A. C. Signaling in the Centre St. Loop

Automatic Features of System in New York City Subway Which Provides 60-Second Headway

By Walter F. Hudson

The Centre street loop subway in New York City was designed to connect the Manhattan terminals of the Brooklyn, Manhattan and Williamsburg bridges across the East river. The Chambers street station on this subway is located in the basement of the new Municipal Building, and at the present time this station serves as a terminal for both the Fourth avenue and the Broadway line. In the completed system there will be a connection to Park Row, the New York end of the Brooklyn bridge, thus connecting the three bridges and there will also be a two-track line down Nassau street to Broad street to a connection with the proposed Whitehall street-Montague street tunnel to Brooklyn.

This section of "The Dual System of Rapid Transit" was placed in service August 4, 1913. At that time only two tracks were in operation and the Fourth avenue connection had not been made. Robert C. Johnson, signal engineer of the New York Municipal Railway Corporation, described the signal installation then existing in his article in *The Signal Engineer* for February, 1914. Since that time the subway has been completed, all four tracks are in operation on the Broadway line and the connection to the Fourth avenue is in service. The Federal Signal Company has installed a new signal system, under Mr. Johnson's direction, removing practically all of the system first installed. Sixty trains an hour are now being operated over the Williamsburg bridge, and in spite of the problems involved and the engineering difficulties to be overcome, the system and the signal installation are working out most efficiently. Fig. 1 shows the track, signal and station layout.

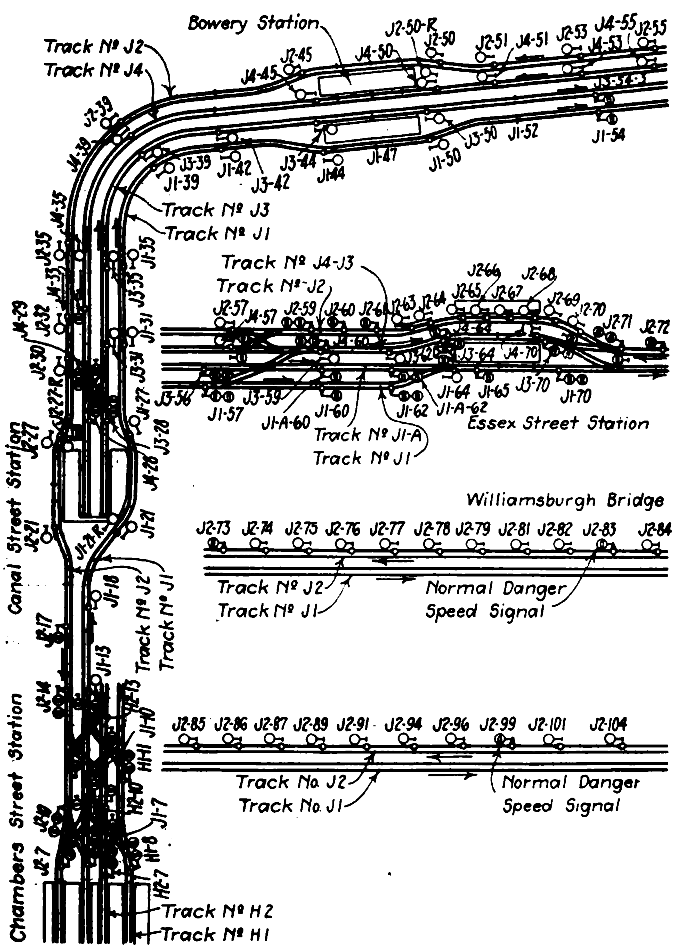

Fig. 1. Track and Signal Layout in Centre St. Loop and Across the Williamsburg Bridge.

POWER SYSTEM

The a. c. power for the operation of the signal system is distributed from the Centre street substation at 2,200 volts, 25 cycles, single phase. This is taken from the 6,600-volt mains, as shown in Fig. 2. One of the transformers carries the full load, the other being held in reserve for emergency use. The only d. c. energy supplied to the system is that required in charging the storage batteries at the Canal street interlocking. This battery receives its charging current from the third rail, through an adjustable resistance.

Both the 2,200-volt a. c. mains and the low-tension cables are run in multiple clay ducts, provided in the tunnel construction so as to form a footwalk along the side of the subway, from Chambers street to the westerly end of the Essex street station platform. From this point, for a distance of several hundred feet through the Essex street station they are carried in 2-in. loricated iron pipe suspended from the top of the subway, then in duct again for about 300 ft. to the easterly portal of the subway. East of this portal, no ducts being available, the cables are carried on two-pin crossarms suspended from girders. The duct lines used for signal purposes in the subway are on the same side as the conduit and crossarms, making a practically straight transmission line throughout.

