AUTOMATIC BLOCK SIGNALS.

CHAPTER I.

PRELIMINARY CONSIDERATIONS.

A **block** is a length of railroad track of defined limits, the use of which by trains is under the control of one or more block signals.

A **block signal** is a fixed arrangement controlling the use of a block.

An **automatic block signal** is one automatically operated by electrical or other energy, this agency being controlled by the passage of trains along the track, or by conditions which interfere with such movement.

A **block system** is a series of consecutive blocks controlled by block signals.

A **home signal** shows the condition of the block directly in front of a moving train; and a **distant signal** the condition of the second block in front, or the block in the rear of the home block.

An **advance signal** shows the condition of a block in conjunction with the home signal of that block. It is placed in advance of the home signal.

In Fig. 1 two signals, having home and distant semaphores, blades, or boards, are shown, with the track protected by each; train movement being in the direction of the arrows. The entire home block, consisting of two sections of the first signal, is represented; and one section of the home block of signal 2, which latter is also the first section of the distant block of signal 1.

A block is usually made about one mile long, although a large amount of traffic, the presence of an interlocking plant, numerous switches, or the necessity of slow-speed movements may require less length. On the other hand, blocks in a sparsely settled district, with thin traffic, can be of greater length. These blocks are protected in automatic visual systems by a disk, semaphore, or revolving member by day, and by colored lights at night; these giving warning of the presence of a train, broken rail, open switch, car outside the clearance point at sidings, an open drawbridge, hand car on the track, or defect in the apparatus.

There are several ways of indicating a danger, caution, or clear condition, among which are: (1) color systems; (2) position systems; (3) motion systems. A type of the first is a colored disk moving before a white surface, either the former or the latter being visible; of the second, a blade or semaphore which is held at various angles to the track; when horizontal, " danger " or " stop " being indicated, and when nearly vertical, " proceed " or " clear." Semaphores may be colored also, and thus become of the first type. The third or motion signal utilizes a revolving member, whose motion indicates that an approaching train may continue to move, and when stationary that the engine must come to a stop. At night a light is flashed intermittently by this member. Such systems, and also illuminated semaphores, have been abandoned, and therefore will not be described.

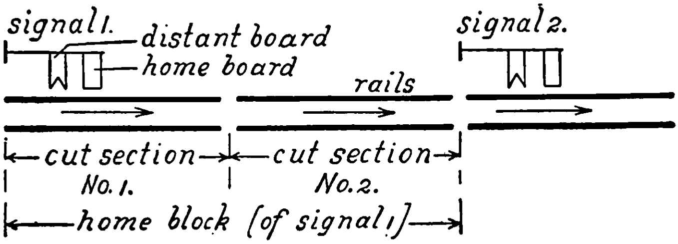

FIG. 1

Usually, signals are numbered in such manner that these numerals will indicate the number of miles and tenths of a mile that the signal is distant from the chosen terminal. Thus on the Lehigh Valley, signal No. 1773 is 177.3 miles from New York City. On this road, odd numbers designate west bound signals and the even numbers the east bound signals. Thus it is evident that 1773 is the west bound signal 177.3 miles from New York

City (the nearest odd number to the actual tenth of a mile being chosen).

Fig. 2 shows four separate main tracks intersecting at right angles, with their respective signals. If these are automatic, track relays, properly interconnected, can be readily arranged to give the protection desired. If they are semi-automatic, electric interlocking will be introduced to prevent conflicting of routes. Thus, when signal 3 is at clear, to allow a south bound train to pass, 1, 2, and 4 must be locked in the normal or stop position when electric locking or interlocking is used, and prevented from moving to clear if the ordinary automatic system is employed.

