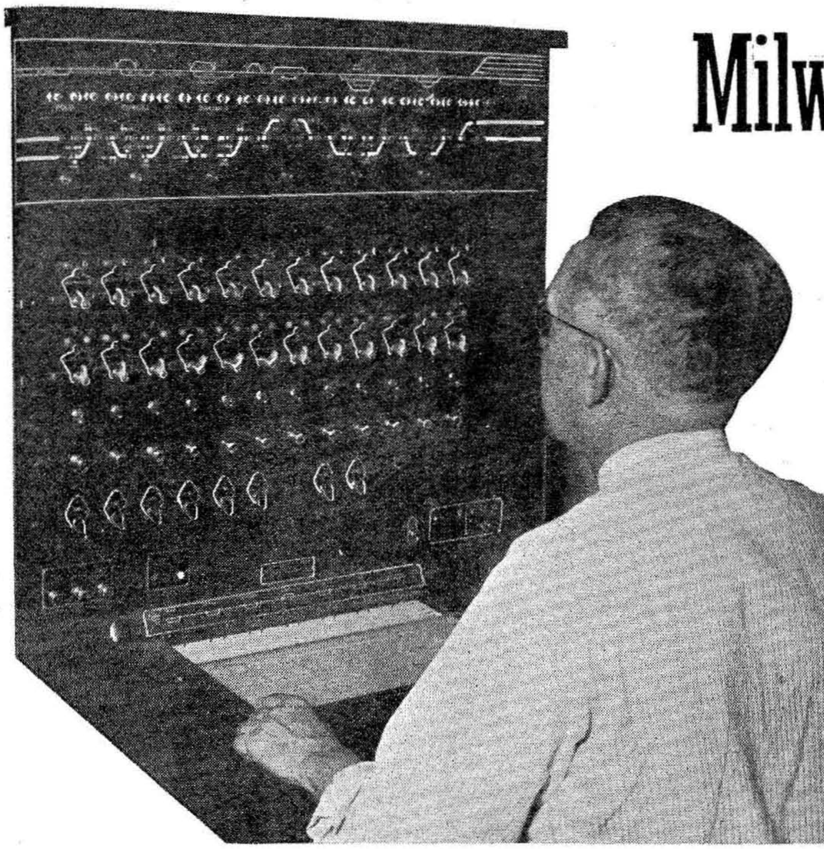


Milwaukee Installs C.T.C. on 51 Miles

The C.T.C. control machine is at Ottumwa, which is 104 miles from the C.T.C. territory

Single-track project between Laredo, Mo., and Polo, includes new idea of normally de-energized coded track circuits which eliminate line control wires as well as a-c. power line wires between the sidings

CENTRALIZED traffic control has recently been installed on 51 miles of single track between Laredo, Mo., and Polo, on the Chicago, Milwaukee, St. Paul & Pacific. This territory is on the route between Chicago and Kansas City, and in connection with other C.T.C. installations placed in service several years ago, the Laredo-Polo project completes train operation by signal indication on the entire 97 mile subdivision between Laredo and Kansas City except for a 7.8 mile section between Birmingham and Kansas City which will be replaced with a new line equipped with C.T.C. within a few months.

Light Grades

In the Laredo-Polo territory the grades are slightly rolling with a maximum of 0.75 per cent and this for only short distances. The curvature is comparatively light, except for two 5-deg. curves between Laredo and Chula, and one 4-deg. curve just east of Chillicothe. The passenger traffic on this route is handled by one through train and one local train, each way daily. A local freight is operated each way on alternate days. Three through freight trains are scheduled each direction daily, and several extra trains are operated. Thus the total number of trains ranges from about 12 to 18 daily. The type L-2 freight locomotives are rated to handle about 2,150 tons westward and 2,600 tons eastward, and the diesel-electric locomotives, of which there are four in regular service, are rated at 5,000 tons in either direction. The maximum permissible speeds on this territory are 70 m.p.h. for passenger trains, and 50 m.p.h. for freight trains.

Changes in Passing Track

As a part of the improvement program, the passing tracks at Sturges and at Ludlow were removed, and those at Chillicothe and Braymer were extended to hold 111 cars. The passing tracks at Chula, Dawn and Cowgill each hold 87 cars. The C.T.C. system includes power switch machines at both ends of these five passing tracks, and also at the west end of the yard at Laredo and the east end of the passing track at Polo, thus totaling 12 power switch machines. At each of these switches there is a conventional arrangement of four C.T.C. controlled semi-automatic signals. The control machine is in the dispatcher's office at Ottumwa, Iowa, which is 104 miles east of the east end of the C.T.C. at Laredo.

An important part of the planning of this project was to provide enough intermediate automatic blocks to handle the traffic without delays to following trains, and yet, at the same time, reduce the number of these intermediates as compared with ordinary automatic block, thus helping to reduce the costs for the C.T.C. so that it would not be greatly in excess of a straight automatic block system.

Fewer Intermediates

The overall distances from the west switch of one siding to the east switch of the next, is in each instance marked on Fig. 1 herewith. A first consideration was that the length of the automatic blocks should be more than maximum train stopping distance, and about two miles was adopted as being not too long for the distance from a station-entering semi-automatic C.T.C. signal back to its "distant" signal. These blocks were not made much longer than 11,000 ft. because this was considered as about

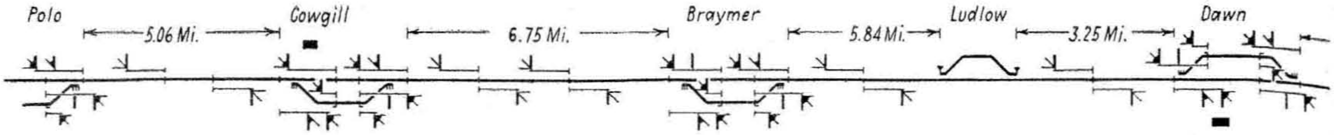


Fig. 1—Track and signal plan of the new centralized traffic

the practical maximum for the length of one coded track circuit.

As shown in Fig. 2, the distance between the west switch at Laredo and the east switch at Chula is 31,449 ft., i.e., 5.9 miles. The eastbound intermediate signal 2142 was located 10,164 ft. from its corresponding station-entering signal 26R at Laredo, and the westward intermediate signal 2161 was located 11,174 ft. from its corresponding station-entering signal 24L at Chula. This left one track circuit 10,002 ft. long between the two intermediate signals.

In addition to serving as distant signals, these intermediate signals also serve to allow a second train to follow into the overall station-to-station block. For example, after the rear of a leading westbound train passes signal 2161, then the westward high signal 26La or leave-siding dwarf 26Lb at Laredo can be C.T.C. controlled to display a yellow aspect for a westbound train to follow. An investigation showed that there would not be very many instances in which a closer spacing of following trains would be needed and, therefore, no second westward intermediate signal opposite signal 2142 was warranted, and similarly no second eastward intermediate opposite signal 2161 was warranted. The point of interest is that the arrangement of only two intermediate signals, as shown in Fig. 2, can be used in C.T.C. because the head-on protection is provided by the station-leaving C.T.C. semi-automatic signals, whereas, with straight automatic block, opposing intermediates must be located twice braking distance apart in order to provide head-on protection.

