



The North Western operates left-handed and the signals are located at the left of the running track—Three-aspect searchlight signal at left and four-aspect searchlight signal at right

New Signaling on the Route of the C. & N.W.—“400”

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THE ADOPTION of faster train schedules and the recent advent of the “400” caused the Chicago & North Western to give special consideration to the signaling then existing between Wilmette, Ill., and St. Francis, Wis., a distance of 65 miles, and between Milwaukee, Wis., and Folsom Place, a distance of $3\frac{1}{2}$ miles, both of these sections being on the route from Chicago—Milwaukee to St. Paul and Minneapolis. These territories were equipped with Hall disk signals and, except for a few sections with home and distant signals, the overlap system was used. The necessary long overlaps and the poor range of vision afforded by the disk signals, together with the facts that they were oil lighted and approximately 30 years old, made the system far from desirable for the operation of trains on high-speed schedules.

Cost Reduced by Eliminating Signal Bridges

It was readily agreed that the most desirable type of signal for this territory was either the color-light or the searchlight type, the searchlight type

High train speeds with heavy traffic required shorter blocks and multiple aspect in certain zones—Special control and lamp checks—A.C. primary power supply used

being considered as preferable on account of the fogs which occur at various times during the year along Lake Michigan.

On double-track lines the C. & N. W. operates left-handed, and previous estimates had been based on the use of a signal bridge at each location in order to mount the signal over the particular track over which it governed. This was thought necessary to give the enginemen a good view of the signal, since it was not practical to place the signal on the ground between main tracks. An analysis of previous estimates showed that these bridges were responsible for approximately one-third of the estimated cost, an item of expense worthy of further investigation. The majority of the existing Hall disk signals were mounted on masts to the left of the track and had been so located since installed. Low-hanging fogs caused enginemen to favor signals located at proper height to the left of the track, rather than on bridges. These facts caused the sig-

nal department to make tests to determine the height of a searchlight type signal which, placed on a mast to the left of the track, would provide the best vision from the right-hand side of the locomotive cab. It was found that with the motive power in use, a height of 16 ft. from the top of the rail to the center of the lenses was most satisfactory to the enginemen. At this height, the engineman retains a view of the signal until he is within approximately 60 ft. and the fireman, of course, can have a view the full distance. This was considered satisfactory enough to warrant installation without the use of bridges, and thus it was possible to reduce the previous estimate of \$300,000 to \$200,000. The desirability of a new signal system in this territory, and the substantial reduction in cost of the proposed installation, caused the management to accept this estimate and authorize the installation on the basis of a monthly expenditure of approximately \$13,000 each month until completed.

Further economies in installation have since been accomplished. For instance, power has been taken from existing service connections at depots and at highway crossing signal installations, and is carried on the line at 110-120 volts to feed two or three signal locations on each side of the connection. This method resulted in the elimination of sections of power line, line transformers, plug cutouts, etc., and kept the wattage and voltage of the power circuits within sufficient limits to eliminate the necessity of providing greater spacing between crossarms, which would have required the installation of higher poles in a large portion of the line. Existing track cuts, signal masts, re-

\$50,000. The matter of financial authority having been settled, the next most important problem was to determine definitely the signal spacing and location of the signals.

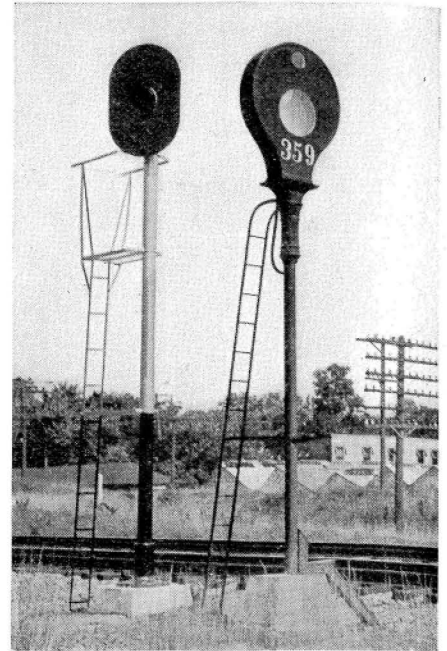
Problem of Spacing Signals

The suburban district extends north on this line to Waukegan, Ill., 36 miles from Chicago. In addition to Waukegan, suburban trains originate and terminate at Highland Park, Ill., and at Winnetka, Ill., 23 miles and 16.5 miles, respectively, north of Chicago, and within the district to be resigaled. At Wilmette, the south end of the installation, the double track merges with three tracks leading toward Chicago. The section of the track and signal layout which is reproduced as one of the illustrations, shows that the suburban stations are numerous and closely spaced in the section between Highland Park and Wilmette.

During the suburban rush period in the morning, there is a mixture of local and express suburban trains, together with several through trains from points north. It can be readily seen that with suburban trains starting out of Waukegan, Highland Park and Winnetka, traffic becomes more congested the nearer it approaches Wilmette. The headway scheduled between some of these trains is only three minutes. Therefore, the problem was to provide signaling which would give protection for the local station stops, give smooth operation, as well as provide for high-speed operation of such trains as the "400" through the same territory, at a speed of 80 to 95 m.p.h., outside of the suburban rush period.

