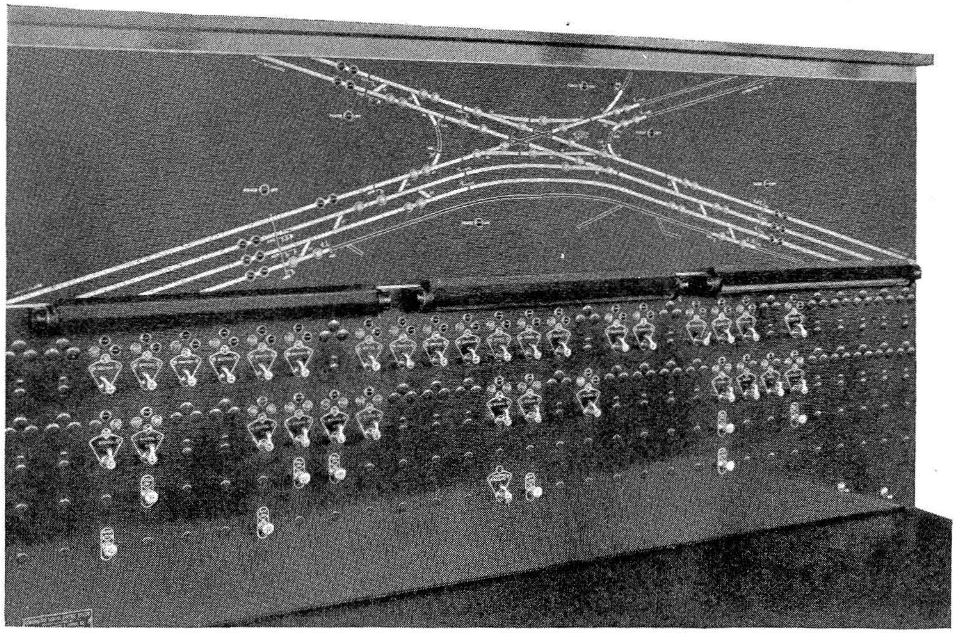


Milwaukee

The new control machine with 32 miniature levers replaces an old 116-lever mechanical machine

Facility with which line-ups can be changed is important factor in saving train time at an important junction in Chicago

At Pacific Junction, five miles northwest of the Union Station in Chicago, the Chicago, Milwaukee, St. Paul & Pacific has installed a 32-lever all-relay electric interlocking to replace a 116-lever mechanical plant which was originally installed more than 40 years ago. The layout of this plant includes various junctions and crossovers, as well as a crossing. Extending southward from the plant toward the Chicago Union Station, there are four main tracks, two for passenger trains and two for freights. The same arrangement of four tracks extends westward from the plant on the line to Omaha. Northward from the plant, two main tracks extend to Milwaukee on the route to St. Paul and Seattle. Also, at the tower a single-track east-and-west line crosses the double-track north-and-south line and extends east about 3.5 miles to C. & E. Junction, this line being used to serve various industries and an emergency detour route for passenger trains to the Union Station.

Traffic and Need for New Plant

The daily traffic through this plant includes 38 through passenger trains, 66 suburban passenger trains, and about 70 to 75 switching or transfer movements. Thus approximately 200 line-ups must be established in each 24-hour period. During the peak periods in the morning and evening, trains are scheduled through this plant on as low as two-minute headways.

The need for replacing the old interlocking was the result of a chain of events starting with the necessity for laying new 131-lb. rail throughout this area. In the old layout, some of the crossovers were too short to be used by the modern locomotives, and, therefore, longer crossovers were to be installed when laying new rail. In order to locate the new crossovers between viaducts over streets, the plant limits had to be extended. These extensions were beyond the practical limits of a mechanical plant, and the operation of such a plant necessitated too much delay when changing line-ups. Therefore, a power interlocking was needed, and the logical time to make the change was concurrently with the track changes. All of the materials for the track and interlocking changes were purchased and assembled early in 1941. However, the plant was not completed and placed in final service until August 15, 1942.

The old mechanical plant had 104 working levers, 19 for 19 high signals, 12 for 12 dwarfs, 28 for 28 switches, 8 for 8 derails, 1 for a switch and a derail, 19 for 33 facing-point locks, 16 for 16 route locks, and 1 as a traffic-lock lever. The high signals were electrically-operated semaphores, and the dwarfs were wire-connected semaphores. When changing over to the new plant, the 8 main-line derails were removed, but no changes were made in the number of switches or crossovers. For switch operation, the new plant includes Model-M-2, 110-volt d-c. machines which operate in about five seconds. The old semaphores were replaced by searchlight-type color signals.

