CHAPTER II.

SIMPLE CIRCUITS.

SIGNAL circuits admit of innumerable variations; and nearly every installation requires a special scheme of interconnection. There are, however, certain generic features adhered to which obtain in most cases. It is their differentiation which produces the seeming complexity when viewed as a whole. A number of simple circuits and their modifications will now be taken up.

The circuit diagram for an old style of disk signal is shown in Fig. 13. The main battery 11 is connected to the track, 15,

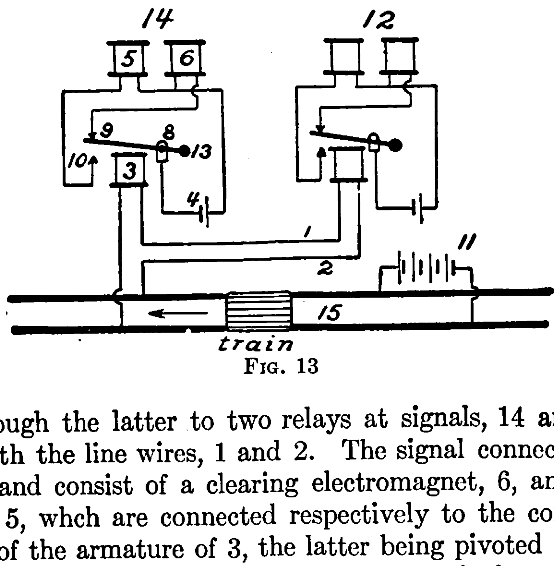

FIG. 13

and through the latter to two relays at signals, 14 and 12, in series with the line wires, 1 and 2. The signal connections are similar, and consist of a clearing electromagnet, 6, and a stop magnet, 5, whch are connected respectively to the connects, 9 and 10, of the armature of 3, the latter being pivoted at 8, and weighted at 13. With a train in the block, 11 is short-circuited, hence the relays are deënergized, their armatures touching the upper contacts, and closing the local circuit of 4 through 6, as shown. Thus, when the block is occupied, 6 is energized; when not, 5 is energized. A disadvantage of this method of connection is the great waste of energy when 11 is short-circuited, and the dangerous effects of a connection between line wires 1 and 2.

It frequently becomes advisable to control a distant signal from a manually or automatically operated home signal through the interposition of a circuit controller. Such an arrangement of circuits is given in Fig. 14, and provides for a power-operated

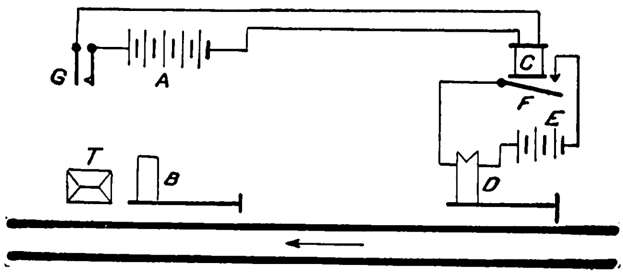

FIG. 14

distant signal. The latter, shown at *D*, is governed by the circuit controller, *G*. When the latter is closed (which will occur when the home signal, *B*, is thrown to the clear position by the operator at the signal tower, *T*) the line battery, *A*, sends current through the relay, *C*, at the other end of the line, which raises the armature, *F*, of the latter, closing the motor circuit of the local battery, *E*, and thereby throws *D* to the clear position.