Calculated stopping distances and tests indicated that for these speeds, signals of a three-aspect, two-block system would have to be spaced 7,000 to 8,000 ft. apart if it were desired to stop a train without making an emergency application. The old overlap system, previously in use, caused innumerable stops during the rush hours on account of the length of the overlap. Although a three-aspect two-block system would probably eliminate some of the stops, it would still cause considerable delay due to the C. & N.W. Rule 501B for an approach signal, requiring a train ex-

ceeding 30 m.p.h. to at once reduce to that speed. Spacing of 7,000 to 8,000 ft. would cause more than one

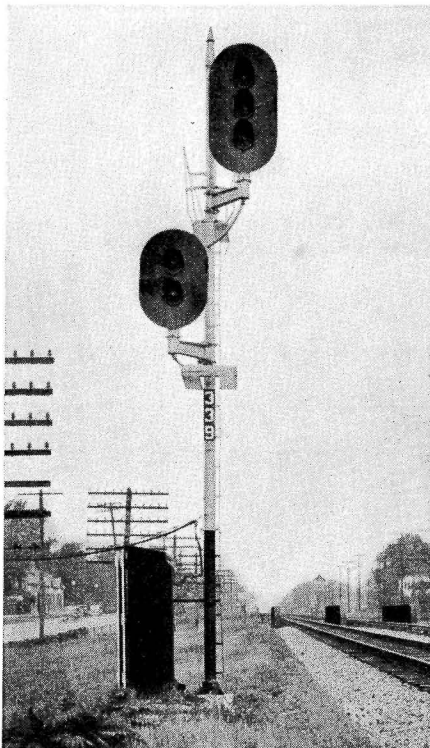


The new ready to replace the old

suburban station to fall within a block, and the benefit of a nearby signal in protecting a station stop, would be lost.

Four-Indication Three-Block Signaling

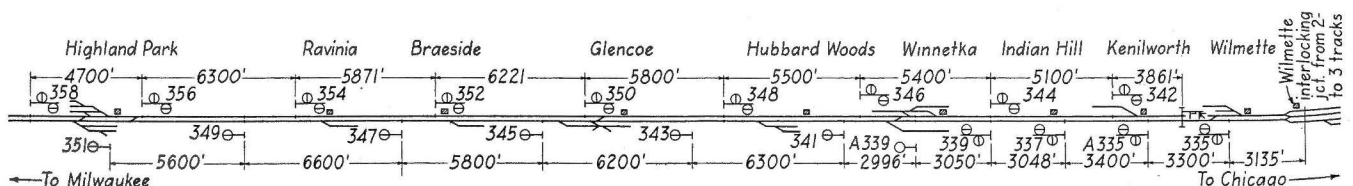
There seemed to be only one thing to do and that was to provide short blocks with four-indication, three-block signaling for the congested section. This has proved to be very satisfactory since being placed in service. This type of signaling extends on the eastward track from a point three miles north of Highland Park to Wilmette, and on the westward track from Wilmette to Winnetka. It was found that there is not as much congestion of traffic on the westward track during the evening rush period, as on the eastward track during the morning rush hour. Although the trains come from two tracks on to one, they space themselves farther apart sooner, and there are few through trains to contend with during the rush hour. Through trains such as the "400" and the Pacemaker do not travel as fast going westward through this territory as they do go-



Four-indication location using Type-D color-light signals

lays, relay boxes, etc., have been used as far as practical, further to reduce the cost.

A close study of the territory and train operation has shown that in certain sections, regardless of the stopping distance required for high-speed trains, blocks could be extended still further and a number of signals eliminated. It now appears that all of these various items will result in a further reduction of approximately



Track and signal plan of typical section of four-indication, three-block territory

ing eastward, partly on account of the grade and partly owing to the fact that westbound they are just leaving territory with some speed restrictions. For these reasons the four-indication, three-block signaling does not extend as far on the westward track as on the eastward.

Three-Indication Two-Block Signaling

The maximum speed attained by the fastest train between Highland Park and Milwaukee is approximately 95 m.p.h. On account of grades and speed restrictions, this maximum speed is attained at only two or three points on the entire section, and these points are on a descending grade terminating in an ascending grade. Our analysis indicated that the maximum stopping distance required is well within 8,000 ft. Therefore, no need was found for other than three-indication two-block signaling in the Highland Park - Milwaukee district, except for two blocks going down grade into Waukegan. Consideration was given to possible maximum speeds, grades and train spacing, and the signals were spaced 6,000 to 10,000 ft. apart, depending on conditions. As far as practical, signals were located to give the enginemen the maximum length of view.

Types of Signals and Aspects

A two-arm color-light or two-arm searchlight signal is used to provide the four-indications for the three-block signaling. The two arms are staggered, the top arm to the right of the pole and the bottom one to the left. Where G.R.S. Type-D color-light signals are used, the height of the bottom lens of the lower arm is 16 ft. from the top of the rail, and the bottom lens of the top arm is 5 ft. from the bottom lens of the lower arm. Where searchlight Type-SA signals are used, the distance is 16 ft. from the top of the rail to the center of the lower arm lens and 5 ft. between the center of the lower arm lens and the center of the top arm.

The aspects and indications given for an occupied block in the four-indication three-block district are as follows: The signal at the entrance to the occupied block presents an aspect of red diagonally above red. Name—"Stop and Proceed" signal; indication—Stop—then proceed in accordance with Rule 509 (a) or (b). This being double-track territory 509 (b) applies. When a train is stopped by a "Stop and Proceed" signal it may proceed (a)..... (b) On two or more tracks at once at restricted speed.

