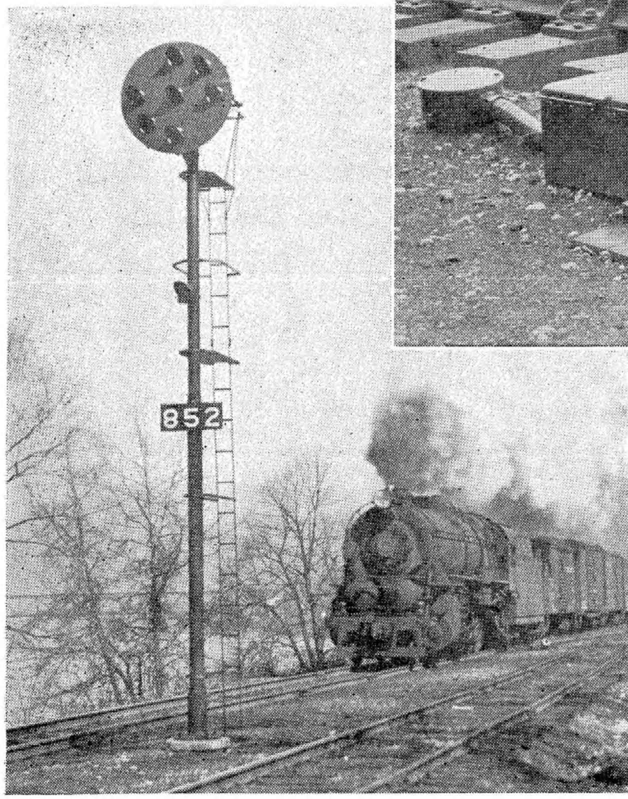
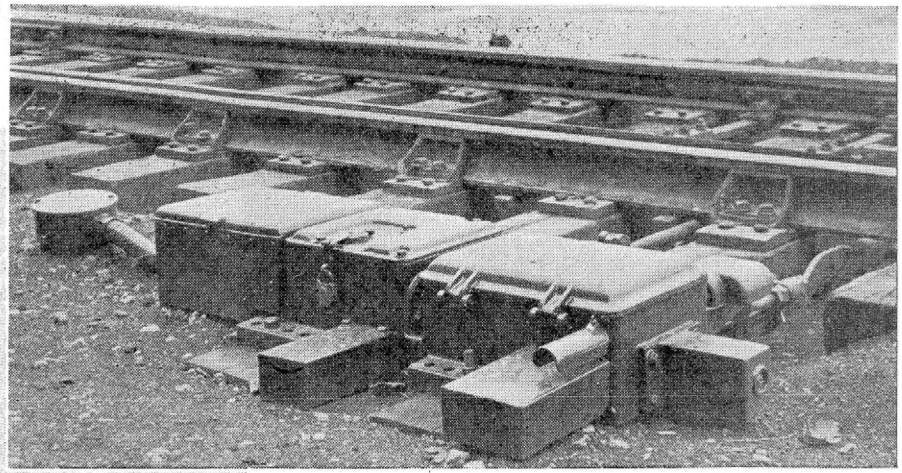
Southbound freight train at signal 852 at Foxburg. Right—The power switches are of the electric type





Reversible coded track circuits eliminate line control signal circuits and line wires for lock controls

Pennsylvania Installs C.T.C.

On 53 Miles of Busy Single Track

The Pennsylvania Railroad has installed centralized traffic control on 52.9 miles of line, most of which is single track, between Brady, at Red Bank, Pa., and RH Tower near Oil City, Pa. This is a portion of the line between Pittsburgh, Pa., and Buffalo, N. Y., via Oil City, Pa., Red Bank being 65.6 miles north of Pittsburgh, and RH Tower 3.5 miles south of Oil City.

In the Red Bank-RH territory, the railroad follows along the east bank of the Allegheny river, so that, for the most part, the line is at river grade. Curves are numerous but the curvature is comparatively light; the speed limit on two curves is 30 m.p.h., on one curve, 35 m.p.h., and on six curves, 45 m.p.h. Also the speed limit in two tunnels is 45 m.p.h. Otherwise the maximum speed on the main track is 50 m.p.h. for passenger trains and 45 m.p.h. for freight trains.

The through traffic includes 2 passenger trains and from 7 to 15 freight trains in each direction daily and, in addition, local freight trains and mine run or industrial pick-up trains make numerous movements in this territory.

Prior to the recently completed centralized traffic control, train movements on this territory were authorized by timetable and train orders and by manual block.

Track Arrangement

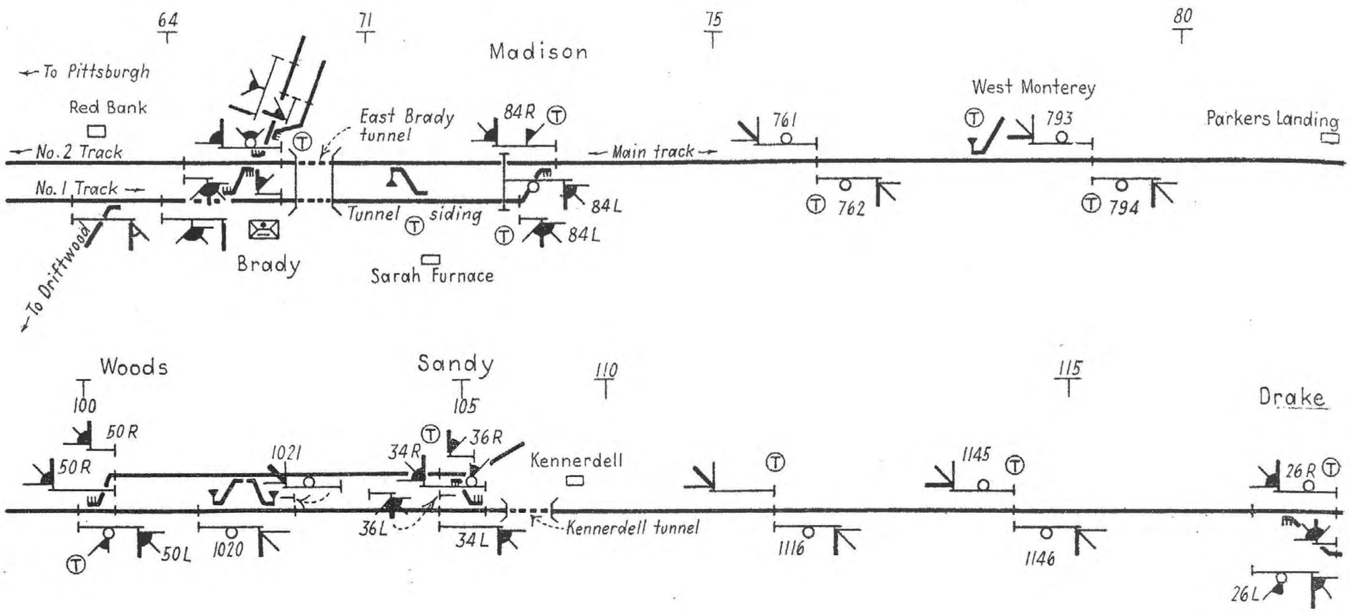
In general, this section of line lies north and south. Between Pittsburgh and Red Bank, 42 miles, there are two main tracks. At Brady Tower, MP64, there is a track layout including one crossover and one junction switch which connects with the East Brady Branch, about 4 miles long, extending to a yard and engine terminal at Phillipston, and on to a stub end at East Brady. The crossover serves as the junction between double track from the south to single track north of this crossover. A siding, known as Tunnel Siding, extends from this crossover through the Brady Tunnel to Madison, 3.1 miles.

