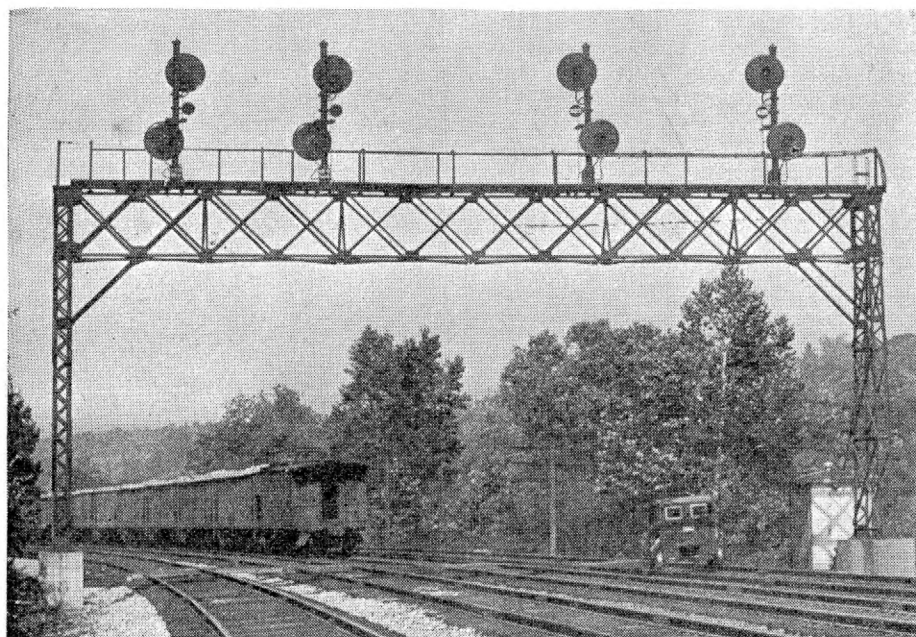




Left—View showing signals for four tracks, on a bridge
Below—Typical bracket mast with signals for two tracks



Signaling Modernized

On the Pittsburgh & Lake Erie

ON the multiple-track main line between McKeesport, Pa., and Youngstown, Ohio, including 246 track miles, the Pittsburgh & Lake Erie has completed an automatic block signal program including the replacement of semaphores with light signals, and the project includes a modern system of coded track circuits, thus obviating the use of line control circuits.

The Pittsburgh & Lake Erie operates nine passenger trains each way daily between Pittsburgh and Youngstown, and five additional suburban passenger trains are operated daily between Pittsburgh and College. One P. & L. E. passenger train is operated each way daily between Pittsburgh and McKeesport. Between McKeesport and B. & O. Junction, the Baltimore & Ohio operates seven passenger trains each direction daily over the P. & L. E. tracks. The freight traffic varies, but on the aver-

age the P. & L. E. operates 20 or more such trains daily and the B. & O. about the same number. Numerous switching moves are made daily in this area. The maximum speed limit is 65 m.p.h. for passenger trains and 35 m.p.h. for freight trains.

In the signaling previously in service the automatic signals were spaced for blocks about 4,000 ft. long. One important reason, therefore, for the modernization program was to re-space the automatic signals so that the blocks would be lengthened, thus permitting higher train speeds. In the new arrangement, the average block length is about 8,000 ft. although one block is 9,500 ft., and the minimum block length is 4,400 ft., which occurs where time table restrictions are in effect on account of physical conditions.

The previous signaling between McKeesport and Youngstown, 80.2

Change from semaphores to light signals on heavy-traffic multiple-track road includes modern coded track circuits

miles, consisted of 64.9 miles equipped with two-arm lower-quadrant semaphores, 5.7 miles of position-light and 9.6 miles of color-light. The color-light signals which had been installed in 1926 were salvaged and re-used on the sections between Pittsburgh and McKeesport, and between B. & O. Junction and Youngstown. Also as part of the program, a total of 23 four-track signal bridges were scrapped, thereby producing a total of 115 tons of scrapped steel, and a total of about 80 miles of bare copper line wire was made available for other uses.

