Signaling of the New York Subways

Independently-owned system installs interlocking and signals on new extensions

SINCE the opening of the Eighth Avenue line of the subway system owned by the City of New York, Board of Transportation, in September, 1932, this organization has constructed several extensions in order to serve Brooklyn, Queens, and the Bronx. This article describes the automatic signaling and interlocking on these extensions.

The first addition to the Eighth Avenue line was an extension to the south into Brooklyn, running from Fulton Street, Manhattan, to Jay Street-Borough Hall, Brooklyn, and shortly thereafter to Bergen street, Brooklyn. This extension is through tubes under the East river at the south end of Manhattan Island and consists of approximately 2.5 miles of double track. It also includes the Broadway-Nassau station on the New York side, and the High Street, Jay Street-Borough Hall, and Bergen Street stations on the Brooklyn side. The Brooklyn section was further extended in October, 1933, to Church avenue, which is the present terminal of the line, involving a further increase of approximately four miles of four-track road. At Bergen street and at Jay Street-Borough Hall, provision has been made to connect with the Fulton street, the Houston street, and the Queens-Brooklyn crosstown lines, all of which are to be equipped in the near future.

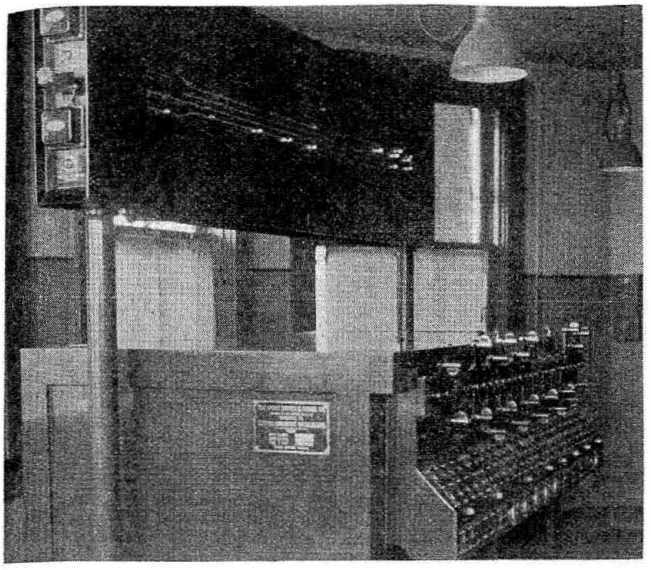
The second important addition to the system, completed in October, 1933, starts at 135th street on the Eighth Avenue line extending into the Borough of Bronx and north under the Grand Concourse to 205th street. This is known as the Concourse line, and in addition to serving this section of the Bronx, affords access to the Polo grounds and the Yankee stadium. The line is approximately 6.25 miles long with three tracks. The center track is used for express trains and is signaled for traffic in either direction under the traffic-direction control system, which will be explained later. The storage and inspection yard at the north end of this line is known as Concourse Yard.

The third important extension of the system, that into the Borough of Queens, was placed in service in August, 1933. This double-track line connects with the Eighth Avenue line at 42nd street and extends eastward under the East river to Queens Plaza in the Borough of Queens, a distance of 3.25 miles. The line from Queens Plaza to Roosevelt avenue, 3.5 miles, is four track and it is planned to extend this line under Queens boulevard to Jamaica in the future.

The portion of the Brooklyn crosstown line now in service consists of two miles of double track from Queens Plaza in Long Island City through tubes under Newtown creek to Nassau Avenue in Greenpoint. This line will later be extended to Bergen street in Brooklyn, to connect with the line now operating through that station. At the future Hoyt-Schermerhorn Street station, on the Fulton Street line, facilities will be provided to permit transfer to all lines and branches in the vicinity of Borough Hall. This Crosstown line, when completed, will be the only direct route between Queens and Brooklyn by subway. Considerable travelling time will be saved between these points as it will no longer be necessary to go into Manhattan from Queens in order to go to Brooklyn by rapid transit.