Similarly, a secondary track, known as "101 Track", extends from Parker to Birch, 10 miles; a secondary track known as "102 Track" extends from Woods to Sandy, 5 miles, and "301 Track" extends from Drake to RH Tower, 12 miles. These sections of secondary track are not main track, but are tracks used by through trains when clearing the main line for meets, and by mine run and industrial pick-up trains when serving coal mines, manufacturing plants, and oil refineries.

The switch, crossover and signals in the vicinity of Brady Tower are included in a new electro-pneumatic machine which also controls the C.T.C. between Brady Tower and RH Tower.

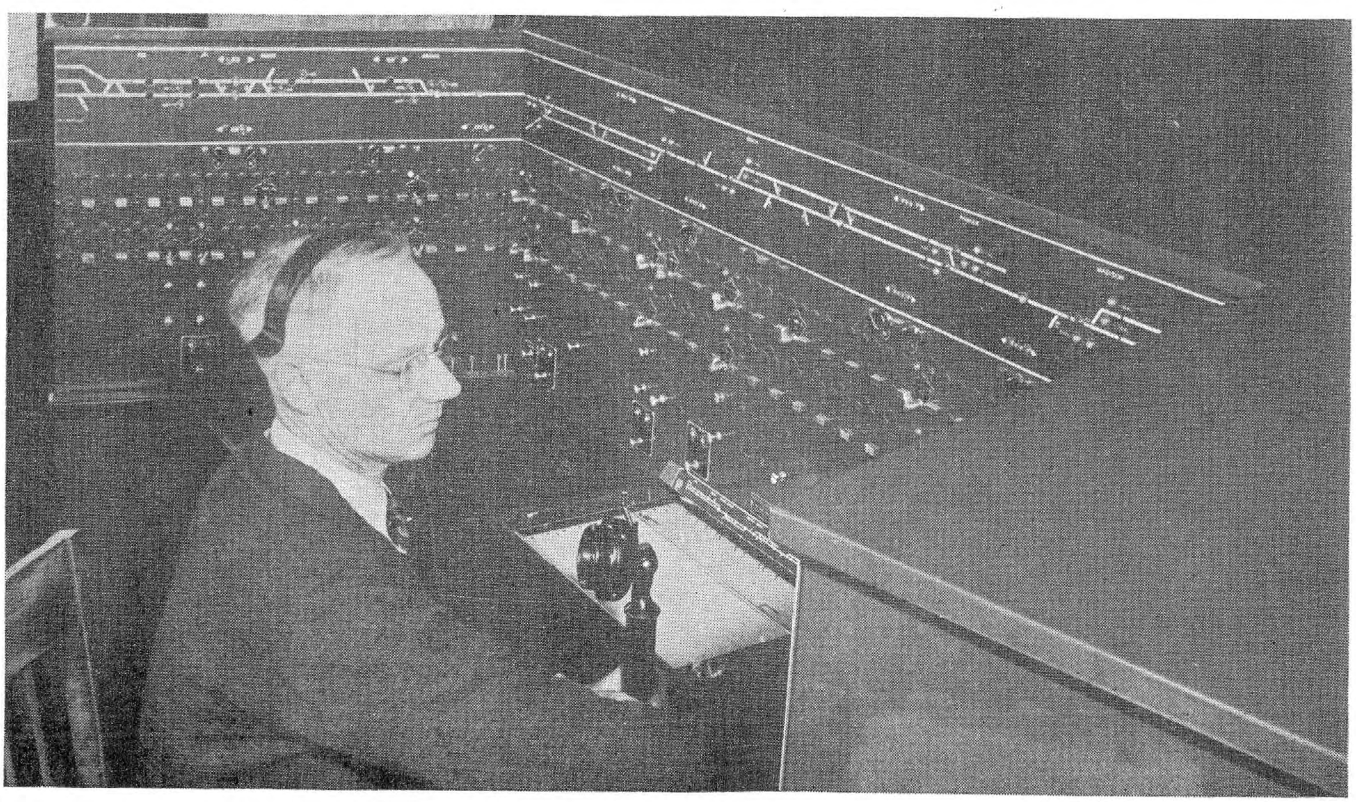
The main-track switches leading to sidings, or, in some instances, crossovers between the main track and the siding at Madison, Parker, Birch, movements, are controlled by the C.T.C. system from the machine in Brady Tower.

The switches and signals at RH Tower at the north end of the C.T.C. territory, are included in an interlocking at that location; however, the

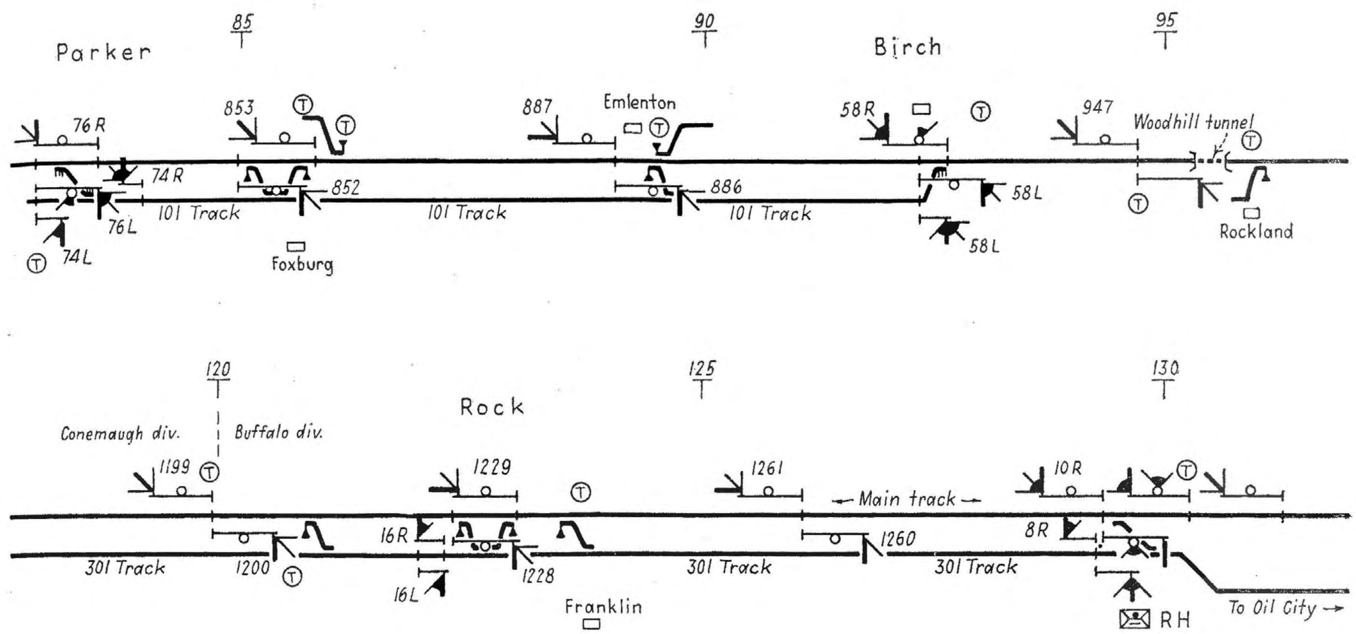


Track and signal plan of the centralized traffic

interlocking, the controls of which are based on the all-relay principle with conventional direct-wire circuits. The control levers for these switches and signals are included in the same Woods, Sandy and Drake, are equipped with low-voltage electric switch machines, and these machines, as well as the semi-automatic signals at these switches for authorizing train southward signals, No. 10R on the main line and No. 8R on the siding at RH Tower, cannot be cleared unless a release is effected from the C.T.C. control machine at Brady.



