Polarized-Coded Track and Control Circuits

For New Single-Track Station-to-Station Automatic Block

On the Rock Island*

A detailed explanation of the timing and operation of the polarized-coded track circuits, as well as the other control circuits, in which no line wires are used for signal controls in station-to-station blocks

BETWEEN Omaha, Neb., and Limon, Colo., on the Rocky Mountain Route of the Chicago, Rock Island & Pacific, there is 490 miles of single track which is being equipped with an automatic block signaling system that includes several new and novel features, not only with reference to the operation and spacing of trains, but also in the use of a new and unique application of polarized-coded track circuits by means of which the signaling controls require no line wires in the station-to-station blocks. In general, the system provides two-indication, absolute normal-clear station-departure signals, shown as signals, 2, 5, 8 and 11 in Fig. 1, for the protection of each station-to-station block. Permissive three-aspect, normal-stop, station-entering signals, shown as signals 3, 4, 9 and 10 in the same figure, are provided at the ends of each passing track to govern the approach of trains through the station block. Normal-stop permissive approach signals, capable of displaying three aspects, are provided, shown as signals 1, 6, 7 and 12 in Fig. 1, located at full-braking distance plus medium-speed braking distance in advance of each station-entering signal, in order to give enginemen information concerning the aspect displayed by the station-entering signals. Signals 1, 6, 7 and 12 are merely approach signals, and are not located as intermediate automatic signals.

General Scheme of Operation

In a station-to-station block, as for example between signal 8 at Station A and signal 5 at Station B, shown in Fig. 1, the signals are controlled by a new and unique adaption of polarized-coded track circuits without the use of line circuits between stations. The commonly accepted term, coded track circuits, does not exactly apply to this new scheme, because different rates of code, such as 75, 120 or 180 per minute, are not used to control the signals to display different aspects. In order to explain the Rock Island scheme, the term, impulse, may well be used. The absolute station-departure signals, such as signals 5 and 8, are capable of displaying only two aspects, and are normal-clear signals. When track circuit energy impulses are not being received at such a signal from the opposing end of the station-to-station block, it is conditioned to display Stop, but when impulses are being received, the signal is conditioned to display Clear.

The track circuits on this Rock Island signaling are the double-end type. In other words, there is a relay and a battery at both ends of every track circuit. With the system dormant, the relay is connected, but if the track circuit is to be fed from a given end, the contacts are operated to connect the battery rather than the relay. Thus, the track circuits can be fed and operated in either one direction or the other. Looking at it in another way, they can be fed first one way and then the other through a station-to-station block as a whole. The new feature on the Rock Island is that as applying to the control of station-departure signals, such as signals 5 and 8, the track circuits for the station-to-station block are normally in operation in both directions to condition both such signals to display the Clear aspect upon the approach of a train thereto, thus in effect duplicating the function of two line-control circuits in a conventional single-track A.P.B. automatic block circuit scheme.

Special Code-Transmitting Combination

In order to operate coded track circuits without line wires for the control of the signals through the relatively long sections of single track, a special code-transmitting combination was developed, in which a 75 CT code transmitter and three CD code-following or CDP code-following-repeater relays are used, the arrangement of which is shown in Fig. 5. Operation of the circuits involved in this combination will be discussed in further detail later in this article.

Commencing the explanation as of a certain instant, say that an impulse of d.c. energy of about 0.4 second duration, is fed eastward from signal 8 to track circuit a, shown in Fig. 2,

