

Block Signaling Practice on a British Railway

Use of Cab Signals to Indicate Position of Distant Signal Arm and Communication Methods Among Subjects Discussed

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THE use of electrically controlled ground frames, fouling bars, telephone and telegraph communication, automatic signaling, electrically operated switches and locomotive cab signaling on the Midland Railway of England is described in this article, which is the last of three covering the block signaling practice on this road.

The first article appeared in the May number of the *Railway Signal Engineer*, on page 159, and was descriptive of the ordinary and interlocking, single and multiple line block. The second article appeared in the June issue on page 188, and was descriptive of the use of track circuiting, signal repeaters, signal light indications, train waiting apparatus and tunnel alarms.

Electrically Controlled Ground Frames

In accordance with the Board of Trade requirements, the maximum distance at which switches may be worked from a tower is 300 yards. At some places it is necessary to have a siding connection at a greater distance than 300 yards from the tower. In such cases an electrically controlled ground frame will meet requirements. In other cases, a "lie by" siding may be arranged as a loop line.

In the ordinary case of a freight train taking siding to allow a more important train to pass, the freight train must go forward clear of the siding switch and then be set back into the siding. If a loop line is provided, the freight train can run direct into the loop line by means of facing switches worked directly from the tower, and after the more important train has passed can run out from the forward end of the loop line, the switch being thrown by the brakeman of the freight train from a ground frame controlled from the tower. By this means there is a considerable saving of the all-important railway factor—time. In each case the method of working

apparatus in connection. When the brakeman requires to use the siding switch he pulls the asking lever; this breaks the detector circuit, and allows the indicator at the tower to fall to the "want points" position, and also allows the bolt lock to fall ready to lock the bolt lock lever in the pulled position. The indicator in this position also closes a local buzzer circuit to call the signalman's attention. If the signalman is prepared to allow the siding connection to be used, he pulls the bolt lock lever. The electric bolt then locks the lever and closes the circuit through the electric lock at the ground frame, and at the sidings switch, unlocking these and also indicating "points free." The shunter may then pull the switch lever and open it. At this stage, the detector circuit is broken at the asking lever, the point lever, and also at the siding switch. At the tower the bolt lock lever is locked in the pulled position, thereby mechanically preventing all conflicting lever movements. When work at the ground frame is completed, all levers are restored to the normal position, and when all the electric bolts have dropped and locked the point lever and the switch, the detector circuit is closed, thereby lifting the lock on the bolt lock lever and moving the indicator to the clear position. The signalman may then put back the bolt lock lever and resume normal working.

Fouling Bars

A fouling bar is the mechanical equivalent of a short track circuit equal in length to the length of the bar. The bar is fixed to the running rail in such a manner as to allow the wheel flanges of any vehicle passing over it to depress it to an amount equal to the depth of the wheel flange. The bar is counter-balanced in order that in the normal position the upper surface is level with the top of the rail. A switch is connected to the bar; the circuit is closed when the bar is normal and open when it is depressed, thereby operating the indicator in the tower and locking the switches and signals as required. Bars are used independently of track circuits in cases where it is desirable to protect the rear end of a train which may stand foul of other roads. In such a case the electric locking of either switches or signals is maintained until the end of the train has passed off the bar and clear of the conflicting roads. A bar may be used in a position where it is not possible to satisfactorily track circuit the rails, as at some special crossings. In such a case the bar really fills a gap in the track circuiting and the track locking circuit is taken through the bar switch. Bars are satisfactory in positions where the train movements are slow, as in siding connections, and in various positions about a terminal station.

Telephonic Communication

Almost all Midland towers are provided with telephones. The number of these in each tower varies in accordance with local requirements. The usual method is to connect the towers on an omnibus circuit, which may have up to 12 stations. Since the introduction of the "Traffic Control Scheme" the practice is to connect these local circuits as required into the district control office. As all the district control offices are directly connected to the chief control office by means of the control trunk circuits, it will be seen that orders may be quickly trans-

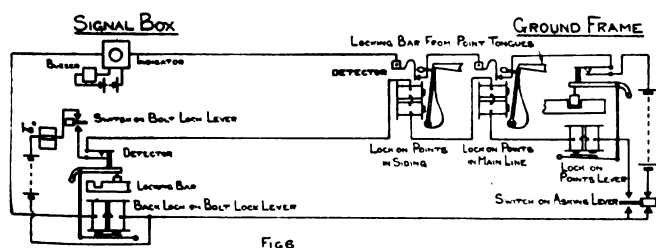


FIG. 6
GROUND FRAME LOCKING

Circuit for Electrically Controlled Ground Frame

is similar. The ground frame is provided with three levers, viz.: asking, point, and signal lever. The point lever is electrically locked, and the switch is also electrically locked by a lock directly connected to the switch tongues. The bolt of each of these locks operates a detector circuit switch, closing this circuit only when the bolt is in the locked position. At the tower a bolt lock lever is provided which, when pulled, mechanically locks all levers which allow any train movement conflicting with the movements permitted by the operation of the ground frame.