The aspects displayed by the new automatic searchlight signals as well as the color-light signals include: green-over-red, staggered, Clear,

Rule 281; yellow-over-red, staggered, Approach, Rule 285; and red-over-red, staggered, Stop and Proceed, Rule 291. When an interlocking signal displays the Medium-Clear Aspect, Rule 283 for a diverging move, the automatic signal in approach to the interlocking home signal displays yellow-over-green, staggered, Approach Medium, Rule 282. When an interlocking signal displays Slow-Clear Aspect, Rule 287 for a diverging move, the automatic signal in approach to the interlocking home signal displays yellow-over-red-over-green, staggered, Approach-Slow, Rule 284.

Searchlight Signals

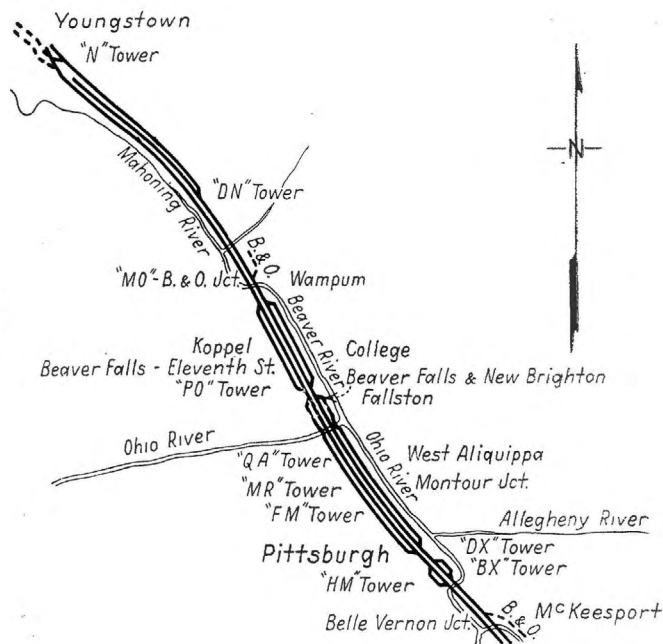
For each of the searchlight signals which displays only three aspects, the upper "arm" is an H-2 searchlight unit with a 500-ohm operating coil, and the lower "arm" is an H-2 type fixed unit with a $8\frac{3}{8}$ -in. red lens. For a signal which displays four aspects, including Rule 282, the upper and lower "arms" are searchlight units. For a signal which displays four aspects including Rule 284, the upper arm is a searchlight unit, the middle arm is fixed H-2 unit, and bottom arm is fixed R-2 one color unit. On all searchlight signal units, the back-

grounds are 40 in. in diameter, so that the appearance of operative units or non-operative units is the same to an engineman.

The upper and lower units are

the right, and, where third unit is used, it is mounted to the left of the mast and 5 ft. below the middle unit. This staggered arrangement, in addition to the number plate, designates

Sketch showing in general the main lines of the P.&L.E.



spaced 5 ft. vertically on the masts, the upper unit being mounted to the left of the mast and the lower unit to

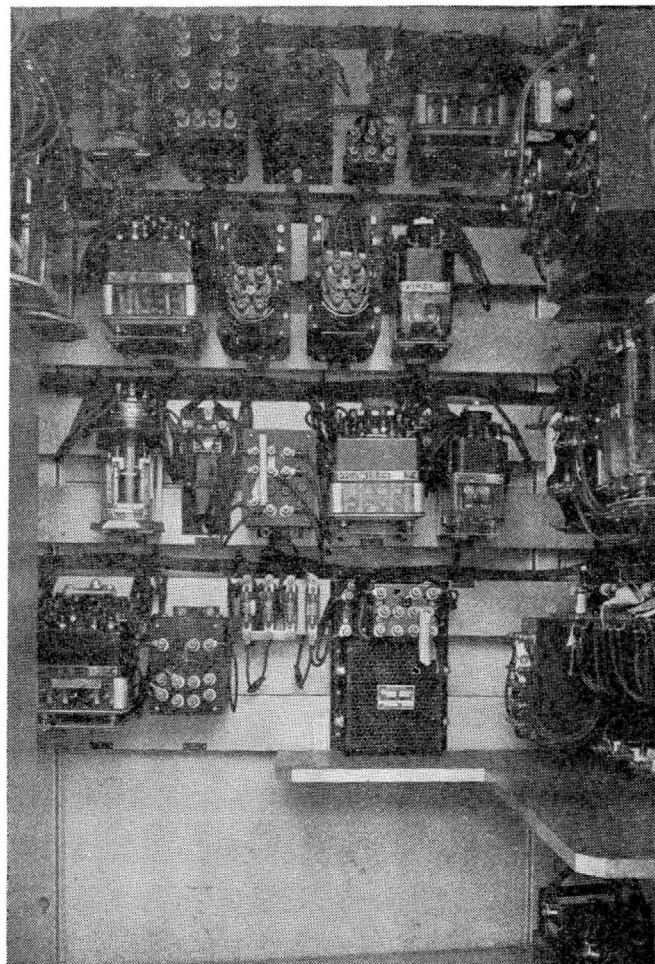
such a signal as being automatic in contrast with an interlocking home signal on which all units are in one vertical line. The lamps in the signals as well as in the marker units are rated at 12-16 volts, 21 c.p.

