CHAPTER VII.

THE TRACK CIRCUIT.

THE track circuit includes that part of the control feature which is affected by the presence of a train within a block. It consists of insulated sections of track across which relays and batteries are connected so that the energization of the latter cannot be effected when the rails are connected by a pair of wheels and axle, or by other conditions which have been predetermined as dangerous to a rapidly moving train.

The simplest imaginable track circuit, combined with an old style of disk signal, is shown in Fig. 93. The section of track,

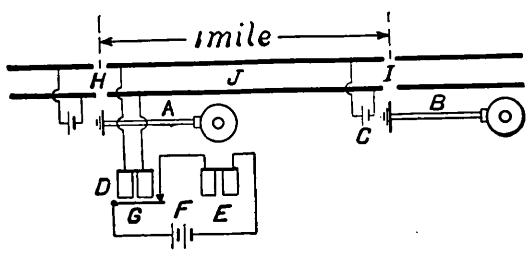

FIG. 93

J, is insulated from the adjacent track sections by the insulating joints, *H* and *I*, and is connected to a relay, *D*, and battery, *C*. The latter thus energizes *D* through the rails as a circuit. This causes the armature, *G*, to press against a contact in series with which is an electromagnet, *E* (controlling the clockwork which operates a banner in signal *A*), and a local battery, *F*. If a train occupies *J*, *D* and *C* will be short-circuited, thus deënergizing *E* and holding the clockworked banner at danger or stop. *B* is another similar signal at the subsequent block; train movement being in an easterly direction.

Continuing the application of the track circuit principle, we have in Fig. 94 a more comprehensive arrangement for tower application than has been heretofore considered. A track relay, *G*, controls movements of the distant semaphore and is connected through the track to battery *F*. When the home signal, *H*, is at clear, the controller, *B*, is on closed circuit, and therefore determines (depending also on the position of the magnetic circuit controller's (*A*) armature) the current which flows through the control electromagnet, *D*, from battery *C*.

If a train be on section *T*, then the track relay at *G* will be deënergized, and the distant blade will move to caution. Also, battery *F* will be short-circuited, hence the armature of *E* must fall, which, in consequence, demagnetizes both *D* and *A*. If the operator should move the armature of *A* up, it will not remain there, owing to *C* being still on open circuit. Thus the

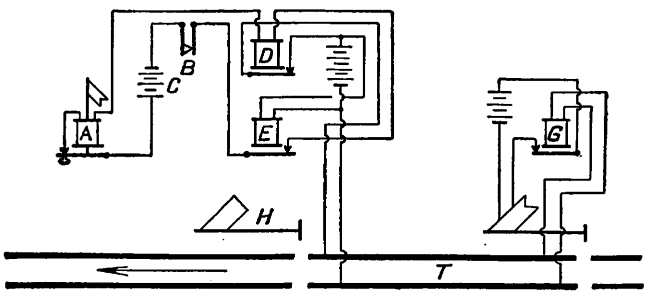

FIG. 94

home signal cannot be cleared except with full knowledge of the electrical indications.

Before track circuits were introduced, track instruments were employed to effect the circuit changes incident to the movement of a train. In purely automatic practice they have been abandoned, but are still used where track bonding has not been resorted to for minor electrical purposes, such as the ringing of a bell, or movement of an indicator. Fig. 95 shows this device in section, it consisting of a hollow upright placed a short distance from the rail, which contains a rod, *C*, forced downward by a spring and carrying at its upper end a contact button which engages in its upward position with the springs, *A* and *B*, to which the circuit wires are connected. When a train passes over the rail, *A* is connected to *B* by the action of the lever, *D*.

These contacts are in series with the device operated, and were formerly in the signal-control circuit.

The track circuit which would be afforded by ordinary rails is unreliable, owing to the poor electrical contact of the fish plates and abutting rail ends. It is evident that a single open contact such as that caused by the scale or oxide usually covering rails, would suffice to break the electrical continuity of the track circuit and render the signal system inoperative. Passing trains and the consequent vibration serve to increase this unreliability. For this reason, rail bonds are used to establish the electrical connection of the adjacent rails.

