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SOME RAILWAY NOTES

OLD AND NEW.

By

Sir John A. F. Aspinall

The Twelfth

Thomas Hawksley Lecture.

Given to a meeting of

The Institution of Mechanical Engineers.

(47 Pages)

THE TWELFTH
THOMAS HAWKSLEY LECTURE:

SOME RAILWAY NOTES OLD AND NEW.

BY

SIR JOHN A. F. ASPINALL, D.ENG.
PAST-PRESIDENT.

EXCERPT MINUTES OF PROCEEDINGS
OF THE MEETING
OF
THE INSTITUTION OF MECHANICAL ENGINEERS.
6TH NOVEMBER 1925.

SIR VINCENT L. RAVEN, K.B.E.,
PRESIDENT.

BY AUTHORITY OF THE COUNCIL.

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SOME RAILWAY NOTES OLD AND NEW

By Sir JOHN A. F. ASPINALL, D.Eng., *Past-President.*

Friday, 6*th November* 1925.

Sir Vincent L. Raven, K.B.E., *President, in the Chair.*

Our Past-President, Mr. Patchell, when he asked me to deliver the Thomas Hawksley Lecture, expressed a hope that I would deal with some matters concerning railways, particularly as it was the Railway Centenary Year and our first President, George Stephenson, who was the great creator of British railways, was being thought of in all parts of the country. I felt considerable difficulty in following this course because of the immense amount of literature which has been got together during the past few months dealing with this subject of the early days of railways, and it seemed to be impossible to say anything new upon the matter. This difficulty has, to my mind, been considerably increased by the fact that a most exhaustive and complete record of locomotive history has been produced during the past few months in the pages of *The Engineer*, so that there is but little to tell which is not already known to the public.

In thinking the matter over, however, and looking back over the long series of years during which I have been connected with railways, I thought there were still a certain number of things which had not hitherto been published, and other things which may have been published but which have been forgotten, which might be of some interest to our members, and therefore I hope I may be forgiven if I have put forward information which is not really new.

It is interesting to note how early our First President became connected with railways, and an instance of this is found in the fact that a tablet has been erected in the front room upstairs at the " George and Dragon " inn at Yarm-on-Tees, North Yorkshire, to commemorate the first railway meeting that was ever held in England, in 1820. George Stephenson was present at this meeting, and it was then decided to apply to Parliament for powers.

Again, in addition to the Stockton and Darlington line, George Stephenson laid out the Canterbury and Whitstable line in 1825, afterwards constructed by his son Robert. The difficulties which were thrown in his way were stupendous, but he overcame them all by his steadfast purpose.

As a nation we have some curious ways of dealing with new proposals, and as an instance it will be recollected by some of our senior members how, when it was proposed to build the Suez Canal, the main opposition came from England, the whole project being ridiculed. Again, when it was proposed to create the great dam on the Nile at Assuan, most strenuous efforts were made by our archæologists and others to prevent this being built for fear that it might depreciate the ruins of Philæ. This kind of difficulty had also been raised when railways were first started, and it is very curious to read some of the objections that were given at the time.

For instance, a Mr. Donald Currie raised strong objections to railways in 1837 because " veins of water will be cut, springs dried up, and sloping fields so deprived of water that they will become sterile and unfit for pasturage and agriculture. Whole estates are cut asunder and disfigured by deep cuttings." He therefore proposed what he called a safety railway, by constructing it of " timber or other materials raised at least ten feet above the ground," removing every obstruction to agricultural operations. Time and knowledge have, however, changed all that.

Prosser's Angular Wheels.—A great many odd proposals were made in the early days of railways with regard to the rolling-stock which should be used upon them, but I think the most curious was that of Mr. William Prosser, who proposed that there should be no flanges on the carrying wheels of locomotives or other rolling-stock, and that the vehicles should be kept upon the line by certain angular guide-wheels pressing on the top and sides of the rail. This system was said by the Author, who patented it in 1844, to have been first adopted on the Guildford and Woking Railway, and that the locomotive had travelled during a period of two months about 3,000 miles without requiring the slightest repair. An illustration of his proposals is shown in Fig. 1.

Plateway.—It is recorded in a Paper by Clement E. Stretton, entitled "The History of the Preston and Walton Summit Plate-way," that the Lancashire and Yorkshire Railway Company ultimately came into possession of parts of the "Outram-way" of the Preston and Walton Summit line which had been made by the Lancaster Canal directors under their Act of Parliament of 1792. Originally this tramway was worked by what was then called a "fire-engine," that is, a steam-engine with boiler for pulling the wagons up and down the incline of 1 in 6 by means of a continuous chain. The new tramway was about five miles in length, and had up and down

FIG. 1.—*Prosser's Angular Wheels*, 1844.

lines of plates. The plates were of cast-iron, each one yard long, and had an upright ledge or flange upon the inner side in order to keep the flat wheels upon the line. Each end of each plate was held down by two iron bolts or spikes, and rested upon stone blocks instead of upon sleepers. Each block was 2 feet long, 1 foot wide, and 10 inches thick, and had two holes drilled into it in order to receive wooden plugs, into which the spikes were driven. This line of tramway gave birth to the expression "platelayer," as the men who fixed the plates to the stone blocks were called "platelayers," and that name has continued to exist although plates have been superseded by rails.

I will now give you some illustrations of the carriages used on early railways.

Horse-drawn Coach on a Railway.—Fig. 2 shows a railway as used in the early days in South Wales, when the carriages were hauled by horses. It will be observed that the wheels and the springs were of a design which continued to be used in a modified form for a great many years after steam railways came into existence.

FIG. 2.—*Early Railway travel in South Wales.*

Carriages.—On the Manchester and Leeds Railway, which was the parent line of the Lancashire and Yorkshire Railway, it is recorded that :—

"Carriages consist of first class weighing 8,100 lb.; second class, of three compartments, open at the sides, with wooden sliding shutters instead of glass sashes, weight 6,150 lb.; third class or Stanhopes, 17 feet long, 8 feet 8 inches wide—four entrances, the whole divided into four compartments by a wooden bar down the middle, and another across intersecting the first at right angles. Weight of this contrivance 5,050 lb., and the number of passengers it will contain depends upon the bulk of the stanhopers."

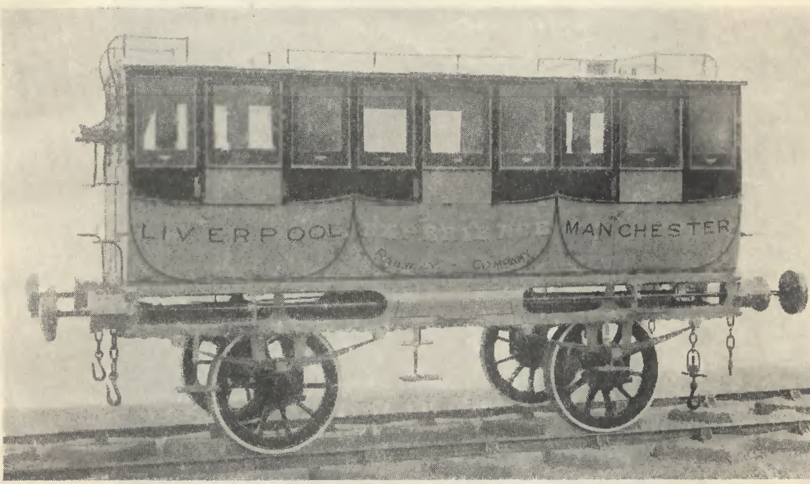
An extract from the Minutes of the Meeting of the Directors of the Manchester and Leeds Railway on 23rd July 1838, gives a vivid impression of the deliberation with which it was determined to prevent the accommodation in a third-class carriage being too good. The Minute is worded as follows :—

" Resolved 1st—

That there shall be three classes of carriages provided :

1*st Class.*—6 inside, complete with everything which can conduce to comfort.

FIG. 3.—*Coach used on Liverpool and Manchester Railway.*



2*nd Class.*—To carry 24 passengers ; division chair high ; windows in doors but none in the panels, and no cushions.

3*rd Class.*—Open boxes ; no roofs nor buffer springs."

There has been a surprising change in the standard of comfort with regard to railway carriage stock.

The screw coupling which connects modern railway carriages in this country is said to have been invented by Mr. Nathaniel Worsdell, and was first made by him at the Crown Street Works of the Liverpool and Manchester Railway.

Most people are familiar with the old illustrations of the four-wheeled carriages which were first used, but they may not have

Fig. 4.—*The opening of the Albany and Schenectady Railroad with the De Witt Clinton Locomotive*, 9*th Aug*. 1831.

FIG. 5.—*Paddington Station.* 1850.

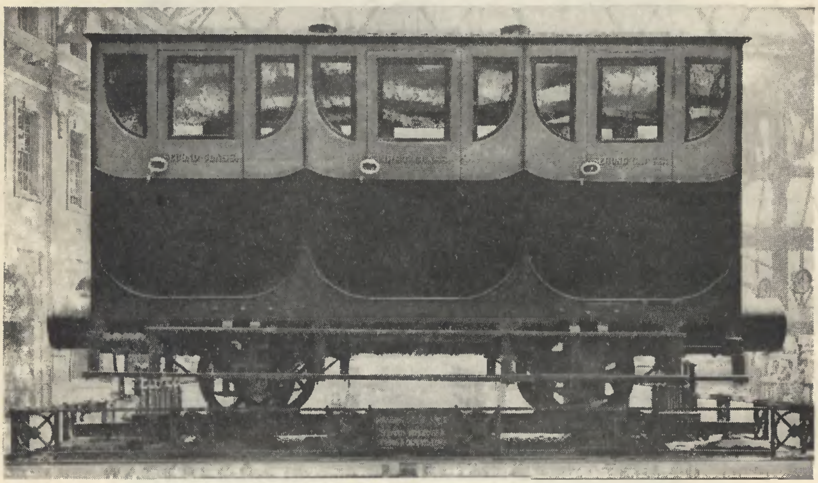
[*By Frith.*

Sherlock Holmes

noticed how low the roofs of these carriages were made, with a railing round the top which was put there to enable baggage to be loaded on top, then sheeted over with a waterproof sheet, and then strapped down with great leather straps running from side to side. When one remembers that the tunnels and bridges of to-day are no higher than they were then, it will be appreciated how necessary it was to keep the roof of the carriage down to allow for the baggage passing safely.

Fig. 3 shows the form of railway carriage which was used on the Liverpool and Manchester Railway. It will be observed that the body of the vehicle is made to represent three coach bodies of

FIG. 6.—*London and South Western Railway. Original Coach and Permanent Way used on the Bodmin and Wadebridge Branch from* 1834 *to* 1886.



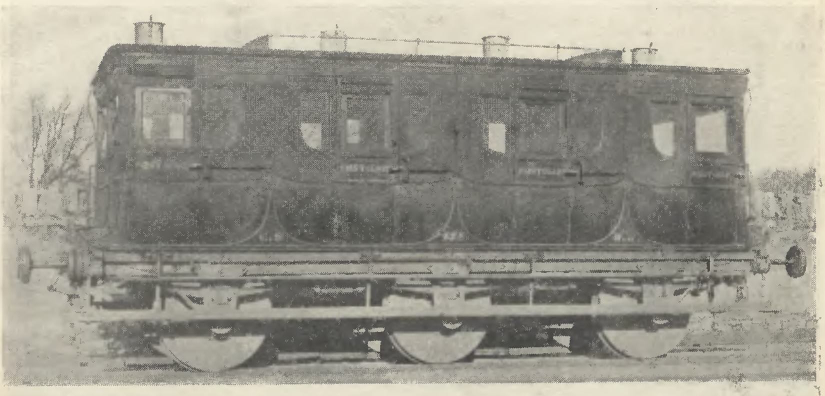
the old road form, and the shape of the panels was followed on other railways for some years. Fig. 4 shows the opening of the Albany and Schenectady Railroad in America in 1831, where it will be noticed that the actual old coach bodies were taken off their road wheels and put on to trucks made for the railway. Here again the shape of the panels followed the British practice.

