The Mechanics' Institute and Technical School Norwich.
With the Authors Compliments

FIFTH SESSION

OF THE

INTERNATIONAL RAILWAY CONGRESS,

TO BE HELD IN

LONDON IN JUNE, 1895.

SECTION I.—WAY AND WORKS.

STRENGTHENING OF PERMANENT WAY IN VIEW OF INCREASED SPEED OF TRAINS.

REPORT BY

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STRENGTHENING OF PERMANENT WAY IN VIEW OF INCREASED SPEED OF TRAINS.

With a view of ascertaining the practices of British, Irish, American, Indian, African, and Australian Railways, the Reporter prepared a list of questions in reference to the subject of this report.

This list of questions was issued by the Brussels Commission of the Congress to such Companies as are members of the Congress, and in addition, the Reporter issued the same list to twelve Railway Companies in America with whose practices he considered it might be desirable for the Congress to become acquainted; of these twelve, six have replied.

It was requested in the list of questions that the replies to them might have reference only to lines on which there are services of Express Trains travelling at a minimum speed of 40 miles per hour. Three of the Indian two of the African, and one of the Australian Lines replied that no advantage would have resulted from their answering the questions, inasmuch as there are no services of express Trains travelling on their lines at the speed specified.

Three Railways in the United Kingdom have not replied to the questions at all, and two have stated that they do not propose to reply, their mileage being only small.

The replies which have been received are from:—

13 Railways in England and Wales, viz.:—
- Cambrian.
- Furness.
- Great Eastern.
- Great Northern.
- Great Western.
- Lancashire and Yorkshire.
- London Brighton and South Coast.
- London and North Western.
- London and South Western.
- Manchester Sheffield and Lincolnshire.
- Midland.
- North Eastern.
- South Eastern.

4 Railways in Scotland, viz.:—
- Caledonian.
- Glasgow and South Western.
- Highland.
- North British.

2 Railways in Ireland, viz.:—
- Great Northern Railway of Ireland.
- Great Southern and Western.

6 Railways in America, viz.:—
- Chesapeake and Ohio.
- Chicago, Burlington, and Quincy.
- Illinois Central.
- Lake Shore and Michigan.
- Pennsylvania.
- New York Central and Hudson River.

1 Indian Railway, viz.:—
- East Indian.

1 Australian Railway, viz.:—
- New South Wales Government Railways.

In order that the practices of the different Companies and Administrations may be the more readily compared with each other, the Reporter has compiled from the above answers 10 Statements which form Appendices to this Report. In these Appendices the actual wording of the replies as received has not been adhered to, but the substance of them is believed to be correctly recorded. The reason for not adhering strictly to the actual wording of the replies was to enable the practice of any Railway to be more easily compared with that of others.

In addition to these Appendices, this Report is accompanied by a book of diagrams, illustrating the type of Permanent Way used by those Companies and Administrations, who have answered the questions addressed to them.

It should be noted that both Appendices and the diagrams show the latest standard of each Company so far as the United Kingdom is concerned. These latest standards are not in use at present over the whole of the several systems, but in their renewals the Companies are gradually introducing them.

The replies received from the American Railways give various weights of Rails on their several lines, but do not state whether the Companies are going to raise everything up to the highest standard, or intend to continue the use of the lighter section of Rails on branches of their lines.

It must be understood that the remarks in this Report apply only to the 27 Companies and Administrations who have replied to the questions addressed to them.

TYPES OF PERMANENT WAY.

As regards the type of Permanent Way, it would appear from the replies received that the Railways in the United Kingdom are almost universally adopting bull-headed Steel Rails, keyed into chairs fastened to transverse sleepers by means of treenails, spikes, or screws, or combinations

of these fastenings. The type of Permanent Way adopted in America by the Companies who have answered the questions consists of flat-bottomed Rails resting directly on transverse sleepers, and fastened to them principally by means of spikes.

The only Engineers who have in their replies expressed any opinion as to the types of Permanent Way, are the Engineer of the Great Northern Railway of Ireland, and the Engineer of the New York Central and Hudson River Railway. The former gentleman, who uses both types of Permanent Way, expresses himself as follows :—

> "As the Steel Rail is immediately in contact with the Sleepers, the result is a very smooth running road, at the same time there is no doubt that our steel bull-headed road with the chairs keyed inside, is far superior, stronger, more permanent, and better in every way than any flange railroad."

and the latter gentleman, writing on the American type, says :—

> "Rails supported in 'chairs' have been out of date in this country for many years past, the Vignoles type, or 'flange' rail, as it is termed in this country, having proved immeasurably superior in service and economy on American railroads."