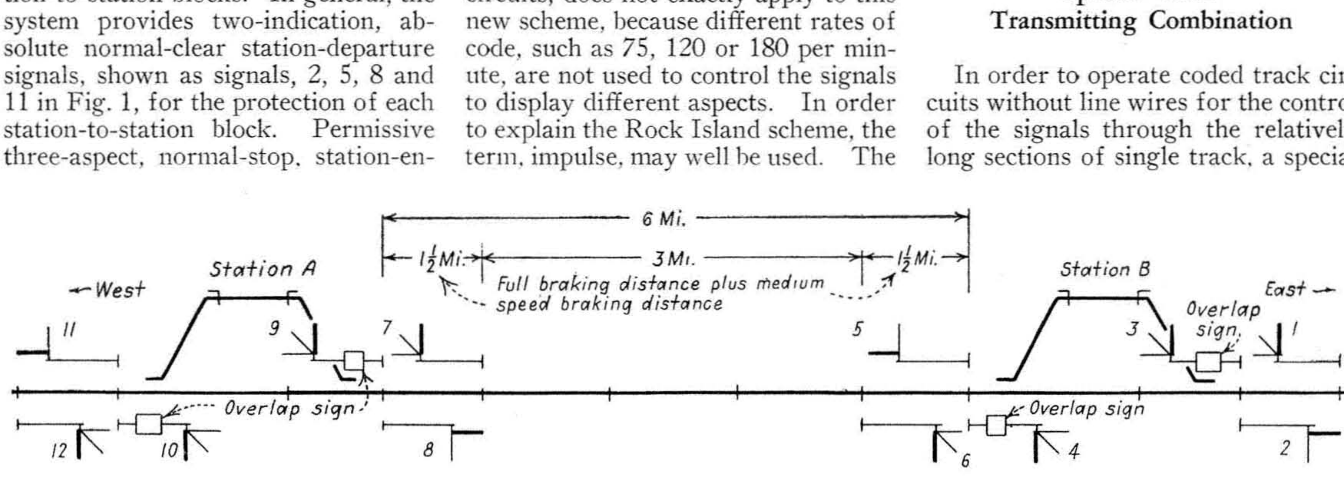
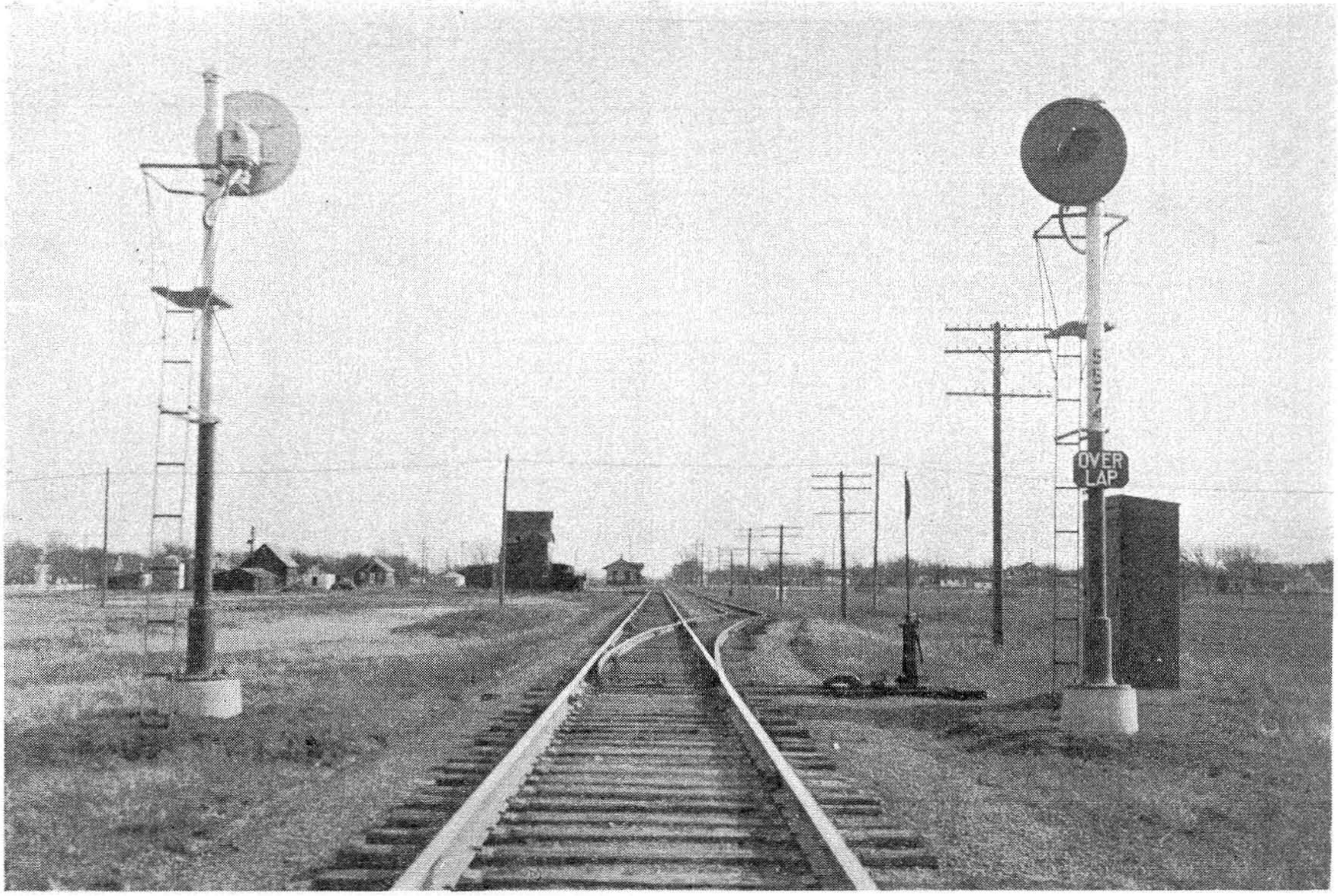


Fig. 1—Typical station-to-station track and signal layout with no intermediate signals as such

*This article is the second of two to appear on the development and installation by the Rock Island of a unique single-track station-to-station automatic block system, based on polarized-coded track circuits without line wires, and which is being installed on 490 miles of single track between Omaha, Neb., and Limon, Colo. The first article appeared on page 264 of the April issue of *Railway Signaling,* and should be read first in order to understand the entire installation, operation thereof, and the circuits explained in this article.



Typical station-entering and station-departure signal location on the Rock Island between Omaha and Limon

and is relayed through track circuit b, c, d and e. On receipt of this impulse the track relay at the east end of track circuit e is picked up and then released. While this relay is up, a surge of energy is fed to the coil of a slow-release relay, and as long as the track relay is operated not less than a certain number of times per minute so that the slow-release relay gets shots at the rate of not less than a certain number of times per minute, the slow-release relay stays up, thus conditioning the controls for the display of the Clear aspect in signal 5 at Station B upon the approach of a train.

In this scheme an eastward impulse goes through the track circuits of the entire station-to-station block which in some instances is as long as 8 miles, including as many as 5 track sections, averaging 8,500 ft. in length. Each time a pulse of energy ceases in a track circuit, some appreciable time is required to allow the relay to release and for the so-called "charge" to dissipate from the rails so that the feed of the pulse in the opposite direction will carry through. Thus, the "off" period between the eastward pulses must be of a sufficient duration to allow time for the release of all track relays at the east end of each track circuit, and in addition, be of sufficient duration to permit the westward pulses to feed through the entire station-to-station block. An important point is that the sending of a westward impulse from signal 5 does not depend on the receipt of an eastward impulse at that location. The eastward pulse must simply get there when it should, otherwise it will be opposing a westward impulse which would cause unsatisfactory operation, and result in station-departure signals being conditioned to display Stop when they should be cleared. The main point here, however, is that each impulse is of about 0.4 second duration, and depending upon the lengths of the track circuits and overall station-to-station blocks and ballast conditions, the lengths of the "off" periods range from 2 to 3 seconds. The 0.4 second on and 2 seconds off totals about 25 impulses per minute.