The C.T.C. machine is located in a new tower at Brady



control territory between Brady and RH Tower

At various locations, as shown on the diagram, there are 4 main-line single switches and 10 main-line crossover switches at each of which the conventional switch stand was replaced by a hand-throw switch-and-lock movement, including an electric lock which normally locks the operating lever in the normal position. These electric locks are controlled as a part of the signaling installation. The semi-automatic signals at the switches, as well as the intermediate automatic signals, are all of the position-light type, and display aspects in accordance with Pennsylvania Railroad standards.

The Control Machine

The control machine, as shown in one of the accompanying illustrations, is located on the second floor of Brady Tower, which is a new building of brick and concrete construction. The machine is made up of three panel sections arranged in a "U" shape. The section to the right includes 3 switch levers and 7 signal levers for the control of the electro-pneumatic interlocking in the vicinity of this tower. These controls are accomplished by direct-wire circuits. The center panel and the panel to the left are for the control of the C.T.C. territory, and include 6 levers for the control of power switches or crossovers, 11 levers for the control of semi-automatic signals, and 6 levers for the control of electric locks on hand-throw main-line switches. Between the C.T.C. control machine and the various field stations at Madison, Parker, Birch, Woods, Sandy, Drake and Rock, the controls and indications are transmitted by the multiple-time code system, using two new line wires throughout the C.T.C. territory.

Above the switch levers and just below the illuminated track diagram, there is traffic-direction lever for each over-all station-to-station section of main track between sidings, also there is such a lever for each section of main line opposite a siding, and there is such a lever for the entire length of each siding between power switches.

Each traffic lever is in effect a "turn-and-push" button which performs the function of a lever and a code-starting button. Referring to the close-up view of a small portion of the machine, traffic lever 53 applies to the section of main line between Woods and Birch. Above the traffic lever there is a set of two purple lamps each mounted in a double-pointed arrow. When the traffic lever is thrown to the right, as shown in this view, codes go out to the field stations at Woods and Birch. The controls set up in the field, establish direction of traffic. When traffic direction has been established, as for example southward, the purple lamp to the right is lighted in the arrow pointing to the south.

On the track diagram, one lamp indicates occupancy of each station-to-station block; of each OS switch detector section; of each section of main line opposite a siding, and of each siding. Also on the diagram, the symbols representing the semi-automatic signals include lamps which are lighted when the corresponding signal has been controlled to display a proceed aspect. A special feature is that a separate lamp indicator is provided to repeat each of the two "arms" on a station-entering signal where the high "arm" controls to the main track and the second "arm" directs diverging moves to the siding. Above the center position of each signal lever there is a red lamp which is lighted when all the signals controlled by that lever are displaying the Stop aspect. Lamps above the two positions of each switch lever repeat the position of the corresponding switch in the field.

Referring again to the close-up picture of the section of the control machine between Woods and Birch, it will be noted that there is a lock lever, No. 51, in the same row with the switch levers, this lock lever being for the control of the electric lock on the hand-throw main-line switch in the Woods-Birch station-to-station block. The controls for the lock will be discussed later.

Feature of Train Chart

An automatic train chart is mounted in the desk portion of the control machine. This chart has a pen for each of the OS switch detector sections on the C.T.C. territory. A new feature of this train chart is that when the switch involved in the OS section is in the normal position, the pen moves to the *right* and stays there as long as the OS section is occupied, but if the switch is reversed for a train to enter or depart from a siding, then when the OS section is occupied, the pen moves to the *left*. This recorded difference is an aid in checking later to determine which trains took siding, whereas, on previous train chart mechanisms of this type, the pens move to the right only for any train movement over a given OS section.

Coded Track Circuits

Codes at different rates in the track circuits control the signals to display the aspects. Track circuit code at the rate of 75 per minute controls a signal to display the Approach aspect, and 180-code the Clear aspect. No code or steady flowing energy in a track circuit causes the most restrictive aspect to be displayed.