Then we have Frith's picture of 1850, Fig. 5, which shows a train going out of Paddington Station. Following the ordinary practice of the day, the roofs of the carriages were made extremely low, and the passengers' baggage was piled on the top as previously mentioned and then carefully sheeted over to protect it from the weather. In this figure the porters can be seen in the act of dealing with the baggage. It is interesting to look at this picture, as on the extreme left you will see one of Daniel Gooch's locomotives standing beyond the train.

Fig. 6 shows a carriage of the Bodmin and Wadebridge Railway built about 1834, which can be seen any day on its pedestal on the concourse of Waterloo Station. This is a particularly interesting vehicle, as it shows how the old methods were continued, with the further interest that the carriage is standing on the original rails, chairs, and stone sleepers, which give a perfect record of the methods of the past. The second-class carriage on the same railway was a mere square box.

Very much later on, when I went to the Great Southern and

Fig. 7.—*Coach, Great Southern and Western Railway* (*Ireland*), 1875.



Western Railway in 1875, I found that they still possessed a number of carriages built in this way, probably made in the early "Forties," arranged for the carriage of baggage on the top, though this practice had been long discontinued. One of these vehicles is shown in Fig. 7. This continuation of the old pattern of coach body is only another illustration of how long it takes to leave behind old practices when there is no longer any reason for their existence, except that their builders had got into a rut.

The late Lord Leverhulme said that "you ought to endeavour to get out of ruts, as a rut and a grave are very much like one another, except that the rut is longer. They have this difference, however, that you can get out of the rut, but you cannot get out of the grave." This tendency in adhering to old patterns was well

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illustrated in modern times when first motor-cars came in, and it was impossible for some time to get the coach-builders to depart from those forms of body which had been in use with horse-drawn carriages.

Fig. 8 shows some of the railway carriages which are still used running round Paris, which are double-decked, seats and a roof being provided above the ordinary ones so as to admit of a double set of passengers. These carriages have been in existence for a good many years, and they are one of the best illustrations I know

FIG. 8.—*French Double-deck Carriages.*

of the very large loading gauge as regards height which is in existence on the particular railway on which these carriages are used. There is no railway in England which could permit these carriages to run through its tunnels or under its bridges.

The six-wheeled carriage was looked upon as a great advance upon the four-wheeled vehicle, though it is strange to see some four-wheeled vehicles yet in use. This was followed by the bogie vehicle, though for a short period on the London and North-Western Railway they used a radial axle-box at each end of an eight-wheeled carriage, which was intended as an alternative to the bogie. It was by no means a success, as the ends of the coaches swung over considerably at the curves and the carriages were uncomfortable to ride in.

Lighting of Carriages.—The lighting of railway carriages has undergone an immense improvement. Some of you, however, will recollect what it used to be like in the old days of the oil lamp, when but little attention had been paid to lighting efficiency, and in the third-class carriages one lamp was expected to serve for two compartments by the expedient of cutting a half-round hole in the partition between the two compartments and inserting the lamp in such a way as to shine both ways. These very inferior lamps were followed by much more efficient lamps burning mineral oil and giving a light which, though better, was very difficult to read by. On the French railways, however, they tackled this question very much earlier, and made some very good oil lamps fitted with a glass chimney, which gave a good light.

Then came the time when ordinary coal gas was stored on the tops of the Metropolitan Railway carriages in containers of the accordion type, the pressures being maintained by weights which tended to force the accordion downwards. This use of ordinary coal gas, however, led to a good many troubles, because of the tendency of the hydro-carbons to become deposited in the gas pipes and necessitate their being frequently cleaned out.

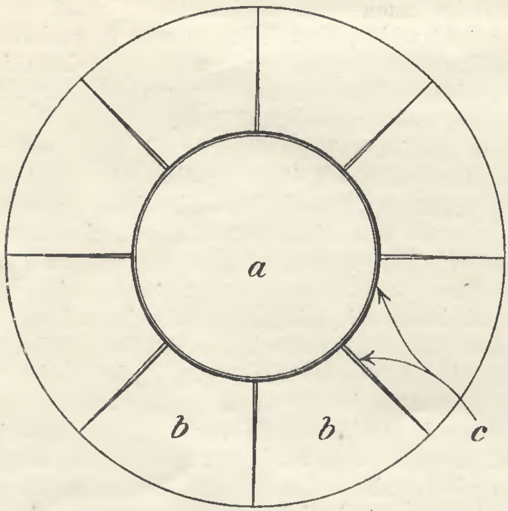
Later came the system of oil gas lighting, which was quite efficient, but did not give a brilliant light with ordinary burners. This again was much improved when the incandescent mantle came into use, and during the War, when there were difficulties about oil, it was found that a mixture of coal gas and of oil gas in combination with the incandescent mantle, gave an excellent light.

With regard to electric lighting that, of course, is familiar to everybody, but as each carriage has got its generator running underneath the coach, being driven from a pulley on the axle, each carriage becomes a travelling generating station, the power for which has to be supplied from the locomotive. It is much more expensive to install and to operate. The coal consumption which takes place in the fire-box of the locomotive to produce this current represents about 4 lb. of coal to the train-mile with a train of about ten carriages running at 40 miles an hour.

Heating of Carriages.—Many will remember how for a number of years no attempt whatever was made to warm the carriages, but that later foot-warmers were introduced, which involved a great deal of handling and which were by no means very efficient, as they did not remain very hot for long and were not of much value on a long journey.

The modern method of steam heating involves more work by the locomotive boiler, and it is probable that lighting, which is mentioned above, and heating during the winter time, when taken together, mean from 10 to 15 per cent of coal added to the ordinary locomotive expenditure for fuel on passenger trains in the winter during the hours of user.

FIG. 9.—*Cross Section of a Wagon Axle Journal made up of numerous pieces which were intended to be welded together.*



(*a*) Soft iron core.
(*b*) Segments of Harder iron surrounding soft core.
(*c*) Interstices between segments and core due to bad welding.

Axles and Tyres.—In the early days the methods of manufacture of axles and tyres had not reached the perfection of to-day, and it was a long time before steel was used for either tyres or axles. Iron axles were made by a number of firms in this country, and an endeavour was made by one firm to construct the journal of wagon axles in such a way as to give a hard wearing surface while the centre portion of the journal was made of softer iron.

No doubt when these things were first made they would be turned out with great perfection and all the surfaces welded together with great care, but as time went on it was found out that many of them were of very defective character, and the illustration, Fig. 9, shows what was the cause of the failure. It was quite easy to put the blade of a penknife in between these surfaces, and, as the journal wore, the exterior surfaces which had been held together by better welding no longer served to make a reliable journal. I have more than once, between 1875 and 1886, brought a striker out of the smithy to give one of these journals on a pair of wheels standing in the shop two or three sharp blows, when it would break off like a carrot. Needless to say, this kind of thing has long ago disappeared.

The same idea of getting a hard surface must, however, have been in Mr. John Ramsbottom's mind when he had all the tender axles at Crewe thoroughly case-hardened.

The best indication that can be given of the improvement that has taken place in axles is the fact that failures have decreased systematically during a long course of years, the following statement showing the number of broken tyres and axles in Great Britain since 1875 :—

Statement Showing the Number of Broken Tyres and Axles in Great Britain since 1875.

Year.	Broken Tyres. Number.	Year.	Broken Axles. Number.
1875	554	1875	461
1880	1,230	1880	494
1885	918	1885	364
1890	577	1890	249
1895	454	1895	182
1900	233	1900	163
1905	159	1905	127
1910	98	1910	101
1915	78	1915	90
1920	54	1920	107

Detailed Returns.

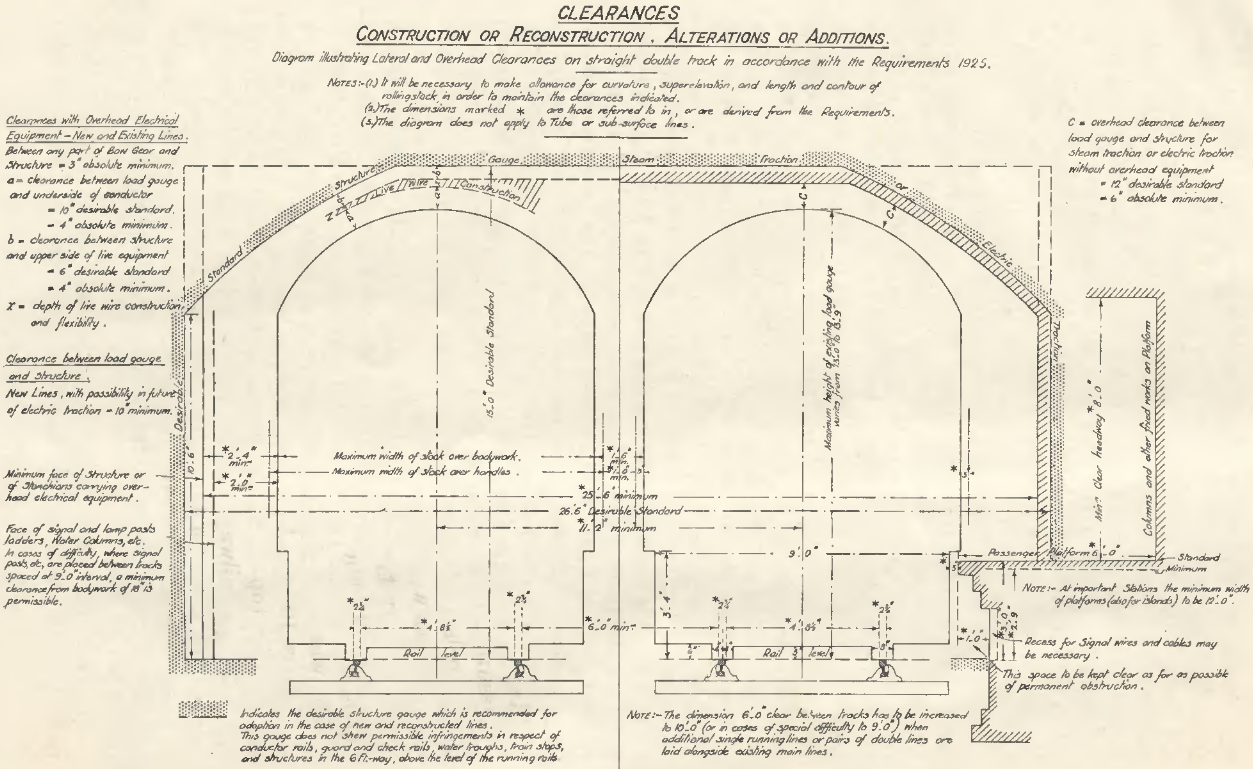
1922—Engine . .	14	1922—Engine . .	53	Crank or driving .	35
Tender . .	2	Tender . .	13	Leading or trailing	18
Coach . .	3	Coach . .	14		
Wagon . .	36	Wagon . .	9		
Total . . .	55	Total . . .	89		
1923—Engine . .	18	1923—Engine . .	46	Crank or driving .	33
Tender . .	1	Tender . .	17	Leading or trailing	13
Coach . .	5	Coach . .	10		
Wagon . .	46	Wagon . .	11		
Total . . .	70	Total . . .	84		

It will be observed that in cases of broken axles the number has fallen from 494 in 1880 to 84 in 1923, while with regard to broken tyres the numbers have fallen from 1,230 in 1880 to 70 in 1923. The large number of tyres in the earlier years which are shown to be broken was due very largely to the fact that a great many old iron wagon tyres remained in existence, and these used to fail circumferentially due to bad welding.