The first signal approaching the "Stop and Proceed" signal presents an aspect of yellow diagonally above red. Name—"Approach" signal; indication—Prepare to stop at next signal. Train exceeding 30 m.p.h. must at once reduce to that speed.

The second signal approaching the "Stop and Proceed" signal presents an aspect of yellow diagonally above green. Name—"Approach Medium"; indication—approach next signal at not exceeding medium speed. Train exceeding 40 m.p.h. must reduce to that speed.

A clear signal in this district will present an aspect of green diagonally above red.

One-arm Type-SA searchlight signals are used in the three-indication automatic two-block territory. The indications given are red, yellow and green for "Stop and Proceed," "Approach" and "Clear" signals, respectively, and the rules are the same as for the two-arm signals of the same name.

Types of Signals and Lamp Burn-Out Protection

The original intention was to use all Type-SA signals for the installation, but it was found that there was in stock a sufficient number of G.R.S. Type-E color-light signals (horizontal type) purchased for another project, which was cancelled, which could be converted to make up 10 double-arm Type-D signals (vertical type). By using these, the storekeeper's stock was reduced and an earlier start was made on the installation.

Up to the time this installation was planned, there had been some objection to the searchlight type of signal

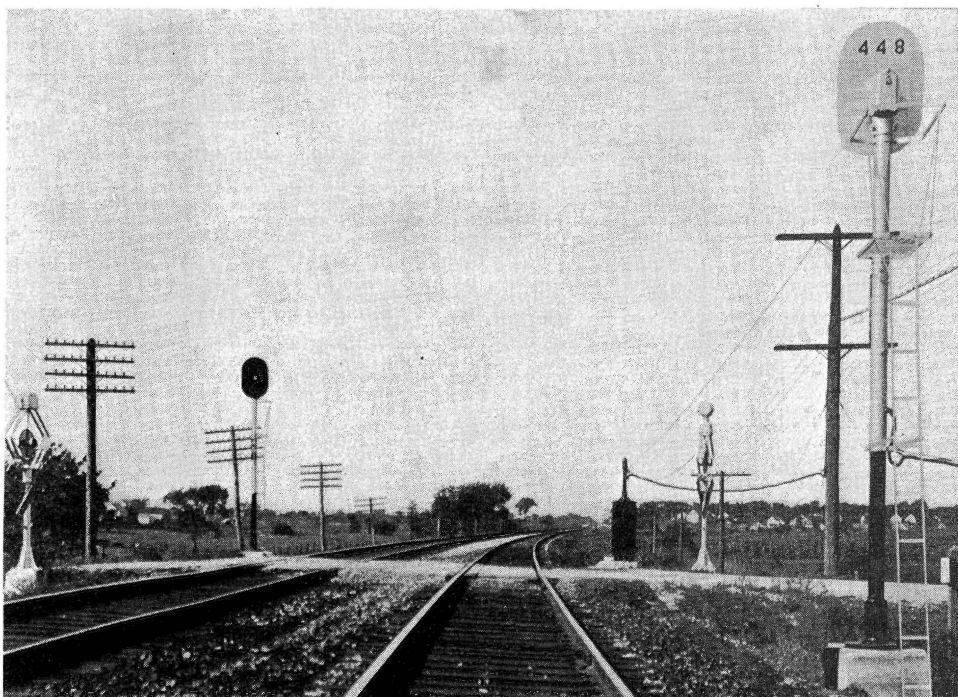
because there was no provision for an emergency lamp. We had no great confidence in a double-filament lamp, though the low-wattage filament in the present-day lamp has at least twice the burning hour rating as the higher wattage filament. The lamp selected for our use is the 8-volt, double-filament 13 plus 3½-watt, S-11 bulb, with a single-contact bayonet base. To overcome the objection, it was decided to install a light-out relay in the lamp circuit, which would release when the high-wattage filament burns out, the release of the relay causing the next signal to display the approach indication, and in four-indication, three-block territory, also cause the second signal to display the Approach-Medium indication.