A description of the operation will explain the use of the levers as mentioned above, and also the auxiliary

mitted from headquarters to any tower on the system. The telephones are of the ordinary pattern, the calling is by code rings, the only special feature being when the circuit is connected to a control office. With code ringing in operation every station on a circuit receives every call, but only gives attention to its own call. This is quite satisfactory so far as towers are concerned, but is very objectionable in a control office where all the telephone circuits of a district are concentrated. To overcome this difficulty a special ringing key is provided at each telephone which communicates with a control office, and the telephone at that point is fitted with a polarized relay. The ringing battery at each station is connected to the ordinary calling key in such a direction as to render the polarized relay inoperative when the code rings are given. When the special ringing key is used the battery is reversed and the call is received in the control office. By this means this office only receives necessary calls and is not annoyed by the code calls in use between the other stations.

In addition to the omnibus circuits it is in some cases of advantage to give a local communication between two adjacent towers. This is effected by connecting two telephones on the block bell wire. Phonopore telephones are also largely used, chiefly to afford special communication between the towers and the district control office. This form of telephone is superimposed on the telegraph line, and allows simultaneous working of telegraph and telephone on one wire. The arrangement is quite satisfactory when the line is carried on a route with only a few conductors, but when the line forms one of possibly 100 conductors on the main telegraph routes, it is not possible to eliminate all the inductive disturbances. With this exception, very good results are attained, and it is possible to establish telephonic communication between stations up to a distance of 80 mi. apart with several intermediate stations in circuit where the circumstances do not justify the expenditure necessary in connection with the erection of two copper wires for this distance. One difficulty in connection with the use of Phonopore telephones is the necessity of using a hooter call. In order to prevent interference with the needles of the telegraph instruments on the same line the frequency of the vibrations of this call must be about 500 per sec. This frequency will inductively disturb any ordinary telephone lines carried on the same route even when the balance of these lines is carried to a point at which all other disturbances are entirely eliminated.

Telegraphic Communication

The present system of telegraphic communication in connection with towers was established before telephones were available. Although the very large growth of the telephone system now absorbs a great percentage of the work and has caused a continuous tendency in the direction of reduction of the number of towers fitted with telegraph message instruments, there is still a need for this class of apparatus. Towers are connected as intermediate stations on local circuits between telegraph offices, and the only type of instrument in use in towers is the single needle instrument. Of all the many forms of admittedly superior apparatus now available for general work, there is no instrument so suitable for this particular work. This instrument is similar to the ordinary block instrument, but the parts are arranged for more rapid movement than is required in the manipulation of the block instrument. The instrument is easy to learn, very economical in maintenance, and the average speed of 20 words per minute is well within the capacity of the average signalman. The average circuit has about 20 stations connected, all in series. The resistance of each

instrument is 200 ohms and the working current is 20 milliamperes.

In addition to the ordinary railway message, it is the practice at many of the Midland stations to forward or transmit ordinary telegraph messages on behalf of the postmaster general. At some of the small stations messages may be handed in at the booking office, then passed by the station master to the signaller, and sent by him to the transmitting office on his circuit, afterwards being handed over to the post office telegraph system by means of the "Handing Over Circuits" provided for this purpose. The public is not allowed to enter the tower or to communicate with the signaller in connection with the transmission of messages. Greenwich time is adopted throughout on the Midland Railway, and the time signal is transmitted over the entire telegraph system at 10:00 a. m. daily. The method in connection with the single needle circuits is as follows: Shortly before 10:00 a. m. all work ceases, the only exception being the transmission of a message with the prefix *DNG* (danger signal). Each transmitting station holds his instrument to *E*, and thereby all needles on the circuit to *E*. When the time signal is received the transmitting station moves the instrument to *T*, and at all the stations served the beginning of the movement of the needle from *E* to *T* is the time signal. The time signal may be given by means of the block bells to stations not provided with a telegraph instrument.