INTERLOCKINGS INSTALLED ON NEW LINES

Smith Street Line	Size of Frame	Working Levers	Number of Switches	Number of Interlocking Signals	Number of Automatic Train Stops
Jay St. Boro. H.	35	28	12	31	32
Bergen St.	35	28	8	48	42
Fourth Avenue	27	21	11	19	13
Church Avenue	47	36	20	39	27
Concourse Line					
161st Street	28	17	4	10	10
167th Street	32	24	7	14	14
Tremont Avenue	40	32	8	21	19
Fordham Road	28	8	4	16	15
Bedford Pk. Blvd.	60	54	19	39	37
205th (Perry Ave.)	28	22	8	13	12
Concourse Yard	80	74	40	56	14
Queens and Crosstown Lines					
Lexington Ave.	24	17	4	12	12
Queens Plaza	44	36	11	32	30
36th Street	28	24	9	16	13
Northern Blvd.	12	8	2	7	6
Roosevelt Ave.	60	42	12	40	32
Court Square	32	25	6	20	19
Nassau Ave.	24	15	4	9	9
Total 18 Machines	664	511	189	442	356



Electro-pneumatic interlocking machine at Fourth Avenue in Brooklyn

Twenty-four-hour express service is maintained on the Eighth Avenue line between 145th street and Chambers street, Manhattan. Express service on the center track of the Concourse line is southward in the morning and northward in the evening, between 205th street—Perry Avenue station, Bronx—and 135th street. Local service only is operated on all other lines or branches, all trains stopping at all stations, the Eighth Avenue expresses continuing into Brooklyn as local trains. The local service in Manhattan terminates at the Hudson terminal—Chambers Street station.

Eighteen additional interlockings were installed on the new sections of line. Of these, four are on the Smith Street line, and seven each on the Concourse and the Queens-Crosstown lines. The number of working levers of each interlocking machine, size of frame and number of switches, signals, and automatic train stops operated is shown in the accompanying table. In addition to the signals and automatic stops listed at interlocking plants, there were installed in automatic territory 494 signals and 492 automatic stops, totaling 936 signals and 848 automatic stops on 67.1 miles of track, an average of 14 signals per mile of track. There are approximately 9 switches per route mile.

The signaling system was installed according to plans and specifications developed by the engineers of the Board of Transportation of the City of New York. The construction was divided into three contracts. The General Railway Signal Company furnished and installed the signaling for the Concourse lines, Queens lines and the Concourse car storage and inspection yard. The Union Switch & Signal Company furnished and installed the signaling on the Smith Street line from Fulton street, New York, to Church avenue, Brooklyn. The operating characteristics of the additional lines are similar to those of the original Eighth Avenue line and the construction and installation of the signaling closely follows the original installation, as described in *Railway Signaling* for October, 1932. Some further developments for traffic-correction control and time signals are later described.

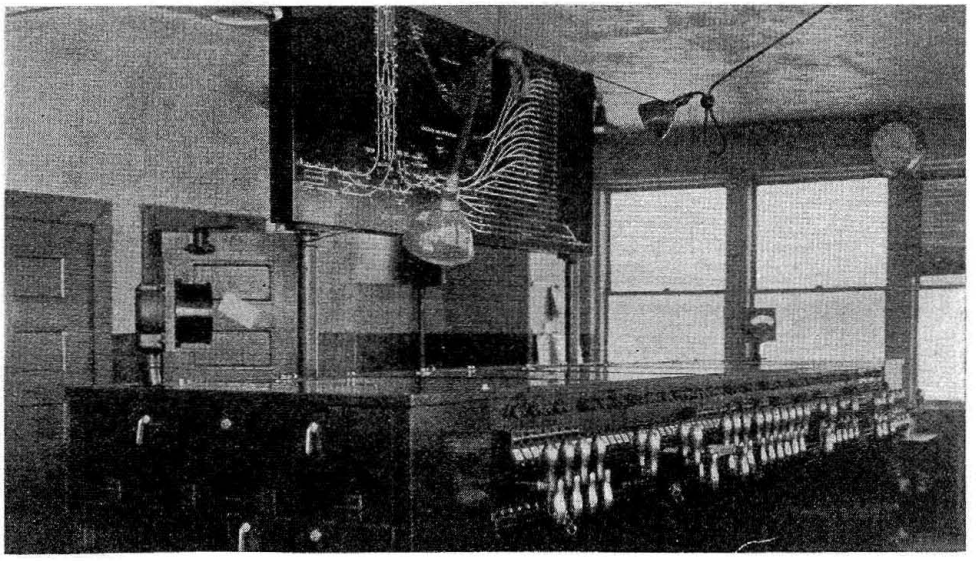
Developments on New Lines

The track circuits are the a.-c. single-rail type, as used on the earlier installation, except that bootlegs of the Raco riser type are installed instead of the wood type formerly used. The track circuit wires for the feeders and the relays are taken from the track case by means of conduits buried in concrete. At the rails, an outlet box (also buried in the concrete) equipped with an ebony asbestos cover with the Raco riser attached, acts as the bootleg. The outlet box is drained into the track trough by means of a conduit buried in the concrete.

