of cast manganese steel trackwork for the North of Spain Railway; the splicing together of rolled manganese steel crossing splices; the oxy-acetylene burning of rolled manganese steel rails; the holing of manganese steel rails, and their straightening. The delegates also examined with interest a number of crossings for the Buenos Aires Western Railway.

The next department to be visited was the large steel foundry, equipped with all sizes and varieties of moulding machines, from the ordinary hand machine built by Edgar Allen & Co., Ltd., themselves to suit particular conditions, to the large jarring machines capable of lifting a mould weighing 5 tons. The largest bay has a total length of 1000 ft. Next came the Fettling Shop, where the steel castings produced in the Edgar Allen foundry are dressed. Inspection of the foundry department was concluded by a visit to the machine shop, where general castings and loco wheels are finished machined. This shop is 575 ft. long and contains two bays, 45 ft. and 20 ft. wide respectively. Work is undertaken from 14 feet diameter down to the smallest size of steel castings that can be made. The largest planing machine has a capacity of 20 feet by 8 feet by 6 feet under the cross slide. It is interesting to note that the Edgar Allen Steel Foundry department can produce upwards of 300 tons of finished steel castings per week

The visit concluded with an examination of the shops belonging to the Edgar Allen engineering department, where all classes of crushing and grinding machine and cement plant are produced, including ball mills, tube mills, rotary kilns, rotary dryers, stone breakers, granulators, crushing rolls, air-separators and so forth, are produced.

The delegates expressed themselves highly pleased with what they had seen, and added that the visit had been most interesting.



DIAMOND ANGLE 1 IN $8\frac{1}{2}$ WITH DOUBLE SLIP ROADS BUILT UP FROM

EDGAR ALLEN'S PATENT ROLLED IMPERIAL MANGANESE STEEL RAILS

Conference of the Permanent Way Institution.

The annual conference of the Permanent Way Institution was held in 1925, in Sheffield. The President of the Sheffield Section was Mr. F. Bland, Director, Tramway Department, Edgar Allen & Co., Limited, whose interesting paper, "A Century of Permanent Way" was delivered as a lantern lecture during the conference to a large attendance of delegates. (The lecture was given at the Union Street Picture Palace, by kind permission of the Directors.) During an interval the orchestra rendered agreeable selections, and a film showing the celebrations of the centenary of the Stockton-Darlington railway at Darlington, was shown. A film showing the arrival of the delegates at the Imperial Steel Works was also thrown on to the screen, and on page 29 is reproduced a photograph extracted from this.

Among other functions in which the delegates participated the following account is given here, being taken from the "*Sheffield Daily Telegraph,*" of July 7th, 1925.

PERMANENT WAY.
BRITAIN'S THE FINEST IN THE WORLD.
SHEFFIELD CONFERENCE.

"The Delegates attending the annual conference of the Permanent Way Institution, which is being held in Sheffield, spent a most enjoyable time yesterday.

In the morning they paid a visit to the Imperial Steel Works of Messrs. Edgar Allen & Co., Ltd., Tinsley, who afterwards entertained the delegates and their wives to luncheon at the Royal Victoria Hotel.

SHEFFIELD STEEL RAILS.

Mr. Edward A. Wilson, President of the Permanent Way Institution, proposing the toast of the directors of Messrs. Edgar Allen and Co., Ltd., observed that their visit to the Imperial Steel Works enabled the delegates to realise what an important part Edgar Allen and Co. Ltd., played in the manufacture of manganese steel. He hoped to see more steel industries prosper in this country because it hurt very much when they had to go to Belgium for steel rails.

Responding to the toast, Mr. R. Woodward, Chairman of Messrs. Edgar Allen & Co., Ltd., said he was informed this was a record gathering for the conference. His recollection of the permanent way went a long way back, and he had seen a great improvement in its construction since the introduction of locomotives. There was, of course, a permanent way in this country before the locomotives. He well remembered the first iron rails being laid on large stone blocks, and in those days the manufacturers complained of the method of laying the rails on some sleepers. His association with railways went back 68 years, when he was on the Stockton and Darlington Railway. The efficiency and maintenance of the permanent way was, he claimed, one of the most responsible duties of the railway companies. The efficiency of the permanent way was reflected in the comfort of modern travel, which presented a striking contrast to the early days of the railway, when a journey between York and Darlington was regarded as a positive terror. He believed it was because of the permanent way. (Laughter). Since that time many improvements had been carried out and one of the most important of these was the introduction of steel rails in place of iron rails.

FINEST PERMANENT WAY.