Station-to-Station Operation of Track Circuits

Referring to Fig. 3, typical circuits for the east end of Station A including signals 8 and 9, and for the westward distant signal 7, assume that the coding apparatus at Station A is operating to apply track circuit code pulses to the left-hand end of track circuit 7T at the rate of 25 impulses per minute. Code pulses are positive to the upper rail which operate relay 7HT at signal 7 through front contacts of the B5TBP back contact track repeater relay. The operation of relay 7HT operates the 7HTP relay each time its front contact is closed. The 7HTP relay is a CD code-following relay which follows the code opera-

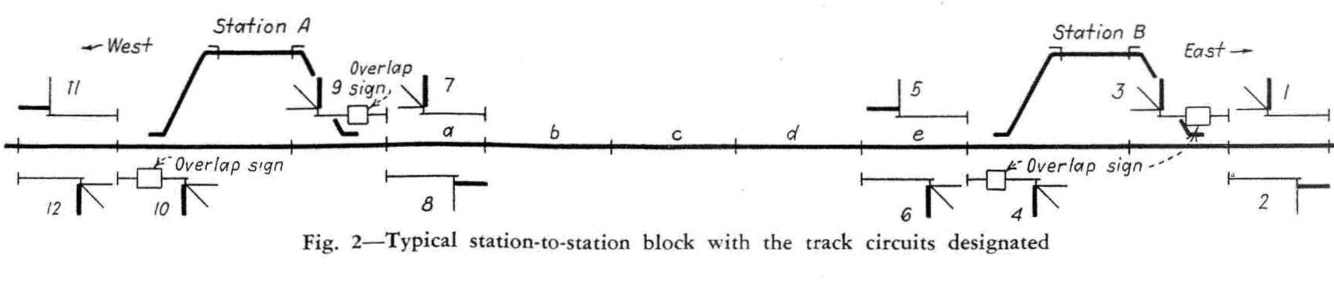


Fig. 2—Typical station-to-station block with the track circuits designated

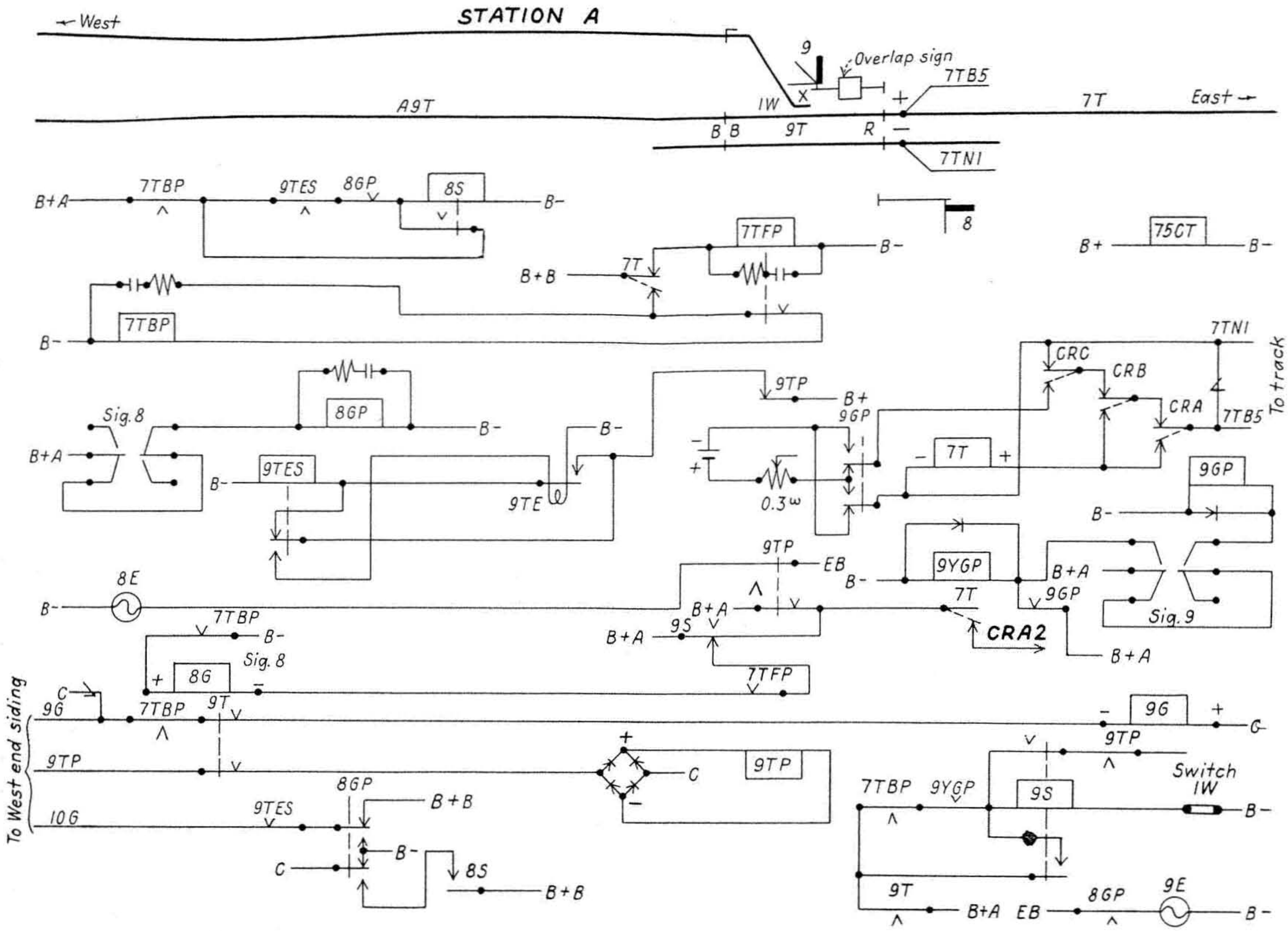


Fig. 3—Left-hand section, showing typical circuits for the east end of Station A, including signals 8 and 9

tion. Relay B5TBP is a repeater of the back contact of the B5TP relay and is energized when the track relay B5T for the section in approach to signal 7 is de-energized. Thus, the circuit for relay 7HT is closed only during the time that track relay B5T is de-energized. Each time the 7HTP relay picks up, it completes a circuit for feeding a code impulse to the left-hand end of section B5T in approach to signal 7. The code action is similar to the action of a front-contact repeating cut section using a track repeater for transmitting the pulse to the next track circuit.

