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"Tramroads in Connection with Street Tramways."

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TRAMROADS over private lands, forming part of a system which includes ordinary tramways on the public roads and streets, will, it is thought, be of considerable importance in the near future. In this connection it is assumed that the cars which run on the ordinary tramways shall also be capable of running on these tramroads.

Electric-tramway systems are being developed with a view to intercommunication between adjacent towns, and to connecting outlying districts with the centres of population; and various considerations outside the province of the engineer may render it advisable to construct a portion of a system on private lands. The general efficiency, also, of a system may thereby be considerably increased, especially in the matter of speed.

The mean speed, including stoppages, of an average tramway system on the public streets and roads does not, in the more populous parts, exceed 8 miles an hour. In most cases it is considerably less, and there are obvious difficulties in materially increasing the speed on these portions of a system. On suitable public roads in less frequented parts, a maximum speed of 16 miles an hour is reasonable; and on the "waste" at the side of the road this maximum speed is moderate. Owing to local conditions, such as junctions with side-roads, steep gradients, sharp bends in the road, and narrow places, restriction of speed at certain points is inevitable. The ordinary road-traffic is also an important factor in reducing the mean speed. It is therefore improbable that even on the less frequented portions of a system a mean speed exceeding 12 miles an hour can be maintained for any distance. In general, the considerations which govern the limitation of speed are the safety and convenience of the road-traffic as a whole. The maximum speed for which the tramway is adapted, apart from the other road-

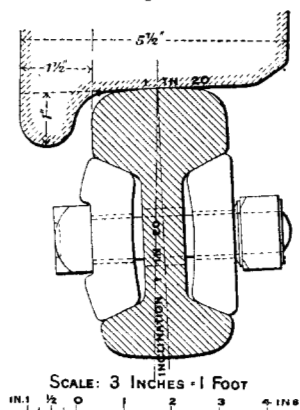
traffic, is not yet reached, but the limit of speed on tramways as at present constructed soon will be attained. Existing electric-tramways are a modification of horse-tramways, and are not adapted, as a railway is, for running at high speed. It may therefore perhaps be assumed that on tramways in their present form the mean speeds will rarely exceed, and seldom even attain, 8 miles an hour in urban districts, 12 miles an hour in less frequented parts, and 10 miles an hour over the whole system. These speeds are not at present permissible in England, but it is assumed that there is a reasonable prospect of their being attained in the near future.

In the case of a tramroad over private lands, on the other hand, a maximum speed of not less than 30 miles an hour may be assumed. Since the restrictions of speed, and the stops, will be few compared with those on an ordinary tramway, the tramroad will materially increase the mean speed of a system. The importance of this, especially when in competition with a railway, need not be pointed out. From an engineering point of view, tramroads tend to connect tramways more closely with railways. In adopting methods which have been found by experience to be the best for a railway, the modifications, if any, entailed thereby on the tramway portion of the system have to be considered, and the special advantages of a tramway have to be maintained as far as possible on the tramroad.

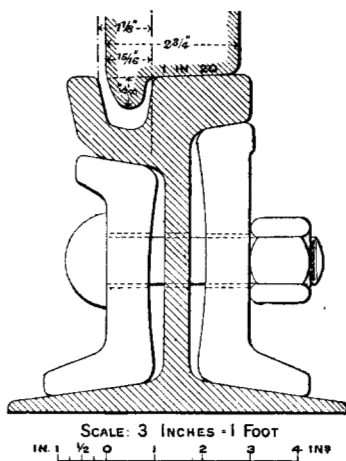
The general design of a tramroad depends, of course, on its importance, and on local circumstances. The cost also can perhaps only be considered in connection with a special case. The construction below formation-level is similar to that of an ordinary light railway, but considerably sharper curves and steeper gradients are, if necessary, possible with electric tramway-cars. It will be assumed throughout that the grooved girder-rail is used on the tramways. No modification of existing practice is necessary, except in the permanent-way of the railway, or in the tramway-wheels, either or both of which must be modified, since the tires used on a railway are unsuitable for running on a tramway and *vice versa*. In the accompanying Figures, which illustrate this, the rails are shown laid true to gauge, and the tires in their normal positions on the rails when running, *i.e.*, with the car central between the rails. The gauge-line is shown in each case, and is the same throughout. It will be observed that, as shown in the Figures, there has been no wear on either the tires or the rails. The designs will therefore be modified to this extent in actual use.