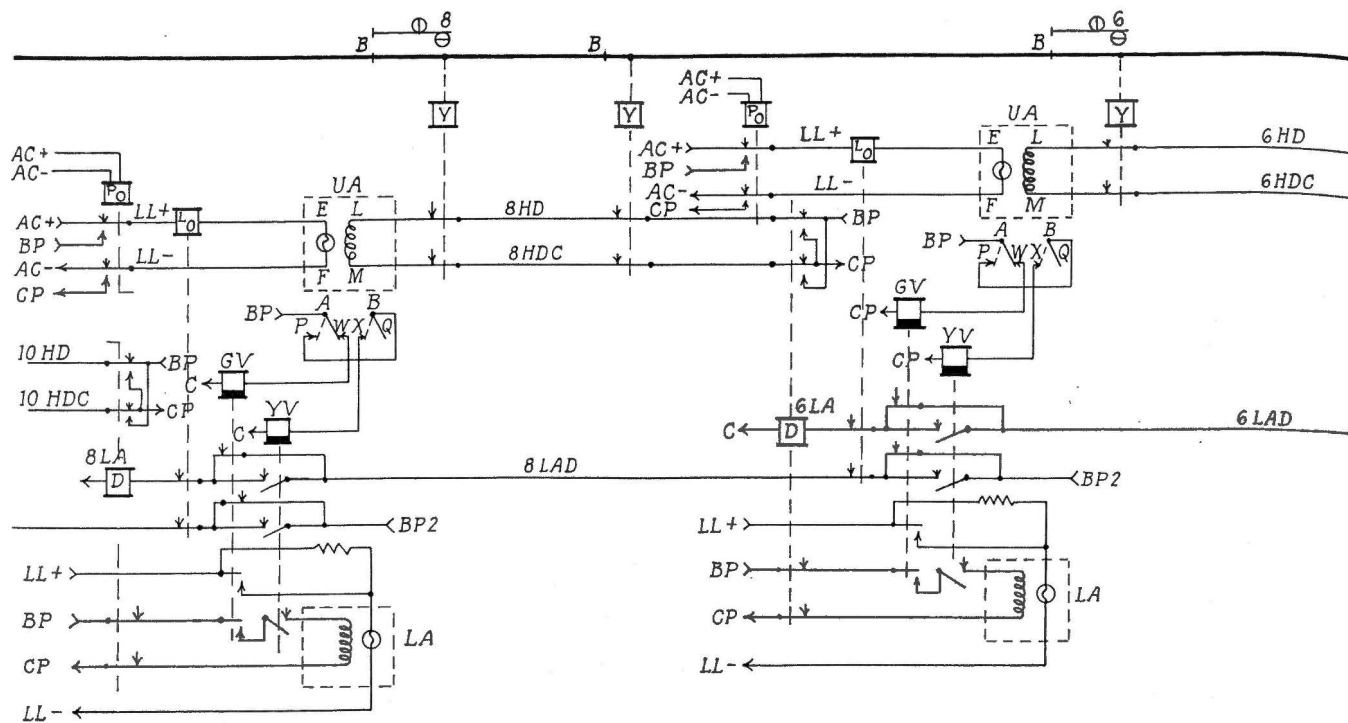
Double-filament lamps and the same light-out relay application are used in connection with the Type-D signals, as well as in connection with the Type-SA signals in the four-indication, three-block territory. The light-out relay is in series with the lamps or lamp of the top arm and in addition to providing approach signals when the higher-wattage filament burns out, will cause the lower arm to show red.

Three-Indication Type-SA Signals

The signal control circuits for the two-block, three-indication district are simple, and can be described without the use of a diagram. Assume that the signals are numbered 1, 3, 5, etc., in the direction of traffic. Searchlight signals being used, a signal-repeater relay at each signal is energized through the signal relay when the indication is yellow or green, and through the front

A joint highway crossing signal and Type-SA automatic signal location in three-indication territory





Typical control circuits for four

contact of a light-out relay, in series with the signal lamp, which drops when the 13-watt filament burns out.

The signal-repeater relay is slow-release to prevent the armature dropping when the signal relay is changing from the yellow to the green position or vice versa, since there is a moment during this movement while the relay passes through the red position that neither the yellow or green contact is made. The signal-repeater relay at each signal serves as the polarizing relay for the control circuit of the next signal, the one at signal 5 for signal 3, the one at signal 3 for signal 1, etc.

Both sides of this signal control circuit are selected through the track relays and the switch circuit controllers within the particular signal block, and directly control the signal relay, or mechanism (if you care to think of it as such). A train in the block of signal 5 will cause signal 5 to display red, and the signal-repeater relay will be de-energized; or a burn-out of the lamp of signal 5, or 13-watt filament, will cause the signal-repeater relay to be de-energized.

Signal 5 repeater relay, when de-energized, polarizes the control circuit of signal 3 in the direction to cause the signal to operate to the yellow position, provided there is no switch open or train in the block of signal 3. The signal-repeater relay polarizes the next signal control circuit in this manner: The two line control wires for signal 3 are connected one to the heel of contact 1 and the other to the heel of con-

tact 2. Positive battery is connected to front contact 1 and back contact 2, and the negative side of the battery is connected to front contact 2 and back contact 1. If signal 5 repeater is energized, battery will be fed in the direction to cause signal 3 to be energized in the position to show green. If signal 5 repeater is de-energized, battery will be fed in the direction to cause signal 3 to show yellow, provided the block is unoccupied and no switches open.

Four-Indication System With Type-SA Signals

In the four-indication, three-block district, where the SA signals are used, the SA relay contacts were used as much as possible to obtain the desired indications. As shown on the circuit diagram, two slow-release relays are provided with each top arm. One relay is energized only when the top arm shows green, and the other when it shows yellow. The relays are known as the GV and the YV relays, respectively. They are slow-release to take care of the time interval required for the signal relay or mechanism to move from the yellow position through the red to the green position or vice versa, to prevent a momentary change of indication on the signals approaching the particular signal.