At the cut section, shown in Fig. 4, the code pulse picks up the track relay B5T through a back contact of track relay A5T. Only one cut section is illustrated here in the accompanying diagrams, but all cut sections in the station-to-station block between distant signals are identical. When the B5T track relay at the cut section picks up it applies a pulse to the next track circuit to the right, A5T, which picks up and operates the A5T track relay, which is connected to the right-hand end of the track circuit in approach to distant signal 6. The circuit for energizing the A5T track relay at distant signal 6 includes back contacts of relays 5HTP and 5DTP. Each time the A5T relay at signal 6 picks up, it energizes a CD code-following-repeater relay A5TP. Each time the A5TP relay picks up, it releases the A5TBP relay, the object of which is to provide a short time interval in the operation of the next track circuit to the right, 5T, so that each time a pulse of energy is removed from this track circuit, there is a short time interval before the track relay is connected to the track. This time interval allows for the reactive kick from the track circuit to take place before the relay is connected to the rails.

Each time relay A5TP at signal 6 picks up and relay A5TBP drops, a positive pulse is applied to the left-hand end of section 5T through a front contact of the A5TP relay and back contacts of the A5TBP relay. In doing so, the track circuit feed by-passes the coils of relays 5HT and 5DT, in order to provide for the operation of a 2-point P-4 track relay at the opposite end of the track circuit 5T. When a pulse is received at the right-hand end of the track circuit at Station B, shown in Fig. 4, relay 5T is energized by current from the positive rail to the positive terminal of relay 5T and through back contacts of relays CRA or CRB to the negative rail. Thus, relay 5T is picked up only when the CRA or CRB relays at Station B are down, at which time the battery feed is cut off from the track at this location. The operation of the 5T relay picks up relays 5TFP and 5TBP when code is being received. Front contacts of the relay 5TBP prepare the circuits for clearing signal 5. It will be noted in Fig. 4, that the control of the coils of signal 5 starts with positive battery B + A over a back contact of the 4S relay, or a combination of a back contact of the 2W relay and a front contact of the 4S relay, over a front contact of the 5TFP relay, through the coils, and to negative battery B— over a front contact of the 5TBP relay.

Code Westward

When the 5T relay at Station B picks up, one of its back contacts opens the CRA2 circuit of the CRA, CRB and CRC relay westward code-transmitting combination at Station B, shown in Fig. 4 and 5. Figure 5 represents the typical power supply circuit and special code-transmitting combination circuits for providing the 25 code required in the operation of

