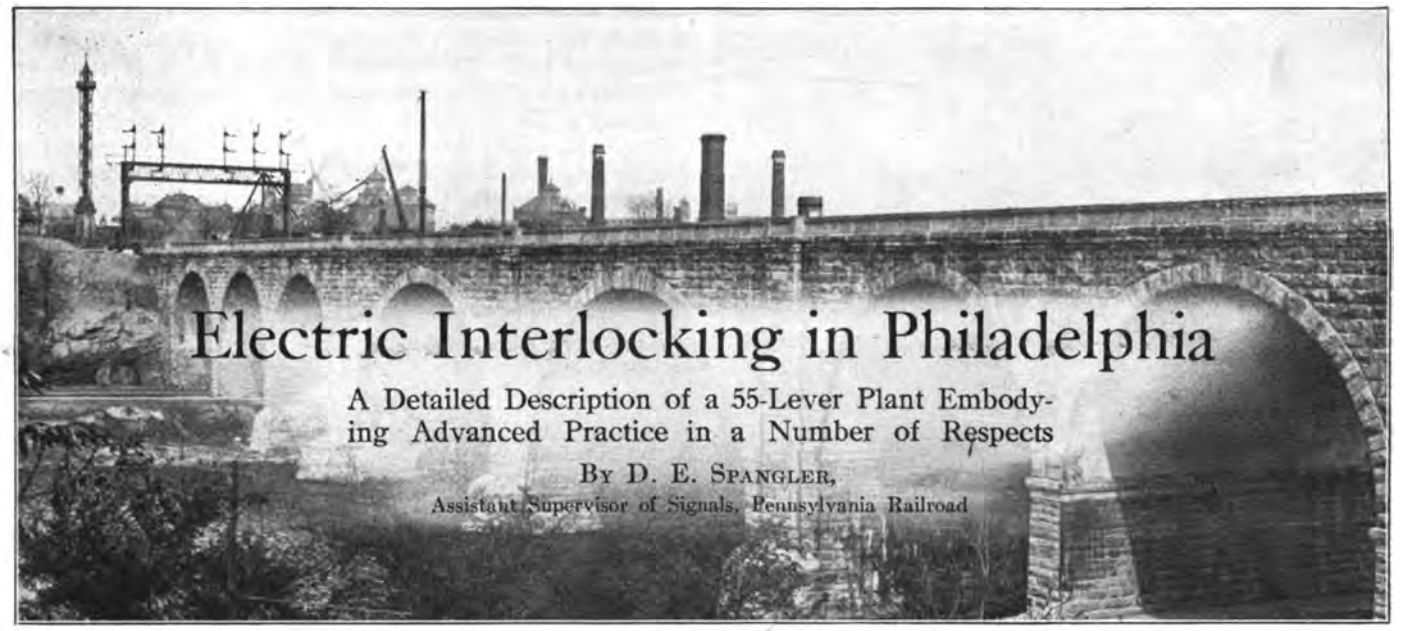

# Electric Interlocking in Philadelphia

## A Detailed Description of a 55-Lever Plant Embodying Advanced Practice in a Number of Respects

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The Pennsylvania Railroad has completed a five-track bridge on the Philadelphia Terminal Division, just west of the unction of the Philadelphia Terminal and the New York divisions. From west to east the bridge spans Girard avenue, Lansdowne and West river drives, the Schuylkill river and the East river drive.