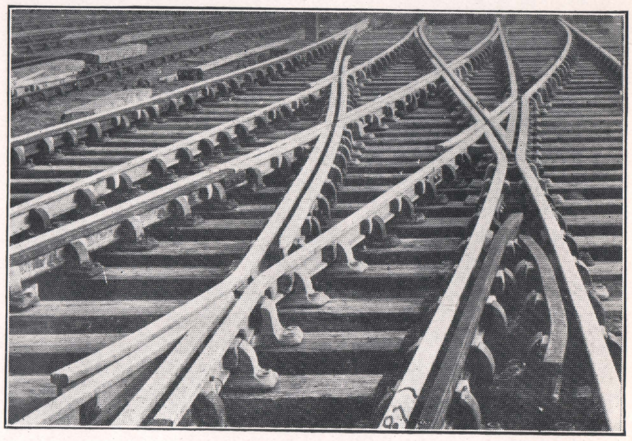
The aims of the Permanent Way Institution were commended by Mr. C. K. Everitt, a director of Messrs. Edgar Allen and Co., Ltd., who remarked that the visit to Sheffield was mainly educational. People who had travelled in other countries frankly admitted that here in the old country we had the finest permanent way in the world. (Hear, hear.) He had been on many railways, but the English railways were the only ones to provide plates for soup, the others supplied cups on account of the vibration. Another good point about the Institution was the fact that it embraced all grades from chief engineers down to plate-layers. He was pleased to learn that the conference had visitors from the Malay and Indian railways.

Mr. W. Cleaver, who has filled the presidential chair on five occasions, sincerely thanked Messrs. Edgar Allen and Co., Ltd., for their lavish hospitality. The delegates, he said, very much appreciated the good fellowship expressed by a function of that kind. He hoped that as a result of the inspection of the works the delegates would leave Sheffield far more efficient than when they arrived.

Mrs. Cowen replied to the toast of "The Ladies," submitted by Mr. W. Crosby, a director of Messrs. Edgar Allen and Co., Ltd.

Thanks were also expressed to Mr. F. Bland, president of the Sheffield section, for his services as organiser of the conference.

The visitors had a civic reception in the afternoon at the Town Hall, where they were welcomed by the Lord Mayor and Lady Mayoress (Alderman and Mrs. A. J. Bailey) who entertained the members and their wives to tea, and after tea were shown through the Town Hall by the Lord Mayor and the Lady Mayoress.



MODERN MANGANESE STEEL TRACKWORK, BAKER STREET, LONDON.

Atmospheric Railways.

By FRED BLAND, Director, Tramway Dept., Edgar Allen & Co., Limited.

Reprinted from "THE EDGAR ALLEN NEWS," July, 1926.

During the preparation of "A Century of Permanent Way," many matters were found interesting in themselves but not entirely in common with the paper. These were, therefore, omitted. One of the points mentioned was the Atmospheric railway (see page 717 of No. 44 of the EDGAR ALLEN NEWS). This was an interesting experiment in locomotion, and an attempt is now made to lay before railway men and others a resume of the history of "Atmospheric railways." which were but casually referred to, in the various Centenary notices of the Stockton and Darlington railway.

Parliament—George Hudson (the "railway king") and George Stephenson against Lord Howick and Brunel who claimed "rapidity, comfort, safety, economy" for the atmospheric railway, and also that a greater number of trains could be worked by its means, and at a cheaper rate than with the steam locomotive; but the locomotive won the day, and the "atmospheric" shareholders were heavy losers. George Stephenson's laconic "It won't do" proved to be correct, and before the end of 1848 all atmospheric lines were scrapped, the cost of working them being found enormous owing to the great rush of air necessitated.

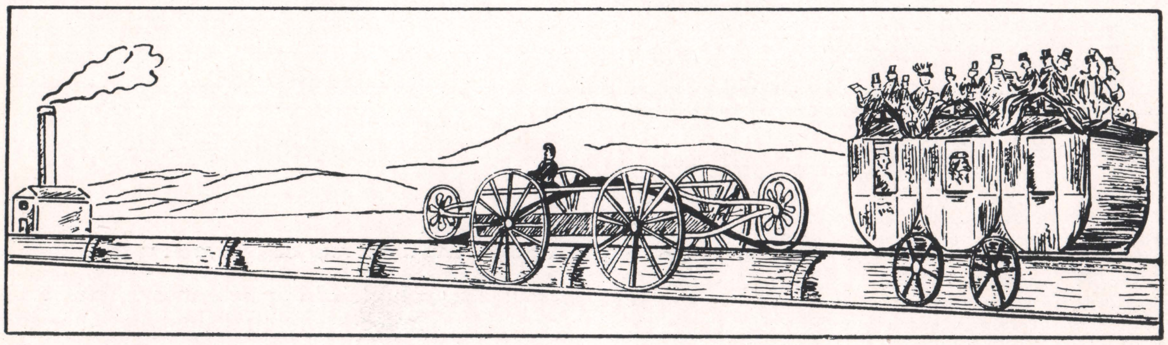


FIG. 1. ATMOSPHERIC RAILWAY.