When, in later years, the Government returns were so subdivided as to show the numbers of engine, tender, coach, and wagon axles or tyres separately, it will be observed that the number of broken crank-axles has fallen to 33 in 1923. Having regard to the fact that there are, roughly, 24,000 locomotives in this country, this is quite a remarkable record.

Battle of Gauges.—The battle of the gauges in this country is still within the memory of many people, and it is not so many years since the Great Western altered from their 7-foot gauge to the ordinary 4 foot 8½ inch, but it is not so generally known that in America they had a great variety of gauges. I remember that when over there in 1872 I was greatly struck by seeing a number of their freight-cars labelled "broad tread" and "narrow tread," and when I came to inquire as to the reason of this, it appeared that there was a variation of gauge, some of the railroads being 4 feet 10 inches, others 4 feet 9½ inches, and others 4 feet 8½ inches.

Fig. 10.



(Reproduced about 1/3rd original size.)

The intention was that these freight cars or other vehicles should run upon any of these tracks, and for that purpose, while the flanges of the tyres were sufficiently near to one another to permit of their running safely on a 4-foot 8½-inch gauge, the tread of the tyre was wide enough to prevent it dropping in between the rails on a wide track of 4 feet 10 inches. I am indebted to Mr. J. T. Wallis, Chief of Motive Power of the Pennsylvania Railroad, for the exact facts as to these differences of track-gauge, and these facts will be found set out in an Appendix (page 1149).

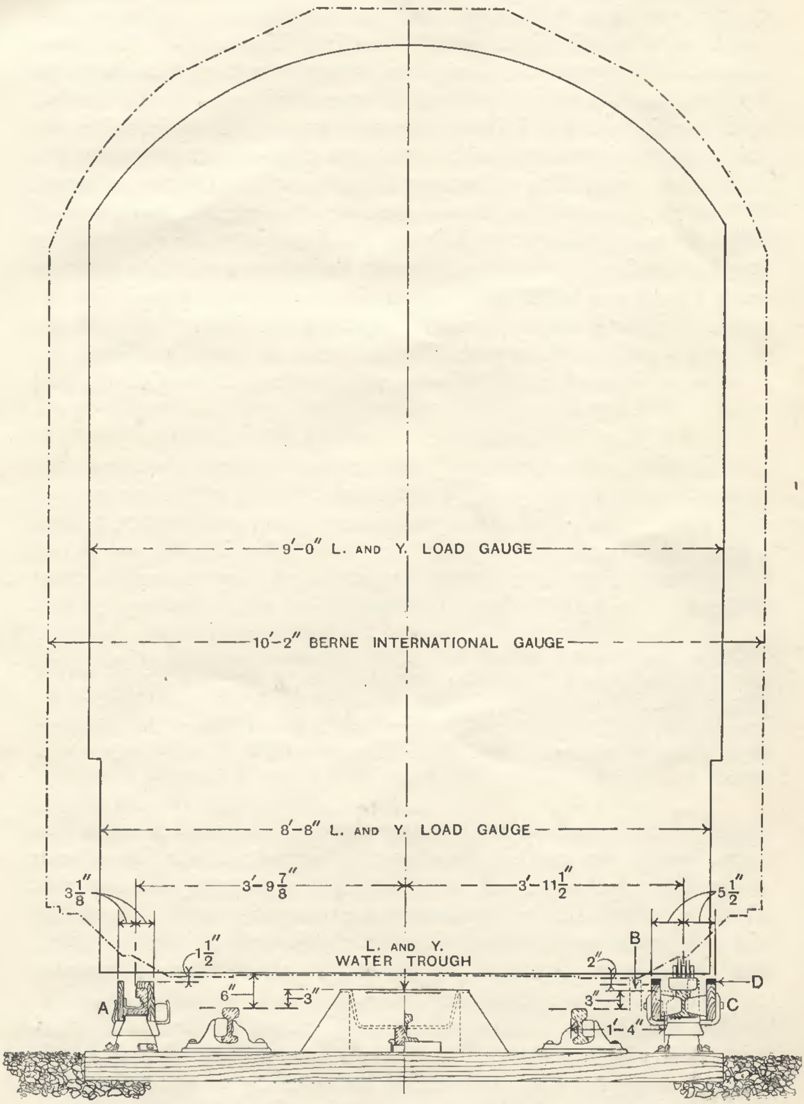
The Ministry of Transport, in the early part of this year, issued both their regulations with regard to new railways, and their recommendations with regard to the changes on old railways, and these documents are of considerable interest to engineers. The result of following these regulations will be to make considerable improvements both in the structure gauge of the railways and in the strength of bridges. The immense variety of the structure gauges on the railways in this country has prevented the construction of larger rolling stock, and we are not in the same fortunate position as the railways on the Continent, who can make their vehicles up to what is known as the " Berne " gauge.

In order to illustrate (*a*) what is known as the structure gauge, and (*b*) what is known as the loading gauge, Fig. 10 is shown, which gives all the leading dimensions with other particulars in the form of notes. This figure is a reduced copy of the new Government Regulations. Allowances are made so that ample clearance will be assured for any overhead electric equipment which may be placed in tunnels or under bridges in the future, but the whole diagram becomes worthy of study as showing the great difficulty of finding space for the attachment of anything more to the rolling stock than is found in practice to-day.

As to the question of existing gauges, Fig. 11 is shown, which gives the old Lancashire and Yorkshire load gauge as being 9 feet wide, while that of the Continental railways known as the " Berne " gauge is 10 feet 2 inches wide. On the right-hand side will be found the top contact rail in the position in which it is used on the electric railways in the North of England, and next to it the top contact rail in the position in which it is used on the electric railways in and about London, while on the left-hand side will be seen the side contact rail which is in use on the old Lancashire and Yorkshire Railway for their 1,200-volt electric lines running out of Manchester.

Two forms of fourth rail are shown in the centre of the track which indicate from their position that a water trough, which is also

Fig. 11.—*The "Berne" International Gauge compared with the Lancashire and Yorkshire Railway Load Gauge.*



A.—M. & B. Third rail and guarding.
B.—L. & S.W. ,, ,, (Dotted on right.)
C.—L. & S. ,, ,,
D.—Railway clearing house, position of guarding.

shown, cannot be laid down on the same length of railway. This has an important bearing on the question of the suspension of triggers for the operation of automatic signalling or methods of train stopping.

A very apt illustration of the difficulties created by small construction gauges and weak bridges at the present time is shown by the fact that when the Great Western Railway and the London and North Eastern Railway recently exchanged locomotives for trial upon their respective lines, and the North Eastern locomotive had to go from King's Cross to Paddington, a distance of about 3 miles as the crow flies, it was necessary to send it as far north as Sheffield to get back to Paddington, a distance of about 300 miles. On the map it would look as if it could have gone by certain railways with a very much less mileage, but in one case the gauge was too small to allow it to pass through the tunnels; in another case the bridges would not carry the engine, and in the third case the bridges again prevented its being safe to send the engine by that route.

Signalling.—To appreciate the immense advance that has been made with regard to signalling and train stopping which has enabled such a state of modern railway efficiency to be produced, you have only to read an old railway rule book to see that in 1846, on one of the railways where signals did not exist, and they controlled their trains by time and distance, it said :—

"All Engines travelling in the same direction shall keep Six Hundred Yards at least apart from each other, that is to say—the Engine which follows shall not approach within Six Hundred Yards of the Engine which goes before; and in coming down any of the Inclined Planes the following Engine shall not come within Nine Hundred Yards of the Train which precedes it."

The changes which have taken place with regard to signalling have been very great. Step by step improvements have been made, not only for the sake of saving time, but mainly for ensuring absolute safety if the appliances are properly used. Signalling not only includes the visual signals by which the driver is guided, but those very numerous appliances of an electrical character connected with the progress of trains.

The description of these would require a volume in itself, but I have seen within my own time the change from the simple hand-worked semaphore to the careful interlocking of all points and signals which control the proper sequence of movement, and later either the electric pneumatic, or the all-electric equipment in the modern signal-box where the hard work of the signalman has disappeared, and he effects the movement of a set of points or a signal by means of a small lever which requires no physical exertion.

The most modern change has produced signalling by lights, both by night and day. The block instruments, perfect telephonic communication between signal-boxes, and the existence of track circuiting in those places where it is found to be necessary, electrical signal repeaters, and, in some cases, arrangements for lock and block, have all tended to relieve the anxieties of the signalman, and thus enabled him to deal with a larger number of passing trains without undue strain. All these appliances have added a great deal to the cost of railways, but they have come about mainly to ensure our modern requirement of "safety first."

It will be recognized that every effort to increase the capacity of a railway and to pass a larger number of trains per hour over any one set of rails, requires a close investigation of the methods by which minutes and even seconds may be saved and time margins reduced, coupled with a demand for those safeguards which will enable the work to be done with safety. It is perfectly true to say that intense density of traffic has been the creator of modern safety appliances.

In the early "Seventies," long before the block system of to-day had been brought to its state of perfection, there was not that keen appreciation of risks which must be avoided. When I was working as a fireman running between Crewe and London, it used to be the practice, when a train arrived at Crewe which was a little heavier than the limit allowed, for the locomotives of the Ramsbottom "Lady of the Lake" class, which then hauled all the expresses, to attach another 7-foot 6-inch wheeled engine of the same class in front, which went as far as the top of the incline at Tring.

When some little distance away from the signal-box at Tring, the fireman on the front engine climbed to the back of the tender and unhooked the coupling between the first and the second engine. The driver then gave five whistles and, while the driver of the train engine slacked a little, the driver of the first engine ran ahead as fast as he could past a pair of points leading to a siding and then backed rapidly into that siding, the train following without stopping and passing these points a few minutes later. This practice would be quite sufficient to make the hair of a modern railwayman stand on end.

It must be recollected that on these trains there were no continuous brakes such as we have to-day, and therefore the stopping power depended entirely upon the hand-brakes on the tender and on the guard's van.

I did not think that such a thing happened elsewhere, but shortly afterwards I went to America to look at some of the American roads, and travelled on a train from Altoona on through the Horseshoe Curve, and then through a tunnel. I was on the footplate of the first engine, and I was astounded when we got out of the tunnel to find that the first engine was running sharply off to the right, having been turned on to a siding through a set of facing points, and I saw the train a second or two later passing off to the left on the main line. The block system has altered all this in this country, and has created a perfection of check which is responsible in a very large measure for the present safety on railways.

To-day, of course, we have in many cases automatic signalling, and upon our underground systems, where automatic signalling is very much more easy to deal with than on main lines with complicated sidings, we have the arrangement whereby the train is brought to a stand by an obstruction raised on the permanent way striking the trigger on the motor vehicle in front, which at once applies the brake in the event of the driver passing the danger point. One of the first applications of this kind of thing which is known to the Author was that produced by M. Lartigue and fitted on the Northern Railway of France in the early "Seventies," where a copper brush was suspended under the foot-plate of the locomotive, which came in contact with what they called a "crocodile," which was a piece of timber covered with a brass plate; and should the signal be at danger, an electric current was conveyed through this copper brush to an arrangement on the foot-plate, which put the brake on.