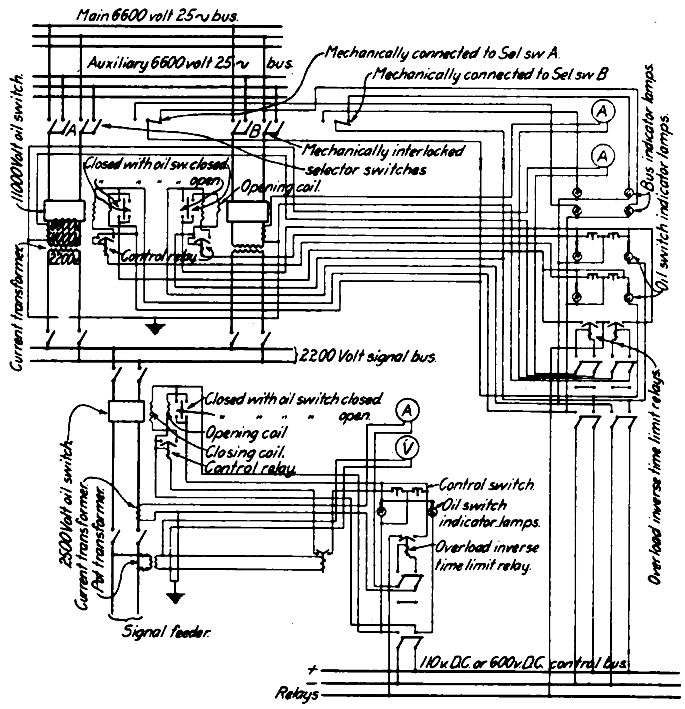

Fig. 2. Typical Sub-station wiring in the Centre St. Loop Signalling.

At points in the subway where it was necessary to locate junction boxes, special compartments were constructed to hold the line transformers, plug cut-outs, sectionalizing switches and low-tension junction boxes. These compartments are used as a center from which the low-tension conductors radiate to all four tracks, being carried overhead in 2-in. conduit along and across the tracks to the instrument cases. Two-inch conduit is also used between instrument cases and signal heads.

A twin conductor lead-covered cable made up of No. 6 B. & S. copper wire is used for the 2,200-volt signal transmission line. Copper clamps are soldered to the lead sheath of this cable at each splicing chamber, and then a bond connection is made to one of the high-tension power cables to provide protection against the possibility of a ground of any kind. Adjacent sections of the lead sheath are also bonded together so as to polarity of the current used in the control of the three-position relays. The load on the two 55-volt secondary windings is equalized as nearly as possible by dividing the local junctions between the two sources. The signal lights, track transformer and the local windings of the two type U relays require energy continuously; the automatic stop valve and the stick relay only while operating. The three secondary wires run from the trans-

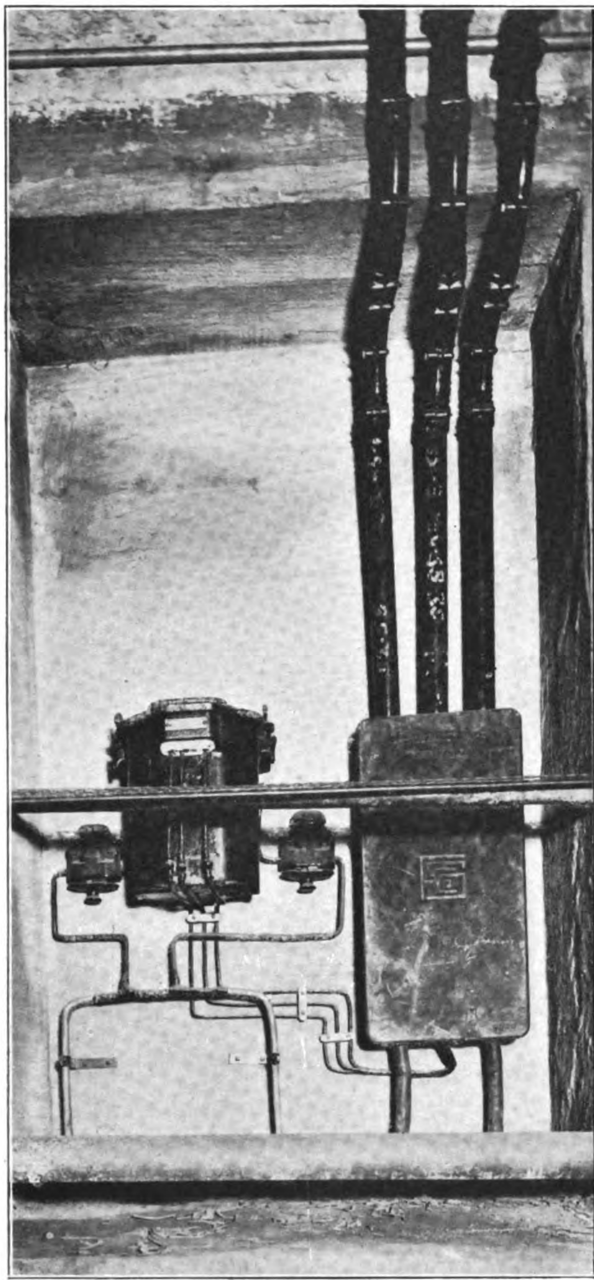

Fig. 3. A Typical Splicing Chamber Compartment in the Subway from Which the Low-Tension Circuits Radiate.