In 1844, after the opening of the Newcastle and Darlington railway, the completion of the line between Newcastle and Berwick was again brought forward, and George Stephenson was called in for consultation. This time a plan was proposed to substitute Atmospheric pressure instead of locomotive steam power, for railways, and this proposal was supported by prominent engineers. It was also supported by the Prime Minister (Sir Robert Peel) together with a strong party in Parliment.

Mr. Vignoles, then a prominent railway engineer (to whose name lies the origin of the term "vignoles rails") took George Stephenson to see the model of the atmospheric tubes. After considering it carefully George said: "It won't do. It is only rope and a fixed engine in another form, and I do not think that this rope of wind will do as well as the rope of wire did— nothing will beat the locomotive for economy for drawing heavy loads, and for power and speed."

Lord Howick, a Northumbrian M.P., formed a strong party in its favour. Mr. I. Brunel appeared as engineer, and George Stephenson did not like this. When he met Brunel later in Newcastle, he asked what business he had north of the Tyne, where he had fought many years for the locomotive. They shook hands, however, and agreed to fight fair.

In December, 1844, at a public meeting in Newcastle, Stephenson's line was unanimously adopted as the best. 1845 saw the beginning of the contest in

When the news of the victory reached Newcastle, a general holiday was proclaimed, and Stephenson's men (800 in number) walked through the city with bands and banners. This introduction over, we can now go into a little more detail.

In 1845 the Croydon Railway Company laid a single line of "Atmospheric Railway," chiefly worked between Forest Hill and West Croydon. The railway may be described as a large tube laid in the centre of the rails, with an opening at the top which was closed by a valve, formed of a leather strap covered with a short plate of iron above and underneath it. The straps, being broader than the plates, pressed against the top of the pipe by a succession of long rods screwed down with hook bolts which formed the hinge.

There was a groove in the side on which the valve opened, and this was filled with a mixture of wax and tallow. When the valve was raised, there was a space for a curved iron plate to pass into the tube. The leading carriages were fitted with a piston attached by means again of a curved plate; upon this piston rod were 4 wheels, 2 in front and 2 behind the bent and curved plate, so that when the piston was in the pipe, these wheels raised the valve and prevented it from touching the bent plate. (See Fig. 2 for an illustration of the engine). In this manner communication was made between the piston in the pipe and the leading carriage. Engines working large air pumps were fixed at intervals along the line. By means of these the air was exhausted in the pipe, whereupon the atmospheric pressure on the back of the piston created the power to draw the train.

The tubes were 15″ inside diameter, and it is said that at a trial trip, with a train of 12 carriages, the remarkable rate of 75 miles an hour was attained. It was in use for about 12 months and then scrapped. Another line was laid on the South Devon Railway (G.W.R.) and there was also one in Ireland from Dublin to Kingston, operated upon the principle patented by Mr. Henry Pinkus in 1825.

Early Railway Engineers knew nothing of the atmospheric railway; Nicholas Wood, Timothy Hackworth, and others, are all silent on the matter, although it must then have been known that the first engineer to work a steam piston was Thomas Newcomen (1163-1729), who is acknowledged to have invented the atmospheric engine for colliery pumping.

The history of the invention appears to be that Papin, a Frenchman, proposed, somewhere about 1680, to force air, by means of a "plenum" through a pipe, by the action of an air pump. Experiments

