(*Paper No. 2366.*)

“On the Use of Heavier Rails for Safety and Economy in
Railway Traffic.”

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(*Abstract.*)

THE following is an abridgment of a communication which should be considered as a sequel to the Paper written three years ago on “Rail-Joints and Steel Rails.”¹

In that Paper the Author gave a design for a 100-lb. flange rail, which has been called the Goliath rail, and recommended its adoption for railways with heavy traffic and high speed. The Author has since devoted considerable time to persuading railway authorities, both in America and on the Continent of Europe, to make a trial of this heavy rail. The Paper now presented gives the result of his labours, and further suggests the adoption of steel base-plates in order to secure a longer duration for the wooden sleeper, and to permit of the use of a harder steel in the rails, with safety against fractures.

The Belgian State Railway was the first to adopt the idea, and after a trial of a 105-lb. rail for an order in 1886 of about 300 tons, a second trial order of 1,000 tons was given in 1887, and in 1888 it was adopted for the whole of the replacements, about 10,000 tons having been ordered for that purpose. These figures show the satisfaction given by this heavy rail, as regards both safety and economy in the maintenance of the road and rolling-stock, as well as comfort in running at high speeds.

Other countries are working in the same direction; on some of the French railways the weight of rails has been increased from 60 lbs. to 86 lbs., and on the German railways to 80 lbs. per yard. But considering the high speed run on some of the continental main lines, there is still room for a further increase in weight of rails. In America, the proposal has met with much favour, and the 60-lb. rail which had been generally used there has been supplanted by rails of 70 lbs. and 80 lbs., and even 90 lbs. per yard on some of

¹ Minutes of Proceedings Inst. C.E., vol. lxxxiv. p. 365.

the heavier worked lines. But in America, however, the heavy rails of modern section have not given as good wearing results as the former light rails. The Author would explain this by the fact that the heavy sections are designed with a wide thin rail-flange, which necessitates the employment of softer steel than was the case in the former sections with narrow thick flanges. Rail-makers must guard against fractures of rails, and the harder the rail and the wider the flange, the greater is the risk; consequently, notwithstanding the desire of the engineer to obtain a harder steel, in order to resist the wear as well as the crushing from the increasing weight of the rolling-stock, manufacturers have been obliged to make the heavy sections softer than the light rails used in former times; and engineers, so far as experience goes, have not had the economically good results from the heavy rails that they expected. Makers have done all they could to obtain safety with these wide and thin rail-flanges, by curving the rails when hot, so as to avoid cold straightening, which much deteriorates the strength of the rail. It would be well for rail-makers in Europe to adopt the same process when meeting the demand for harder rail steel, in order to secure safety against fractures. In Europe there is a general demand for harder rails. That this hardness must be carefully dealt with, the Author proved by experiments made during the summer and winter of last year upon an extensive scale, at the Domnarfvet Works, in Sweden, where it was desired to increase the proportion of carbon from 0.3 to 0.4 per cent. The rails were cut in halves; and the one half was tested in the winter at a temperature of -30° Centigrade = -22° Fahrenheit; the corresponding half being tested in the summer at a temperature of $+30^{\circ}$ Centigrade = $+90^{\circ}$ Fahrenheit. The result was, that out of the twenty-one rails tested, nearly all broke in the winter, and all stood in the summer with a specified drop-test of 1 ton falling 15 feet for a 63-lb. rail. It was consequently thought unsafe to increase the proportion of carbon to 0.4 per cent.; but that it was better to go back to 0.3, which had given satisfaction as regards safety ever since the introduction of steel rails, notwithstanding the excessively cold climate of that country.

The rail-section has a good deal to do with the determination of hardness. For instance, a bull-headed rail or a flange rail with a narrow, thick flange, can be made much harder than a rail with a wide thin flange, such as that which has been adopted in America. The danger of copying specifications as to the constituents for different sections of rail is therefore evident. However, as where flange-rail sections have been adopted, harder rails are neces-