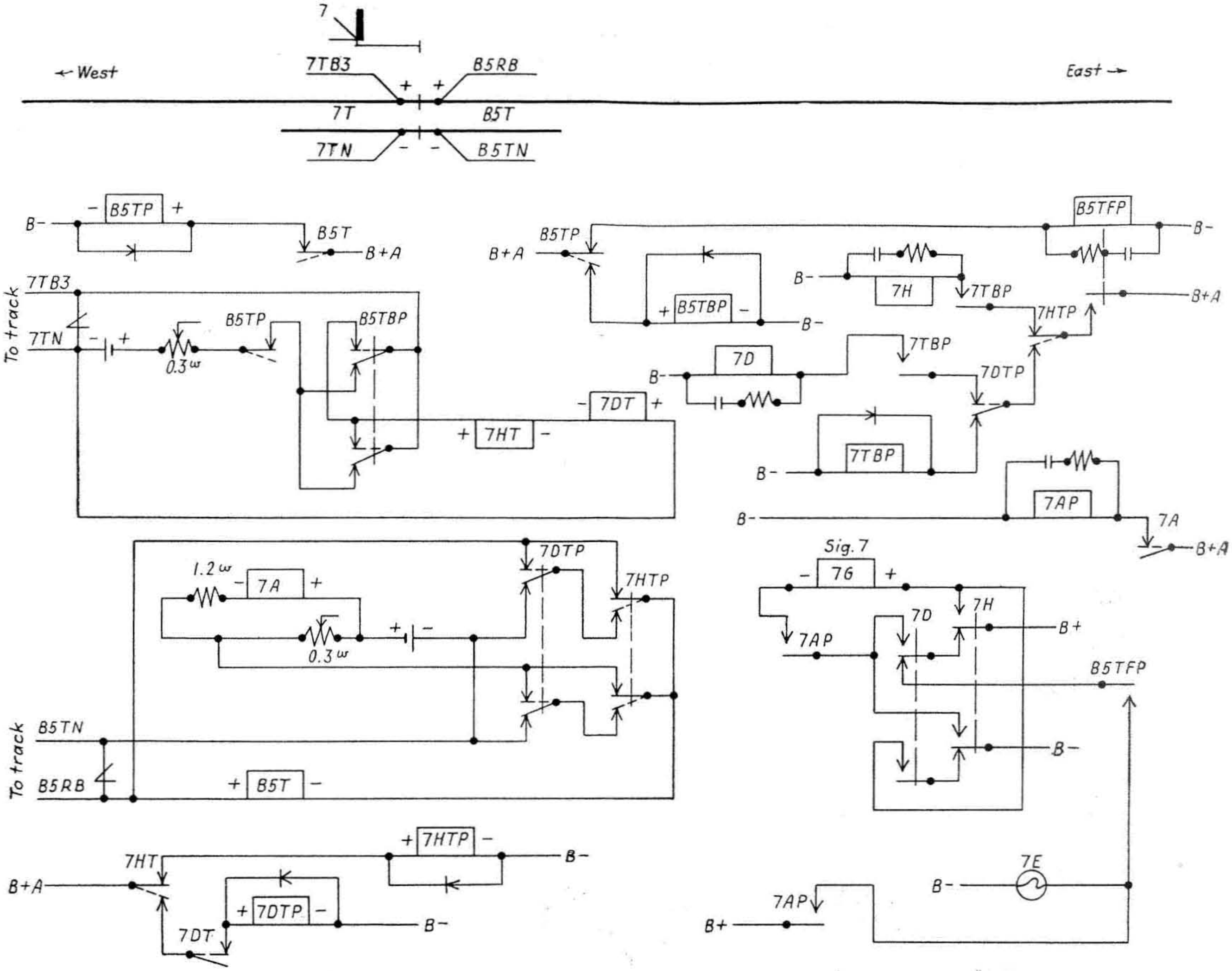


Fig. 3—Right-hand section, showing typical circuits for the westward distant signal 7

the polarized-coded track circuits. Thus, if relay CRA is up at the time that the 5T relay at Station B, shown in Fig. 4, picks up, it becomes de-energized and remains so until the 5T relay releases. After the release of the 5T relay, relay CRA is again energized the first time the code transmitter closes its front contact. The CRB relay at Station B is picked up when the code transmitter closes its back contact after picking up the CRA relay. In a similar manner, the CRC relay is picked up when the code transmitter closes its front contact after picking up the CRB relay. The picking up of the CRC relay opens one branch of the stick circuit of the CRA relay, and when the code transmitter opens its front contacts, the CRA relay is released. The CRA relay then opens one branch of the stick circuit of the relay CRB. The next time the code transmitter picks up, it opens the other branch of the stick circuit of the relay CRB so that this relay releases. In a like manner, the release of relay CRB opens one branch of relay CRC, and the next time the front contact of the code transmitter opens the CRC relay is released.

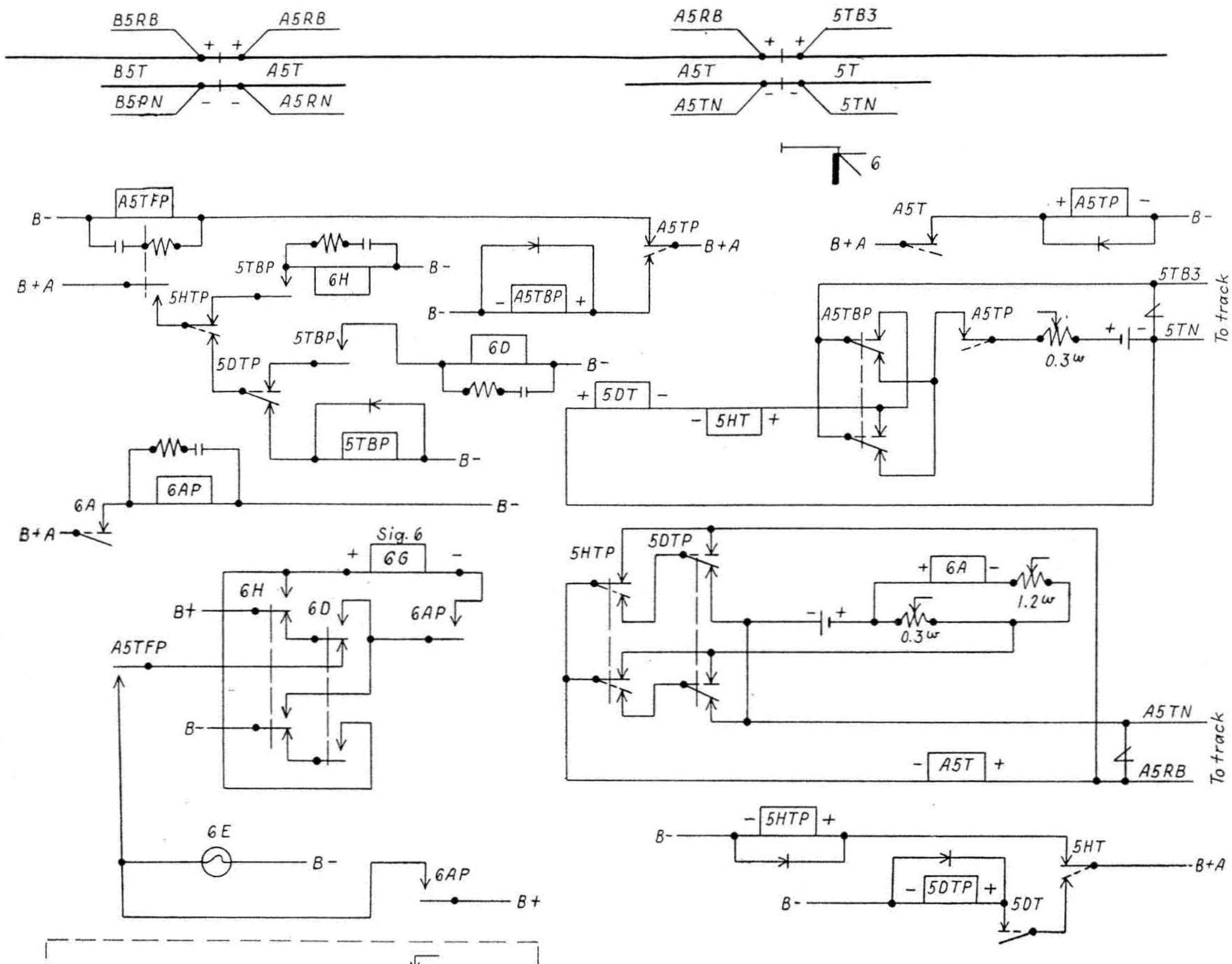
This action continues and when the CRA and CRB relays again pick up, a pulse of energy is applied to the track through back contacts of the CRC relay and pole-changer contacts of the 4GP relay. The pulse of energy is applied only while the 5T relay is down. Therefore, it is applied only during an off period of the track code transmitted from Station A. The track pulse applied to the right-hand end of track section 5T at Station B picks up relay 5HT at distant signal 6 through front contacts of the A5TBP relay in the same manner as described in connection with the 7HT and B5TBP relays at signal 7. Each time the 5HT relay picks up, it energizes the 5HTP relay, which is a code following relay, and each time relay 5HTP picks up it applies a pulse of code to the right-hand end of track section A5T in approach to signal 6. This code pulse operates the A5T relay at the cut section and, this applies a pulse of energy at the right-hand end of section B5T which picks relay B5T at signal 7, shown in Fig. 3. With relay B5T up, the B5TP relay is energized which in turn releases the B5TBP relay so that a pulse of energy is applied to the right-hand end of track section 7T through relays B5TP up and relay B5TBP down. Pulses of energy in track circuit 7T operate relay 7T at signal 8 to pick up relays 7TFB and 7TBP to prepare the circuits for clearing signal 8. The control of the coils of signal 8, it will be noted in Fig. 3, start with positive battery B + A, over a back contact of the 9S relay, a front contact of the 7TFP relay, through the coils, and to negative battery B— over a front contact of the 7TBP relay.