Figs. 1 and 2 are intended to show a comparison between a railway-tire on a railway-rail and a tramway-tire on a tramway-rail. *Fig. 1* represents the London and North Western Railway standard engine-tire and 90-lb. rail. *Fig. 2* is taken as a typical section of a tramway-rail and tire. A comparison between the railway- and tramway-tires illustrated in *Figs. 1 and 2* is shown in *Fig. 3*.

The head of the railway-rail has a more rounded shoulder than the head of the tramway-rail. The railway-tire has a tread $3\frac{1}{2}$ inches in width, and a strong flange 1 inch in depth, joined to the tread by a curve having a radius larger than that of the shoulder of the rail. The tramway-tire has a narrow tread, less than 2 inches in width, and a small flange, only $\frac{5}{8}$ inch in depth, joined to the tread by a curve of the same radius as that of the shoulder of the rail. The diameter of the tramway-wheel also is less than that of the railway-wheel. The tramway-rail has a groove $1\frac{1}{8}$ inch in width, which may perhaps be taken as the limit of width now adopted for tramways, although a wider groove is sometimes used. On a railway, the head of the rail forms a ramp which offers a gradual and successful opposition to the lateral motion of the tire tending to derailment. On a tramway, this lateral motion is directly opposed by the sides of the groove when the flanges come in contact with them. They act as a check-rail or guide, in direct opposition to further lateral motion. The free lateral motion which can take place before these forces come into action is rather more than $\frac{1}{4}$ inch

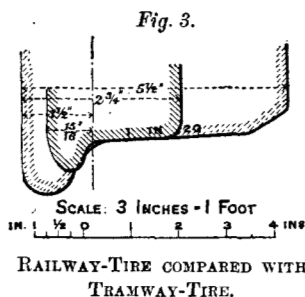
Fig. 1.

RAILWAY-TIRE ON RAILWAY-RAIL.

Fig. 2.

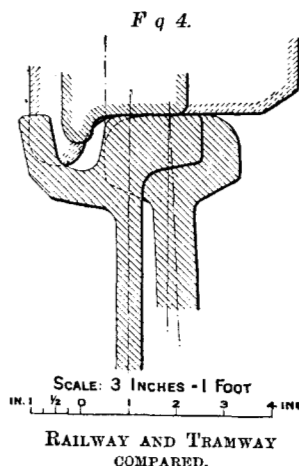
TRAMWAY-TIRE ON TRAMWAY-RAIL.

on a railway, and about half this amount in the case of a tramway. The contour of the tramway-tire illustrated in *Fig. 2*, is the same as the contour of the corresponding portion of the head of the rail with which it comes in contact. In *Fig. 4*, in which



the relative positions of tramway- and railway-tires and rails are compared, another contour of tramway-tire is illustrated. The radius of the curve joining the tread to the flange is $\frac{5}{16}$ inch, or $\frac{1}{16}$ inch larger than the radius of the shoulder of the rail. There is no flat part parallel to the side of the head, before the curve of the bottom of the flange commences, and the common tangent of the two curves is parallel to the side of the head. The resistance to derailment with this contour is similar to that on a railway, but, being on a smaller scale, it is not so efficient. It is, however, assisted by the direct action of the side of the lip on the opposite tire.

In *Fig. 5* is shown a tramway-tire on a railway-rail, and in *Fig. 6*



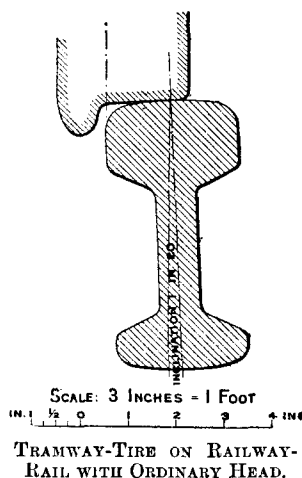
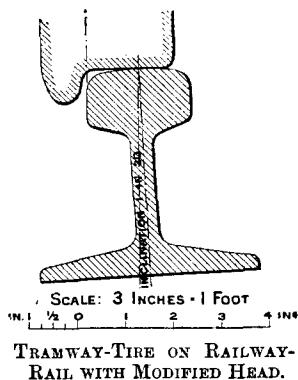
is shown the same tire on a rail having a modified head, such as is used in car-shed yards, etc., where paving is not required and railway construction can be adopted. A derailment on a public road need cause little or no damage, but a derailment on even a low bank would probably result in the car being overturned. Moreover, the permanent-way of a tramroad is more likely to get out of order than that of a tramway, and, even if a high standard of maintenance is preserved, small faults of line and level, which would be immaterial with a railway-wheel, might lead to a derailment with a tramway-wheel. With a tramway-tire it is