Progressive Steps In Form of Interlocking Machines

The new all-relay electric interlocking at Pacific Junction is controlled by a miniature-lever machine which includes no mechanical locking between levers or electric lever locks, and an explanation of the studies made by the Milwaukee engineers in arriving at the decision to use this form of control may be of interest to other roads.

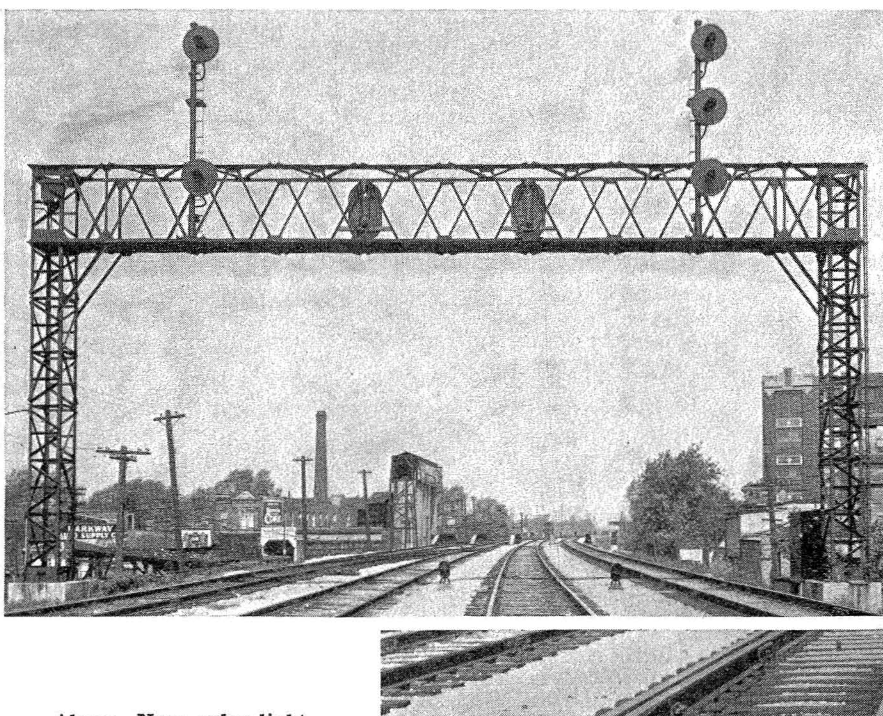
In 1938, when the Milwaukee road was planning the installation of a large power interlocking at a different layout near Western Avenue in Chicago, investigations were made of the possibility of using a route interlocking system of control or the all-relay system with miniature levers. On account of the numerous complications in the track layout and the fact that some signals controlled as many as 35 routes, a decision was made to use a Model-14 interlocking machine with mechanical locking and electric lever locks. An intensive study was made to coordinate the use of mechanical lockings, electric lever locking, and circuit interlocking to the greatest

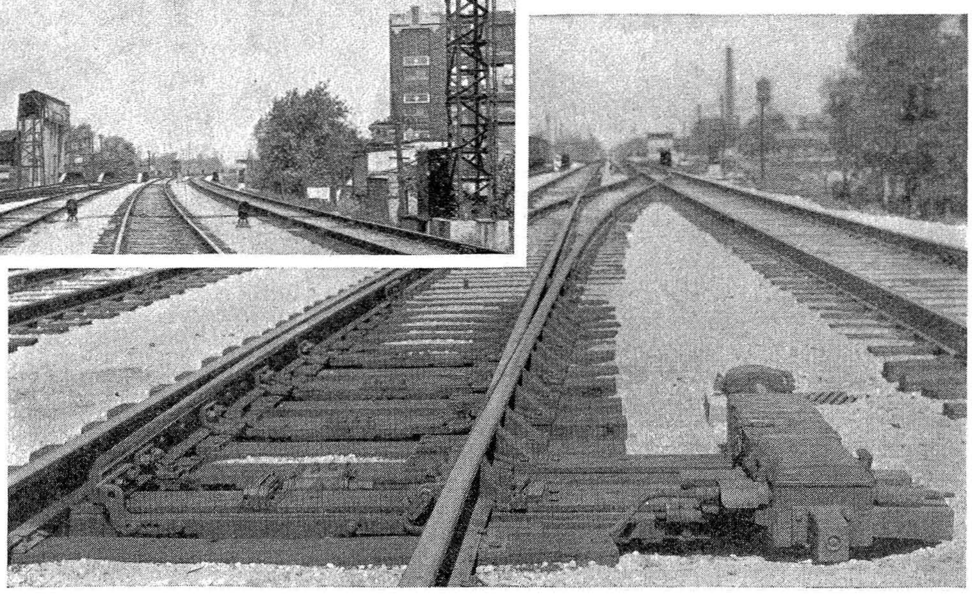
Replaces Mechanical Plant With All-Relay Electric Interlocking