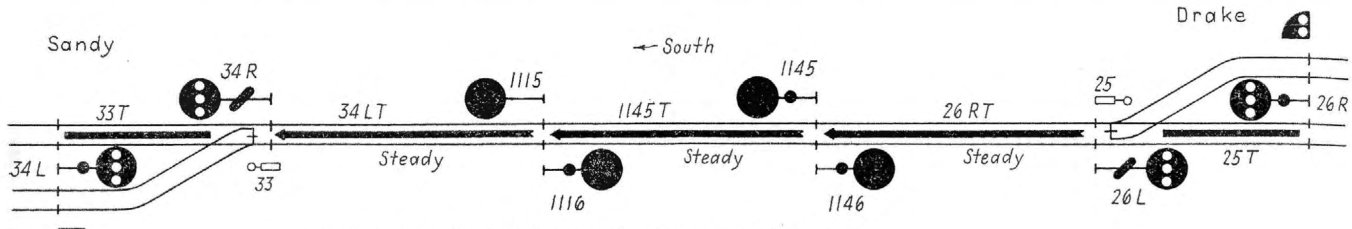


FIG. 1 Steady track circuit energy flowing south

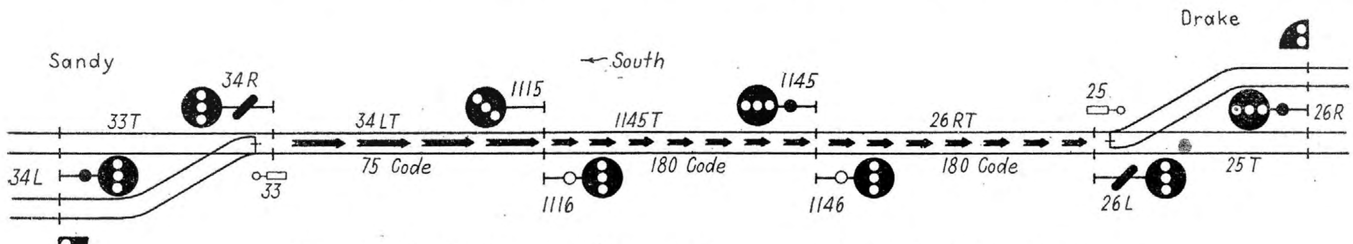
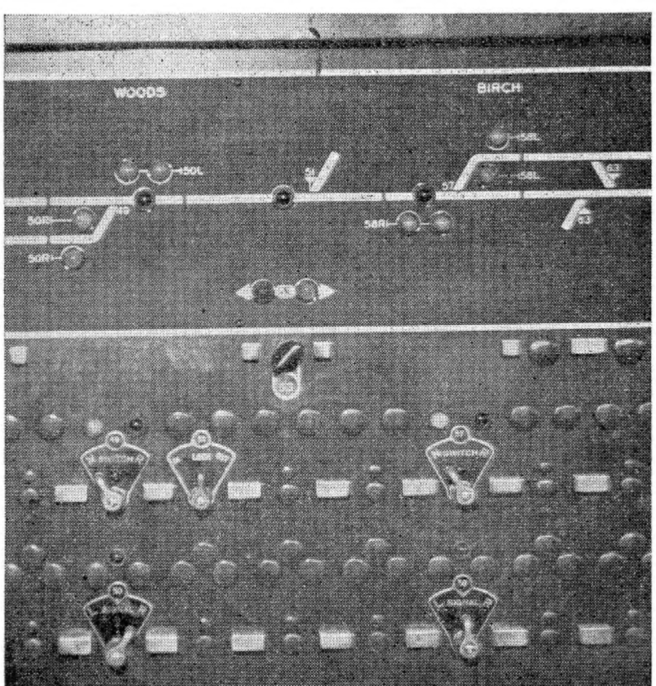


FIG. 2 Track circuit codes feeding north in entire station to station block

The code in the track feeds in the direction opposite the train movement to be made. The direction which the track circuits are to feed in an entire station-to-station block is established by the traffic direction control as a part of the C.T.C. system. Referring to Fig. 1, the switch detector OS track circuits such as 33T at Sandy and 25T at Drake are conventional d-c. track circuits which are normally energized. However, in the three intermediate automatic blocks the track circuits are the coded type. The coded track circuits range in length up to a maximum of about 10,000 ft. If an automatic block is longer than this maximum, a cut section is used to divide the block into two track circuits.



Close-up view of the panel of the C.T.C. machine for section between Woods and Birch

The coded track circuits are arranged to be fed at either end; this means that there is a battery and a track relay at each end of every track circuit.

The selection which determines whether the battery or the relay is to be connected to the track leads is made through contacts of a relay, the controls of which depend on traffic direction established by C.T.C. control. Say, for example, that traffic direction between Drake and Sandy has been established southward. This was accomplished by placing traffic lever No. 29 to the left. This causes code controls to go to the field stations at Drake and Sandy to control a relay at each station. These are so-called polar stick relays in which the contacts when positioned either way, stay there even though energy is later removed from the coils.

Traffic Direction South

In the instance being discussed, traffic direction has thus been established southward, and, as a result, steady flowing energy is being fed southward in track circuit 26RT from signal 26L to signal 1146, where the track relay is thereby energized steadily. This causes steady energy to be fed on the track southward from signal 1146 to 1116. This picks up a track relay that in turn feeds steady energy southward on track circuit 34LT from signal 1116 to signal 34R. At the 34R location this steady energy picks up a relay which sends indications to the C.T.C. control office to indicate that the station-to-station block between Drake and Sandy is unoccupied and the blue lamp in the arrow is lighted to indicate that traffic is lined southward.

With steady energy effective at

the intermediate automatic block signals, the lamps in these signals are extinguished.

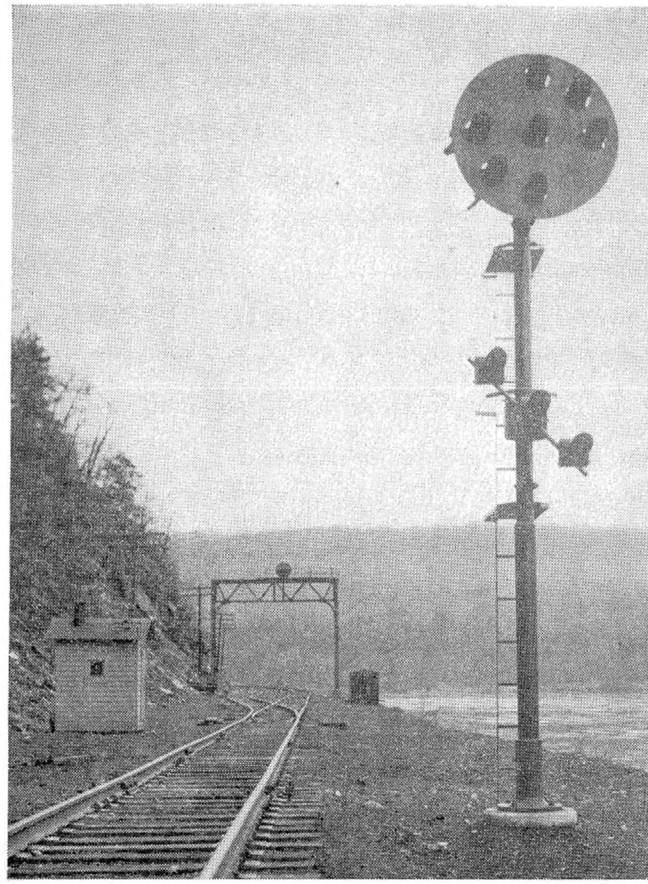
To Clear a Signal

With traffic lined southward, if southward signal 26R at Drake is to be cleared, lever 26 is thrown to the right and the code starting button is pushed which causes a line code control to go to the field station at Drake. This picks up a relay that cuts off the flow of steady track circuit energy flowing south in track circuit 26RT. This releases the track relay at signal 1145 which cuts off the steady energy feeding south in track circuit 1145T. This releases the track relay at signal 1116 which cuts off the steady energy flowing south in track circuit 34LT. At signal 34R, the release of the track relay initiates action which causes 75 code to feed northward in track circuit 34LT, as shown in Fig. 2.

At signal 1115 this 75 track code picks up the 1115H relay which causes the Approach aspect to be displayed on signal 1115. Also with the 1115H relay up and the track relay repeater up, the southward directional stick relay 1115S is picked up.

Then 180 code is fed northward in track circuit 1145T to signal 1145 which energized the 1145H relay which in combination with the 1145D relay causes the Clear aspect to be displayed on signal 1145. Also, with the 1145H relay and the track relay up, the directional stick relay 1145S is picked up.

Then 180 code is fed northward in track circuit 26RT which causes the track relay and repeater to be energized and in combination with controls in effect from the office cause the Clear aspect to be displayed on the semi-automatic signal 26R. Also the directional stick relay 26RS is picked up.



Power switch and southward signal 84R at Madison

The southbound train accepts signal 26R and proceeds. When the locomotive passes signal 1145 and releases the track relay, the pick up circuit of the directional stick relay 1145S is opened but its stick holding circuit is closed through the track relay down so that this stick relay is not released at this time.

