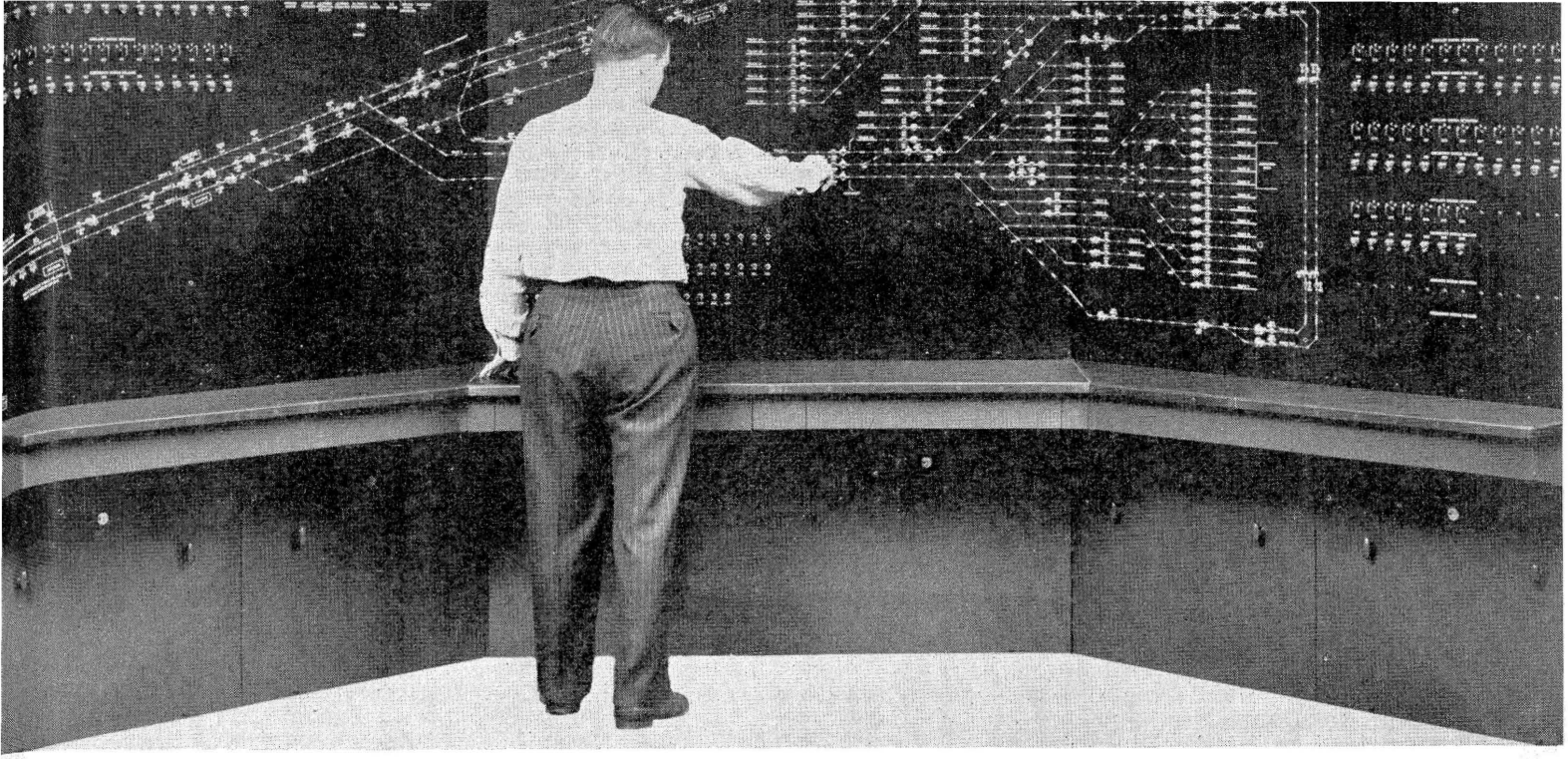


The center section and the two wing sections of the control panel total the length of 15 ft.