evidently not safe to run at a speed of 30 miles an hour on a tramroad, with railway permanent-way even of the section of rail shown in *Fig. 6*.

The following are examples of the methods which have been

adopted to effect the alternative modification of the permanent-way of the railway, or of the tramway-wheels:—

The Kinver Light Railway, near Stourbridge, carries ordinary electric tramway-cars on the overhead-trolley system; a portion of it is laid on the public roads, about $1\frac{1}{4}$ mile is on the “waste” at the side of the road, and for about $1\frac{3}{4}$ mile it runs as a tramroad over private lands. It is connected with a large tramway system, and tramway-wheels having a slightly deeper flange than that shown in *Fig. 6* are used. It is a single line, of 3 feet 6 inches gauge, with passing-places. On the tramroad there are five small under-bridges and six small flood-openings; a considerable portion of the line runs through low-lying land, and on this portion in high floods the water comes up to formation-level. The gradients are easy, but curves are frequent, and there is a curve of $2\frac{1}{2}$ chains radius over one of the girder-bridges. On the tramroad and “waste” a Vignoles rail having an ordinary railway head was originally laid throughout. The head of this rail was not considered satisfactory, and a low tramway-rail with tramway points and crossings was substituted at the passing-places and on all curves of less than 5 chains radius, the Vignoles rail being retained on the other portions. The rails are all laid on wooden cross-sleepers ballasted to the top of the sleepers, and iron tie-bars, about 10 feet apart, are fixed through the web of the rail. A check-rail is provided on all curves of 5 chains to 10 chains radius, standing slightly above rail-level, and on the bridges a timber guard was placed inside each rail, standing $1\frac{1}{2}$ inch above the rail. The Author does not suggest that this is a typical tramroad, or that the final construction is altogether satisfactory; but he indicates the

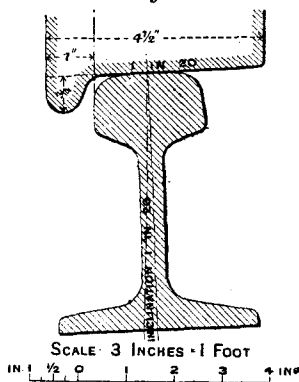
Fig. 5.*Fig. 6.*

conditions under which the line is running, and the compromise that it was considered best to adopt under the circumstances, without going to prohibitive expense. The line was inspected by the Board of Trade, and was opened for traffic early in 1901. It was the first of its kind in England, and a maximum speed of 10 miles an hour on the tramroad was sanctioned provisionally. The maximum speed has since been increased to 12 miles an hour. Single-deck cars only were to be used, and trailers were not sanctioned. The line has been running satisfactorily, but the speed is insufficient.

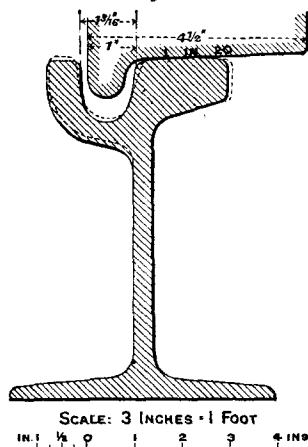
Two tramroads, opened in 1902, one between West Hartlepool and Seaton Carew, and the other between Wallsend and Gosforth, run in connection with street tramways. In both lines the ordinary tramway-tire is used, with a low tramway-rail laid on wooden cross-sleepers. In the former, the rail is of the ordinary girder-section, and a maximum speed of 16 miles an hour is sanctioned. In the latter, the girder-rail has a groove $1\frac{1}{4}$ inch in width, the lip standing $\frac{3}{8}$ inch above the head of the rail, and the maximum speed is 20 miles an hour. The lip of the girder-rail is intended to act throughout as a guard to each wheel. The ordinary permanent-way of a railway has thus been altered to suit the tramway-wheels.