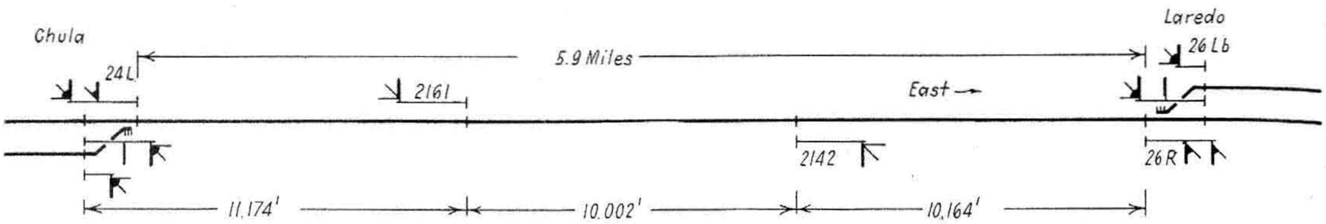


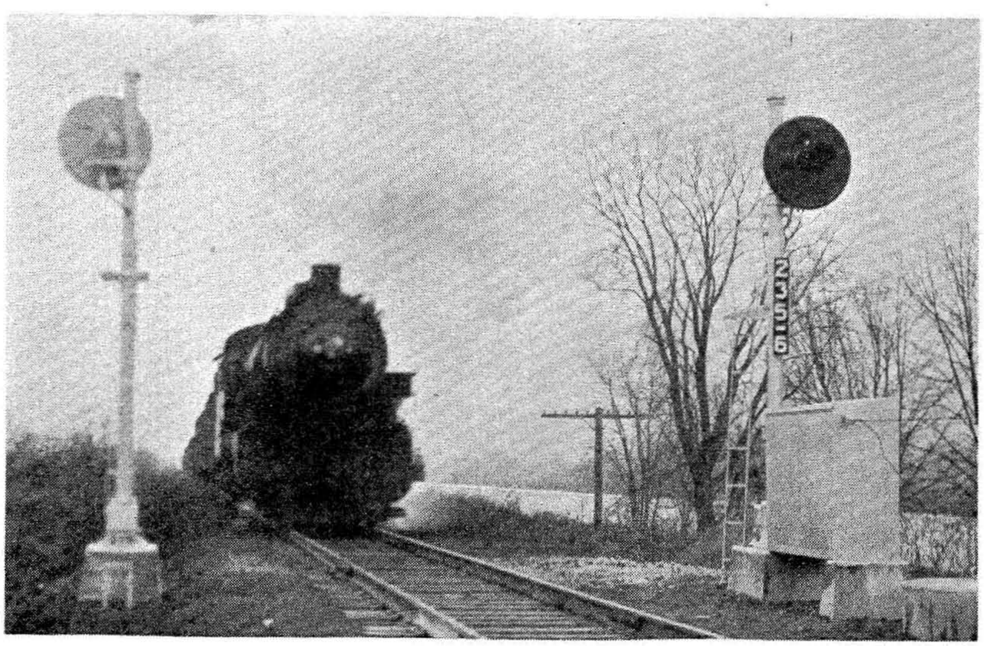
Fig. 2—Layout of intermediate signals between Chula and Laredo

For Longer Station-to-Station Blocks

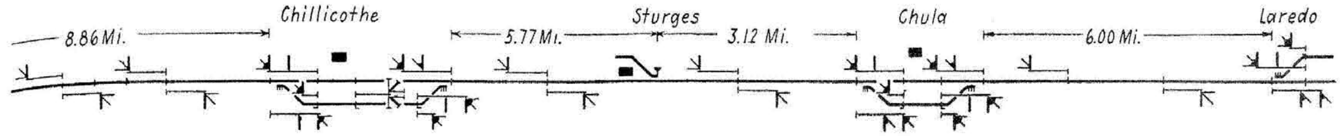
Referring to Fig. 3, the overall distance from the west switch at Chillicothe to the east switch at Dawn is 46,613 ft., i.e., 8.6 miles. Keeping in mind the train stopping distance and the maximum length for one track circuit, the eastward distant signal 2310 was located 10,377 ft. from eastward station-entering signal 18R at Chillicothe, and westward distant signal 2357 was located 11,235 ft. from its station-entering signal 16L at Dawn.

The distance from westward signal 2357 back to westward station-leaving signal 18L at Chillicothe is 35,643 ft., i.e., 6.7 miles, and in order to cut this into two automatic blocks as a means for reducing spacing between following trains, a second westward intermediate signal 2311 was installed opposite the eastward signal 2310. Also for a corresponding reason, the eastward intermediate signal 2356 was installed opposite the westward signal 2357.

For example, if an eastbound freight train is in the siding at Dawn waiting for an eastbound through passenger train to pass, it is desirable



At an intermediate signal all the controls are handled by the rails, no cable to line being needed



control territory between Laredo, Mo., and Polo, Mo.

for the freight to depart as soon as practicable, i.e., after the rear of the passenger train proceeds a minimum distance for an automatic block, therefore, the logical location for the eastward signal 2356 is opposite signal 2357. After the rear of the passenger train passes eastward signal 2356, and the switch is reversed and signal cleared for the freight to pull out, the passenger train will be gone several

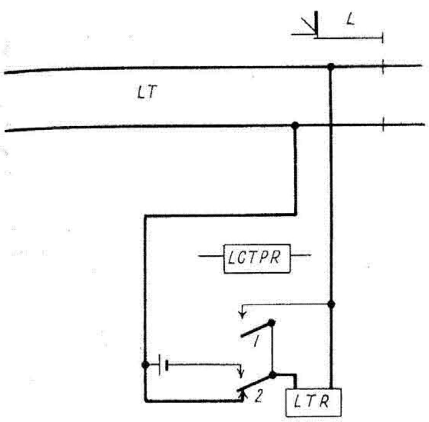


Fig. 4—Ready to receive

miles, in the time required for the freight to pull out of the siding and get under way. For this reason the length of the block between intermediate signals 2356 and 2310 can be long without causing delay to a following train, in this case the block is 25,005 ft., i.e., 4.7 miles long, and this is cut into three coded track circuits each 8,335 ft. long. Thus in the over-all station-to-station block 8.6 miles long, there are only two double locations of intermediate signals.

Normally De-energized Track Circuits

As applying to an extended section of C.T.C., this is the first installation in which the track circuits in the station-to-station blocks are normally de-energized. This feature permits the controls to be arranged so that the coils in the searchlight signals and the code transmitters for the track circuits are also normally de-energized. Thus under normal conditions, no electrical energy is being consumed in the blocks between stations. The track circuits are of the either-direction type, i.e., either a relay or coded track feed battery can be connected to the rails at any given end of a track circuit.

The diagram in Fig. 4 shows the basic principles of the circuits at one end of a typical track circuit in a station-to-station block. Normally the connection from the upper rail extends through the coil of the track relay LTR, through the back point of contact finger 2 of left code transmitter repeater relay LCTPR, and

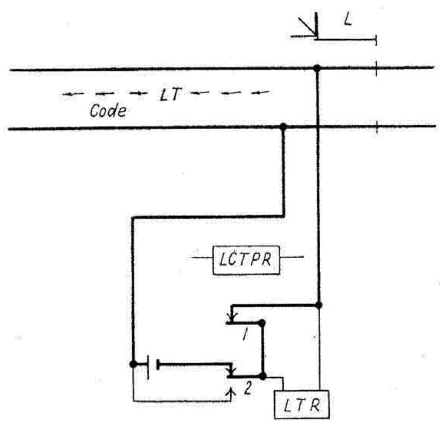
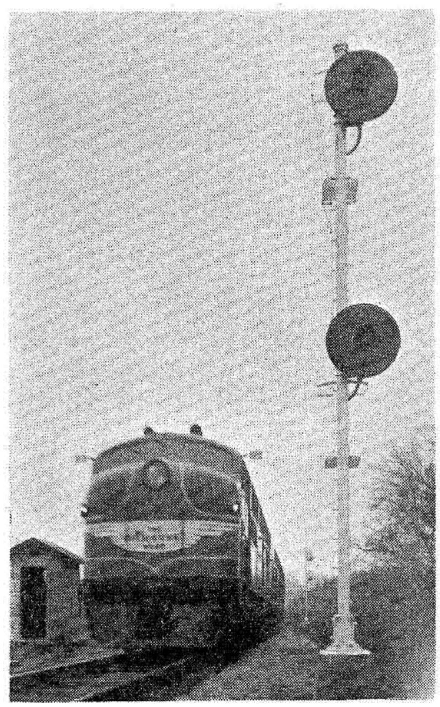


Fig. 5—Sending an impulse

then to the lower rail. In this condition, when any energy comes in on the rails from the other end of the track circuit, the relay LTR is energized and de-energized 75 or 180 times per minute in accordance with the track circuit code being received. Contacts of this code-following track relay LTR, control circuits through a decoding transformer to energize relays to control the operation of searchlight signal L, as will be discussed later.