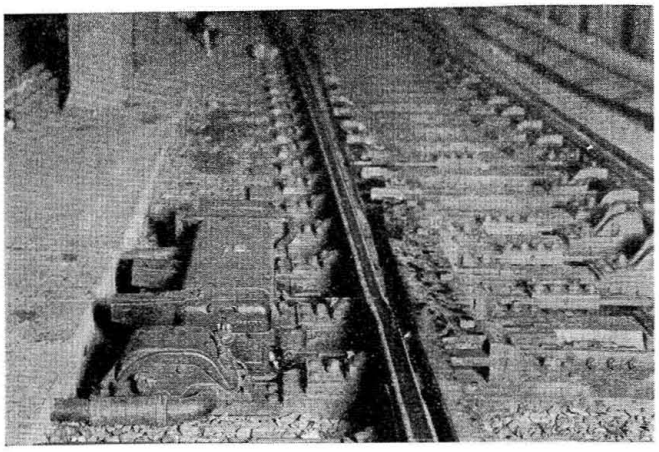
The Concourse yard track circuits are of the centralized type and are fed in multiple from one track feed bus. Each track circuit tap is separately fused and has a separate resistance. The track-circuit equipment is concentrated in the tower. The track feed bus is energized by either, or both, of two track transformers. The signal controls are substantially the same as formerly used with some slight modifications.

On the Eighth Avenue installation moves against traffic were allowed, but on all other lines no moves against the normal flow of traffic were allowed except under special conditions and at terminals, etc. On the Eighth Avenue line, these reversed traffic moves were made without an absolute stop signal in the normal direction of traffic, it being understood that when these moves were made, flagging was required. On the extension herein described, the reverse-direction moves are protected by an absolute stop signal, located braking distance away from the limit of the reverse move. Such protection is illustrated by a reverse move into a station platform adjacent to an interlocking, (as for instance northbound on track B1 at Church avenue) where it has been found desirable to place an absolute stop signal at the normal entering end of the station, to provide signal and stop protection for a train making a reverse move into the station. This protection is retained until the rear of the train has cleared into and is at stop in the station.

Signals that govern normal-direction moves over tracks that have opposing-signal and stop-protection cannot be displayed as proceed signals until after the opposing stop has been lowered. This assures that no clear signal will be given with an opposing train-stop in the



Electric interlocking machine at Concourse Yard



Electric switch machine

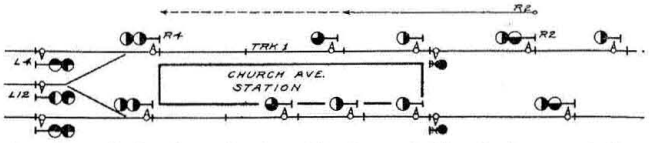
tripping position, due to failure of the stop-clearing apparatus to function properly and assures, as far as possible, that a train will not be tripped after receiving a proceed indication.

On the Eighth Avenue line three yellow lights is an indication that the route is set for a siding or yard track, which is already occupied by a train. When this indication is given it is not necessary for the motorman to operate the stop-release key to get a home signal, as is required when a call-on signal is displayed. On the new extensions, the use of the yard-indication signal (three yellows) has been extended to include any yard, siding, or third move that may be desired to be made, without stopping and keying by. The route signal on the home signal is limited to two routes. Thus, in general, a third move, when the track circuits are unoccupied, can be made under three-yellow indication signals without resultant delays due to stopping at the signal and keying by, as would ordinarily be had under a call-on signal.

On account of the grades and locations of the stations it was necessary, in numerous instances, to install "grade-time" or "station-time" signal control. On the Concourse line between Tremont avenue and 145th street southbound, the grade is all descending, so that if the grade control signal did not the limit the speed to 30 m. p. h., a speed of over 70 m. p. h. might be attained. The grade-time signals have proved very successful, and it is to be noted particularly that with these signals controlled by two-block clearing, the maximum of safe speed with even running and the minimum of braking is possible.