possible advantage with respect to simplicity and safety, as well as rapidity of operation of the plant. The primary use of the arrangement of mechanical locking was for the signal lever of a route, when reversed, to lock the switch levers mechanically. The simplified mechanical locking arrangement predetermined that the levers for the switches in a route were properly positioned before the signal lever could be reversed. The signal lever, reversed or in the normal-indication position, locked the switch levers. There was no mechanical locking between switch levers in a route, except on the yard tracks where derails were in use. Therefore, switches can be operated behind a train, moving in either direction, as fast as the directional sectional locking is released.

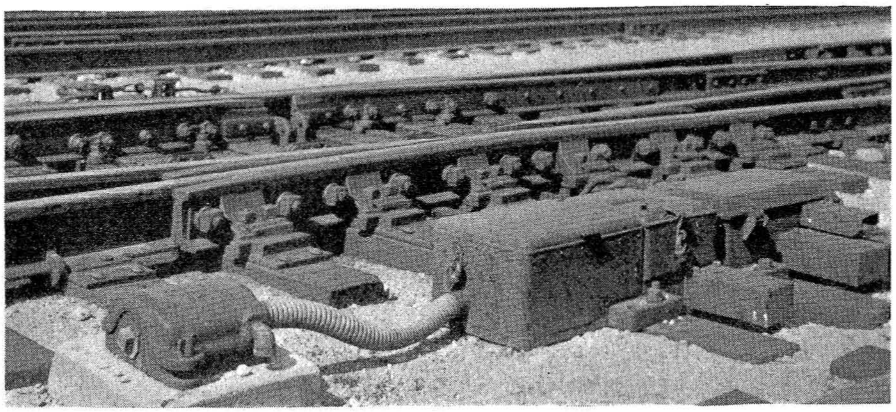
Miniature-Lever Non-Locking Machine for Pacific Junction

Although an interlocking machine with mechanical locking and electric lever locks had been used at the Western Avenue plant, when planning the new Pacific Junction interlocking in 1941, another study was made concerning the system of control and form of interlocking machine to be used. In consideration of the time required to change line-ups between consecutive train movements, the preference was to use some form of interlocking other than one including mechanical locking and electric lever locks. Study showed that a miniature-lever machine, without mechanical locking or electric lever locks, could be adapted to the Pacific Junction layout without requiring an excessive number of relays or circuit interconnections to accomplish the interlocking protection. One reason for not adopting the route control system, using buttons at the points on the diagram representing the beginning and the departure of routes, was the increased number of relays required. Some signals lead to as many as 14 routes, and the 22 operative arms, not counting the 5 call-on arms, lead to a total of 133 routes. An important item is that with a miniature-lever machine the switches are controlled by levers, thus obviating the track line-up selection relays and circuits as used in the Union route control system.





Above—New color-light signals on the northward home signal bridge
Right—Typical 110-volt d-c. switch machine at a single switch layout



Switch machine with extra rods at single slip No. 61

On the new interlocking machine at Pacific Junction, the levers and illuminated track diagram are mounted on a panel as shown in one of the accompanying illustrations. The signal levers normally stand in the center position, being operated to the left to clear northward or westward signals and to the right to clear southward or eastward signals. For this reason, and also in consideration of selections through position of switches, only 13 signal levers are required to control a total of 22 operative signal units governing a total of 133 possible routes. In addition a call-on bottom operative unit is provided on each of five signals, 42R, 34R, 44R, 70L and 76L. These call-on signals do not add to the number of levers or the total number of possible routes. Each call-on signal is controlled by positioning the corresponding signal lever for the upper arm, and then also pushing a button mounted just below that lever.

A red indication lamp above the center position of each signal lever is lighted when the signal being controlled is displaying the Stop aspect, and a green indication lamp at the left or right is lighted when the signal being controlled is displaying a Proceed aspect.