On the other hand, if track circuit code is to be transmitted to the left from the location shown, then the contacts of relay LCTPR are operated a certain number of times each minute, as for example, 75 or 180, as will be explained later. Each time the front points of the contacts of relay LCTPR close, as shown in Fig. 5, the battery feeds through the front



Eastbound train at east end of Chillicothe

point of finger 2, through the jumper connection and through finger 1, and out to the top rail. The negative side of the battery is directly connected to the bottom rail. Thus one impulse of energy is fed to the left on the track each time the front contacts of relay LCTPR are closed, and similar impulses are sent one after another at the rate then in effect. The circuits for controlling and operating the left code transmitter repeater relay, LCTPR, will be discussed later.

An item to note in Fig. 5, is that when the front contacts of relay LCTPR are closed, the connections to contact 1 are a shunt across the coil of relay LTR, so that this relay

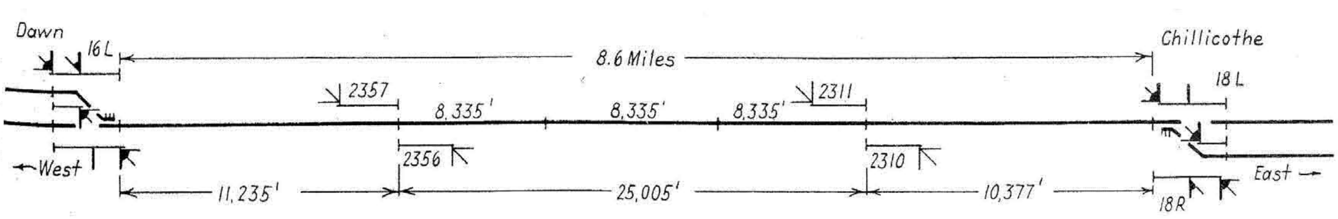


Fig. 3—Intermediate signals between Dawn and Chillicothe

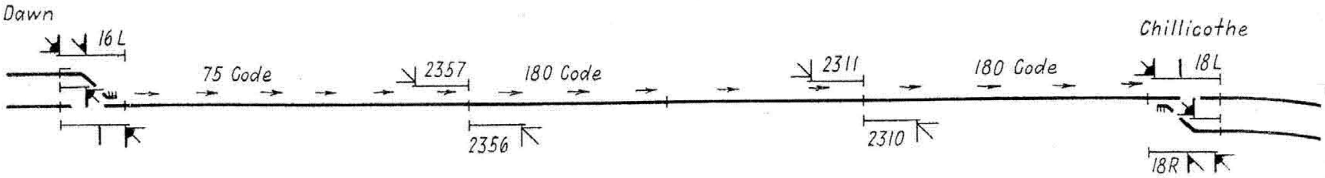


Fig. 6—Codes to clear westward signal 18L at Chillicothe

is not energized by the track battery shown in this drawing. The track relays are polar biased so that they will not be operated by energy from the local track battery.

Referring now to Fig. 6, when a line-up is to be established, as for example westward from signal 18L at Chillicothe to signal 16L at Dawn, then C.T.C. line controls go from the office to Dawn to cause 75 track circuit code to be fed eastward from signel 16L to intermediate signal 2357 which causes the spectacle in this searchlight signal to be operated to the yellow position, but the lamp is not lighted. Then 180 code is fed from signal 2357 eastward through the track circuits to signal 2311 which is operated to the green position, and 180 code feeds eastward on the track circuit to signal 18R at Chillicothe. Receipt of this 180 code, in combination with a C.T.C. control from the office to the field station at the west switch at Chillicothe, causes westward station-leaving signal 18L at that location to display the green aspect. Thus, in order to clear signals for a westward move, the track circuit feeds are established to feed from west to east.

Approach Lighting Controls

The lamps in the intermediate signals are normally extinguished, being lighted by approach control circuits when a train, which is traveling in the direction which the signal controls, enters the track circuit in approach to the signal to be lighted. The basic circuits, shown in Fig. 4 and 5, are now applied, with certain additional features, as shown in Fig. 7. An item not shown in previous diagrams is a 1.2-ohm adjustable resistor in series with the track battery, and connected across this resistor is a 0.3-ohm relay known as the approach relay. This LAR, which is the left approach relay to light the lamp in the westward signal L, is connected with the feed of the track circuit RT to the right.

When a line-up is for a westbound train, code is being sent eastward, that is to the right, on track circuit RT. When the westbound train enters the far end of track circuit RT and proceeds toward signal L, shown in Fig 7, the shunting of the track circuit increases the current fed from the battery to the track, and when

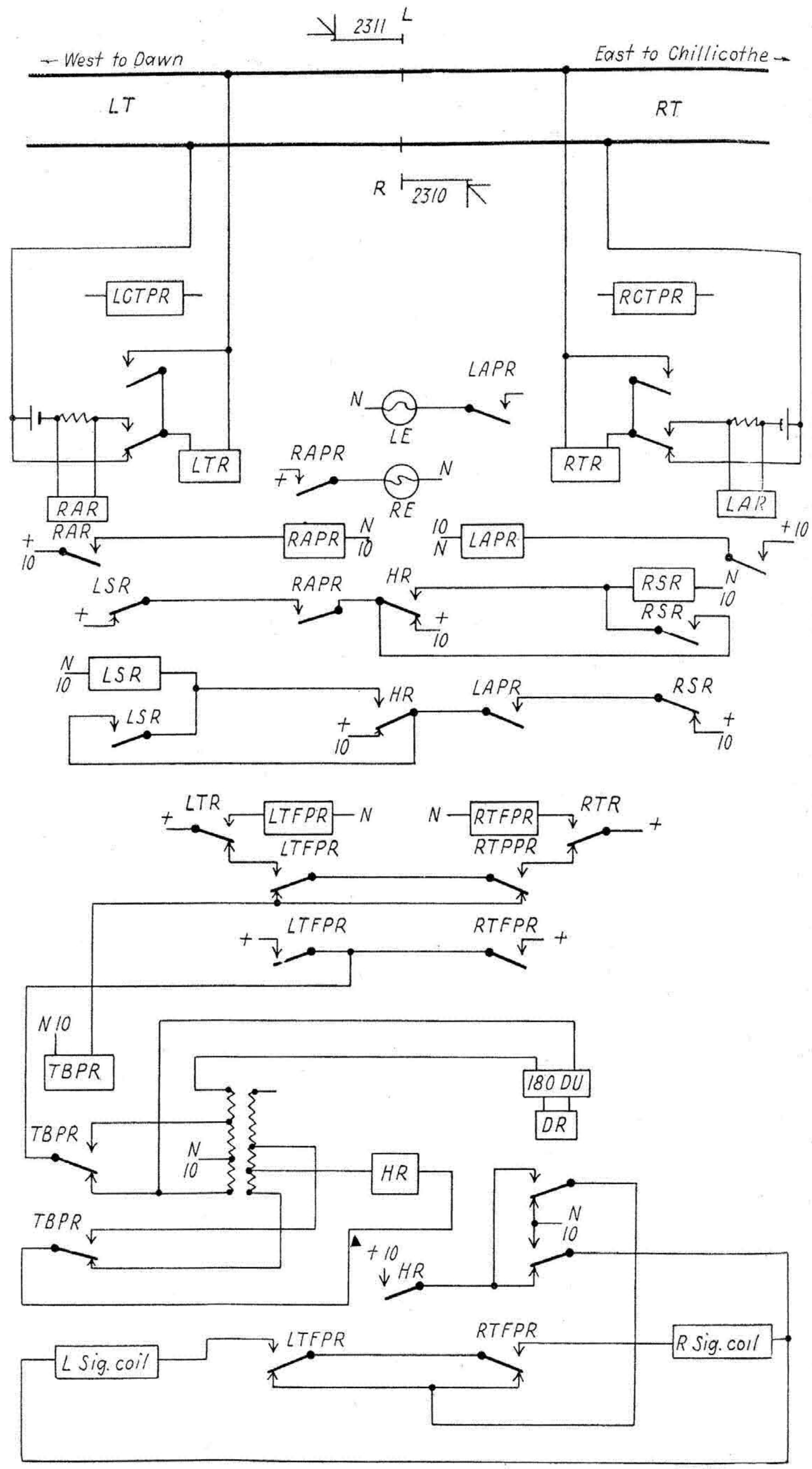


Fig. 7—Diagram of circuits at a typical intermediate signal

the current increases to a certain amount determined by adjustments of resistors, the relay LAR starts to follow code, i.e., pick up and release with each outgoing pulse of code. A front contact of relay LAR closes a circuit to pick up relay LAPR, and due to the slow release characteristics of this relay, it stays up as long as relay LAR follows code. A circuit, through a front contact of relay LAPR, lights the lamp in the westward signal L, and the lamp stays lighted until the rear of the train passes the signal.