The alternative method of altering the tramway-wheels to suit railway permanent-way has been adopted on the Düsseldorf-Crefeldt Line in Germany. This is a suitable line for comparison with those in this country, as the local conditions are very similar. It was opened for traffic in December, 1898; it is about 14 miles in length, of standard-gauge, and runs through the streets of both towns. The overhead-bow system of electric traction is used, except for a length of about $\frac{1}{2}$ mile in Düsseldorf, which is on the conduit system, and the cars are fitted for both these systems. On the through-traffic between Düsseldorf and Crefeldt, a car and trailer are ordinarily used for the passenger-traffic, and freight is carried in special cars drawn by a motor. The cars for the fast service are 43 feet in length over all, weighing about 18 tons, on two bogie-trucks of 5 feet 2 inches wheel-base. The trailers are of similar dimensions, and weigh about 11 tons. The tramroad portion is a single line, about 10 miles in length, connecting the two towns, and is an ordinary light railway, capable of carrying railway rolling-stock and fitted for electric traction. It runs through a flat country, and the gradients and curves are easy. There are small stations with signals, and telephonic communication between the stations. Vignoles rails, with ordinary railway points and

crossings, are used on the tramroad, and the rails are laid on steel cross-sleepers. In *Figs. 7* and *8* respectively, the tire is shown in position on the tramroad-rail, and on the girder-rail used on the tramway portions in the towns; the dotted line in *Fig. 8* represents the wider groove used on sharp curves of the tramway. The tread of the wheel is the same width as that of a railway-wheel. The flange is similar in shape to a railway-flange, and about $\frac{3}{4}$ inch in depth. The wheels are 2 feet $7\frac{1}{2}$ inches in diameter. The groove of the tramway-rail is $1\frac{3}{8}$ inch in width, as against $1\frac{1}{8}$ inch in *Fig. 2*. The side of the head is slightly more sloped and rounded off than in *Fig. 2*, and is considerably more so in the rail used on sharp curves. With a flange of this section the wear of the rails and rolling-stock on the sharp curves of the tramway must be severe, unless the groove is made considerably wider than is necessary on the straight portions. This will not materially inconvenience even the light road-traffic, and, even if it did, it appears reasonable that, where the tramway-cars represent a large part of the whole traffic, they should receive proportionate consideration. The size of the groove is of vital importance, especially to the tramroad, if railway permanent-way is adopted. Perhaps it may be fair to expect that, in the future, existing interests and hitherto assumed rights in the public roads will, when necessary, give way for the general good of the community; at present it can hardly be said that this is the case. The overhang of the tread of the wheels on the tramway-rails is somewhat objectionable, but in this case the paving is set level with the head of the rails, and does not appear to cause any inconvenience.

Fig. 7.

DÜSSELDORF-CREFELDT TRAMROAD-TIRE ON TRAMROAD-RAIL.

Fig. 8.

DÜSSELDORF-CREFELDT TRAMROAD-TIRE ON TRAMWAY-RAIL.

The common English custom of laying the rails slightly below the paving would not be suitable. The maximum speed sanctioned on the tramroad is 40 kilometres (25 miles) an hour, and about 40 miles an hour was attained at the trials. The Author has been on a car on this line going quite 25 miles an hour; it travelled very steadily, and he suggests that a maximum speed of 30 miles an hour is fully justified in this case. In America, speeds higher than 30 miles an hour are attained on the tramroad portions of inter-urban lines, but the Author is not aware of any case where this speed is exceeded under the conditions that prevail in England; that is to say, where the cars have to run through the streets on girder-rails having a groove only $1\frac{1}{8}$ inch in width.