Control of Energy for Special Code Transmitting

The energy for operating the CRA, CRB and CRC relays at Station A is controlled by a front contact of relay 9TP to provide for the overlap control of signal 7 into the siding area in advance of signal 9. This energy is also controlled by a back contact of the 7T relay to provide co-ordination between codes sent from opposite ends of the block. In a like manner, the control of 6 is overlapped into the siding area in advance of signal 4 by controlling the energy for operating the CRA, CRB and CRC over a front contact of the relay A3T. Similar to the arrangement at the opposite end of the block, this energy is also controlled by a back contact of the 5T relay to provide co-ordination between codes sent from opposite ends of the block. In Fig. 5, it will be noted that a TFP contact is also used at the west end of the block only to provide for sufficient difference in code speeds to return the system to normal after the passage of a train in either direction.

When an eastbound train arrives at Station A and enters track circuit A9T, it releases track repeater relay 9TP, which stops the operation of the code transmitting relays at Station A so that code pulses are no longer received by relay 5T at Station B, releasing relays 5TFP and 5TBP and opening the circuit of signal 5. The coding apparatus at Station B continues to operate and transmit code pulses to the track as described before to maintain signal 8 in condition to display the Clear aspect for the train to proceed. With an eastbound train in section A9T, the 9TP track repeater relay is down, and a circuit completed over a back contact of that relay to light signal 8 for the display of the Clear aspect of green.

When signal 4 is cleared at Station B to display green by no code being received from Station A and relays 5TFP and 5TBP down, it picks up the 4GP relay. In Fig. 4, the control of coils of signal 4 ends with battery C, through the coils, over front contacts of the A3T, 2W and a back contact of the 5TBP relays to line circuit 4G which extends to the east end of the siding and breaks through front contacts of the 3TES and 2GP relays (not shown) to battery B + B for the green aspect of Clear, similar to the line circuit 10G shown in Fig. 3. For a yellow aspect of Approach, the circuit breaks over a back contact of the 2GP relay to battery B—, resulting in change of polarity. The 4GP relay up with signal 4 cleared pole changes the track circuit feed to the track circuit 5T in approach to signal 4 so that positive code pulses are applied to the lower rail to operate relay 5DT at signal 6, but not relay 5HT, due to the difference in polarity. The operation of the 5DT relay is repeated by the 5DTP relay. With the A5TFP relay down, which is the case if a train is approaching from the left, relays 5TBP and 6D at signal 6 are picked up by the code operation of the 5DTP relay. Relay 6D up prepares the cir-



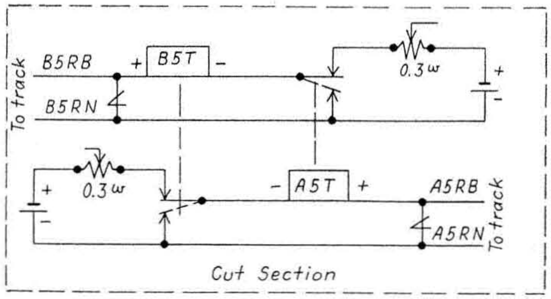


Fig. 4—Left-hand section, showing typical circuits for a cut section and the eastward distant signal 6

cuits for clearing signal 6. The Clear or green control of the coils of signal 6 starts with positive battery B+ over a back contact of the 6H relay, front contacts of the 6D and 6AP relays, through the coils and to negative battery B— over a front contact of the 6D and a back contact of the 6H relay. The 6H relay up results in a change in polarity and the display of the yellow aspect of Approach, providing the 6AP approach relay is up. Controls of signal 7 are similar.

When relays A5T and A5TP at signal 6 are operating, relay A5TFP is energized each time the A5TP relay picks up. Therefore, when a train is approaching from the left and the coded energy is cut off from the operation of the A5T relay, relay A5TFP is released and completes the circuits for approach energizing of relays 6D and 5TBP at signal 6.