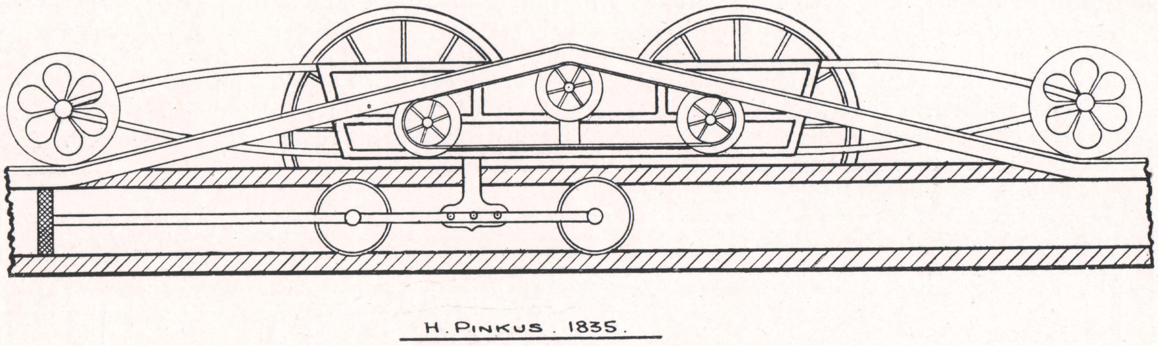


FIG. 2. ATMOSPHERIC RAILWAYS.
SECTION SHOWING TUBE, WITH DRIVING PISTON, GOVERNOR CARRIAGE AND CONTINUOUS VALVE.

When the Manchester and Liverpool Railway was opened, Mr. Pinkus prepared plans of this atmospheric patent suitable for railways. In 1832 he applied for a patent, which was sealed in 1834, and models were exhibited. Second patents were taken out in 1836, and again in 1837. An association was formed and considerable money was expended, and this seems to have been the beginning of the atmospheric railways, afterwards tried fully and finally scrapped.

A line 3 miles long was laid, and a 30 h.p. pressure engine was put down with 3 air pumps 29″ dia., and 5 feet long with pipes $13\frac{1}{2}$″ dia. Fixed steam engines were to be erected at about every 5 miles, communicating with pipes 7″ or 9″ dia, with intersecting self-acting valves at suitable intervals every 2 or 3 miles. Mr. Pinkus also claimed that the same principle could be applied to agriculture to replace horses, and went into great detail, but these are not relevant to the present paper.

A long description is given in his specification. Great things were claimed and a working model was shewn at the Colosseum, Regent's Park. A demonstration was made at Wormwood Scrubs, near London, in accordance with his invention. (Experiments were also made in 1836 at Hyde Lane Colliery, Nr. Manchester, by Dr. Lardner, F.R.S., with the pneumatic machine by Thomas Browne, which drew the coal wagons of 16 cwt. up an incline). Very few records are to be found, and it is only from searching old patents that earlier details were obtained, which the writer has now endeavoured to put together in the hope that they may awaken interest in a forgotten railway relic.

failed; then he tried opposite means, *viz.*, a vacuum. This also failed—possibly through the imperfect machinery of that time. His propositions were discussed by the Royal Society of England, but he only met with ridicule and opposition. He attempted to drain a lake in Germany, but failed, and so did others who tried a "plenum."

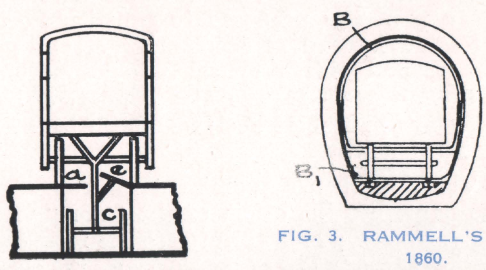


FIG. 3. RAMMELL'S PATENT, 1860.

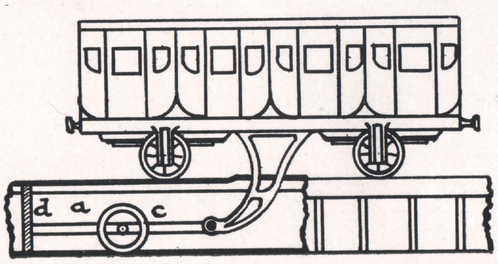


FIG. 4. SIR J. LILLIE'S PATENT, 1865.

Watt (about 1810) applied Papin's vacuum to work lathes at his Soho Factory, and afterwards enlarged on this method. In 1800, a Mr. Adams proposed Papin's plenum for road transit under the pressure of many atmospheres in reservoirs, to be taken from pipes where and as required. In 1810, Mr. Medhurst patented a project for pneumatic despatch of letters, with a view to working passenger carriages by air pressure, but he was unsuccessful, and in 1824, a Mr. Vallance projected his underground tunnel and exhibited a model on a large scale on the principle of partial vacuum. The vacuum power being constantly in action in all sections at the same time, several trains could be moved simultaneously in rapid succession, but contact was impossible.

In 1860, Mr. T. W. Rammell (Patent 356/60) proposed to run carriages within tubes or tunnels upon this principle (see hand-made sketch Fig. 3) with elaborate descriptions as to how to diminish speeds, etc. See later.

Then G. Remington (patent 2830/63) patented a similar tube arrangement which was followed by one taken out by Sir J. S. Lillie (patent 598/65) for pneumatic railways (Fig. 4). The latter proposed to use canal beds for his track, roofing in the top.