Six brief descriptive Papers on "Signalling on Railway Trains in Motion" were read by French engineers at our Paris meeting in 1914.* Also five brief Papers by English engineers on "Audible and other Cab Signals on British Railways" at our London meeting in the same year.†

Continuous Brakes.—Continuous brakes were in use on the Lancashire and Yorkshire Railway in 1853, the form of brake being that known as the "Fay and Newall" brake, which was applied by the guard throughout the train by means of a shaft that went

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* Proc. I.Mech.E. page 463.

† Proc. I.Mech.E. page 843.

underneath all the carriages and had universal joints with a telescopic arrangement between the carriages to allow not only of the rise and fall of the vehicles, but of the compression of the buffers. These brakes remained in use for many years, and of their kind were very efficient.

Then came the time when the Westinghouse brake was first introduced into this country in its non-automatic form, to be followed not long afterwards by Smith's vacuum brake, which was operated by means of an accordion-like rubber cylinder, this form of brake being later much improved by the use of what was known as the "Hardy" cylinder, later by the "Clayton" cylinder.

The London and North Western Railway, desirous of avoiding the use of the continuous air-pressure brake, adopted a form of chain brake with the chain running throughout the train, which was applied by the guard and was worked by a drum on the axle. It was not an experiment which lasted long, as it was extremely harsh in its application and on more than one occasion led to breakaways.

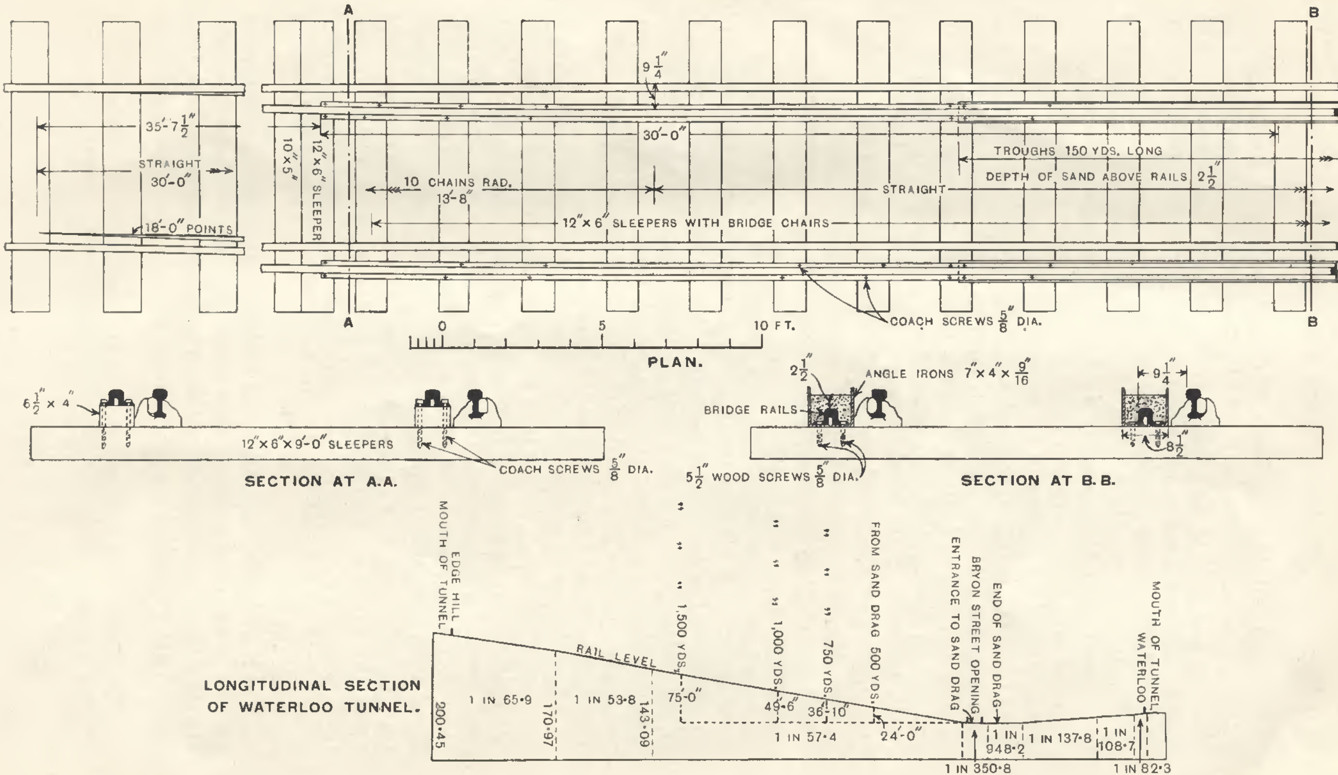
Later on, pressure from the Board of Trade resulted in modifications of brakes, making them automatic in the event of an accidental severance of a train. The first so altered was the Westinghouse brake. This was followed by the vacuum brake being made automatic, with the result that in this country all passenger vehicles are fitted with either the vacuum brake or the Westinghouse, and some goods vehicles also.

The number of goods vehicles fitted with continuous brakes is comparatively small, but it is to be hoped that this will be changed as rapidly as it is reasonably possible, because the tendency is to haul heavier goods trains; and they could be made even heavier than they have been, in any case at present, if all the vehicles were fitted with continuous brakes so as to give the power of stopping rapidly, whereas now the trains are almost wholly dependent upon the brake on the engine and in the guard's van. If this modernization took place, the length of goods trains in this country would only be limited by the strength of the three-link coupling between the wagons.

The introduction of continuous brakes led to careful investigation on the part of Captain (afterwards Sir Douglas) Galton and Mr. George Westinghouse of the results of skidding, and they showed quite clearly that:—

"The resistance which results from the application of brakes without skidding is greater than that caused by skidded wheels. Just at the moment

Fig. 12.—*Details of Catch Siding leading to Sand Drag in Waterloo Tunnel, Liverpool.*



of skidding, the retarding force increases to an amount much beyond that which prevailed before the skidding took place; but immediately after the complete skidding has taken place, the retarding force falls down again to much below what it was before the skidding."

The result of this was that in some cases in the early days of continuous brakes, when the brake was improperly applied and the engine wheels skidded, the engine lurched forward at a higher rate of speed and broke the couplings between the engine and the train.

Those who are interested in this subject are referred to the Proceedings of this Institution, 13th June 1878, 24th October 1878, and 24th April 1879.

Sand Drag.—The most effective train stop, however, for use in case of runaway trains that has ever been produced, is the sand drag. This was invented by an Austrian engineer named Herr C. Kopcke, of Dresden, but it was first applied in this country by the London and North Western Railway in the tunnel which runs from Edge Hill, Liverpool, down to their Waterloo Dock Goods Station, Fig. 12.

It consists of a second pair of rails laid in close to the main track, which rails are enclosed, as it were, in a wooden trough, the sides of which stand up about 3 inches above the rails. The internal space is then filled in with either sand or fine gravel kept level with the top of the troughing. In the event of a runaway train the signalman can divert the vehicles from the running road into the sand drag. The retarding effect is instantaneous, and the whole of the runaway vehicles are rapidly but gently brought to a stand.

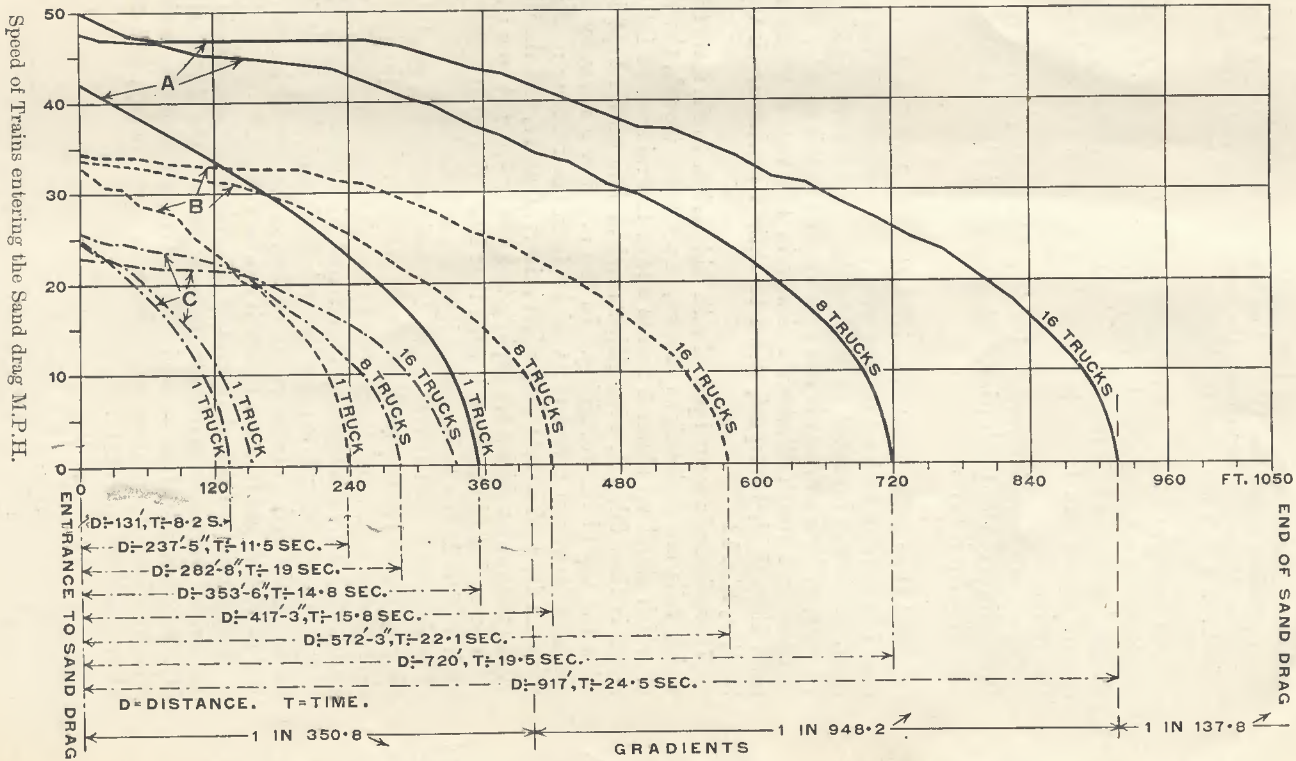
The action of the drag is such that it applies itself equally to each vehicle in the train, and if it be a goods train, the couplings of which are at full stretch when the train enters the sand drag, they remain at full stretch through the whole period of the journey through the drag, and there does not seem to be any tendency to buffer up. It has frequently been found with such drags as these that it is most difficult to move the train back again into its position on the main line, even down an incline, and a second locomotive has to be brought into use before it can be shifted.

Some curves which show clearly the rate of retardation in the Waterloo Tunnel experiments were given to me in 1902 by Mr. Footner, the London and North Western Railway engineer who first laid down these sand drags in this country, and these are reproduced in Fig. 13.

FIG. 13.—*Retardation curves of Sand Drag in Waterloo Tunnel, Liverpool.*

A.—Speed curves for trains starting at 8,000 feet from entrance of the sand-drag.
B.— ,, ,, ,, ,, 4,000 ,, ,, ,, ,,
C.— ,, ,, ,, ,, 2,000 ,, ,, ,, ,,

Each truck loaded and weighed, $11\frac{1}{2}$ tons.