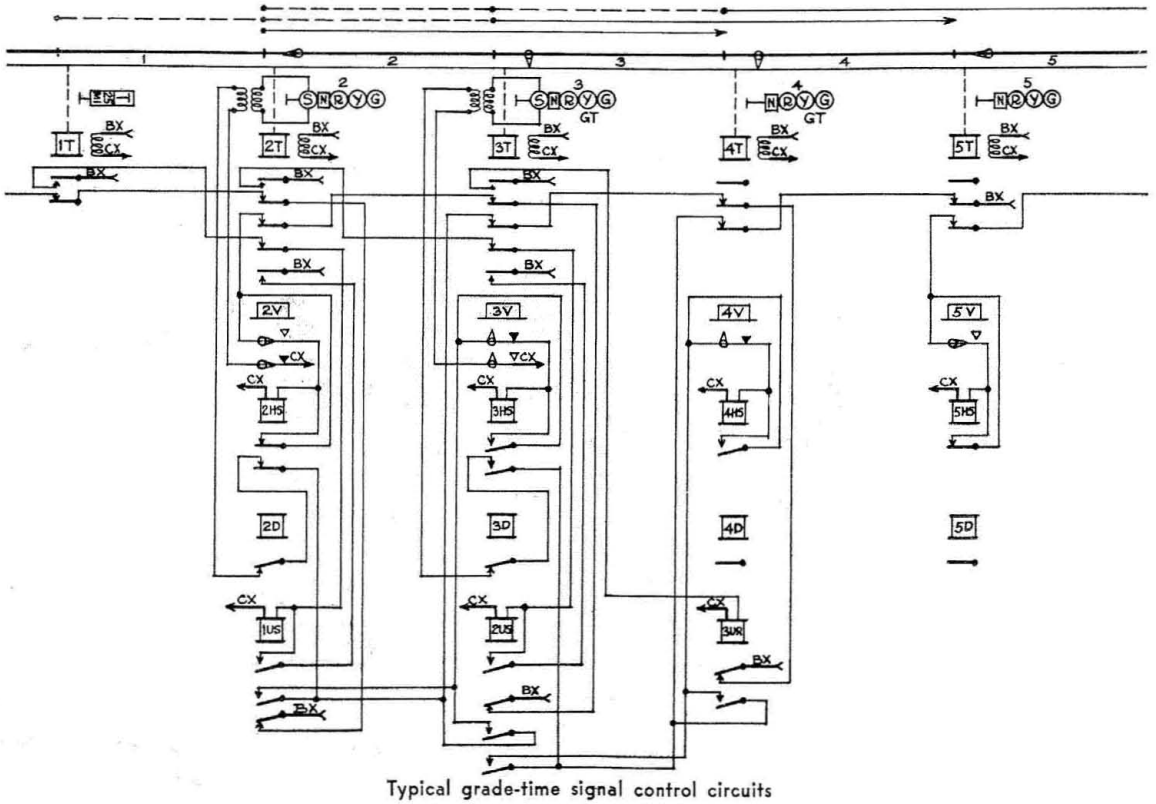
Special Controls

Upon entering the "grade-time" controlled territory the signal ahead will, under normal-clear track conditions, display a yellow and an illuminated "S," indicating to the motorman that the second signal ahead will also clear, provided he limits the average speed of his train to that posted at the entrance to the "grade-time" territory. When the motorman obeys the speed limit, the yellow will change to a green, and the illuminated "S" will go dark. This indicates to the motorman that he has obeyed the posted speed limit, and that he can safely



Location of signals and automatic stops at Church Avenue station

continue at that speed to the second signal, this second signal having changed from red to yellow with an illuminated "S." With continued normal-clear track conditions all subsequent signals and "S" indications in the series will clear and illuminate, providing the train does not exceed the posted speed limit. Thus trains can continue running, under "green" signals at the maximum safe speed to the end of the "grade-time" territory. Should he, however, bring the average speed of his train above the posted speed limit the signal will not change

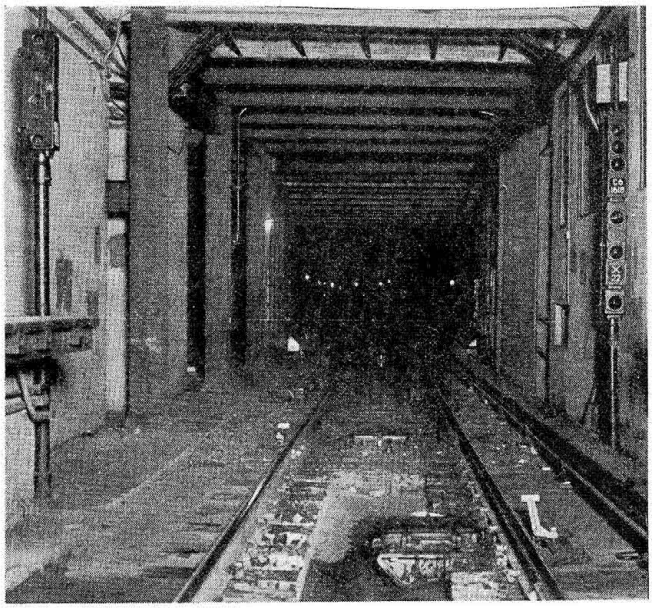


Typical grade-time signal control circuits

to "green," and indicates to the motorman as he passes it, that his train has been running at a higher average speed than the posted limit. It is also a warning to him that he must bring the average speed down to that posted, before reaching the next signal (which is still at red), or the signal will not clear and permit his train to pass, without the brakes being automatically applied. If a "grade-time" signal shows only yellow without the letter "S," it indicates that the signal will not change to green under speed-control, and that caution must be exercised.