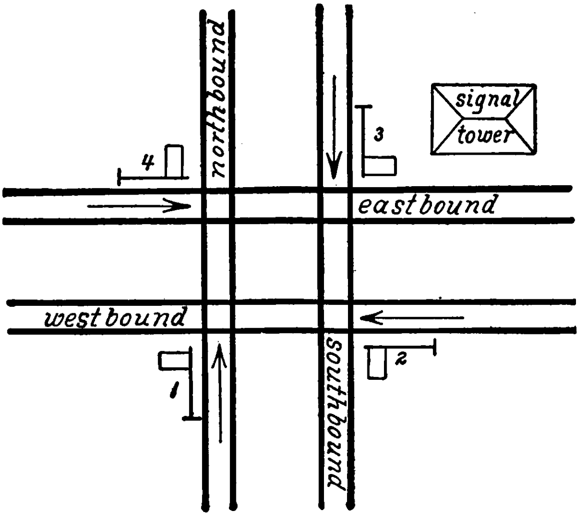

FIG. 2

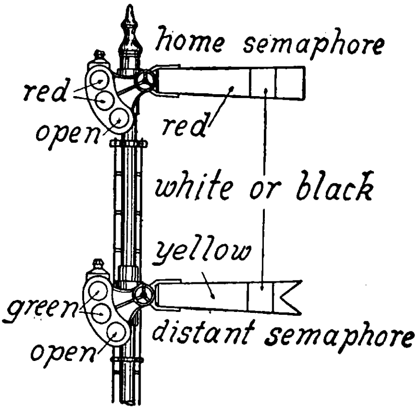

FIG. 3

A standard sixty-degree home and distant semaphore arrangement is shown in Fig. 3. Until either blade has reached a position approximating thirty degrees from the vertical it will indicate the same as though at the full horizontal position. This is effected by using several spectacles, each held in place by independent bezel rings, or by so-called continuous light spectacles. Semaphores vary in length from four to five feet, about four and one-half being regarded as standard.

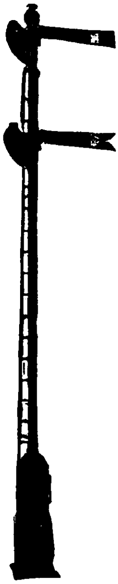

FIG. 4

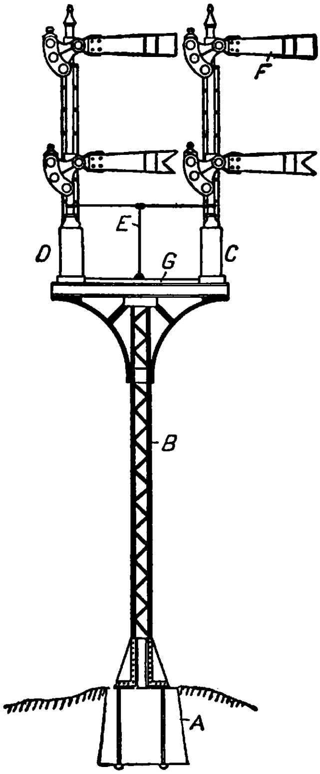

FIG. 5

A self-contained standard home and distant, three-spectacle, semaphore signal (electro-gas or motor), is shown in Fig. 4, the motor, mechanism and battery housings being at the base. This represents the highest development in external design that such signals have reached, unless exception be made of the top post arrangement.

A three-spectacle, automatic, double-route, home and distant semaphore signal is illustrated in Fig. 5. The post, *B*, consists of two lengths of channel iron strengthened by a lattice structure, the base being bolted to, or incorporated with, a foundation of concrete, *A*. The top consists of a platform, *G*, and railing, *E*, semaphores, *F*, being pivoted to short posts and operated by motors and accessories housed in the waterproof base boxes, *C–D*. This arrangement represents the latest order of construction for the protection of two tracks having trains running in the same direction.

In Fig. 6 *A* is a short mast distant semaphore signal with an automatic mechanism housing at the base; *B* is a high home signal; *C* a short mast two-arm or double-route, *D* a high mast two-route, and *E* a three-arm or triple-route arrangement. The standard heights of each are also given, and although this latter may vary somewhat, it represents the usual practice.

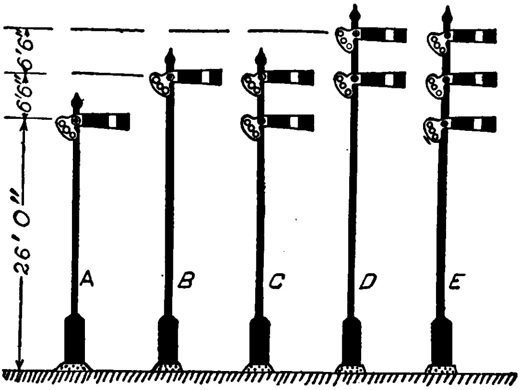

Fig. 6

Bridge signals, which are of more substantial design than mast signals, are shown in Fig. 7. The letters designate types similar to those in the preceding figure. The tracks pass beneath the bridge at *G*. Most lines having four main tracks or over use this disposition of semaphores.