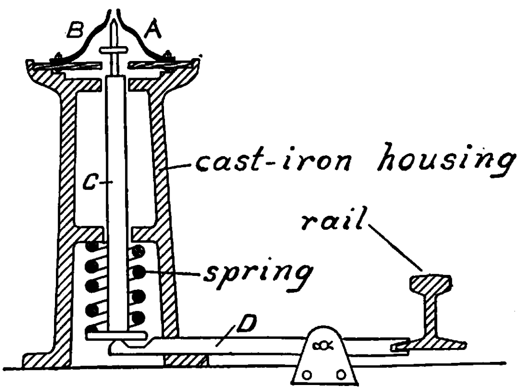

FIG. 95

In Fig. 96 the method of applying bond wires to two butting rail ends, *A* and *B*, is shown. The fish-plate, *F*, is bridged over or shunted by two bond wires, *C–C*, which are usually No. 8 B.W.G. galvanized E.B.B. iron, dependence not being placed on the contact of the former. The connection is effected by channel pins, *D*, one of which is shown at *E*, these being driven in a $\frac{5}{16}$-inch hole drilled in the web of the rail, with one end of the bond wire. The channel pin is recessed and tapered so that when driven home it grips the wire with considerable force. The wedge compresses tightly around the wire, thus producing a large contact area, the hole in the pin before driving being slightly larger than the diameter of the wire. The operation of driving also cleans the pin, the wire, and the rail; thus affording a good electrical contact, which is impervious to rain or dust. A section of the rail and channel pin is given at *G*.

Riveted bond wires are sometimes used, although the consensus of opinion is that they are not so reliable as channel pins. A riveted joint is illustrated at *H* in the above figure, a rivet being shown at *K*, the latter being upset in a hole drilled in the flange of the rail. No. 6 B. & S. copper wire is used at planked highway crossings, tunnels, or other damp localities when rivets are used.

In some cases bond wires are placed beneath the fish-plate; in others, outside the latter. The advantages of the first are the protection afforded the wire from mischievous persons, who often force the loose wire up on the face of the rail to be cut off

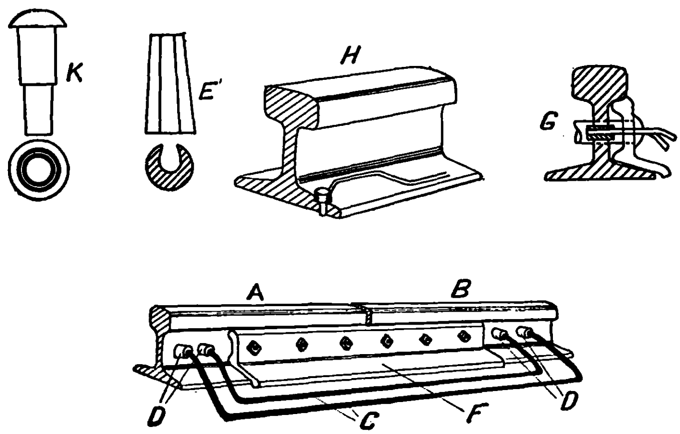

Fig. 96

by a passing train; and also from the operations of the maintenance-of-way corps. The disadvantage is the case of oxidization, caused by the entrained moisture, and the labor of inspection. The second method has a reverse order of advantages and disadvantages.

When a track relay fails to be energized, after a survey has shown that the track battery is in proper condition, it is necessary to inspect the bond wires on both rails of the entire section, to locate the open circuit. With bond wires placed beneath the fish-plates, this is a laborious process, since each bond must be pulled to determine its continuity. With open bonds it is merely necessary to glance at the wires to discover any break in the circuit, riding on the rear of a train giving ample time for inspection.