By means of the "station-time" control, it is possible, at stations and other congested points, to close in on trains that have stopped or slowed down, provided that the train closing in has reduced speed to a predetermined low value, which speed in turn reduces the braking distance required between the next danger signal and the rear of the preceding train. The track controls of "station-time" signals are shortened by time-element relays, operated by the following train, running at a predetermined required speed, while approaching these signals. The trains can operate because of this reduced speed, on a much shorter headway than would be possible if signal controls were not shortened by the time-element relays.

Where there are two or more signals in a series using "station-time" control, the controlling circuits are so arranged that certain signals in the series may be cleared by "time-control" on successive track sections in approach to a signal, so that if the speed of the train is not reduced sufficiently on the first section or other conditions are not satisfactory, a second or even a third chance to clear the signal is obtained, each successive timing device being set for a lower speed. By this means delay is avoided, that would otherwise cause a train stop whenever a signal requiring "time-control" was approached on an approach section at a speed greater than that determined as necessary to operate the time-element relay. It provides a second or third opportunity to avoid this stop, by forcing a reduction of the speed of the train. This method of signal control also permits a train to move into a station at approximately the same speed as the preceding train is moving out of the station, and reduces to a minimum the number of train stops at signals within station platform limits or closely approaching station platforms.

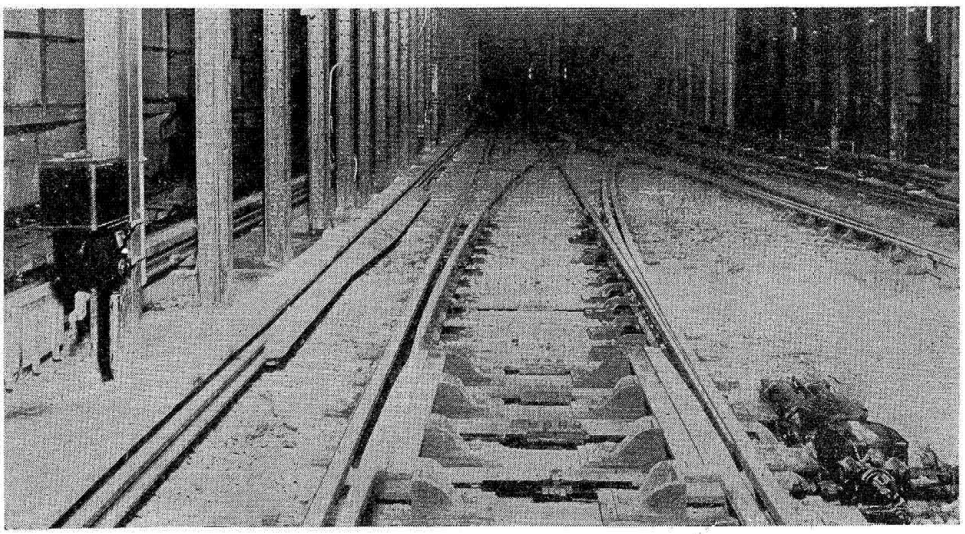


Train stop and signals at end of station platform

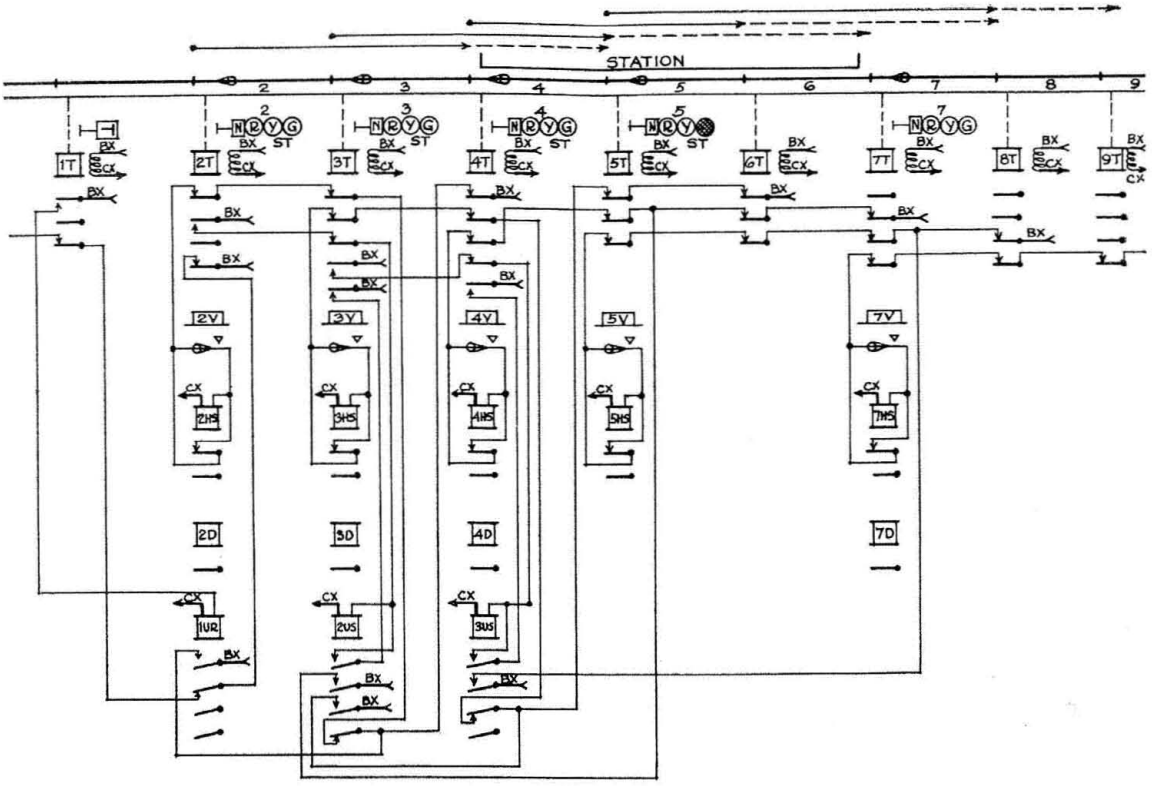
Traffic-Direction Control