Route Type Interlocking on New York Subway

Features of this new plant include, electronic smoke detector, call-on controls, biased neutral switch control relay circuits and automatic d.c. ground detectors

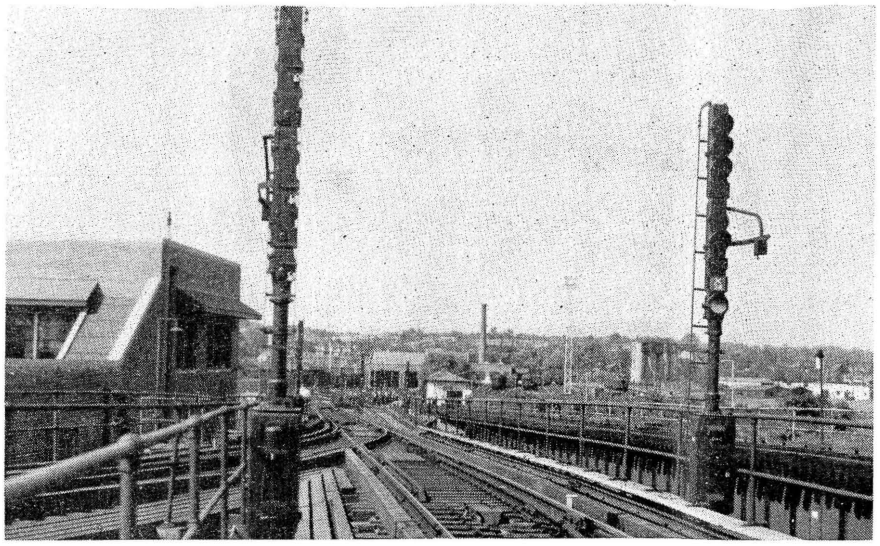
A large electro-pneumatic interlocking, with "UR" route control, has recently been installed by the Board of Transportation, City of New York, at Westchester Yard, in the Borough of Bronx in New York City. The new plant is about one mile south of the north terminal of the Pelham Bay Line. Three main tracks are in service on this route from Pelham Bay Park south past Westchester yard and to 138th Street, a total of about seven route miles. Local trains are operated on the two outside tracks. The center track is used by express trains, inbound to New York during the morning rush hours, and outbound in rush hours in the evening. The express trains return to their starting points on the appropriate local track in between the regular local trains. The line is signaled to handle 20 trains per hour on the express track and 40 trains per hour on each of the two local tracks. At present, local and express trains are made up of seven cars, but the signaling provides for operation of ten car trains in the future.

Formerly, cars were stored on the middle track during the slack hours of the day and night, between rush traffic periods. A great increase in housing facilities has made a large growth in population in this area, thus necessitating more train service. For that reason, arrangements had to be made to store the cars somewhere, other than on the middle track. This necessitated an extensive enlargement and reconstruction of the Westchester Yard. As rebuilt, this yard now has 48 storage and shop tracks with a total capacity of 465 cars. Provisions were made so that 16 more storage tracks capable of holding 160 cars, may be added in the future.

Crossings Eliminated

In the former layout, trains on the northbound local track or the middle track had to cross other tracks at grade when entering or leaving the yard. This caused considerable delay, because of the close headways between trains. To eliminate such delays, the center track and the southbound local tracks were reconstructed on higher elevated structures throughout the junction area, so that trains can now enter or leave the yard without crossing any main track. Thus, the tracks in the entire junction area and yard lead layouts were reconstructed. As the track changes progressed, new A-10 electro-pneumatic switch machines with new CP valves and new modern color-light interlocking home signals were installed.

Previously, there was an electro-pneumatic plant with a Model-14 interlocking machine in service at this junction and yard lead. The ma-



View looking along track from main line down toward yard with upper floor of new tower at the left and signals and switch in the foreground

chine was in a tower on the elevated structure beside the main track. As a part of the new project, a new brick tower was constructed near the yard throat. On account of the increase in the number of switches and signals to be included in the reconstructed track area, and because of the numerous train movements, a decision was made that the new interlocking should be of the route-control type. The new interlocking layout includes 49 single switches, 13 crossovers, 60 high home signals, 51 dwarf home signals, and 73 trip-type train stops. Within home signal limits, there are 88 track circuits. The track circuits are the single-rail type using vane-type track relays. In addition, on yard storage tracks beyond home signal limits, there are 48 track circuits for indicating track occupancy only. There is no relay associated with these track circuits. They serve only to light a light on the control panel when a train is waiting at the dwarf signal.

New Control Machine

The new route-control interlocking machine is of the panel type, located in the third floor of the new tower. The panels are 3 ft. 8 in. high; there is a center panel and two wings. Each panel is 5 ft. long, totaling 15 ft. The machine cabinet was designed to mount the panels at a height that is convenient for a man to operate the controls when standing or when seated on a high stool. The panels are made of heavy-gage sheet steel with reinforcing angle irons to make it rigid. The track sections, symbols and lettering are engraved in the sheet metal, and are filled with white filler on the dull black background.