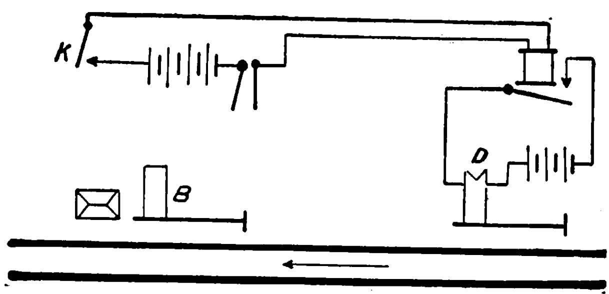

FIG. 15

If the above arrangement does not include sufficient precautionary measures, other functions are included which will prevent, in various ways, the conflicting of routes, false indications, and delay in train movement. It is the proper recognition of these factors, and their successful elimination, which produces the complexity often met with in signal circuits. In Fig. 15, a switch, *K*, is introduced in the simple-control circuit given above, which requires operation by the tower attendant before the distant signal will assume the clear position. This condition is effected by including it in series with the line battery and relay governing the distant signal's motor circuit.

In Fig. 16 is shown a circuit arrangement which employs a

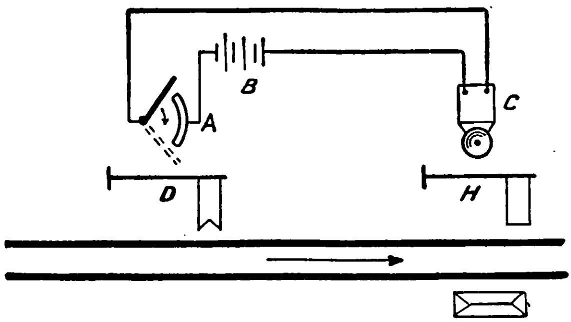

FIG. 16

vibrating bell, *C*, to communicate the desired announcement of the motion of a distant signal blade, *D*, to the tower operator. Motion of the semaphore produces a movement of the contact arm of the special controller, *A*, and consequently closes the circuit of the battery, *B*, in which *C* is included. This controller

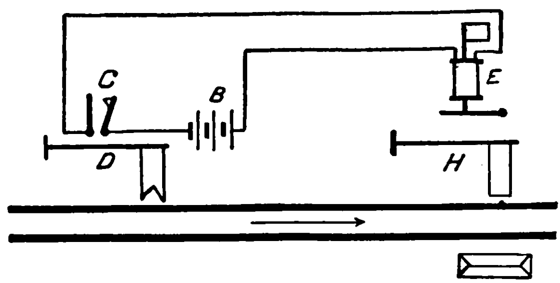

FIG. 17

is so arranged that when the blade is in either the extreme caution or clear position the circuit is opened. While the blade is moving, on the other hand, the circuit is closed. *C* may be a combination bell and indicator, or it may include a setting device.

A visual indication of the clear or caution position of a distant signal requires the use of an indicator, as shown in Fig. 17, at *E*.

When C is closed by the motion of the semaphore of D, the battery circuit is completed and the armature of E will be raised, in the type of indicator illustrated. Another type is used, however, which will indicate clear when its armature falls, requiring the use of a controller whose make and break is in the opposite sense to that shown.

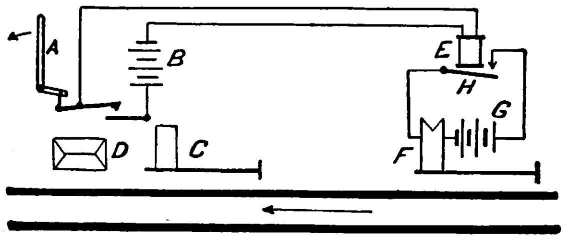

FIG. 18

In Fig. 18 we have a semi-automatic arrangement of circuits in which the circuit controller, D, is operated by the representative lever, A, of an interlocking machine. This lever controls by its mechanical movement a certain function, the electrical adjuncts being for another and distinct purpose, but of a concomitant nature, in the scheme of protection. When A is thrown in the direction of the arrow, the circuit of the line battery, B, is closed, thus energizing the distant relay, E, which, through its armature, H, sends a clearing current from the local battery, G, through the distant signal, F.