In 1865, an influential meeting was held in Liverpool, presided over by Mr. E. Lawrence, ex-Mayor, when Sir Charles Fox explained the pneumatic principle and prepared a plan of a tunnel under the Mersey, at a cost of about £300,000, to run 20 miles an hour and to carry passengers up to 500 at a time, there being no danger of collision, plenty of fresh air, and comfortable well-lighted carriages ; but evidently the project failed, though later a similar scheme was carried out by the Post Office in London in 1865, and extended, and is to-day of the greatest service for parcels, letters, etc. : but this is not the place in which to enlarge on Post Office pneumatics, however interesting the details may be.

Mr. Rammell's ideas (1860) were carried out, and he claimed that the result showed the " immortality of inventions " ; but the inflexibility and cost prevented the railways from being worked upon the atmospheric principle. Robert Stephenson himself, it is said, admitted that for short lines of 4 to 5 miles it might do. It is hoped, however, that these few notes will have been found of value to railway men and others with an interest in past engineering schemes.

CORRESPONDENCE.

1, Marlborough Villas,
Blue Bridge, York.

Dear Sirs,

A CENTURY OF PERMANENT WAY.

The article in your paper Edgar Allen News of Jan. (No. 44), "A Century of Permanent Way," by Mr. F. Bland, has just been shown me. The portion of it dealing with the invention of the fishplate by my grandfather, Mr. Peter Schuyler Bruff, when he was Engineer for the Eastern Counties Railway, interested me in particular very much. I have always understood from my father that the fish plate was my grandfather's idea. but that he in his busy life did not pay much attention to it. However, one of my uncles is still alive, a Railway Engineer like my father, and I would very much like to send him the article in question and ask him if he is able definitely to settle this point, which I was asked questions in regard to at the Centenary Celebrations last summer. I shall therefore be very much obliged if you will be so kind as to let me have three copies of the article in question, the concluding portion of which appeared in the January number. If I am not asking too much, will you kindly send the papers to my office in York.

H. Bruff, The Bridge Assistant, North Eastern Area,
L.N.E.R., York.

I am, Gentleman,
Yours faithfully,
(*Signed*), HAROLD BRUFF.

This letter, being handed to Mr. F. Bland, the author of the paper, was replied to by him as follows :

Dear Mr. Bruff,

Your letter has been handed to me by our Publicity Department, after acknowledgment.

As author of the Paper, "A Century of Permanent Way," I am very pleased to receive criticism, especially from relatives of men well-known in the past, as Mr. Peter Bruff was. I did not know him, but I have met men who did in their younger days.

I have again read the paragraph about fishplates in No. 44 of the Edgar Allen News, and I enclose another press notice which gives a little more information ; no doubt, you have also seen the official number of the P.W.I. Journal.

You will observe that I refer to a paper read in 1857 by Mr. W. Bridges Adams upon this subject, when he claimed to have introduced the fishplate joint. I have before me a printed copy of that paper, re-printed by permission of the Institution of Civil Engineers in 1857, from which I have taken my paragraph, as of course the whole discussion would have been too long to include. This paper was read on February 3rd, 1857, together with a paper by Mr. Percival Moses Parsons. These two papers together with the discussion occupied four nights.

The President at that time was Robert Stephenson ; *Vice-Presidents*, George P. Bidder, Isambard K. Brunel, John Hawkshaw, Joseph Locke, M.P. ; *Members*, William G. Armstrong, Joseph Cubitt, John E. Errington, John Fowler, Charles H. Gregory, Thomas Hawkesley, John R. M'Clean, J. Scott Russell, Joseph Whitworth, Nicholas Wood ; *Associates*, Robert W. Kennard, Sir MacDonald Stephenson.

The first beginning of fishplates appears to have been the use of an iron wedge-plate packed between the key and the chair, without holes. There were also iron plates used at each side of the rail held in position by the chairs which are illustrated in my paper.

In 1847 the double head rails were in use on the Eastern Counties railway. and an improved joint was wanted. *Mr. Adams* removed the joint chair and sleeper 3″ back from the joint, and fixed a second joint chair and sleeper 3″ on the other side of the joint. An iron fishplate was placed in each rail channel and supported by the two chairs, so that the joint became practically suspended. To avoid casting extra chairs, a trial was made of removing chairs to, say, 20″ apart, and bolting fishplates to and through the rails by 4 bolts.

In some cases the fishplates were fixed by simply removing the joint sleeper, leaving a distance of from 3ft. to 4ft. unsupported, as a result of which the bolts broke. Various types of fishplates were then tried.

