American Railway Signaling Principles and Practices

CHAPTER XV

Automatic Block Systems

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In the description and explanation of the operation of automatic block systems given in this chapter it is to be understood that the circuits, special symbols and wire nomenclature are not necessarily specifications, nor the recommended practice of the Signal Section, Association of American Railroads; they are indicative of those that are now in use in connection with the automatic block systems described. These descriptions are given with the thought that they will enable the student to more readily understand circuits of a similar nature, the details of which, however, may be somewhat different, depending upon the practice of the individual railroad.

Definitions.

The Standard Code of the Association of American Railroads defines Automatic Block System as: A series of consecutive blocks governed by block signals, cab signals, or both, actuated by a train, or engine, or by certain conditions affecting the use of a block.

It defines Fixed Signal as: A signal of fixed location indicating a condition affecting the movement of a train or engine.

It also defines Block Signal as: A fixed signal at the entrance of a block to govern trains entering and using that block.

Types.

An automatic block signal system is generally designated as a single-track or a multiple-track system. The single-track automatic block signal system is either of the overlap or the absolute permissive block (A.P.B.) scheme of signaling, the track being signaled for train operation in both directions, while on the multiple-track system the tracks are usually signaled for train operation in one direction only. In congested traffic areas, however, one or more of the tracks in the multiple-track system may be signaled for train operation in both directions.

Historical.

The signals first used in the automatic block system were of the Hall enclosed disc type; this was in 1866; they were operated by a simple electromagnet. In the order stated, the following types came into use: clockwork, by Gassett and Fisher, was installed in 1879; electro-pneumatic semaphore in 1883; low-voltage electric motor semaphore in 1893; electro-gas semaphore in 1902; color light in 1906; position light in 1915; color position light in 1921.

Prior to 1902 all the installations of automatic block systems were installed on steam railroads using direct current track circuits; however, the traffic conditions on the electric elevated railroads brought about consideration of the advisability of using this system of operation on their roads, and as direct current propulsion was used with the rails acting as a return circuit, trouble was experienced in the use of direct current track circuits. In 1902 the first extensive trials of alternating current track circuits were made in California. In 1906 the first installation of an automatic block signal system operated by alternating current was installed on the Union Pacific Railroad. Since that date many other roads have made more or less extensive installations.

Semaphore signals were used almost exclusively up to 1913 when the efficiency of color light signals was improved to such an extent that their use became practicable for long range daytime indications.

Description.

There are two systems of operating automatic block signals in general use, the normal clear and the normal danger. The normal clear system is a term used to express the normal indication of the signals in an automatic block system in which an indication to proceed is always displayed except when the block is occupied. The normal danger system is a term used to express the normal indication of the signals in an automatic block system in which the indication to proceed is given only upon the approach of a train to an unoccupied block. In both systems the signals assume their most restrictive indication when a train enters a block. On tracks signaled for train operation in both directions the same object is obtained; and, in addition, signals governing movements in the opposing direction display their most restrictive indication for a specified distance ahead of the train, or from one siding to the next, depending upon the scheme of signaling employed.

Signals may be continuously lighted with oil or electric lamps; when the latter are used they may be approach lighted.

Direct current and alternating current are used for operating automatic block systems. Direct current is generally obtained from primary or secondary cells, or both, for the operation of the track circuits and signals. The signals usually operate on first voltage range (30 volts or less) while approximately 1 volt is applied to the track circuits. Alternating current is obtained from a transmission line; the necessary power houses, substations and allied equipment are distributed throughout the signal territory. Transformers are connected to the transmission line to step the voltage down to that required for the operation of signals and track circuits. Direct current track circuits are explained in Chapter VII, alternating current track circuits in Chapter XI, semaphore signals in Chapter XII and light signals in Chapter XIII.

MULTIPLE-TRACK SYSTEMS

Theoretically, in multiple-track signaling, the signals should be spaced a uniform distance apart on level tangent track, this distance being compensated when signals are located on grades or curves. In practice, however, it is impossible to obtain this desirable arrangement, as various conditions on the road will tend to vary more or less the spacing between signals. The exact site of the signal is always selected with care, consideration being given to such factors as the approach view of the signal, presence of turnouts, crossovers or sidings, curves, grades, fills, bridges, tunnels, etc.

Signaling on multiple-track roads is generally of the two-block indication type, although considerable three-block indication signaling has been installed on roads of heavy traffic density or where necessary to provide proper braking distance. There are some installations of four-block indication.

Two-Block Indication System

A fixed signal for a two-block signaling system displays a proceed, approach, or "stop; then proceed" indication, depending upon block conditions. This fixed signal may have one three-position unit or two two-position units operating in either the upper or lower quadrant. The two-block indication system is so named for the reason that a clear aspect indicates that at least two blocks in advance of such a signal are unoccupied. A fixed signal displaying an approach aspect indicates that only the block immediately in advance of the signal is unoccupied and that a train must be prepared to stop at the next signal. The two-block indication signals are generally spaced braking distance apart as a minimum, but this spacing is frequently increased where traffic is light.

Figure 1 illustrates the aspects displayed by the different signals when a block is occupied in a system of two-block indication signaling on a section of double track, the signals being normally clear.

Normal Clear Color Light Signals with Direct Current Neutral Track and Polarized Line Control

Figure 2 illustrates circuits used in a two-block indication color light signal installation, double track, employing direct current neutral track circuits and polarized line circuits.

Signal control circuits.

The indication displayed by each signal is controlled directly from the polarized line control relay (HDR). The control of relay 2996HDR is as follows: positive and negative battery B and C through front contacts of relay 2984HDR when it is energized, or when relay 2984HDR is de-energized, positive and negative battery B and C through back contacts, changing the polarity of the controls of relay 2996HDR, so that it will be energized reverse, 2984HDR is the control relay for signal 2984 and singles out the approach and proceed indications displayed by signal 2996, through front contacts of track relay 2996TR (as with 2996TR de-energized, signal 2996 must be in its most restrictive position) to coils of relay 2996HDR. A shunt circuit is provided through back contacts of track relay 2996TR which shunts the coils of relay 2996HDR, so that with track relay 2996TR de-energized the control battery is not only removed from the circuit, but the coils of the relay are shunted to further assure that relay 2996HDR is de-energized.

Signal lighting circuits.

The lighting circuit for the proceed indication of signal 2996 is as follows: alternating current BX10 from secondary of transformer through front con-

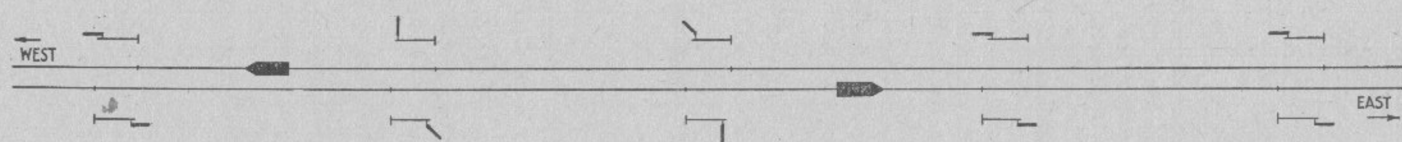
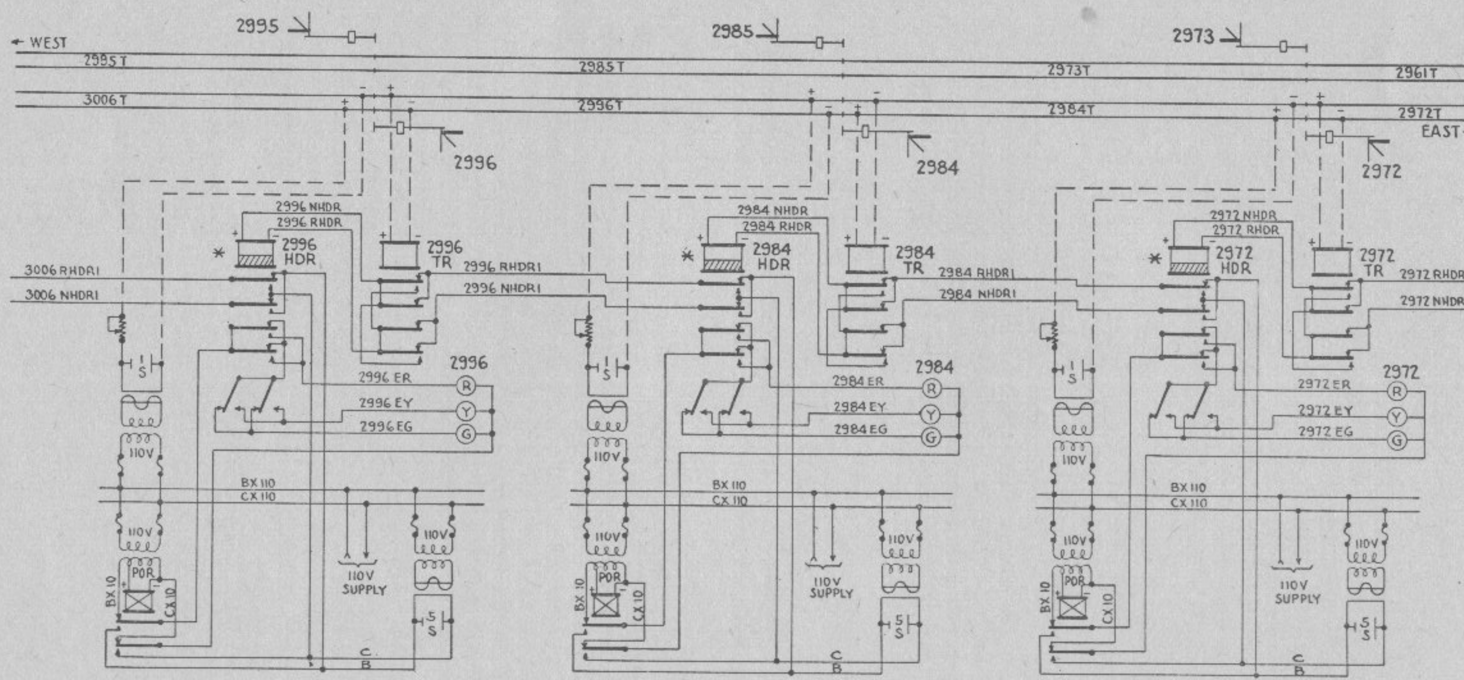


Fig. 1.