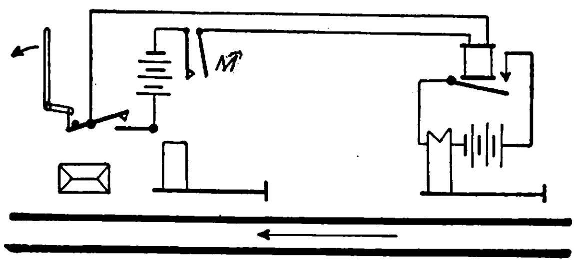

FIG. 19

In Fig. 19 the same principle is contemplated, but in addition a circuit controller, M, is employed, which thus prevents the distant signal from being cleared until the function the controller protects has been properly manipulated. This function, as will be shown throughout this book, may have any desired application or complexity.

In Fig. 20 we have another semi-automatic scheme of connection for a distant signal; the bonded track circuit being used instead of line wires. The track battery, *T*, maintains a difference of potential across the section, *S*, and normally, by energiz-

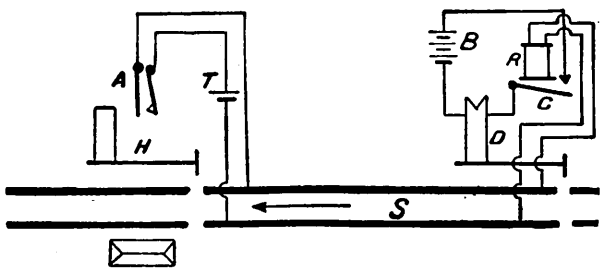

FIG. 20

ing the track relay, *R*, causes a current to pass from the local main battery, *B*, to the distant signal, *D*, through the armature, *C*. When *H* is cleared, the controller, *A*, is closed, and the reverse condition of affairs to that given in the figure obtains. Such an arrangement is more desirable, and less complicated than a line-wire system.

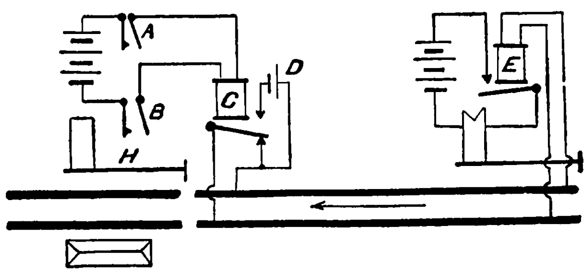

FIG. 21

The above distant signal cannot be controlled otherwise than through the movement of the home board. It sometimes is advisable to give the signalman authority to throw the distant board to caution without altering the clear position of the home signal. This is effected as shown in Fig. 21. When *H* is cleared, *B* will be closed as before. In addition, the hand switch, *A*, must be closed, or the track relay, *E*, cannot be energized due to the position of the armature of *C*, and its connection with track battery, *D*. Thus, when both *A* and *B* are closed, the distant signal can be cleared. The armature of *C*, by short-circuiting the track, thereby performs the same function that a train in the section would.

In Fig. 22, *H* and *F* are normally clear home signals protecting the respective insulated track sections, 5, 4, 3, 2, and 1. The reason for such a division of a block is to increase the reliability of the track circuits by decreasing the effect of the track-circuit current leakage from rail to rail. The track batteries, *G*, are connected to the west or extreme end of each section, so that a train moving in the direction of the arrows will shunt the relays, the batteries discharging their current through the entire length of the rails. This protects against broken rails or open bonds,

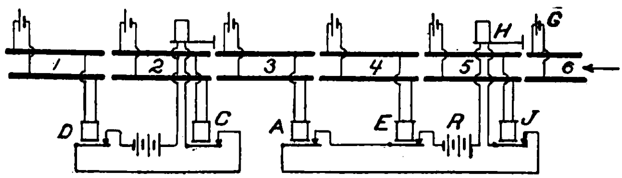

FIG. 22

by depriving the relays, such as *J*, *E*, *C*, *A*, and *D*, of current when such an open circuit occurs.