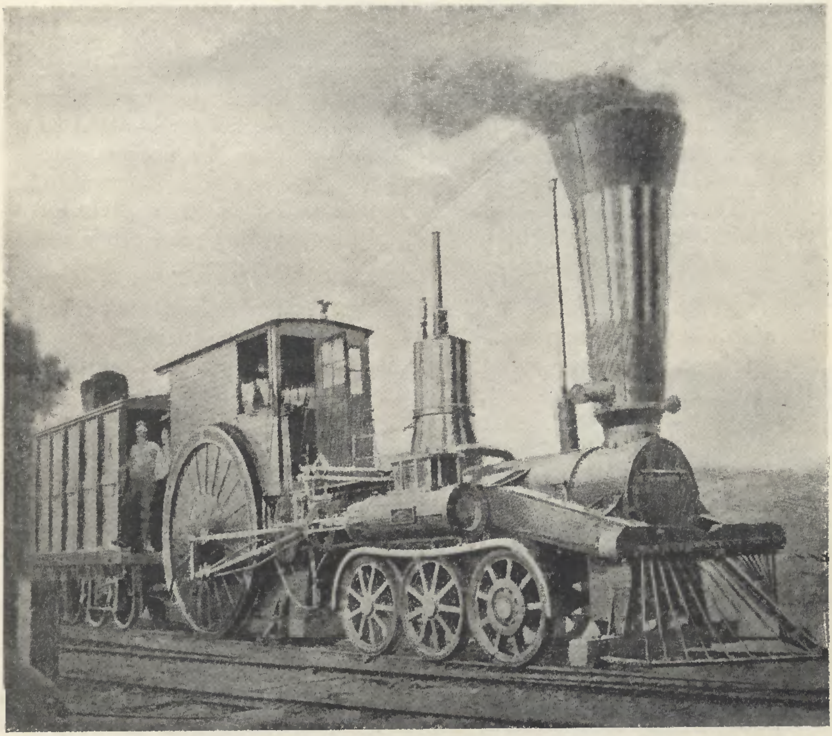


NOTE :—Distances measured from the entrance of the Sand drag to the leading wheel of the leading truck.

It will be found that there are slight discrepancies in the figures shown for the length of the wooden trough and the depth of the sand between Figs. 12 and 13, the former representing what was carried out for the permanent arrangement, and the latter what was done in the case of the first experiments,

A statement was recently made about a drag on another railway

FIG. 14.—*Locomotive, Camden and Amboy Railroad, U.S.A.*, 1845.



(the Great Western) where, upon an incline of 1 in 57, a drag 1,000 feet in length had been installed, a train under runaway conditions weighing 1,003 tons and running at 33 miles an hour was brought to a stand in thirty-two seconds. I had a number of these sand drags laid down on the Lancashire and Yorkshire Railway, and the experience gained from them was wholly satisfactory, and they had the effect of saving many serious accidents on inclines.

Inspection of Railways.—For a large number of years now all railway accidents have been inquired into by the Inspectors of either the Board of Trade or the Ministry of Transport, who have exercised constant vigilance in suggesting changes or improvements which would minimize any railway risks that may exist.

There have no doubt been differences of view as between the Government inspectors and those who control and operate the railways, but these have only had the effect of creating further study of the points in question, which study has resulted in the end in agreement as to what is really desirable. There is no doubt, however, that the railway companies have appreciated the absolutely impartial investigations which these inspecting officers have held into the various matters which have been submitted to them, and the public have to thank them for the patient care with which each case is gone into.

I do not propose to give many illustrations of locomotives for the reasons stated in the first part of this Lecture, but I think one illustration of an old American locomotive is of interest.

Early American 8-foot Single.—Fig. 14 illustrates the Camden and Amboy locomotive of 1845, which had a large 8 feet diameter driving-wheel at the end of the boiler, showing that the Crampton idea was not confined to this country.

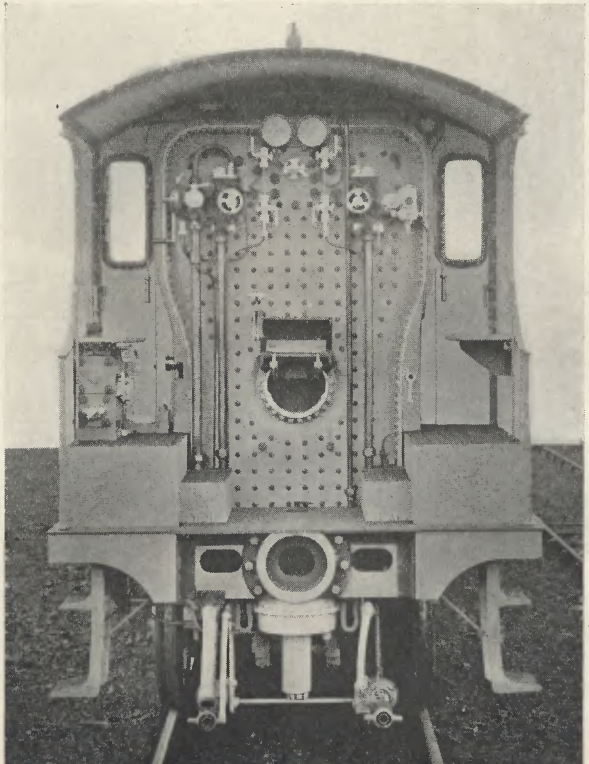
Footplate Views.—In order to show the difference between the footplate of a modern locomotive and those built many years ago, Fig. 15 has been prepared, which shows the footplate of Lancashire and Yorkshire Engine No. 1,400, built in 1899, and the footplate of engine No. 36 built by Messrs. Bury, Curtis and Kennedy for the Great Southern and Western Railway in 1848. It will be observed that there is no protection from the weather for the driver on the Bury, Curtis and Kennedy engine, and even later it was only usual to put a weather-board in front.

I can well remember the time, about 1872, when Mr. Webb put the first cab on to a London and North Western engine. As these cabs were added to other engines, much indignation was expressed by the drivers, who had from their daily exposure to the weather become very hardy, whereas when they worked on an engine with a cab they were kept much warmer while there, but were much more affected by the weather on account of the changes of temperature when they were off the engine.

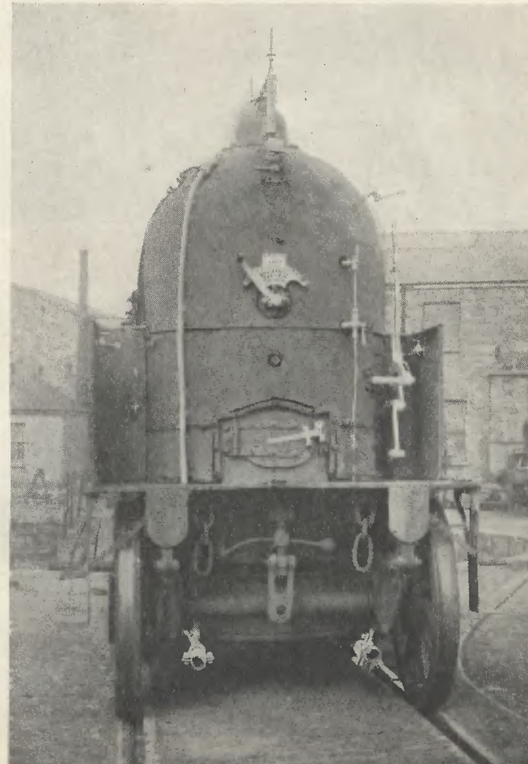
Increase in Size of Locomotives.—Fig. 16 shows two engines which I designed for the Lancashire and Yorkshire Railway, one

Fig. 15.—*Footplate Views.*

Engine No. 1400, designed by the Lecturer, 1899.



Engine No. 36, Messrs. Bury, Curtis and Kennedy, G.S. & W.Ry., Ireland, 1848.



No. 1,099 built in 1891, and the other, No. 1,400, built in 1899. So far as the mechanism is concerned, these engines are almost identical in design, but No. 1,400 was fitted with a large boiler, of which an illustration is shown in Fig. 17, which stood very much higher above the rails than had been the practice in this country before.

Looking back over the history, during a number of years, of the practice as regards the Lancashire and Yorkshire Railway, I have found that, speaking roughly, every ten succeeding years has demanded a change, higher speeds and heavier loads having called for a much more powerful machine, and Fig. 16 shows the difference between engine No. 1,099 and No. 1,400, and is merely an illustration of this growth.

It is an amusing fact that when engines of the No. 1,400 class first began to run on the Lancashire and Yorkshire Railway, a very prominent director of one of the locomotive building firms of the country, who travelled in these trains every day, was asked by his fellow-passengers to come and see me with regard to them, because they could not believe that these engines were safe. I was, however, able to put such information in his hands as to convince his fellow-passengers that the high centre of gravity ensured better riding and a better use of the springs, which all made for safety, as contrasted with the days of the very early engines of the Bury, Curtis and Kennedy type, which had their boilers placed very low and used to waddle in such a way as to tend to burst the road.

I have thought it right to illustrate, Fig. 18, the largest passenger locomotives which are at the present moment being used upon the four groups of railways in this country.

These six illustrations are made out to the same scale, and give exactly the same kind of information with regard to each of the respective machines, so as to make a comparison easy and form a perfect record of modern practice. The engines illustrated are :—

The L.M. and S. Railway . .	4–6–0	No. 8 Class.
,, ,, . .	4–6–0	Claughton Class.
,, ,, . .	4–4–0	Compound.
,, Southern Railway . .	4–6–0	No. 15 Class.
,, G.W. Railway . . .	4–6–0	Castle Class.
,, L. and N.E. Railway . .	4–6–2	Pacific Class.

Several of the locomotives are of such over-all dimensions that no real practical increase can be made in their size in the future owing to the limitations of the structure gauge.

It is as well to remember that with us the limiting factors

Fig. 16.—*Engines Nos.* 1099 *and* 1400.

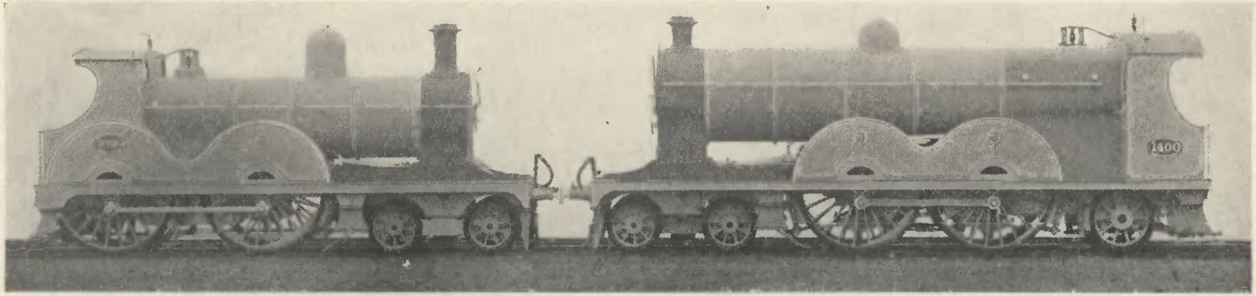


Fig. 17.—*Boiler of Engine No.* 1400.