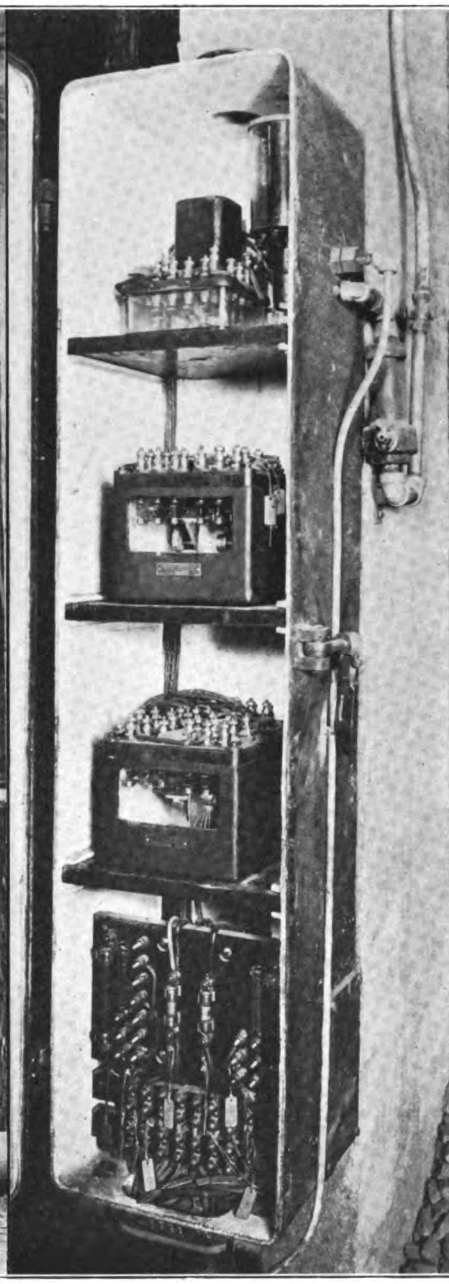

Fig. 4. Open Instrument Case, Showing Relays, Terminal Boards and Automatic Stop Valve.

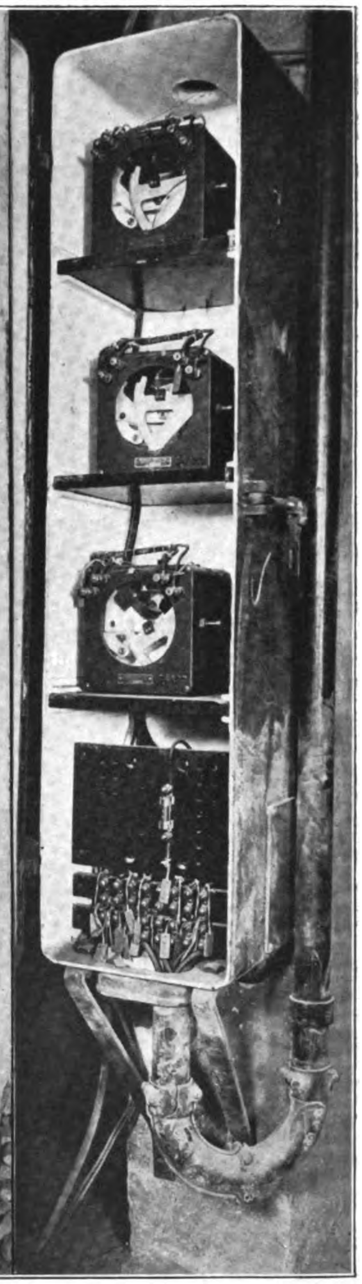

Fig. 11. Interior of Instrument Case Containing Time Elements and Terminal Board.

form a continuous path, and each transformer is bonded to the lead sheath of this cable for the same reason, i. e., for ground protection. Within the splicing chambers both the high and low tension cables are covered with a preparation of sand and cement to protect them from short circuits, blow-outs, etc. Between the splicing chamber and the plug cut-outs the 2,200-volt wires are carried in split iron conduit.

The primary side of the line transformers, which feed both the line and local circuits, is wound for 2,200 volts, 25 cycles, with a plus 10 per cent tap to allow for drop in the transmission line voltage. The secondary side of these transformers is wound for 110 volts with a neutral tap of 55 volts. The neutral tap is connected to common and upon the selection of the 55-volt tap, one side or the other of the neutral tap, depends the former to the low-tension junction box on cleats, as shown in Fig. 3.

The high tension cable will, in the permanent arrangement, run to sectionalizing switches at the line transformer locations, which means that this cable will be broken at each of these locations. These switches are installed to enable a section of the system to be operated by a sub-station, other than that which usually supplies it, if the usual supply is cut off. As only the Centre street sub-station supplies energy to this section of the system at the present time, no switches have been installed.

LOCATION OF SIGNALS

It was necessary to so locate the signals as to permit the handling of 60 trains an hour, i. e., with one minute headway between trains. The conditions determining these locations were: First, the location of stations, station stops and interlocking plants; second, the acceleration and deceleration of trains; third, the curves and grades of the tracks; fourth, the length of trains, and fifth, the headway, which, as stated above, was taken as 60 trains per hour. This means that in the rush in the morning 60 trains an hour run west on track J2 to Essex street, where the traffic splits to take care of the unloading of passengers, part going straight down track J2 and the remainder going down track J4. In the evening rush the operation is just reversed, track J4 becoming J3 and taking care of eastbound trains only.

The construction plans provided all the necessary data on the location and design of stations, platforms, curtain walls, interlockings, splicing chambers, etc. The real problem was to so place the signals as to give the one-minute headway and still keep the system safe. The system decided upon is one in which the signals have an overlap, which is usually a full block in length, but is at least equal to braking distance at the maximum speed, plus a certain factor dependent upon conditions at the given point. A factor which complicates matters considerably is that some of the trains run through stations express, while others stop to unload passengers. It will be seen at once that to facilitate traffic and to provide maximum capacity to the system, an automatic means of adjusting the signal conditions to the traffic must be provided. And this means that when the trains are running express the following trains must remain behind a distance equal to maximum braking distance, plus the safety factor, but when the trains are reducing speed and stopping, those behind must be enabled to close in, in order to save time. The method of taking care of this will be described in a later paragraph.

All of these factors having been considered, and having obtained from actual tests the braking characteristics of the equipment to be used, time-distance curves were developed for the entire new system, and from these studies the signal locations were determined.