Under normal conditions, when neither of the sections is occupied by a train, the main batteries, as *R*, are in closed circuit with the signal mechanism, thus holding the discs in the clear position. When a train is approaching a signal, it is not affected, as the control functions remain the same. After entering the block, however, the relay, *J*, at the first section is deënergized, thus allowing its armature to fall, and open-circuiting the signal or working circuit and throwing the disc (or semaphore) to stop. This will occur on any section within the block, as the armatures and contacts are in series.

The functions introduced in a normal danger system, which clears the semaphore when the train enters the preceding block and causes it to remain clear until the train has left the block, irrespective of the number of sections it contains, are set forth in the diagram, Fig. 23. When the lower or back-contact armatures or points of relays, *M*, *W*, or *T*, drop, the home semaphore, *V*, will move to clear, providing the front contacts of *K* and *L* are closed. This occurs by reason of the back contacts of the relays, *M*, *W*, and *T*, at sections 3, 4, and 5 being connected in multiple, so that if one back contact closes, the same electrical condition is set up that would be the case if all or any other one of these contacts were closed. The front contacts of these relays

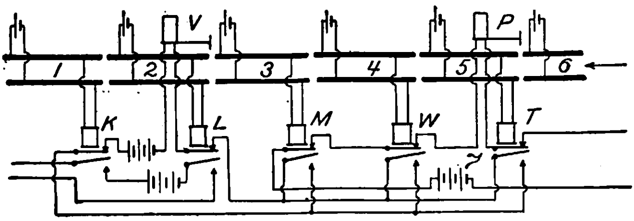

FIG. 23

are in series with the main battery, 7, which operates signal *P*, so that if either be open, the signal will remain at danger; a condition occurring when a train occupies either section. These relays thus become double functioned; and it frequently is possible to have all the contacts at a section box controlled by one relay. A modification or extension of this arrangement is used in all normal danger non-polarized line-wire systems.

In Fig. 24, 1 and 2 are two independent normal danger home signals, giving indications for trains bound west. The cut sec-

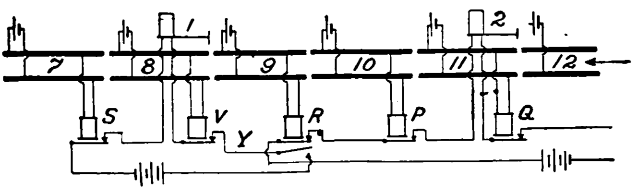

FIG. 24

tions, 7, 8, 9, 10, and 12, are connected to the respective relays, *S*, *V*, *R*, *P*, and *Q*, whose armatures, with one exception, close the circuits to which they are connected when the relays are energized. The lower, or back contact, armature prong on *R* is normally open, and consequently keeps the main battery in open circuit. Its purpose is to hold the semaphore at stop when *R* is energized, and to clear the blade when *R* is deënergized. This latter will occur only when a train occupies section 9, which may thus be termed a setting action. This clearing of the semaphore takes place under restricted conditions. If a train or broken rail occur in sections 7 or 8, 1 cannot be cleared by this armature falling, since the front contacts of either *S* or *V* will be open. Thus, if a train occupy section 8, the circuit will be opened at the armature of relay, *V*. The line wires, *Y*, are placed upon poles, and pass from one relay to the others. This arrangement is somewhat similar to the preceding, with the exception that the home signal is cleared only at the setting section.

Another simple, normal, clear home and distant (on the same mast) scheme of connection is shown in Fig. 25. The signals, *T* and *P*, each protect the track for two blocks, and are operated by the relays, *Q*, *W*, *B*, *O*, and *M*, each having two armature