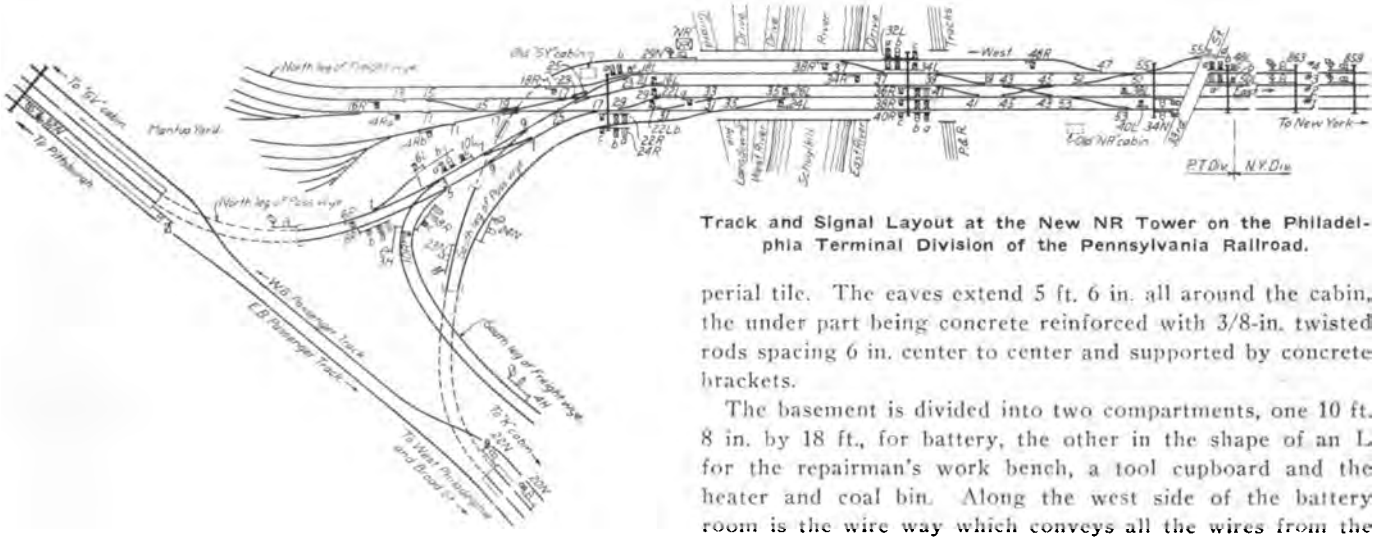
This bridge, which replaces a two-track viaduct, carries all the passenger and the majority of the freight trains between Philadelphia and New York, the Chestnut Hill Branch trains and the passenger and freight trains to and from the West Jersey & Seashore via the Delaware river bridge. At the west end of the bridge, the lines diverge and the freights are separated from the passengers. The south leg of the pasenger wye (two tracks) is used by inward and outward trains to and from West Philadelphia and the Broad Street station, and the north leg (two tracks) leads to the New York and Pittsburgh subway for through New York trains to and from the west, which do not run into the Broad Street station. The south leg of the wye is for freight for the southern part of the city and the Philadelphia, Baltimore & Washington railroad trains, via the West Philadelphia elevated branch. The north-leg handles freight from the West and that for West Philadelphia.

Formerly this traffic was controlled by two interlockings, the switches heing operated mechanically and the signals being electro-pneumatic, controlled from a mechanical machine. The interlocking at the west end of the bridge (a 40-lever machine) governed the east end of the passenger wyes. The interlocking at the east end of the bridge, an 8-lever machine, was located at the end of the four-track line and governed all movements. Under the new layout, these two interlockings are replaced by one 55-lever interlocking.

### TOWER.

The new tower is located at the west end of the bridge. It is rectangular with a bay and is 19 ft. 7 in. by 26 ft. 4 in. inside. The walls are solid concrete and contain the telegraph, telephone and electric light conduits which were placed before the concrete was poured. The floors of the tower are of 5-in. concrete slabs, reinforced with 3/8-in. twisted rods spaced 6 in. center to center, these being supported by 12-in. I beams, spaced 5 ft. 4 in., center to center. The first floor has a 1-in. surface of fine cement, composed of two parts sand and one part cement, and on the second is a ½-in. coat of carbolith, a compound which resembles cement and forms a very hard and smooth surface.

The roof is built up of yellow pine rafters and hemlock sheeting, two layers of roofing paper and Green Spanish Imperial tile. The eaves extend 5 ft. 6 in. all around the cabin, the under part being concrete reinforced with 3/8-in. twisted rods spacing 6 in. center to center and supported by concrete brackets.




Track and Signal Layout at the New NR Tower on the Philadelphia Terminal Division of the Pennsylvania Railroad.