ARRANGEMENT OF APPARATUS

The junction boxes, as previously stated, are located in the splicing chamber compartments. These boxes are of cast iron, and each is fitted with two vertical terminal strips, each supporting 20 terminals. Entrances are provided at both top and bottom for three runs of 2-in. conduit. From these openings the wires, which are the continuation of the low-tension cable conductors, are carried in 2-in. conduit to the instrument cases. Each case is provided with entrances for one 2-in. conduit at the top and for two at the bottom. All the outside line connections are brought to two terminal boards at the bottom of the case. Above these boards another is located, on the front of which are located the fuses, resistances for the track circuit leads and terminals for track and for low-tension connections. On the back, the track transformer is supported.

Above these boards are three shelves, supporting the required relays. On the Williamsburg bridge, where vibration caused by the elevated trains and trolley cars presents a very serious problem, felt pads are placed under all the relays. The track relay is on the lowest shelf, the three-position line relay on the next and the stick relay on the top shelf. The line and track relays are Federal type U. The automatic stop valve is supported on the side of the instrument case to the left of the stick relay. The air pipes leading to this valve and to the main air line are brought out through holes in the case, and the air strainer, cocks, etc., are placed on the outside. A view of the above-described apparatus is shown in Fig. 4.

Two typical layouts of apparatus at automatic signal locations are shown in Fig. 5. The signal at the left, numbered J4-35, is typical of cases where the signal is for one of the middle tracks. In this arrangement the signal head is directly above the instrument case, and is fastened to the curtain wall. The signal to the right, J2-35, shows the arrangement for the outside tracks, where it is necessary to fasten the signal to the wall and then to run to an instrument case installed in a refuge

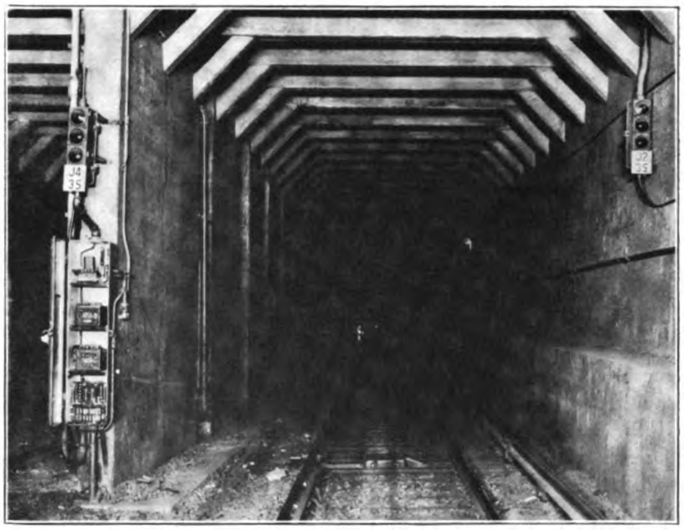

Fig. 5. Two Typical Signal Locations, Showing Also Automatic Stop in the Track.

in the curtain wall between tracks. Every precaution has been taken to keep the bench wall unobstructed.

In the stations, except at the Bowery, where cases were fastened to columns, all instrument cases have been kept between tracks. On the bridge many novel arrangements were necessary, each location being a problem in itself. Owing to the diversity of these arrangements, no attempt will be made to describe them here.

Conduit fittings, such as bends, tees, short, straight lengths etc., are split castings designed by the Federal Signal Company, especially to meet the requirements of this subway work. Iron conduit of ¾-in. diameter is used to connect each signal head to its automatic stop key release box. This is well shown in Fig. 12, together with the relative location of the signal head and conduit runs.

The signals are Federal standard light signals. They are of cast iron with four sections in each signal head formed by cast shelves, the upper three sections being for the lights and the lower one for the terminal board and fuses. The lenses are 5 in. in diameter, the green being at the top, the yellow next, and the red at the bottom. Each light is given by two bulbs,

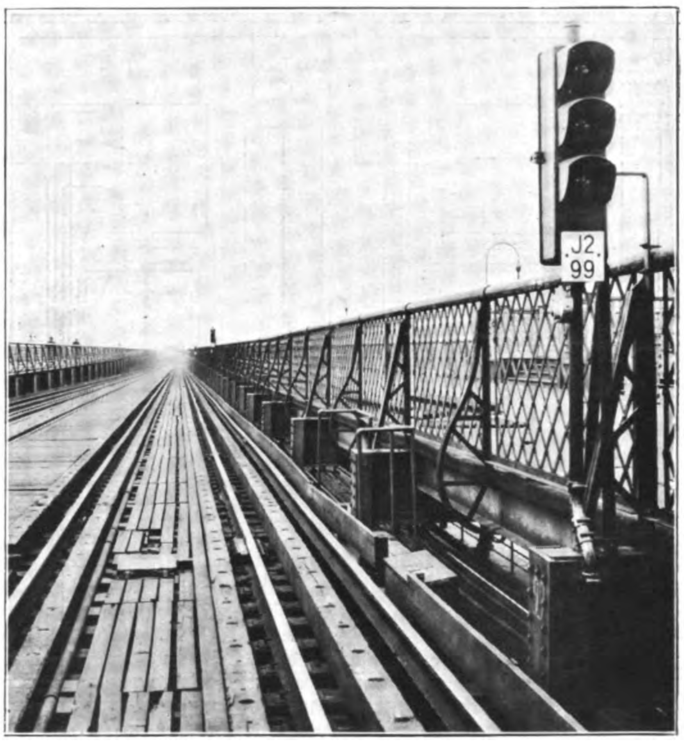

Fig. 6. One of the Signal Locations on the Williamsburg Bridge.