On the track diagram on this panel, each home signal is represented by a chromium plated button, which ordinarily is used as a push button, but can be rotated, and can be pulled. When a route is to be lined up, the towerman pushes the button representing the home signal at which the train is to enter interlocking limits, and then he pushes the button representing the location where the train will depart from interlocking limits. The same buttons serve either as entrance buttons or departure buttons. The machine panel has a total of 119 of these route push buttons. Adjacent to each button there is a small indication lamp. This lamp is round to distinguish it from the other lights on the panel and lights yellow or red to indicate when the corresponding signal is clear or not. The buttons operate a group of non-vital relays which comprise the selection network.

Track Indication

The panel uses the "line of light" method of presentation. Each track is represented by a continuous row of sections of translucent glass. Each section is ⅛ in. wide by 1 in. long, and is mounted in a slot cut in the panel. The machine as a whole has 811 of these line-o-light glass sections. Behind each section there are two lamps, one of which will throw white light through the glass section, and the other will throw red light through it. Normally these sections are dark.

When a switch is in operation, the glass sections representing that switch flash red, until that switch is over and locked in the position called for. When a route has been selected by operating the push buttons, and all the switches are in the position called for by a route, all the track lamp sections throughout the route, are lighted white. Following this the automatic train stop will lower its trip arm, which is located beside the right-hand rail, and finally the signal will clear. The lamp in the signal indicator adjacent the entrance button will change from red to yellow.

When a train accepts and passes the signal, the lamp in the signal indicator is extinguished, and lamp sections representing track occupied by the train are lighted red, instead of white. When a train passes out of a section, the track lamps are extinguished. If trains are to follow one another on the same route, as for example through moves on a main track, non-stick control is established by turning the buttons 45 deg. after the button is pushed. With this control, the home signal involved will automatically clear again as soon as the train clears the home signal control limits.

One of the features of the interlocking is the "forcing" of a switch located in the overlap control of a signal. The control of each signal is overlapped into the next block. When there are trailing switches in this overlap section, the manipulation of the push buttons to call for the signal to clear, positions and locks these switches. The movement of these switches is indicated by the flashing red light, but the final position of the switch is not indicated by the line of light unless the signal immediately controlling the route into these switches is also called for by the operation of its push button.

Flashing Indication

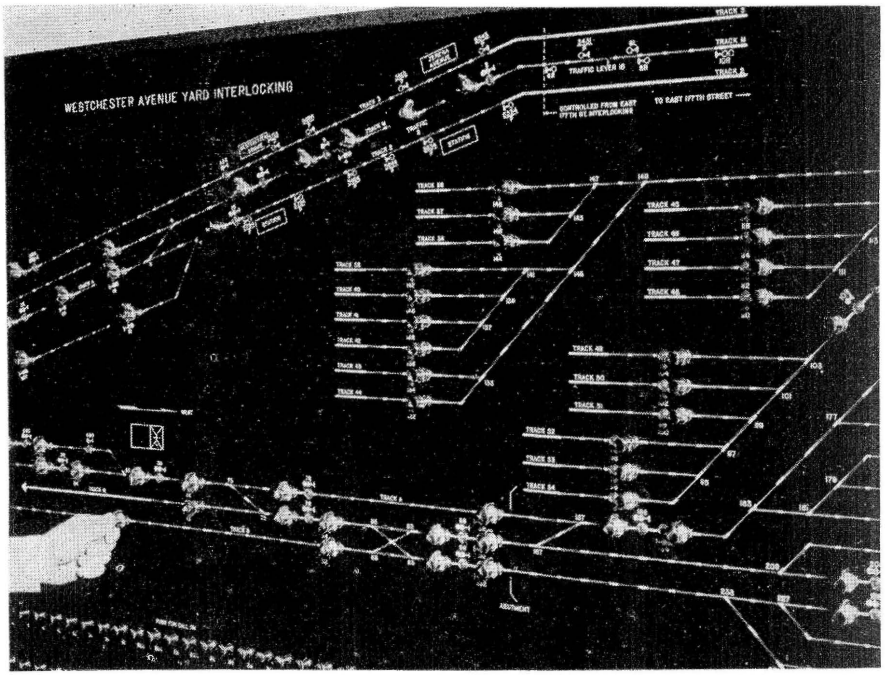
To inform the towerman that these switches, which are not normally illuminated on the panel, are locked, a flashing white indication is used. When the towerman presses a button to initiate a route which might conflict with the position of these switches, the line-o-light section, showing the position of the conflicting switch, flashes white and at the same time the signal indicator light associated with the signal, which is locking the switch, begins to flash to call the towerman's attention to it. In this way the ma-

chine indicates to the towerman what route must be cancelled in order to unlock the switches so that the new route may be obtained.