sary, and it is at the same time desirable to have rails with wide flanges to lessen the damage to the sleepers, a problem is presented which does not exist with the rail of bull-headed section fixed to a cast-iron chair, or when metal sleepers are used, namely, how to obtain good wearing-results combined with safety in a rail with a wide flange. The engineer demands a hard and at the same time safe rail, while the manufacturer prefers a rail with thick flange, to enable him to make it of hard steel without risk of fracture. Thus, the wide flange must either be made thick, or the narrow flange must be provided with a steel base-plate fixed on to wooden sleepers. Several railways in Europe have already been provided with steel base-plates, but these have not yet reached the dimensions of the cast-iron chairs used on the English roads. The Author suggests the adoption of a wider base-plate, the conversion of the light flange rail into a heavier one, by giving greater thickness, both to the head and to the flange, and by using a base-plate at least 10 inches long, as shown by Plate 9. The Swedish 63-lb. section is proposed to be increased to 80 lbs., and 10 lbs. additional weight given to the base-plate; this is instead of making the flange wider and thinner, as has been the case with the American roads. Thus a hard and safe rail could be obtained that should satisfy both producer and consumer, besides providing a much broader base, which would prolong the duration of the wooden sleeper to an extent impossible with a flange rail.

The English roads are the best in existence, and a proof of that is given by last year's experience in the run from London to Edinburgh in eight hours (which means over 50 miles per hour) without accident; but this should not tempt the managers of continental roads of weaker construction to imitate such speed until these have been strengthened. High speed requires heavier rails for safety and economy, both of road and rolling-stock. High speed is dangerous on light rails, producing fractures, widening the gauge, and thereby causing accidents. The rails used on the continental lines are generally too light for the speed actually run upon them. The price of steel rails is now much less than formerly, and as at least 50 per cent. is recouped by the value of the old rails, there is no excuse for delaying the change to heavier rails for all main lines. The cost and quality of sleepers should decide what system should be adopted, either steel sleepers, or steel base-plates, or rails with wide flanges laid upon sleepers of hard wood; but thin-flanged rails should be avoided, as incompatible with hardness combined with safety.

In Plate 9 is shown the English permanent way with 80-lb. or 90-lb. bull-headed rails fixed to cast-iron chairs attached to wooden sleepers; also steel sleepers of different designs; and Irish, Scotch, and Welsh rails applied to wooden sleepers. The second row of Figs. shows the 100-lb. flange-rail section with angle fishplates on wooden sleepers, according to the Author's design as published in the former Paper; also the 105-lb. Belgian Goliath, as it is called, with but slight alterations from the Author's designs. Dutch, Danish, Swedish, French, German, Russian, and American sections of rails, of the heaviest weights used in those countries, are also shown; and, finally, the Author's design for converting a light weak road into a strong road, by increasing the rail head and the thickness of the flange, and by the application of steel base-plates.

Here may be given the approximate cost of the different types of road. Metal sleepers being dearer, but lasting longer, could not be compared with the other systems; and as fishplates, bolts, spikes, wood screws, or fang-bolts, are used for local reasons, or for reasons arising from climatic conditions, their cost may be left out.

ENGLISH PERMANENT WAY, 1 MILE, SINGLE LINE.

	£.	s.	£.	s.
For 80-lb. bull-headed rails, 125 $\frac{3}{4}$ tons at £4 per ton . .	503	0		
3,625 chairs, 40 lbs. each, at £2 10s. per ton . . .	162	0		
Total cost per mile . . .	£665	0		

GOLIATH FLANGE RAILS, 100 LBS. PER YARD.

156 tons at £4 per ton. Total cost per mile . . .	£624	0
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FLANGE RAILS, 80 LBS. PER YARD.

125 $\frac{3}{4}$ tons at £4 per ton	503	0
2,921 base-plates (two for every sleeper), at 10 lbs. per } plate, at £6 per ton	78	12
Total	£581	12

These calculations show that there is ample room for increasing the weight of the flange-rail system before it comes up to the cost of the bull-headed rail with cast-iron chairs, and that even a 100-lb. rail would be cheaper than an 80-lb. bull-headed rail with chair.

To balance economy with safety and all other conditions, an international discussion, not only between English and continental engineers, but also between them and their American brethren would be highly valuable. The Author having shown his designs,

travelling at the time of the accident); No. 12, the Imperial children's carriage; No. 13, the Czar's sleeping carriage; No. 14, the Czarevitch's carriage, followed by others.

The lesson, technically speaking, to be drawn from this ought to be invaluable, not only to Russia, but also to other countries on the Continent of Europe, namely, not to attempt to exceed the speed which the condition of the road will permit with perfect safety. Taking into consideration how slowly a change can be brought about in strengthening the road, a commencement should be made without delay on all main lines where it is desired to increase the speed, and to use heavier rolling-stock than was originally contemplated.

ON THE USE OF HEAVIER RAILS.

Scale: 1/2".

C.P. SANDBERG, DELT

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