During the discussion *Mr. Parsons* stated that Mr. Adams depended entirely on screw bolts and nuts, which he thought would be dangerous, and gave his reasons, too long to insert here.

Mr. Hemans then thought great credit was due to Mr. Adams for the fishplate joint, but he thought the merits were exaggerated. He said that on the Dublin and Galway line he had used a fish joint with bridge rails of somewhat different type. *Mr. Robert Richardson* then claimed that he was the joint inventor with Mr. W. B. Adams of the fish joint, and produced correspondence with Mr. Adams in the year 1846-7 in which the invention was discussed. This invention, he said, was brought out and secured to them by Patent as joint inventors.

Mr. W. H. Barlow said that he had used a fish joint on 300 miles double line on the Midland Railway, 50 miles supported and 250 miles suspended ; the latter proved the best.

Mr. Errington (of the South Western Railway) said that he had tried them for about 3 years. They had difficulty at first, but not more than one bolt in 50 was in the slightest degree loose. He said that the platelayers at first were not accustomed to bolts and nuts, and it was not surprising there was trouble to begin with.

Mr. C. May (South Western Railway) spoke with regard to trying fishplates on the South Western Railway, and said the fish joint was first introduced in 1847 as the invention of Messrs. Adams & Richardson, and Mr. Adams ought not to have claimed all the credit. He (Mr. May) had personally been connected with the early experiments.

Mr. Bruff (Eastern Counties Line) then said the fish joint system had been generally applied to all rails which were very much worn, particularly at chair ends. It had been used more to give assistance than to make a perfect road. He said that the fish joint system was not so useful with the single head rail as with the double head rail. He did not anticipate difficulty with bolts and nuts if he got proper articles, but he had to throw a lot away, and the cost of keeping the bolts and nuts tight was as much as that of maintaining the road before it was fished.

He believed Mr. Adams had nothing to do with the invention beyond christening it. The invention as patented was taken by Mr. Richardson to Mr. Adams, who was sufficiently far-sighted to perceive the value of the Patent, but Mr. Bruff stated that the fish joint was laid down by himself before the patent when Mr. Richardson was his assistant, in order to overcome a difficulty, *viz.* :—

A timber bridge of about 50 feet opening was considered too weak for a locomotive to run over safely. It occurred to him that the simplest method of increasing the strength was to fish the rails, converting them into a tension bar across the bridge. This had the effect of rendering the bridge temporarily safe until a stronger erection could be put up, and was the first application of a fish joint.

Mr. Richardson improved on it, then he went to Mr. Adams and they patented it.

Mr. W. Pole (East Indian and Madras Line) said that the fish joint system had been adopted on the Indian line to a considerable extent and gave certain reasons and suggestions as to the improvement of the same.

Mr. Adams, in reply, said that the fish joint was simply proposed to assist the defects of the battered ends of existing rails, and at the time was not contemplated by him for fitting to new rails. With reference to the priority of invention, he said the idea did not come to him either by Mr. Bruff or Mr. Richardson. It was true that Mr. Richardson had asked him to join in taking out a patent, which he declined on account of the difficulty in getting the patent into use. Two months later, Mr. Richardson came to him again and said Mr. Bruff would lay these joints on the Eastern Union line. Then for the first time Mr. Richardson shewed his plan, which was different from Mr. Adams's. However, the discussion led to the invention being jointly patented. The patent contained a fish joint, a scarf joint and other inventions. The Scotch and Irish patents were taken out in Mr. Adams's name alone for the fish joint, and Mr. Adams said that his assertion was corroborated by *Mr. James Samuel* who spoke on a previous paper given in 1852, when he said that Mr. Adams claimed the invention of the " fished " suspended joint which, Mr. Samuel said, was perfectly valid, as he (Mr. Samuel) had become first connected with it by introducing it on the Eastern Counties railway. *Mr. Adams* then stated that after the Patent was taken out it remained in abeyance for some time, as Mr. Bruff would not lay it down on the Eastern Union. Two years after the patent was taken out a premium was about to be offered by the Eastern Counties Board for the best joint. Mr. Adams thought his joint was the best, and prepared a plan, which was seen by Mr. Peter Ashcroft, who was then in charge of the Permanent way of the Eastern Counties. 10 joints were put together with bolts, and from that they gradually came into use.

Mr. Adams had prepared a chart, which I have used in the paper, and fig. 3 shews the joint invented by Mr. Adams in May, 1847, including fishplates between the chairs, without bolts.

Mr. Samuel in 1850, fig. 6, has a chair of one jaw with fishplate on the outside, said to have been claimed by Mr. Greaves in 1846.