Through Routing

"Through routing" is provided very extensively in this interlocking. This means that when the towerman desires to set up a long route requiring the clearing of a number of interlocking signals, he may line up the entire route merely by pushing two buttons—the one representing the home signal where the train will enter, and the button representing the place where the train leaves home signal limits. Some routes as for example from a main track to a yard track may include as many as 12 switches and six home signals. Thus through routing is of special help in a plant of this nature.

Approach locking is provided for signals on main tracks; time locking for yard signals. If an occasion arises to cancel an established route before a train accepts the cleared signal, the towerman pulls the entrance button. If the route is being held by approach or time locking, the track lamps on the panel stay lighted. When the route is released, the lamps go out.



Close up picture of a part of the control panel showing push-buttons, indication lamps, and the track lights

Call-On Control

Call-on aspects are provided on each home signal to authorize moves in the event a track circuit fails or to permit cars to approach each other and couple. This aspect is red-over-red-over an illuminated CO sign. The automatic trip-type train stop is not cleared when this aspect is displayed until after the motorman of the train involved has reached out of his car window and operated a "key by" lever which is mounted on a bracket on the signal. The towerman, in order to clear a call-on signal, operates the proper entrance and departure push buttons on his control panel in the usual manner and also operates the call-on button associated with the control of that signal. These call-on buttons, one for each home signal, are in a group on the panel.

As information to the towerman, when a call-on is displayed, the indicating lamp for the signal on the control machine is flashed yellow. When the motorman operates his "key by" lever, and the train stop arm at that signal is lowered so that it will not stop the train, the flashing-yellow in the signal indication light changes to a steady yellow. On automatic signals and interlocking approach signals, automatic "key by" is in service. This is signified by an enamel "AK" sign on the signal. This makes the signal in effect a stop-and-proceed signal. The signal and automatic train stop are located 15 ft. or less in advance of the block joint, and the circuits are arranged so that the "key-by" is accomplished by clearing the trip arm automatically when a train enters this track circuit. Because the distance between the block joint and the trip arm is so short, a train must practically stop in order to allow time for the trip arm to clear and effect a "key by."

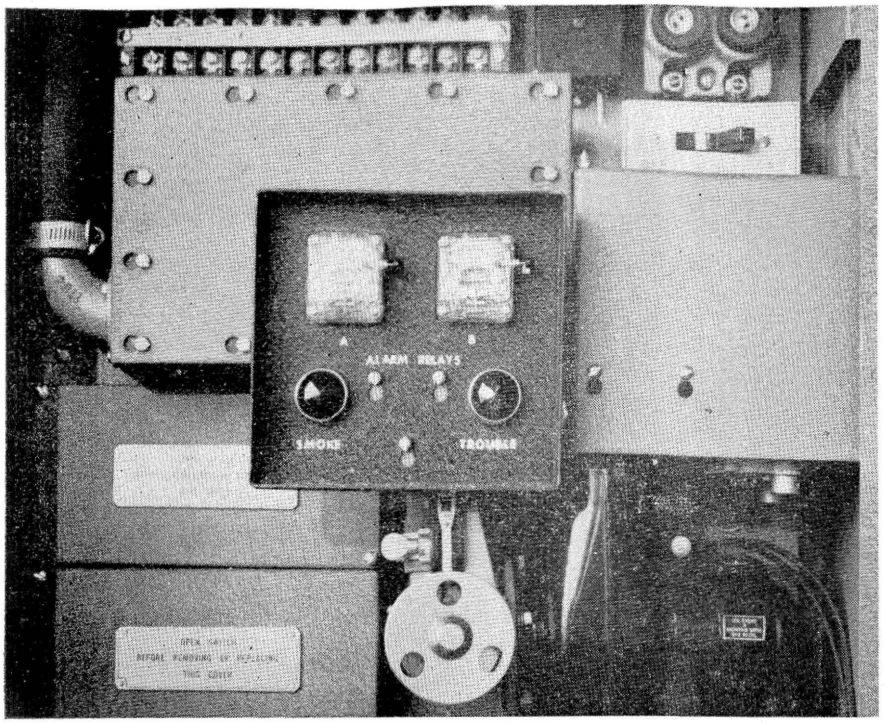
Test Control of Switches

Ordinarily, the switches are controlled as part of the UR system as previously explained. However, when testing or making adjustments on a switch, each switch can be controlled individually. This is done by small three-position thumb levers, one for each switch or crossover, these levers being mounted in rows on either side of the track diagram on the control machine. If a maintainer is testing a switch and he wants it to be operated, he telephones to the towerman who throws the corresponding thumb lever.