Automatic Train Stop

The protection in service between Pittsburgh and Youngstown includes intermittent automatic train stop equipment, an inductor being located between 70 and 90 ft. in approach to each signal. Each locomotive operated in this territory is equipped with automatic train-stop equipment, which includes an acknowledging lever by means of which an engineman can forestall an application of the air brakes at a signal which is displaying any aspect other than Clear, Rule 281, or Medium-Clear, Rule 283.

Changes in Controls

The old semaphore signals were controlled by polarized d-c. track circuits, but line wire circuits were required for approach locking, annunciators, etc. at interlockings, or for line circuits in blocks which included highway crossing protection. On the 20.3 miles of four-track line between Pittsburgh and West Aliquippa, alternating-current track circuits were installed in 1926. When making the recent change-over, all of the old d-c. and a-c. track circuit equipment was removed. In the new signaling, the



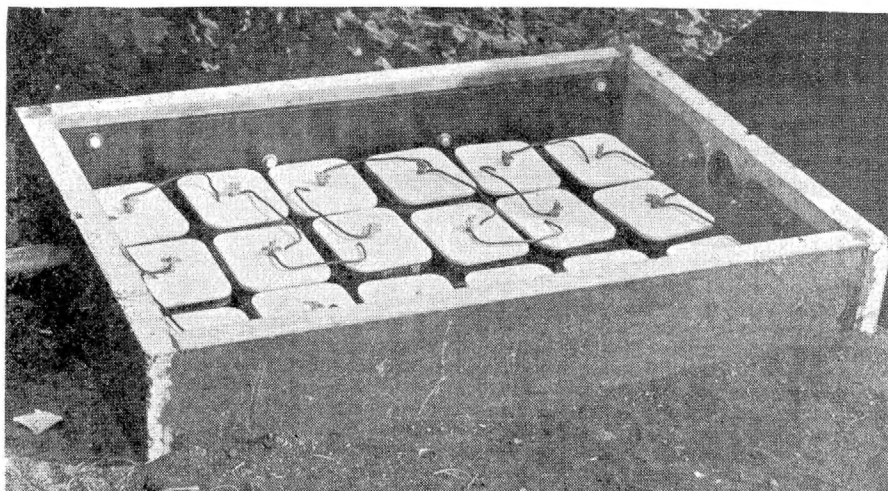
Interior of typical instrument house in the new signaling project

track circuits throughout the entire project are of the d-c. coded type, a total of 192 such circuits being included in the project. Reverse direction track circuit coding is used for approach lighting and also for approach locking controls.

New Methods of Power Supply

The equipment and circuit arrangements for the applications of coded track circuits depends somewhat on the battery used, and, therefore, the power supply will be explained before discussing the coded track circuits. Between Pittsburgh and West Aliquippa, a single-phase a-c. power distribution circuit at 6,600 volts on aluminum conductors was previously in service. This circuit was retained for the present but at a later time will be changed over to 440 volts. Also between College and Fallston and between Wampum and B. & O. Jct., a 440-volt single-phase circuit was in service. On the remainder of the territory, a new 440-volt single-phase power distribution circuit was installed, using No. 8 copper wires with weather-proof covering.

The searchlight signal coils, code transmitters and all of the relays are operated on direct current. This apparatus at any given signal location is normally fed from either a R3Q208



The primary batteries are used for stand-by only

or R3Q408 type rectifier, depending on whether it is a 2-track or 4-track signal location, the maximum output of which is rated at 1.5 or 3.0 amp. 14.0 volts. This form of power supply is known as rectified a-c. In case of an a-c. power outage, a power-off relay switches this load to a set of Edison primary batteries which is normally on open circuit. Where space is available, this battery consists of eighteen 1,000-a.h. cells, while at some other locations, two sets of 18 cells of 500-a.h. are used.