At each of the signals there is a neutral relay, known as the LAD relay, whose control circuit at the signal location is selected through a light-out relay, which is in series with the top arm lamp, and through

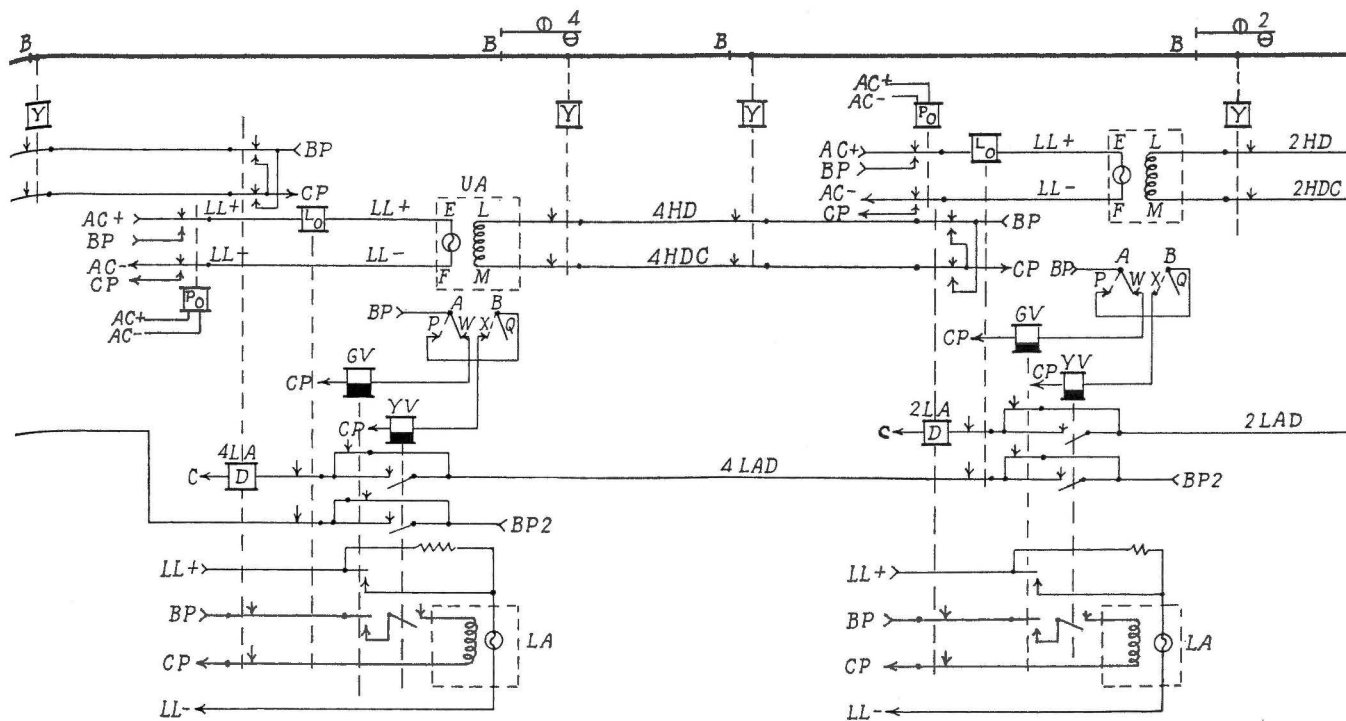
a front contact of the GV relay in multiple with a front contact of the YV relay, and also through a similar set of contacts at the next signal in advance.

The top-arm signal relay circuit is polarized through contacts on the LAD relay at the next signal in advance and is selected through the track relays and switches within the block. This LAD relay, when energized, polarizes the circuit in the direction to cause the top-arm relay or mechanism to operate to the green position, and when de-energized, polarizes the circuit in the direction to cause the top-arm relay or mechanism to operate to the yellow position. The opening of a switch or occupancy of a track circuit between the signal and the next signal in advance will, of course, de-energize the top-arm SA relay, causing it to assume the red position.

The lower arm signal relay or mechanism is controlled through front contacts on the LAD relay in series with a back contact on the GV relay and a front contact on the YV relay, and the circuit is so polarized that the SA relay moves from the red to the green position. To provide for the possibility of a movement of the relay to the other position, a red glass is installed in the relay vane instead of the yellow.

Example of Train Operation

Assume that the signals are numbered in the direction of traffic 8, 6, 4 and 2, a train in the block of signal 2 will cause the upper-arm SA



indications using Type-SA signals

relay of 2 to be de-energized and show red. The 2GV and 2YV relays will be de-energized, causing 4LAD and 2LAD relays to be de-energized and the lower-arm SA relay control circuit to be open, causing the lower arm to display red, and the light indication given by signal 2 is red diagonally above red.

Signal 2LAD relay being de-energized, cuts off the battery feed to 2 lower-arm relay, assuring that the lower arm shows red. Also, 2LAD polarizes the control circuit for signal 4 upper-arm SA relay, causing it to assume the yellow position, no train being between signals 4 and 2 and no switches open. The 4LAD relay is de-energized because 2GV and 2YV are open. Therefore, signal 4 lower-arm SA relay is de-energized, and the light indication shown by signal 4 is yellow diagonally above red.

The 4LA relay being de-energized, polarizes the control circuit for signal 6 upper-arm SA relay in the direction to cause it to assume the yellow position. The 6LAD relay remains energized through a 4YV front contact and current is applied to signal 6 lower-arm SA relay, through a front contact of 6LAD relay, 6GV relay back contact and 6YV relay front contact, causing the relay to assume the green position. The light indication given by signal 6 is yellow diagonally above green.