In special circumstances it may be desirable to operate a switch although the detector track circuit for that switch has failed. To meet such an emergency this UR interlocking machine is equipped with a special push-and-pull button below the thumb lever for each switch. When a switch is to be operated independent of track-circuit-controlled electric locking, the signals must be placed at Stop, and time allowed, if necessary, for all approach and time locking to be released. Then the towerman, with authority from the dispatcher, breaks the lead seal on the button located under the thumb lever for that switch. Then he operates the thumb lever and pushes the emergency release button and holds it in until a checking relay picks up, which condition is indicated by a special red lamp on the control panel.

Next, he pulls the release button and holds it until a special emergency time-release relay operates. When the switch completes its movement and locks in the desired position, the flashing ceases and the new position is indicated by a steady light on the track diagram. With the switch thus controlled to the position desired, the route can then be established by pushing the entrance and departure buttons and the call-on button in the usual manner. The emergency button is sealed as soon as possible by the proper person.

The relays in this interlocking are the modern plug-in type; a total of 2,868 relays being used, including



Panel of smoke detector showing relays, photo-electric cell, lamps and fan to pull smoke from pipes extending to room

1,791 type PN-50B (biased neutral relays), 91 type PTV-42 (vane-type track relays), 71 type PT-55 (time element relays) and 915 type LP-58 (non-vital type relays.)

The signal control relays for the signals on the three main through tracks are in cases along the right of way. All of the remainder of the relays are in a large room on the second floor of the tower. These relays are on racks each of which has a capacity of 13 relays to the horizontal row and 7 rows high. A total of 62 racks are used in this room for relays, rectifiers and terminals. The spring contact fingers in the receptacles of the plug boards together with the wire attached can be pulled out of the rear of the plug board. One advantage is that, when testing, circuits can thus be opened or closed without operating the relay which would also open or close other circuits at the same time. Changes to the wiring, if required in the future, can be made with relative ease and rapidity.

Smoke Detector Equipment

There is very little chance that a fire in the signal equipment furnished for the Westchester Avenue Yard will ever start by reasons of conditions inherent in the signal system or from the equipment other than signal equipment that is installed in the relay rooms. However, there is the danger of a careless person leaving rags or waste in the room which may ignite from spontaneous combustion or a discarded cigarette. To protect against the possibility of a fire developing beyond its incipient stage, it was deemed necessary to provide means of detecting the fire before damage to the signal system could result.

Automatic Control

The system decided upon was an automatic detection system. In case fire breaks out, a bell sounds continuously in the control room and the bell can be cut off only by a person going to the detection apparatus in the room involved. It is necessary for this person to extinguish the fire by using the CO_2 fire extinguishers located within the relay rooms and throughout the tower building.

The alarm system is an air-sampling device. It is so sensitive that it will detect and give the alarm when the personnel in the relay rooms are smoking cigarettes. A one-inch thin wall, air-sampling pipe with holes spaced along its length is located near the ceiling over the apparatus to be protected. Two installations were made, one in the relay room and one in the power and cable terminal room. A 1 1/16-h.p. blower draws air into the apparatus at the rate of 3 cubic feet per minute.

There are two duplicate photo cell circuits, each consisting of a detecting cell and a balancing cell and a galvanometer type relay. The polarity of the cells is such that the cells normally balance each other, and no current flows in the galvanometer relay. The detecting photo cells are mounted parallel to the light beam, and normally receive only a small amount of indirect illumination. Enough light from the beam is allowed to fall on the balancing cells to compensate for the stray illumination of the detecting cells. When smoke passes through the light beam, light is reflected by the smoke particles into the photo cell. Unbalance between the intensity of light, to which the detecting and balancing cells are subjected, causes current to flow through the galvanometer type relay coil, and the relay contacts are closed. When the contacts of both relays close the alarm bell rings. A trouble buzzer is provided which is energized immediately whenever any part of the apparatus such as the blower, light beam or photo cells goes out of order. This equipment was furnished by the C-O Two Fire Equipment Co.

