THE RAILWAY TRACK OF THE PAST, AND ITS POSSIBLE DEVELOPMENT IN THE FUTURE.*

J. W. Schaub, M.W.S.E.

If you have ever noticed the approach of a heavy train on a modern railway by keeping your eye down near the track, you could not have failed to notice the extraordinary wave in the track which is formed in front of the engine. This wave appears to be about twice the height it actually is, as it is formed not only by depressing the track immediately under the engine, but the track immediately in front is actually lifted, thereby forming a true wave motion. If the train is moving at a high rate of speed as it passes, you will be impressed by the noise and the lack of rigidity of the whole structure. The cause of this wave motion is the yielding of the track. The dynamic action of the moving load must be absorbed by the rails, the ties, and the substructure underneath. This tends to push the entire track in front of the wave, and this yielding of the track accounts largely for the creeping of the rails. If the ballast is hard and frozen, as well as the sub-structure underneath, the rails must absorb the bulk of this energy, and if the conditions are such as to produce an uneven hardness, such as a sudden frost in earth full of moisture, when combined, perhaps, with a low joint, the chances are that a broken rail will result.

The railroad commission of the State of New York reports that over 3,000 rails were broken in that state during the past January, February and March. These breakages are reported by the railroads themselves, so that they can be considered as authentic. This means that over thirty-three rails per day were found broken, or one rail per day for every 240 miles of track in the State of New York alone.

The railroads are so alive to this condition that they are patrolling their tracks day and night in order to forestall the danger presented by a possible broken rail. How does this appeal to you from an engineering standpoint? Imagine a stationary engine, developing at times 2,000 horse-power, on a base or foundation which is so certain that you are compelled to have someone watch it day and night in order to forestall the danger of a wreck to the machine itself, to say nothing about the gravity of the situation when this wreck becomes a matter of life or death, every time. The Railroad Gazette has given this subject a good deal of attention, and in a recent issue publishes a collection of letters bearing on this subject, from a number of railroad officials. These letters are in answer to a request to give their views as to the cause of the great increase in rail breakages, and with one or two exceptions they all blame the poor quality of the steel. One letter, the shortest of them all, is by far the most instructive. Quoting from the above issue, " I should say, the quality of the rails furnished is gradually getting worse and the axle load of engines and their speed is gradually increasing." In a few words this correspondent sums up the whole situation. " The rails are getting worse, and the loads are getting heavier "; so that, there are two sides to this question and both sides should be given due consideration.

An examination of the rails shows the breakages usually occur near the ends of the rail. Some shows flaws due to "pipes," or a lack of weld owing to the presence of some foreign substance. These flaws correspond to " cold shuts " in the days when iron was used. Others show fractures due to brittle steel, and still others the characteristic coarse crystals due to imperfect physical treatment. Of these fractures the ones due to the brittle steel are most to be feared, as they are most insidious. The " pipes " and the imperfect physical treatment can perhaps be guarded against, but what can be done to guard against a brittle steel.

Steel is brittle, as a rule, owing to the presence of phosphorus; but, the rail manufacturer says that phosphurus has been gradually eliminated, until now it is at least 25 per cent. less than it was fifteen or twenty years ago. But what of the carbon. In the last few years the requirements for carbon have been increased by 100 per cent. It is safe to make a high carbon steel, carrying 0.60 per cent. of carbon, in the presence of 0.10 per cent. of phosphurus? In other words, has the phosphorus been eliminated sufficiently to compensate for the increase in carbon. The railroads should insist upon a reasonable limit for phosphorus and make the rail manufacturers live up to it. Just now it would be interesting to know why the railroads have to accept the manufacturer's standard.

No concerted effort has been made to analyze this problem, other than to blame the rail manufacturer, for the poor quality of the rails, but there is another side to this question that has not received proper consideration. Quoting from the excellent paper on track superstructure by Mr. O. E. Selby, bulletin No. 80, American Railway Engineering and Maintenance of Way Association, "Railroad track has grown in strength as heavier loads have made increased strength necessary, but such growth has been entirely along empirical lines, and not one single detail of track superstructure bears marks of engineering design."

To begin with, is the difficulty due entirely to the poor quality of the rail? We have heard much of the speed with which rails are rolled, and of the high temperature of the steel when on the cooling bed. This may account for some of the difficulty; but, on the other hand, is the structure upon which the rail rests free from blame?

To be sure the quality of the steel can be improved, but so can the substructure upon which it rests in the track. If it is true that the heavier rail sections have shown a higher percentage of breakages than the higher sections, under the same conditions, then the cause of the rail breakages should not be hard to find.

Increasing the weight of the rail in a track does not necessarily make a better track than a lighter rail does. Something must be left for the ties, ballast and substructure to do. If the original form of railway track, with its strap rails laid on longitudinal timbers resting on cross-ties, had been developed along these lines to its logical conclusion, the present form of railway track would have been unknown. Let us see what are some of the defects of the present cross-tie system of rail support. In the first place it is not mechanical. Given a line of rails which have to carry moving loads reaching 20,000 or 30,000 lbs. and more per wheel, the loads which they carry must be distributed over large areas. The cross-tie sytsem accomplishes this by inserting sixteen to twenty independent supports under each thirty feet of rail, and upon the track department is placed the impossible task of so adjusting these supports that each shall bear an equal part of the load. This is the real secret of the enormous amount of labor spent on surfacing a track in order to carry trains at high speeds, and it is a work that goes on forever. Moreover, assuming a joint has not been kept up to surface, what happens when a wheel passes over it? Within certain limits the ends of the rail will deflect until the tie receives a firm bearing; and, all track shows, more or less, the effect of the lack of continuity in the rail, by the dip of the rail at every joint. This happens in an instant, when the operation is repeated by the next wheel, and so on. (Fig. 1.) Assuming the deflection of the end of the rail to be Δ when the tie reaches a firm bearing;

Let " W " be the wheel load;
Let " l " be the space between the supports;
Let " E " be the modulus of elasticity of the steel;
Let " I " be the moment of inertia of the rail section;

$$\text{Then } \Delta = \frac{Wl^3}{3EI} = \frac{(Wl)\,l^2}{3EI} = \frac{Ml^2}{3EI}$$

Let " f " denote the fibre stress on the rail due to bending;
Let " y1 " denote the distance from outer fibres to neutral axis.

$$M = \frac{fI}{y_1} \cdot \Delta = \frac{fl^2}{3Ey_1} \therefore f = \Delta \frac{3Ev_1}{l^2} \quad . \; . \; . \; . \; . \quad (1)$$

* Read before the Western Society of Engineers.