Aspects Displayed in Two-Block Indication System, Double Track.



* RETAINED NEUTRAL POLARIZED RELAY.

Fig. 2.

Circuits for Two-Block Indication, Normal Clear, Three-Position Color Light Signals, Double Track, Using Direct Current Neutral Track and Polarized Line Circuits.

tact of power transfer relay POR through front neutral and normal polar contacts of relay 2996HDR, wire 2996EG to lamp in green unit, through filament of lamp, to wire CX10, through front contact of relay POR to secondary of transformer. Should track circuit 2996T be occupied, relay 2996HDR would be de-energized. The lighting circuit for signal 2996 when displaying its most restrictive indication is as follows: BX10 through front contact of relay POR, through back contact of relay 2996HDR, wire 2996ER to lamp in red unit, through filament of lamp, through front contact of relay POR to CX10.

The lighting circuit for the approach indication of signal 2996 is as follows: BX10 through front contact of relay POR, through front neutral and reverse polar contacts of relay 2996HDR, to lamp in yellow unit, through filament of lamp, through front contact of relay POR to CX10.

Should the source of alternating current fail, relay POR being energized from the same transformer that supplies alternating current energy for the lamp would become de-energized and change the source of energy for lighting the signal lamps from the alternating current furnished by the transformer to the storage battery furnishing direct current to BX10 and CX10, through back contacts of relay POR.

Normal Clear Semaphore Signals with Direct Current Polarized Track Circuit Control

Figure 3 illustrates circuits used with a two-block indication semaphore signal installation, double track, employing direct current polarized track circuits.

Signal control circuits.

The indication displayed by each signal is controlled directly from the polarized track relay (TR). The control of relay 3018TR is as follows: positive and negative battery from primary track battery at signal 3006 through contacts of pole changer circuit controller, operated by signal mechanism closed from 40 to 90 degrees, to rails of track circuit 3018T, positive battery being on the left-hand and negative battery on the right-hand, to coils of relay 3018TR, energizing it in the normal position. When 3006TR is de-energized, signal 3006 will display a "stop; then proceed" indication causing the polarity of track circuit 3018T to be reversed because of the pole changing circuit controller on signal 3006. When relay 3018TR is energized in the reverse position the motor circuit for the control of the semaphore signal is as follows: positive battery through front contact of relay 3018TR, wire 3018HG to mechanism of the signal, wire N3018G to front contact of relay 3018TR, to negative battery. The motor control circuit is thus energized to operate signal 3018 to give an approach indication as signal 3006 displays a "stop; then proceed" indication.

When relay 3018TR is energized, the circuit for signal 3018 is as follows: positive battery through front neutral contacts of relay 3018TR wire to signal mechanism 3018HG, which will cause signal 3018 to display an approach indication. Positive battery through front neutral and normal polar contacts of relay 3018TR, wire 3018DG to the signal mechanism and wire N3018G to negative battery, thus causing the signal to display a proceed indication.

Normal Clear Color Light Signals with Alternating Current Track and Control Circuits

Figure 4 illustrates the circuits used on a two-block indication color light signal installation on a double-track electric road using alternating current propulsion. This installation employs double-element two-position centrifugal track relays; double-element three-position, and single-element two-position line relays. The 110-volt busses at all locations are fed and so connected from the same source that they will be of the same instantaneous polarity.

Local element circuits.

The local element of all double-element relays is connected direct to the BX110 and CX110 busses, by wires HQ or TQ and NX110. The circuit for the local element of track relay 60TR is as follows: BX110 through fuse to wire 60TQ through local element of relay 60TR and wire NX110 to CX110 bus.

Signal control relay circuits.

The line element of the signal control relay (HR) is only energized when the track circuit in advance of the signal is unoccupied. The instantaneous polarity of the line element and the local element are the same when the signal control repeating relay (HPR) at the signal in advance is energized and opposite when relay (HPR) at the signal in advance is de-energized. The circuit for the line element of relay 58HR is as follows: from the secondary of a transformer, the primary of which is connected direct to the BX110 and CX110 busses, through front or back contact of relay 56HPR, through front contact of relay 58TR, wire 58H, through the line element of relay 58HR, to wire N58H, through front or back contact of relay 56HPR to secondary of transformer.

Signal control repeating relay circuits.

The signal control repeating relay (HPR) is energized whenever the signal control relay (HR) is energized and the slow-acting feature causes the front contacts of the relay (HPR) to remain closed thereby preventing the red lamp lighting while the relay (HR) changes from one energized position tc the other. The control circuit for relay 60HPR is as follows: from BX110, wire 60HP1, through contact of relay 60HR closed in either of its energized positions, through coil of relay 60HPR wire NX110 to CX110 bus.

Signal lighting system.

The filament of each lamp is connected direct to the secondary of a transformer located in the signal unit. The primaries of these transformers are connected, through relay contacts, to the BX110 and CX110 busses. When the relay (HPR) is de-energized the transformer at the red lamp will be energized. When a train approaches a signal at which relay (HPR) is energized, either the transformer at the yellow lamp or at the green lamp will be energized

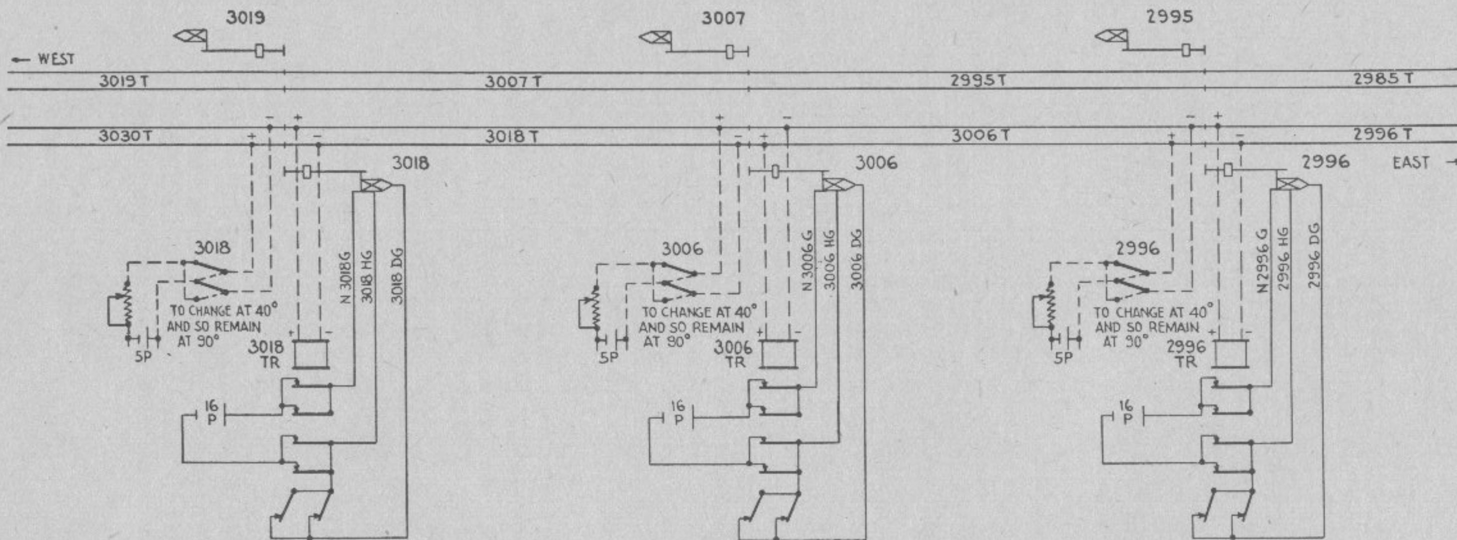


Fig. 3.

Circuits for Two-Block Indication, Normal Clear, Three-Position Semaphore Signals, Double Track, Using Direct Current Polarized Track Circuits.

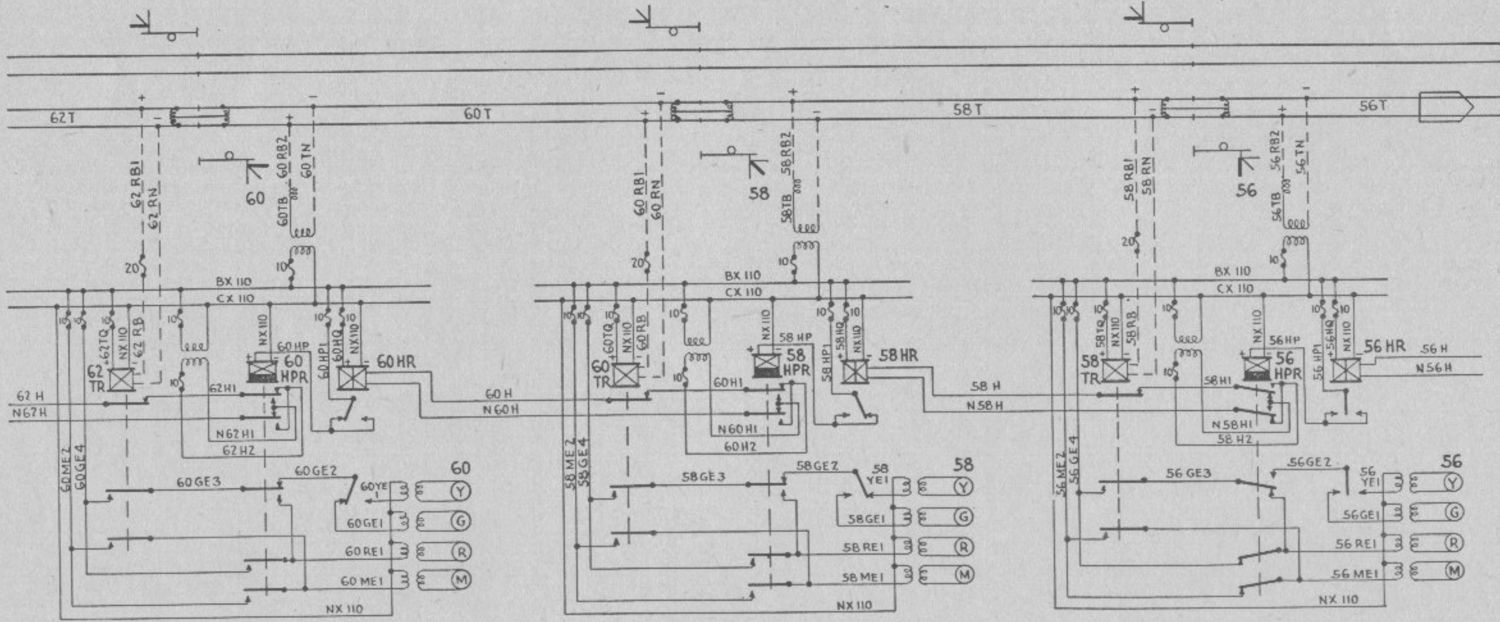


Fig. 4.