Maintainer's Panel

Especially during rush hours, it is highly important that the maintainer should quickly locate the cause for any case of signal trouble, that is delaying trains. As an aid, a special lamp-type indicator panel was provided in the maintainer's headquarters room. On this panel there is a lamp corresponding with each switch. Such a lamp flashes red during the time its switch is in transit. If a switch fails to operate or if it is obstructed from going over, the lamp continues to flash. Lettering above each lamp on the maintainer's panel tells him the number of the switch and the relay rack number on which he can locate the relays for the control and indication of that switch. By checking these relays he can see whether the switch control relay has been energized, and he can check the switch-position relays.

Switch Control Circuits

A new switch control circuit was designed, employing two biased-neutral relays, NWZ and RWZ. This was an improvement over the circuits used at Euclid Avenue and

Pitkin Yard which employed a polar relay as a switch control relay. Typical switch control circuits are shown in a diagram herewith.

Control to Reverse

When the manipulation of the push buttons or keys on the control panel calls for a switch to be thrown to the reverse position, the RLP relay is picked up. Provided the switch locking relay LS is up, indicating it is safe to throw the switch, and the RWP, Reverse Switch Repeater relay, is down, indicating the switch is not already reversed, the RLP relay closes the circuit to the RWZ relay which picks up. The stick circuit of the NWZ relay is broken, the NWZ drops out and the RWZ is then stuck up over the NWZ down.

The NWC relay, Switch Correspondence Relay checks correspondence between the switch position as indicated by the NWP and the switch control relay NWZ. Its circuit is through the Emergency Release relays down, RWZ down, NWZ up, RWP down and NWP up. When the RWZ relay picks up the NWC relay drops.

The reverse switch valve is energized by a circuit through the NWZ down and RWZ picked up. The switch lock valve is energized by a circuit through the NWZ relay down and both NWC and RWC relays down. When the RWC relay picks up, as the switch completes its movement, the lock valve is de-energized and air is cut off the switch.

Advantages

The circuit is very simple in arrangement but a number of features are achieved. If the polar switch control relay is used, special precautions must be taken to prevent the switch being thrown if a polar relay is removed and replaced by another relay in which the contacts are poled to the opposite position. With the circuit used herein, if a relay is removed and replaced there is no danger of operating the switch under a train. This is especially important where plug-in type relays are used, because relays can be changed so easily and quickly.

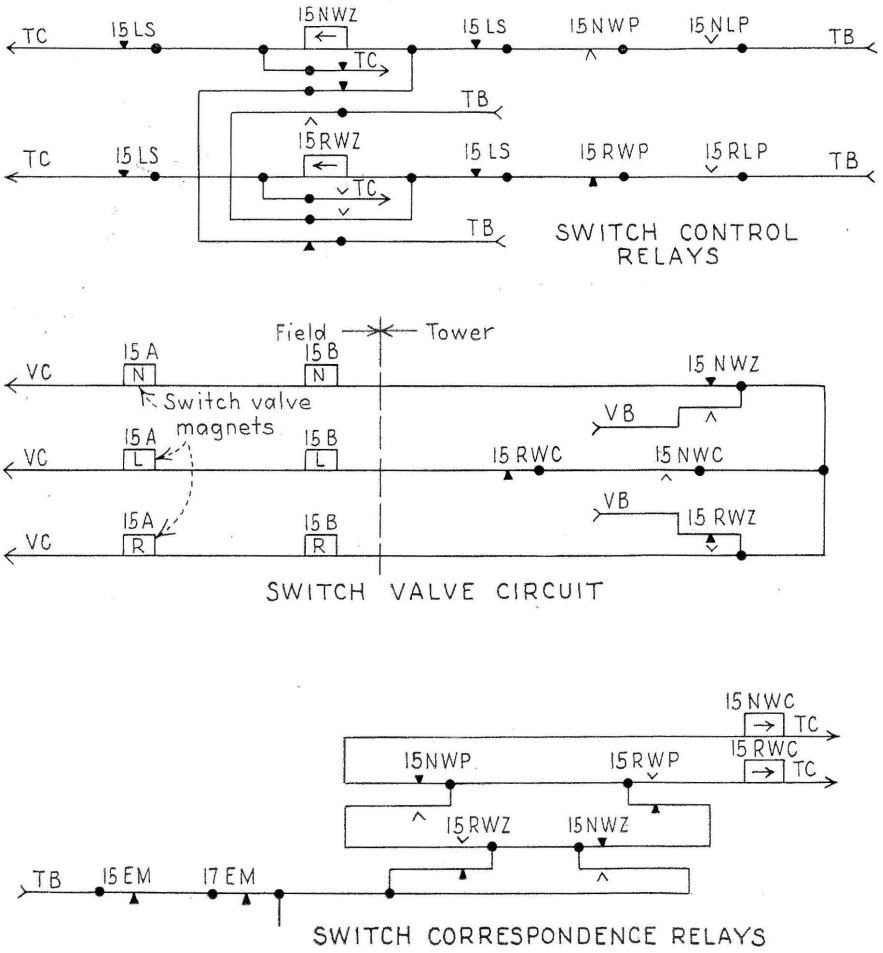
The "TB" tower battery energy which supplies the NWZ and RWZ relays is fed from a battery "floated" across a rectifier so that in the event of a momentary loss of a.c. power, the NWZ and RWZ relays will remain picked up. This is necessary so that the restoring feature of the switch circuit will remain in effect in the event of a momentary loss of a.c. power. This restoring feature which causes the switch to be returned to its original position if the switch should start to drift open while laying in the locked position, depends on the NWZ or RWZ relay being picked up. Incidentally, the fact that the NWZ or RWZ relay is picked up is checked by the signals. The NWZ or RWZ must be up to pick up the NWC or RWC, and the signal clearing circuit is broken through a front contact of the NWC or RWC relay.