The signaling on the middle track C3-4 of the Concourse line is for both directions, the service being downtown in the morning and uptown in the evening. An express service is operated and full signal and automatic stop protection is provided for both directions. A directional control system is used to assure safe conditions when traffic direction is changed; and is such that clear signals can be displayed in but one direction at a time, in any section of track between two controlling interlockings. The main points of the system are that opposing signal protection is always in effect; that track sections between the limiting points are unoccupied before an "unlock" is received; that a check is received showing that all direction-control relays respond to lever and are open; and that all signals go to danger before traffic direction can be changed. The direction-control relays are the three-position polyphase type, and the circuits are so arranged that "stop" indications are displayed by the signals for the traffic direction not in service. To change the traffic direction at any time requires the cooperation of the towermen at both ends of the direction-controlled track.

The traffic-direction control involves three distinct circuits: the lock circuit, the direction-control circuit, and the indication circuit. Southbound is arbitrarily assumed as the normal traffic direction. When it is desired to reverse the traffic-direction control from south to north, the towerman at the north end of the section reverses the position of his traffic-direction control lever (which he can do at any time), thus stopping any further entry of trains into the controlled section of track, from his end. Upon the arrival of the last train to enter the controlled section of track and the clearing of the limits of the controlled section, the towerman at the south end receives an "unlock" and can reverse the position of his traffic-direction control lever to the reverse indicating position. This action opens the direction-control circuit and all direction-control relays are de-energized, all signals display the stop indication, and the lock circuit for the direction-control lever at the north end of section is



Electro-pneumatic switch machine

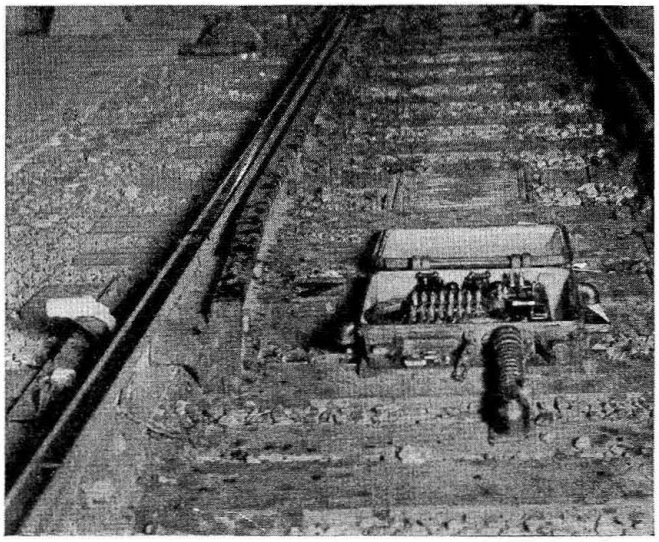


Typical station-time signal control circuits

broken, thereby locking the lever. After the satisfactory de-energizing of all the direction-control relays the indication circuit is completed, and the towerman at the south end can accept his indication and complete the movement of the lever, allowing all northward signals in the controlled section to clear.