Ten levers each control a crossover, and 8 levers each control a single switch, the control of the movable-point frog No. 61 being included in the control of switch No. 61. An indication lamp with a red lens located directly above each switch lever is lighted whenever the electric locking is in effect to prevent operation of the corresponding switch. A lever can be operated at any time but no action would take place if a switch lever is moved when the electric locking is in effect, and the red lamp is information to this effect. Another advantage is that, in the sectional route release locking, the red lamp is extinguished as soon as the rear of a train clears the section so that the leverman is informed and can start making the next track line-up. A lamp with a green lens mounted above the left position of the lever is lighted when the corresponding switch is in the normal position and locked, and a red indication lamp above the right position of the lever indicates the reverse position of the switch.

The four push buttons in the bottom row on the machine panel are for initiation of the operations of release of approach locking circuits. The lever in the bottom row is for the control of the initiation of a release of detector locking, including the track circuit over the crossing. This lever is sealed in the normal position. In the track diagram above the levers, normally-extinguished lamps are lighted when corresponding sections of track are

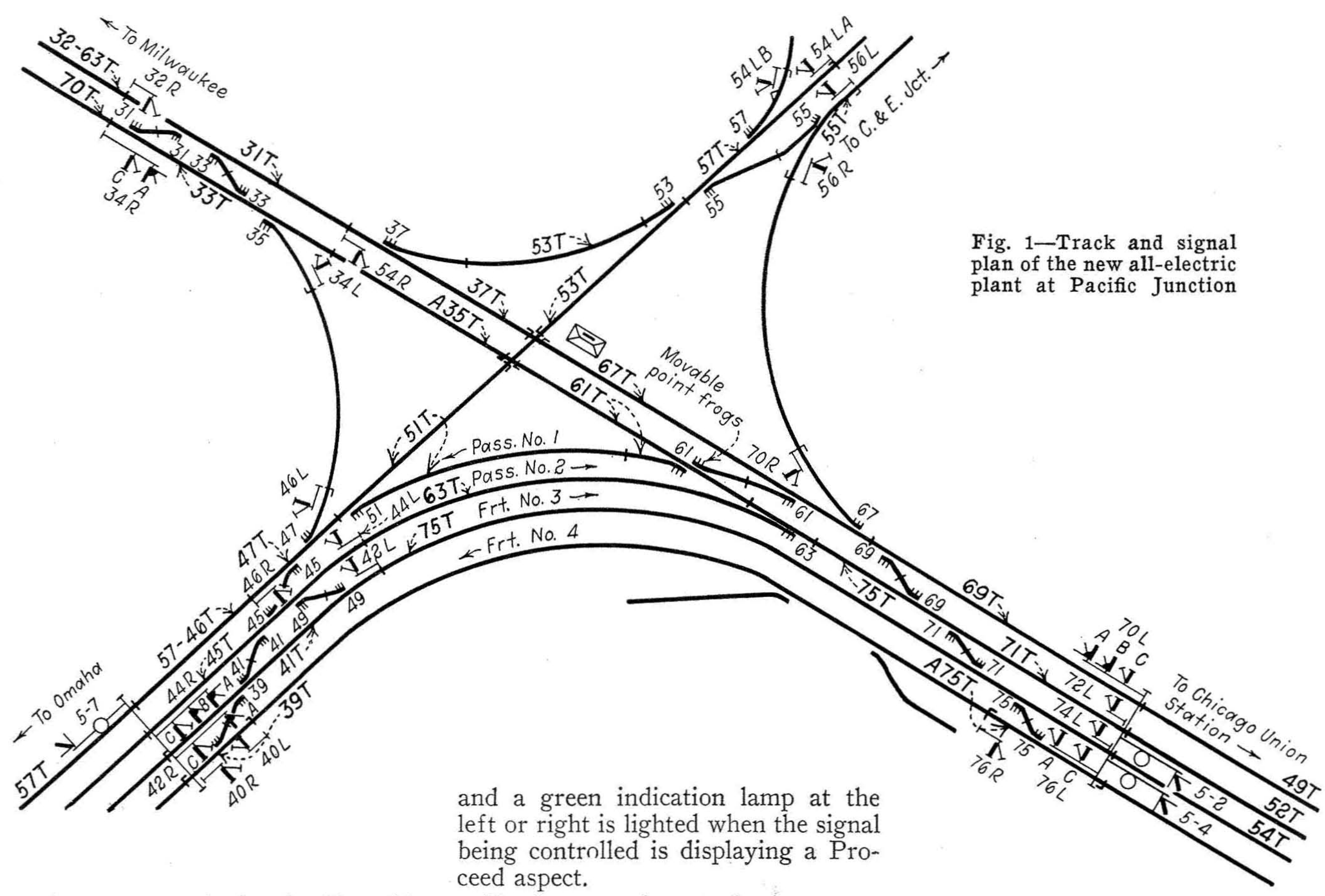
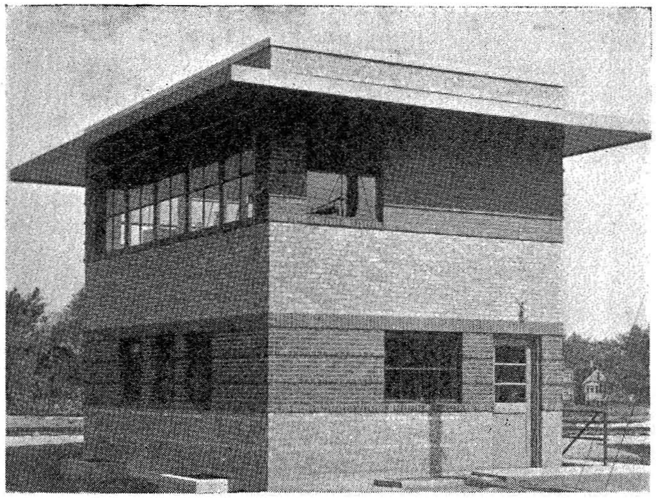