In the RWZ circuit, the RWP contact provides a premature indication check feature. If the switch were to indicate reverse prematurely; that is, if the RWP relay were picked up before the switch was operated to the reverse position, the pick up of the RWZ relay would be prevented. The RWC relay would be down and the signal could not be cleared nor the switch operated until the fault was discovered and corrected.

Power Supply

The control circuits in this interlocking operate on low-voltage d.c. Fourteen-volt energy, known as VB local battery, feeds all control circuits that must extend to switch machines, switch circuit controllers, point detectors and train stop mechanisms, where there is some chance that such circuits might become grounded. Other circuits extending outside the tower are fed by a 14-volt energy known as LB line battery. There are three separate VB and LB sources, one feeds north, the second feeds south, and the third feeds the yard. Vital circuits entirely within the tower are fed from a 14-volt energy TB tower battery. Non-vital selection circuits are fed from a 14-volt energy SB selection battery. The switch-repeater relays for each switch consist of two biased-neutral 1300-ohm relays in series, and these circuits are fed from a 32-volt energy B32. The advantage of using separate sources of d.c. energy for these various purposes is that a failure or a ground affects a limited number of circuits so that the trouble can be located more quickly, and in the meantime a smaller area of the plant is affected thereby reducing train delays.

The VB, LB, and B32 circuits are fed from rectifiers. The TB and SB circuits, are fed from sets of



Typical switch circuits using biased relays

storage battery, floated across rectifiers, to prevent the dropping out of stick relays should the incoming a.c. power fail momentarily. For instance, the circuits fed from SB selection battery include the relays operated by the route selection push buttons which call for the positioning of the switches and condition the signals to clear. Some of these relays are stick relays, and if they were to drop out during a momentary loss of a.c. power it would be necessary to push the buttons again to restablish all the routes. If no towerman were on duty at the time, trains would be delayed. Since SB energy is supplied from batteries this difficulty is averted. The battery on TB is required because of stick relays in the switch control and restoring circuit as explained above.

D. C. Ground Detector

This interlocking includes automatic ground detectors to detect and indicate grounds on each of the various d.c. mains. Each ground detector consists of a code transmitter CT, a code following ground detecting relay GDR, a decoding or alarm elay GDDR, and a test unit containing indicator lights and test switches, as shown in the diagram.

Current flows from the positive side of the main, B, through a resistor, through the disconnect switch, through a contact on the coding relay, to ground, and continues from a separate ground through the disconnect switch through another resistor to the coil of the code following relay, GDR. If there are no grounds, the GDR follows code. If a positive ground occurs the coder contact is shunted out and the code-following relay GDR remains picked up. If a negative ground occurs, it acts as a shunt on the GDR relay which remains down.

The biasing winding on the GDR reduces the effect of variations in the battery voltage on the sensitivity of the relay. The condenser connected across the main coil eliminates a slight hum when rectifier power supplies are used. A rather novel decoding relay circuit uses the charging and discharging of a condenser. The purpose of the decoding relay GDDR is to indicate that the GDR has not stopped following code.