When it is desired to change the traffic-direction control back to southward, all track circuits in the controlled section must be clear of trains. The towerman at the south end of the section moves the traffic-direction control lever from full reverse to the normal indication position. When all direction-control relays have been de-energized and all signals show "stop" indications, the indication circuit is completed and the direction-control lever can be placed full normal, allowing all southward automatic signals in the controlled section to clear.

When the traffic-direction control relays in the controlled section have been energized in the normal position, the traffic-direction control lever at the north end can be unlocked and moved from the full-reverse position to the full-normal position, and the interlocking signals at the north end can be cleared to allow a train to enter the controlled section. Light indicators on the interlocking machine and the illuminated track indicator are arranged to show when an "unlock" is received, when indication is received, when all signals are at danger, and also the traffic direction in effect at any time.



Train stop trip mechanism with cover open

Master Lever Control

The five intermediate towers between 135th street and Bedford Park boulevard interlockings, inclusive, are each equipped with a master lever for the purpose of cutting out the interlocking control when the interlocking is out of service. This is accomplished by having the master lever mechanically lock normal all of the switches leading from or to the express track C3-4, and electrically relaying the traffic-direction control in use through the interlocking to the next tower. The master lever also cuts around the lever contacts of the interlocked signals for track C3-4, so that with the master lever normal (tower out of service) they function as full automatics. Each master lever is mechanically locked in such a way that the lever must be reversed to put the tower in service before any switch operation for movements to or from the express track C3-4 can be made. Each master lever is also electrically controlled in such a way that the lever can be put normal (tower out of service) at any time with trains approaching or passing the interlocking, provided always that all switch levers for movements to or from express track C3-4 are normal.

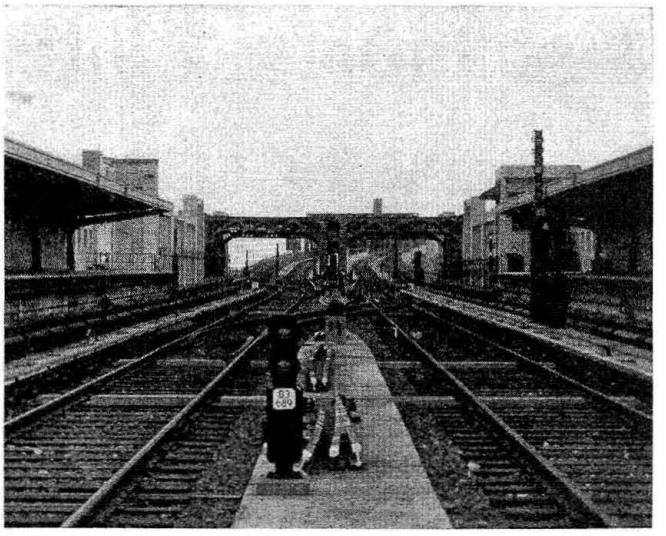
To close the tower, the traffic-direction control levers for traffic on either side of the interlocking must be in accord, either both for northbound, or both for southbound traffic. With these conditions set up, the master lever may be placed normal and the tower closed, with or without previously placing the signal levers for track C3-4 normal. In either case, however, the master lever

contacts shunt around the signal lever contacts and the mid-track signals function from then on as fully automatic block signals. This allows the towerman to put the tower out of service without having to wait for all trains to clear the interlocking and approaches.

The local-track signal levers do not affect the master-lever circuits in any way, and they must be left reversed in the usual manner, that is, the local signals always retain their interlocking features.