A series approach relay is also provided in connection with the track circuit in approach to signal 6. Energy is applied to this relay every time energy is supplied to the right-hand end of track section A5T, but as long as this track circuit is unoccupied, the energy flowing in relay 6A is not sufficient enough to cause it to close its front contacts. However, when the eastbound train approaches within approximately 4,000 ft. of signal 6, a train shunt causes relay 6A to close its front contact and energize relay 6AP. This relay is snubbed by a condenser so that it remains energized during the off period of the code. Relay 6AP up completes the circuits for signal 6 when either the 6H or 6D relay is picked up. The lighting circuit for signal 6 is also completed by a front contact of the 6AP relay. An additional lighting circuit is provided for signal 6 over back contacts of the 6H, 6D and A5TFP relays to assure the lighting of signal 6 for an approaching train if the block of signal 6 is occupied.

When the eastbound train from the left passes signal 6 and clears section A5T, coded energy from the left operates relay A5T and causes relay A5TFP to pick up, provided, of course, that no following train is within the control limits. Thus, the second lighting circuit for signal 6, described before, will usually be closed only during the time the train is passing the signal.

When a train occupies any section of the track between signal 8 and signal 4 the train shunt prevents the transmission of track circuit pulses

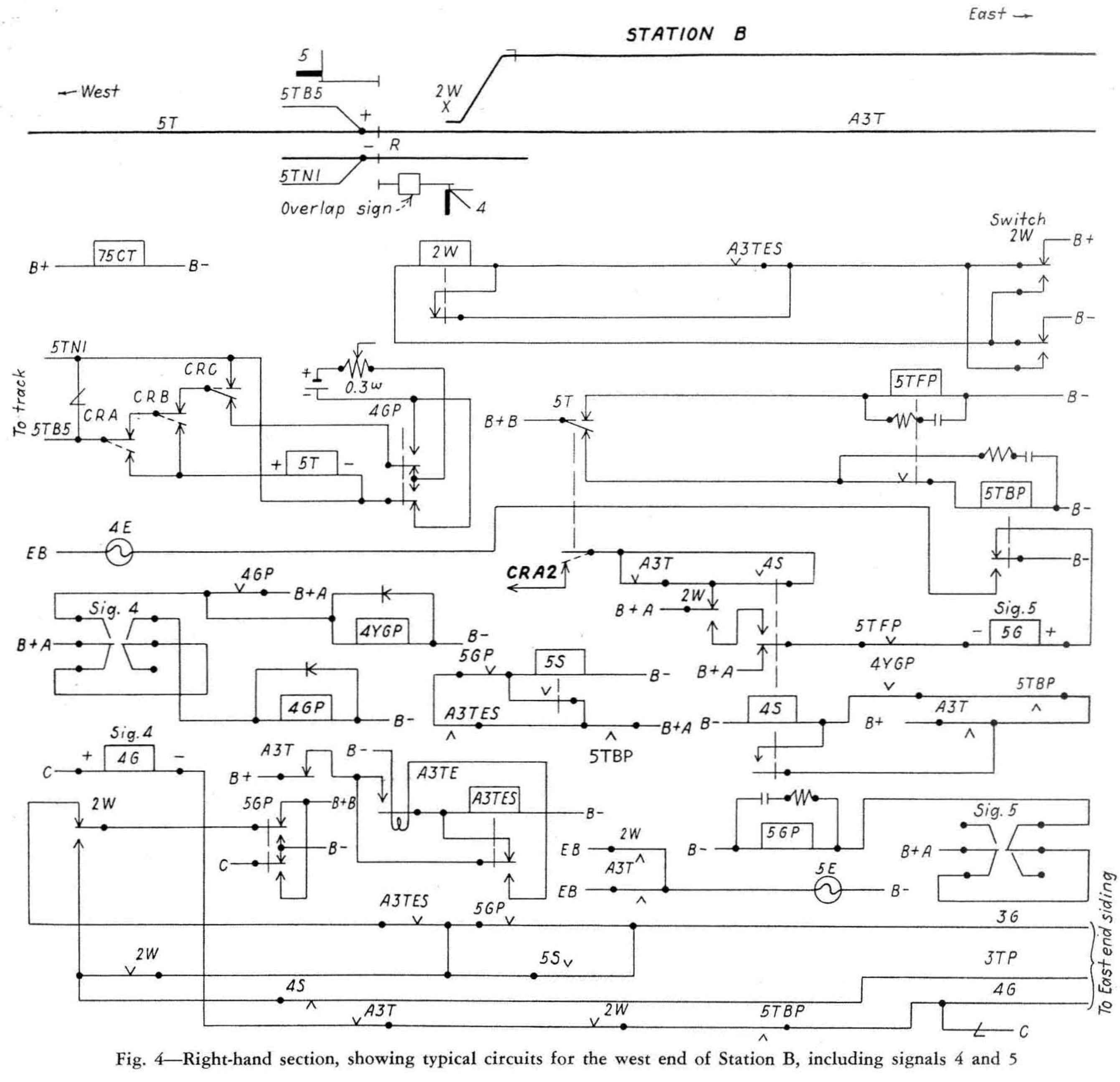


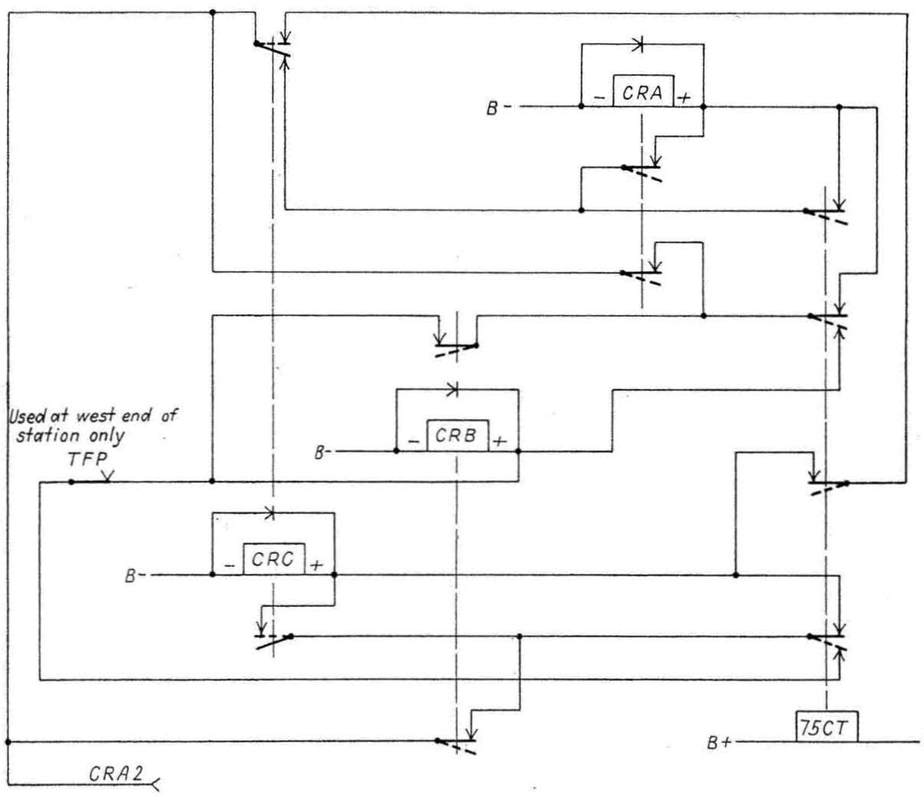
Fig. 4—Right-hand section, showing typical circuits for the west end of Station B, including signals 4 and 5

through the station-to-station block. Therefore, the track relays 5T at Station B and 7T at Station A will not operate while the eastbound train described above is in the block. At Station B, relays 5TFP and 5TBP will release, to hold signal 5 at Stop, and signal 4 will be lighted through a back contact of the relay 5TBP. Likewise, signal 8 at Station A will be held at Stop and signal 9 will be lighted.

When the train passes signal 4 at Station B, with the A3T and 5TBP relays down and the 4YGP relay up, the 4S relay is energized, thus permitting code to move westward all the way through to Station A again, and allowing signals 6 and 8 to condition for clearing for other train movements. The operation of the circuits for westbound train movements is similar to that for eastbound train release when a westbound light engine passes signal 5, and thereby closes the pick-up circuit of relay 5S, and thereby prepares the control of signal 3 to display a yellow aspect for a following move. This is important because overlaps for following train movements are different from those for opposing moves, as described in the preceding article in the April issue of *Railway Signaling*.