In 1852, a Mr. R. C. Mansell patented a fish joint, fig. 12, in which a short piece of rail was placed between the rail ends and bolted through the fishplates, but without any holt-holes in the rails themselves.

You will find my remarks with reference to Mr. Greaves and Mr. Stephenson having seen link-plates years before.

Mr. Locke, M.P. also spoke on the matter,

I have had to go somewhat fully into this matter, as I have been desirous of placing the whole thing semi-officially before you as it appears on record, and I am inclined to think that your uncle will agree with my letter. Like many other patents, lapse of time seems to have caused differences of opinion.

There may also have been several engineers who experimented at the same time who did not patent, and all railway students have read about the great work that Mr. Bruff did on the Eastern Counties. During a talk with Mr. E. A. Wilson, last year's President of the P.W.I., I was delighted to hear that he expressed such a high opinion of Mr. Bruff's work, and I shewed him this particular pamphlet at the time.

I hope that I have not wearied you with these details, but if a reply was to be given to you, it was absolutely necessary that full details should be gone into.

When you are coming through Sheffield, I should be delighted if you have time to visit our works, and assure you of a welcome not only for yourself but of the family name.

Yours truly,

FRED BLAND.

A correspondent, having read the second instalment of the article "A Century of Permanent Way " in the EDGAR ALLEN NEWS for October, raised a question in regard to sleepers put down at Sirhowy. According to the article, he pointed out, the cast iron sleepers used by George Overton were put down " at Sirhowy on the Lydney and Lidbrooke Tramway." He suggested that this probably meant that they were made at Sirhowy for the Lydney and Lidbrooke Tramway, Sirhowy, in the valley of that name, he said, was in the west of Monmouthshire, a little north of Tredegar ; Lydney, on the other hand, is in Gloucestershire, several miles east of the Wye. Lidbrooke is also in Gloucestershire on the Wye, between Monmouthshire and Ross.

Mr. F. Bland, the author of the paper, replied to the correspondent as shown below :—

" Dear Sir,

Your letter of the 2nd inst. has been handed to me, and I am very pleased to see the interest you have taken in the paper. It is sometimes difficult after a time to trace exactly the source from which information is compiled, and this is a case in point, but if you will add the word " and " before the word " upon " it will make it clear.

Warren's " Century of Locomotives " states that " George Overton had his Cast Iron Rails in use on the Sirhowy and Monmouthshire Tramroad into Newport, a distance of 28 miles," and Francis in his history of the English Railway, Volume 1, 1851, page 58, states :

" 1802. The Sirhowy tramroad was undertaken by the Monmouthshire Canal Company, in conjunction with the proprietors of the Tredegar Iron Works and extends from the canal of the former Company to the Sirhowy furnace. Its length was eleven miles, and its cost £45,000."

" 1809. The Severn and Wye Railway connects these two rivers. It commences at Lidbrooke on the Wye, and terminates at the lower Verge, near Newern, in Gloucestershire. It is connected with the Severn at Nass point by a canal one mile long. Its length, including branches, is about twenty-six miles, and the Capital of the Company £110,000. Its object and use is much the same as that of the preceding Railway."

This, no doubt, was the Lydney and Lidbrooke line referred to by me, for which Stephenson built Samuel Homfray's Engine in 1892.

The following letter appeared in the columns of the "Sheffield Daily Telegraph":————?

WHO INTRODUCED STEEL RAILS ?

Sir,—Referring to the several letters which have appeared the past week or so from Mr. Snell and Mr. Osborn, during the recent visit of the Permanent Way Institution to Sheffield, a lecture was given by myself as President of the Sheffield Section in the Union Picture House, when I mentioned this question, and stated that there was no definite information on this point. Since then I have had references made to old records of the Institute of Civil Engineers and also the Mechanical Engineers.

Mr. Snell is quite correct in his extracts from the paper read by Mr. Thomas W. Dodds, of Rotherham, at the Institute of Mechanical Engineers, on June 25th, 1857, when Joseph Whitworth was in the chair, and when he showed details of his furnace for converting the faces of the iron rails, and calculated that they would have three times the life, but the fact remains that these were not solid steel rails, which is what Mr. Joseph Ward had in his mind when speaking at the Institution dinner on July 4th; also Mr. F. M. Osborn when he wrote certainly referred to steel rails, and I believe that this is the earliest record.

He refers to rails rolled by Ebbw Vale Co., from Bessemer and mushet ingots, and I find in the report of a paper by Percival Moses Parsons, A.I.C.E., upon "Recent improvements in the permanent way of railways," read at the Institution of Civil Engineers on February 3rd, 1857 (Mr. G. P. Bidder, V.P., in the chair), and during the discussion which followed, Mr. C. May exhibited a specimen of a bridge rail rolled from a cast steel ingot by the Ebbw Vale Co., and made under the "Uchatius" process, that was of such a quality that razors could be made from it. Mr. May added, "he believed that before many years steel rails would be as cheap as iron rails were now, and that the permanent way would then deserve its name."