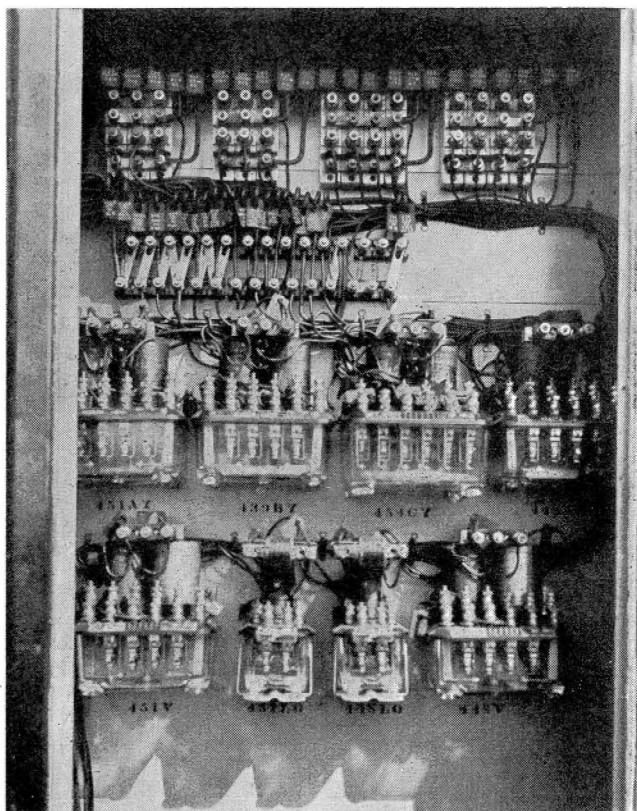
The 6LAD relay and the 6YV relay are both energized. Therefore, 8 upper-arm signal relay is polarized in the position to show green,

and, although 8LAD relay is energized, 8 lower-arm signal relay is de-energized and in the red position because the 8GV relay is energized and the 8YV relay is de-energized. The indication given by signal 8 is, therefore, green diagonally above red. The GV relay being energized, a dimming resistance is in series with the light on the lower arm. The

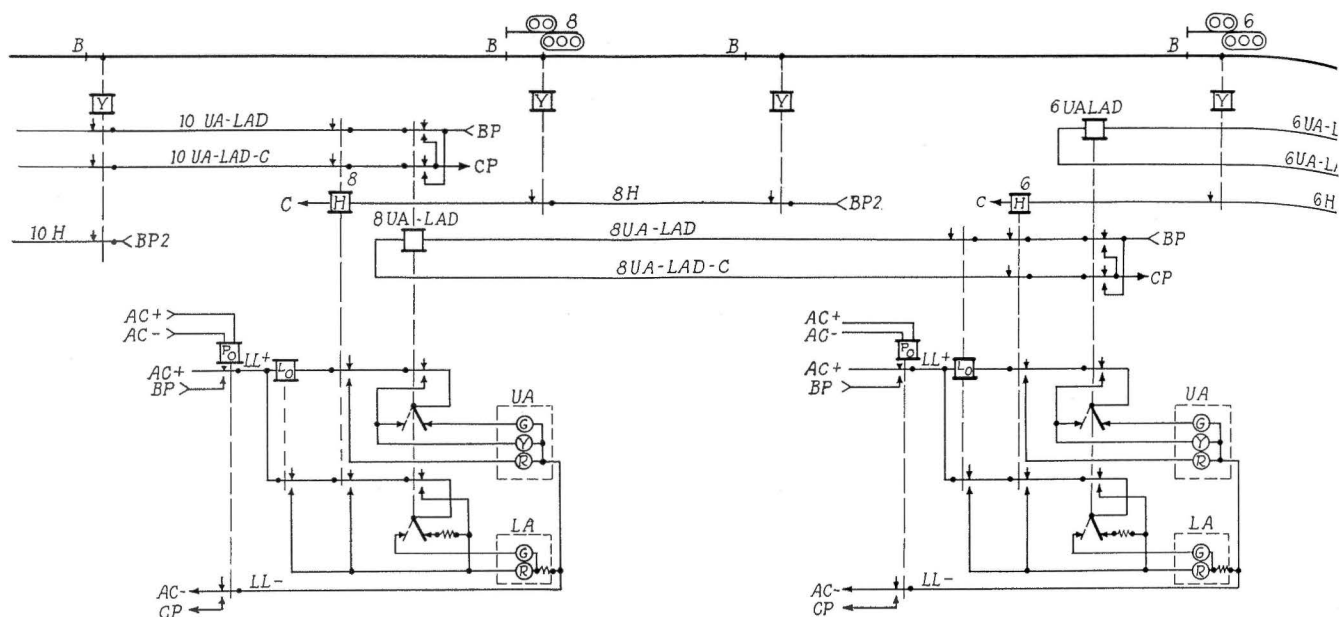
burning-out of the top-arm lamp or the 13-watt filament at signal 2 will produce the same indications at signals 4, 6, and 8, as a train in the block of signal 2.

