wire, generally of hard-drawn copper, known as the trolley wire. The normal practice is to use a wire not less than 0·325 of an inch in diameter to assure permanence, since smaller wires wear out rapidly from the friction of the trolley and the burning of the surfaces of contact. The wire is usually of circular cross-section. Sometimes wires of other sections have been used, notably one having a cross-section similar to the figure 8, but the advantage of these forms is problematical, while the difficulty attending their proper installation is considerable. In some cases the working-conductor, or trolley wire, is suspended at one side of the track, connexion with it being made by a side-bearing trolley, but its usual place is directly over the track, as this arrangement leads to simpler and more efficient construction of the trolleys and their accessory parts. For certain special cases, where very large currents are employed, the overhead conductor is made of bar metal or structural shapes. In the Boston (Massachusetts) subway, where the traffic is very heavy, a bar of rectangular section is used, supported at frequent intervals from the roof. In the Baltimore & Ohio railway tunnel at Baltimore, Md., the steel working-conductor originally consisted of two Z bars forming a trough, the current being collected by an iron shoe, but this form has been replaced by a sectional third rail. But what­ever the nature of the conductor, it is usually insufficient to carry the current necessary for the operation of the system without excessive loss. Recourse is therefore had to feeders or reinforcing conductors. These may be of any form, but are most frequently copper wires or cables of large section, connected at intervals of a few hundred feet to the working-conductor. They are sometimes carried on poles, but municipal ordinances frequently require their installation in underground conduits. In general, it is customary to divide the working-conductor into sections of from 1000 to 5000 ft. in length, insulated from one another and fed separately through manual or automatic cut-out switches, so that an accident causing a short-circuit or break in continuity on one section will not impair the operation of others.

In ordinary street railway construction two methods of suspending the trolley wire are in vogue. The most usual construction is to hang it from insulators attached to transverse wires running between pairs of poles set on opposite sides of the track. Bracket arms attached to poles are often used, especially on suburban lines; they arc frequently double, or T-shaped, and placed between the two tracks of a double-track line. In the standard construction for either variety of suspension, the insulators are bell-shaped, and composed of some hard moulded or vitreous material. The trolley wire is supported by a clamp about 9 in. long, which embraces about three-quarters of its circumference. This clamp is usually made of bronze, and is now generally fastened to the trolley wire by a screw, causing the two parts of the clamp to close upon the wire as would the jaws of a vice, or is automatic, clamping the wire the more tightly as the strain upon it increases. It was formerly con- sidered expedient to solder the wire into the clamp, but this practice is now generally abandoned. The insulating bell is so designed that its material is subjected only to compression stresses by the weight of the wire. It is provided at its upper part with a single catch for attachment to the transverse wire or to the bracket arm. If a span wire is used it is fastened to the poles, there being turn­buckles to tighten it, while a strain insulator on either side gives a double insulation between the trolley wire and the poles. With a bracket construction it was formerly the custom to attach the insulator directly to the bracket arm, but the blow of the trolley wheel broke great numbers of insulators, and it has therefore become the. practice to adopt some more flexible method of attachment, a number of different forms being in use. the poles between which the span wires are stretched, or to which the bracket arms are attached, are of wood or iron. They are firmly set in the ground, usually with concrete.

Another form of overhead construction for high speed service, brought out by the Westinghouse Company and known as the “ Catenary ” system (fig. 6), is designed to hold the contact or trolley wire in a horizontal position above the track without any dip or sag. Essentially it is made up of a pupporting cable made of stranded galvanized steel wire 7/16 in. in diameter which is firmly fastened to brackets attached to the supporting poles and from which the trolley wire is suspended by means of rigid iron hangers spaced about 10 ft. apart. A proper sag is given the supporting cable, and the lengths of the hangers vary so that the trolley wire is held horizontal without sag. The con- struction resembles a single supporting cable and suspended chord of a suspension bridge. The trolley wire, the hangers and the sus- pension cable are all mechanically connected together and in metallic contact, so that the whole system acts as a conductor. The support­ing cable is held by insulators at the points where it is supported on the brackets at the poles. For heavy work there the currents taken by the passing cars and locomotives are great, requiring a very large trolley wire, two supporting cables are strung from pole to pole and the trolley wire suspended below and between the two.

In this case the hangers are triangular in form and hung with the apex of the triangle downward. The two upper angles are fastened to the pair of supporting cables, while to the lower angle is attached the trolley wire. This arrangement is called the “ double catenary ” construction (fig. 7).

In order to provide a proper return path for the current, the track must be made electrically continuous. This is accomplished by bonding the individual lengths of rail together in some way, or by actually welding them together to form a continuous length. There are many types of rail-bonding. In most of them holes are drilled in the ends of adjacent rails, and a copper conductor inserted between them, its ends being in some way forced against the walls of the holes, ln one type the bond is in the form of a hollow cylinder, the ends of which are inserted in the holes in the rails, a tapered steel pin being driven in so as to expand the cylinder out against the rail. In another form the end of the bond is a solid cylinder, which is upset by hydraulic pressure, forcing it against the rail. A semi-plastic amalgam of mercury has been used to give a contact between the adjacent rails and the fish-plate connecting them. The most usual practice is to use a short bond covered and protected by the fish-plates. Tracks used for a return circuit are cross-bonded at intervals. If the track return has too great an electrical resistance it is reinforced by conductors connected to it at intervals and extending back to the power-house. Neglect to provide a proper return circuit has often caused a great loss of energy, and, in many places, excessive electrolytic action on iron pipes, cable sheaths and other metallic bodies buried in the earth. The lightning arresters provided on overhead lines are placed on the poles at intervals determined by the location of the line.

In a few places the municipal authorities, in order to avoid the disturbances on telephone lines due to the fluctuation of a trolley current, and the electrolysis of gas and water pipes which may arise from a grounded return, have required the erection of a double overhead system. In this each track has two trolley wires forming a complete metallic circuit. The largest system of this kind is in Cincinnati, Ohio, U.S.A., where there are over 225 m. of tram-lines. The system has the advantages to which it owes its existence, but the multiplicity of wires at crossings, right-angle turnouts and switches is so complicated that automatic switching cannot be attempted. The man in charge of the car removes the double trolley from the wires at such points, and replaces it when they arc passed. The construction adopted, except in respect to the points mentioned, is practically similar to that already described for the track-return system.

A number of patents have been granted in various countries for electric traction systems in which one or both of the fixed conductors are installed in a conduit underground, communication being had with them by means of an open slot, into which projects a current-taking device of some nature carried by the car as it moves along. A system of this character was installed at Blackpool, England, in 1885, and later one was very successfully operated in Budapest. the first large and important