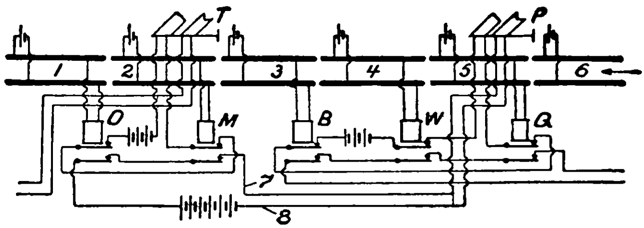

FIG. 25

contacts, the lower of which are connected to the distant blades, and the upper to the home blades. The home semaphore at *P* is controlled through the armatures of relays, *B*, *W*, and *Q*, which are connected to sections 3, 4, and 5. The distant is in series with the normally closed armatures of *O* and *M* at sections 1 and 2. These relays and semaphores are interconnected by line wires, as 7 and 8. It will be noted that the relays and track batteries are connected to opposite ends of each section, thus requiring the relay energizing current to pass along the rails, neutralizing the effect of fall in potential, and assuring the positive shunting of the relay by the train; at the same time guarding against broken rails.

The two general methods of throwing a signal member to danger when there is an open switch in the block are shown in Fig. 26. At sections 8 and 10 we have two switches, at which are placed the switch instruments, *B* and *F*. When the switch at

8 is opened, *B* short-circuits the track, and consequently the relay and track battery, thus setting up a condition analogous to that of a train in the section, the signal, *K*, being thrown to

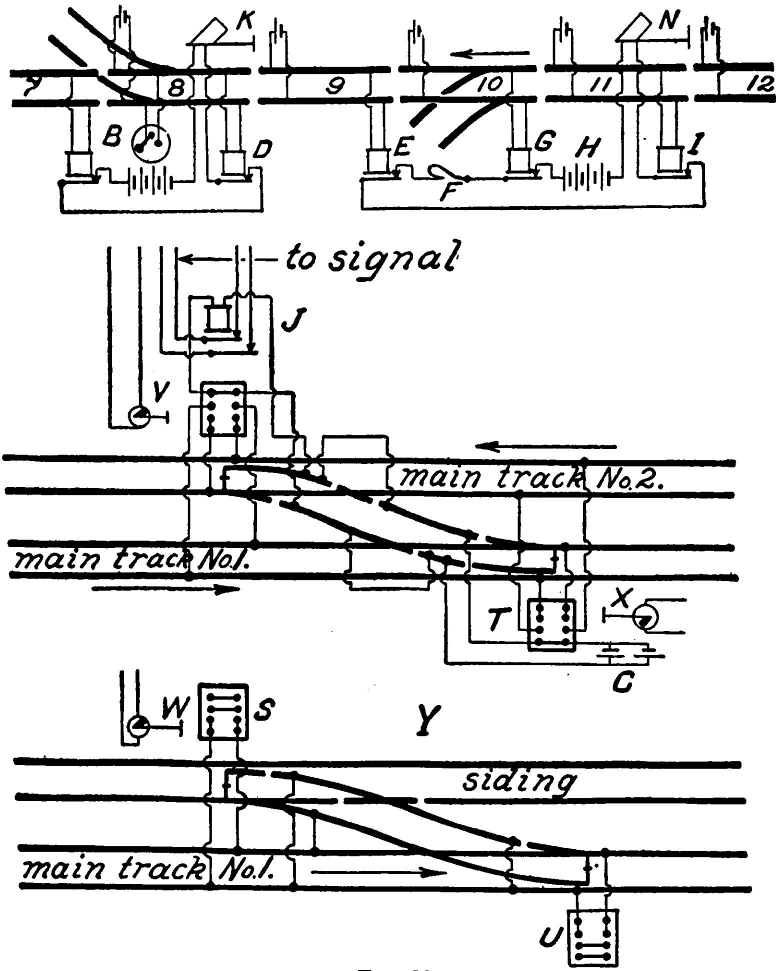

FIG. 26

stop in this case by the deënergization of *D*. This is effected by contacts within the switch instrument box which are connected to the rails of the track, so that when a revolving or rocking member is operated by a switch point, the rails become connected electrically.