The basement is divided into two compartments, one 10 ft. 8 in. by 18 ft., for battery, the other in the shape of an L for the repairman's work bench, a tool cupboard and the heater and coal bin. Along the west side of the battery room is the wire way which conveys all the wires from the terminal board to the ducts leading to the manholes in front of the cabin. This wireway is 9 ft. long and 18 in. deep. The frame is made of 2 in. by 2 in. angle and T irons and paneled with ¼-in. asbestos lumber. The angles and T's are so arranged that no wires can come into contact with them. The wireway runs upward along the wall and across, forming a false ceiling, to an opening in the first floor, doors being placed at the bottom where the ducts enter and also at the

The New Concrete Tower With Tile Roof.

opening in the first floor, so there would be no difficulty in fishing in the wires and cables. The first story contains a toilet room and the relay cabinet.

MACHINE.

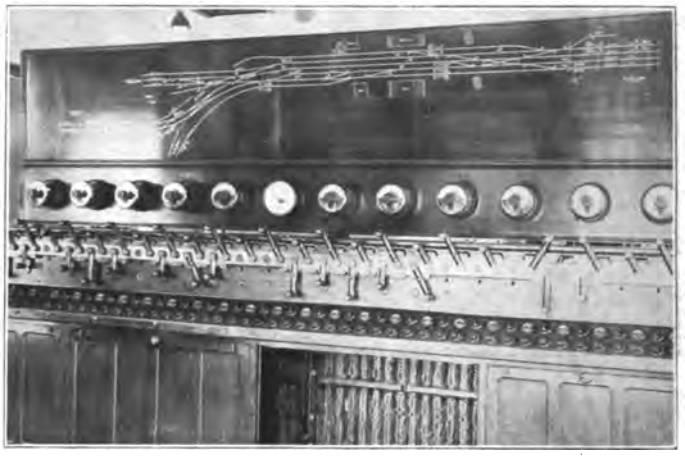
The machine is a Union Switch & Signal Company's type F, 55-lever frame, with 27 switch and 17 working signal levers and is similar in construction to the electro-pneumatic machine. Only the added features will be covered in this article.

The lever lights are placed below the levers. On the front of the machine is an iron ledge, the top being at an angle of 45 deg. to the front plate. This contains cup-shaped receptacles, at the bottom of which are candelabra lamp sockets arranged with connections on the outside. The lamps are lighted by 10-volt a. c., taken from a special tap on the primary coil of track transformers. Another new feature is the lever latch depressor, a device which is placed over the quadrant to force the lever latch into engagement with the quadrant at midstroke, thus causing the quadrant notches to receive the impact of the lever movement instead of the latches of the electric locks, preventing jamming and failure to release. The magnets are of the one-coil type, supported and protected by a back strap. The armature stem is on the outside of the coil instead of passing through the center of the armature core as on the older machines. Each of the switch levers has three of these magnets, two for switch indication and one for the detector lock.

On the signal levers which control signals located less than 100 ft. from the first switch over which they govern, there is a mercury time release that has no electric contacts. These have a separate segment, which is notched at the indicating point and is so shaped that when the lever is put in the proceed position, it will force the latch down. The release is cylindrical in shape and about the size of the iron-encased magnet, except that it is longer. Within the outside cylinder is a smaller cylinder with a hole in the bottom that will allow the mercury to flow through very slowly. At the top of this cylinder there are two holes about ¼ in. in diameter. On the end of the latch stem which extends through the bed plate into the small cylinder is a plunger and when the latch is forced down, this plunger forces a portion of the mercury out through the holes in the top into the large cylinder. Then when the lever is thrown to the indicating position, the mercury being heavier than the plunger which displaced it will flow through the hole in the bottom of the small cylinder floating the plunger and raising the latch.