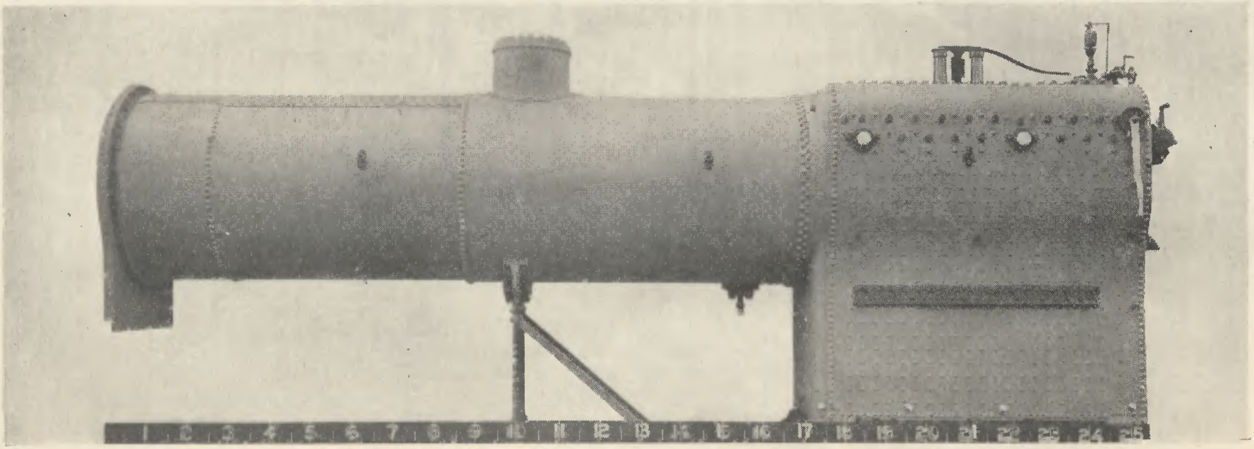
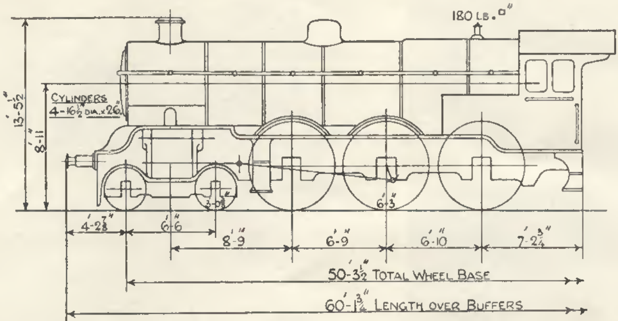


FIG. 18.—*Six Diagrams of Modern Locomotives.*

L M S.

4-6-0. CLASS 8. SUP^HD.



	T.C.Q.	T.C.Q.	T.C.Q.	T.C.Q.
WEIGHTS LOADED	19-15-0	20-0-0	19-17-0	19-9-0

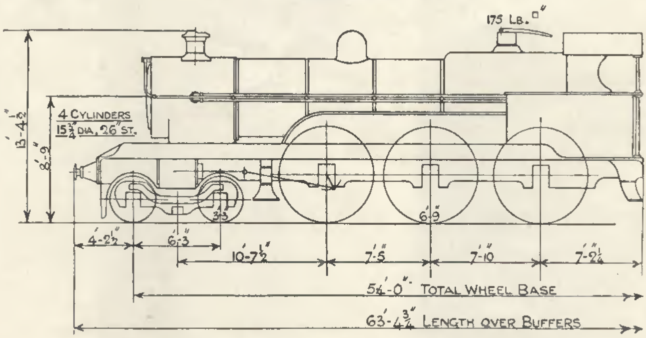
	T.C.Q.
ENGINE LOADED	79-1-0
DO. LIGHT	72-12-0
TENDER LOADED	40-0-0
DO. LIGHT	19-11-0
ENGINE & TENDER LOADED	119-1-0
DO. DO. LIGHT	92-3-0

TRACTIVE POWER AT 85 % B.P. = 29,470 LB.

TENDER:— (6 WHEELS) WATER, 3,000 GALLONS; COAL, 6 TONS.

L M S.

4-6-0 CLAUGHTON CLASS SUP^HD.



	T.C.Q.	T.C.Q.	T.C.Q.	T.C.Q.
WEIGHTS LOADED	18-15-0	19-15-0	19-15-0	19-10-0

	T.C.Q.
ENGINE LOADED	77-15-0
DO. LIGHT	71-15-0
TENDER LOADED	39-5-0
DO. LIGHT	19-2-0
ENGINE & TENDER LOADED	117-0-0
DO. DO. LIGHT	90-17-0

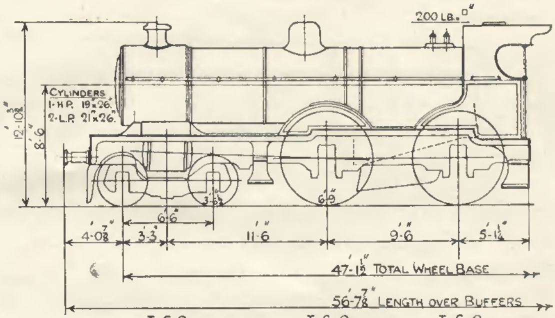
TRACTIVE POWER AT 85 % B.P. = 24,130 LB.

TENDER:— (6 WHEELS) WATER 3000 GALLONS; COAL 6 TONS.

Fig. 18.—(*Continued.*)

L M S.

SUP^HD. COMPOUND PASS^R ENGINE



WEIGHTS LOADED	T. C. Q. 22-10-0	T. C. Q. 19-15-0	T. C. Q. 19-9-0

	T. C. Q.
ENGINE LOADED	61-14-0
DO. LIGHT	57-9-1
TENDER LOADED	42-14-0
DO. LIGHT	21-11-2

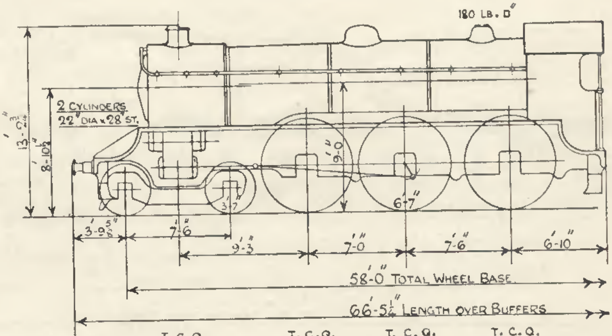
	T. C. Q.
ENGINE & TENDER LOADED	104-8-0
DO. DO. LIGHT	79-0-3

TRACTIVE POWER AT 80 % B.P. = 22,649 LB.

TENDER:– (6 WHEELS) WATER 3500 GALLONS; COAL 5½ TONS.

S. RY.

N 15 CLASS, SUP^HD.



WEIGHTS LOADED	T. C. Q. 22-0-0	T. C. Q. 19-7-0	T. C. Q. 19-10-0	T. C. Q. 19-10-0

	T. C. Q.
ENGINE LOADED	80-7-0
DO. LIGHT	74-8-0
TENDER LOADED	57-16-0
DO. LIGHT	30-18-0

	T. C. Q.
ENGINE & TENDER LOADED	138-3-0
DO. DO. LIGHT	105-6-0

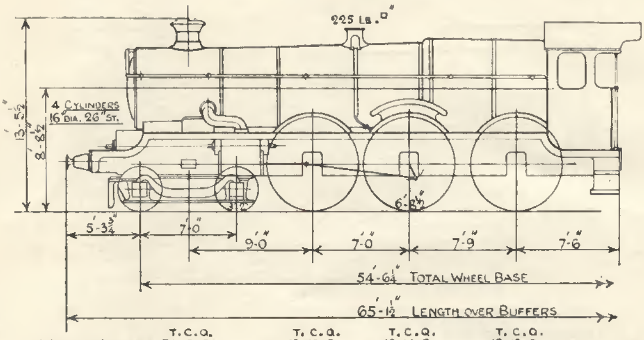
TRACTIVE POWER AT 85 % B.P. = 26,246 LB.

TENDER:– (8 WHEELS) WATER 5,000 GALLONS; COAL 5 TONS.

FIG. 18.—(*Continued.*)

G W RY.

CASTLE CLASS, SUPHD.



	T.C.Q.	T.C.Q.	T.C.Q.	T.C.Q.
WEIGHTS LOADED	21-0-0	19-10-0	19-14-0	19-13-0

	T.C.Q.		T.C.Q.
ENGINE LOADED	79-17-0	TENDER LOADED	40-0-0
DO. LIGHT	73-15-0	DO. LIGHT	18-5-0

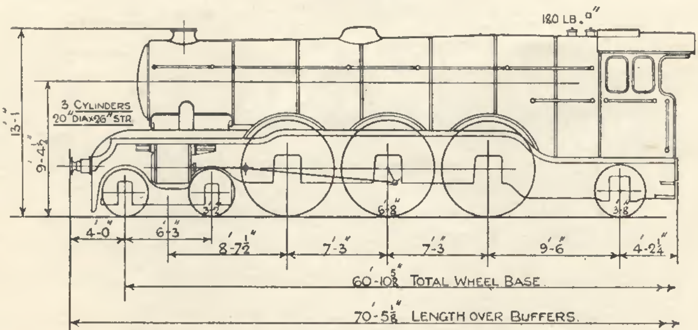
	T. C. Q.
ENGINE & TENDER LOADED	119-17-0
DO. DO. LIGHT	92-0-0

TRACTIVE POWER AT 85% B.P. = 31,625 LB.

TENDER:- (6 WHEELS) WATER 3500 GALLONS; COAL 6 TONS.

L & N E RY.

"PACIFIC" CLASS SUPHD.



	T.C.Q.	T.C.Q.	T.C.Q.	T.C.Q.	T.C.Q.
WEIGHTS LOADED	17-1-0	20-0-0	20-0-0	20-0-0	15-8-0

	T.C.Q.		T.C.Q.
ENGINE LOADED	92-9-0	TENDER LOADED	56-6-0
DO. LIGHT	82-9-0	DO. LIGHT	26-7-0

	T. C. Q.
ENGINE & TENDER LOADED	148-15-0
DO. DO. LIGHT	108-16-0

TRACTIVE POWER AT 85% B.P. = 29,835 LB.

TENDER:- (8 WHEELS) WATER 5000 GALLONS; COAL 8 TONS.

against very big loads are at present: the strength of bridges, the strength of the three-link coupling, and the absence on goods trains of continuous brakes.

The probable tendency with regard to future locomotives will be to use higher pressure in the boilers, as the outside cylinders of locomotives have already reached dimensions which cannot be exceeded on account of the station platforms projecting as far as the construction gauge will admit. One means of getting over this difficulty, apart from other advantages, is to use the three or four cylinder engine.

With a view to seeing what can be done in higher pressures the Delaware and Hudson Railroad, assisted by the advice of Sir Alfred Yarrow, have quite recently designed and built a locomotive boiler with a large number of water tubes, the pressure being 350 lb. per square inch. This is illustrated in Fig. 19.

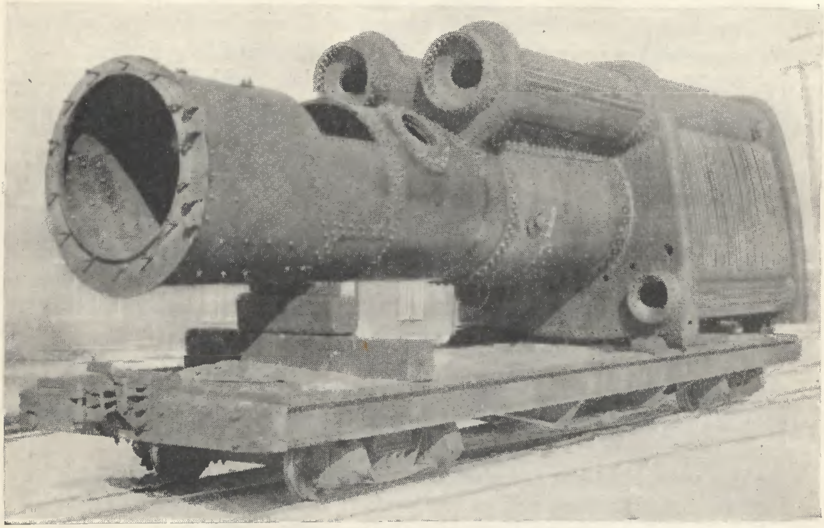
The wearing capacity of the machinery of a locomotive, apart from the boiler, is very great, and it is very true to say that it far outlasts its capacity for haulage, which is brought to an end by the increase of loads.