The number of bond wires used at a joint is a matter of individual opinion, but usually two are employed. With covered bonds, the general practice is to use one, while at grade crossings, bridges, and tunnels, three are used, to decrease the liability of an open circuit, due to the vibration and moisture evident under these conditions. Continued vibration results in crystallization of the metal at the junction with the rail; and when a break occurs, it is difficult to detect.

A representative installation at a switch or crossover is shown in Fig. 97. The trunking, *A*, shown in section, carries the insulated leads from the switch instrument, *B*, and the track connec-

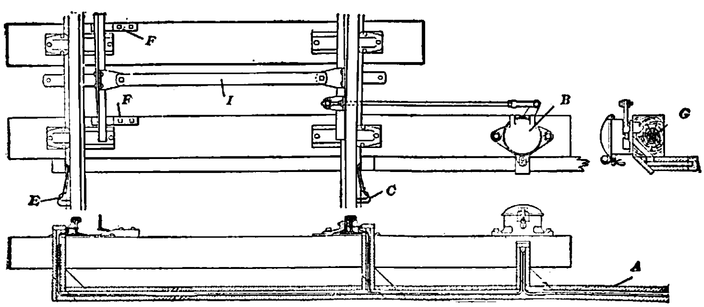

FIG. 97

tions, *E–C*. When the switch is open, *B* short-circuits the track, thus giving the block the same condition as that obtaining when a train is in this section. The switch-point rail rides upon two or more wedge blocks, *F*, that prevent it from coming in contact with the rails at *E*, from which it must be insulated when the switch is in its normal position, as the point rail is in electrical connection with the rail at *C*, through the uninsulated cross-bar, *I*, and the remainder of the rail. An end elevation of *B* is given at *G*. The short-circuiting action of the point rail cannot be depended upon; otherwise the switch instrument would not be used. This is an important consideration, as the open switch must hold its home signal at danger.

The same object is obtained in a line-wire system by opening the signal circuit when a switch is open. This is accomplished through the arrangement shown in Fig. 98. The wood, w, is of a width conforming to the number of contact springs, n, used. One of the latter is used for each of the circuits, and it makes and breaks connection by its end, a, with a stationary contact piece, h. This is effected by the small insulated roller, f, which is operated by the switch movement through the pivoted lever, m. When the switch is closed, the end, a, is in contact with h, and when open it is disengaged from the latter, due to the removal of the roller from the hump in the spring. One circuit wire is connected to n and the other to h. On double-track lines, four contact springs, which are in series with home east, home west, distant east, and distant west, are often used.

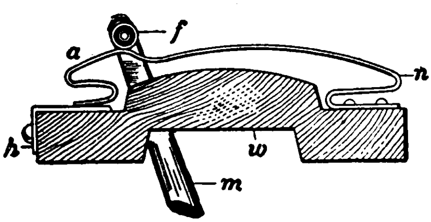

Fig. 98

Since cross-bars and switch rails would ordinarily short-circuit the track, it is necessary that insulation be introduced in these members to maintain the normal electrical isolation of the rails, which are of opposite polarity. As the track voltage is very low, the insulation resistance need not be relatively high, as is required in power circuits. For this purpose fiber is almost universally employed, due to its economical initial cost and subsequent ability to withstand excessive pressure and vibration. Several schemes of switch construction are in use which eliminate the use of insulation at these points. One very meritorious arrangement was described in connection with Fig. 97.

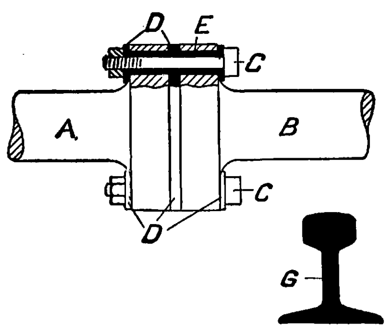

Fig. 99

In Fig. 99 a standard type of switch-rod insulation is shown. The rod is divided into two parts, A and B, the adjacent ends being secured mechanically by the bolts, C, and insulated by the fiber bushings, E and strips, D. Adjacent rail ends in an insulated track section are separated by fiber sheets of the same shape as the rail section, as at G. The rails are held either by wood splice bars, or the regular steel fish-plates are supplemented by fiber sheets conforming to the rail sides. The bolts passing through the rails are insulated by means of fiber bushings. Where special reinforced fish-plates are used, a more substantial disposition of the sheet fiber is effected.