Circuits for Two-Block Indication, Normal Clear Color Light Signals, Double Track, with Alternating Current Track and Control Circuits.

depending upon the position of the relay (HR). In order to have the marker lamp burning at any time any other lamp is burning the transformer at the marker lamp is energized whenever relay (HPR) is de-energized or whenever a train is approaching the signal.

The circuit for the red lamp on signal 56 is as follows: BX110 wire 56GE4, through back contact of relay 56HPR, or through back contact of relay 58TR, wire 56GE3 through back contact of relay 56HPR wire 56RE1 to the transformer at the red lamp, wire NX110 to CX110 bus. The circuit for the yellow and green lamps on signal 56 is as follows: BX110 wire 56GE4, through back contact of relay 58TR, wire 56GE3, through front contact of relay 56HPR, wire 56GE2, either through a normal polar contact on relay 56HR, wire 56GE1 to the transformer at the green lamp, wire NX110 to CX110 bus or through a reverse polar contact on relay 56HR, wire 56YE1 to the transformer at the yellow lamp and wire NX110 to CX110 bus. The circuit for the marker light at signal 56 is as follows: BX110 wire 56ME2 through a back contact of relay 58TR or through a back contact of relay 56HPR wire 56ME1 to the transformer at the marker lamp and wire NX110 to CX110 bus.

Fuses are used at different locations in the circuits to protect the apparatus and are shown in Fig. 4.

Three-Block Indication System

A fixed signal for three-block systems usually displays proceed, approach-medium, approach, or "stop; then proceed" indications, depending upon block conditions. This fixed signal has two operating units, one three-position unit above a two-position, or a three-position unit. The three-block indication system is so named for the reason that a proceed indication cannot be given until at least three blocks in advance of such a signal are unoccupied. A fixed signal cannot display an approach-medium indication until at least two blocks in advance of such a signal are unoccupied. A fixed signal can display an approach indication only when the block immediately in advance of the signal is unoccupied; a train accepting such indication must prepare to stop at the next signal.

Three-block indication signaling is employed where it is desired to increase track capacity, that is, to permit closer spacing of trains moving under proceed signals than would be possible with two-block indication signaling. It will be recalled that with two-block indication signaling the signals are generally located braking distance apart, as a minimum, to permit a train to stop at a stop and proceed signal when moving at authorized speed at the approach signal. Take for example a three-block indication signaling system, with the signals spaced ½ mile apart compared with a two-block indication signaling system with the signals spaced 1 mile apart. In the three-block indication system an approach indication would be displayed ½ mile in the rear of a stop and proceed signal, an approach-medium indication would be displayed ½ mile in the rear of the approach signal and a proceed indication would be displayed ½ mile in the rear of the approach-medium signal.

It will be noted that the approach-medium indication would be displayed 1 mile in the rear of the stop and proceed signal which is the same distance that an approach indication would be displayed in the rear of a stop and proceed signal with the two-block indication system. The display of an approach-medium indication requires that a train approaching at authorized speed must reduce its speed so as to approach the next signal at not exceeding medium speed. Medium speed is approximately one-half the authorized speed and therefore the approach and approach-medium signals need only be spaced a sufficient distance apart to permit a reduction from authorized speed to medium speed. This distance may be considered as being approximately one-half the distance required to permit a train to stop from authorized speed. It follows that the approach signal should be located a sufficient distance from the stop and proceed signal to permit a train traveling at medium speed at the approach signal to stop at the stop and proceed signal, which distance may be considered as approximately one-half braking distance at authorized speed.

It is evident that a proceed indication would be displayed approximately 1½ miles in the rear of a stop and proceed signal, whereas in two-block indication signaling the proceed indication would be displayed 2 miles in the rear of a stop and proceed signal. Therefore, in the three-block indication system trains spaced 1½ miles apart will receive proceed indications, whereas in the two-block indication system trains must be spaced 2 miles apart in order to receive proceed indications.

Figure 5 illustrates the aspects displayed by the different signals when a block is occupied in a system of three-block indication signaling on a section of double track, the signals being normally clear.

Normal Clear Searchlight Signals with Direct Current Neutral Track, Neutral and Polarized Line Control

Figure 6 illustrates circuits for searchlight signals used in a three-block indication normal clear color light signal installation, on double track, employing direct current neutral track circuits, neutral and polarized line circuits.

Signal mechanism circuits.

Each signal mechanism has two windings known as the field and armature windings. The field winding is energized continuously, positive and negative battery B and C being connected direct to the positive and negative terminals. The armature winding, when energized through the contacts of the signal control relay (HDR or DR) causes either the yellow or green aspect to be displayed depending upon the direction of current.

The circuit for signal mechanism A230 is as follows: positive and negative battery B and C, through normal or reverse polar contacts and neutral front contacts of polarized relay A230HDR, wires A230G and NA230G to the armature terminals. When relay A230HDR is de-energized the armature will be de-energized and the signal will display the "stop; then proceed" indication. When relay A230HDR is energized and its reverse polar contacts are closed, current will flow in the armature in such a direction as to cause the

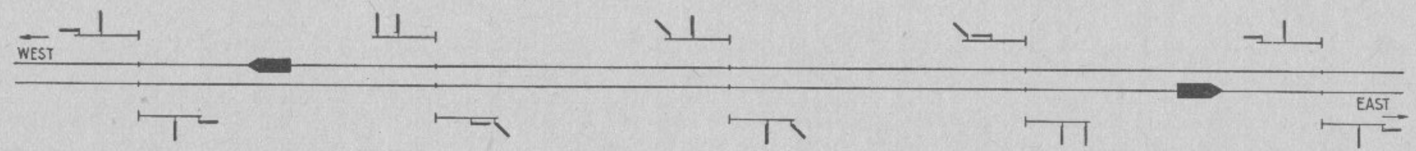


Fig. 5.
Aspects Displayed in Three-Block Indication System, Double Track.

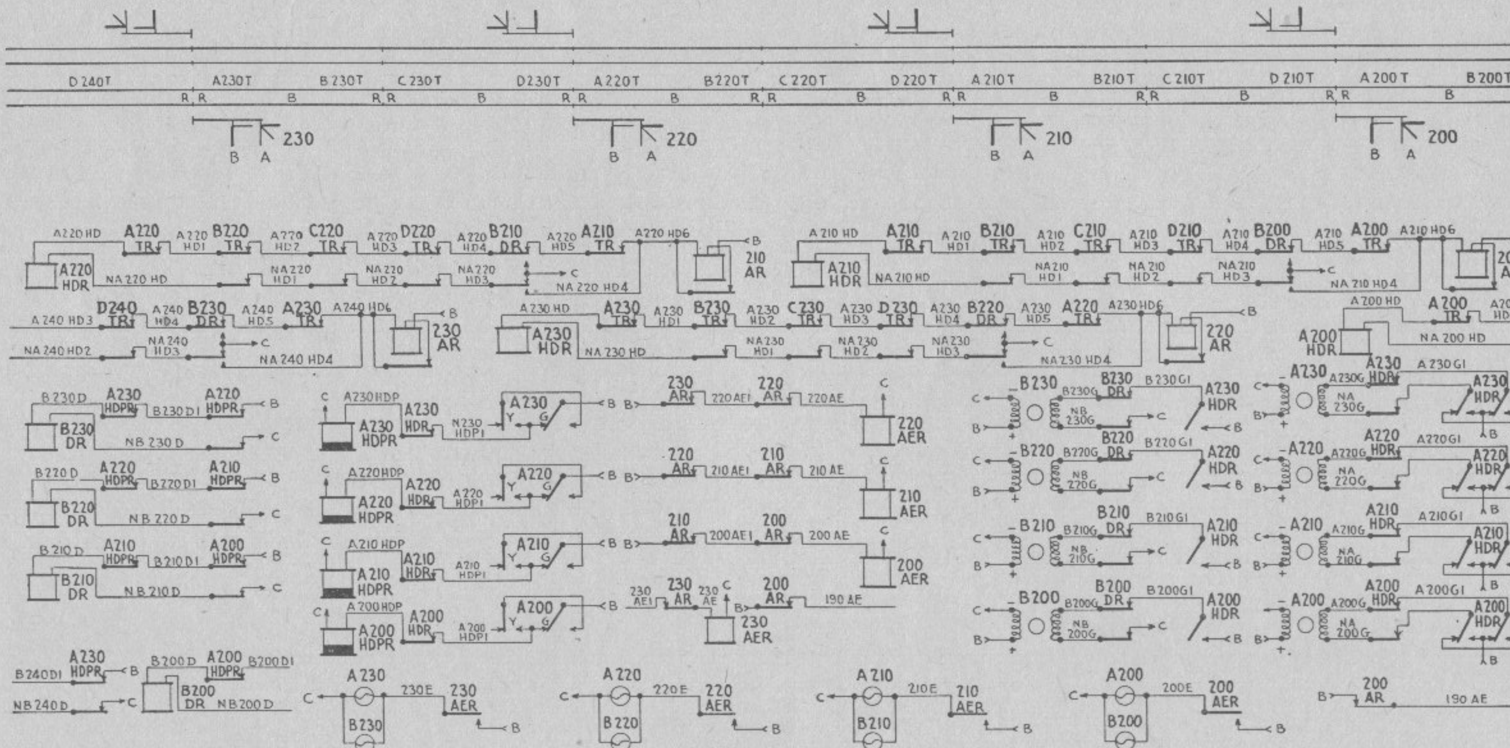


Fig. 6.
Circuits for Three-Block Indication, Normal Clear Searchlight Signals, Double Track, with Direct Current Neutral Track, Neutral and Polarized Line Control Circuits.

signal to display an approach or approach-medium indication, depending upon whether relay B230DR is energized or de-energized. When relay A230HDR is energized and its normal polar contacts are closed, current will flow in the armature in such a direction as to cause the signal to display a proceed indication.