At a typical location on double track

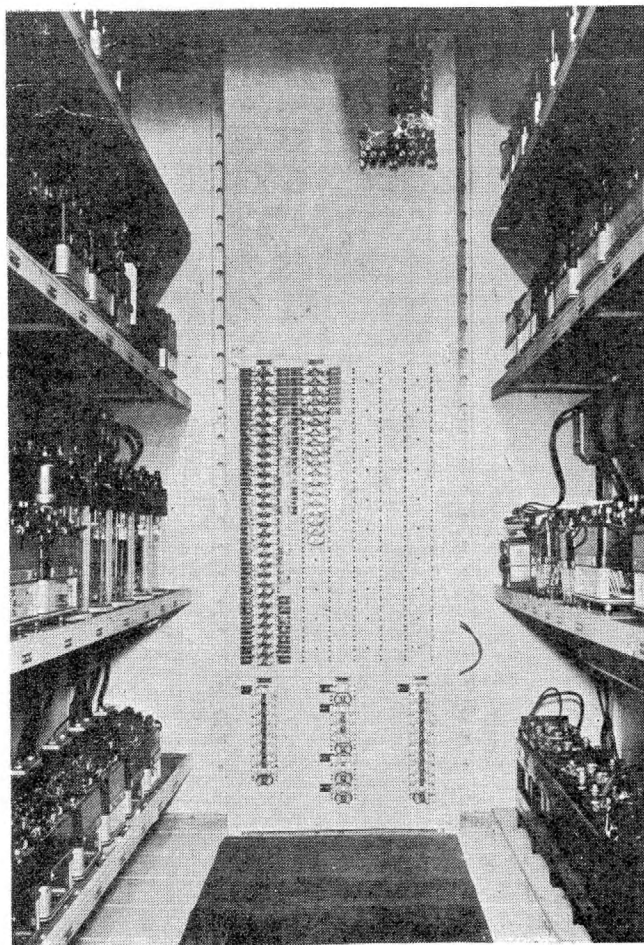
with two signals, the discharge from a set of these primary batteries is about 1.25 amp. when the power-off relay is released with no trains approaching. The signal lamps, when lighted on approach control, are normally fed from the low-voltage transformer. In case of an a-c. outage, the power-off relay switches the lamps to the set of primary batteries, with approach control in effect. In order to keep these batteries active, each set is discharged once a month by using a $\frac{1}{2}$ -ohm shunt to give a discharge of about 20 amp. for 10 minutes. The estimated life of these batteries is 7 years. The normal voltage of each set of batteries is about 15 volts, with a minimum of 10 volts at 0 deg. F.

Each track circuit is fed from one cell of B4H Edison storage battery rated at 75 a.h. at the 5-hr. rate. Each cell is normally on floating charge from an R3X-104 rectifier, the maximum output of which is 2.2 amp. at 3.0 volts d-c.

Approach Lighting Control

In general, coded track circuits may be designed to provide 4,000-ft. approach lighting, using normal code only, or, by employment of a reverse code, to provide full-block approach lighting. The latter arrangement is incorporated into the P. & L. E. circuits. In four-track territory where two adjacent tracks are used for traffic moving in one direction, and the other two are used for traffic moving in the opposite direction, the reverse code is employed on only the outside track of each pair of tracks. Nevertheless, approach lighting is effected on both tracks, as will be disclosed in the following circuit information.

Figure 1 illustrates diagrammatically the principle of full-block approach lighting on two adjacent tracks in coded track circuit territory by application of the reverse code to only



All the relays are equipped with the quick - detachable connector units

one track. On both tracks, normal code is fed from the exit end of the block to the entrance end to control the aspects of the entrance signals. In addition, on No. 1 track a reverse

and 3 and 7 are unoccupied. At Signal 1, coded energy is fed to the track at the rate of 75 to 180 interruptions per minute, depending upon the position of the contacts of relay 1HR,

energized through a back contact of relay 5-7TRP, the former will continue energized during the "on" period of the code.