Referring now to Fig. 3, after the rear of the train passes signal 1145, the fact that stick relay 1145S is up and the track relay at signal 1145 for track circuit 1145T is down, closes circuits to cause 75-code to be sent north in track circuit 26RT from signal 1145 to signal 26L. This 75 code picks up a relay which releases the stick relay 26RS. This causes steady energy to feed south in track circuit 26RT. The result is that the steady energy feeds through the code during

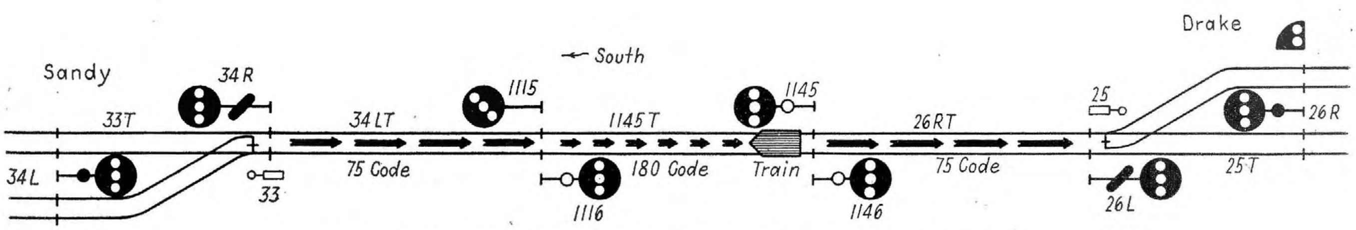


FIG. 3 Action which occurs immediately after rear of train passes signal 1145

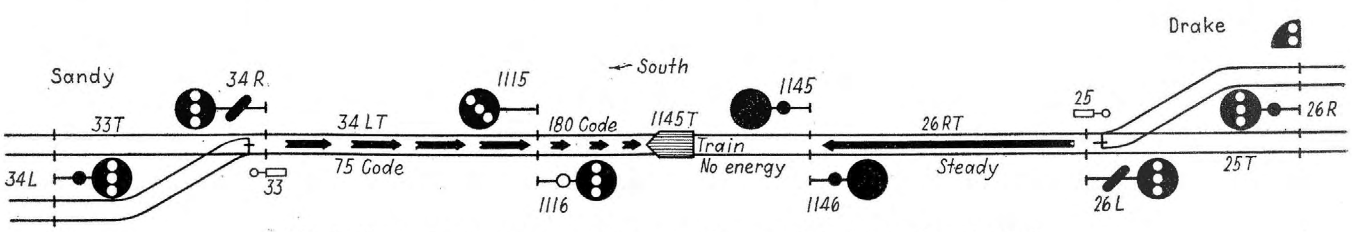
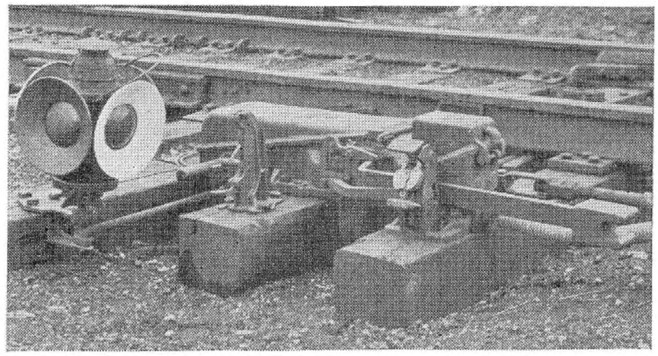


FIG. 4 Then steady energy continues to flow south in track circuit 26RT

the off periods. This steady energy picks up the 26RT track relay at signal 1145 which cuts off the code, leaving steady energy flowing south in track circuit 26RT to signal 1145, as shown in Fig. 4. As the train proceeds in track circuit 1145T it shunts the 180 code going toward the train. Between the rear of the train and signal 1145, there is no energy in the track circuit.



Hand-throw switch and lock mechanism with electric lock

To Clear Signal 26R For Second Train

If signal 26R is to be cleared for a second southward train while a leading southward train is within the limits of the block between signals 1145 and 1115, then when the line code control goes to Drake to clear 26R, the first action is to cut off the flow of steady track circuit energy southward in track circuit 26RT. This releases the track relay which, with the 1145S directional stick relay still up, causes 75 code to be sent northward on track circuit 26RT, as shown in Fig. 5, in combination with the C.T.C. controls, causes signal 26R to display the Approach aspect.

With Leading Train in Third Block

If no C.T.C. control had been sent out to clear signal 26R for a second train until after the rear of the first train had passed the second intermediate, signal 1115, then in the meantime when the rear of the train passed signal 1115, the 75 code would be sent northward in track circuit 1145T, as shown in Fig. 6. This, at signal 1145 would release the 1145 stick, which in turn would cause steady energy to feed south in track circuit 1145T. This steady energy feeds through the code, and at signal 1115 the code is cut off so that steady energy now feeds south all the way to signal 1115, as shown in Fig. 7.

Now with the rear of the leading train south of signal 1115, if control is sent out to clear signal 26R for a second train, the steady energy feeding south in track circuits 1145T and 26RT is cut off. With directional-stick relay 1115S still up, circuits are closed to send 75 code back northward in track circuit 1145T to control signal 1145 to the Approach aspect and then 180 code is fed northward in track circuit 26RT to cause the Clear aspect to be displayed in signal 26R to authorize the second southward train to enter the block.

On the other hand, if no second train is involved, when the rear of the southbound train passes out of the station-to-station block, i.e., south of signal 34L, then 75 code is fed north in track circuit 34LT to signal 1115 which releases the directional stick relay 1115S which causes steady energy to be fed south in track circuit 34LT. This feeds through the code and causes the code to be cut off. Thus the circuit arrangement returns to the conditions shown in Fig. 1, with steady energy fed from north to south through the track circuits of the entire station-to-station block. This causes an indication control to go to

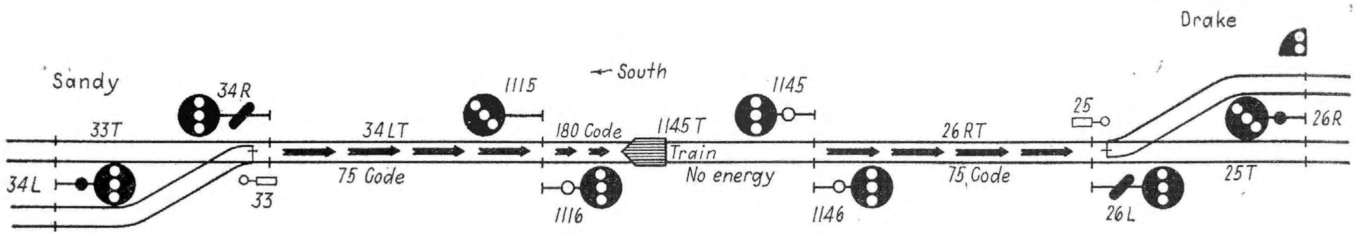


FIG. 5 When 26R is to be cleared for second train, the steady energy going south in track circuit 26RT is cut off, and then 75 code feeds north.

