Typical signal location on four-track line showing the signals, inductors and the concrete house. Note the grade marker at the right

Signaling for Higher Train Speeds

New York Central replaces three-indication semaphores with four-indication color-light signals, thus increasing braking distances

In order to meet the requirements for longer braking distances brought about by higher train speeds, the New York Central has, during the last few years, made changes in its automatic block system on various extended sections of the main line between New York and Chicago. Excellent examples of the changes required are included in an 80-mile territory recently reconstructed between Toledo, Ohio, and Elyria.

In the major portion of this territory, two-arm, two-position, lower-quadrant Style-B semaphores were installed in 1906, the aspects and indications being as explained in a chart shown elsewhere in this article. On some short sections of the territory, three-position, upper-quadrant signals were in service, using the standard aspects and indications. In 1927, the automatic signaling protection was supplemented by the installation of the General Railway Signal Company system of intermittent inductive automatic train stop. An inductor is located 70 ft. in the approach to each signal.

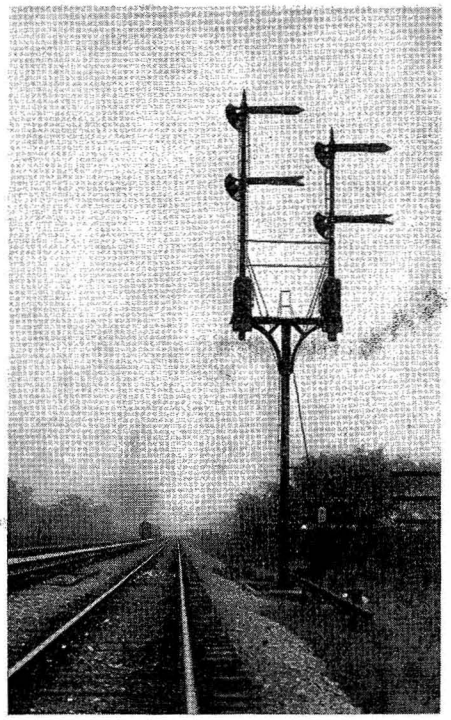
On the 80 miles of line between Toledo and Elyria, there are four sections of four-track line with intervening short sections of two-track or three-track line. On the four-track line, the two tracks on the south side are used for eastbound trains and the two on the north side for westbound trains, the inside tracks being for passenger trains and the outside tracks for freights. The automatic signals are mounted on bracket masts at the right of the two tracks over which they govern.

Arrangement of Old Signaling

Throughout extended portions of this territory the grade is practically at lake level, although there are a few light ascending grades long enough to warrant the use of grade markers. Furthermore, the line has comparatively few curves, none of which are sharp enough to require material speed reductions.

When the automatic signals were installed in 1906, the maximum speeds were about 60 m.p.h. for passenger trains and 35 m.p.h. for freight trains. The passenger trains handled from 8 to 10 cars, and the freight trains up to 70 cars. The braking distances for either passenger or freight trains was comparatively short, so that block lengths of about 4,200 ft. were adequate for braking distance, plus allowance for variations in the handling of trains. On this basis, and also to provide maximum track capacity for following trains, the automatic signals were spaced approximately 4,200 ft. apart, depending on the grades and other local conditions affecting train speeds and braking distances.

As train speeds, as well as the lengths and weights of trains, gradually increased during recent years, it was evident that the signaling must be revised accordingly. Extensive braking tests indicated that, where maximum speeds of 80 m.p.h. for passenger and 50 m.p.h. for freight trains are in effect, at least 5,333 ft. should be provided for braking distance, plus allowances for descending grades. In order to provide adequate safety, a temporary measure adopted was to extend the controls for the shorter blocks so that the approach



The semaphores were removed

aspect was displayed on two successive signals in the approach to a signal displaying the stop aspect.

Reason for Using Four Aspects

The practice of removing every other signal, thus doubling the braking distance and retaining the three-aspect automatic signaling, would, of course, provide safe operation but would not meet the requirements for flexibility of train operation. On the same basis, with reference to braking distance and safety of train operation, following trains can be spaced closer with the four-aspect system than with the three-aspect system. Thus, the four-aspect system provides the greater track capacity.