Fig. 1—Track and signal plan of the new all-electric plant at Pacific Junction

occupied. The reason for using normally-extinguished lamps is that lighting of one or two lamps on a dark background is more noticeable than extinguishing the same number of lamps when the remainder are still lighted. In order to minimize the results of lamp filament failures, two indication lamps are provided for each of the important sections.



The new tower is of brick construction and modernistic design

Circuit Interlocking

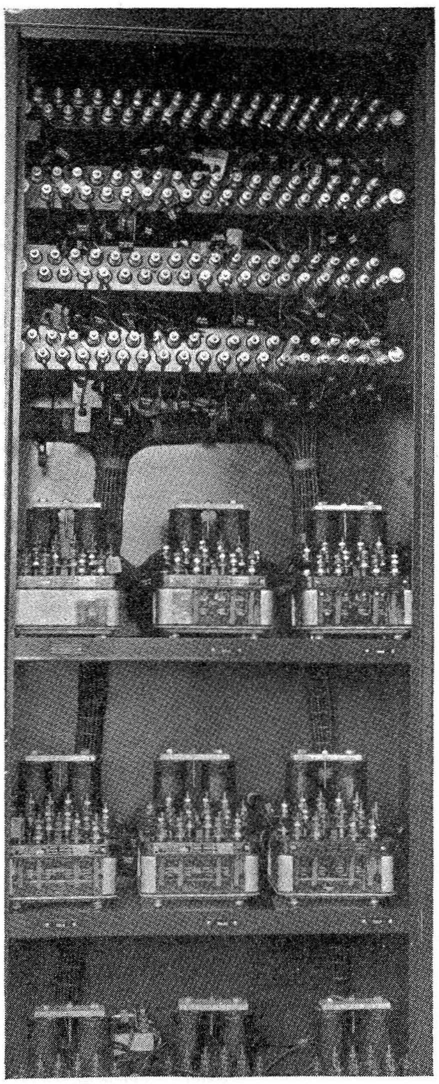
With a miniature-lever machine, including no mechanical locking between levers or electric lever locks, the interlocking protection must all be accomplished by interconnections of circuits. This result is nothing new, having been accomplished on numerous plants since the first all-relay interlockings were installed in 1929 and 1930. The circuits used on this new Pacific Junction plant, however, represent late developments in simplicity as well as safety. The circuit schemes include numerous principles of a route control interlocking, and thus are decidedly different from conventional circuit practices. For the benefit of those readers who are interested, an explanation will be given of the basic principles as applied to typical circuits.