The circuit for signal mechanism B230 is as follows: positive battery B, through a reverse polar contact of relay A230HDR, wire B230G1, through front contact of relay B230DR, wire B230G to the armature wire NB230G, through front contact of relay B230DR to negative battery C. When the reverse polar contacts of relay A230HDR are open, the armature will be de-energized and the signal will display any of its indications except approach-medium depending on the position of relays controlling mechanism A230.

Signal repeating relay circuits.

The signal repeating relay (HDPR) for each signal is energized when the signal displays the approach, approach-medium or proceed indication.

The circuit for relay A210HDPR is as follows: positive battery B through contacts of signal mechanism A210 closed when the signal displays the approach, approach-medium or proceed indication, wire A210HDP1, through front neutral contact of relay A210HDR, wire A210HDP, through coils of relay A210HDPR to negative battery C.

Slow-release relays are used for signal repeating relays so that the front contacts will remain closed while the indication changes from approach or approach-medium to proceed, or vice versa.

Signal control relay circuits.

The signal control relay (DR) for the B unit of any signal is energized when the signal displays an approach-medium or proceed indication. The circuit for signal control relay B220DR is as follows: positive and negative battery B and C through front contacts of relay A210HDPR, through front contacts of relay A220HDPR to the coils of relay B220DR.

The signal control relay (HDR) for the A unit of any signal is energized reverse, that is, the front neutral and reverse polar contacts are closed, when all the track circuits between that signal and the next signal in advance are unoccupied and the signal in advance displays a "stop; then proceed" or approach indication. The signal control relay (HDR) for the A unit of any signal is energized normal, that is, the front neutral and normal polar contacts are closed, when all the track circuits between that signal and the next signal in advance are unoccupied and the signal in advance displays an approach-medium or proceed indication. The circuit for relay A230HDR is as follows: positive battery B, through the coils of relay 220AR (the operation of this relay will be explained later), through a back contact of relay B220DR or through a front contact of relay A220TR and front contact of relay B220DR, through front contacts of all track relays between signals 230 and 220, through the coils of relay A230HDR, through front contacts of all track relays between signals 230 and 220, through front or back contact of relay B220DR to negative battery C. In this circuit, to energize signal control relay A230HDR it is first necessary that all the track relays between signals 230 and 220 be energized; when such is the case, the direction of the current in the coils of polarized relay A230HDR depends on whether the front or the back contacts of relay B220DR are closed. When the back contacts of relay B220DR are closed, polar armature of relay A230HDR will be energized reverse and when the front contacts of relay B220DR are closed, polar armature of relay A230HDR will be energized normal.

A front contact of relay A220TR is included in the control circuit for relay A230HDR to prevent relay A230HDR being energized before the front contacts of relay B220DR open, should a short train pass signal 220 at high speed thereby preventing a "green flash" on signal 230.

Approach relay circuits.

The approach relay at any signal is connected in series with the signal control relay (HDR) for the A unit of the first signal in the rear; thus it is energized only when all the track circuits between the signal where it is located and the first signal in the rear are unoccupied. When the approach relay is energized, one of its coils is shunted by a front contact and the resistance in series with the signal control relay is reduced accordingly.

Signal lighting circuits.

With the short spacing of signals in this system it is desirable that two signals be lighted in advance of each train. For that reason the approach lighting relay (AER) at any signal is controlled through front contacts of the approach relay (AR) for that signal and through front contacts of the approach relay (AR) for the signal in the rear.

The filaments of the lamps of the A and B units of any signal are connected in multiple, and positive battery B is taken through back contact of the approach lighting relay (AER), through the lamp filaments, to negative battery C.

Double-Red Indication System

This system is shown in Fig. 7 in which the fixed signals operate in three positions and display proceed, approach, and "stop; then proceed" indications. The "stop; then proceed" indication displayed by each signal is controlled through two blocks instead of one. Systems of this type are used on subway and elevated railway lines where light trains are operated at high speed at frequent intervals. An automatic train stop device is generally used in such a signal indication system.

Figure 8 illustrates the circuits used with normal clear color light signal installation on a subway line where trains are operated by direct current, the signal system employing alternating current track circuits and direct current neutral control circuits.

The track circuits are single rail alternating current using double-element relays, one rail acting as a common rail for the return of the direct current propulsion and for the alternating current track circuit.

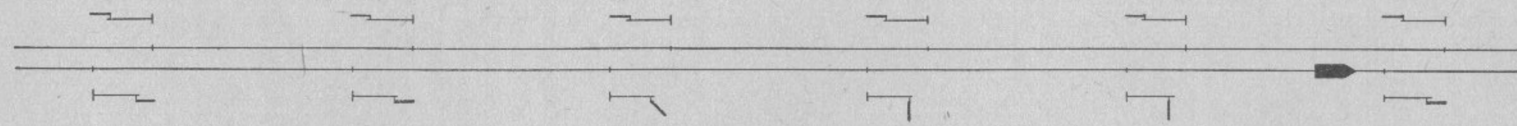


Fig. 7.
Aspects Displayed in a Two-Block Indication System, Double Track, with One Block Overlap.

With a train occupying the block protected by signal 2 it will be noted that signals 2 and 4 are displaying "stop; then proceed" indications, signal 6 an approach indication and signal 8 a proceed indication. In this system the signals are spaced braking distance apart for the maximum speed so that a train is always protected by the automatic train stop at the stop and proceed signal one block in the rear from a following train, should it pass a signal indicating "stop; then proceed."

Local element circuits.

The local elements of all track relays are energized continuously, BX55 and CX55 being connected direct to the coil terminals.

Automatic train stop control circuits.

An automatic train stop assumes the non-tripping position when two track circuits in advance are unoccupied, and assumes the tripping position when either of these two track circuits is occupied except that it will not change from the non-tripping position to the tripping position while the track in the rear is occupied. This insures that a train passing a signal will not cause the train stop at that signal to change from the non-tripping position to the tripping position until the entire train has passed.

The circuit for the train stop 6V at signal 6 is as follows: positive battery B-20 through front contacts of track relays 4TR and 6TR, through coil of 6V to negative battery C-20, or positive battery B-20 through back contact of track relay 8TR, through a contact which is closed when train stop 6V is in the non-tripping position, through the coil of 6V to negative battery C-20.

Signal control relay circuits.

The signal control relay (HR) which controls the approach indication circuit of a signal is energized when the train stop at that signal is in the non-tripping position and two track sections in advance of that signal are unoccupied. The signal control relay (DR) which controls the proceed indication circuit is energized when the H relay at the signal in advance is energized.

The circuits for the signal control relays at signal 8 are as follows: positive battery B-20 through front contacts of track relays 6TR and 8TR, through the coils of relay 8HR, through a contact that is closed when the train stop at signal 8 is in the non-tripping position to negative battery C-20. Positive battery B-20 through front contact of 6HR through the coils of relay 8DR to negative battery C-20.

Signal lighting circuits.

When signal control relay HR is de-energized the red lamp will be burning. When relay HR is energized and relay DR is de-energized the yellow lamp will be burning. When signal control relays HR and DR are energized the green lamp will be burning.

The lighting circuits for signal 4 are as follows: BX55 through a back contact of relay 4HR through the filament of the red lamp to CX55, or BX55,