At section 10, another arrangement is employed. *F* is a normally closed contact-spring, which is in series with the main battery, *H*, contacts of *E*, *G*, and *I*, and the home line of *N*. When the switch is thrown, *F* is opened, thus causing *N* to assume the danger position. Such a device is used only in line-wire systems, and particularly on normal danger circuits.

At *P*, the switch instruments, *T*, are applied to a cross-over; or from one main track to the other (trains moving in opposite directions), *V* and *X* are indicators, whose functions will be described later. Battery *C* supplies current to relay *J*, which current is cut off and the track rails short-circuited, when the switch is thrown. At *Y*, the same arrangement is applied to a siding, *S* and *U* being switch instruments, and *W* an indicator.

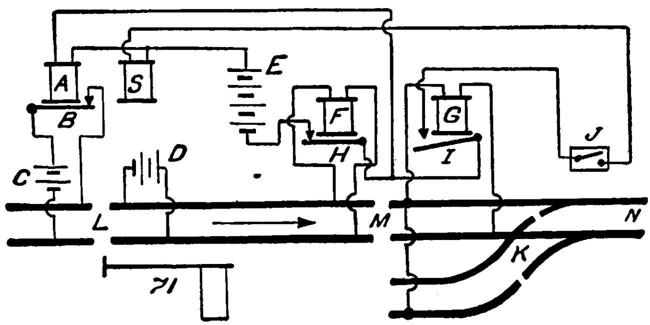

FIG. 27

A simple arrangement of overlap circuits in which distant signals are not used is shown in Fig. 27. Overlap was used in most early systems, to give an indication of a block's condition prior to the arrival of a train at the entrance of this block, thus eliminating the speed reduction that would be otherwise necessary in case a fog or other obscure condition prevented a clear view of the signal. The block, *L–N*, consists of two sections, *L–M* and *M–N*; in the latter an open switch, *K*, being present. Signal 71 protects this block, and is placed between signals 61 and 81.

The signal electromagnet, *S*, is in series with the armatures, *H* and *I*, of relays, *F* and *G*; main battery, *E*; and switch instrument, *J*, at switch, *K*. Since the latter is open, *E* cannot discharge current into *S*, because of the open circuit at the switch instrument. Due to the rails at *K* short-circuiting the section, *M–N*, *G* is also short-circuited, and its armature is in the lower position. *F*, however, is still energized by the track battery, *D*, but does not affect *S*. As *H*, *E*, and *A* are in series, the armature, *B*, of the latter closes its contact and allows the track battery, *C*, to maintain a difference of potential across the rails of the section before *L–M*, or the second section of signal 61.

If a train were to occupy *L–M*, *A* would be deënergized, thus holding 61 at danger. Also, if *M–N* is occupied, 71 will be at danger, while 61 is at clear. Signal 81 is unaffected by train or switch movement in the block protected by 71, but operations in the block of 81 would affect 71 in the manner above shown.

Overlaps may have application equally well to normal clear or normal danger systems. Figs. 28 and 29 show the circuits used in a line-wire system for overlap on a single track for the former, with home signals only. Should a train occupy the section between 161 and 162, track relay, *C*, will be deënergized, and its armature contacts consequently opened. This open-circuits the clearing magnet or slot, *H*, and moves 162 to danger. The middle armature of *C* also open-circuits the operating magnet of 161, moving the latter to danger; 160 remains cleared, however, as *A* receives current from the battery at the next signal in its rear (in the same direction) through the line.

E and *F* are circuit breakers operated by the moving to stop of 163, and *I* is an indicator placed at the switch, *K*, in series with *F*. Hence, when *F* is closed, *I* should be at clear, since it receives battery current from *B* (through *J* and *K*). *L* is another switch indicator in series with circuit breaker, *M*, of 161. The remainder of the circuit is a repetition of the above.