The control of signal overlaps for opposing and following moves is accomplished automatically by train movements in connection with a special arrangement of long and short track circuits, switch circuit controller connections at the passing tracks, which can be noted in Fig. 3 and 4. Functioning of this arrangement depends upon the direction in which the train is moving on the main line and ing trains to enter the siding without fouling the overlap.

The switch circuit controller on the east-end switch of the passing track, shown in Fig. 3, shunts the short track circuit, while the switch circuit controller on the west-end switch of the passing track does not, the latter controlling a switch repeater relay 2W, which in turn controls a track repeater relay, not always acting as such, shown as 9TP in Fig. 3, and controlled by a line circuit, shown as 9TP in Fig. 3 and 3TP in Fig. 4. This arrangement, providing a relay at each end of the siding, was found to be the most economical and effective arrangement, and furthermore, additional line wires are saved. The system may be designed to use a short track circuit at both ends of the passing track, with a long track circuit between them,



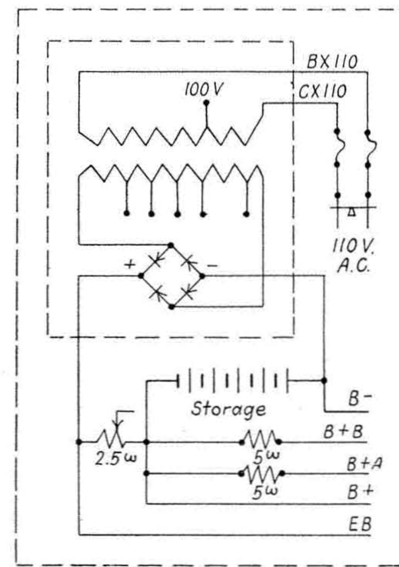


Fig. 5—Typical power supply and special code-transmitting combination circuits

movements. It will be noted in Fig. 4 that the A3TES time-element stick relay is normally held up by positive battery B+ over a front contact of the A3T track relay and its own front stick contact. However, once the A3TES relay is down it will not pick up again until the time limit, imposed by the A3TE time element relay, has lapsed. To complete the A3TE circuit the A3T track relay must again be up, causing positive battery B+ to pass over a front contact of that relay and over a back contact of A3TES relay, through the A3TE coils, and to negative battery. The main purpose of this circuit arrangement is to give the 5TFP and 5TBP relays time to whether the train is taking siding, an example of which was just covered briefly. Referring to Fig. 3, it will be noted that at the east end of the passing tracks there is a short track circuit through the switch, designated as 9T in this case, but in Fig. 4, there is no similar circuit at the east end of the passing track, the long track circuit, designated as A3T in this case, extending through the switch. A long and short track circuit in this arrangement are employed for several reasons, the most important being that a relay is required at the east end to pick the inbound stick relay 9S. This short track circuit, furthermore, is not part of the actual overlap, thus allow- but this requires additional line wires for the necessary overlap controls.

Line circuits at sidings include two power wires, and three control wires, the track repeater wire mentioned heretofore and shown as 9TP and 3TP on Fig. 3 and 4, and a green control wire for each station-entering signal which extends to the opposite end of the passing track. These wires are shown as 9G and 10G in Fig. 3 and 3G and 4G in Fig. 4.

This system was devised, planned and installed by the Rock Island under the direction of C. R. Swenson, signal engineer, the major items of signaling material being furnished by the Union Switch & Signal Company.