TR= 2PST- NO
HR= 1PST- NO & 1PDT
DR= 1PDT

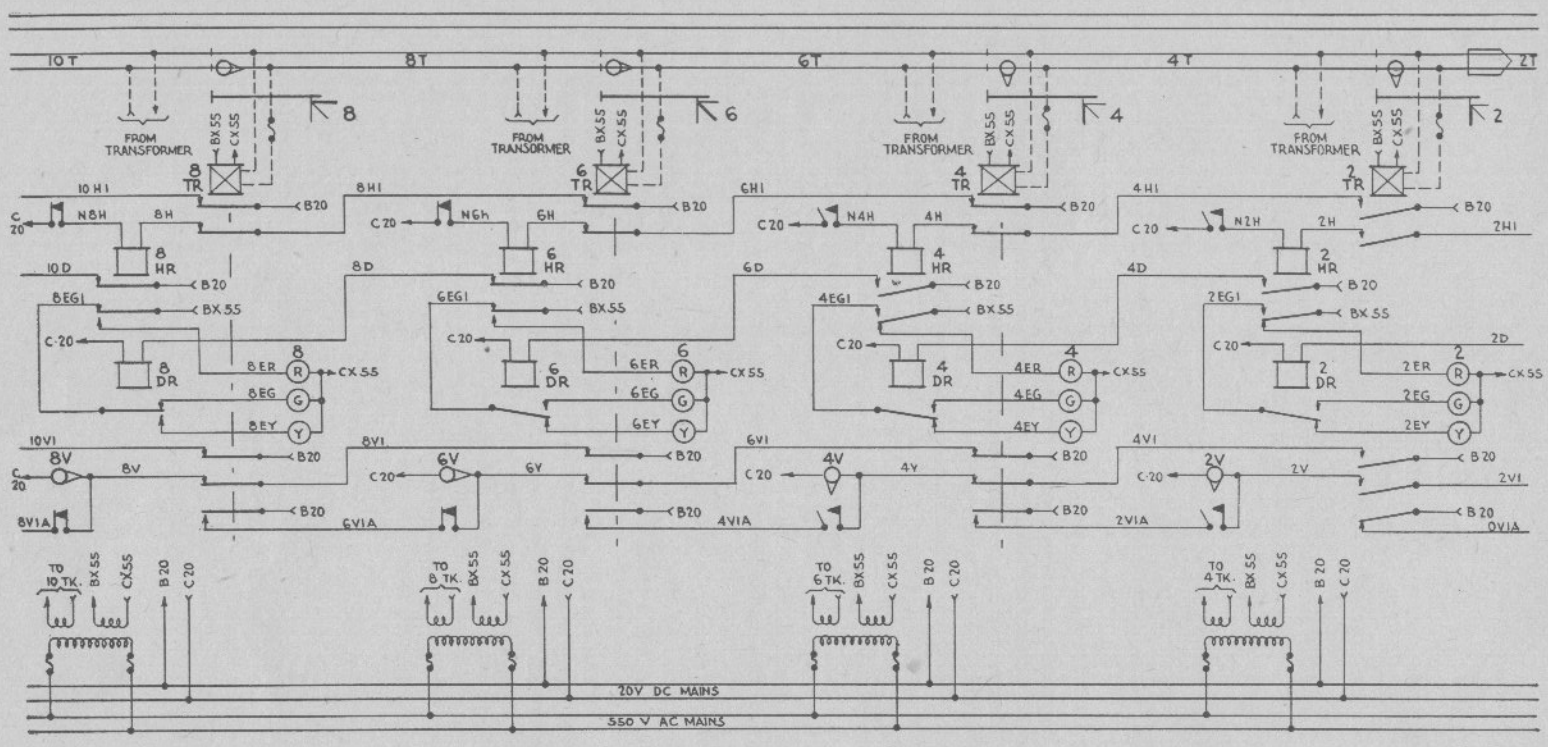


Fig. 8.
Circuits for Two-Block Indication, Normal Clear, Color Light Signals, Double-Track, One Block-Overlap with Alternating Current Track, and Direct Current Neutral Line Circuits.

through a front contact of relay 4HR, through a back contact of relay 4DR, through the filament of the yellow lamp to CX55, or BX55 through a front contact of relay 4HR, through a front contact of relay 4DR, through the filament of the green lamp to CX55.

SINGLE-TRACK SYSTEMS

Overlap System

On single track, train movements are in both directions and signals are arranged to permit following movements and also opposing movements. For opposing movements the signal control circuits must be so arranged to prevent the display of signal indications that would permit opposing trains to enter the same block at the same time. On the overlap system this is accomplished by extending the control of a signal beyond the next signal in advance governing in the same direction.

Figure 9 illustrates the controls for an overlap system in which the leaving signals at the sidings are located at the clearance point. These signals are sometimes located at the switch.

Figure 10 illustrates the circuits for normal clear semaphore signals used in a single-track overlap system of signaling employing direct current neutral track and polarized line control.

Referring to Fig. 10, trains moving in opposing directions, one moving westward at siding marked A and the other eastward at siding marked B, the westward train at A would receive a proceed indication at signal 7, likewise the eastward train at B would receive a proceed indication at signal 14. Westward signal 9 would also display a proceed indication as would eastward signal 12, while westward signal 11 and eastward signal 10 would display an approach indication, because westward signal 13 and eastward signal 8 are displaying a "stop; then proceed" indication. Signals 8 and 13 are displaying a "stop; then proceed" indication because they are directly controlled over the track circuits now occupied by the trains at sidings A and B. Signals 10 and 11 are displaying an approach indication, although none of the track circuits involved in the control of these two signals are occupied, but the polarized line relays controlling those signals are reverse, because the control of each of these relays is taken through pole changing contacts operated by the mechanism of the signal in advance, or vice versa.

Consider the westward train leaving "A" and passing signal 7 at approximately the same time the eastward train leaving "B" passed signal 14, both trains traveling at approximately the same rate of speed. When the westward train entered track circuit 7T, signal 7 would assume the stop position and likewise signal 14 would assume the stop position when eastward train entered track circuit 13T, each signal being controlled over the track circuits mentioned. When the eastward and westward trains occupy track circuits 7T and 13T, signals 10 and 11 will assume the stop position because each is controlled over the track circuits mentioned, while signals 9 and 12 would display an approach indication, because the control circuit of each is taken through the pole changer of the signals in advance, which are displaying a "stop; then proceed" indication.

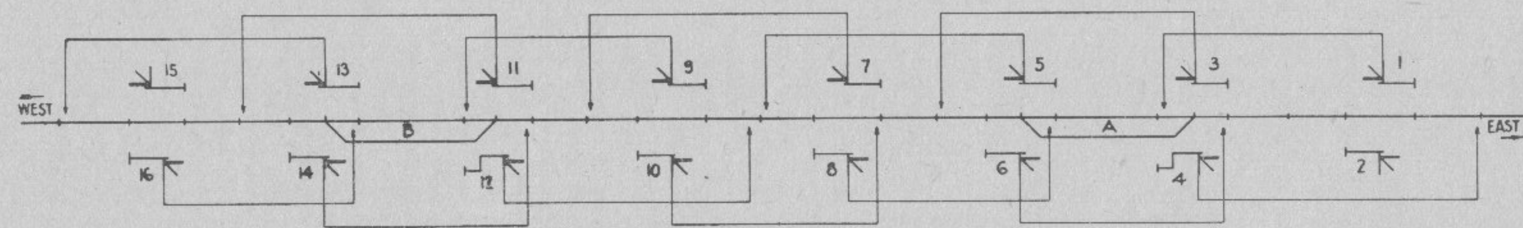


Fig. 9.
Diagram Showing Track Limits for Signal Controls of Single-Track Overlap System.

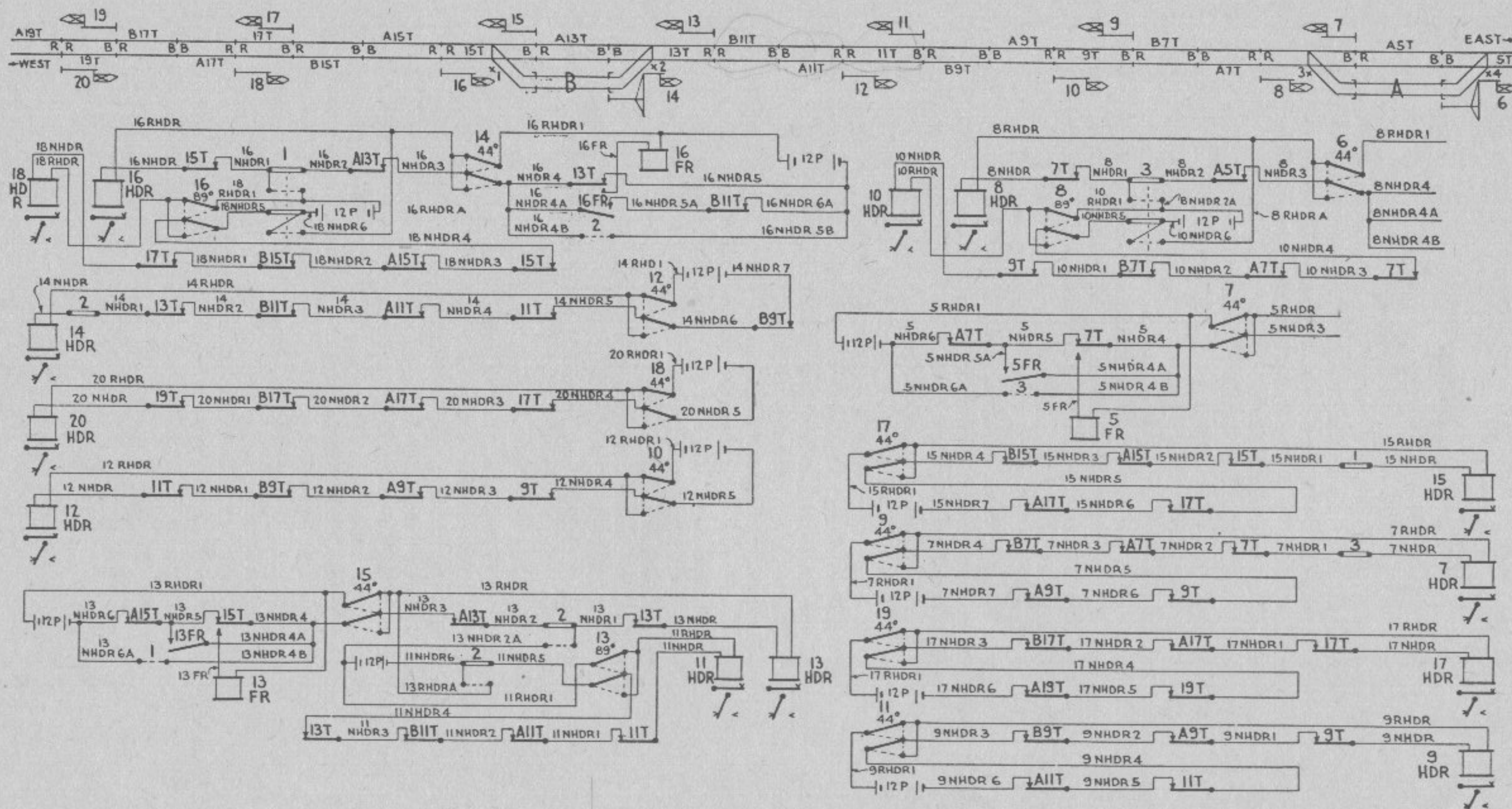


Fig. 10.

Circuits for Single-Track Overlap Two-Block Indication Three-Position Semaphore Signals, Normal Clear, with Direct Current Neutral Track and Polarized Line Control Circuits.

As each train approaches the next signal, the indication of opposing signals will not change until the eastward train has entered track circuit A11T, when signal 9 will display a "stop; then proceed" indication, as this signal is controlled by track circuit A11T. This will cause the westward train to receive a "stop; then proceed" indication at signal 9, while the eastward train will receive an approach indication at signal 12; this will cause the westward train to stop at signal 9 and permit the eastward train to move to signal 10. Thus both trains will be stopped. Both trains having stopped at a stop and proceed signal, each could proceed under the rules governing the movement of trains in such territory.