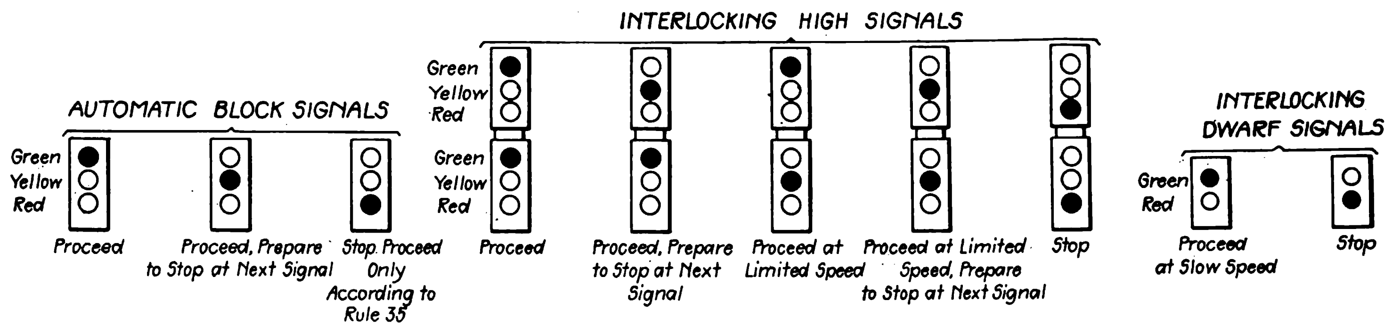

Fig. 7. The Standard Light Signal Indications Used in This Installation.

one behind the other. They are mounted on a porcelain block having two marine sockets with standard bases, the focal point of the lenses being midway between the two bulbs. Practically the same signal is used on the bridge as in the subway, except that hoods are attached to the bridge signals, as shown in Fig. 6 to prevent the direct rays of the sun from striking the lenses. The normal danger, speed control signals on the bridge are distinguished by enameled plates, indicating the proper speed for the approaching trains.

In Fig. 7 the standard light signal indications for the Brooklyn Rapid Transit are shown. It will be noted that the automatic block signals have the usual aspects, the upper light, green, for proceed; the middle light, yellow, for proceed, prepared to stop at the next signal, and the lower light, red, for stop. At the interlockings, the scheme of indication is unique and works out very satisfactorily. Two three-light units are used, the upper giving the usual automatic aspects, and the lower serving as a route signal, with green for the most important route, yellow for the secondary route or routes, and red for stop. As an example of the manner in which this scheme works out, consider the following: Two main-line tracks Nos. 1 and 2 run in the same direction; there is a crossover from 1 to 2; the signal for track 1 is No. 2; the signal in advance of No. 2 is No. 4 on track 1, and No. 5 on track 2.

Aspect.	Indication.
Green over Green......	Proceed, Signal No. 4 is at proceed (yellow or green).
Yellow over Green.....	Proceed, Signal No. 4 is at stop.
Green over Yellow.....	Proceed at limited speed, Signal No. 5 is at proceed (yellow or green).
Yellow over Yellow.....	Proceed at limited speed, Signal No. 5 is at stop.
Red over Red.........	Stop.

AUTOMATIC SIGNAL CIRCUITS

In the usual automatic signal circuit installed in the subway, the blocks are of sufficient length to make a single block overlap enough to protect against following trains. Fig. 8 illustrates this circuit and the method of controlling the line relay, which is really the signal mechanism. The Federal type U three-position line relay (Fig. 9) is used. When it is de-energized it causes the red light to show: when energized, the green or yellow lights show, depending upon the polarity of the incoming energy. This energy depends upon the position of the track relay at the second signal location from the given one, the circuit being as follows: The control wire for the line relay runs over a normally-closed contact in the automatic stop, then back to the track relay, thence to the relay of the block ahead, and then to the track relay of the second block, mentioned above. The method of procuring the different polarities, as shown in this figure, is as follows: 110 volts is received on the secondary of the line transformer, a center tap is taken and used as common, which gives 55 volts of opposite polarity. The reason that the control circuit runs through the stop circuit breaker is to insure that the stop is in the proper position before the signal can be cleared. It will be noted that after the control circuit leaves the stop breaker, it joins the automatic stop wire and the two are the same for the remainder of the circuit.

With further reference to the automatic stops, one of which is used at all signal locations, except the dwarfs, the stop is always held in the down or clear position whenever the signal indicates yellow or green, and in the up or stop position when