In Fig. 100 an Atlas rail joint is shown in section. Such a massive construction is required on the outer side of a curve for any rail section, and is used on roads having heavy rails, such as 90 or 100 pounds to the yard.

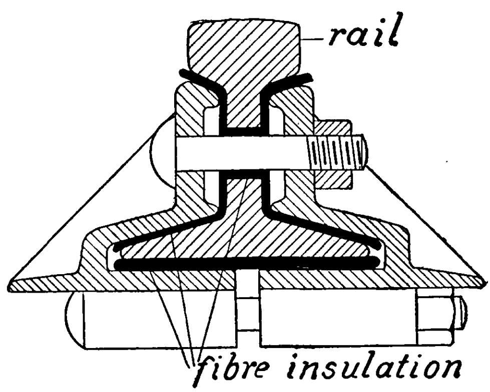

FIG. 100

Properly designed insulated joints are of the utmost importance in maintaining the integrity of the track-circuit equipment. Great trouble has been heretofore experienced with this adjunct, but experience and time test have sifted out the forms of joints that are fitted for this purpose. A good joint will have great mechanical strength, stand excessive vibration and wear, continue the proper alignment of the rails, have high insulation, and be easily renewed. Turnouts, local freight lines, sidings, and secondary tracks are sufficiently well insulated by wood splice-bars; while main tracks should have joints reinforced by steel plates.

In completing track or other circuits between a drawbridge and the abutments, it is not often advisable to use a submarine cable, as the latter is not only too costly and undependable, but it does not break the circuits when the bridge is open. A circuit-breaking device, operated coincident with the movement of the bridge is a desirable feature, and it should have sufficient flexibility to prevent misalignment of the draw from affecting it. A so-called bridge circuit-coupler, which is used

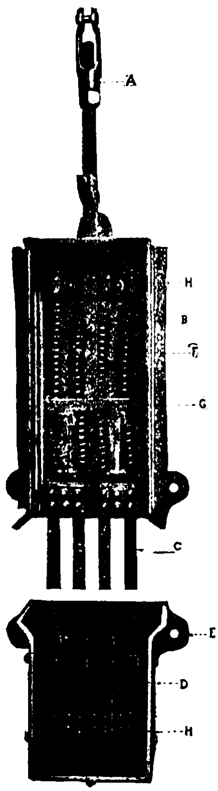

FIG. 101

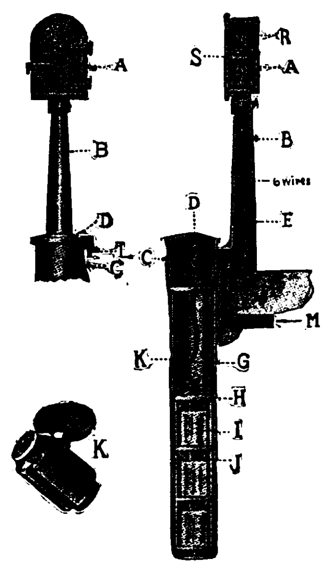

FIG. 102

to preserve the continuity of such circuits, so that when the bridge is open they will be opened, is shown in Fig. 101, and consists of two boxes, *B* and *E*, containing the connecting arrangements, either of which may be movable, one being fastened to the bridge end, and the other to a cross-tie at the rail ends. *A* is fastened to a lever of the bridge locking, and operates the fingers, *C*, through the cross-bar, *G*, so that when the bridge is to be opened, the contact fingers, C, can be withdrawn from D, thus breaking the respective circuits. Flexible cables, F, allow a wide range of movement of C, the bridge circuits being completed through the binding contacts, H.