Semi-Automatic Signaling

The object of the semi-automatic signaling is to allow a train to leave the tower in the rear before the preceding train has passed the one in advance, and to prevent more than one train being in the section between the tower in the rear and the semi-automatic home signal, or between the semi-automatic home signal and the tower in advance on the same line, at the same time. On the main line three sections of Up and Down lines have been fitted, and on the Tilbury line two sections of Up and Down lines, and one section of Down line only have been fitted with semi-automatic signaling. Figure 7 shows the arrangement of signals and the track circuit controls for one section on the main line. On the Tilbury line the arrangement of signals is somewhat different, the semi-automatic signal in the center of the section becomes an advance signal controlled by the track circuiting and by the signaller in the rear.

The following details refer only to the sections on the main line. The normal position of all signals is the "On" or danger position. The controlling tracks are indicated in both towers. All trains are signaled on the block bells and the needle block instruments are dispensed with. Signals *c* and *d* are worked from one lever in tower *B*. In the lever frame in the tower the mechanical interlocking is such that when the lever for signals *c* and *d* has been pulled and replaced, it cannot be again pulled until after the lever for home signal *f* has been pulled and replaced. A special feature in connection with the Midland semi-automatic signaling is the fog lever arrangement. A lever is provided in the tower in advance. In the length shown in Figure 7 the fog lever for the Up line is in tower *B* and the fog lever for the Down line is in tower *A*. Dealing with the Up line: When a fog comes on, or snow commences to fall, the signaller at *B* will pull the fog lever. The effect of this is to bring into a circuit a switch on the arm of the semi-automatic home signal *d*. The line wire of the controlling track circuit between the Up starting signal *b* and the semi-automatic home signal *d* is taken through this switch, which closes the circuit only when the signal arm is "Off" (or clear), with the result that the starting signal *b* will, after being

replaced by a train, remain locked until the train has passed clear of track circuit *B*, and also track circuit *C*, thereby combining the two track circuit controls and ensuring that under these conditions a train must pass 440 yards beyond signal *f* before the starting signal *b* can be lowered for a following train to enter the section.

Under normal conditions the sequence of actions in connection with the trains passing through the section is as follows: The train entering track *A* will lock signal *a* and on clearing track *A* the lock is taken off signal *a*. On entering track *B*, signal *b* is replaced to "Danger" and on clearing this track the control is taken off signal *b*, allowing this to be pulled "Off" for a following train. When the first train enters track *C*, signals *c* and *d* are replaced to "Danger" and maintained in this position until after the train has cleared this track. On entering track *D* the home signal *f* is locked until after the train has cleared track *d*.

The result of this arrangement is to make the original block section between towers *A* and *B* into two sections, and allow a closer working of traffic.

Electrically Operated Switches and Signals

One tower has been fitted for the electrical operation of all switches and signals controlled from it. The lever frame has 48 levers, and in addition to the electric locking these levers are mechanically interlocked. All switches

control circuit, thereby allowing the signal to go "On" by gravity.

Electrically Operated Signals

When approaching a tunnel it is in some cases desirable to give the engine driver some indication of the position of the signals controlling the train immediately after leaving the tunnel. In such a case an electrically operated outer distant signal is provided in a position convenient for observation before entering the tunnel. This signal is operated by a 10-volt signal machine controlled by a switch arm of the mechanically operated inner distant signal. As the home signal and also the starting signal must be "Off" before the inner distant signal can be pulled "Off," and as the circuit of the motor operated signal can only be closed when the inner distant arm is "Off," it is clear that if the outer distant signal is "Off," all the other three signals concerned must also be "Off."

Electric banner signals are very light enclosed signals with a clear glass front in the facing direction, and opal glass for a background in order that this may be illuminated during the hours of darkness. These signals are in use at some stations, and are usually suspended from the girder of the platform awning. In such a position it is more convenient to run electric wiring than the wire connection for a mechanically operated signal. Such