STRENGTHENING OF PERMANENT WAY.

With regard to the strengthening of Permanent Way so as to permit of an increased speed of trains, the Railway Companies in the United Kingdom have, over a long series of years, been gradually increasing the weight of their rails, and the weight and bearing area on the sleepers of their chairs, but from the information which the Reporter has received, most of the principal Companies do not contemplate any further strengthening

of the roads, as their latest standards of Permanent Way are fully capable of taking the highest speeds that can be obtained with the present Rolling Stock. The Great Western Railway Company, however, state that greater strength of the Permanent Way could be obtained by increasing the weight of the rail, and the bearing area of the chair, which should be made with a wider jaw to provide for a larger key. The London and South Western Company strengthen their road on sharp curves and down steep inclines by introducing an additional sleeper under each pair of rails.

The American Railways have been and are evidently strengthening their rails with a view to suit high speeds, but none, except the New York Central and Hudson River Railway Company, state that they intend to further strengthen their road with a view to still higher speeds.

GREAT BRITAIN AND IRELAND.

A. RAILS, &c.—See Appendix A.

The section of Rail usually adopted is the Steel Bull-headed Rail, the bull-head being much larger than the bottom member, to allow for wear and tear, the bottom member being made sufficiently strong, after allowing for oxidation, to form with the top member when worn down a sufficiently strong girder to carry the rolling load.

In England the weight of the Rails varies from 80 to 92 lbs., in Scotland from 77 to 90 lbs., and in Ireland from 74 to 85 lbs. per lineal yard. (There are some Rails weighing 100 lbs. to the yard but these are few in number.) With the exception of the Great Western, whose Rails are 32ft. long, and the London and North-Western Company, who are adopting a standard length of 60ft., the length of Rail adopted by English Companies is 30ft. In Scotland and Ireland the standard length of the Rails is also 30ft., with the exception of the Caledonian and Great Northern of Ireland, who use Rails 32ft. and 26ft. long respectively.

No absolute weight per yard appears to be adopted to which Rails may be worn down before being renewed, the general condition of the whole of the materials forming the Permanent Way, and other varying circumstances, being taken into consideration in determining when the road should be renewed. The renewals, when they take place, are usually in long lengths, and the material recovered, when not too far worn, is utilized for the repairs and sometimes renewals of Branch Lines, Loop Lines, and Sidings.

As regards the calculations of the strains imposed on Rails by the rolling load, as the various stresses cannot be ascertained sufficiently accurately to enable a rail to be designed on the same scientific principles as a girder would be, it is considered by English Engineers that close and careful observations of the effects produced upon the road by the rolling loads which pass over it is the best means of determining the size and shape of the Rail.

B. MODE OF MANUFACTURE AND NATURE OF RAIL METAL.

See Appendix B.

From the replies received, it is clear that most of the Railway Companies have their Rails rolled from steel manufactured by the Bessemer Acid process, although some of them return the Bessemer process without stating whether it is the Acid process or the Basic process. The only Companies who, in their Specification, permit the use of the Basic process, are the Manchester Sheffield and Lincolnshire and the North Eastern. The London and North Western, the Manchester Sheffield and Lincolnshire, Caledonian, and North British Companies have a specification for the Siemens Martin Acid process.

With reference to the testing of rails, all Companies, except the Cambrian, test their rails by blows produced by various weights falling from various heights on various lengths of rail supported on bearings from 3ft. to 3ft. 6in. apart. The amount of permanent deflection varies in each case in proportion to the weight used and the height from which that weight is dropped.

Some Railway Companies, in addition to this, test the Rails as girders, suspending dead weights from the centre, and specifying the deflections which will be allowed under the test of certain weights.

The Chemical tests do not appear generally to form part of the Specification for Rails, only four Companies giving a more or less detailed specification of the Chemical analysis. The Great Northern Railway of Ireland state that they test their Rails chemically, but do not give particulars of their requirements.

The breaking weight in tons per square inch is only specified by five Companies. The extension per cent. is only specified by three Companies, and the contraction of area per cent. is only specified by one Company.

It appears, therefore, from these returns, that the Railway Companies mainly rely on the falling weight test to determine the quality of the Rail manufactured for them.

As to the relative merits of hard and soft steel, only five Companies give any information, and of these five, four lean to the use of mild steel as being less liable to fracture and therefore ensuring a greater measure of safety.

C. RAIL CONNECTIONS.—See Appendix C.

The form of joint universally adopted in the United Kingdom is a suspended one, the rails being connected by two fish plates bolted together through the rails by four fish bolts.