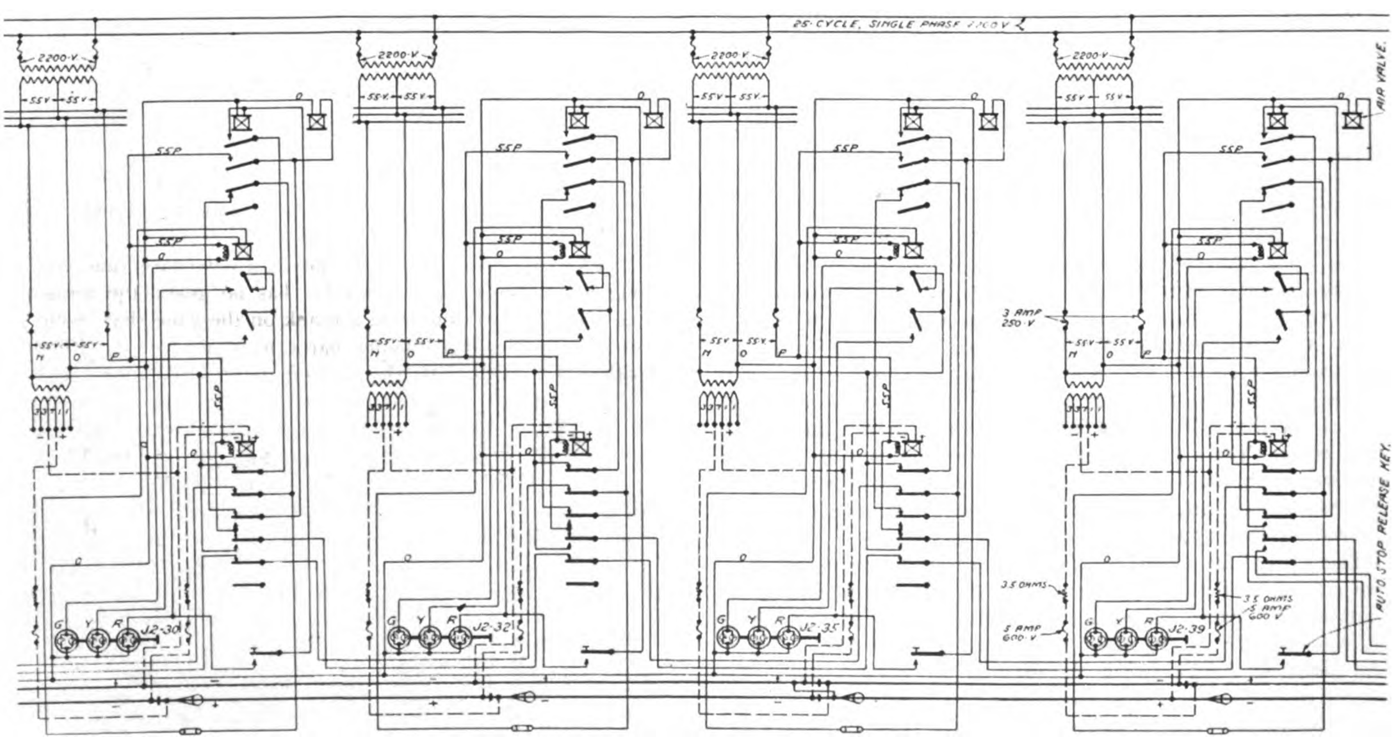

Fig. 8. Typical Automatic Signal Circuit, Showing Signal and Automatic Stop Control.

the signal indicates red, due to the presence of a train in the second block ahead. It will be seen in Fig. 8 that the stop is retained in the clear position, receiving energy over the back contact of the track relay of the section ahead of the given signal, until the train has passed into the next section and has entirely cleared this first track circuit. This is to prevent the stop arm from applying the air brakes on the cars of a train and allows the use of all air-equipped cars on trains. By this arrangement a train always has the protection of the automatic stop located at the second signal in the rear. Each motorman is provided with a special key used for releasing the automatic stop when it is desired to pass a signal indicating red. The insertion of the key into the key release box causes the stick relay to pick up, and to remain up until the train has cleared the first block protected by the red signal, the holding circuit being cut through a back point on this track relay. The key release box is so located as to be within the motorman's reach when he has brought his train to a stop, about 20 ft. before reaching the signal in most cases. Owing to the necessity of special signal locations it is not always possible to get this 20 ft., and in all such cases the release box is placed as near the signal as possible and painted white, so that it can be readily located by the motorman. Releasing the automatic stop by means of this release key does not change the indication given by the signal.

In each instrument case and junction box is pasted a blueprint of the wiring for that location. This print shows the wire number, the terminal or binding post to which it is attached, and also indicates where the wire is next brought to a terminal.

SPECIAL AUTOMATIC SIGNAL CIRCUITS.

To facilitate traffic through the Essex street station it was necessary to use time elements in all of the signal circuits approaching the platforms. This station is situated just inside the tunnel portal at the foot of the long grade from the bridge. Between the bridge and the first interlocking home signal, 22 signals are located in a distance of a little over half a mile. To further complicate this situation there is an abrupt curve at the foot of the grade in which a facing-point switch is located. It is desired to keep the trains moving, even if at a reduced speed, and at the same time to keep them a safe distance apart. The circuits were first made up to cover braking distance for maximum speed, the time elements were then inserted which cut out some of the track circuits if the approaching train has reduced its speed to a certain predetermined rate. The automatic adjustment is accomplished when an approaching train starts the time-element relay to operating by de-energizing the track relay for the track section in the rear of the signal it is desired to clear. If the train consumes time enough in traveling the length of this section to permit the time element to close its contact, then energy is supplied through this contact to complete the signal control and eliminate the length of one or more track sections, as previously determined.

The time element used in this installation is the Federal type T relay operating on alternating current. It is a vane type with dampening windings, and the time-element part is adjustable so that a range of from practically instantaneous to 25 seconds may be had from the time the relay is energized until its front contact is closed. The time required for the relay to resume its normal position after being de-energized is comparatively small, so that it may be operated in quick succession without affecting the time interval. All moving parts of this relay are visible from the front, and the time adjustment is made without opening the relay. This relay is shown in Fig. 10, and the method of installing in an instrument case in Fig. 11. The same scheme of time control is used on the two westbound tracks entering the Bowery station.