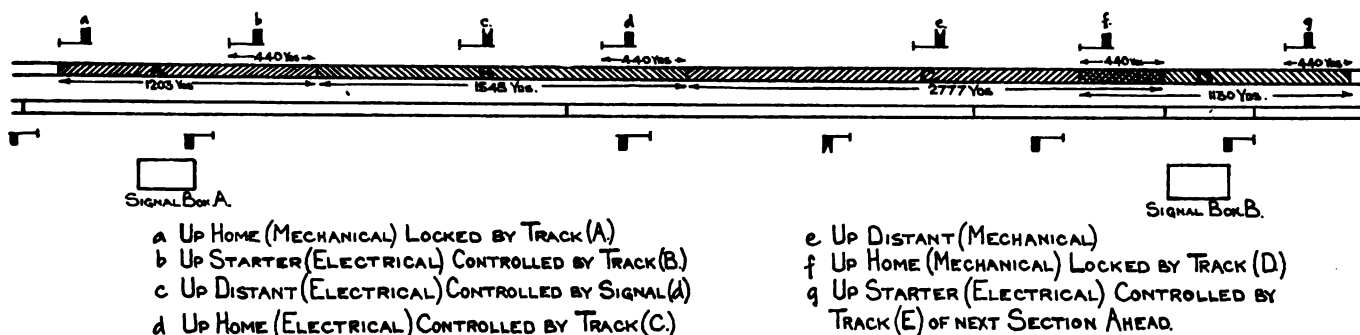


FIG. 7.

Track Circuit Layout for Semi-Automatic Signaling

are operated by motors, and all signals by solenoids. This installation is worked direct from the 210-volt d.c. supply, with a 30-volt permanent current control for signals, and the electric interlocking is direct from the switch tongues to the signal arm, and also from signal to signal. When the switch levers applicable to any required road are pulled, the switch motors run in parallel, but on completion of the proper movement of all switch tongues concerned, the detector switches complete the control circuit, which passes in series through all the switch detectors, finally unlocking the signal lever. At the same time all conflicting signals are locked. On pulling the signal lever, the signal solenoid is switched in to the 210-volt circuit, and on completion of the movement of the signal arm the solenoid is automatically transferred to the control circuit, and this circuit holds the signal arm in the "Off" position, but any interference with the switch will break the control circuit and allow the signal to go to the danger position by gravity. The controlling circuits may be compared to a suspended chain, with the signal attached to the lowest link; and the break of any one link allows the signal to fall to the danger position. The control circuit for the distant signal is in each case taken through a switch on the home signal arm, and also through a switch on the starting signal arm, each closed only in the "Off" position. Each of the running signals is replaced to the "On" position automatically by the train passing over a mercury treadle and breaking the

signals are only of use where the traffic movements are comparatively slow.

In some positions it is desirable that a mechanically operated signal be automatically replaced to the danger position by the train passing a controlling point. In such a case an electric replacer is fitted on the signal between the counterweight lever and the signal arm. The mechanism is so arranged that the signal arm can only be pulled "Off" when the replacer coils are energized, and afterwards held "Off" only so long as the current is maintained. The circuit is carried through a mercury treadle fixed to the running rail at the required controlling point. When the train passes over the treadle the circuit is broken, the replacer mechanism and the signal arm then move to the "On" position by gravity, irrespective of the position of the signal lever. When the signal lever is put back the entire mechanism of the replacer is restored to the normal position ready to engage on the closing of the circuit, as required for the passage of the next train.

Locomotive Cab Signaling

An experimental installation of locomotive cab signaling has been installed on one of the single line branches, and although this is not strictly tower equipment, the controlling apparatus is in the towers and is operated by the respective signalmen. The object in connection with this system of cab signaling is to give the engine driver an

audible indication of the position of the distant signal arm. These audible signals are: a whistle to indicate "Caution" or distant signal "On," a bell to indicate "Clear" or distant signal "Off." The signals in the cab are operated by means of a ramp fixed on the ties central between the running rails and by a contact shoe fitted on the engine. The caution signal is operated by the opening of a local electric circuit on the engine. The opening of this local circuit is effected by the lifting of a plunger attached to the contact shoe, and is a mechanical operation occurring each time the contact shoe passes over a ramp. The "Clear" signal is operated by current picked up from the ramp, passing through the cab apparatus, then through the frame of the engine to the rails and to the return wire. This current in addition to causing the bell to ring, prevents the operation of the "Caution" signal. As the operation of the "Caution" signal depends on the mechanical lift of the shoe when passing over the ramp, and the suppression of this signal depends on the successful picking up of the current from the ramp, it will be seen that any electrical failure can only result in the operation of the "Caution" signal. As this is a single line, Down trains will pass over Up and Down ramps, and Up trains will also pass over Up and Down ramps. In order to suppress the signals not required, in the case of an Up train the Down ramps are rendered inoperative, and in the case of a Down train the Up ramps are rendered inoperative.