The great reliability of the steam locomotive is illustrated by the fact that the failures are so few, and it is really a testimonial to reliability when you remember that the daily newspapers consider it such an unusual occurrence for an engine failure to take place that they make it the subject of large headlines. When you look also at the fact that there are 24,000 locomotives on the English railways and that the number of engine-miles run in 1924 was 398,000,000, you will appreciate that to run over 1,000,000 miles per day with only occasional failures is a very wonderful performance.

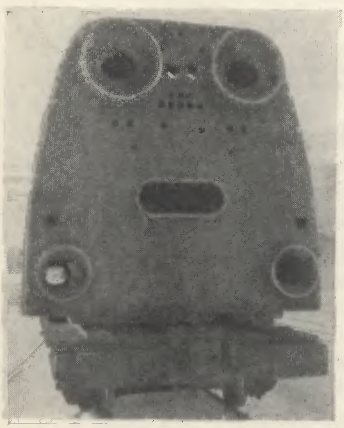
American Locomotives.—In the United States the difficulties of increasing train loads are less than with us, and taking the Pennsylvania Railroad as typical of American practice we find that with passenger locomotives the tractive effort of their engines has increased between 1899 and 1923 by 301 per cent, their 4–8–2 class M.1. with 27 inches by 30 inches cylinders and 250 lb. boiler pressure, giving a tractive effort of 64,550 lb.

With their freight locomotives, between 1901 and 1922, the percentage of increase with the HC1s class, which has four cylinders 30½ inches by 32 inches and a boiler pressure of 205 lb. per square inch, has risen 320 per cent, having a tractive effort of 135,000 lb., while their 2–10–0 with two cylinders 30½ inches by 32 inches, with 250 lb. pressure, gives a tractive effort of 90,000 lb., or 213 per cent increase.

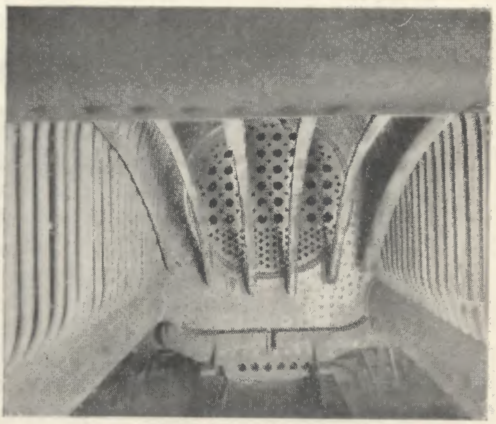
FIG. 19.—*Locomotive Boiler, Delaware and Hudson Railroad.*



The Back Head.



Interior of Water tube Boiler.



In all cases the mean effective pressure has been taken at 75 per cent of the boiler pressure.

Wooden-framed Tenders.—As showing the desire to avoid possible injury to passengers, it may be of interest to know that John Ramsbottom told me that the reason why, on the London and North Western Railway, they made their tender frames of timber for so many years, was that, according to his view, the tender between the engine and the train should be the weakest part of the train, and that this should break up first in case of collision and thus save the passenger carriages. The idea seems to have been similar to that with regard to having a breaking spindle in a rolling mill.

Views of High Speed in 1862.—Looking backwards, some will recollect what was considered a wonderful run over sixty years ago at the time of what was known as the "Trent" affair, when Messrs. Slidell and Mason, two Confederate representatives, were taken from the British ship by the "San Jacinto," a Federal ship, and made prisoners. This led to an incident on 7th January 1862 in locomotive running which was thought much of at the time, when a special train was kept ready at Holyhead to carry the British representative to London. A run of 130½ miles from Holyhead to Stafford was made by Ramsbottom's engine called "Watt," in two hours and twenty-five minutes, the average speed being 54 miles per hour, and then the train was taken on 133½ miles to Euston by one of McConnell's single-wheeled inside cylinder engines of what was known as the "Bloomer" Class, No. 372. - 7'6"

Modern High Speed Timing of Trains.—Nowadays, however, we have arrangements such as those on the London, Midland and Scottish for running high-speed trains between London and Birmingham. The time between Willesden and Birmingham is scheduled to be 109 minutes for a distance of 107½ miles, and it has been shown that on some occasions the journey has been done in 102 minutes, while on the Great Western Railway there are several instances of trains which are actually timed to run between Swindon and Paddington and Paddington and Bath at over 61 miles per hour.

Old-time Heavy Goods Train Loads.—It is recorded by Mr. Salt that a trial was made in August 1846, on the Manchester and Birmingham line, of a powerful engine made by Messrs. Sharp, Brother and Co. for the company, possessing several improvements, suggested by Mr. John Ramsbottom, the company's locomotive superintendent. A train of merchandise was drawn by this engine from Manchester to Crewe, which comprised ninety-seven wagons, the gross weight of which was 586 tons and the net weight of the goods 264 tons. The rate of speed was 15 to 25 miles an hour.

Again, under the heading "Monster Train": on Saturday, 3rd October 1846 a train of merchandise left Manchester for Crewe composed of 101 wagons. Its gross weight was 600 tons and its length 1,550 feet. The distance, 30 miles, was accomplished in two hours and nine minutes, being at the rate of 14 miles an hour over gradients varying from 1 in 377 to 1 in 880. The engine was made by Sharp and Co. and accompanied by Mr. Beyer, Mr. Ramsbottom, and Mr. Salt.

It will be observed that the first train mentioned gives an average load of merchandise per wagon of 2·7 tons in the ninety-seven wagons used, and it is instructive to look at the modern returns produced in the form presented by the Ministry of Transport, as here it will be found that the average wagon load in Great Britain for merchandise is 2·92 tons, so that we have not made much progress in the load per wagon. When we find these modern returns showing that the average number of wagons per train is only thirty-five, we see how very misleading a system of average figures may become when it is well known that there are many goods engines in this country hauling loads of 1,000 to 1,200 tons.

Lubrication.—Methods of lubrication have been immensely improved, and, with the certainty that all moving parts could be properly lubricated, the possibility of high speeds has increased. I remember in the very early days that Mr. Ramsbottom produced what I believe was the first form of displacement and sight-feed lubricator. As I was employed to assist the draughtsman who was trying the experiment, I have a vivid recollection of the way in which it was done.

To the outside cylinders of one of his "Lady of the Lake" class locomotives he fitted two glass lubricators, which were nothing more than two old-fashioned egg-ended soda-water bottles, which were attached to the underside of the cylinders by means of brass unions. The amount of oil which these contained on leaving Crewe was recorded, and they were carefully examined on arrival at Euston. This experiment led to the creation of the spherical form of brass lubricator which was put on the side of smoke-boxes of London and North Western engines, but which was first of all attached underneath the steam-chests as illustrated in Zerah Colburn's book on Locomotive Engineering.

With lower pressures than we have to-day, lubrication was a less difficult matter than it is at the moment, hence there has been a widespread tendency to use piston-valves instead of any of the flat-faced D valves. I am not aware that anyone has recorded the results of any experiments with piston-valves to show the force required to move them, but the experiments which I tried in 1888 on the Great Southern and Western Railway are recorded in the Proceedings of the Institution of Civil Engineers of 18th December 1888.

In these experiments it was found that flat brass valves measuring 16½ inches by 10 inches with a steam-chest pressure of 139 lb. gave a resistance to movement at mid stroke of 1,321 lb., giving a co-efficient friction of 0·068.

Permanent Way.—Some idea of the prices which had to be paid for work in the year 1827, before the Liverpool and Manchester Railway was actually opened, is given in Fig. 20, this being a copy of an estimate signed by George Stephenson himself and dated 28th February 1827.

How great have been the changes in permanent way I think might be illustrated by quoting some facts which were given in a report made by Mr. Hawkshaw (afterwards Sir John Hawkshaw) to the Lancashire and Yorkshire Railway in 1850, though it must, of course, be understood that there were many forms of track which were used by the earliest railways long before this. The illustrations which are reproduced in Fig. 21 show that there were great varieties of permanent way in use, varying in weight from 46 lb. per yard up to 85 lb. per yard, and of many different sections. These great varieties of sections gradually disappeared, and a form of double-headed rail weighing from 80 to 85 lb. per yard was very generally adopted.

Of course, the idea underlying this double-headed rail was that when one head had worn out the rail could be turned upside down and the other head brought into use, and there must be many of the senior members of this Institution who recollect what the effect of this turning was. The rail became seriously chair-galled on the lower head, and when the time came that the upper head was worn and the rail was turned, there were a series of depressions in what now became the upper head which resulted in a tremendous rattle being created in the train as the wheels went over these depressions, which were about a yard apart.

Then came the rail which is almost universal in England to-day known as the bull-headed rail, where some of the material which used to be put in the bottom head was placed in the top head,

Fig. 20.

Permanent Way.—George Stephenson's Estimate of Prices, 1827.

Estimate

	£	s	d
10 Miles of Malleable Iron Railway	8250	0	0
Cast Iron Chairs for ditto	1760	0	0
Stone Blocks for ditto	3520	0	0
Laying the Way	2640	0	0
2 Permanent Engines	4700	0	0
Rollers for the Inclined Planes	594	0	0
Ropes for do	550	0	0
Keys and Pins for chairs	880	0	0
40 Small Waggons	240	0	0
40 Large do	960	0	0
Forming Embts and Excavations	8331	1	6
Carriage of Rails, chairs, & blocks to different parts of the Line	2000	0	0
Bridge	300	0	0
Culverts	500	0	0
Fencing	880	0	0
Depots at each end of the Line	800	0	0
Agencies & Casualities	1000	0	0
	£37905	1	6

Liverpool Feby 28th 1827

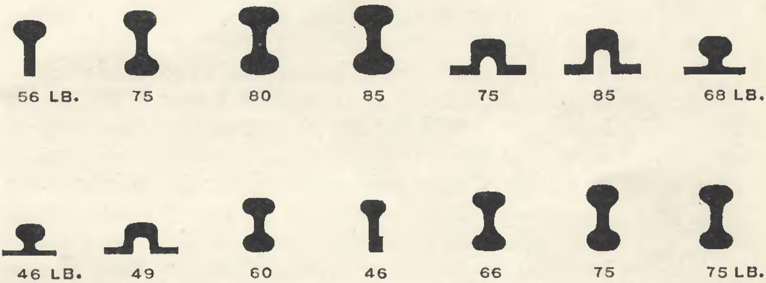
Geo Stephenson

The superior material of to-day enables that upper head to be worn down to the utmost limit without getting any unevenness of track.

The earlier rails were in many cases not more than 15 feet long, and this was no doubt due to many of these rails being made of iron, and to the fact that rolling mills had not arrived at their present state of perfection. When steel rails were introduced, ingots from which they are rolled could be made of any reasonable size, and powerful rolling mills were capable of dealing with any section.

Nowadays a rail weighing 95 lb. to the yard and 45 feet in length is very commonly used on British railways, but on the London, Midland and Scottish a very large mileage of 60 feet rails will be found.