A more important reason for adopting the four-aspect system for this installation, however, has to do with securing flexibility of train operation, reduction in the number of unnecessary train stops and increased average speeds overall. When operating a train under the four-aspect system, an engineman receives a less restrictive indication quicker than he would under the three-aspect system. This feature of operation, in view of the several interlockings and grades involved, increases the number of instances in which unnecessary stops can be eliminated and in which a train can be kept moving at as high a rate of speed as is consistent with safety, when otherwise, with the three-aspect system, the train would in many such cases be run at a much slower speed or have to stop.

The Toledo-Elyria section is a high-speed line, this division handling a comparatively heavy traffic, including 34 scheduled passenger trains and about 24 freight trains daily. In some instances, following passenger trains are scheduled to run on as close as a 10-min. headway, and, furthermore, on certain days each week, especially in the heavy traffic seasons, some of the scheduled trains are operated as two or more sections which must be run on comparatively close headway. At first consideration, it would appear that two following trains operated at 80 m.p.h. on 10 minutes headway would be spaced 13.3 miles apart, or on a 5-minute headway would be spaced 6.7 miles apart. The 6.7-mile

L. Q. Semaphores	*Indication*
R / Y	*Stop; Then proceed.*
G / Y	*Proceed at one half maximum authorized speed at point involved (not exceeding 30 m.p.h.) prepared to stop at next signal.*
G / G	*Proceed*

Aspects and indication of the two-arm lower-quadrant semaphore signals

distance would include at least three blocks, an average of two miles long, and, therefore, it would seem that block lengths averaging about two miles each would not decrease the track capacity or interfere with train operation.

In day-to-day operation, however, the distance varies between following trains spaced on a time basis, because train speeds must be varied on ascending and descending grades, and frequently when approaching and passing through interlockings. When going between Toledo and Elyria, a train travels on a four-track line for 23 miles, on two-track for 11 miles, on four-track for 7 miles, on two-track for 1 mile, on four-track for 16 miles, on two-track for 11 miles, on three-track for 7 miles, and on four-track for 7 miles. Interlockings are located at the seven places where the number of main tracks change, including Millbury, Oak Harbor, each end of Bay Bridge, Sandusky and Amherst.

In instances where two trains are following on a certain time spacing, and the leading train reduces speed on a grade, or when passing through an interlocking, efficiency in track capacity dictates that the spacing between the trains, in terms of distance, can be reduced because the first train, after passing the grade or interlocking, will be accelerated and thus bring about the normal distance spacing during the time the following train is incurring its reduction in speed on the grade or through the interlocking. In order to provide the flexibility needed for efficient train operation under the circumstances outlined above, it was decided that four-aspect signaling, with comparatively short blocks, was much better than three-aspect signaling with long blocks.

A further fact leading to the adoption of the four-aspect signaling in the Toledo-Elyria territory was that the existing signal locations were spaced from 4,200 to 6,800 ft. apart so that the locations, with a certain few exceptions, were spaced about right for the four-aspect system.

Changes and Additions

In making the change-over, the old semaphores were replaced with Type-G color-light signals. The upper unit displays one of three colors—red, yellow, or green. The lower unit displays either red or green. The aspects and indications of the four-aspect system are shown in an accompanying chart.

Track Layout

Section	*Length (Miles)*	*No. of Tracks*	*Status*
Toledo-Vickers	3		
Vickers-Millbury	5	4	Completed
Millbury-Rocky Ridge	12	4	Previously c. t.
Rocky Ridge-Oak Harbor	3	4	Under construction
Oak Harbor-Port Clinton	11	2	To be done
Port Clinton-Bay Bridge	7	4	To be done
Over Bay Bridge	1	2	To be done
Bay Bridge-Sandusky	6	4	Completed
Sandusky-Huron	10	4	Previously c. t.
Huron-Vermillion	11	2	Completed
Vermillion-Amherst	7	3	Completed
Amherst-Elyria	7	4	Completed

Where medium speed, 30 m.p.h., is permitted for a diverging train movement over a No. 16 crossover in an interlocking, the control of the home signal is arranged to display red over green over red as a clear-restricting indication authorizing a train to proceed through the plant at 30 m.p.h. In such instances, the automatic signal in approach to the home signal displays the approach-restricting aspect.

Although the previous signaling

had been properly maintained, the system included certain types of equipment, materials and construction practices which were obsolete and in need of replacement. Therefore, the program of changing from the three-aspect to the four-aspect system included not only a change from semaphores to color-light signals but also replacement of instrument cases, local wiring, terminals, arresters, track connections, etc., so that the reconstructed system represents practically new signaling.