With the exception of the Great Western and London and North Western Railways, whose fish plates are 20 inches long, all the Companies adopt a fish plate 18in. long. Much longer fish plates than these were in use some years ago, but there seems to be a general opinion that the fish plates should be as short as possible in order to bring the chairs and sleepers at the joints as near together as possible, and in reply to the question as to whether this form of joint gives satisfaction, 16 out of 19 Companies state that it does.

As to the shape of the fish plates in use, they may be divided into two classes, viz., plates whose depth is the distance between the top and bottom flange of the rail, and plates in which the depth is increased to the underside of the bottom flange, and even deeper, in some instances underlapping the rail. The sections of this class of fish plate are shown in the book of diagrams. 10 Companies use the former class, and 9 Companies use different sections of the second class. There are no suggestions as to how the joint could be improved.

All the Railways (so far as their bull-headed Rails are concerned) support the Rails in chairs fastened to transverse sleepers, using various kinds of fastenings. The Great Northern Railway of Ireland for their flat bottom Rails, and the Great Southern and Western Railway of Ireland, fasten their flat-bottomed Rails direct to the sleepers by means of fang bolts and spikes.

The weight of the chairs used by the different Companies varies considerably, the smallest weight being that of the South Eastern Company, 37lbs., the heaviest being that of the Lancashire and Yorkshire Railway which weighs 56 lbs.

The bearing area of the chair on the sleeper also varies considerably, the smallest area being that of the South Eastern Railway, viz.:—70 square inches, the largest being that of the Manchester Sheffield and Lincolnshire Railway which has a bearing area of 117 square inches.

The only Companies who place felt between the chair and the sleeper throughout their systems are the Cambrian and the London and North Western Railways. The London Brighton and South Coast Railway use it in special Tunnels where the noise is excessive. No other Company uses a packing of any kind between the chair and the sleeper.

The pattern of the chair on each side of the joint used by any Company is the same as that of the rest of the chairs in the road.

The number and kind of fastenings for attaching the chairs to the sleepers varies with almost every Company. The details are given in Appendix C.

KEYS AND SLEEPERS—See Appendix D.

Of the eighteen Companies who use the chair road, eleven of them use oak for their Keys, two use teak and oak, one teak only, one fir, one pine, and one elm. Eight Companies compress their keys, and ten do not. All the Companies are keying on the outside of the Rail except the Furness Railway, but they are now gradually adopting outside keying.

Baltic Red Wood is the timber most generally used for sleepers, although some Companies use Memel, Riga Red Wood, Scotch Fir, Red Pine. Every Company creosotes its sleepers.

The lengths of sleepers are 8ft. 11in. or 9ft., and the breadth 10 inches amd the thickness 5 inches.

The distance apart of the sleepers on the several lines is shown in the accompanying Book of Diagrams.

Although metal sleepers have been put down in places, notably on the London and North Western Railway, they do not seem to have found favour with the Railway Companies of the United Kingdom. The London and North-Western Railway have not put any down since 1888; the Great Eastern and London and South Western Companies have experimented with a few, but are not continuing their use.

E. BALLAST.—See Appendix E.

The Ballast used by the various Companies, details of which are given in Appendix E, varies according to the locality through which the lines pass. The bottom ballast generally consists, in districts where it can be obtained, of large hand-packed stones, but where this cannot be obtained, slag, burnt clay, and ashes are used. For top Ballast various materials are used, viz.:—Broken stone, gravel, slag, chippings, ashes, and cinders

screened and unscreened, and Thames gravel; the best material in each district consistently with economy being obtained, so as to get the best drainage possible.

The practice of laying Ballast above the level of the top of the sleeper varies a good deal. Details are given in Appendix E.

AMERICAN, INDIAN, AND AUSTRALIAN RAILWAYS.

A 1. SECTION OF RAIL.—See Appendix A 1.

The Section of Rail usually adopted by the six Railway Companies in America, who have answered the questions, and by the East Indian Railway, and New South Wales Government Railways, is a flat bottom Rail with bull head. The area of the bottom member is somewhat stronger than need be, considering the Rail as a girder, being apparently so made to distribute the weight of the traffic over as large an area of the sleeper (or "tie" as it is called in America) as possible.

The weight of the Rails varies from 60lbs. to 85lbs. per lineal yard, but the New York Central Railway have laid down for trial a certain length of road with Rails weighing 100lbs. per lineal yard. The result of this trial will guide them as to what weight of Rail they will adopt in the future.

As to the length of Rails used, the standard length is 30 feet, but the Pennsylvania Railway have used 60 feet Rails though, they do not say whether they intend to continue them or not. Rails of 60 feet length are also in use on a portion of the New York Central and Hudson River Railway, where their Engineer writes, "This length promises well, with the prospect of a substantial economy in maintenance of way expenses."