Consider two trains of the same class approaching siding B for a meet, the eastward train being superior by direction will hold the main track while the westward train will take the siding. Westward train is approaching signal 9 which is displaying a proceed indication, the track circuits controlling this signal being unoccupied and signal 11, over which the control for signal 9 is pole changed, is at "proceed." Likewise the eastward train approaching signal 20 will receive a proceed indication for the same reason.

Signals 11 and 18 are also displaying a proceed indication because the track circuits controlling these signals are unoccupied and the signals over which these signals are pole changed are also at proceed.

Signals 13 and 16 are also at proceed because the track circuits controlling these signals are unoccupied and the signals over which their control circuits are pole changed are displaying an approach indication for westward train and a proceed indication for the eastward train.

Signal 15 is displaying an approach indication with the eastward train occupying track circuit A19T because the track circuits controlling this signal are unoccupied and signal 17, over which the control of signal 15 is pole changed, is displaying a "stop; then proceed" indication. Signal 14 is still displaying a proceed indication with the westward train occupying track circuit B7T, because the track circuits controlling this signal are unoccupied and signal 12 over which the control circuit for signal 14 is pole changed, is displaying an approach indication since signal 10 is displaying a "stop; then proceed" indication.

Signal 17 is displaying a "stop; then proceed" indication because track circuit A19T is occupied by eastward train; likewise signal 19 is displaying a "stop; then proceed" indication because track circuit A19T is occupied. Signal 12 is displaying an approach indication because signal 10 over which the control of signal 12 is pole changed is displaying a "stop; then proceed" indication. The reason for the difference in the indications displayed by signals 12 and 17, which are located relatively in the same location to the approaching trains, is that the scheme of overlap in this layout is such that the control of all westward intermediate signals is overlapped over a track circuit in advance of the second opposing signal, thus giving the eastward train an advantage in closing in on the westward train.

When the eastward train has passed signal 20 and is occupying track circuit 19T causing signal 20 to display a "stop; then proceed" indication, there will be no change in the indication of any of the opposing signals. However, when the westward train has passed signal 9 and is occupying track circuit 9T, causing signal 9 to display a "stop; then proceed" indication, the indication of signal 12 has changed to "stop; then proceed" because signal 12 is controlled by track circuit 9T now occupied by the westward train; likewise signal 14 will display an approach indication because the control circuit of signal 14 is pole changed over signal 12, all other eastward signal indications remaining unchanged by this movement. There is no further change in the indications displayed until each train enters the track circuit in approach of the next signal in the direction in which they are moving. With the eastward train occupying track circuit A17T, signal 15 will display a "stop; then proceed" indication because track circuit A17T controls signal 15; this in turn will cause signals 13 and 11 to display an approach indication because the control circuit for signal 13 is pole changed by signal 15 in the "stop; then proceed" position; likewise the control of signal 11 is pole changed by signal 13 in the approach position. With the westward train occupying track circuit B9T, signal 14 will display a "stop; then proceed" indication because track circuit B9T controls signal 14. This in turn will cause signals 16 and 18 to display an approach indication, because the control circuit for signal 16 is pole changed by signal 14 in the "stop; then proceed" position; likewise the control of signal 18 is pole changed by signal 16 in the approach position. Attention is called to the fact that both signals in advance of the trains are displaying an approach indication, otherwise known as a double approach to a meeting point.

There is no change in the indications displayed by the signals until each train is occupying the track circuit in approach of the next signal in the direction in which they are moving. When the eastward train occupies track circuit A15T, signal 13 will display a "stop; then proceed" indication because track circuit A15T is in the control circuit for signal 13, while signal 16 is still displaying an approach indication, thus permitting the eastward train to pass signal 16.

As the westward train is to enter siding B to permit the eastward train to pass, the switch at the east end of siding when reversed allows signal 13 to display an approach indication for the westward train to enter the siding by means of a special circuit completed through the switch circuit controller connected to the switch.

Consider two trains of different classes, the eastward train being superior. The westward train is entering siding at "B" and is occupying track circuit 13T with the switch reversed and the eastward train is approaching signal 16 which is displaying an approach indication due to a special circuit arrangement in the control circuit for signal 16 which operates as follows: with the switch at the east end set for the siding, a special circuit is provided through a contact in the switch circuit controller energizing the control relay of signal 16. This special circuit nullifies the track occupancy of track circuit 13T and as soon as track circuit B11T is cleared by the entering train, directional traffic relay energizes 16FR which keeps the control circuit for signal 16 energized as long as the entering train occupies track circuit 13T, thus permitting trainmen to set switch for main-track movement without causing signal 16 to change from approach to the "stop; then proceed" indication.

This arrangement permits the eastward train to make a through movement without stopping at signal 16, and as soon as the westward train has cleared track circuit 13T with the siding switch in the normal position, signal 14 will indicate proceed, permitting the eastward train to proceed. As soon as the eastward train has cleared track circuit 15T, signal 15 will assume the proceed position and the westward train can then proceed from the siding accepting the indication of signal 15 for authority to proceed as no siding signals are provided in this installation. The local wiring of each signal is shown in Fig. 11.

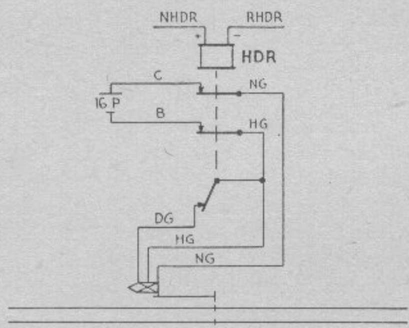


Fig. 11.
Local Wiring for Each Signal Shown in Fig. 10.

Figure 12 illustrates circuits for normal clear, lower-quadrant semaphore signals used in a single-track overlap system employing direct current neutral track and line circuits.

In this installation the controls are arranged differently from those for the overlap system illustrated in Figs. 9 and 10. The signals governing train movements leaving the siding block are controlled to the corresponding signal at the next siding. For example, signal 8 is controlled by the track circuits between signals 8 and 3, and signal 6 is controlled by the track circuits between signals 6 and 3. Therefore the block spacing for following trains is from signal 8 to signal 4. Signals 5 and 6 are installed for the protection of opposing movements only, should two trains pass signals 3 and 8 at the same time.

It will also be noted that some of the signals in this installation display three indications, such as signals 1, 4, 7 and 10, while all other signals display two indications. Signals 2, 3, 5, 6, 8 and 9 display "stop; then proceed" and proceed indications and signals D1, D4, D7 and D10 display an approach and a proceed indication.

Consider a westward train leaving siding A and passing signal 3 at approximately the same time that an eastward train leaving siding B passes signal 8. Signals 3, 5, 6 and 8 will now display a "stop; then proceed" indication, therefore each train will receive a "stop; then proceed" indication on signals 5 and 6

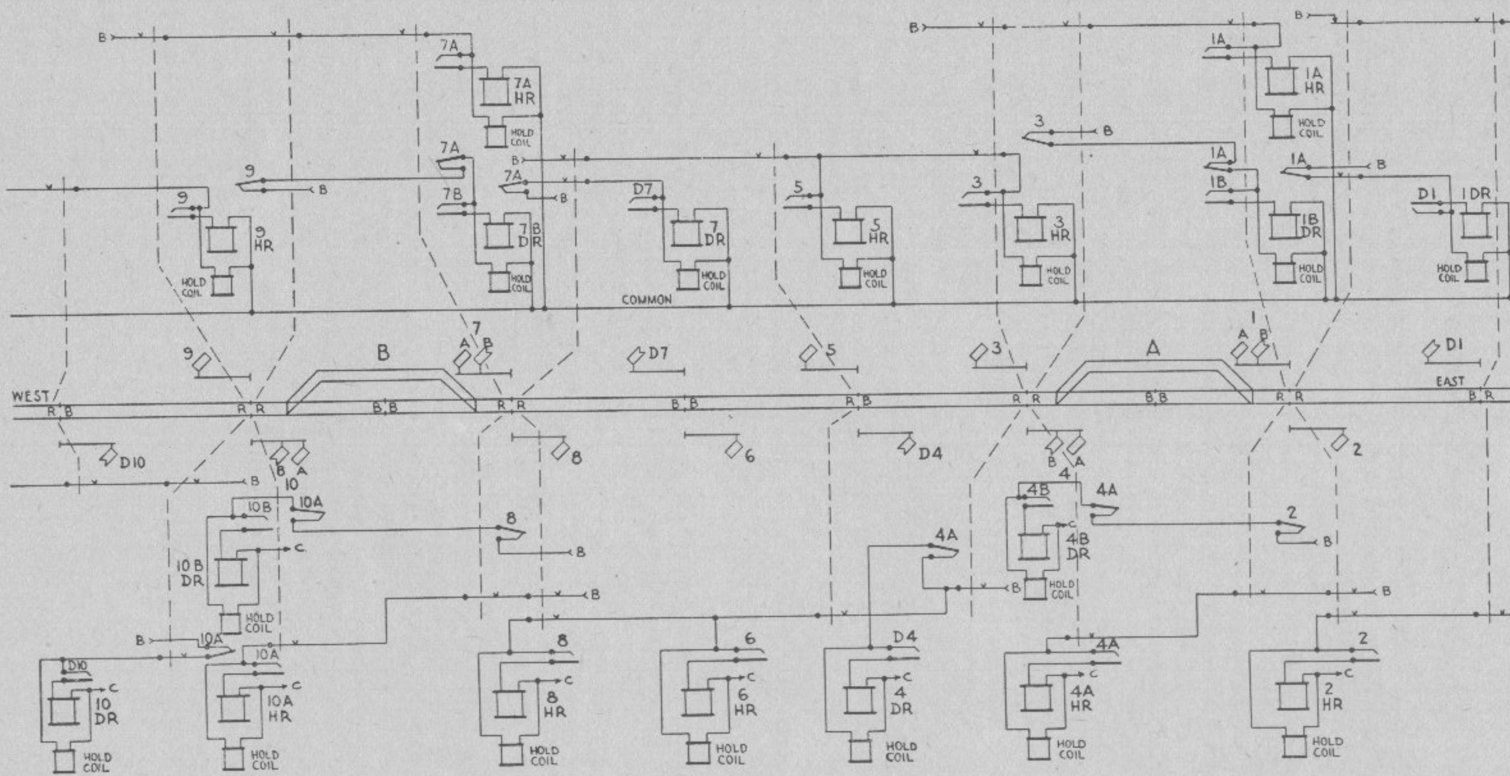


Fig. 12.