Construction Features

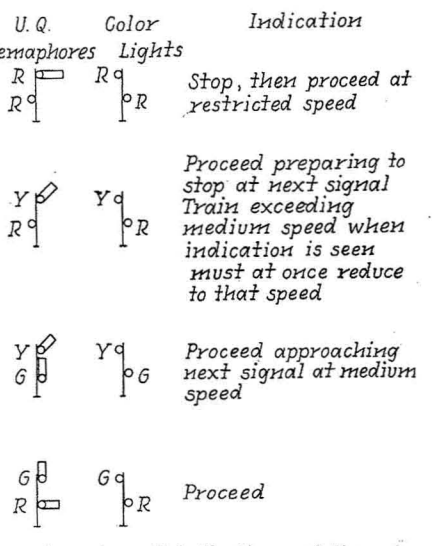
The old wooden instrument cases were discarded, using new six-way, welded sheet-metal cases at locations where only one or two signals are involved, and concrete instrument houses where three or more signals are located.

At locations where cases are used, the two or more cases are attached to two 3-in. channel irons mounted horizontally between two concrete posts, the bottoms of the cases being 2½ feet above ground level. The relays, which are of the wall type, as well as the transformers, rectifiers, terminals and arresters, are all mounted on the wooden back walls of the cases. The new arresters on the line circuits are the multiple-path type furnished by the Railroad Accessories Corporation. From the slack boxes at the bottom of the cases, the wires are run through enameled bridle rings to the instrument terminals. The No. 14 flexible jumpers between cases are run through a section of 2-in. conduit.

The incoming underground cables are brought up through a section of 4-in. soil pipe, the top end of which is 5 in. from the case. When the cable is in place, the voids in the pipe are filled with sealing compound. While the compound is soft, a section of 4-in. conduit is slipped down over the cable, through a hole in the bottom of the case, and seated in the compound before it hardens. The aerial cable runs down a cable post and into the case through a bushing in the bottom. In the concrete houses, the underground cable is brought in through sealed holes in the floor, and the aerial cables through holes in the walls near the ceiling.

The sheet-metal instrument cases were wired, complete with instruments in place, at construction headquarters, but the concrete houses were wired at their final locations. The concrete houses were unloaded from cars and set in place by a wrecking derrick.

At each location, a complete new system of cable was installed. The connections from the cases to the rail are in single-conductor No. 10 trench cable, using new bootleg outlets. A seven-conductor No. 10 underground cable extends from the case to a junction box near each signal mast from which point a seven-conductor trench cable extends to the top unit of each signal, with a jumper cable down to the lower unit. Two single-conductor No. 8 underground cables extend from the case to each train-stop inductor. The underground cable, made by the various wire companies, has a protective covering including rubber insulation, non-metallic sheath, etc.,



Aspects and indications of the four-aspect system

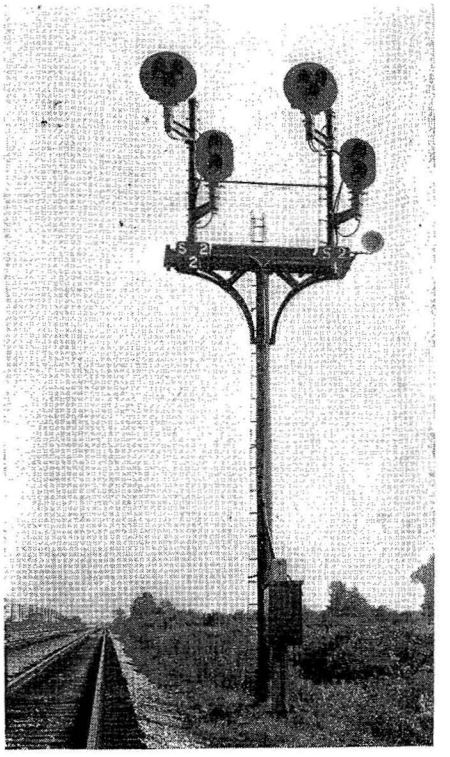
made according to New York Central specifications.

New cables between the line poles and the instrument cases were made up using single-conductor insulated No. 12 soft-drawn copper wires, laced with marlin to No. 6 Copperweld messenger. The new line control circuit required the stringing of one No. 10 Copperweld wire with weatherproof covering.