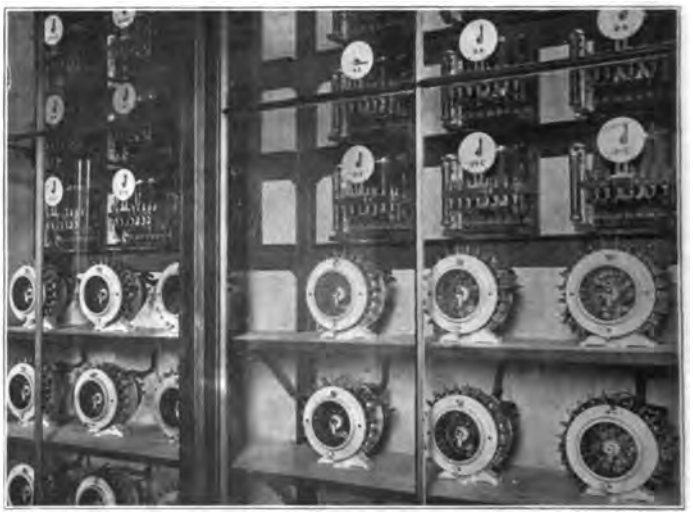
The combination plate is made of a composition material instead of hard rubber which has previously been used and is made up with small plates about 11 by 13 in., supported on channel bars. These plates are held firmly in place by tap bolts and will not warp, thereby doing away with the reinforcing strips.

The track model cabinet, finished in the same color as the machine, is 12 ft. 4 in. long, 3 ft. 3 in. high and is placed over the machine between the mechanical locking and the magnet bed plates, being raised ¾ in. above the machine by 5 blocks



The Interlocking Machine, Track Model and Time Releases.

about 4 in. long. The blocks, being drilled, also serve as a conduit concealing the wires running from the machine to the model board. The front is ⅞-in. board, with molding around the edge and a double strip of molding dividing it into two panels. On the smaller panel (at the bottom of the cabinet and extending the entire length) are the clockwork time releases for the approach locking and the ammeter, which shows the current consumption of the interlocking. On the larger panel is a plan of the tracks and signals in gold leaf on a black background. In the section of tracks between the home and distant signals are placed approach lights for the benefit of the leverman, there being a duplicate set on the



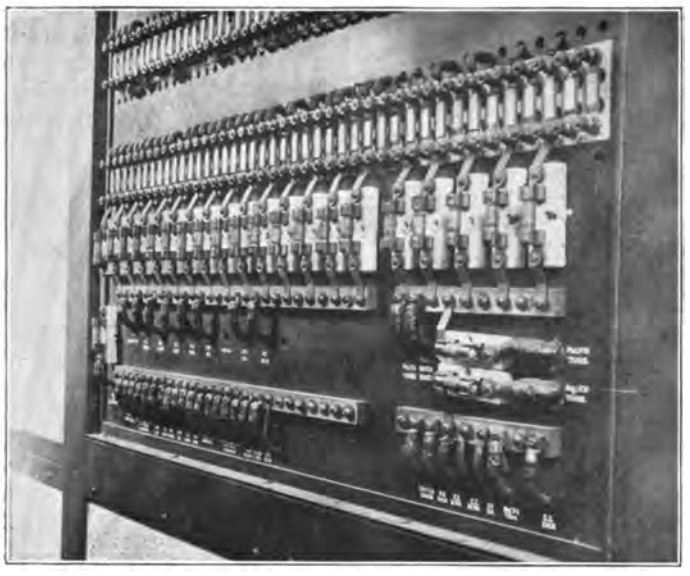
A Portion of the Relay Cabinet in the Tower.

operator's table. The model cabinet is 4 in. deep and has four removable panels in the back which conceal the wiring of the releases and approach lights.

RELAY CABINET.

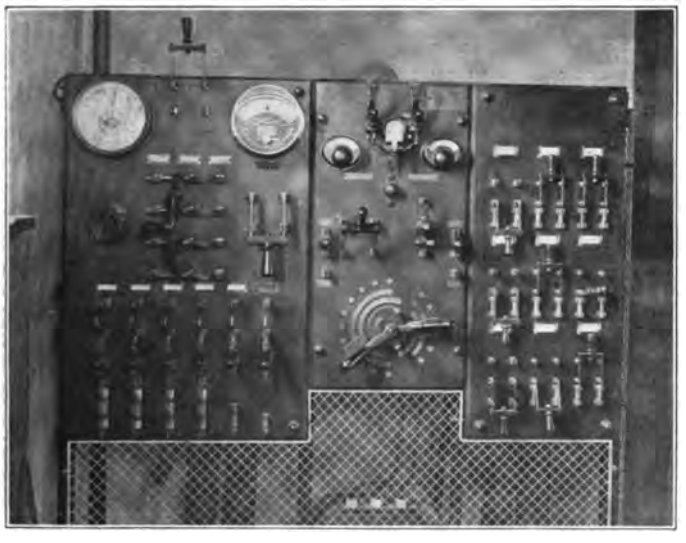
The relay cabinet is fireproof throughout, being 14 ft. 1½ in. long, 7 ft. 8 in. wide and extending from the floor to the ceiling. The frame is made of angle-iron riveted together and is fastened to the floor with 5/8-in. anchor bolts, the inserts for these being placed before the concrete was poured.