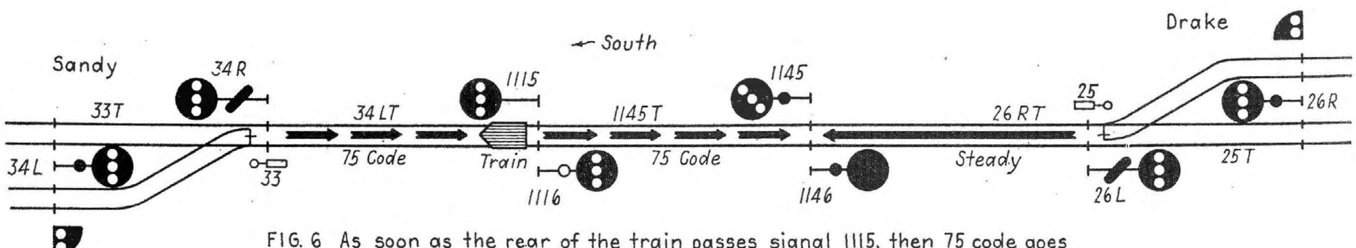


FIG. 6 As soon as the rear of the train passes signal 1115, then 75 code goes north in track circuit 1145T to signal 1145

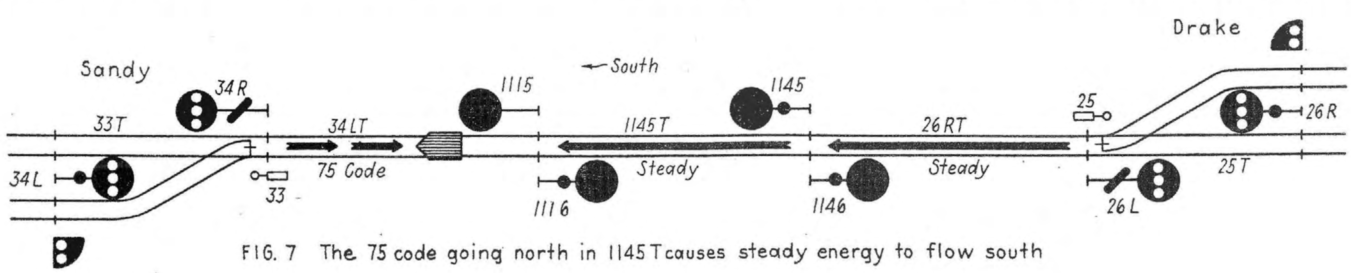


FIG. 7 The 75 code going north in 1145T causes steady energy to flow south

the office to indicate that the station-to-station block is unoccupied and that the traffic direction is still southward.

Change In Traffic Direction

With the traffic direction established southward between Drake and Sandy, as shown in Fig. 1, if the traffic direction is to be changed to northward, the traffic lever 29 is thrown to the opposite position. This causes line codes to go to the field stations at Drake and Sandy to operate the contacts of the traffic relays to the opposite position. At Drake the flow of steady energy southward in the track circuits is cut off. As a consequence the track relays at the south ends of the track circuits are released. When the track relay at the south end of track circuit 34LT is released, then in combination with the control set up by the traffic direction, steady energy is fed northward in the track circuits all the way through the station-to-station block. When the track relay at the north end of track circuit 26RT is picked up, this action in combination with the traffic relay causes an indication to go to the office to show that the station-to-station block is unoccupied and that traffic is now established northward.

Control of Electric Switch Lock

A hand-throw main-line switch with an electric lock is located about midway in the station-to-station block between Madison and Parker, as shown in Fig. 8. In approach to the facing point of the switch there is a short conventional type d-c. track circuit, about 150 ft. long. In ordinary through train operation, not involving the use of this switch, the coded track circuits feed through the automatic block between intermediate signals 793 and 761, being extended around the short track circuit by wires which break through the front contacts of the short track circuit relay.

Three-Position Lock Levers

In the C.T.C. control machine, each lock lever normally stands on center with the handle vertical. When the electric lock is to be released to allow the switch to be reversed to permit a train on the main line to enter the spur track, the train must occupy the 150-ft. track circuit in approach to the facing point, and also the man in charge of the control machine places the corresponding lock lever to the "IN" position which is to the left, and then the code starting button is pushed to send out a code to the field station at Madison. At this field station, 100-cycle energy is superimposed on the two C.T.C. line code wires and is transmitted as carrier current on these wires to the location of the lock where this 100-cycle energy is detected and used to pick up a relay. Front contacts of this relay are included in the circuit to energize the lock.

At the Madison field station and at the lock location there are electric "blocks" connected in the C.T.C. line circuit which prevent the 100-cycle energy from going beyond these limits, but these "blocks" do permit the C.T.C. line code as well as telephone voice frequencies to pass. The 100-cycle current is produced by a reed-type tuned alternator, which is operated only when needed.

To Let a Train Out

When a train which is in the clear on the spur is ready to come out, the conductor uses the telephone to communicate with the man in charge of the C.T.C. machine who informs the conductor when the lock is to be released. Then the conductor at the switch and the control operator cooperate in effecting controls to release the lock, see Fig. 8 and Fig. 9.

The man at the switch removes

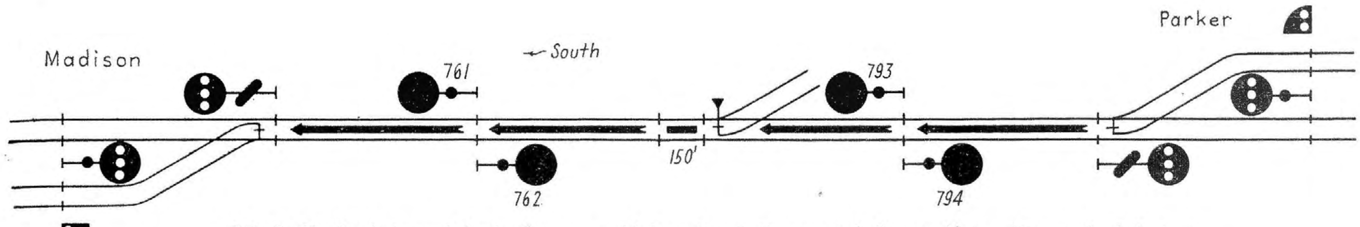


FIG. 8 Typical layout including an outlying hand-throw mainline switch with an electric lock