Four-Indication System with Type-D

Where the Type-D color-light signals are used in the four-indication,



Typical instrument case on new installation



Typical control circuits for four-

three-block district, a different circuit is required because there is no signal mechanism or signal relay available. Referring to the typical circuit diagram, it will be noted that there is a neutral H relay for each signal. Its control circuit is selected through all track relays and switch circuit controllers in the block of the signal. Also, at each signal there is a retained-neutral polar relay, known as the UA-LAD relay, and an LO (light-out) relay, which will drop when the 13-watt filament or lamp burns out. The UA-LAD relay control circuit extends to the next signal in advance and is polarized by

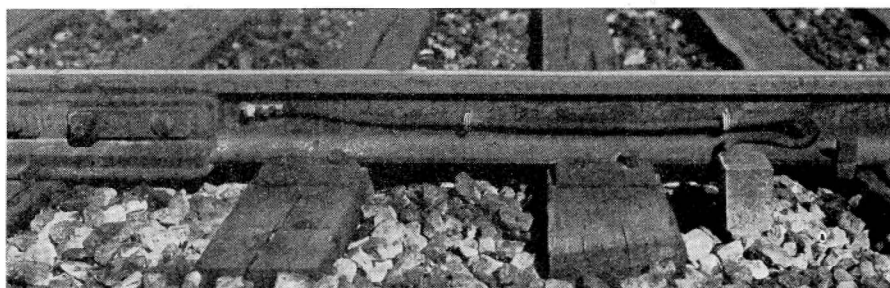
the LO relay, a front contact of the H relay and a front contact and a reverse polar contact of the UA-LAD relay or a back contact of the UA-LAD relay. The top-arm red light is in series with the LO relay and a back contact of the H relay. The bottom-arm red light is in series with a back contact of the LO relay, or in series with a front contact of the LO relay and a back contact of the H relay; or with a front contact of the LO relay, a front contact of the H relay and a back contact of the UA-LAD relay; or in series with a front contact of the LO relay, a front con-

through the back contacts of the 4UA-LAD relay, and the indication at signal 4 is a yellow light diagonally above a red light.

The 4UA-LAD relay being de-energized, and its back contacts being made, reverses the current feed to 6UA-LAD polar relay, causing the polar contacts of 6UA-LAD relay to assume the reverse position. The 6LO relay and 6H relay being energized and 6UA-LAD relay being energized reverse, the yellow lamp of the top arm and the green lamp of the bottom arm are lighted, and the indication given at signal 6 is yellow diagonally above green. The 6UA-LAD relay, being energized, feeds current in the normal direction to the 8UA-LAD relay at signal 8. The 8LO, 8H and 8UA-LAD relays being energized, the green lamp of the top arm is lighted from a normal polar contact of 8UA-LAD relay, and the red lamp of the bottom arm is lighted from a polar contact of the 8UA-LAD relay through a dimming resistance, and the indication given at signal 8 is green diagonally above red.

It will be noted that a burn-out of a lamp on the top arm of signal 2 will cause 4UA-LAD relay to drop, causing signal 4 to give an indication yellow diagonally above red. The dropping of 4UA-LAD relay will polarize 6HD relay, causing signal 6 to give the indication of yellow diagonally above green. At signal 8, its circuit being normal, the indication will be green diagonally above red.

In all of the four-indication, three-block territory, when the "Proceed" indication is given, we endeavor to burn the red light on the lower arm at approximately 0.5 volts lower than the green light of the top arm so as to cause the two lights to be more equal in range.



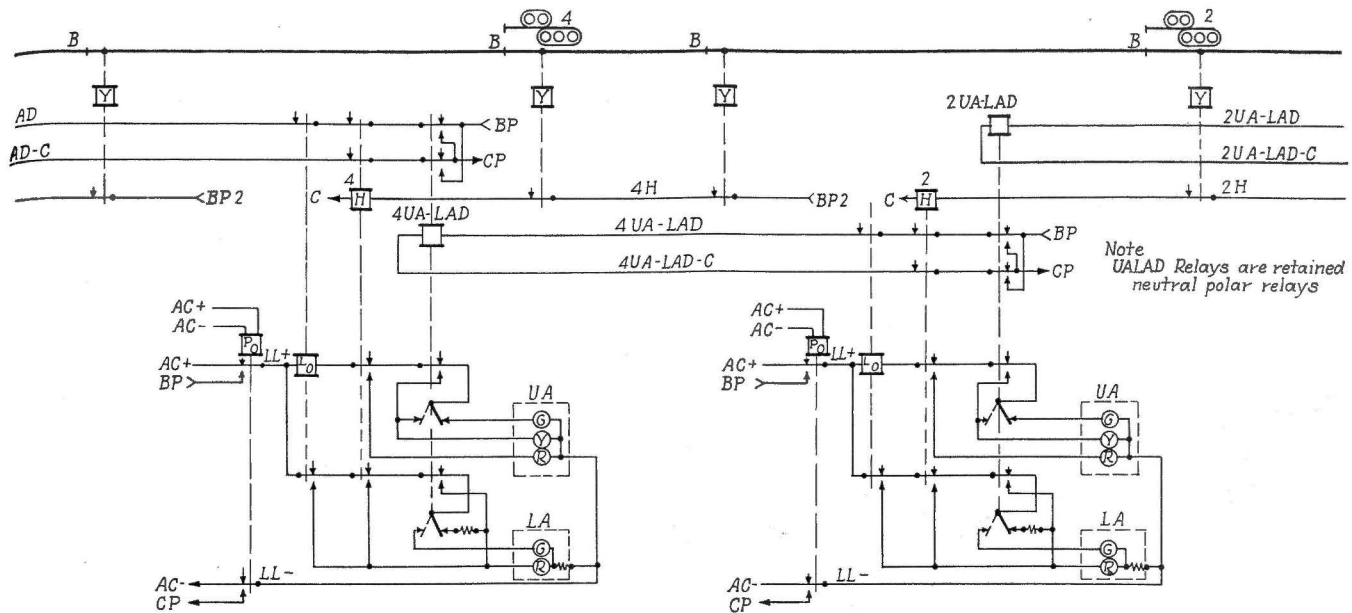
Bootleg outlet and rail connection

use of two neutral dependent front and back contacts of the UA-LAD relay, and is selected through front contacts of the H relay and LO relay at that location.