Power Supply System

The power supply system previously in service was used without change. A 440-volt, 60-cycle, single-phase power circuit is carried on two No. 4 weatherproof copper line wires. This line is fed from commercial sources 5 to 15 miles apart, being sectionalized at service points. A power-off warning consisting of a lamp and buzzer tell-tale is located in a tower or station at the west end of each feed section, at which point a manually-operated switch is provided to connect the power circuit to the next section.

At each location there is a G.R.S. 440-110-volt line transformer, which is housed either in a sheet-steel case



New color-light signals were installed

or in the concrete house. These transformers are used for feeding the signal lamps normally, as well as to feed the rectifiers. At each location involving one or two signals, there is a set of five cells of Exide EMGO-7, 120-a.h. storage cells, while at locations including three or more signals, two such sets of battery are used. Each track circuit is fed by one cell of either Edison B-6 or Exide EMGS-7 storage battery. The storage batteries are housed in concrete boxes, except at locations where concrete houses are used, at which points the batteries are in the houses.

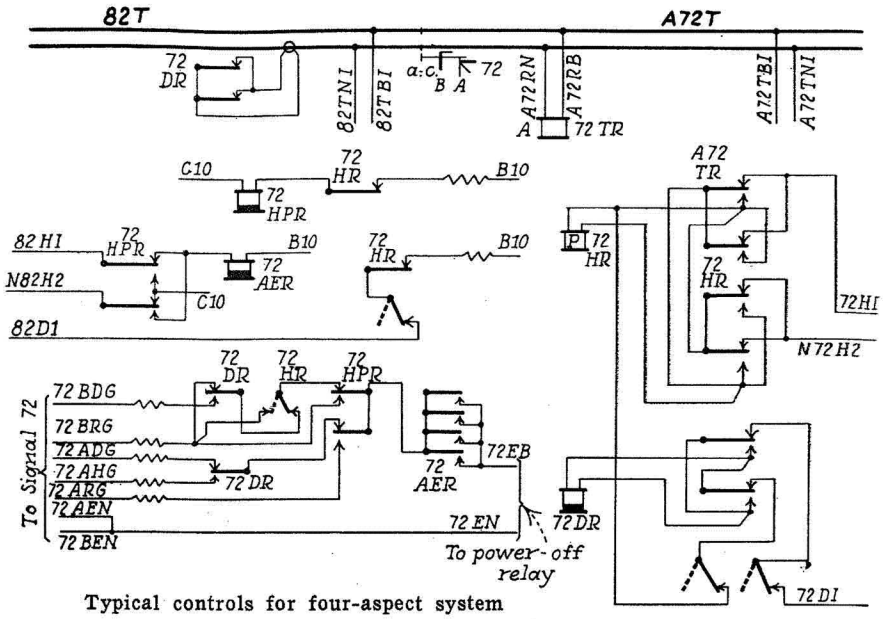
Change-over in 15 Minutes

Having completed the preliminary construction, consisting of the installation of the cables, instrument cases and houses, and stringing the new line wire, on a section involving 10 to 20 miles, the section was then ready for the change-over to the new system. At this time a blanket bulletin was issued notifying train crews to expect semaphore signals to be changed over to light signals progressively within a certain period on the section designated. When making the change-over at a location, the construction forces chose a time between trains so that no train was stopped or proper protection sacrificed. The average time required to remove the Style-B mechanism, complete with mast and arms, and to install a new mast with the color-light signals and to make the final wiring connection.

was 15 min. New channel iron crosspieces had to be installed on the single-mast platforms to support the bases for the new masts, but these were all cut and drilled to fit previously, so that they could be installed quickly.