FIG. 21.—*Sections and Weights of Rails per yard, L. & Y. Ry.*, 1850.



As an illustration of the endeavour of some of the earlier engineers to get long rails and save the number of joints, I found when I was on the Great Southern and Western Railway of Ireland that the civil engineer who had had charge of their permanent way department a good many years before made a practice of having the iron bridge rails which they used brazed together at the ends so as to make three rails into one length. As different parts of the railway had to be relaid these rails used to come in as scrap for shipment to South Wales, where the different works were glad to receive them as good old iron, but we received grievous complaints from the managers of the works that we were sending brass to them mixed up with the rails, which spoiled their furnace bottoms. These rails very seldom broke at the brazed joint. So far as the brazed work was concerned, resting as it did upon cross sleepers, it made it difficult to get a satisfactory joint at the ends where it usually rested upon what was known as a Harty chair, which was formed of an inverted " T "-shaped section.

At the date of the Hawkshaw Report already referred to (1850), there were on the Lancashire and Yorkshire Railway no engines which weighed more than 24 tons, while there were seventy-six which weighed less than 20 tons, twenty-eight that weighed less than 15 tons, and ten that weighed less than 10 tons. It will thus be observed that no serious demand was made on the permanent way such as occurs to-day with modern engines which weigh without their tenders in many cases well over 70 tons, and in one prominent instance 92 tons 9 cwt., and have weights on a single pair of wheels of from 19 to 20 tons.

The changes which have taken place since George Stephenson's time, which have enabled high speeds combined with safety to be made, are very numerous. Facing points have been so well constructed that there is no risk with regard to them. In the earliest days the points and crossings as we know them to-day did not exist, but movement from one line to another was made by "shifting rails."

I have not seen any absolutely reliable record as to who invented the first set of points, but the idea has been attributed to Sir Charles Fox, and it is easy to understand how, in the earliest days of their use, they were looked upon as being somewhat dangerous, but as time has gone on these have become so perfect in their fitting, have been so securely locked to prevent movement at the wrong time, and have withstood the severe work of high-speed trains with heavy locomotives passing over them, that they have proved themselves to be quite as safe as any part of the permanent way, and the old idea that a pair of facing points contain an element of danger has long passed away. These points are now absolutely secured by the facing point lock, and where it is necessary in other places locking bars are used, which prevent any kind of movement of the points so long as there is a railway vehicle standing on them.

The balancing of locomotive moving parts and of their wheels has reduced the punishment of the permanent way to a minimum, and the balancing of carriage wheels, which was not understood for some time, has contributed to the easy riding of the coaches.

Post Office Pick-up.—As a method of saving delay, one of the most useful inventions produced in 1838 was that of Mr. John Ramsay, an officer of the Post Office, whose apparatus was used on a letter-sorting carriage between Birmingham and Liverpool for exchanging mail bags *en route.* This apparatus was later on improved by Mr. John Dicker, also of the Post Office, and mail coaches are still fitted with this arrangement, which is almost to the original design. This invention of the means of dropping the mails and of picking them up has made the non-stop runs of mail trains an easy matter, and enabled many country towns to get an earlier delivery and a later collection of letters than could possibly have obtained before.

Again, as a time-saver the same kind of idea, modified to suit the requirements, was used for the purpose of enabling tablets or train staffs on single lines of railway to be exchanged without stopping the train. I first saw this on the Callander and Oban line. Later on, somewhat similar apparatus was produced by Mr. James Manson on the Great North of Scotland Railway, and again, a modification produced by Mr. A. Whitaker was used on the Somerset and Dorset line in 1905.

Water Troughs.—One of the most important inventions for time-saving on the railways was that produced by John Ramsbottom when he made the first set of water troughs, which were laid on the Chester and Holyhead Railway. They were 441 yards long and enabled a train going at 60 miles an hour to pick up 5 tons of water in a quarter of a minute. A Paper, giving the details of these troughs, was read before this Institution by Mr. John Ramsbottom in January 1861. The Ramsbottom water troughs had a very great influence on the speed of trains, not only for passenger trains but also for heavy goods trains. It is a curious fact that these were not appreciated very much by the English railways although, as stated above, Ramsbottom dealt with them in the early "Sixties."

The Americans, however, on the Pennsylvania Railroad put them in with great advantage to themselves, but it was not until I asked my directors on the Lancashire and Yorkshire Railway in 1886–87 to put them in upon that line, where there are now a number of them, that they were adopted by any other English railway. This practice was followed later on by several other railways in this country.

As to the future of railways, everyone is aware of the way in which railway traffic has been profoundly affected by the use of the modern motor-vehicle, whether for passengers or for goods, and while it should be remembered that the use of the motor-car in England only dates back about 30 years, the increase in the number of vehicles used has been stupendous.

It seems probable that the swelling volume of motor traffic will create its own blockade, and that for some services the railways will again be called upon to handle certain classes of traffic, and we shall find motors competing with one another to collect and deliver traffic at railway stations and avoid the intolerable delays on the high roads near the great towns.

The congestion which is likely to take place on roads is perhaps best estimated by the fact that there were at the end of last November 1,242,000 motor-vehicles of all kinds which had been licensed, and these work on a total road mileage in England, Scotland, and Wales of 178,000 miles, which thus gives 6·98 machines to the mile.

The rate of addition to the total stock of motors may probably be estimated at about 200,000 a year, having regard to the fact that the increase in 1924 was 176,000 over 1923; therefore, if this rate of increase continues for ten years, there will be about eighteen vehicles to the mile, even if equally distributed over the whole country, whereas the congestion in and around our great towns will be something which no traffic authority has yet shown its capacity to deal with.

On the other hand the railways have 20,171 miles of track operated by 24,000 locomotives, slightly over one to the mile, thus giving much wider spaces into which traffic can be placed.

It is probable that George Stephenson never contemplated the effect which railways would have, apart from the carriage of passengers and goods, in finding an enormous amount of work for all sorts of manufacturers in this country. The railways are very great consumers of stores, and whether it is steel or iron, brass or copper, timber or cloth, gas or oils, which are required in very large quantities, the companies have become great supporters of home industries, involving the expenditure of millions of pounds every year.

Nor is it likely that George Stephenson would have imagined that railway employment would require a staff of 700,000 men, of which about 150,000 are skilled mechanics.

There are very few things in which railways do not help the manufacturing industries of this country, and it would almost seem as if Mr. Rudyard Kipling was right when he recently said :—

" Everything in life from marriage to manslaughter turns on the speed and cost at which men, things and thoughts can be shifted from one place to another."

The Lecture is illustrated by 21 Figs., and is accompanied by an Appendix.

APPENDIX

Pennsylvania Railroad System,
Operating Department,
Philadelphia, 19 January 1925.

Sir John A. F. Aspinall.

Dear Sir,

Answering your letter of January 5, with reference to the different track gauges in use in this country about 1872, the situation at that time, so far as the Pennsylvania Railroad was concerned, is described in the following extracts from the Annual Reports for the years 1868 and 1869:

> "(1868). By some oversight, local considerations or a limited conception of the important part that railways were to play in the movement of the internal commerce of the country, Pennsylvania and Ohio have each been placed between two different railway gauges which for a long time forced transhipments of freights at their connexions.
>
> The Pennsylvania Railroad Company has, both on its eastern and western connexions, a gauge of 4 feet 10 inches, and Ohio, on each side of her, a gauge of 4 feet 8½ inches—the latter being the prevailing gauge north of the Ohio and James Rivers; while south of these the gauge of 5 feet prevails, which should have been adopted originally as the uniform gauge of the United States.
>
> To obviate the inconvenience, the increased cost, and the additional capital required to move traffic, in consequence of these frequent transhipments, from a difference of gauge of only 1½ inches, broad tread wheels were introduced for through traffic, which has, to a large extent, overcome these evils. Owing, however, to the great oscillation of the cars on the wider gauge, the Ohio lines insisted upon a play upon the narrow gauge, that added materially to the cost of hauling upon the gauge of 4 feet 8½ inches; to remedy which the gauge of your road has been changed to 4 feet 9 inches, and the Ohio roads have been or are being changed to 4 feet 9½ inches, leaving but a difference of ½ inch, which it is presumed that time will reduce to the uniform gauge of 4 feet 9 inches."
>
> "(1869). In our last annual report the diversity of railway gauges between the East and West was alluded to. Since that period all of your immediate Western connexions have

> reduced the gauges of their lines from 4 feet 10 inches to 4 feet $9\frac{1}{2}$ inches, which, when their machinery is adapted to it, will be further reduced to 4 feet 9 inches—the present gauge of the Pennsylvania Railroad."

In 1892 the Pennsylvania Railroad adopted a 4 feet $8\frac{1}{2}$ inch gauge as standard for passenger tracks and 4 feet 9 inches for freight tracks. The present gauge for all tracks is 4 feet $8\frac{1}{2}$ inches, in accordance with the standard gauge established by the American Railway Association in 1897.

As to the early gauges of other American railroads: The first roads built in Eastern States conformed to the English gauge of 4 feet $8\frac{1}{2}$ inches. Later, however, gauges were adopted ranging from 3 feet to 6 feet. The States of New Jersey and Ohio established by law a gauge of 4 feet 10 inches; 5 feet was fixed as the gauge of the South Carolina Railroad, and was adopted by its connecting roads, and this extended generally throughout the South; $5\frac{1}{2}$ feet was established for Missouri and Canada roads; and 6 feet as that of the New York and Erie and the Atlantic and Great Western. By 1880 the Northern lines had pretty generally come to a uniform standard of 4 feet $8\frac{1}{2}$ inches, or the interchangeable standard of 4 feet 9 inches, to facilitate the convenient interchange of cars and traffic.

During the interval from 1880 to 1888 many of the narrow gauge (3 feet) roads were changed into standard gauge lines, or a third rail laid down which supplied a standard gauge track, and nearly all the Southern lines which formerly maintained a 5 foot gauge narrowed their tracks (1886), the new standard generally adopted being 4 feet 9 inches.

In 1897 the American Railway Association, in view of the importance of the proper adjustment of wheel and flange gauges to the track, and therefore the necessity for a standard track gauge, adopted the following resolution:

> "That 4 feet $8\frac{1}{2}$ inches shall, hereafter, be the standard gauge of all tracks owned by the railroad companies forming this Association. This gauge shall be the shortest distance measured between the inside of the heads of the two rails forming the track."

Yours very truly,

(Signed) J. T. WALLIS,

Chief of Motive Power.

Sir John Dewrance, K.B.E., Past-President, proposed a hearty Vote of Thanks to Sir John Aspinall for his interesting Lecture, which was seconded by Mr. A. W. Marshall, Member, and carried with great acclamation.

The attendance was 154 Members and 28 Visitors.

The Lecture was repeated by Sir Henry Fowler, K.B.E. (Vice President), on behalf of Sir John Aspinall, in Leeds, Bristol, Glasgow, and Birmingham :—

Leeds (Yorkshire Branch), in the Philosophical Hall, Park Row, on Friday, 13th November.
Chairman : Professor G. F. Charnock, *Member of Council.*

Bristol (Western Branch), in the Merchant Venturers' Technical College, on Thursday, 26th November.
Chairman : Lieut.-Colonel R. B. Pitt, M.C., *Member of Council.*

Glasgow (Glasgow and West of Scotland Branch), in the Royal Technical College, on Thursday, 3rd December.
Chairman : Professor A. L. Mellanby, D.Sc., *Member of Council.*

Birmingham (Midland Branch), in the Queen's Hotel.