Switch Control Circuits

The switches are operated by electric machines, the 110-volt d-c. power supply being distributed to the various machines on bus circuits. In an instrument case near each power switch machine there is a Style-DP-25 polar 450-ohm d-c. polar relay, the contacts of which control the 110-volt d-c. feed for the operation of the switch machine to either the normal or the reverse position, depending on the polarity of the circuit through the coils of the relay. Each of these relays is controlled by a two-wire circuit extending to the tower and then through contacts of a lock stick relay and to the contacts of its respective switch lever on the control machine. In the relay case near each switch there is a Style OR-11, overload relay. If the switch is obstructed so that the clutch is caused to slip, the overload relay will operate to open the motor circuit in from 2 to 25 seconds depending on the clutch adjustment. Reversal of the control circuit of the DP-25 releases the stick circuit of the OR-11 and restores it to normal operation.

For checking and repeating the position of each switch, a two-wire circuit, originating from low-voltage battery at the switch, is checked through contacts of the point-detector in the switch machine to check the position of the switch as well as the plunger in the facing-point lock, the polarity of the feed to this circuit depending on whether the switch is normal or reversed. At the tower, each of these switch indication circuits control a Model DP-17, 250-ohm d-c. relay, known as a switch-repeater relay.

For every track relay not located in the tower, a two-wire circuit extends from contacts of each track relay to a neutral track-repeater relay in the tower. Likewise, a single-wire circuit from each searchlight signal mechanism extends to a neutral repeater relay in the tower. Thus the switches, signals and track relays all have repeaters in the tower, where the circuit interlocking is accomplished.



Section of case in the tower

From the operating coil of each searchlight signal mechanism, a two-wire circuit extends to the tower, where each of the two wires is connected to the heel of separate contact fingers in a route lock stick relay, which in turn is controlled by lever-position, track-occupancy and other features, as will be explained later. With the relay energized, negative battery is connected to one wire extending to the signal, and the other wire constitutes a single-wire selection through contacts of various switch-repeater relays, route-lock lever-repeater relays, etc., to positive battery. The single-wire circuit, interior to the tower, is used to control opposing and conflicting signals and check the position of switches. This scheme not only increases the safety of the circuit arrangements but also reduces the number of selections.

Lever-Route Stick Relays

Having positioned the switch levers to set the switches for a given track line-up, the direction in which this track line-up is to be used is determined by throwing a signal lever, for example, to the left, for a northward signal, or to the right for a southward signal, both signals governing over the same track line-up. The lever contacts, however, do not directly control the signal circuits, but are included in the controls of track-repeater stick relays and route-check control relays and, in some instances, lever-repeater relays, all of which in turn control the actual signal circuits.

The basic principles of the control

of a typical track-repeater stick relay is shown in Fig. 2. In order for track-repeater stick relay 39TPS to be in the energized position, the track-repeater relay 39TP must be energized, and lever 40 must be in either the normal center position N or in the right position R. Placing lever 40 to the left position L does not release

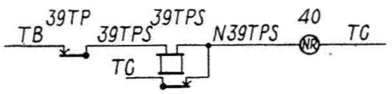


Fig. 2—Control of a track-repeater stick

relay 39TPS, because it is held by the stick circuit through its own front contact until such time as track relay 39TP is released by a train, which releases 39TPS, and it cannot again be picked up until lever 40 is restored from the L position to the normal position. Therefore, although lever 40 may be left in the L position after a train has accepted and passed signal 40L, the signal will not again clear for a second train. Also, unless lever 40 is moved from the L position to cause relay 39TPS to be energized, no opposing or conflicting signal, the control of which included front contacts of 39TPS, could be cleared. These control features insure that signal levers must be placed normal, which is equivalent in this respect to mechanical locking.

Route Check Network

Signal 40L leads to only one possible route; therefore, the route check network circuits are a minimum. When lever 40 is thrown to the L

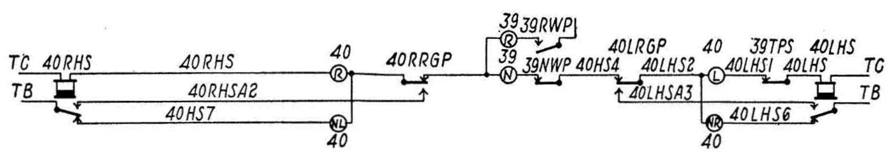


Fig. 3—Controls for relay 40LHS

position, the lever contact 40L is closed, and the next objective is to energize relay 40LHS, as shown in Fig. 3. Negative battery tower common, TC, is connected to the right-hand terminal of the relay 40LHS. Starting from the other terminal, the circuit extends through a front contact of 39TPS, previously explained in Fig. 2; then through lever contact 40L, which is now closed; through a front contact of 40LRGP to establish a stick feature for relay 40LHS after the check of the route has been made and 40L signal clears; through a front contact of 39NWP to check that 39 switch is over and locked in the normal position; through a lever contact 39N to check that 39 lever corresponds in position with 39 switch; through a front contact of 40RRGP to check that the opposing signal 40R is displaying the Stop aspect; through a 40NL lever contact to check that lever 40 is in either the normal or left position; through a back contact of 42RHS to check that no control is in effect to clear signal 40R; and then to positive battery TB. Thus relay 40LHS is energized. As soon as signal 40L clears, 40LRGP relay will be de-energized and establishes a stick feature through its back contact for