Each time the GDR relay picks up, a circuit is made from TB through the blocking rectifier, front contact of the GDDR, front contact of GDR, another front contact of GDDR, through a small resistor to charge a condenser. Each time the GDR drops out, this condenser discharges through the resistor, a front contact of the GDDR, back contact of the GDR, front contact of the GDDR to the coil of the GDDR. The condenser connected across the GDDR makes it slow-acting, so that, as long as the GDR follows code, the GDDR remains picked up. If the GDR stops following code and remains picked up as with a positive ground, the GDDR relay is not connected and drops out, sounding the alarm. If the GDR relay remains down as with a negative ground, the condenser is discharged through the GDDR and then the GDDR drops. When the GDDR relay is dropped out, the contact on the GDR is connected to control the red indicator lights which indicate the polarity of the ground.

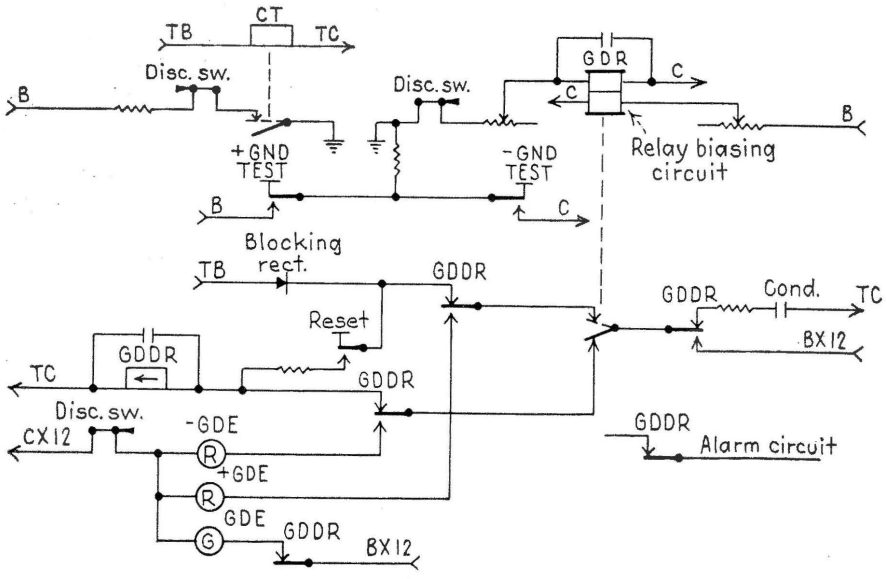
The test unit has a disconnect switch which disconnects all connections to ground in the ground detector when it is desired to make tests externally as in clearing an accidental ground. The test unit also contains a positive ground indicator light +GDE, a negative ground indicator light –GDE, a green "no grounds" indicator light GDE, and ground test and reset switches. All relays and the test unit are plug-in equipment.

The insulated wiring in the tower is No. 16. Outside the tower the wire is No. 14 except for power circuits which are No. 6 or larger as required. From the tower to manholes or junction boxes the cables are in duct lines. From there to signals and switches, the cables are buried. A 12-conductor cable extends to each switch machine. The largest cables are 37-conductor. All the insulated wire and cable on this project was furnished by The Okonite Company.

All the wires coming into the tower are terminated on a board on which all terminals are equipped with insulated type nuts. Solderless wire connections made by the Aircraft-Marine Products are used for the wiring in the control machine. Stay-kon wedge type connectors made by Thomas & Betts, are used for connections on terminal boards and certain other places.

On account of the numerous train movements, it was necessary that this interlocking be continued in operation without interruption throughout the reconstruction of the track layout and installation of the new interlocking including the changeover from the old Model-14 interlocking machine to the new UR route control machine in the new tower. This phenomenal result was accomplished by dividing the project into four separate steps which were changed over, one at a time, at intervals of several days or more depending on the progress of the track changes and interlocking construction. This changeover was effected without any delay to regular traffic.

This interlocking was planned by railroad forces under the direction of C. A. Reed, Engineer Line Equipment, Board of Transportation, New York City Transit System. The construction was done under Mr. Reed's direction by the Watson Flagg Engineering Company. The signal and interlocking equipment was furnished by the Union Switch & Signal Company. Wire and cable were furnished by The Okonite Company.



Circuits for automatic ground detector