Fig. 8 shows two forms of motor-operated high signals, *A* being a single arm, and *B* a two-route arrangement. The circuit breakers, *H*, are operated by the rods, *G*, connected to the semaphore castings. The cast iron box, *A*, contains the motor and gearing constituting the signal movement (see Fig. 119), and part of the sheave, *B*, which carries the chains, *C*, projecting from below. The blades are connected to the counterweighted levers, *E*, resilient members, *D*, being introduced to prevent injury to the parts when they fall, or should the motor wind up too high. Reversal of the motor on *B* is effected by a ground selector, described in Chapter XIV.

The electric-motor semaphore signal has several advantages, among which may be mentioned: (1) localization, it being self-contained, and therefore independent of all other signals; (2) comparatively large reserve power; (3) an isolated plant is not required for its operation; (4) economy of installation and operation; (5) working and control functions are unified; (6) external simplicity of design.

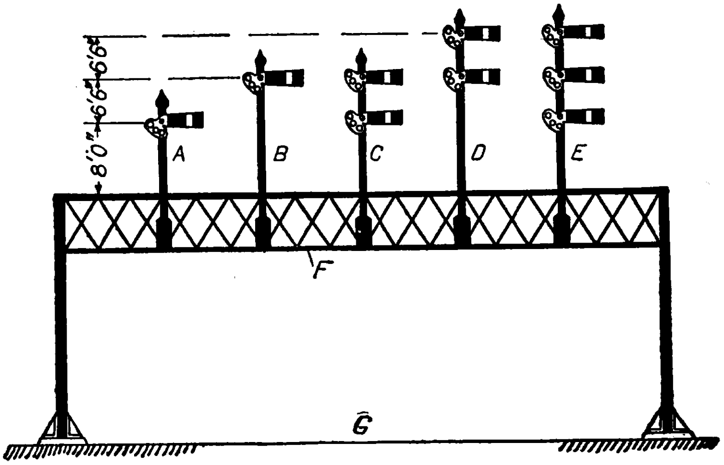

FIG. 7

The motor and control mechanism is somewhat complicated, and numerous factors of failure have been necessarily introduced. A clumsy structure is used to transform the high-speed rotary armature movement into a slow, direct reciprocating motion, while the motor itself is not a perfectly reliable device under the restrictions that must be imposed upon it. Frost may accumulate upon the commutator, the lubricant may gum, or the mica cause an open circuit, thus resulting in inoperation. The clutch or slot magnet armatures may also freeze in the clear position, as they are not acted upon by a powerful force.

The generic purpose of the electric circuits applied to devices whose electrical operation establishes the right of train movement, is to prevent conducting continuity when a conflicting or non-clear condition exists. Thus imagine a home-signal receptive device whose energization cannot occur until twenty-four independent contacts have been closed, each having a function which determines the right to proceed; then the opening of any one or more of these prevents the flow of current which is obviously the concomitant of a clear condition. It is the comprehension of this principle which will render evident the application of signal circuits and their close approach to being an ideal selective intermediary.