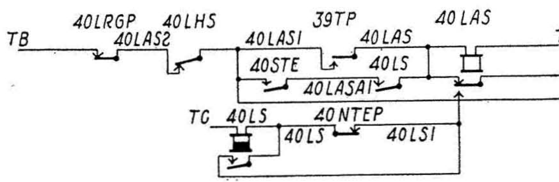


Fig. 4 — Circuits for the control of the relay 40LAS

relay 40LHS. Relay 40LHS is stuck up over its front contact; through the back contact of 40LRGP relay; through lever contact 40L; through front contact of 39TPS relay; to the left-hand coil terminal of 40LHS relay, the right-hand coil terminal to TC. Relay 40LHS is held up over this stick feature after a check of the route has been made to prevent signal 40L being placed to Stop after once cleared by the manipulation of any other lever but 40, the lever that cleared 40L signal. Thus a check is made of the switch position for the track line-up, track occupancy and the opposing signal at Stop.

In the approach locking circuits as shown in Fig. 4, when relay 40LHS opens its back contact, the stick holding circuit for relay 40LAS is opened, and this relay is released. Relay 40LHS locks the switches in the route and the opposing signal at the Stop aspect. This locking is in effect until 40LAS is again picked up, and, for this to occur, signal 40L must assume the Stop aspect as checked by front contact of 40LRGP, relay 40LHS must be released, and either 39T track circuit must have been occupied or else the time locking release period, as measured by the time element relay, must have expired after 40L had been placed at Stop. Thus the signal lever locks the switches and opposing signals the same as if mechanical locking had been used. These features prevent a change in the position of switches up to the time a train passes the signal and until the signal lever is placed normal, which is identically the protection afforded by mechanical locking between signal and switch levers. In a conventional plant with mechanical locking, the protection to prevent switch operation after a train has passed the signal, and the signal lever is placed normal, is provided by electric locks on switch levers, but, in this all-relay plant without electric lever locks, this protection is provided by switch lock circuits, as will be explained later.

In the signal control network as applying to signal 40L, as shown in Fig. 5, when relay 40LHS is energized and relay 40LAS is released, as explained above, the circuit for operating searchlight signal 40L is connected to negative battery TC by one contact, and from the other contact of 40LHS a circuit extends through a front contact of 39TPS to check non-track occupancy and lever position; through a back contact of 40LAS to check that the electric locking as applied to 40L has been placed into effect; through contacts of 39WP to check that switch 39 is normal; and then on wire 40G2 through a front contact of relay 40RAS to check that no electric locking, as applied to signal 40R, is in effect; and then to positive battery TB. Thus signal 40L is energized to operate it to display a yellow aspect.

When a train accepts this aspect on signal 40L and occupies track circuit 39T, the track relay 39T is released. As shown in Fig 2, when 39T is re-

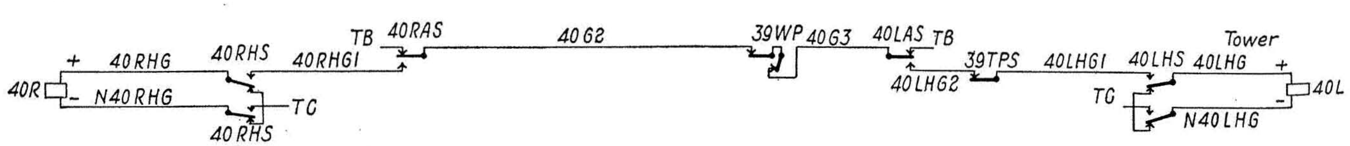


Fig. 5—Signal network for signal 40

leased, the stick holding circuit for relay 39TPS is opened, thus releasing relay 39TPS. In the route check network, Fig. 3, the front contact 39TPS is opened, thus opening the circuit for relay 40LHS, regardless of whether the lever is placed normal to open lever contact 40L. In the signal control network, Fig. 5, the release of relay 40LHS opens the control for signal 40L, and also the opening of the front contact in 39TPS opens the circuit for signal 40L. When signal 40L assumes the Stop position, relay 40LRGP is energized.