Asbestos board was used throughout for paneling and is bolted to the angle-iron frame with ¼-in. by ¾-in. stove bolts. The lower part of the cabinet is occupied by three shelves, which support the indication relays, the first being 18 in. from the floor. These are made of ¾-in. asbestos board with two angle-iron supports, the outer support forming an edge for the shelf. Above the shelves 2½-in. by 3-in. angle-irons are arranged in the form of racks, to which the indicators are fastened with stove bolts.



**A Portion of the Terminal Board at the West End of the Relay Cabinet.**

Sliding iron sash doors with ¼-in. plate glass panels protect the indicators and relays from dust. Inside the cabinet is a space 4 ft. 8 in. wide and the entire length, admission to which is gained through a door in one end. This makes the wiring of the relays and indicators accessible from the front and back. At the other end of the area way is an



**Distributing Boards and Rectifier Panel.**

opening into the wireway from the basement and at this end of the cabinet is the terminal board, which is arranged in one large panel. Square-end porcelain terminals of the R. S. A. type are fastened to a 1-in. asbestos board in horizontal rows 7⅜ in. center to center, and between these rows are placed 4-in. strips of ebonite asbestos, which serve as stiffeners to support the weight of wires and cables. At the bottom of the terminal board are the d. c. and a. c. distributing buses, which are ½-in. by 1-in. brass. The board is held in place by 1-in. by 1-in. angle-irons, which are arranged to form a frame both in and outside of the cabinet.

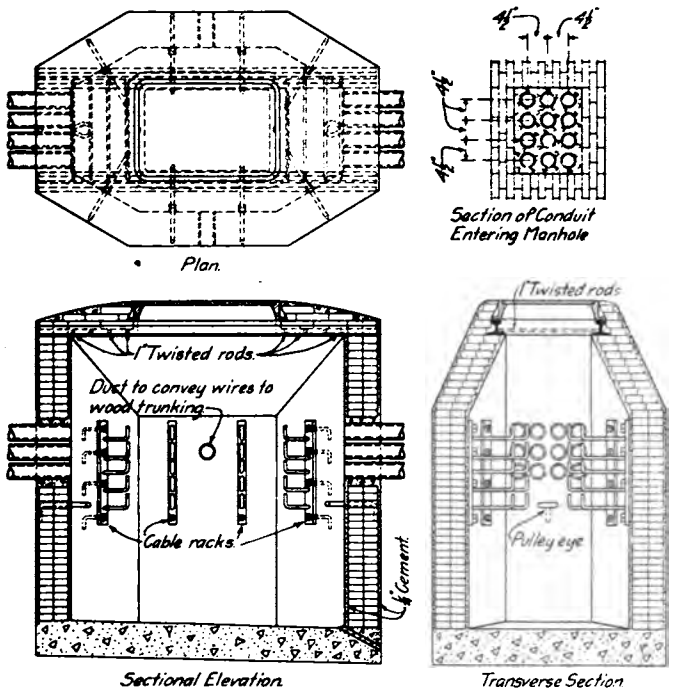
Direct current for operating repeating relays, track indicators, signals and switches is furnished from two sets of 85 cells each of Edison type A6H battery, which are charged separately from a mercury-arc rectifier and distributed to the different sections of the interlocking by means of a separate panel located to the left of the rectifier. At the right of the rectifier is the a. c. panel, from which current is drawn for the rectifier and also for lighting the cabin.

CONDUITS.