Control of Directional Stick Relays at Intermediate Signals

The control for a directional stick relay is shown in Fig. 7. When the line up was established for the westbound train, the track circuit code caused the home relay HR to be energized. When the westbound train approached near enough to pick up the approach lighting relay LAPR, as explained above, a front contact of LAPR completes a circuit from battery through RSR down, LAPR up, and HR up, to energize the left stick relay LSR. When the head end of the train passes signal L, then relay HR is released, but relay LSR is slow release so that it sticks up through its own front contact and a back contact of HR.

Track Code for Following Move

When the rear of the westbound train passes the intermediate signal L, then code transmitter repeater relay RCTPR is operated 75 times each minute to cause 75 code to be sent eastward on track circuit RT, so that signal 18L at Chillicothe can be cleared, by C.T.C. control, to display the yellow aspect for a second westbound train to enter the station-to-station block.

When the leading westbound train passes the second intermediate signal 2357, see Fig. 6, then 75 code is fed east from that signal to signal 2311, which is shown in Fig. 7, and this causes relay HR to be energized and signal L to be operated to the yellow position. As shown in Fig. 7, this releases left stick relay LSR, and, as shown in Fig. 8, the operation of signal L to the yellow, and the release of LSR, closes circuits to cause right code transmitter repeater relay RCTPR to be operated by the 120 code transmitter rather than the 75. As a result, as shown in Fig. 9, 120 code is sent east on track circuit RT which permits station-leaving signal 18L to be cleared to the green.

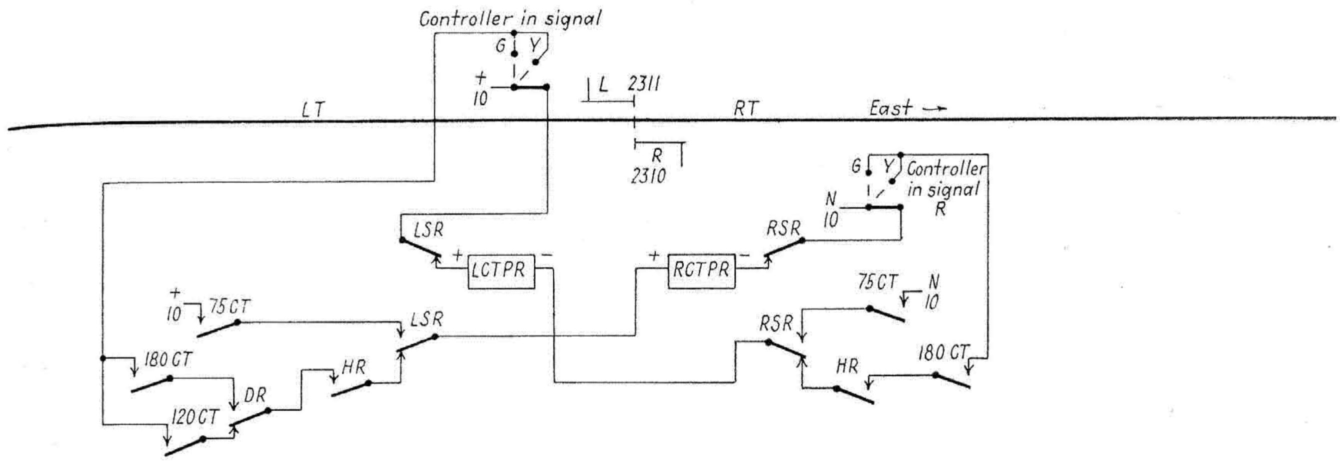


Fig. 8—Diagram of circuits for directional stick relays at an intermediate signal

Track Circuits Turned Off When Train Leaves Station-to-Station Block

Referring to Fig. 6, and assuming that there is no second train, when the westbound train passes out of the station-to-station block between Chillicothe and Dawn, then 75 code, which was previously in effect, is again fed eastward from the east end of Dawn to intermediate signal 2357. This energizes the HR relay at that location, which releases the left stick relay at that location, and clears the signal to yellow. This causes 180 code to be fed eastward to intermediate signal 2311, which is the location shown in detail in Fig. 7. In this instance, the HR relay and the DR relay are energized, and the signal is operated to the green position.

As shown in Fig. 8, this causes the right code transmitter repeater relay RCTPR to be operated 180 times each minute whereas previous to this change it was operated 120 times each minute. Thus 180 code is now sent eastward on track circuit RT. The receipt of 180 code at the west end of Chillicothe causes an indication to be sent to the control machine to show that the station-to-station block between Chillicothe and Dawn is now unoccupied, and also the receipt of this indication at the control office causes a C.T.C. line control to go to the field station at Dawn to stop the 75 code which was feeding eastward. This results in stopping the code in the track circuits all the way through the station-to-station block to Chillicothe, so that the signal operating coils as well as all relays and code transmitters are returned to the de-energized condition until another line up is established.

Only One Set of Control Relays and Transmitters at a Double Location

At a double location of intermediate signals, such as shown in Fig. 7, only one of the two signals can be cleared at any one time, and, therefore, the circuits are arranged so that only one decoding transformer, one home relay HR, and one distant relay DR are required for the control of both the Left signal and the Right.

As shown in Fig. 7, a front contact of code-following track relay LTR completes a circuit to energize the left track front repeater relay LTFPR which is just enough slow release that it will stay up as long as the contact of LTR is operated by code at 75 or more times a minute. With front contact 1 of LTFPR closed, then each time back contact 1 of LTR is closed, battery feeds through this back contact, through front 1 of LTFPR, back 1 of RTFPR to energize track back contact repeater relay TBPR which is then picked up and released to follow the code being received. A point of interest is that this one TBPR relay is used when either track relay LTR or RTR are in operation receiving incoming code, i.e., one TBPR serves for either a westward or eastward traffic direction.

Referring now to Fig. 7, with LTFPR up and with TBPR following code, battery feeds through contacts of these relays in the conventional manner to energize the coils of the decoding transformer which picks up relay HR if the code is 75 or to pick up HR and DR if the code is 180. In Fig. 7, the operating coil of the searchlight signal for the westward signal L is represented by a rectangle marked L, and the coil of the eastward signal by a rectangle marked R. The selection to determine whether the L signal or the R signal is to be operated from the red position is determined by selections so that if L is to be operated, relay LTFPR must be up and RTFPR down. If DR is down, the signal is operated to the yellow position, or, if DR is up, the signal is operated to the green position.

One Set of Code Transmitters

Only one set of track circuit code transmitters is required at an intermediate double location. As shown in Fig. 10, with either the left stick relay LSR or the right stick relay RSR picked up, a circuit is closed to operate the 75 code transmitter 75CT. Also in Fig. 10, with relay LTFPR up and DR up, a circuit is closed to operate the 180CT, which would be the case when a line up is established for a westbound train throughout the station-to-station block. On the other hand, when a westbound train, in the second automatic block to the left, has the stick relay up at that location, as shown in Fig. 9 then DR at the location shown in Fig. 7, is released. Then with LTFPR up and DR down the 120-code transmitter is operated. As a result, 120 instead of 180 track code is received at Chillicothe, and the receipt of 120 code will not cause an indication to go to the office that the station-to-station block is clear.