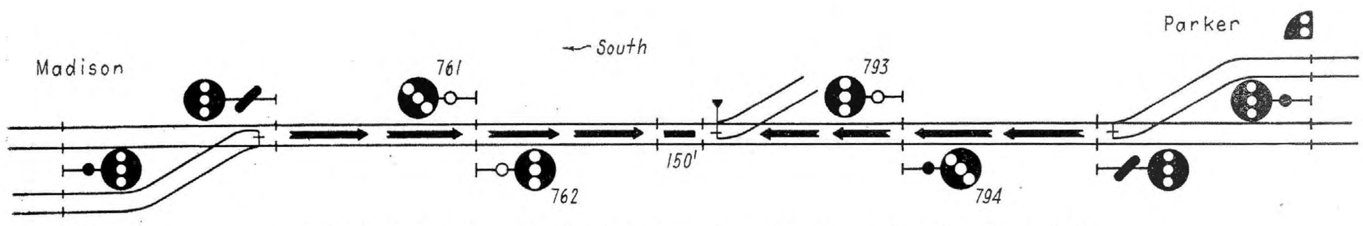
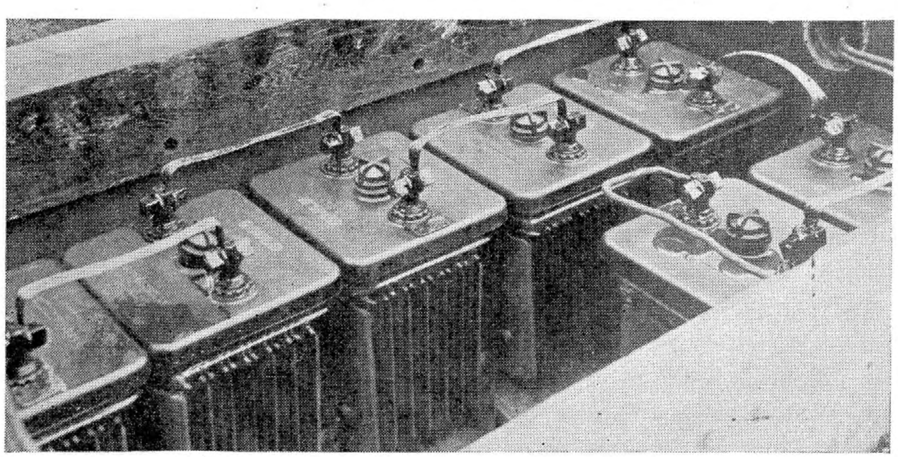
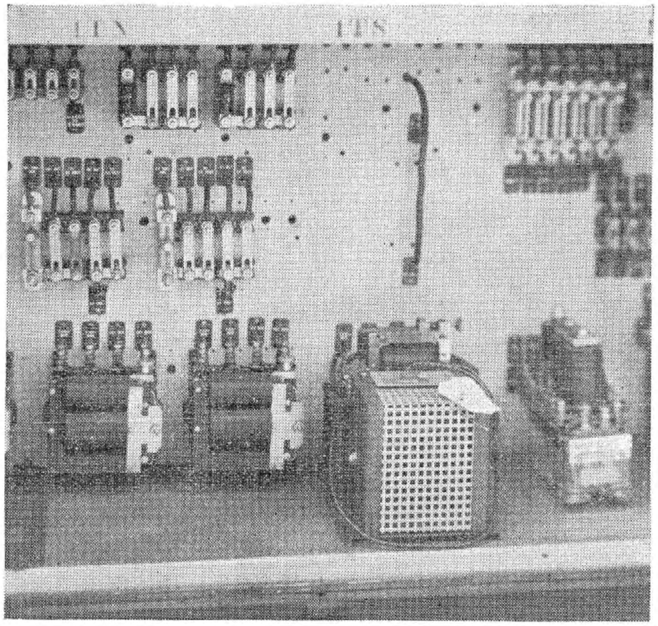


FIG. 9 Control to release lock when a train on the spur is to enter the mainline



Battery in box at the Brady tower



Rectifiers in case at crossing protection signal location near Emlenton

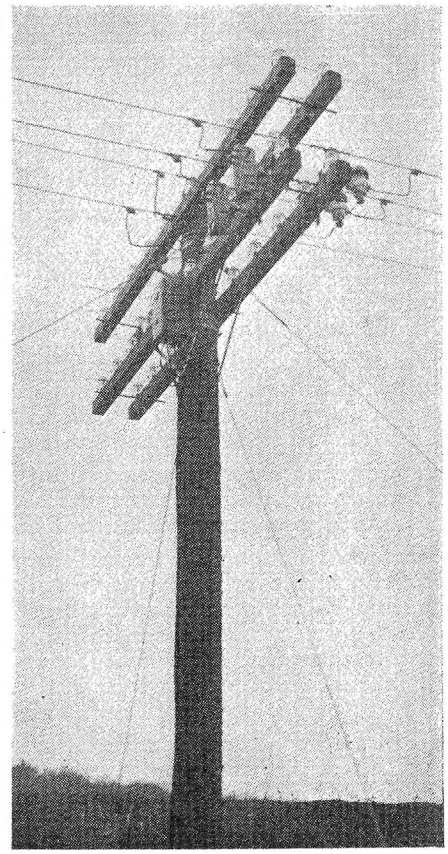
the switch padlock from the foot latch on the operating lever. This operates contacts which cut off the flow of steady track circuit energy beyond the switch. This results in 75 code being sent north from Madison to the location of the switch. In the meantime, the man at the C.T.C. machine moved lock lever from the center position to the "Out," which is to the right, and pushed the code starting button. This causes a control to be sent to Parker to send 75 code in the track circuits southward from Parker to the location of the switch. Only when coded energy is received at the switch from both directions is it possible to release the electric lock. Obviously the coded energy would not be received until a train passed the automatic signal beyond the switch. Another item is that the code will not be sent from Parker or Madison unless the station-leaving signals are displaying the Stop aspect. Thus the release of the electric lock for either "In" or "Out" moves are lever controlled without requiring the installation of extra line wire circuits for this purpose.

Instrument Housings

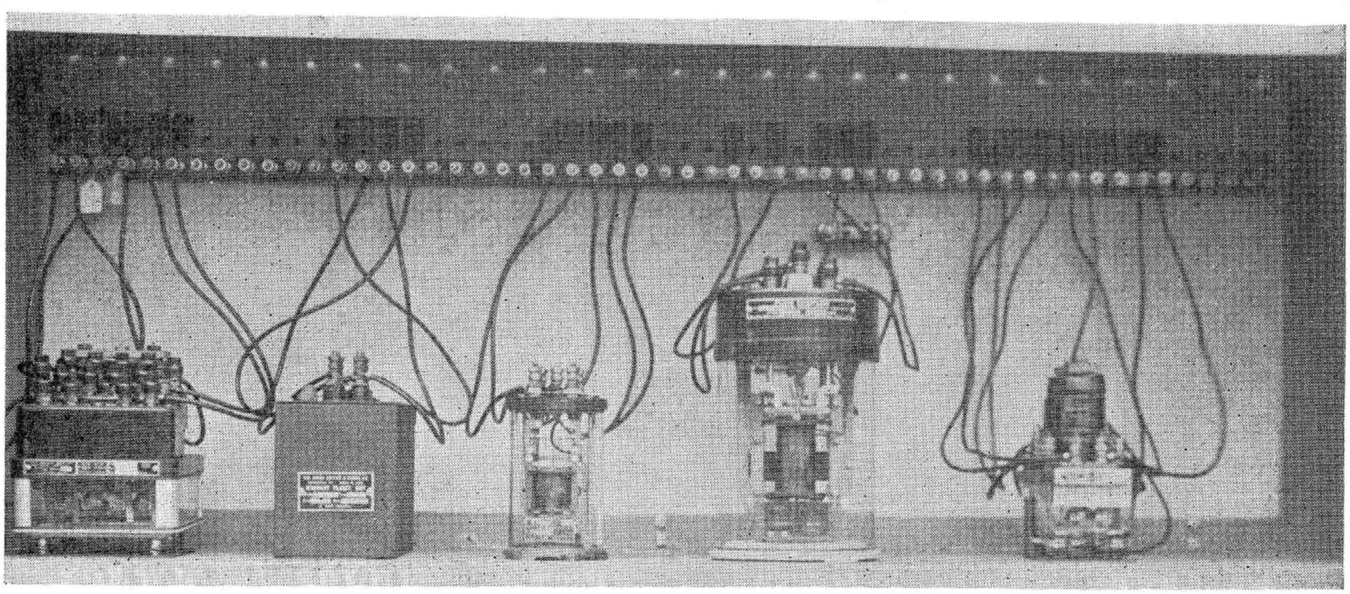
At the field stations the relays and line code equipment are located in sheet metal housings. The relays and code transmitters are the shelf type and are equipped with plug-couplers. When a relay, for example, is to be replaced, the plug-coupler is lifted off, the relay is replaced with a new one and the plug-coupler is pushed down over the terminal posts. This can be done quickly and with no delay required in careful checking to be sure that the wires are attached to the proper terminal posts.