One method of installing track cells and relays is shown in Fig. 102. Within the cast iron chute, C (which is embedded in the earth near the track to such a depth that only about one foot of the top appears above ground), the three cells, I, held in a wooden cage, H, are placed. This cage is raised and lowered by the rope, G. The wires, K, leading from the cells pass to the track by way of the trunking, F. Other wires, E, within the hollow upright, B, pass from the relays, R, to the track. These relays are placed upon the shelves, S, and in the design given

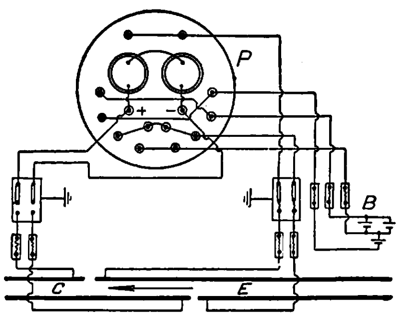

Fig. 103

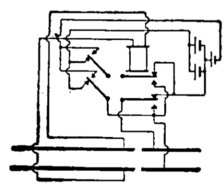

Fig. 103 *a*

are of the polarized and neutral types. The number of wires, M, will vary; in a double-track system there would be ten or twelve, although eight only are shown in the figure, which is for single-track. The number also varies accordingly as the section is at a signal or not; in the former case more wires being used. For the batteryman's convenience and for protection, a cover, D, provided with a lock, L, is added. The casing, A, is of cast iron, and both water and insect proof. Sometimes the track chute is separate, consisting of a simple cast-iron cylinder. At K a connector, which is soldered to the leads at the cells, is shown. The groove at the side is for the reception of the soldered wire.

In Fig. 103 the relay and track connections at a cut section on a normal clear, wireless, two-arm home and distant system appear, the diagram of circuits being given at A. P is a polarized relay having two contacts in multiple on both polar and neutral armatures. The track battery, *B*, has two components, the greater ampere-hour capacity (of a given polarity) being connected to the track during the normal operation, which is when the semaphores are at clear. When a train occupies either section *C* or *E*, section *E* will be short-circuited by the action of the neutral armature contacts when the magnets are deënergized. When the distant blade at the preceding signal is at caution, the ampere-hour capacity (at the opposite polarity) of the connected track battery, *B*, is least, since this occurs only when a train occupies the distant section.

In Fig 104 the track and other connections at a normally clear wireless, with overlap, banjo-disk home signal, *S*, are shown. *R* is a polarized relay, the distant signal being placed

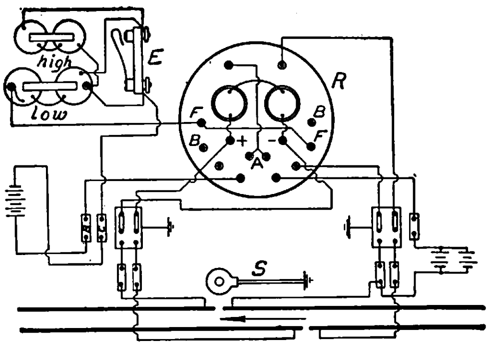

Fig. 104

at a relayed cut section. Such a scheme of connection is also used for a distant with a home in the rear, the latter having a separate distant signal. An electromagnet energizes the disk armature, this magnet having two windings, one of high resistance, and the other of low resistance. The high-resistance coil is connected in shunt with the contacts of the normally open spring-switch, *E*. When the signal is at danger this shunt is closed, thus short-circuiting the high-resistance coil and leaving in circuit the low-resistance winding. This produces a high initial current discharge, and consequent torque, when the front contacts at the relay are closed, insuring the proper clearing of the banner. When once cleared, the latter can be held in this position by the low energy of the high resistance winding. At the connection points, *B* is the free battery terminal, and *C* the common.