At 1, in Fig. 30, *L* is a switch indicator placed at the main-line switch, *D*, which will indicate clear to a brakeman only when the home signals in the two preceding blocks, *A* and *B*, are at clear. This is effected through the use of circuit controllers or relay-armature front contacts at these signals, as shown. At 2, *G* is a polarized instrument which consequently has two (or three) indication positions. The controller at signal *E* determines the setting up of current in *G*, and the pole changers at *F*, the polarity of this current. In this fashion, the banner of *G* may either be in a central or side position, the language to the brakeman being effected by its moving before one or more apertures in the mechanism housing.

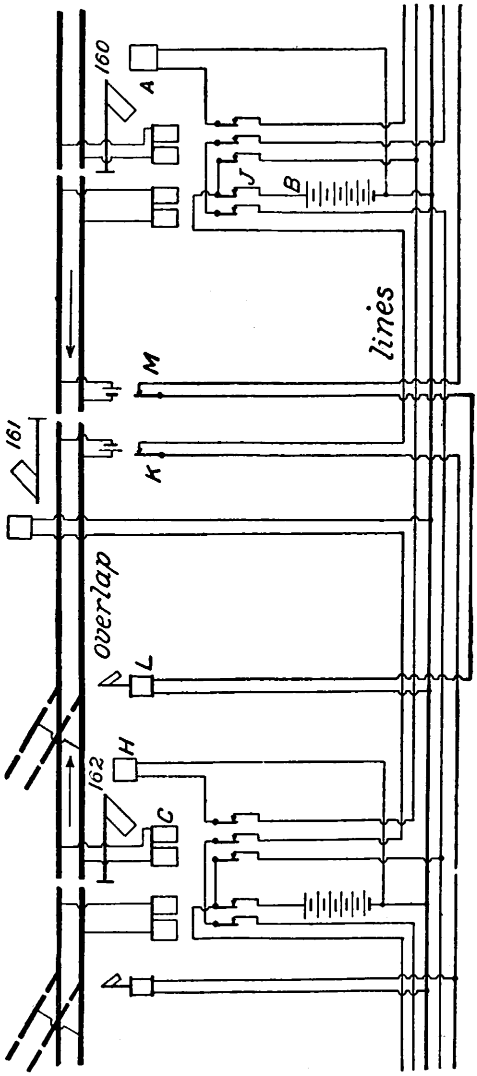

FIG. 28

Crossing signals are employed to warn pedestrians or teams at a highway or grade crossing of the approach of a train or locomotive. Fig. 31 shows a common circuit arrangement for such a scheme, two insulated and bonded sections of track adjacent

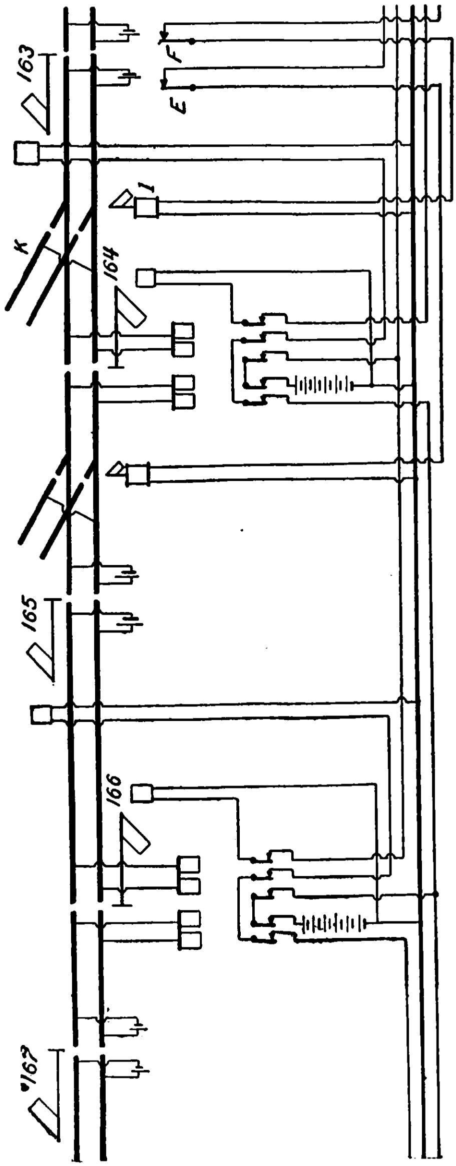

Fig. 29

to a highway forming part of the control elements, although line wires may also be used. These sections, 1 and 2, are electrically isolated by the insulating joints, *G*, and energized by the track batteries, *A*. At the highway a signal, 3 (which contains the accessories diagrammatically shown), gives warning of train