Circuits for Single-Track Overlap Two-Block Indication, Normal Clear, Two-Position Semaphore Signals, with Direct Current Neutral Track and Line Control Circuits.

On account of the simplicity of the signal relay control circuits, they will not be described. Attention is called to the battery saving scheme employed at each signal location whereby the line control relay is de-energized by a circuit controller actuated by a signal in the clear or approach position; the holding coil of the signal being the only apparatus that is using energy when the line control is energized.

The local circuit for the control of each signal mechanism is omitted because it is essentially the same as those shown for Styles B and S semaphore signals in Chapter XII.

Figure 13 shows the circuits for a single-track overlap two-block indication normal danger system, using three-position upper-quadrant semaphore signals, with direct current neutral track and line control. This system differs from that shown in Fig. 10 in that the clear or 90 degree indication is controlled over the same wire that is used for the approach or 45 degree indication control. This is accomplished by using an approach control relay having one coil of 800 ohms resistance and the other coil of 100 ohms resistance, and a clear control relay of 50 ohms resistance.

Referring to Fig. 13, assume a train to occupy track circuit B14T, proceeding toward signal 12. With the block unoccupied between signals 10 and 12, and signals 10 and 6, signal 12 will display a proceed indication and signal 10 an approach indication, as follows: B10 through front contact of relay B10TR, over wire 12H, through front contact of track relays A10TR and C12TR, over wire 12H, through front contact of relay B12TR, through circuit breaker on the mechanism of signal 11 closed at zero degree, over wire 12H, through front contact of track relay A12TR, through the 800 and 100 ohm coils of relay 12HR, through a back contact of relay B14TR, to C10. Relay 12HR will thus be energized and cause signal 12 to assume the 45 degree position. At the same time, signal 10 will be operated to the 45 degree position as follows: B10 through the front contact of relays A6TR and C10TR, over wire 10H, through the front contact of relay B10TR, through a contact on the mechanism of signal 7 closed at zero degree, over wire 10H, through a front contact of relay A10TR, through the 800 and 100 ohm coils of relay 10HR, over wire 10HN-12D, through a front contact of relay 12HR, through the 50 ohm coil of relay 12DR, through a back contact of relay B14TR, to C10. This will cause signal 10 to assume the 45 degree position. It will be noted that relay 12DR is included in this circuit but it will not be energized due to the resistance of the two coils of relay 10HR being such as not to allow sufficient current to flow and energize relay 12DR. When signal 10 reaches the 45 degree position, the 800 ohm coil of relay 10HR will be shunted by a circuit which is closed by a mechanism contact of signal 10, when the signal is between the 45 and 90 degree positions. With the 800 ohm coil shunted by this circuit, sufficient current will then flow to energize relay 12DR, which in turn will cause signal 12 to operate from the 45 to the 90 degree position. After the train passes signal 12 and passes off track circuit B14T, relay 10HR will remain energized through back contact of relay A12TR to C10; and, similarly, after the train passes off track circuit A12T and on to B12T, through a back contact of relay B12TR.

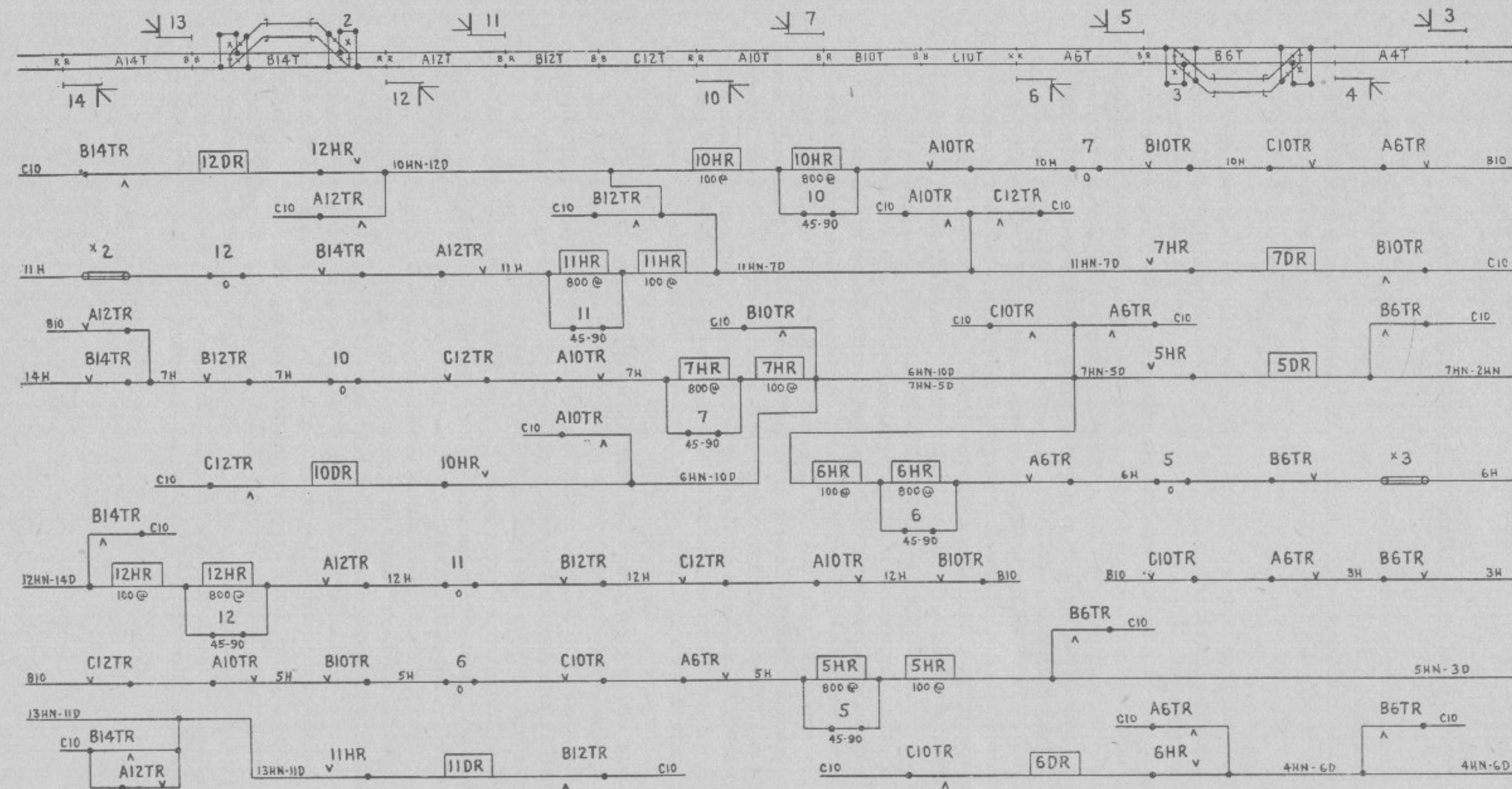


Fig. 13.

Circuits for Single-Track Overlap Two-Block Indication Normal Danger System, Three-Position Upper-Quadrant Semaphore Signals, with Direct Current Neutral Track and Line Control.

It is also to be noted that wire 10HN-12D is used as a similar wire for westward signals 11 and 7.

In other respects, this normal danger, single-track overlap system is similar to that described in Fig. 10.

Absolute Permissive System

In the absolute permissive system of signaling for single track, the block for opposing train movements is from siding to siding and the signals governing entrance to this block are "absolute" or "stop" signals. For following train movements the sections between sidings are divided into two or more blocks, as traffic conditions may require, and train movements into these blocks, except the first one, are governed by intermediate signals, commonly called "permissive," usually displaying "stop; then proceed" as their most restrictive indication.

It will be recalled that in describing the overlap system shown in Fig. 10 with two trains moving toward each other from sidings A and B, the westward train received a proceed indication from signal 7 and a "stop; then proceed" indication from signal 9, or no warning that it was approaching a stop and proceed signal. In the absolute permissive system opposing trains are held at the sidings by an absolute stop signal and a train will always receive an approach indication before reaching a stop or stop and proceed signal.

This system permits the same facility of operation for following trains as in double track due to the fact that the direction of traffic is established by the train which first enters the section between sidings. Other trains may then follow as if the main track were one of the two main tracks of a double-track line. Each of these trains must pass out of this section between sidings before the signal indications will permit a train in the opposite direction to enter. This train will then in turn establish the opposite direction of traffic and trains may follow it with the same facility as in the first case. The controls for opposing and following movements are shown in Fig. 14.

Stop signals are located at the sidings and govern the movement of trains into the track sections between sidings. These stop signals may be distinguished from the stop and proceed signals by a red or lunar white marker light in a vertical line with the signal light or by some other means.

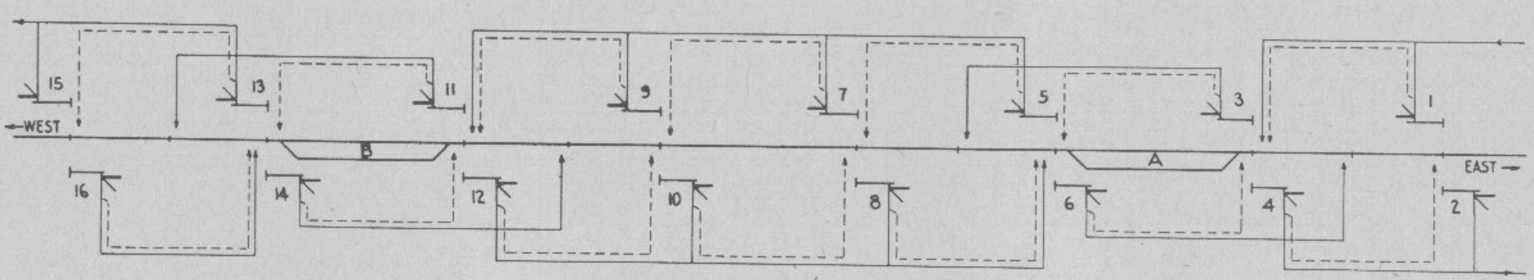
Figure 15 illustrates a system of circuits for searchlight signals used in single-track absolute permissive system, employing direct current neutral track and polarized line circuits. The method by which the variable control of the signals is accomplished in all A.P.B. systems is by means of a directional stick relay located at each intermediate signal. The circuits are arranged so that the directional stick relay will become energized by the movement of a train in the direction in which the signal governs, when the signal displays a proceed or approach indication. Means are also provided to prevent the energization of the stick relay when a train is moving in the opposite direction. In the circuits illustrated in Fig. 15 the stick relay is energized when a train approaching the signal in the direction in which it governs enters the first track section in the rear of the signal, provided the signal indicates "proceed" or "approach." Means are also provided for holding the stick relay energized until the train has moved through the block in advance of the signal or has backed out of the approach track circuit. The stick relay, when energized, shunts the control for the signal in the rear, where it breaks through the front contacts of the signal repeating relay.