Controls in Siding Limits

Within station limits, i.e., between the two switches of a passing track, the track circuits are the conventional normally energized d-c. type with 2-ohm d-c. neutral relays. For the controls of the two opposing station-entering signals, as for example signals 24L and 22R at Chula, there is a reversible two-wire line circuit which breaks through the front contacts of the track relays, and is used under C.T.C. control to control either signal 24L or 22R. The details of this type of two-wire either-direction circuit were explained on page 420 of *Railway Signaling* for August, 1943.

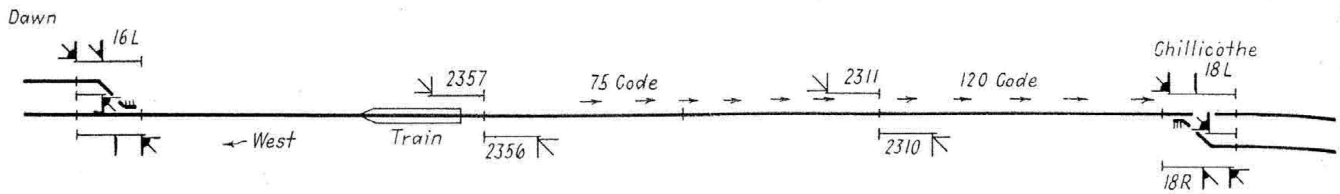


Fig. 9—Track code in effect while a train is passing through a station-to-station block

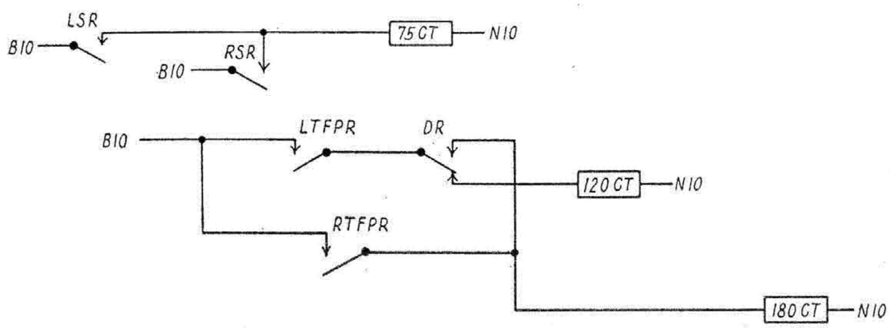
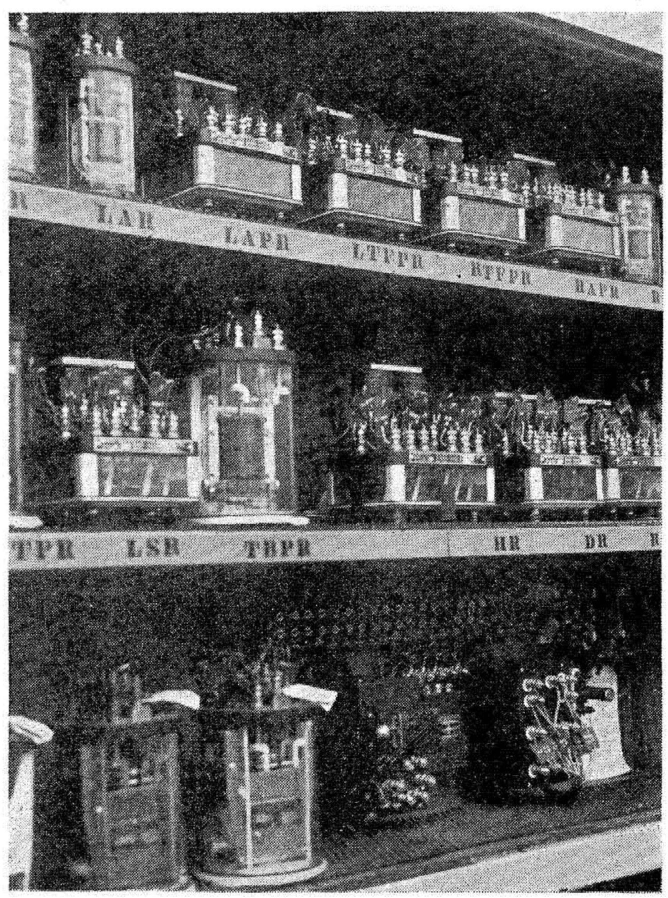


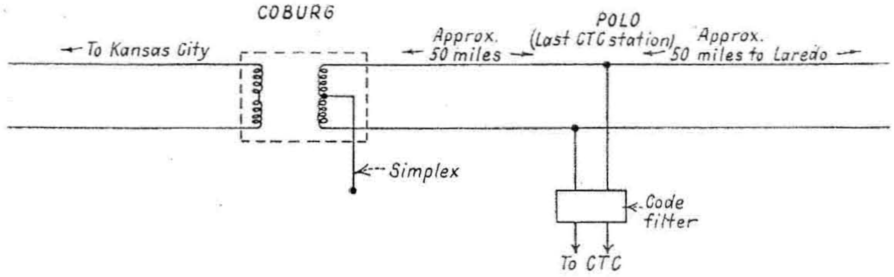
Fig. 10—Controls for code transmitters

Control of Electric Lock on an Outlying Hand-Throw Switch

At Sturges, which is between Chula and Chillicothe, there is a spur which is connected to the main track with a hand-throw switch which is equipped



Apparatus in steel case at an intermediate signal



Left portion of Fig. 13 which continues on next page

with an electric lock. As shown in Fig. 11, there is a short track circuit 117 ft. long on the main track just east of this switch. This is a normally energized track circuit with an ordinary 2-ohm d-c. neutral track relay. The coded track circuits work up to both ends of this short track circuit, the circuits at this location being arranged so that normally this layout is practically the same as a cut section. For example, if track circuit code is coming in from the left on track circuit LT, then relay LTR follows code. Then battery feeds through the closed front contact of the short track circuit relay TR, through the front contact of LTR and NWPR to operate right code transmitter repeater relay RCTPR, which causes the code to be sent on to the right on track circuit RT.

On the other hand, if code is coming in from the right on track circuit RT, then relay RTR is following code. Then battery feeds through front contact of TR, front contact of RTR and NWPR to operate LCTPR which causes the code to be repeated west on track circuit LT. Normally all track circuit code equipment is de-energized, and the only relays energized are the track relay TR on the short track circuit and the normal switch repeater relay NWPR.

When a train in the clear on the spur track is ready to depart, the conductor telephones the man in charge of the C.T.C. control machine, who informs the conductor when a release is to be given. A lever on the control machine is positioned and a line code control goes to the field station at the west end of Chula as well as to the field station at the east end of Chillicothe. This causes track circuit code to be fed east from Chillicothe to the location of the switch at Sturges, and also track circuit code is sent west from Chula to the switch.

Say, for example, that the code feeding west arrives at Sturges and operates code-following track relay RTR, and this causes relay LCTPR to operate as previously explained. In the meantime, the conductor has opened the door of the lock case which closes the door contact. Then battery feeds through front contact 4 of LCTPR, the coil of switch lock repeater relay WLSR, and the door contact to negative. This energizes WLSR, and it sticks up through its own front and a front of the track relay TR.

Referring now to the circuit for the normal switch repeater relay NWPR, the back contact 2 of relay WLSR is open. The conductor moves the operating handle of the lock just a little off from its normal position, which opens the band contact N-WL. This releases relay NWPR.