Pole Line Work

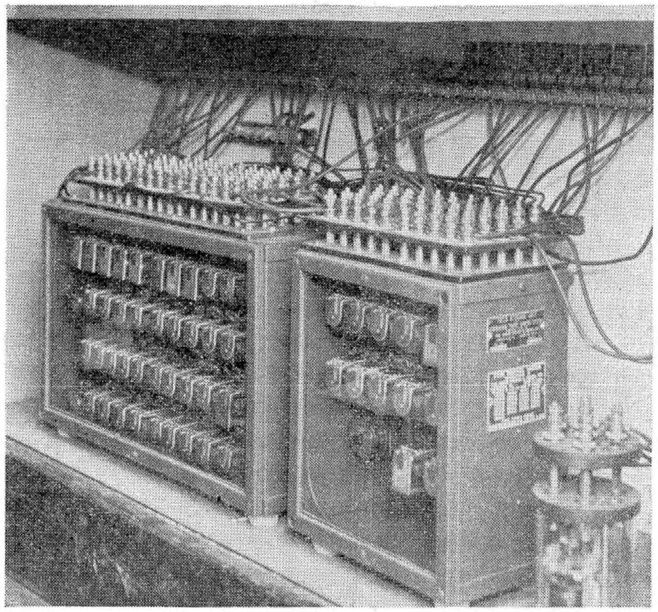
The new C.T.C. code line is on two new No. 6 Copperweld wires with 40 per cent conductivity of solid copper. These wires have double-braid weather-proof covering. In order to locate these wires where the



Line pole at a signal



Typical relays used in coded track circuits on this territory



The line coding equipment in a field station

chances for damage would be a minimum, they were placed on the top crossarm on the pins next to the pole, one on each side. In some sections other wires were relocated on other pins in order to use the pole pins for the C.T.C. line.

This C.T.C. line also carries a telephone circuit at ordinary voice frequency. Also in some short sections these line wires also carry 100-cycle current for the control of electric locks, as explained elsewhere in this discussion. An important fact is that the use of coded track circuits obviated the need for installing line wires for the controls of signals.

Power Supply Line

Two new No. 6 copper wires with weather-proof covering were installed throughout the C.T.C. territory for distribution of power at 440-volts a-c. These wires are on the two pins on the field end of the lower crossarm. Power is fed north from Brady Tower to Parker, in both directions from Emelton, and south from Sandy.

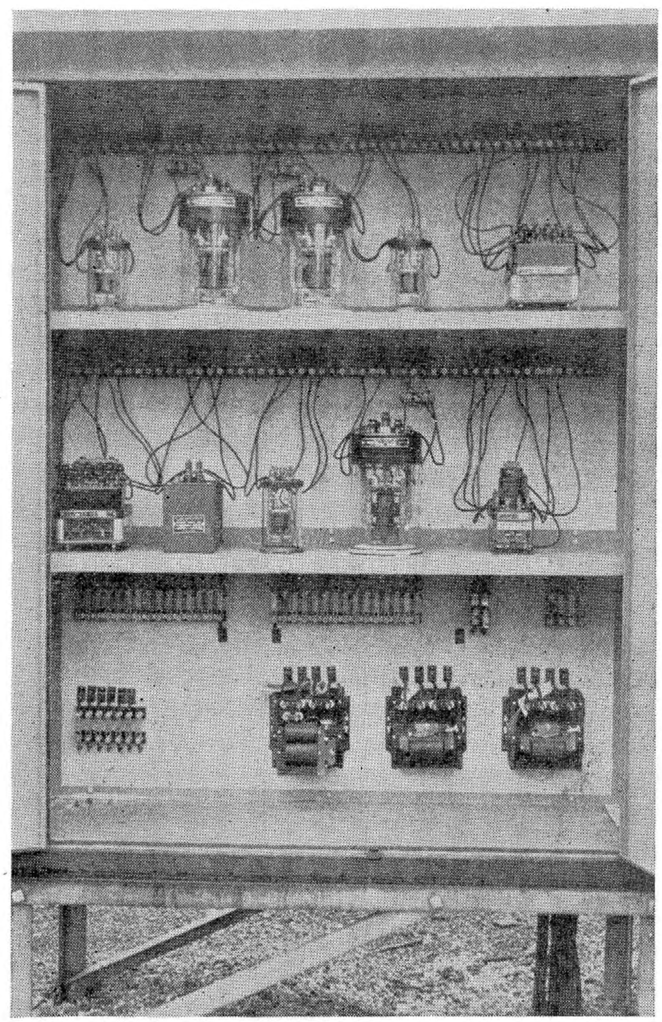
At each field station location there is a 1.5-KVA, 440 115-volt air-cooled line transformer, mounted on the crossarm, with arresters and fused plug cut-outs, as shown in one of the pictures. The 110-volt circuit extends into the instrument housing. One low-voltage transformer with a 110-volt primary and two other low-voltage secondaries feeds the signal lamps. A power-off relay normally connects the lamp load to the transformer, but in case of an a-c. outage the load is switched to feed from a storage battery. Other secondaries of the low voltage transformers feed rectifiers each of which charges a single cell of 120-a.h. lead storage battery for feeding a track circuit.

Three rectifiers operating from the 110-volt supply are used to charge three sets of lead storage batteries. One set of 6 cells rated at 240 a.h. is a standby for the signal lamps and feeds various low-voltage circuits and relays. A second set of 4 cells rated at 180 a.h. and a third set includes 8 cells of 180-a.h. capacity. These two sets in series feed the switch motor. By separate connectors the 8 cells feed the line code equipment and emergency supply for the dwarf signal lamps.

Two-Rate Charge

The charging rates of these three storage batteries are controlled by "two-rate charge" relays. A normally open back contact of such a relay is connected around a resistor in series with the secondary which feeds the rectifier. If the battery voltage is less than a specified figure, the relay is released, thus shunting the resistor and thereby increasing the voltage on the rectifier to charge the battery at a higher current until the voltage is again increased to pick up the relay.

This interlocking and centralized traffic control was planned and installed by the forces of the Pennsylvania Railroad.



Interior of a typical sheet-metal instrument case showing coded track circuit apparatus