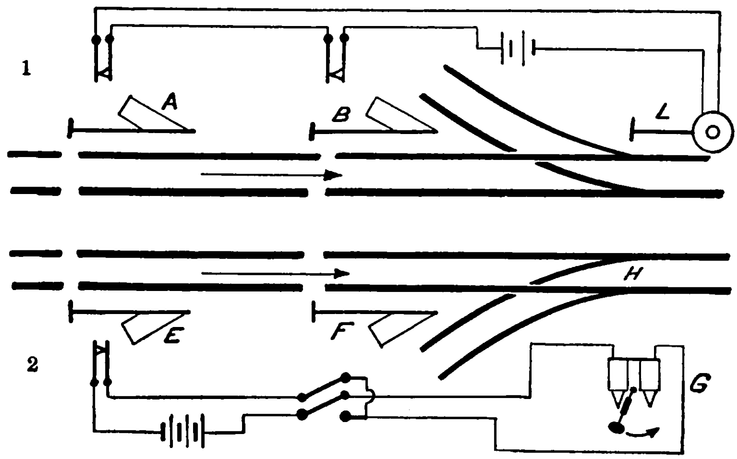

FIG. 30

movement by the ringing of a bell; which latter is sometimes supplemental to a small low-voltage incandescent lamp for night

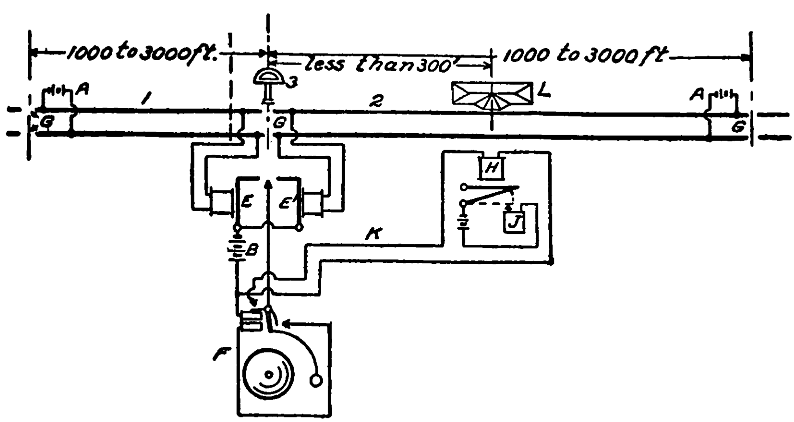

FIG. 31

indications. *L* is a station or block tower, provided with an automatic drop, *H*, containing an audible or visual indicating device, *J*, introduced in a local circuit closed by the release of the contact armature. *E* is a relay having two interlocking armatures and separate magnets, so that if a train begins moving in either direction, the bell, *F*, will ring, but as soon as it passes the highway, *F* will cease to ring, due to the interference of the armature prongs which hold open the bell circuit. Thus, suppose a train moves from 1 to 2. *A* will be short-circuited and *E* deënergized, allowing a current to flow from *B* through *F*. At the first stroke of the bell clapper, a shunted current passes over the lines, *K*, and thereby operates *J*. As soon as the train passes the highway, the armatures of *E* and E^1 interlock, one holding the other away from the common contact, thus open-circuiting *F*. When the train passes out of section 2, E^1 is energized, thus retaining both armatures from interference.