Now battery feeds through front 1 of TR, front 1 of RTR back 2 of NWPR to pick up right track front repeater relay RTFPR, which is slow enough in releasing to stay up if the code is 75 or more times per minute. Then when RTR next closes its back contact, the battery feeds through

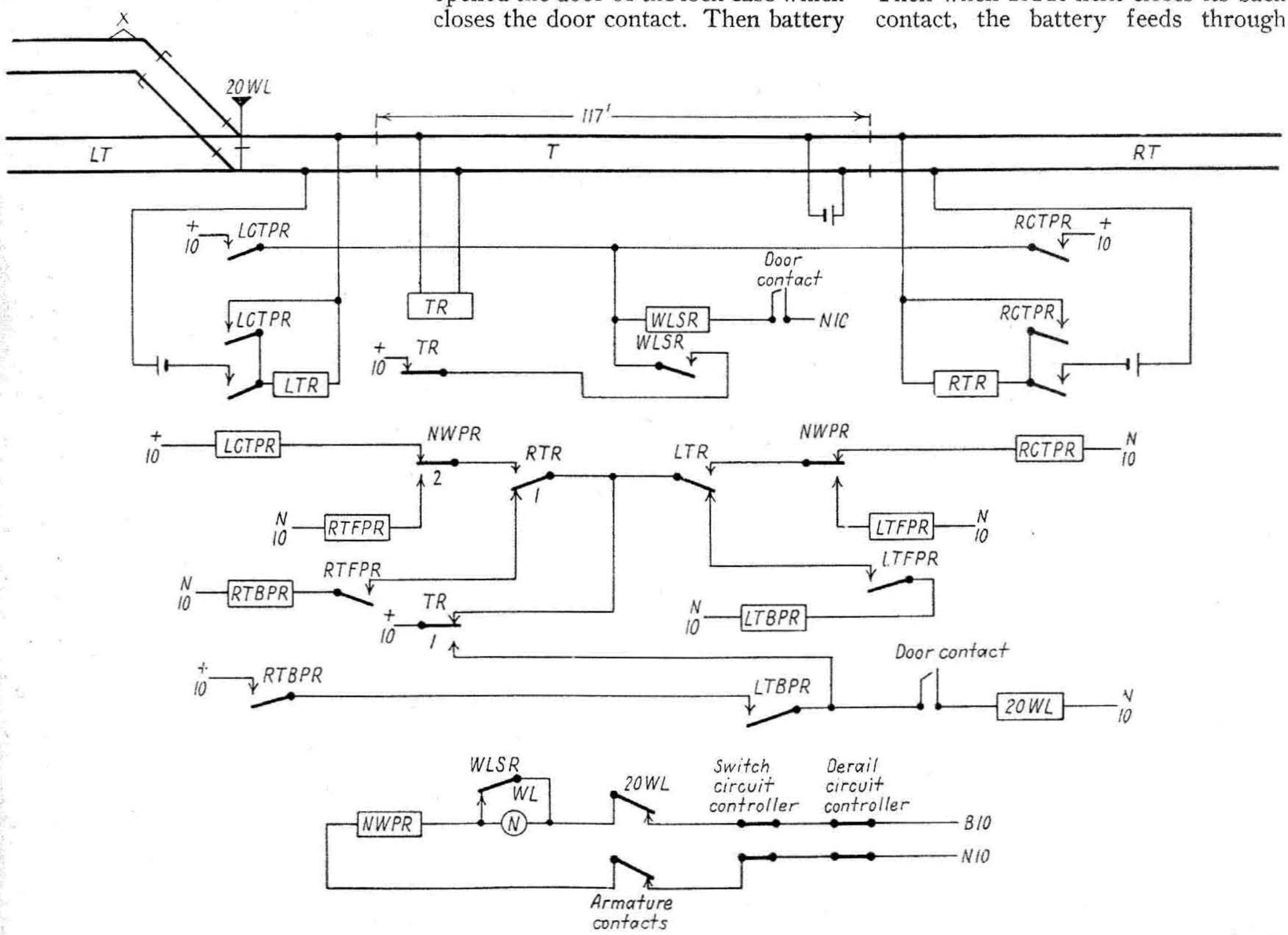
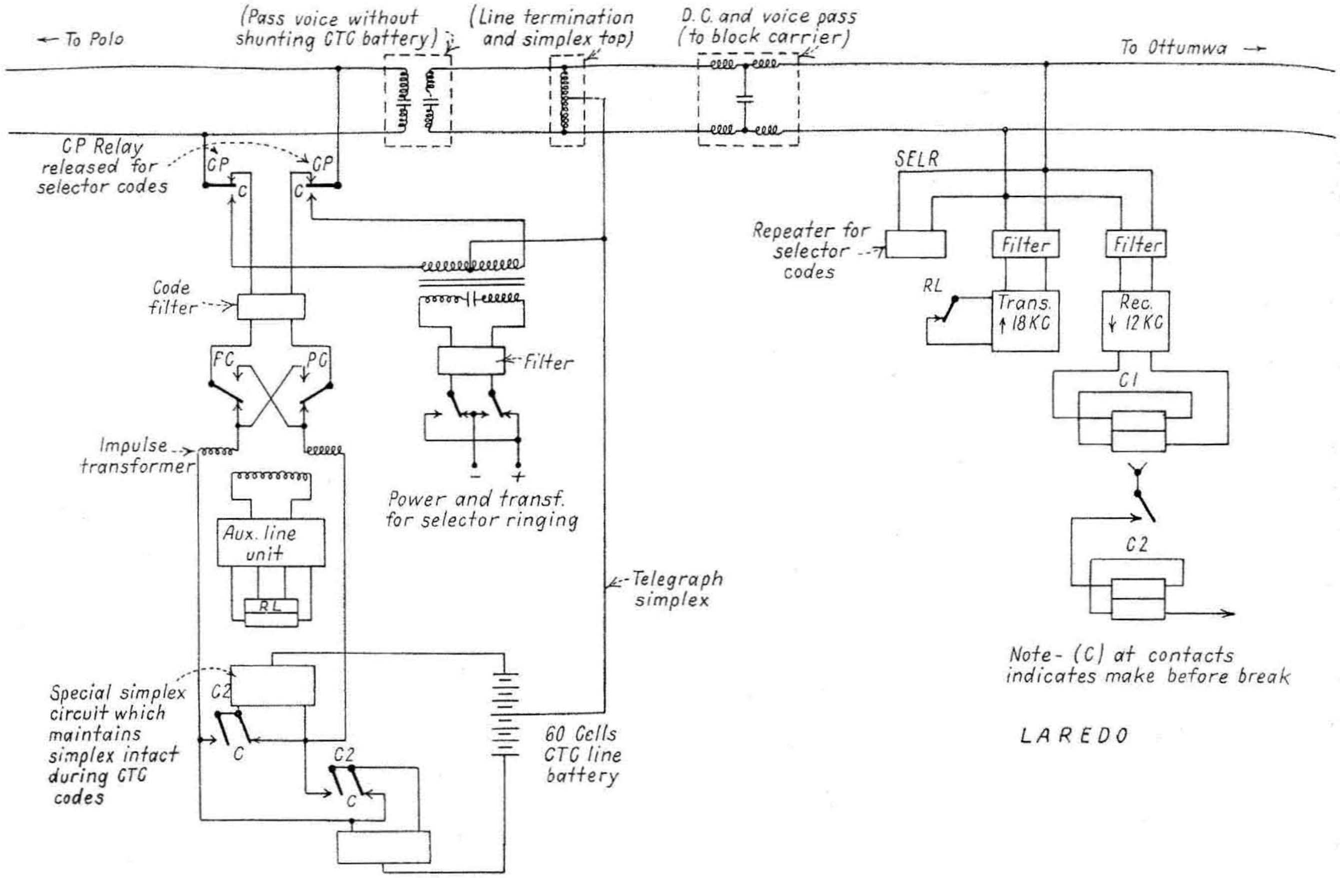
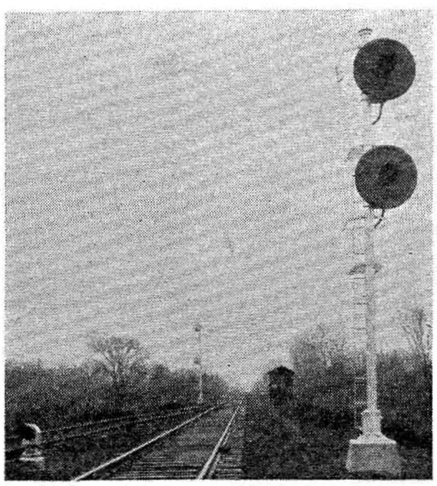


Fig. 11—Circuits for electric lock on hand-throw switch



This portion of Fig. 13 shows circuits and apparatus at Laredo

front 1 of RTFPR to pick up right track back repeater relay RTBPR and it stays up as long as the incom-



Eastward signals at Dawn

ing code is 75 or more. In a corresponding manner, the left track back repeater relay LTBPR is picked up. With both RTBPR and LTBPR energized, battery feeds in series through front contacts and a door contact to energize the coil of the lock, so that the conductor can complete the operation of the handle to pull the plunger out of the rod and thereby unlock the switch.