At the time the back contacts of the

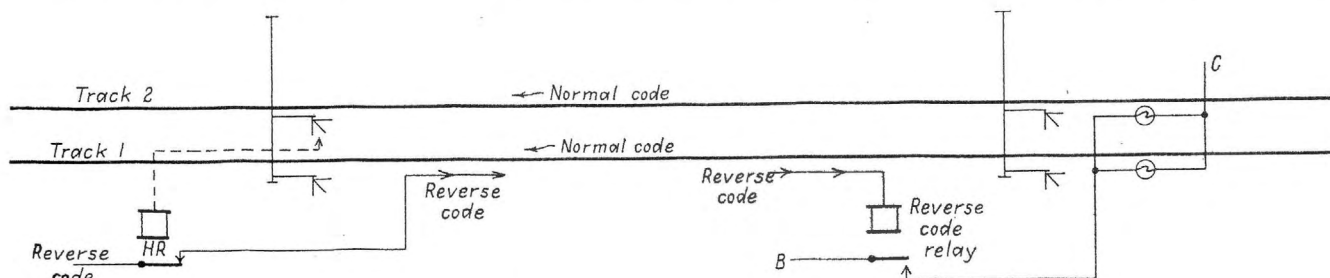


Fig. 1—The principle of full-block approach lighting on two adjacent tracks

code is transmitted from the entrance end of the block to the exit end, during the off period of the normal code, to energize the reverse code relay at the exit end. This reverse code is fed through a front contact of the HR relay controlling the signal on No. 2 track at the entrance end. The local

which select the circuit over a contact of either the 75 or 180 code transmitter. Polarized code-following relay 1-3 AR, which is connected in series with the track energizing circuit, will have its contacts in the right-hand position at the time the code transmitter contact is closed and

code transmitter are closed at signal 1, reverse code relay 1-3AR is connected directly across the track. Code-following track relay 5TR at signal 5 is de-energized, thus reversing the flow of current in the primary winding of the decoding transformer. This induces a voltage in the secondary,