All conduits running east or west center in two manholes in front of the cabin. The one for the power wires is located between tracks 3 and 4 and the other for the telegraph, telephone and signal wires, is located between tracks 4 and 5. Four fibre ducts from the former and 24 from the latter convey the wires to the wireway in the basement of the cabin. Extending eastward there are two separate conduits; a 4-duct for the power wires and a 12-duct for the telegraph, telephone and signal wires. These conduits are 3½-in. J. M. fibre tubes (style M straight socket joint) spaced 4½ in. center to center and encased in concrete. Across the Girard Avenue span they are suspended at the side of the girders by iron brackets. The forms for covering these girders with concrete were then built around the ducts, so that when the concrete was poured, they formed part of the bridge structure. At each end of this span, expansion joints were arranged. This was done by concreting the same number of iron pipes as there were ducts in the abutment of the bridge, the inside of the pipes being a trifle larger than the outside of the duct. The joint of the ducts on the shore with those on the span were made to come in the center of the iron pipes and were left loose so that when the bridge contracts they can pull apart and come together again when it expands. Over and between the arches a rubble wall was built and on this the ducts were laid and concreted before the filling was placed between the arches. This conduit extends from the cabin to the signal bridge east of Thirty-third street. The 4-duct conduit for the power wires is similar in construction to the 12-duct and extends from the cabin to the signal bridge just east of the Schuylkill river. The spacing of the manholes was determined by the signal relay locations and the position of crossover switches, the maximum distance being 500 ft. and the minimum 209 ft.

The manholes were built of brick with ¼ in. of cement both in and outside, and are 6 ft. long and 3 ft. wide, inside dimensions. The corners are cut, narrowing the ends to the width of the conduit. The depth is 6 ft. 10½ in. from cover to bottom. Four ft. from the bottom, the sides were

**One of the Relay Locations.**




**Details of One of the Brick Manholes.**

drawn in so that the top is 1 ft. 10 in. or the width of the cover. The covers are rectangular in shape and are supported on two lengths of 85-lb. rail, which extend lengthwise and rest on the end walls.

The bottom has a slope of 3 in. toward one end, where a 1-in. drain pipe was placed. The cable racks, 8 in number, 4 on each side, are made of 2-in. by 1-in. strap iron, fastened by 4¾-in. by 7-in. anchor bolts, which are imbedded in the wall.

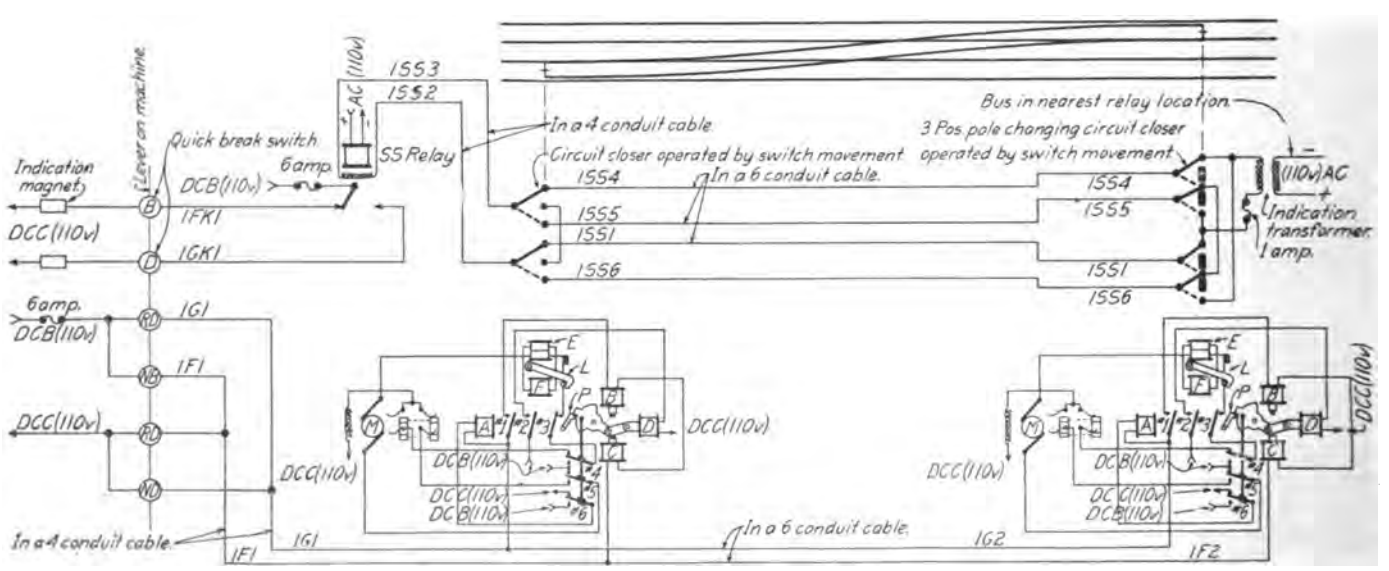
These straps were drilled and tapped for five ¾-in. round iron supports 10 in. long, on which the cables and wires are laid, the iron supports being bent up at the end to prevent them from sliding off. A pulley eye was placed in each end of the manhole, just under the conduits, for fastening block and tackle for pulling in heavy wires and cables. One or more 3½-in. fibre ducts were placed in the side to convey the signal wires to wood trunking and thence to signal locations. West of the cabin the wires and cables were run in wood conduit.