Switch Locking

During the time that any part of the train is occupying the track circuit, track repeater 39TP is de-energized, a front contact of which opens the control of a relay 39LS. As the control of the switch control relay 39WR extends through front contact of 39LS, the switch is locked in the normal position as long as 39LS is de-energized, which is true as long as 39TP is de-energized.

After the train departs from track circuit 39T, relay 39TP is energized, thus releasing the locking of 39 crossover. Also, as shown in Fig. 2, if lever 40 has been restored from the L position to the N position, relay 39TPS will be de-energized, and it will stick up. The controls are thus returned to normal.

For a Selection of Diverging Routes

Signal 40L governs to only one route with crossover 39 normal, thus the route check for signal 40L includes the contacts of only one switch-repeater relay, 39WP, normal, and the track circuit 39T energized. On the other hand, signal 40R controls not only on the straight route to signal 40L, but also via various facing-point crossovers and switches on additional possible track line-ups. Therefore, the route check network and signal control network for 40RHSR would include switch repeater relays for crossovers 39, 41, 45, 49, 75, 71, 69, and switches 47, 51, 61, and 63. Each combination of selections through these switch repeaters would also include contacts of the respective track repeater relays of the track circuits in the corresponding routes, all of which is not shown in the diagram. On the through routes, sectional route release locking is provided so that as soon as the rear of a train clears a given track circuit, the locking, as applied to the switches in that section is released, and the leverman can operate these switches as required for the next track line-up.

With reference to line-ups on one or the other of the two routes which form a crossing, the crossing is not operative like a switch to effect selections automatically. For this reason when establishing circuits for a route over a crossing, the controls for the route relays and lock relays extend through contacts of so-called crossing relays. In turn, the control of the north-south crossing relay NSXR checks through front contacts of all track circuits within signal limits of routes on north and south tracks which can lead to the crossing. The controls of the east-and-west crossing relay EWXR is correspondingly the same as applied to east and west tracks leading to the crossing. For a north-and-south route, the controls for the route check control relay includes a front contact in the normally energized east-and-west crossing relay EWXR, and the circuit for the HR relay includes a normally-open back contact of the EWXR.

Power Supply

At the tower, a set of 55 cells of 160-a.h. lead-type storage battery feeds the 110-volt d-c. switch operating circuit which extends over the plant on a two-wire circuit of No. 6 wires. A set of 5 storage cells in the tower feeds the control circuits. A 110-volt a-c. power circuit extends from the tower to the various signal bridges to feed low-voltage transformers. The signal lamps are normally fed from these transformers. At each bridge, a 10-volt set of storage battery on floating charge is used to feed control and indication circuits, as well as a reserve supply for the signal lamps in case of an a-c. power outage. Each track circuit is fed by two 500-a.h. primary cells in multiple, with a rectifier across the cells to take all but 10 m.a. of the normal load.

The distribution from the tower to the switches and signals is all in mummy finished Kerite underground cable, buried at least two feet. The control circuits are No. 14 wire, the 110-volt a-c. circuit No. 9, and the 110-volt d-c. circuit No. 6. The track circuit connections are single conductor No. 9.

The ground floor of the tower is used exclusively for housing the relays, which are located in sheet-metal cabinets with hinged glass panel doors. Each cabinet is 4 ft. wide, 7 ft. high and 15 in. deep, and has 4 or 5 shelves. The relays are of the shelf type, each equipped with a shock-absorbing spring base. A total of 245 relays are located in a total of 20 cabinets. The wires from terminal posts on relays extend in laced cables up to terminals on boards in the upper section of the cabinet. At the signal bridges and at other centrally located points on the plant, relays and battery are housed in sheet metal cases.

The new tower building was constructed with concrete foundation and floors, and with brick walls. The building is 27 ft. by 18 ft., this dimension being determined by the space required for the relays and cabinets to be located on the ground floor. The battery room, maintainer's headquarters, and a heater room including an oil-fired boiler for the steam heating plant, are located in the basement.

This new interlocking was planned and installed by signal forces of the Milwaukee road, under the direction of L. B. Porter, superintendent of telegraph and signals, the major items of equipment being furnished by the Union Switch & Signal Co.

Automatic interlocking at Holdenville, Okla., at a crossing of the Frisco and the Rock Island