The mode of operation may be illustrated by the passage of a Down train. Before reaching the first ramp the steam whistle valve is held in the closed position by the local circuit on the engine. On passing over the ramp the shoe is lifted $1\frac{1}{2}$ in., breaking the local circuit. If the distant signal is "On," the ramp is electrically dead, and the whistle will continue to sound until stopped by the engine driver. If the distant signal is "Off," a switch on the lever closes the contact of a battery circuit, making the ramp positive and the adjacent rails negative. The local circuit on the engine is broken, but the current picked up from the ramp will maintain in the whistle valve in the closed position, and also ring the bell in the cab. This bell once started, continues to ring until stopped by the engine driver. As traffic on this branch is worked by electric train tablet, the signalman at the Up end of the section will have obtained a tablet for the train, and the act of obtaining the tablet will, by means of a switch in the tablet instrument, close the Up ramp circuit, but the polarity at the ramp and also at the adjacent rails will be in the reverse direction to that at a Down ramp. When the engine passes over the Up ramp, the local circuit on the engine is broken as before, and the current picked up from the ramp will hold the whistle valve closed, but as this current is in the reverse direction, the tongue of the polarized relay on the engine is held on the dead stop, and the bell will not ring. In the passage of an Up train, the operations are reversed; obtaining a tablet at the Down end of the section will make the Down ramp negative and clearing the Up distant signal will make the Up ramp positive.

It will be seen that the cab signals are positive; any failure of the electrical circuits either on the engine local circuits or on the ramp circuits will give the steam whistle or caution signal. There is no attempt made to indicate the position of either the home or starting signals. The question of indicating the position of a distant or caution signal is a simple matter, but if cab signals are required in connection with stop signals, the problem is of an entirely different character, which bristles with difficulties at every stage.

The number of signal boxes and ground frames in use on the Midland Railway, and the number of the chief

items of electrical apparatus in use in connection with these signal boxes are as follows:

Elevated signal boxes.....	1,226
Ground signal boxes.....	73
Ground frames	725
Ordinary block instruments.....	3,837
Interlocking block instruments.....	914
Tablet block instruments.....	199
Track circuits.....	644
Signal repeaters	5,523
Light indicators	1,573
Telephones	6,087
Single needle telegraph instruments.....	1,166

The foregoing descriptions apply chiefly to electrical equipment which is in general use, but in addition to this there is a large amount of special auxiliary apparatus in use to meet special local requirements. The interlocking block used on the London, Tilbury & Southend Railway (now the Tilbury section of the Midland), is different in design to that in use on the Midland main line. Although it has the very great merit of successfully working a heavy suburban passenger traffic in and out of London during a number of years, it is not possible within the limitation of a short article to adequately describe the working of either this interlocking block system, or the semi-automatic signaling system, both of which are peculiar to the Tilbury section.

APPORTIONMENT OF COST OF JOINT INTERLOCKING

THE Puget Sound & Willapa Harbor found it necessary, in the construction of a new line in 1914, to cross at grade, at two places, tracks which had been laid in 1890-92 by the Northern Pacific. The Willapa is organized under Washington laws, the Northern Pacific under Wisconsin laws. The Washington Public Service Commission granted the required permission, subject to the condition that suitable interlocking signals, of a type to be agreed upon by the two companies, should be installed at the crossings. The companies agreed on all the conditions, except as to the cost of installing and maintaining. On submission of the question to the Commission, it decided that the entire expense should be borne by the Willapa. The Supreme Court of the state reversed this decision, and ruled that the expense should be divided equally between the two companies. The Northern Pacific argued that when it entered the state of Washington and constructed its line, an act of the Legislature, passed in 1888, was in effect which gave to railroad companies formed under the act the right to cross any other railroad theretofore constructed, but subject to conditions which the State Supreme Court held, in 1908, in *State vs. Northern Pacific*, 49 Wash. 78, required the junior company to pay the entire cost of the crossing, including the installing and maintaining of interlocking where necessary; that this constituted a vested right of property in the senior company, and that the later statute of 1913, which the Supreme Court held, in this case, required it to bear one-half of the cost of installing and maintaining the apparatus, deprived of its property without due process of law.

The Supreme Court of the United States holds that at most the earlier statute, and the interpretation which the State Supreme Court placed upon it, was a rule of law applicable to the assessment of damages in a proceeding to appropriate a crossing to which a junior company was entitled by the statute. It was no part of the charter of the Northern Pacific, which was organized under the Wisconsin law, and that company had no vested right to insist that the rule should not be changed by statute or by court decision. While that was sufficient to dispose of