ordinary vehicular traffic, and it has come to be largely used in the principal cities of America.

After the passing of the Tramways Act of 1870 the construction of tramways proceeded rapidly in England. A flat grooved rail supported on a longitudinal timber and laid on a concrete bed was generally adopted. The paving consisted of stone setts from

4 to 6 in. in depth, laid on a thin bed of sand and grouted with cement, mortar or a bituminous mixture. With the exception of the design of the rail and the manner of supporting it on the concrete foundation, which has continually changed, this method of constructing the track has varied but little to the present day.

The flat section of rail which was wanting in vertical stiffness soon proved unsatisfactory. A fillet or flange was then added to each side, which, bedding into the supporting timber, not only increased the vertical strength but also prevented horizontal displacement of the rail. With the addition of the side flanges a greatly improved method of fixing the rail to the sleepers was adopted. The old vertical spike, which was a crude fastening, was replaced by a “ dog ” or double-ended side spike, one end of which was driven through a hole in the flange of the rail (fig. 2). This fastening was very strong and proved a great improvement.

The next change was the use of cast-iron chairs to support the rails, which were introduced by Kincaid in 1872. These led to a modification of the rail section, and instead of the two side flanges a rail with a central flange (fig. 3) which fitted into the cast-iron chairs was used. The chairs weighed about 75 lb each, and were spaced at intervals of about 3 ft. The Barker rail laid in Manchester in 1877 was somewhat similar to that shown in fig. 3, but a continuous cast-iron chair was used to support it.

The introduction of steam traction about 1880, with its heavier axle loads and higher speeds, was a severe test of the permanent way. The flat section laid on timber sleepers and the built-up rails of the Kincaid and Barker types began to be discarded in favour of the solid girder rail rolled in one piece. The solidity and depth of this section gave it great vertical stiffness, and its introduction materially assisted in solving the problem of providing a smooth and serviceable joint.

The merits of the girder rail soon caused it to be generally adopted, and although the design has been greatly improved it remains to-day the standard form of tramway rail used through- out the world. At first difficulty was experienced in rolling the heavier sections with thin webs and wide bases, but the introduction of steel and improvements in the rolling mills overcame these troubles. The early girder rails laid about 1880 usually weighed from 70 to 80 lb per lineal yard, and were 6 or 6½ in. deep. The groove varied from 1 to 1⅛ in., and the tread was about 1¾ in. in width. The fish-plates were not designed to give any vertical support, and were merely used to keep the rail ends in line. The girder rails were either bedded directly on the foundation or spiked to timber sleepers which were buried in the concrete.

The form of head adopted for tramway rails in Europe has almost universally been one with the groove on one side. With this section the wheel flange forces out the dirt clear of the tread. In a few isolated cases a centre grooved rail has been used. As with railways, the adoption of many different gauges has led to much inconvenience. This want of uniformity in the gauge is in some parts of the country a great obstacle to the construction of inter-urban lines. London and the larger provincial towns adopted the standard gauge of 4 ft. 8½ in., but in many towns narrow gauges of 3 ft. or 3 ft. 6 in. were laid. Glasgow and a few other towns adopted the gauge of 4 ft. 7¾ in. with a view of making the narrow grooved rail of the tramways available for railway wagons, but without any real success.

With the introduction of electric traction the weight and speed of the cars greatly increased, and experience soon proved that only the most substantial form of permanent way was capable of withstanding the wear and tear of the traffic. The early electric lines were laid with girder rails weighing about 75 lb per lineal yard. These proved to be too light, and, at the present time, rails weighing from 95 to 110 lb per lineal yard are in general use. The large number of rail sections designed a few years ago gave considerable trouble to makers of rails. The issue in 1903 by the Engineering Standards Committee of a set of standard girder tramway rail sections was therefore generally welcomed. The sections comprise rails of five different weights. Modified sections for use on curves were also published, together with a standard form of specification. Fig. 4 shows the section of the 100 lb. B.S. raiI (No. 3).

Tramway rails are generally ordered in 45 ft. lengths. Rails 60 ft. long are sometimes used, but they arc difficult to handle, especially in narrow streets. The rail joints still prove the weakest part of the track. Numerous patents have been taken out for fish-plates and sole-plates of special design, but none has proved quite satisfactory. The“ Dicker ’’joint, in which the head of the rail on the tread side is partly cut away and the fish-plate carried up so that the wheel runs on its top edge, and the “ anchor ” joint, in which a short piece of inverted rail is bolted or riveted to the undersides of the abutting rails, have been largely used. The latter makes a good stiff joint, but when buried in concrete it interferes with the bedding of the rail as a whole, often causing it to work loose in the centre. Various processes have also been introduced for uniting the ends of the rails by welding. Electric welding was first tried in the United States about 1893, and has since been considerably used in that country. In this process two specially prepared fish-plates are applied, one to each side of the joint. Each fish-plate has three bosses or projections, one in the centre opposite the joint and one near each end. By passing a heavy alternating current of low voltage between the opposite bosses the fish-plates are welded to the rail. The current is obtained from the line by means of a motor- generator and static transformer. Another process which has been used considerably in the United States, and at Coventry and Norwich in England, is the cast-welded joint. To make this joint the rail ends are enclosed in an iron mould filled with molten cast-iron, which makes a more or less perfect union with the steel rails. The