The circuit for the mechanism of signal 12 is as follows: positive battery B and negative battery C, through contacts of signal 10 repeating relay 10YGP, through back contacts of stick relay 10S, front contacts of track relay B12TR, front contacts of track relay A12TR to terminals L and M of searchlight relay armature or line coil. With the polarity thus established signal 12 will display a proceed indication. However, if signal 10 is displaying a "stop; then proceed" indication due to a train occupying the block between signals 10 and 8 and having passed into the block in the direction from signal 12 to signal 10, the polarity then would be such as to cause signal 12 to display an approach indication due to relay 10S being energized and relay 10YGP de-energized. A train proceeding from signal 12 to signal 10 would energize stick relay 10S as follows: positive battery B through contact A-W of signal mechanism if signal is in the proceed position or through contacts A-P and B-X if the signal is in the approach position, through back contact of track relay B12TR, through coil of relay 10S to negative battery C. This relay will remain energized after train has passed signal 10 as follows: positive battery B through back contact of relay 10YGP through front contact of relay 10S to negative battery C. A multiple path for this circuit through back contact of relay 10YGP is provided through signal mechanism contacts A-P and B-Q both closed when the signal is in the "stop; then proceed" position so as to insure that relay 10S will remain energized should a short train pass signal 10 at high speed. It will, therefore, be seen that a train in the opposite direction will not energize relay 10S since signal 10 must be in the proceed or approach position when track circuit B12T is de-energized in order to energize relay 10S.

The circuit for signal repeating relay 10YGP is as follows: positive battery B through contact A-W of signal mechanism, closed when the signal is in the proceed position or through contacts A-P and B-X when the signal is in the approach position, through front contact of track relay B12TR to coils of relay, to negative battery C. Thus it will be seen that relay 10YGP will be energized when signal 10 is in the proceed or approach position, and de-energized when the signal is in the "stop; then proceed" position.

With relay 10S energized, signal 10 in the "stop; then proceed" position and relay 10YGP de-energized, the circuit for the control of signal 12 would be as follows: positive battery B and negative battery C through front contacts of relay 10S, through front contacts of track relays B12TR and A12TR to terminals L and M of searchlight relay armature or line coil, the polarity now causing signal 12 to display an approach indication.

A train in passing signal 12 and entering the track sections between sidings A and B will cause signals 9 and 7 to display a "stop; then proceed" indication and signal 5 to display a stop indication as follows: When the train enters track circuit A12T, the control of signal 9 will be opened by front contacts of track relay A12TR and signal 9 will assume the "stop; then proceed" position.



CONTROLS FOR OPPOSING MOVEMENTS SHOWN WITH SOLID LINES.
CONTROLS FOR FOLLOWING MOVEMENTS SHOWN WITH BROKEN LINES.

Fig. 14.
Diagram Showing Track Limits for Signal Control of Absolute Permissive Block System.

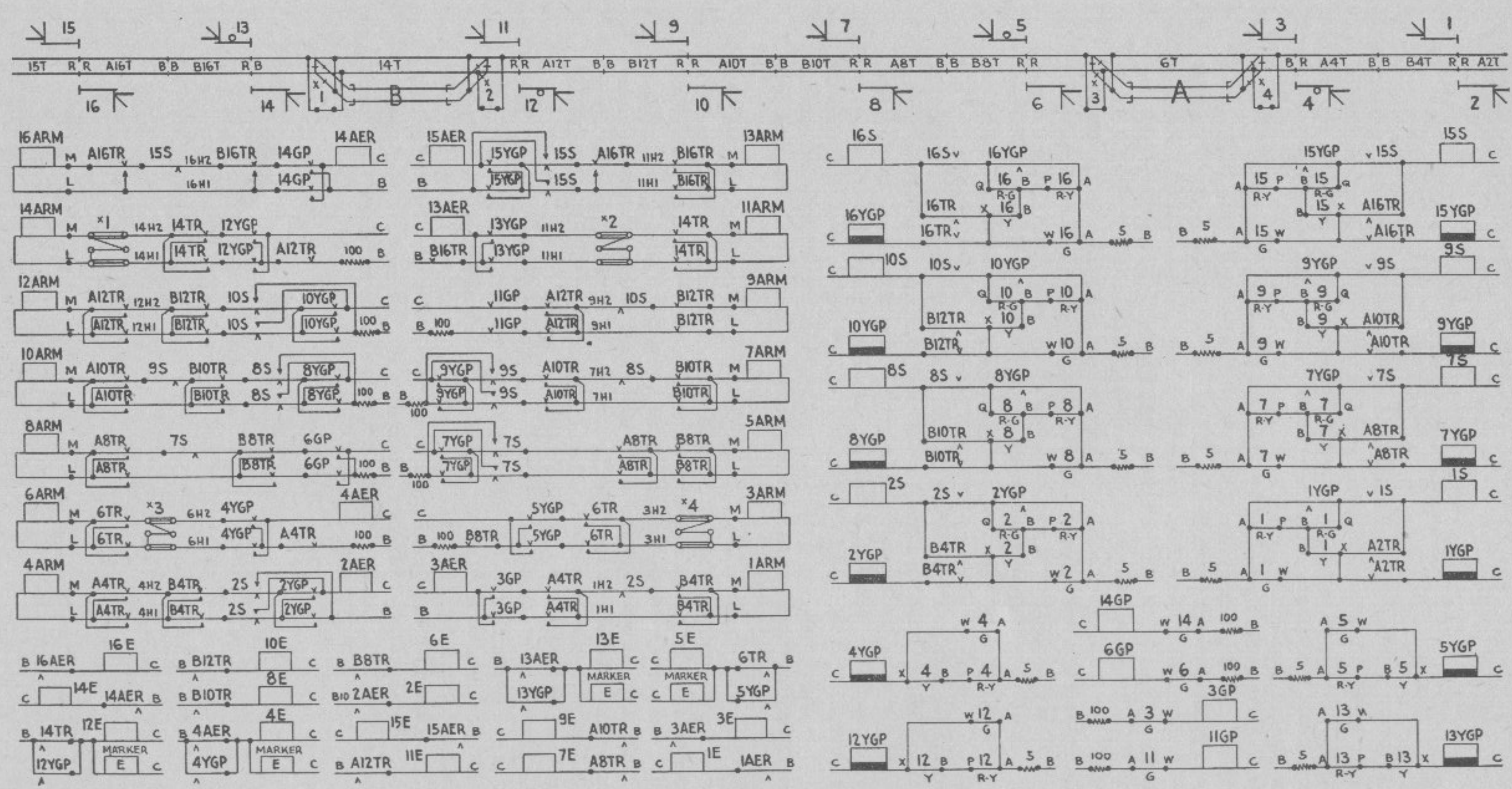


Fig. 15.

Circuits for Single-Track Absolute-Permissive Two-Block Indication, Normal Clear Searchlight Signals, with Direct Current Neutral Track and Polarized Line Control Circuits.

Relay 9YGP will thus be de-energized and signal 7 will then display a "stop; then proceed" indication due to its control being opened by front contacts of relay 9YGP. Signal 5 will then assume the stop position due to its control being opened by front contacts of relay 7YGP when signal 7 assumes the "stop; then proceed" position.

In order to avoid the possibility of a train which is approaching a siding to meet a train in the opposite direction, from receiving a proceed indication on the signal approaching the siding and then a "stop; then proceed" indication on the signal at the siding, the repeating relay for the signal at the siding is energized only when that signal is in the proceed position. For example, relay 14GP at signal 14 is controlled as follows: positive battery B through contact A-W on signal mechanism closed when the signal is in the proceed position, through coils of relay to negative battery C. Therefore, when signal 12 is displaying a stop indication due to a train having passed signal 5 at siding B, signal 14 will display an approach indication thereby de-energizing relay 14GP, thus causing signal 16 to display an approach indication also.

In Fig. 14 the control of signals 3, 6, 11 and 14 at the sidings are shown as extending to the next signal for following movements and overlapping through the next track circuit in advance of the next signal for opposing movements. This is accomplished by installing stick relays at signals 4, 5, 12 and 13. In the system shown in Fig. 15 no stick relays are used at corresponding signals 3, 6, 11 and 14, the controls for these signals overlapping through the track circuit in advance of signals 4, 5, 12 and 13 for both opposing and following movements.

In the system shown in Fig. 15 the signals are approach lighted, those for the stop and proceed signals are lighted from the track relay of the track circuit occupied by a train as it approaches the signals or from an AER relay, while those for the stop signals at ends of sidings are lighted from the track circuit within the siding limits or an AER relay, and whenever the signal is in the stop position so as to give information to a train which may be on the siding to meet or pass a train, that the expected train has left the siding in the rear or beyond.

Light circuit for signal 12 is as follows: positive battery B through back contact of track relay 14TR or through back contact of relay 12YGP to lamp 12E to negative battery C. The lamp in the marker light is connected in multiple with signal lamp 12E.

Light circuit for signal 14 is as follows: positive battery B through back contact of relay 14AER to lamp 14E to negative battery C. Relay 14AER is in series with signal 16 armature circuit and is de-energized when track relay A16TR or B16TR is de-energized.