When the train occupies the track circuit T, relay TR is released which opens the stick circuit for WLSR, thus releasing this relay. The purpose for this WLSR relay, is to insure that track code is being received at the time the circuit of relay NWPR is opened. This arrangement is used to provide means for the release of the directional stick relay at the intermediate automatic signal in the rear of a train.

Reviewing the discussion, it is evident that the entire station-to-station block between Chula and Chillicothe must be unoccupied, otherwise the track code would not feed through from both directions to Sturges to release the lock. Another point is that the codes would not feed if either station-leaving signal were displaying a proceed aspect. The point of importance is that the lock release is accomplished from the C.T.C. control machine without the use of local line wire circuits.

When a train on the main track at Sturges is to set out a car on the spur, the car or any part of the train is stopped on the 117-ft. track circuit, thus releasing relay TR. Then the conductor opens the door of the lock which closes the door contact. This completes a circuit to energize the lock, thus effecting a release.

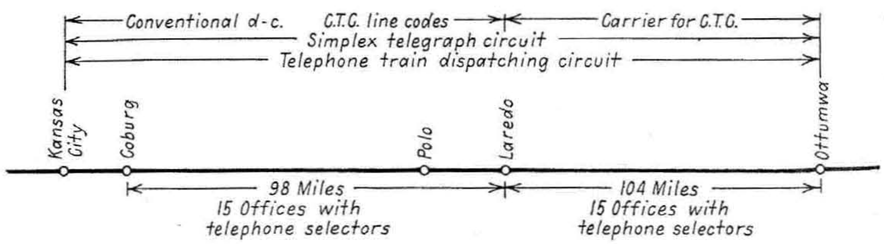
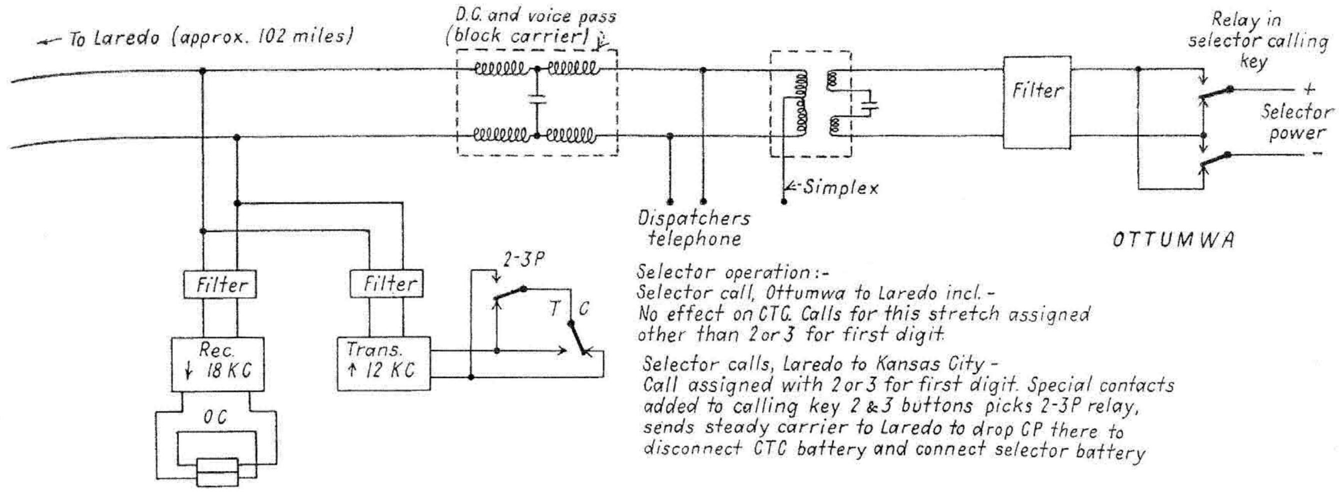


Fig. 12—Diagram of various uses of the two line wires

Line Codes on Telephone Wires

The C.T.C. line code controls between the office and the field stations as well as the return of indication codes are handled by the Union Switch & Signal Company's Type L Form 504B time code control system, which operates on two No. 9 bare copper line wires which were previ-

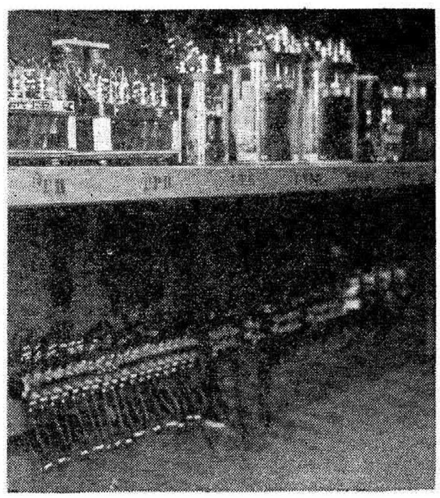


This portion of Fig. 13 shows circuits and apparatus at the control office at Ottumwa

ously in service for the telephone train dispatching line circuit.

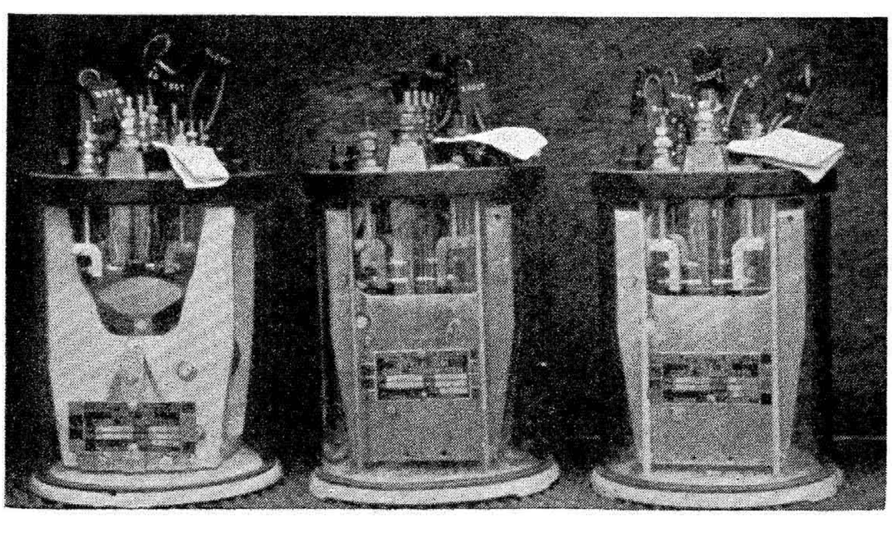
The C.T.C. control machine is in the dispatcher's office at Ottumwa, Iowa, 104 miles east of Laredo, which is the east end of the 51 miles of C.T.C. between Laredo and Polo. See Fig. 12. On the 104 miles between the office at Ottumwa and Laredo, the C.T.C. line codes are handled by carrier using 12 kilocycle for outgoing controls and 18 kilocycle for returning indications. At Laredo, the 12 kilocycle controls are converted to conventional d-c. codes which are superimposed on the same two telephone train dispatching circuit for transmission to the field stations in the C.T.C. territory between Laredo and Polo. Similarly, conventional d-c. codes transmit the indication from the field stations to Laredo where these codes are converted to 18 kilocycle carrier for transmission to the office at Ottumwa.