Changes in Control Circuits

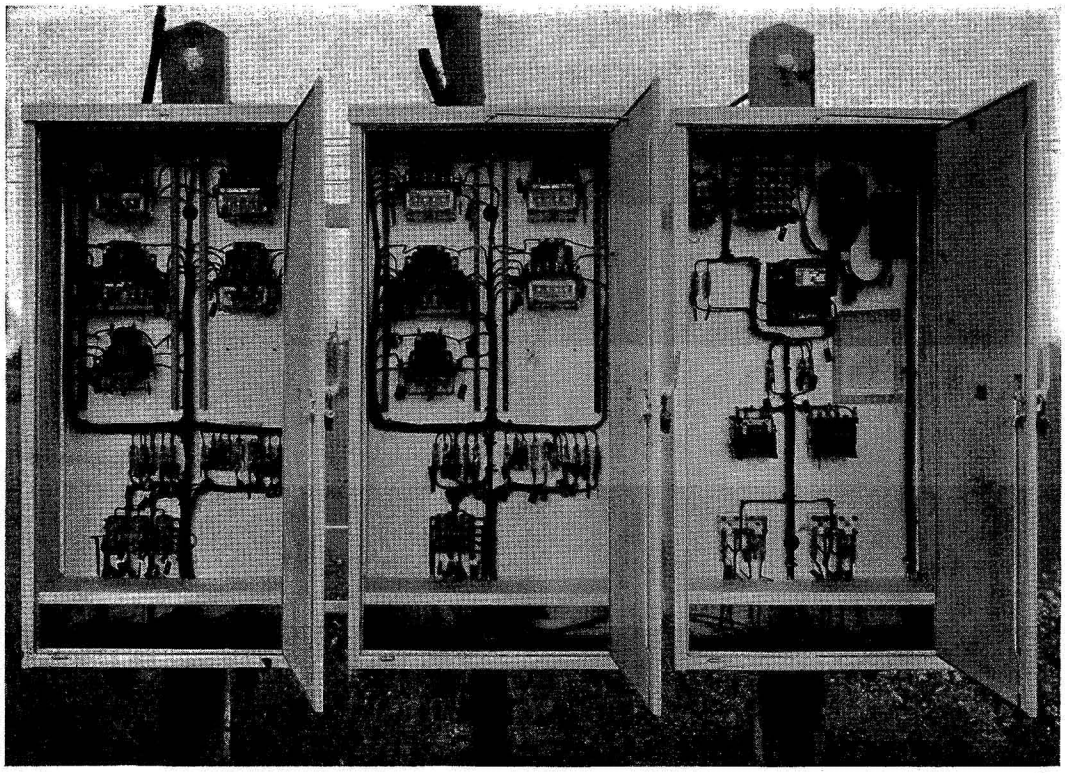
In order to provide the control for the fourth aspect, an additional line circuit and certain changes and additions were required in the control circuits, a typical example of the new controls being shown in the accompanying circuit diagram. In the previous arrangement, the signal was controlled to the approach and to the clear aspect by two d-c. neutral relays with single-wire line control circuits through the d-c. neutral track relays and to the d-c. neutral control relays at the next signal. The additions to the controls include an additional line control wire, a 200-ohm polar neutral relay, a 400-ohm d-c. neutral, slow-release relay, and a 400-ohm d-c. neutral slow-acting relay termed the "clear" relay. With the block occupied, track relay A72T is de-energized and as a result, relays 72HR and 72DR are released. This causes the display of the stop-and-proceed aspect—red over red. With the second block in advance occupied, the polar relay 72HR is picked up with the polar contact to the left, thus leaving 72DR released. This results in the display of the approach aspect—yellow over red. With the third block in advance occupied, relay 72HR is energized with the polar contacts to the right, thus completing circuits to display the approach-restricting aspect—yellow over green. With the three successive blocks in advance unoccupied, relay 72HR is energized with the polar contacts to the right. In addition, line circuit 72DI, fed through a polar contact in the HR relay of the signal in advance, is feeding through a closed polar and neutral contact of relay 72HR to pick up "clear" relay 72DR, and this combination causes the proceed aspect—green over red—to be displayed.



Typical controls for four-aspect system

The inductor winding of the intermittent train stop system is closed only when the "clear" relay is picked up, i.e., only when a "proceed" aspect is displayed by the signal. If a train passes a signal displaying any of the other three aspects, a service application of the air brakes is initiated, unless the engineman acknowledges within a 15-sec. period.

This change-over program was handled by the New York Central signal department forces under the jurisdiction of F. B. Wiegand, signal engineer, and E. N. Bousquet signal supervisor, was in charge of the field construction, with two crews of 17 men each, with W. F. Kalk and J. F. Pinneger as foreman of the crews. The new signals, relays and other major items of signal material were furnished by the General Railway Signal Company.



Sheet-metal instrument cases were used at the locations involving only one or two signals