As with the English Railways, these Companies, as a rule, do not fix an absolute weight per yard to which the Rails may be worn before being renewed, but the New York Central Railway gives a minimum, a medium,

and a maximum weight of Rails at which they should be renewed, and the New South Wales Government gives the weights to which the Rails are worn down.

B 1.—MODE OF MANUFACTURE AND NATURE OF RAIL METAL.

See Appendix B 1.

Six Companies specify that the steel from which the Rails are rolled shall be manufactured by the Bessemer process, two out of the six specifying the Acid process. The Chicago, Burlington, and Quincy Railway do not specify any particulars by which the steel from which the Rails are rolled is to be manufactured. The East Indian Railway prefer the Siemens Acid process.

As far as tests go, the six American Railways do not subject their Rails to any bending test. The Chesapeake and Ohio and the Illinois Central Railways test the steel, however, from which the Rails are rolled, by hammering two test pieces into bars which, when cold, must bend to an angle of 90 degrees without breaking. The Chicago, Burlington, and Quincy Railway purchase the Rails under a five years guarantee.

The East Indian and New South Wales Government Railways adopt the falling weight tests, similar to those used by the English Railways. They also test the Rails as girders with suspended weights.

The New York Central and Hudson River Railway Company specify a chemical test.

The New York Central and Hudson River Railway and the New South Wales Government have also a breaking weight in tons per square inch, that of the former being from 49 to 58 tons per square inch, and that of the latter being 44 tons per square inch. The elongation in the case of the New York Central and Hudson River Railway is from 6 to 12 per cent., and the New South Wales Government Railway 14 per cent.

It is clear from the returns that the American Railways prefer a hard steel to a mild one, as giving a longer wear.

C 1. RAIL CONNECTIONS.—See Appendix C 1.

Three of the American Railways state that they use suspended joints, and the other three use supported joints. In two instances, viz., the Chicago Burlington and Quincy Railway, and the New York Central and Hudson River Railway, the joint is supported by a transverse sleeper centrally underneath it.

The East Indian and the New South Wales Government Railways use suspended joints.

The Fish Plates on the American Railways vary from 20in. to 38in. long. Four of these Railways have long fish plates with six fish bolts. The other two use short fish plates 20in. and 24in. long with four fish bolts.

The East Indian Railway uses fish plates 22in., and the New South Wales Government Railways use for their flat bottom Rails, fish plates 18in. long, and for their bull-headed Rails, fish plates 20in. long, each with four fish bolts.

On the Chicago, Burlington, and Quincy Railway, and the New York Central and Hudson River Railway the Rails are laid with broken joints, that is, the joints in one Rail being opposite the centre of the other Rail in its road.

Six of the Companies consider their joints are satisfactory. The Lake Shore and Michigan Railway do not consider the joint satisfactory, stating "a joint fastening which is as strong as the Rail is required." The Pennsylvania Railway Company state that their joint is not universally satisfactory, and they suggest an improvement by shortening the fish plates. The New York Central and Hudson River Railway throw out a suggestion that joints should be abandoned altogether, and some form of compound continuous Rail substituted for them, but so far as the Reporter can ascertain this has not been tried.

The American Railways fasten their Rails to the Sleepers in various ways, by spikes, clips, and screws, details of which are given in Appendix C 1.

The bearing area of the Rails on the sleeper varies from 36 to 50 square inches.

The iron chairs used by the East Indian Railway are 30lbs. weight, having a bearing area on the sleeper of 86 square inches; on the New South Wales Government Railway, where bull-headed Rails are used, the weight of the chair is 45lbs., and the bearing area on the sleeper 108 square inches.

On both these last mentioned lines the chairs on each side of the joint are of the same pattern as the rest.

D 1.—KEYS AND SLEEPERS.

Keys are of course not used on the American Railways.

Keys of teak are used on the East Indian Railway, and teak and cedar on the New South Wales Government Railways. On the first-named line the keys are not compressed, but on the latter they are. Both Railways key on the outside of the Rail.

The wood used for the sleepers, as will be seen by the Appendix, varies with the locality. Neither of the Railways creosote their sleepers.

The length of the sleeper varies from 8ft. to 9ft. 6in., the breadth from 8in. to 10in., and the thickness from 5in. to 7in.

E 1.—BALLAST.

The American, Indian, and Australian Railways, like the English Railways, adopt for bottom ballast, broken stone, gravel, or sand according to the locality. The top ballast varies in thickness from 5in. to 12in., and consists principally of gravel, crushed stone, cinders, or slag.