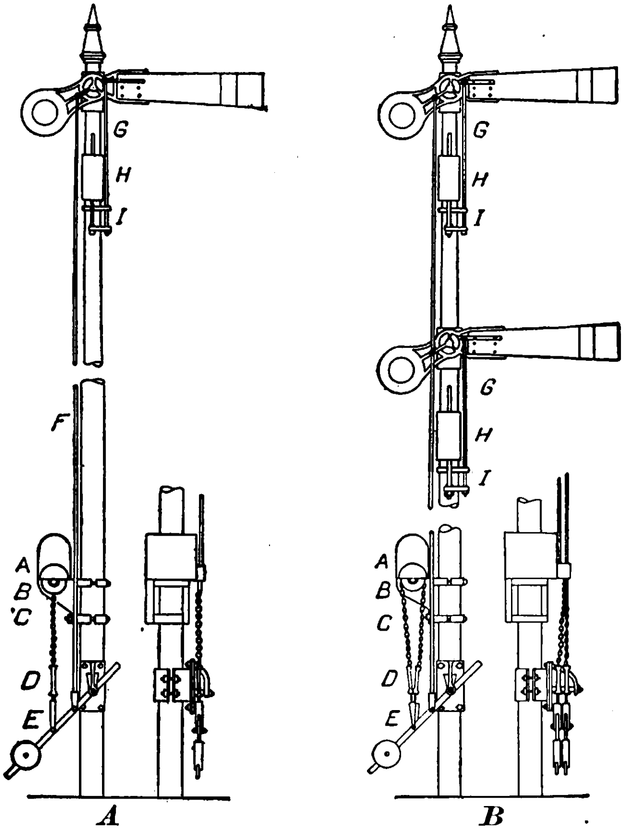

Fig. 8

Commercial signal circuits may be divided into two parts, which are more or less generic according to the system employed. These are respectively control circuits and working circuits.

Usually a control circuit has a relatively low impressed voltage, and the circuit wires are not of great length. The most common type of control circuit is that constituting what is ordinarily termed the "track circuit," which includes the rails of the section to which it is applied, with the requisite track battery, relay, and interconnecting wires. The primary purpose of the control circuit is to close and open another circuit, the latter delivering considerable energy and actuating the devices included in the direct operation of the signal banner or semaphore.

This latter constitutes the working circuit. The main battery, which is in this circuit, cannot be short-circuited, owing to the loss of energy which would result, the deleterious effect upon the cells, and the excessive sparking at the shunt contact, which latter would necessitate the use of unusually heavy or special circuit breakers. With a resistance in series, such as the line wire, motor, slot magnets, or other accessories, these precautions do not apply.

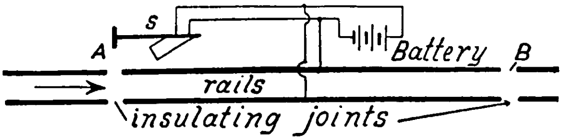

FIG. 9

Considering the arrangement in Fig. 9, with a normally clear signal, *S*, whose current is obtained from a battery in shunt with the rails of the insulated track section, *A–B*, it is evident that as soon as a car, train, or locomotive passes along this section in the direction of the arrow, the resulting short-circuiting of the battery will deprive the signal of current, and thus throw the semaphore to the danger position. A train which is on any other section of the rails will not affect this signal, which therefore indicates only the condition of the section it immediately precedes. Such a circuit, while readily comprehended, is not commercially practicable for the following reasons:

(1) Too great a length of line wire is required.

(2) Unnecessary waste of energy, due to the short-circuiting of the battery.

(3) Adequate protection is not afforded (for reasons that will be clearer later).

(4) Too great a current loss will occur, due to the high difference of potential between the rails.

The principle of introducing series switch-contacts to throw a signal at danger when track switches in its block are opened into the home circuit of a signal is set forth in Fig. 10. In the block of *S* are three switches, *C*, *E*, and *G*, having three switch instruments, *A*, *D*, and *F*. Battery *B* energizes the operating mechanism of the home semaphore, *H*, through the successive relay points and the single pole contacts at *A*, *D*, and *F*. Therefore, should either of these switches be thrown open, the signal circuit will be broken and the signal held at danger, regardless of the condition of the relay contacts.

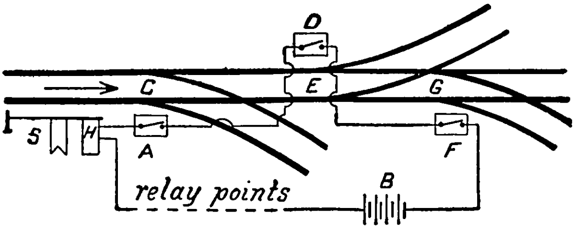

FIG. 10

In general, it is better to place the dependence of a safety condition or a danger indication upon the opening of a circuit rather than its closing. In the low-voltage circuits used in signaling, there is greater certainty in opening than in closing a contact. This is because a poor connection (or particles of dirt preventing the intimate metallic contact which is the prerequisite of a closed circuit) may introduce a sufficient resistance or air-gap to oppose the desired flow of current. As an example, the closed-circuit and open-circuit types of switch instruments may be cited. In the former, with an open switch, the track must be short-circuited; in the latter, the signal circuit must be opened to hold the signal at danger. The latter is obviously the most reliable, as a poor contact will merely mean a false danger condition, while in the former, it will set up a false clear signal.