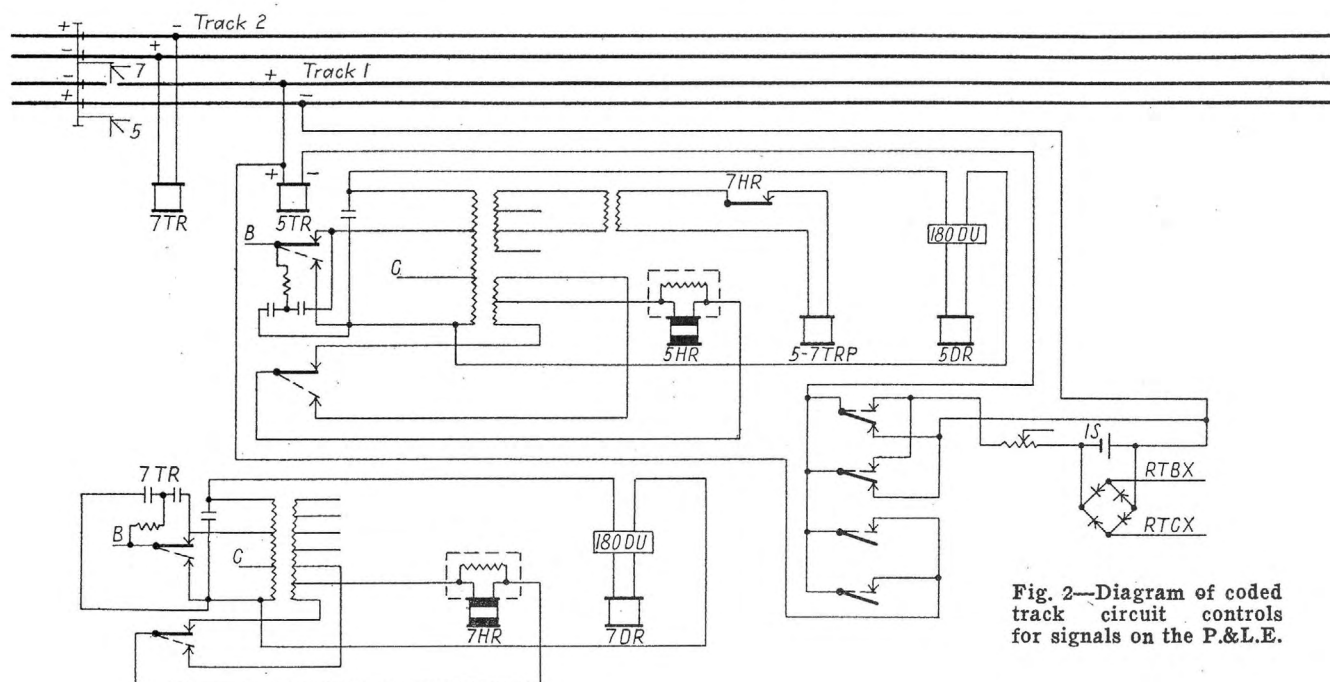


Fig. 2—Diagram of coded track circuit controls for signals on the P.&L.E.

lighting circuits for both signals at the exit end of the block are controlled by a back contact of the same reverse code relay. Consequently, with a train approaching on either track, both signals will be lighted, for the reverse code will either be removed at a front contact of the HR relay on No. 2 track, or shunted away by the train if it is approaching on No. 1 track. The reverse code relay will, therefore, be de-energized to light the signals.

Coded track circuits as used in four-track territory on the P. & L. E. are shown in Fig. 2. In describing the circuits it will be assumed that the blocks between signals 1 and 5,

energy is applied to the track. The code applied at signal 1 is followed by track relay 5TR at the opposite end of the block. When the front contacts of relay 5TR are closed, the direction of flow of current in the primary winding of the decoding transformer is reversed. A secondary winding of this transformer is connected through an impulse transformer to the coils of the reverse-code impulse relay 5-7TRP, which is a polar biased type. Therefore, it will pick up only when it receives energy of the proper polarity, which is not the case at the time the code-following track relay 5TR is energized. Since relay 5TR is

which picks up relay 5-7TRP for a brief interval. The windings of the transformer secondary and the 5-7 TRP relay are so proportioned that the time the relay is energized is less than the "off" period of the normal code.

During the brief period that the 5-7TRP relay is picked up, reverse code is fed from the reverse code battery through the upper two front contacts and then the lower two front contacts of the 5-7TRP relay to the rails at signal 5, and at signal 1 it is fed from the rails through the windings of reverse code-following relay 1-3AR.

It is to be noted that the TR terminals of relay 5TR are short circuited through the lower 2 front contacts of relay 5-7TRP, which makes it impossible for reverse code battery to energize relay 5TR due to bridging contacts. The direction of flow of the current during the "on" period of the reverse code is such that the contacts of the 1-3AR relay move to the left-hand position. Now if a train passes signal 5, relay 5TR becomes de-energized and applies one more pulse of reverse code energy which is shunted by the train. If a train passes signal 7, the reverse code will be removed from track No. 1, because the 5-7TRP energization circuit includes a front contact of relay 7HR which would, of course, be de-energized. When reverse code is not received at signal 1, the contacts of relay 1-3AR move to the right-hand position.

Signals 1 and 3 are lighted through multiple back contacts of relay 1-3AP, which has slow release characteristics

With the block unoccupied, code-following track relay 7TR will follow 75 or 180 code, depending upon the indication displayed at signal 3 in advance. One contact on the 7TR relay reverses the flow of current to the primary winding of the decoding transformer each time the contact opens and closes. The low frequency alternating current thus induced in the secondary winding of the transformer is mechanically rectified by a second contact on the 7TR relay to cause direct-current to flow to the 7HR relay. As this relay is not tuned or selected, it will energize on both the 75 or 180 code and is used to control the Approach aspect of signal 7.

Relay 7DR, which controls the Clear indication of signal 7, is energized through a 180 decoding unit. This decoding unit is so tuned that it will allow only 180 code energy to pass through and energize the relay.