In Fig. 1, two normal danger speed signals are shown on the bridge approach to the tunnel. These signals serve the purpose of obliging trains to reduce speed while decending the grade. The introduction of a time element into the control and stop circuit keeps the signal at danger, and the stop arm up until this time relay is energized. To illustrate this method of control by a concrete case: It is desired to reduce the speed of trains approaching signal J2-99 (Fig. 1) to 17½ miles per hour. If the train travels at this rate from signals J2-104 to J2-101, the normal danger signal will clear, but if the motorman does not reduce to this speed in this section the signal will not clear, and he must still further reduce speed or be tripped by the stop arm at J2-99.

TRACK CIRCUITS.

The track sections are much shorter than is usual in surface-line installations, none exceeding 600 ft. These circuits are of the a. c. single-rail type, one rail being given up exclusively for signal purposes. Current is supplied by Federal track type transformers, located in the instrument cases, which in turn receive current from the line transformer at 55 volts. The secondary of this track transformer is provided with six leads, allowing a range in voltage from 1 to 15 volts.

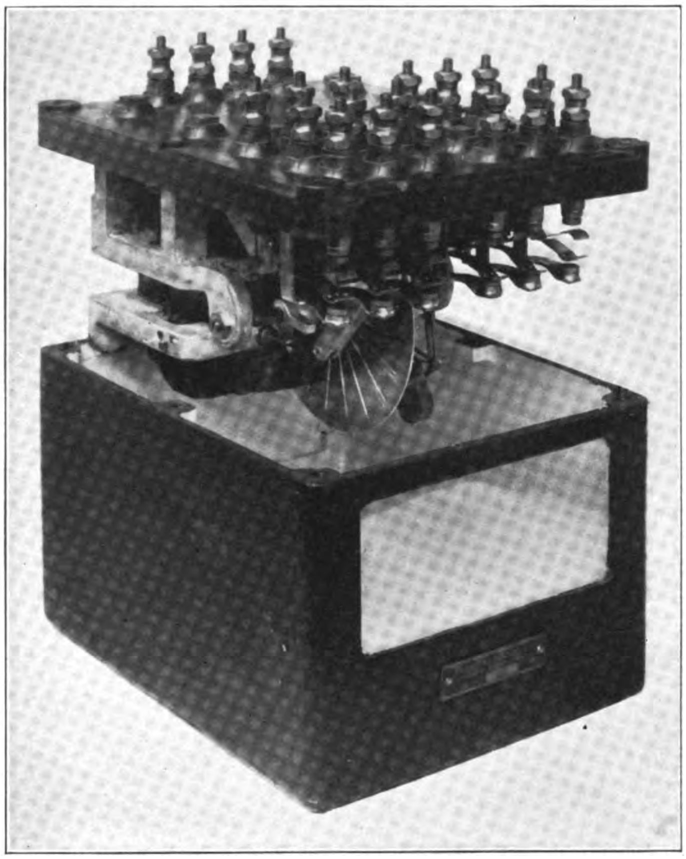

Fig. 9. The Federal Type U Three-Position Line Relay.

The track relay is the Federal type U, a polyphase vane type, working in two positions. This relay has no gears, the contact carrying member working from a crank on the vane shaft which reduces the number of moving parts to a minimum without affecting its efficiency. All the moving parts are plainly visible from the front of the relay, as may be observed in Figs. 4 and 9. All the binding posts are erected upon a molded insulation.

Track leads of No. 6 solid insulated copper wire connect the rails to the transformers and relays. In the connection between the transformer and the signal rail, and also between the track relay and the signal rail is installed a fuse and resistance unit. This is to protect the signal apparatus from possible short circuits between the third and running rails. The leads are carried to the rails from the instrument cases in trunking, except in cases where the insulated joints are located in the platform area, where small loricated iron pipe is used. Wood pulling boxes are provided at all branch leads in the trunking line and at points where the small iron pipe is joined to the trunking, or to the large iron pipe. Trunking is used for crossing under the tracks, for track connections, track leads, and for low-tension cable connections between the line and the instrument cases on the bridge. Two-inch loricated iron pipe is used at all other points, except those already mentioned. Two No. 6 B. & S. copper-clad bond wires, 50 in. long, are used with copper-plated channel pins for bonding each joint in the signal rail. The power rail is bonded with two No. 4-0 propulsion bonds. Where

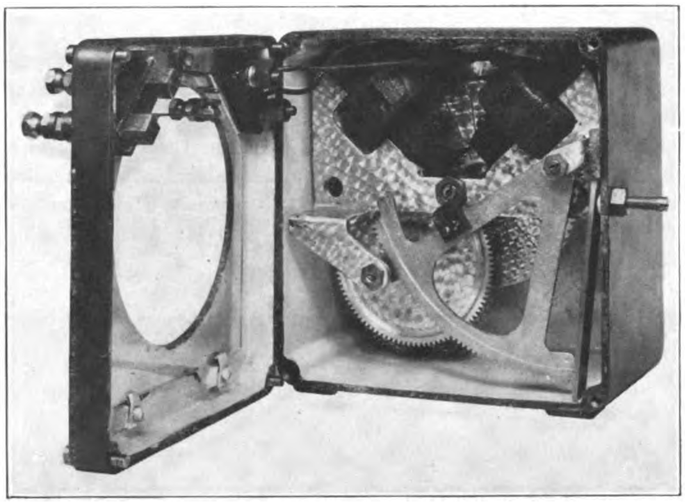

Fig. 10. Federal Type T a. c. Relay Used as Time Element.