Cables of No. 16 gage wire were used from the cabin to and between relay locations, the cables being of a size to accommodate switch, signal and relay repeating wires. The relay locations are the distributing points and cables and wires run from them to each switch and signal in their vicinity.

### SWITCHES.

The switch movements are the Union Switch & Signal Company's type B-3 electric, operated by 110-volt d. c. The switch points are operated through a worm, which is geared 25 to 1 for single switches and 45 to 1 for slips and moveable-point frogs and is connected to the motor by a friction clutch, which prevents damage to the motor in case of obstruction between switch point and stock rail. The motor is run forward or backward by changing the direction of current through the armature, this being done by a master circuit controller, which is housed in an iron case mounted on a concrete foundation at each switch. The master controller is of the de-energized type, only consuming current when the switch is in operation. The swinging armature which changes the direction of the motor current is locked in position by a plunger which inserts itself into a square hole in the support for the overload circuit breaker, which is closed by a coil spring. The circuit breaker shown on the circuit diagram is in the normal position, and when the lever is thrown from the normal to the reverse position, band N B is broken and band R D makes contact. Wire 1G1 becomes positive, energizing magnet A and going to common over spring 6 on the swinging armature. Magnet A, energized, opens contact 3, which is the overload circuit breaker and disengages the plunger P on the swinging armature. Contact 1 closes the circuit for the pole-changing magnets B and C, which changes the position of the swinging armature, reversing contacts 4, 5 and 6.

This opens the circuit on magnet A, which through the action of the coil spring, locks the swinging armature and closes contact 3, opening contacts 1 and 2. Contact 2 closes the circuit for neutral magnet D, which energizes the poles of the swinging armature. The motor current flows through contact 4, then contact 3 through magnet E to motor armature, then over contact 5 to circuit-closer on movement to motor fields. Magnet E has two windings, one heavy with few turns and in series with the motor circuit, the other smaller and connected to magnet F. When the current is turned on the motor by the swinging armature changing position, the surge in the heavy winding induces a current in the small winding, which discharges through magnet F, holding the latch L down until the motor gains speed. If the motor fails to start and continues drawing heavy current after the small winding on E is discharged, latch L will pick up allowing the overload circuit breaker to open. The circuit breaker can be restored by throwing the lever on the machine back




**Circuit Diagram of B3 Switch Movement.**

to the indicating point and starting over again. In throwing the switch from the reverse to the normal position, the operation is practically the same, except that contact 6 is laying to the positive side, and when contact N B closes, putting common on circuit, magnet A is held until the swinging armature has changed position. Each switch has a separate indication circuit. The current is taken from the nearest 110-volt bus through a 6-amp. fuse to a 1 to 1 transformer located in the iron case with the master controller and then to a three-position circuit controller, operated by the switch

**Looking West from the New Tower Toward the Wyes, Showing the Old SY Cabin at the Right.**

movement, which changes the polarity, and onto the other end or ends where it passes through similar circuit closers, and then to a three-position relay in the cabin over which direct current is taken to operate the magnets on the machine. The signal circuits are taken over the contacts of these relays to insure that the switch is in proper position before the signal, which controls movements over it, can be given.