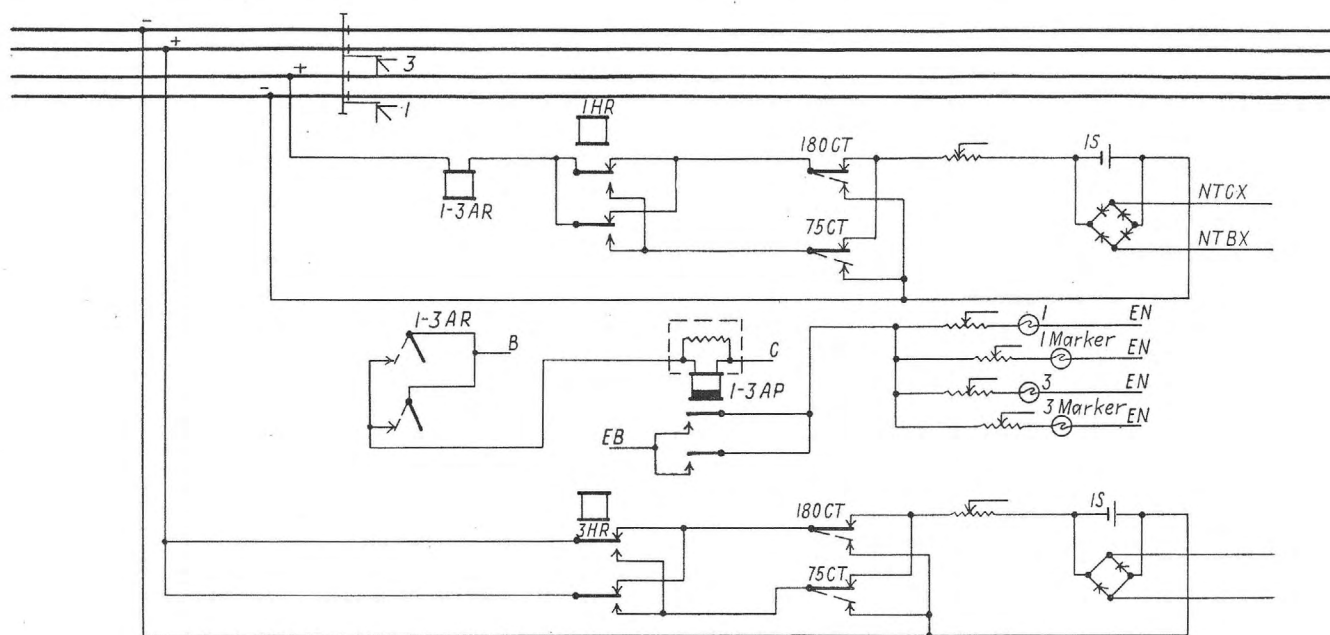
Code-following track relays installed on the P. & L. E. are of the

under this condition, steady energy would flow through one section of the primary coil of the decoding transformer which would not cause the HR relay to be energized. In two locations on this territory, foreign current was effective in producing the result explained above. Although no hazardous condition existed, the result was that the signals could not be cleared by coded track circuit controls. By adding cut sections, the effects of the foreign current were isolated and minimized so that proper operation was secured.

General Construction

At signal locations, the instruments and storage battery for the track circuits are located in welded sheet metal houses. The primary batteries are located in Permacrete sectional-type concrete boxes, as shown in one of the views.

The relays and code transmitters are equipped with quick-detachable



and remains steadily energized as long as the contacts of relay 1-3AR are moved to the left-hand position during the "on" period of the reverse code. When the reverse code is removed by a train approaching on either track, relay 1-3AP becomes de-energized, thus lighting signals 1 and 3.

When normal coded energy is received at signals 5 and 7, this energy is decoded in the usual manner to control the aspects of signals 5 and 7. For the sake of clarity, the circuits controlling signal 7 will be described, as they do not include the energization circuit for relay 5-7TRP, details of which were given previously.

polar-biased type. The polarity of adjacent track circuit is, therefore, staggered in order to obtain protection against broken down insulated joints, since any leakage across a bad joint will then repel the contacts of the relay. Where reverse code is used for approach locking purposes, both track circuits would be equipped with reverse coding facilities.

Absence of energy in a track circuit causes the code-following track relay to be released, thus causing the signal to be positioned for a red aspect. Likewise, steady-flowing energy, such as might result from foreign current, may cause the code-following track relay to be energized constantly, but,

plug-couplers so that instruments can be replaced quickly and without chances for errors when attaching wires to terminal posts. The instruments are supported on spring brackets which are attached to wood planks bolted to upright sections of the wall of the houses. The insulated wiring in the houses is No. 14 AWG stranded. The underground cable leads to rail connections which are No. 9 AWG solid. This signaling project was planned and constructed by the signaling forces of the Pittsburgh & Lake Erie, the major items of signal equipment were furnished by the Union Switch & Signal Company.