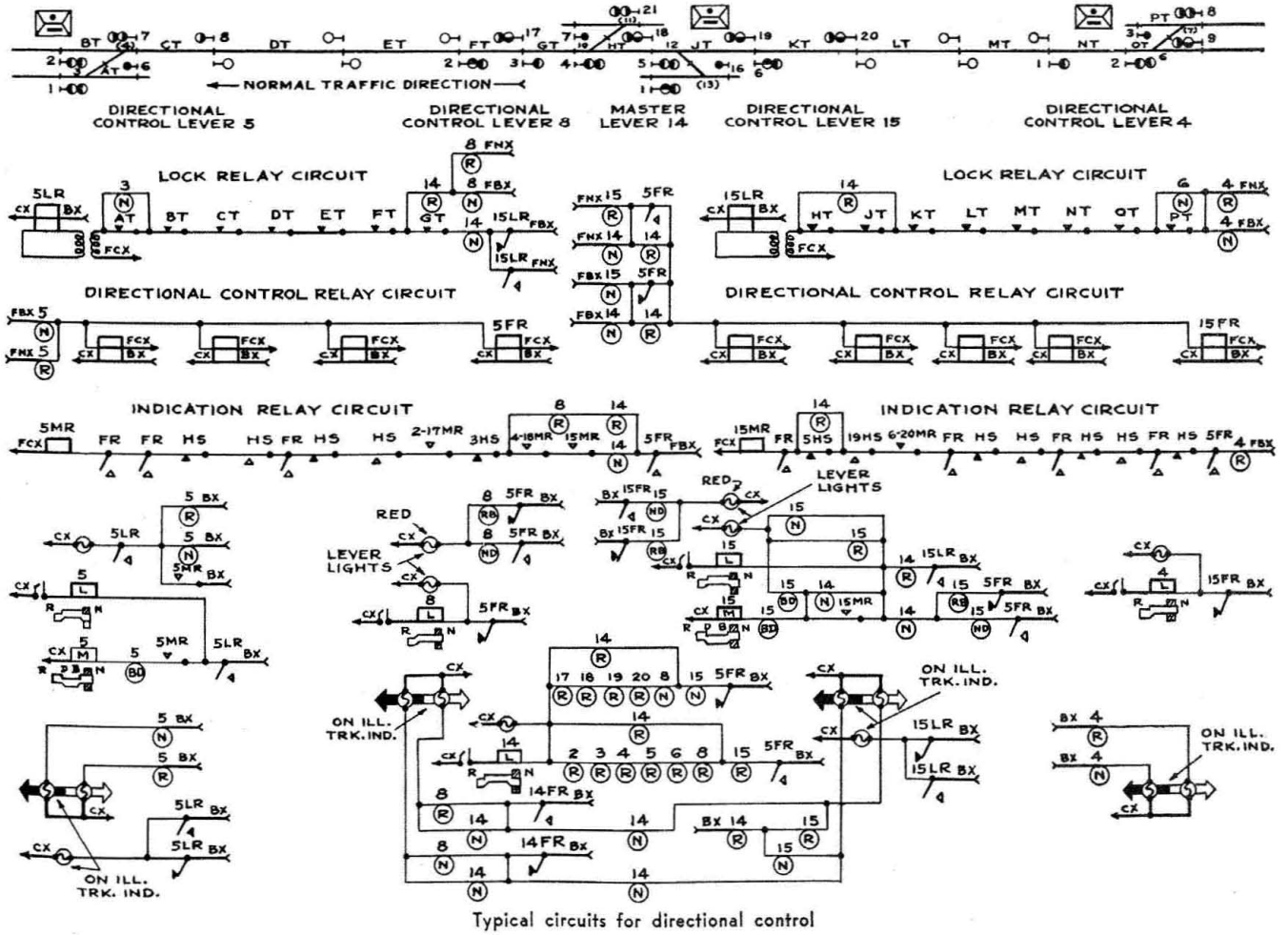
Opening a Tower

With the tower out of service (master lever normal) traffic-direction may be changed by the towerman on either side of the closed tower, all circuits being relayed through the closed tower by normal contacts on the master lever. Opening a tower on the three-track line and bringing the interlocking into service requires the reversal of the master lever. Before this can be done, both the traffic-direction control levers and the signal levers for all signals on the C3-4 track must be set up for train moves in the direction of traffic in effect at the time. This must be done to avoid tripping or delaying trains that may be passing through or approaching the interlocking at the time of opening the tower. Also since the traffic-direction control through the interlocking may have been changed since the tower was closed, it is important that traffic-direction control be set up for the direction of traffic in effect at the time, and the signal levers reversed for train movements accordingly. When this is done the master lever can be reversed and the interlocking comes under the full control of the towerman. The position of the lights in the illuminated arrows on the track indicator shows the traffic direction in effect at the time, and the lever lights on the traffic-direction levers show whether the lever positions agree with the traffic direction.



Signals and switches at north end of Fourth Avenue station in Brooklyn

In all other respects the control, construction, and installation of the switch and signal system on the new lines closely follow that on the original Eighth Avenue installation as described in the October, 1932, issue of *Railway Signaling*. The contractors for the Eighth Avenue work were also the Union Switch & Signal Company and the General Railway Signal Company.



Typical circuits for directional control