SIGNALS.

The signal bridges, one 4 and three 5-track, are of an extra heavy type, with a view to supporting the trolley wires when the Chestnut Hill Branch is electrified.

The high signals are the Union Switch & Signal Company's style T-2 motor, operating on 110-volt, d. c. circuit and giving indication in the upper right-hand quadrant for three blocks in advance.

The three-position dwarf signals are also of the type T-2, while the two-position are of the solenoid type. All signals are electrically lighted by two 12-volt incandescent globes in each lamp, the current being taken from a special 10-volt tap on the primary coils of the track transformers and fused by a 6-amp. fuse.

The lighting circuits are so arranged or distributed that not all the lamps on any one signal mast are supplied by the same circuit, so that it will require the burning out of more than one fuse to darken the lights in all the signals on one mast.

TRACK CIRCUITS.

With the idea in mind that this interlocking will be in the electric zone when the Chestnut Hill Branch is electrified and that the propulsion current will be 25 cycles a. c., frequency relays to operate on 60 cycles were used throughout. For track sections 500 ft. or under, the double vane relay, as described in *The Signal Engineer* of February, 1914, was used with a rheostat, having .14, .23, .34, .43 and .52-ohm taps, between relay and track. On the transformer end a rheostat having .34, .54, .90, 1.0, 1.3 and 1.58-ohm taps was placed between the transformer and track. On sections over 500 ft. long the centrifugal relay as described in *The Signal Engineer* of February, 1914, was used, with a special impedance coil, with an air gap of .026 and having .02, .05, .07, .11, .18, .26, .35, .46, .58, .71, .86 and 1.03-ohm taps. The track transformers (.6-kv.a. primary, 110 volts) are of two designs, one having two separate secondary coils of 300-v. a. each, and the other four secondaries of 150-v. a. each, with taps on each coil for 3, 5, 9, 12, 14 and 17 volts. The two coil transformers were used on distant and automatic signal track sections and the four coil on sections of 500 ft. or under, each section having a separate secondary. No. 9 stranded wire was used throughout for track wiring.

POWER DISTRIBUTION.

The normal source of a. c. power will be the West Philadelphia substation, which is at the present time under construction. This substation will furnish power for the signal service and also for propelling electric trains between Broad Street station and Paoli. The signal service line (3,300 volts) is No. 0 wire from West Philadelphia station to Overbrook and No. 2 wire from there to Paoli, with the "NR" line branching off at Thirty-third street, "K" Interlocking and at Fortieth street. The Thirty-third street branch follows the outward passenger track to "NR" cabin and the Fortieth street branch follows the passenger tracks through the New York and Pittsburgh subway to the cabin, where it is connected to the Thirty-third street line,

**One of the Signal Bridges at the East End of the Plant.**

forming a loop. By means of oil switches, power can be fed either way or the Broad Street-Paoli line can be opened between Thirty-third street and Fortieth street and power fed around the loop. An emergency 20-kv.a. step-up transformer (2,200 to 3,300 volts), which is now supplying the interlocking with power from the Forty-sixth street power house, will be used in case the normal supply fails. This emergency line is tapped on to the main line through oil switches just west of the cabin. The power line east of the cabin is dead-ended and will be until the Chestnut Hill branch is electrified, but through the operation of switches on the a. c. panel in the cabin, 110 volts can be fed to each location from the 10-kv. a. transformer which feeds the rectifier. The power line is No. 2 stranded wire and west of the cabin is placed in cypress trunking, pitched. From the cabin to the east side of the bridge it is run in concrete fibre conduit, and from this point to Thirty-third street it is in cypress trunking pitched. The line is sectionalized at every transformer location and with the loop arrangement any section may be cut out without interfering with the working of any part of the interlocking.

The d. c. feeders east and west of the cabin are No. 0 wire and run direct from the d. c. switchboard in the cabin to the first location east or west, where they are terminaled on brass bus bars, and from these bus bars in the next adjacent case and so on to the farthest location. From these bus bars, wires of the required size are run to the operated functions.

All plans were prepared in the signal engineer's office and the work was installed by the Philadelphia Terminal Division forces.