Furthermore, in 1861, Mr. John Brown (afterwards Sir John Brown) read a paper at the annual provincial meeting of the Institution of Mechanical Engineers on July 31st, 1861, at the Music Hall, Surrey Street, Sheffield (when Mr. H. Bessemer also read another paper), upon the manufacture of steel rails and armour plates, and I give you extracts bearing upon steel rails.

After describing various processes he refers to the fact that the chief item of railway maintenance is the renewal of rails. He refers to the conversion process that was in use (possibly Dodds being included), and also for rolling steel into the iron rail, which are open to the same objection, *viz.*, a hard surface and a soft body.

He recognised the Bessemer system opened out a new method and though the cost was high, there were places where it would be economical to be used, especially points and crossings (only averaging at present four years).

Mr. Brown described the Bessemer process and took 24ft. rails as his text, adding that the only limit to the length of this rail is the weight of the ingot.

The following is an important paragraph, Mr. Brown said "Cast steel rails are not an entire novelty, several years ago a few were rolled at Ebbw Vale, and were laid at the bridge at the north end of Derby, where they now are, perfectly sound and good, while the iron rails round them have been re-laid many times.

"The cost of the steel rails prevented them being made commercially, but with the Bessemer process steel rails bid fair to become a permanent matter."

Mr. Brown exhibited specimens of steel rails, also a piece of 75lb. double-headed rail drawn down into 1-inch square and twisted cold. He said "Steel rails had been used on the Continent, but not many in this country, some had been laid six or seven months at the New Pimlico Railway Station, London, and were as good as at first, and steel points and crossings were in use there, also for the Caledonian, L.Y. and L. and N.W. Railway, Rhymney, but not sufficiently long for reports to be made. There has been no fracture in the working, and the rails were tougher than wrought iron. He believes steel rails would last out five ordinary. The price was £18 10s. 0d. per ton in England.

Replying to a question, he said he had not tried welding rails because each rail was rolled from a single ingot.

The rails at Derby station, to which Mr. Brown referred, are evidently the same rails that are included in Mr. Mushet's report

I think the reports above given cover the whole ground, and there is nothing earlier.

It is quite evident that while there is no actual date there is no doubt this is the history of the early steel rails.—Yours, etc.,

FRED BLAND,
President, Sheffield Section, 1925.
July 28th, 1925 Permanent Way Institution.

Menai Tubular Bridge.

Very few are aware that Robert Stephenson designed this famous bridge, and I show a photo. of a Council meeting held in 1845 which includes many noted men of that day. The Admiralty insisted upon a height of 100 ft. above the water. The bridge was put together and then placed into position. His proposal of a tubular bridge 460 ft. long strong enough to carry a train and bear its own weight was received with almost universal incredulity. The centre pier is based upon the Britania Rock which gives its name to the bridge. The first stone was laid in May, 1846, by Frank Forster, acting engineer. Some of the stones are 20 ft. in length, and weigh from 12 to 14 tons, and were cut out of Anglesey Quarries. Four years were occupied in the construction.

MENAI TUBULAR BRIDGE COUNCIL—ROBERT STEPHENSON PRESIDING,

From Left to Right.

(1) Admiral Moorson, chairman of the Chester and Holyhead Railway; (2) Latimer Clark, Esq., assistant engineer; (3) Edwin Clark, Esq., chief assistant engineer; (4) Frank Forster, Esq., resident engineer to the Bangor District; (5) G. P. Bidder, Esq., civil engineer; (6) Robert Stephenson, Esq., M.P.; (7) Mr. Hemingway, contractor for the masonry for the bridge; (8) Captain Claxton, R.N., superintendent of the nautical arrangements; (9) Charles H. Wild, Esq., assistant engineer during the floating; (10) Alexander Ross, Esq., resident engineer of the Conway District; (11) Joseph Locke, Esq. M.P., and (12) J. K. Brunel, Esq., "friendly volunteer assistants on the, occasion."

If one of these tubes could be fixed on end in St. Paul's Church Yard, London, the tube would reach 107 feet higher than the top of the Cross, and Southwark Bridge London, which has the largest rigid span in the country, is only 240 ft. The weight of one large tube when complete was said to be approximately 1,800 tons, the eight tubes being nearly 10,000 tons.

This article was included in the original paper, but was crowded out.