Nearly all existing types of automatic signals may be used in a semi-automatic sense; for example, placed at an outlying switch or interlocking scheme, and controlled by a line or track circuit from the nearest tower. Such a provision eliminates the use of cumbersome and costly mechanical interconnection, and involves no appreciable labor on the part of the operator in clearing or releasing. When the track circuit is used, the operation of this signal is taken from the immediate control of the tower operator, although the conditions required to be set up by train movement may class the signal as not purely automatic. The extension of these principles will be considered in Chapter V.

The conditions that may set up a false or dangerous condition in a signal system are manifold; but their actual occurrences few. The failures at danger can only wrongly delay a train; but failures at clear, by giving the engineer a proceed indication when such may not be safe, are the only ones that can really be termed dangerous. Such failures have in practice occurred on an average of one in a million movements. On a normal clear system, an average of one in about six hundred thousand has often been reported. Many such failures occur from inability of the moving system to move from its normal position. It is not, primarily, the external parts which are sensitive to such checks to movement, as they are thrown by a powerful force, and with sufficient inertia to remove a retardation; but the light control parts, whose motion is due to the expenditure of energy measured in thousandths of a watt.

Among the causes of false clear conditions are, fusing of control contacts, improperly counterweighted banner or semaphore, breaking of the color spectacles, rusting of sliding parts, foreign currents, residual magnetism in relays, imperfect contacts, dust or insects in relay boxes, crossing or grounding of wires, interconnection of wires with common, poor armature pivots, failure of clutches or locks to return, breaking of mechanical connections, and poorly insulated circuit wires.

The use of white as a clear indication is meeting with disfavor. This is due to the liability of a spectacle's breaking, or the chipping off of its color film. The adoption of green or red for clear has many advantages, among which are the normal danger indication of a white light, except when a color spectacle is actually and properly before it, and the restricted conditions under which safety indications are given.

Failures at danger may be caused by a broken rail, bond wires rusted off or broken, rusty channel pin, high-current leakage between the tracks, broken wires in the relay, polarity reverser, track battery or signal circuit, exhausted track or main batteries, poor connections, unsoldered joints, broken battery jar, useless or poor connection in switch boxes or controllers, blowing of the protective fuses, failure of an arrester, broken line wires, short-circuiting of an individual or series of batteries, open circuit at motor commutator, failure of electric slots or locks, poor insulation, short-circuits in relays, and the depredations of mischievous persons.

As far as visual indication is concerned, the normal danger position is undoubtedly the best, and has been so recognized since the inception of mechanically operated semaphores; while argumentative opinion, from a purely electrical standpoint, also favors such a disposition. Formerly, standard normal clear circuits were more economical in initial installation, but this consideration no longer obtains.

Various signal engineers and others have from time to time regarded a certain modification or departure as ideal. Such arrangements, when actually applied, have frequently an ephemeral existence. In no specific instance has such unproductive effort been expended as in rail bonding. Railroad accessories undergo hard usage, and are subjected to extremes of weather, so that a scheme which seems temporarily of a revolutionary character is found hopeless after a few years of service. The greater part of the accessories introduced since automatic signaling began have been abandoned for this reason, so that standardization appears distant when viewed from the present.

Numerous attempts have been made to introduce protective arrangements supplementary to a visual system, in which the control of a train is taken temporarily from the engineman in case a danger signal is ignored or unapprehended. Fig. 11 shows an impracticable, though a generic form of such an accessory. When the home semaphore is in the danger position, it raises a finger or projection which engages with a pivoted lever secured to one of the trucks of a train. This lever, *B*, is fastened to a valve, *A*, which is connected to the train pipe, *T*, of the air brake equipment by a flexible tube, *C*, the travel of this lever being limited by the quadrant *D*. Obvious reasons can be advanced against the application of such a device. We will take up in Chapter XVI a development of this principle, which has the merit of being in use.

