great drawback to these two processes is the costly and cumbersome apparatus required. The “ thermit" process (see Welding) does not require any large initial outlay, and has been applied to welding the joints on both old and new tracks. The cost of making each joint is about *£*1*.*

Points and crossings are used on a tramway to deflect a car from one road to another. In the days of horse traction no movable switch was used, the car being guided by making the horses pull the leading wheels in the required direction. With the introduction of mechanical traction a movable switch was fitted in one of the castings to act as a guide to the wheel flanges. On modern tramways the points consist of a pair of steel castings, one being a fixed or dummy point, and the other containing a movable switch. On a single track at passing places the cars in Great Britain always take the left- hand road, and a spring is fitted to hold the movable switch to lead in that direction. The bottom of the grooves at open points and cross­ings are raised so that the car wheel runs on its flange over the break in the tread of the rail. Double switch points in which the two tongues are connected are sometimes laid. In recent years the size and weight of the castings and the length of the movable switches have considerably increased. Manganese steel is very generally used for the tongues and sometimes for the whole casting. Ordinary cast steel with manganese steel inset pieces at the parts which wear most quickly are a feature of the later designs. At some junctions the points are moved by electric power.

While the form of concrete foundation remains the same as that laid at Liverpool in 1868, far greater care is now given to the bedding of the rails. After the excavation has been completed the rails are set up in the trench and carefully packed up to the finished level. The concrete is then laid and packed under the rail, generally for a depth of 6 in. When the surface is to be paved with stone setts bedded on sand the concrete may be left rough, but where wood is to be laid the surface must be floated with fine mortar and finished to a smooth surface. Both hard and soft wood blocks are used for paving. Wood should not be used unless the whole width of the carriage-way is paved. Many different qualities of stone setts have been laid. Hard granite such as that supplied from the quarries near Aberdeen is the most suitable.

In urban districts the road authorities almost always require the tramway surface, *i.e.* between the rails and for 18 in. on either side, to be paved. In country districts many tramways have been laid with only a sett edging along each rail, the remainder of the surface being completed with either ordinary or tarred macadam. This construction, however, is only suitable on roads with very light traffic. After a tramway is laid, especially in a macadamized road, the heavy vehicular traffic use the track, and the wear is very much greater than on other parts of the carriage-way.

*Steam and Cable Tramways.—*Horse traction, especially in hilly districts, has many limitations, and early in the history of tramways experiments were made both with steam cars and cable haulage. Although experimental steam cars were tried in England in 1873 the first tramways which regularly employed steam engines were French, though the engines were supplied by an English firm. About 1880 many improvements were made in the design of the engines employed, and this form of traction was adopted on several tramways in England. Beyond requiring a better constructed track it does not necessitate any modifications in the general design of the permanent way. The first cable tramway was constructed at San Francisco in 1873. In England the first cable system was a short length at Highgate in 1884. Cable tramways were also laid down at Edinburgh, Birmingham, Matlock and Brixton (London). Cable traction, with the expensive track construction it necessitates, and the limited speed of haulage, belongs to the past. Only gradients too severe to be worked by ordinary adhesion will in the future justify its use. The construction of the conduit or tube in which the cable runs adds very considerably to the cost of the permanent way. On the Edinburgh system the conduit was formed of concrete, with cast-iron yokes spaced at intervals of 4 ft. to support the slot beams. The conduit was 19 in. deep by 9 in. wide. The slot was ¾ in. wide. The running rails were of the ordinary girder type bedded in concrete. Fig. 5 shows a cross-section of the track at a yoke. This form of construction is very similar to that employed in forming the tube on a modem electric conduit tramway. At Edinburgh and other places where a shallow conduit is used the supporting pulleys are placed in pits sunk below the general level of the tube. On the Birming­ham cable tramway, where the tube is 2 ft. 8 in. deep, pits are not required at the supporting pulleys. This reduces the difficulty of draining the conduit. The yokes in this case are made of steel T-bars spaced 4 ft. apart.

*Electric Tramways.—*Electricity is now the standard motive power for tramway service, and is applied in three main ways: (1) the overhead or trolley system; (2) the open conduit system; and (3) the surface contact or closed conduit system. (See also Traction.)

On a tramway worked on the overhead principle current is supplied to the cars by two overhead conductors or wires. Round copper wires varying in size from 0 (o∙324 in.) to 0000 (o∙4o in.) S.W. gauge are generally used. With feeding points at every mile, the 0 wire is electrically sufficient on most roads, but from a mechanical point of view 00 wire is the smallest it is desirable to erect. Wires having figure 8 or elliptical grooved sections have been employed, and have the advantage of allowing the use of a mechanical clip ear which is clear of the trolley wheel. The ordinary round wire is usually supported by a gun-metal or gun-metal and iron ear grooved to fit the wire, which is soldered or sweated to it. In Great Britain the overhead conductors are re­quired by the board of trade to be divided into half-mile sections. The wires on adjoining sections are connected by section insulators. These consist of gun-metal castings in two parts, insulated from each other. The line wires are clamped to the metal ends. The continuity of the path of the trolley wheel is provided for on the underside of the insulator by fixing a hardwood strip between the ends or by the ribs on the castings with air gaps.

The trolley wires are supported by ears either from span wires which extend across the roadway between two poles or from bracket arms carried on a pole on one side only of the road. The span wires and short bracket suspension wires are also insulated, so that there is double insulation between the conductor and the pole. The overhead conductors are usually hung about 21 ft. above the rails. (For catenary suspensions see Traction.) The poles which carry the span wires and the bracket arms are placed not more than 40 yds. apart and are generally placed at the edge of the kerb. They are built up of three sections of steel tubes, one overlapping the other; the joints are shrunk together while hot. A cast-iron case is used to improve the appearance of the pole, and cast-iron collars hide the joints. Standard specifications for poles have been issued by the Engineering Standards Committee.

When permission can be obtained the span wires are sometimes supported by rosettes attached to the walls of the houses on either side of the street. This method has been largely adopted in Germany, and by dispensing with the poles in the roadway it improves the appearance of the street.

Overhead conductors will not be tolerated in some cities, and to avoid the use of them open conduit and surface contact tramways have been introduced. In the conduit system the conductors are carried in a conduit or tube beneath the surface of the track, and the electric current is picked up by means of a plough carried by the cars. Modern conduit tramways are divided into two kinds: those which have the conduit at the side under one running rail, and those which have it under the centre of the track. The only example of the former to be found in England is at Bournemouth, but it is used at Vienna, Brussels, Paris, Berlin and Budapest. Centre conduit construction has been adopted in London, Nice, Bordeaux, New York, Washington, &c. The advantages of the side slot system are the reduction in the amount of metal