manganese rails are in service large copper plugs are used. Holes are left in these rails for this purpose. The plugs are first driven in and then drilled in place in the same manner that holes are drilled in the softer rails, which makes it possible to use the standard channel pins and bond wires. On the curve at Broome street the outside rails are bonded for signal purposes, and the guard rails on the inside rails for the propulsion return, which means that the inside running rail is not bonded. This, after careful test and observation, has been found to work out satisfactorily for the given location, although it is of doubtful advisability for longer sections of track. All the insulated joints in the subway are of the Weber 4-bolt type, and, owing to the use of so much special work and of guard rails, a large

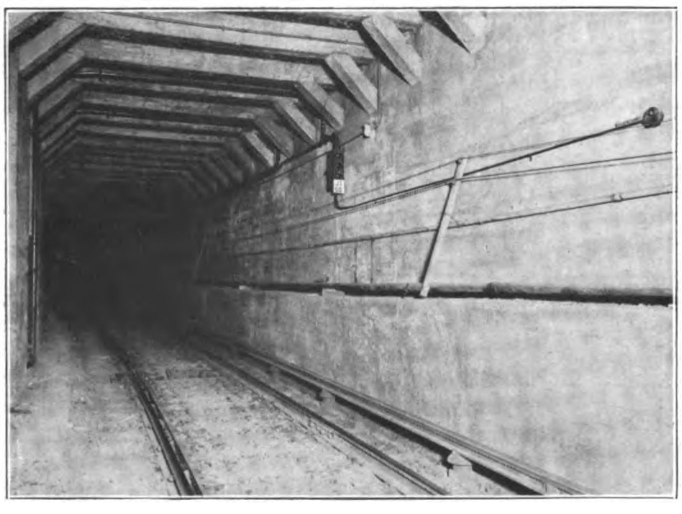

Fig. 12. Automatic Signal Location and Automatic Stop Release Box.

percentage are twin joints. All frogs and switch points are bonded into the track circuit.

COMPRESSED AIR EQUIPMENT.

The two compressors in use are those installed for the first installation. They were supplied by the National Brake and Electric Company and are type 3 B. S., each having a capacity of 150 cu. ft. per minute. From the Centre street substation, at Centre and Walker streets, where these compressors are located, the air is supplied to all of the automatic stops included in this contract. The motive power is derived from direct-connected National Brake and Electric Company C. C. type 27 hp., 600-volt d. c. motors, current for the motors being taken from the 600-volt bus bars in the substation. Automatic controlling devices are used, which keep the air pressure between 90 and 100 lb. per sq. in. These controlling devices consist of pneumatically-operated governors, which open and close one side of the motor circuit, and a combined rheostat and electric unloader which reduces the load to a minimum at the time of starting, so as to use as little starting power as possible. The compressed air is taken from the compressor to two tanks, each having a capacity of 63½ cu. ft. These tanks are located in the subway at the south end of the Canal street station, and are connected to the compressors by three 2-in. air pipes, which are hung on the subway wall, and are brought up through the floor of the substation alongside the compressors. A ½-in. pipe is also brought up from the air tanks to the substation for the supply of air to the automatic governors. Compressed air is carried from the tanks throughout the system's entire length in 2-in. extra heavy galvanized iron pipe and from this main in smaller pipes to the stops.

AUTOMATIC STOPS.

The Federal Signal Company's automatic stops are installed at all signals, except at the dwarf signals. These stops, shown in Fig. 5, are of the electro-pneumatic trip type actuated by compressed air at a pressure of about 90 lb. per sq. in. The mechanisms are in practically all cases bolted to the ties between the rails, the stop arm being located outside the running rail on the left-hand side from 4 to 5 in. outside the gage, depending upon the curve. The only exceptions are the cases where the stops are located in the concrete roadbed within the limits of the stations. Here special short ties are used to allow for drainage between tracks. One side of the stop is bolted to the ties near the inside end, and the other is supported by iron legs and then cemented around, making a very compact and durable construction.

The main for the compressed air is of 2-in. extra heavy galvanized iron pipe. It starts at Canal street and runs along the wall of the subway supported by iron clamps, except through the station platforms and on the Williamsburg bridge. Within the station limits the pipe is under the ledge of the platform, and on the bridge it rests on the ties between the rails of the westbound track next to the inside guard timber. From the main air line ½-in. galvanized iron pipe carries the compressed air to the automatic stop valve in the instrument cases. One-eighth-inch galvanized iron pipe is used between the automatic stop valve and the cylinder of the stop between tracks. The air strainer, etc., as has already been mentioned, are located on the outside of the instrument case between the valve and the ½-in. line from the main.

The details of the interlocking work in this subway will be described in an early issue.

THE MID-YEAR MEETING of the American Electric Railway Association was held in the Congress Hotel, Chicago, on February 3. A number of papers were presented by men prominent in the electric railway field.

THE AMERICAN MUSEUM OF SAFETY, at its annual dinner on February 3, awarded the Anthony N. Brady memorial medals to the Union Traction Company, Anderson, Ind., for its record in accident prevention during the year 1915. Honorable mention goes to the Chicago Elevated Railroads, which made the next best record. The award was based on accident prevention, not only among employees, but the traveling public, on the sanitary conditions of cars and shops, and on welfare and benefit work among employees. The principal medal is of gold, and is presented to the road. A replica in silver is presented to an operating chief, and a replica in bronze to a workman.