The normal danger system admits of the employment of normally open-track circuits. This condition allows the use of open-circuit batteries (gravity cells cannot be employed) with consequent economy of operation. Instead of the customary two weeks' intervals between patching and renewing, it is possible to run six months. The circuits are closed in the preceding two blocks by the approaching train, and should anything be wrong in the block, the track relays will receive no energization. The continual heavy demand upon track batteries by the low-resistance track relays under a clear track condition has been heretofore one of the greatest disadvantages of signal installation.

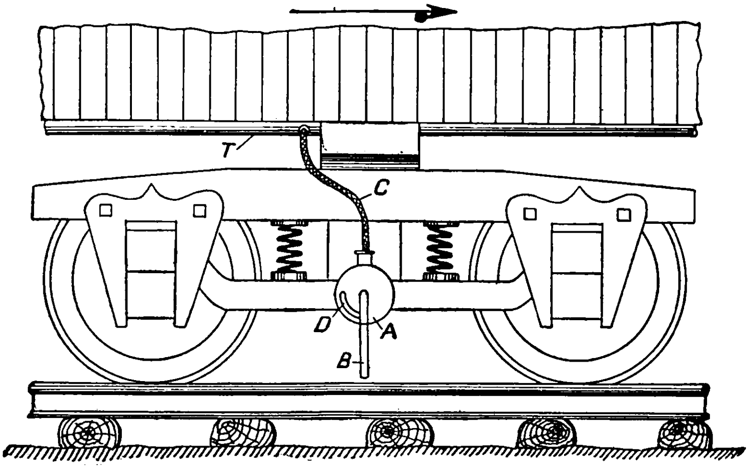

Fig. 11

In Fig. 12 a diagrammatic representation of relays and contacts, such as is used throughout this book, is given. *A* has one front (upper) and one back (lower) contact, each being a single-pole break, and so disposed that both cannot be in simultaneous contact with the armature. *B* is a single front contact, and is more frequently applied than any other combination. *C* has two front contacts, with independent armatures; *D* two front and one back; *E* three front with common armature; *F* two front and two back; *G* three front with independent armatures; and *H* four front and four back, each having a double simultaneous break. In reality, these connections are usually effected by a single armature on each relay, but a more definite conception is afforded by representing as shown.

The application of automatic signals, by giving to trainmen the right to shift their trains at all reasonable times, renders imperative a positive knowledge of the condition of the track to which they are to proceed. Should a train be approaching this block or is already within it, there must be some means of warning the trainmen not to open the switch. Should such a switch be opened, the main line signal must be held at danger, and information be conveyed to the trainmen that it has, and that the opening of the switch was the cause of such movement. This is now accomplished by means of a polarized indicator, as the neutral type cannot be thus applied; for, if a train enters the main block in question at the moment the switch has been thrown, the trainman will necessarily assume that he has been the cause of such indicator's movement, and unconsciously proceed to the main line without expectation of danger. Thereby delay would result to the train passing the main signal, if the latter's indication were understood by the engineman, but should the latter fail to note the condition of the block, a collision might result.

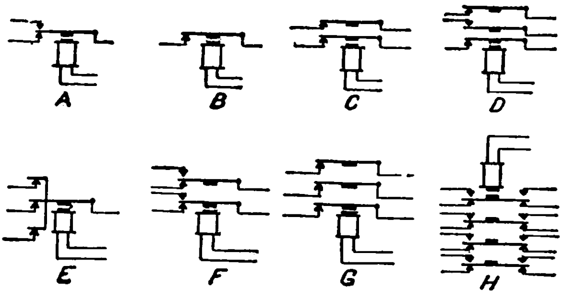

FIG. 12

Primary cells are employed almost exclusively for the operation of automatic signals, because of their peculiar adaptability to the requirements of these devices. Although not nearly so economical as other methods of setting up currents of electricity, yet, when a small amount of energy is to be delivered continuously, or for long periods of time with extreme reliability, the question becomes not economy, but constancy of operation.

Thermoelectric devices, in which currents have been set up directly from heat, have been tried, but as yet have been found wanting, owing to their multiplicity of parts and the necessity of maintaining a flame continuously. Improvements along this line are anticipated, but may be hopelessly remote.