In order to form an opinion of the relative merits of tramway and railway methods for use on a tramroad, it will perhaps be of advantage to note some additional points of difference between the two systems. The tramway permanent-way is rigid; that of the railway is elastic. The rails of the former, including the joints, are rigidly supported throughout on concrete. The rails of the latter, including the joints, are suspended between the sleepers. A tramway-rail has to withstand more abrasion and wear than a railway-rail, owing to the dirt from the road getting on to it, and to its having to sustain a considerable amount of the ordinary road-traffic; moreover, any depression or splay of the head is a more serious defect in a tramway-rail than in a railway-rail. On the other hand, it is not subjected to severe transverse strains, and is comparatively little subject to expansion and contraction through variations of temperature. A hard compact steel is of the first importance for the rails and fish-plates of a tramway. This has been difficult to procure in England, possibly to some extent because rails of the comparatively soft steel and short length suitable for a railway, are still occasionally used on tramways. The chief function of the tramway fish-plates is to support the joint rigidly, and to assist the concrete in preventing any vertical movement. In the railway-joint the fish-plates do not offer so great a resistance to vertical strain, and provide for considerable longitudinal movement. A car does not run as smoothly at high speed on the vertically-rigid tramway as on the vertically-elastic railway. The easy lateral motion of a car, possible within limits on a railway, is not possible on a tramway, owing to the wheels coming in contact with the sides of the groove; this is detrimental to smoothness of running at high speed, and causes additional friction, even when not causing danger of derailment. The groove of the tramway-rail provides a place for the flange of the wheel to

roll in ; dirt in the groove adds to the friction on the flange, and obstructions lodging in it are frequently the cause of derailment. The lip forms one side of the groove, and also acts as a check-rail. The adoption of the girder-rail on a tramroad is only justified on this account.

In summarizing the relative values of the two methods under consideration for use on a tramroad, the following conditions may be said to apply to both. The vertical elasticity of a railway is obtained. The permanent-way will be liable to get out of order to the same extent as that of a railway. A derailment may lead to the car being overturned. As the outside dimensions of the cars are practically the same for all gauges, the standard-gauge has the advantage of greater stability as compared with a narrower gauge.

If the railway permanent-way is altered to suit the tramway-wheels, and a girder-rail is used, the raised lip and $1\frac{1}{4}$ -inch groove adopted by the Wallsend and Gosforth line has obvious advantages over the ordinary tramway-section for this purpose. Obstacles may lodge in the groove, although the groove is not so liable to become choked with dirt as on a tramway. The easy lateral motion of a railway is not obtained, as both wheels are checked throughout by the lips of the girder-rails. Possibly check-rails, separate from the rails and standing well above them, would be more efficient than the lips of the girder-rails, as, although the first cost would be greater, they would allow of adjustment for wear ; on curves additional clearance could be given, and they could be dispensed with altogether on the outer rails of curves. Moreover, obstacles would not be so likely to lodge between these check-rails and the running-rails as in the groove of the girder-rail. The double check to the wheels will in any case cause additional friction and be a source of danger at high speed. The use of tie-bars between the rails is advisable, as it is important that the gauge should vary as little as possible. With a $1\frac{1}{4}$ -inch groove, about $\frac{1}{2}$ inch increase of gauge would, even on the straight, jam both wheels against the lips. Under these conditions, the safety at a speed of 30 miles an hour is open to grave doubt.

If the railway permanent-way is adopted, and the tramway-wheels are altered to a section similar to that used on the Düsseldorf-Crefeldt line, the conditions of a railway are practically obtained, with the exception that the flange is only about three-quarters of the size of a railway-flange. A speed of 30 miles an hour under these conditions can be adopted with ease and safety. If the standard-gauge is adopted, the tramway-cars would

not only be able to run on the tramroad, but also, within limits, on an ordinary railway, and, in suitable cases, the railway rolling-stock could run on the tramroad. Any desired play of the wheels on the tramroad can be given by widening the gauge. The broad tread renders ordinary railway-crossings suitable, but care is necessary in designing the points as the flange is smaller and more subject to wear than a railway-flange. It may be advisable to alter the permanent-way of a railway in certain cases, where the tramroad is not of importance compared with the rest of the system, and where high speed is not contemplated. For inter-urban lines, and for lines connecting outlying districts with the centres of population, a speed of 30 miles an hour or more is desirable on the tramroad. The conditions of a railway have to be met, and under these circumstances there does not appear to be room for doubt that the permanent-way should be similar to that of a railway, and that the wheels of the cars should approximate as closely as possible to railway-wheels. The exact design of the flange of the wheels, and to a great extent the ultimate speed attained on the tramroad, will depend on the latitude allowed in the groove of the tramway-rail.

The Paper is accompanied by a tracing, from which the Figures in the text have been prepared.