In addition to the telephone train dispatching and the C.T.C. line codes, these two line wires are also connected simplex to handle a telegraph circuit extending through from Chicago to Kansas City. Line blocks, at Ottumwa and at Laredo, isolate the carrier frequencies to that mileage. Also a filter was connected between the line and each telephone set in the various offices. At 15 local offices between Ottumwa and Laredo there are telephone selectors which can be operated simultaneously with the handling of C.T.C. carrier codes.

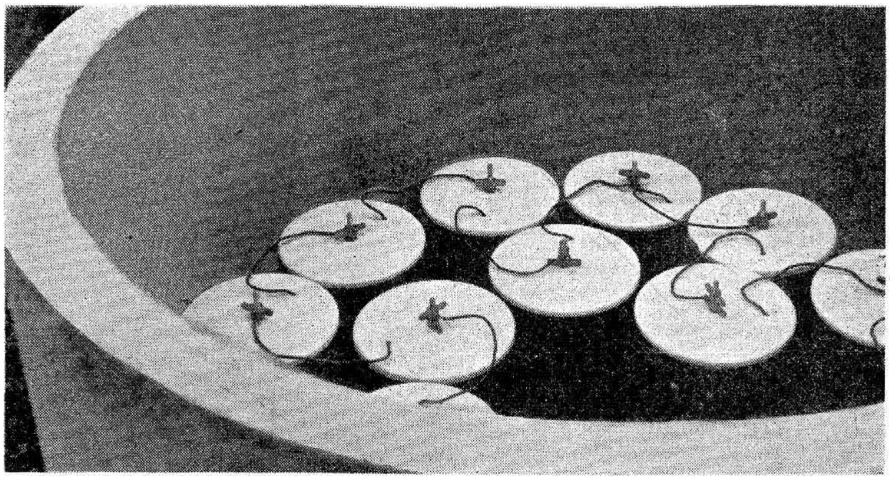


Wiring inside of instrument house

In the C.T.C. territory between Laredo and Polo and on west to Kansas City there are 15 more telephone selectors. The synchronous motor driven Western Electric type 62A key is used for selector calling. Co-operative circuits have been installed which permit the operation of the C.T.C. levers and selector calling key simultaneously. As arranged, the selector codes for the territory between Laredo and Kansas City take preference over C.T.C. control or indication codes. The C.T.C. codes, in event of simultaneous operation, are merely stored temporarily and delivered to the line at the end of the selector code. The diagram in Figure 13 shows the circuit arrangements required at Laredo to use the existing line for train dispatching, telephone selectors, through telegraph and C.T.C. Particular attention is directed to the fact that the installation is also arranged in such a way as to accommodate the superposing of a Type "H" carrier telephone circuit which is contemplated between Ottumwa and Kansas City. An important fact is that, in spite of some rather difficult problems in the design, it is possible to utilize the existing line wires for the C.T.C. line codes, thus avoiding the installation of new



Three code transmitters operating at 75, 120 and 180 times each minute are used at an intermediate



Primary battery in a concrete tub at an intermediate signal

line wires for this purpose, and also permit the installation to be controlled from the dispatcher's office.

Primary Battery at Intermediates

As previously explained, in an overall station-to-station block the track circuits, searchlight signal operating coils, signal lamps, and track circuit code transmitters, are all normally de-energized, all of this equipment being set in operation when a line-up is being established. After the train departs from the station-to-station block, all this apparatus is again de-energized. With a traffic of about 15 trains in 24 hours, it might be assumed that the track circuits and signals are energized each way about 2 hours out of every 24 hours. On this basis, the Milwaukee decided that all of the equipment at the intermediate signals and track cut locations could be fed from primary battery, and the batteries of this type on this territory were purchased from the Thomas A. Edison, Inc.

Each track circuit is fed by 2 cells of 500-a.h. battery connected in multiple. At each signal there is a set of 16 cells of 500-a.h. battery which feeds the searchlight signal operating coil, the signal lamp and operates the track circuit code transmitters. At each track cut location there is a set of two 500-a.h. cells to feed each track circuit, and a set of 16 cells of 500-a.h. battery to operate the other equipment. A track circuit and one track code transmitter are energized at each location from the time a line-up is established until the train departs from the station-to-station block, and one signal operating coil is energized throughout this period except for the time the train is occupying the automatic block of the signal.

With 10 volts at its terminals, the operation of a code transmitter takes .02 amp. A signal operating coil rated at 250 ohms, takes .04 amp. at 10 volts. The lamps in the intermediate signals are rated at 5 watts, and with 8 volts at the terminals, such a lamp takes .625 amp. A lamp in an intermediate signal is lighted during the period while a train is occupying the track circuit in approach to that signal.

With an average of two hours of operation daily, an estimate is that the two-cell 500-a.h. battery of each track circuit should render a life of about 24 months, and the 16-cell 500-a.h. battery at a single intermediate signal should have a life of about 17 months, and 10 months at a double intermediate signal location.

Storage Battery at Switches

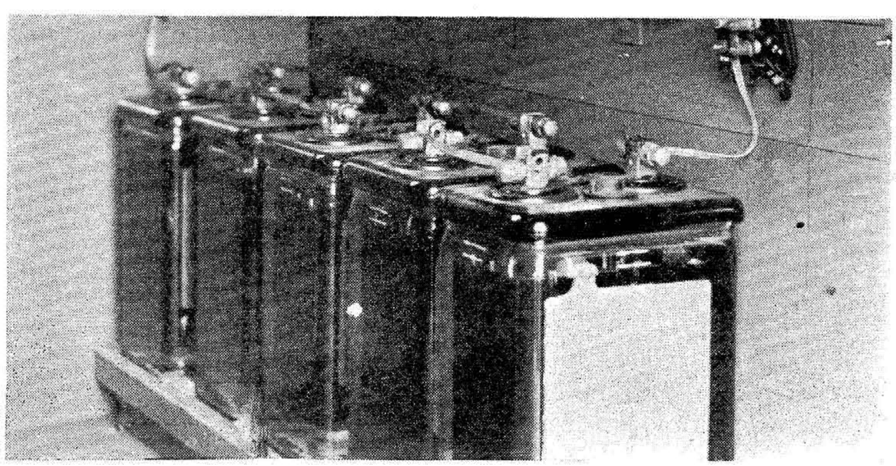
At each field station including a power switch machine, there are two sets of Exide storage battery rated at 160 a.h. on the 8-hr. rate. One set of 8 cells feeds the line coding apparatus, at 16 volts, and a second set of 5 cells feeds the various relays and other circuits at 10 volts. The two sets connected in series feed the switch machine at 26 volts. At Laredo there is a 12-cell B4H 80-a.h. Edison storage battery which operates the relays in the case and the tuned alternator which supplies the 110-volt 60-cycle stand-by for the carrier units if the commercial a-c. fails.

Each storage battery is charged by a rectifier which is fed from the low-voltage secondary of a transformer which has a 115-volt primary. The 115-volts to feed this transformer is supplied from a 115-volt a-c. power line distribution circuit from the passage station out to the switch location, thus requiring two No. 10 copper line wires out from the station to each of the two passing track switches. Commercial a-c. power at 115 volts was already in service for lighting at all of the stations in this C.T.C. territory.

Small Amount of Line Wire Construction

A recapitulation of the line wire construction required for this C.T.C. project shows that: (1) No additional line wires were required for the C.T.C. code line; (2) No signal line wires or a-c. power line wires were required in the station-to-station blocks; (3) Between the two switches of any given passing track there are two No. 10 line wires for the 115-volt power, and two No. 10 line wires for the two-wire reversible signal control circuit.

This installation of centralized traffic control was planned and installed by signal forces of the Milwaukee Railroad. The instrument cases and houses were wired at construction headquarters. The concrete signal foundations were poured in place. Most of the insulated wire and cable was furnished by the Kerite Company. The signaling equipment, including the C.T.C. control machine and line coding system, was furnished by the Union Switch & Signal Company.



Part of a set of storage battery at a power switch location