The light circuits are fed alternating current through the front contacts, or direct current through the back contacts of a PO (power-off) relay. Considering that all of the light circuits start at the heel of the PO relay, the green light of the top arm is in series with the LO relay, a front contact of the H relay, a front contact and normal polar contact of the UA-LAD relay. The top arm yellow light is in series with

tact and a normal polar contact of the UA-LAD relay and a dimming resistance.

Assume that a train is in the block of signal 2 or that a switch is open in this block. The 2H relay control circuit would be open, causing signal 2 top arm and bottom arm to show red, these two lamps being fed direct from the back contact of the H relay. The 2H relay, being de-energized, opens 4UA-LAD circuit, thus causing this relay at signal 4 to be de-energized; and 4LO relay and 4H relay being energized, the yellow lamp of the top arm and red lamp of the bottom arm are lighted



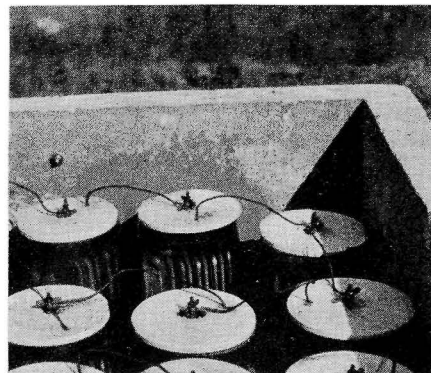
indication territory using Type-D signals

In addition to the circuits discussed, it was necessary to extend switch-indicator circuits to correspond with the changes in signaling, and to provide an approach of 2,500 ft. or more beyond the last signal affected by the operation of a switch. Annunciators have been placed in all gate and flagman's cabins and at manually-protected crossings. The control circuits are designed to give an approach of one mile to one and one-half miles, depending on the speeds in the territory and whether the crossing is manually flagged or gate protected. The automatic highway protection approach circuits are of sufficient length to provide 20 sec. warning for the fastest train, and in many cases are 3,000 ft. in length.

Stand-By Power Supply

Edison HA-500 primary cells are used as emergency battery in case of power failure, one set of 16 cells or two sets of 16 cells in multiple, depending on whether one, two or more lights are burning at a location. This battery is also used for emergency operation of the UA-LAD circuits and the searchlight relay control circuits. Resistances are used to reduce the voltage to proper lamp values. Rectifiers are being installed for the normal feed to the relay circuits and are connected in multiple with the battery, the circuit being so balanced that normally the emergency battery supplies 10 to 20 m.a. of the required current. These batteries are located in battery wells at the locations, the majority of which were in service when the work was started. Track circuits are fed from primary battery at present. However, in the near future, rectified circuits, with primary reserve, will be installed.

In connection with the power feeds there is, at each location, an I.T.E. circuit-breaker having a thermal element which causes the circuit breaker to open on a short circuit of



Primary battery as stand-by

10 amp. or more. The breaker is also used as an "On" and "Off" switch for the power feeds.

It will be noted from the illustrations that the front of the backgrounds of the signals are painted black, and the back of the signals and the poles, down to the height of the top of the relay case, are painted aluminum, and the remainder is painted black. This was done because it was thought that this painting would cause the signal to be more readily seen at night in case of a light out as well as give a neat appearance.

As evident from the accompanying illustrations, the roadbed in the vicinity of the signal locations is free from trunking, and presents a neat appearance. This result was obtained by the use of Okojute for track wiring and the use of parkway cable for carrying wires from one side of the track to the other, these being buried at a depth of 18 in. The Okojute is brought up to the rail through a boot-

leg, 18 in. in length, made of an asphaltum compound formed like a piece of trunking and capping. The Okojute is brought out at the top of the bootlegs through a notch, cut on the rail side, and carried along the rail through two helix feed wire holders to the joint, and is connected to the rail by the use of Saco or Flath terminals. Horn signal cement is used to seal the top of the bootleg. Parkway cables are terminated and sealed in small boxes or Aldo-seals near the foot of the signal masts, or are terminated and sealed in the goose-neck bracket entrance to the relay boxes.

It will be noted, in the illustration showing the combined highway crossing and signal location, that the automatic signal is placed beyond the crossing in the direction of traffic, this being done to insure that the highway crossing signals will continue to operate with a train on the crossing, without the need of a special track circuit.

Signal material used in connection with this installation such as signals, relays, rectifiers and relay boxes, etc., was purchased from the General Railway Signal Company. Okonite rubber-covered copper wire is used for hand-made cables, track and box wiring. Other accessories were furnished by the Western Railroad Supply Company.

The installation is being made by Chicago & North Western division construction forces under the direct supervision of the assistant signal engineer, assisted by C. W. Biggers, general foreman, and E. F. Shaw and K. Chamberlain, signal inspectors. The installation is now approximately 70 per cent completed, and it is expected that it will be entirely completed by March 1, 1936.