

Automatic Signal NJ9 on the main span of the bridge—note special bay, sheet iron case on the walkway at the left, stop control magnet on the outside of the case, train stop mechanism, and illuminated speed sign

Delaware River Bridge Signaling

AN important extension of Philadelphia's rapid transit facilities was placed in service on June 7, 1936, when regular passenger service was inaugurated on the Delaware River Bridge Line, connecting downtown Philadelphia with Camden, N. J. This line, constructed and completely equipped by the Delaware River Joint Commission of Pennsylvania and New Jersey, is leased and operated by the Philadelphia Rapid Transit Company. Prior to the establishment of this service, the heavy passenger traffic between these two cities was handled on ferry boats operated, for the most part, by the various railroads, or on bus lines and by private automobiles operating over the Delaware River Bridge, which has been open to vehicular traffic since 1926.

The new line provides rapid transit multiple-unit car facilities on two tracks extending from the present terminus of the Ridge Avenue subway at Market street, Philadelphia, to a terminal at Haddon avenue and

C.T.C. control of interlocking facilities is outstanding feature of installation on Philadelphia-Camden high-speed line

Carman street, Camden. While, at present, both the Delaware River Bridge Line and the Ridge Avenue Line terminate at Eighth and Market streets, the contemplated extension of the subway will make it possible to extend both of these lines so as to serve additional territory in Philadelphia. Although not yet equipped for operation beyond Market street, the subway structure is already complete to Eighteenth and Locust streets. It is expected that operation will be provided to a new terminal at Sixteenth and Locust within the near future. Ultimate plans of the Philadelphia Department of City Transit call for the extension of the Ridge Avenue subway

out Locust street, through a tunnel under the Schuylkill river, thence to Thirty-Sixth and Woodland avenue, and out Woodland avenue to Fifty-Second street, a total length of approximately 6 miles. Like the Broad Street subway and the existing portion of the Ridge Avenue subway, this extension would be made by the city of Philadelphia and leased to the Philadelphia Rapid Transit Company for operation.

The use of C.T.C. for the control of all intermediate interlocking facilities, consisting of the junction of the Delaware River Bridge Line and 8 "emergency crossovers" which are to be used in the case of tie-ups or for turning back trains during rush

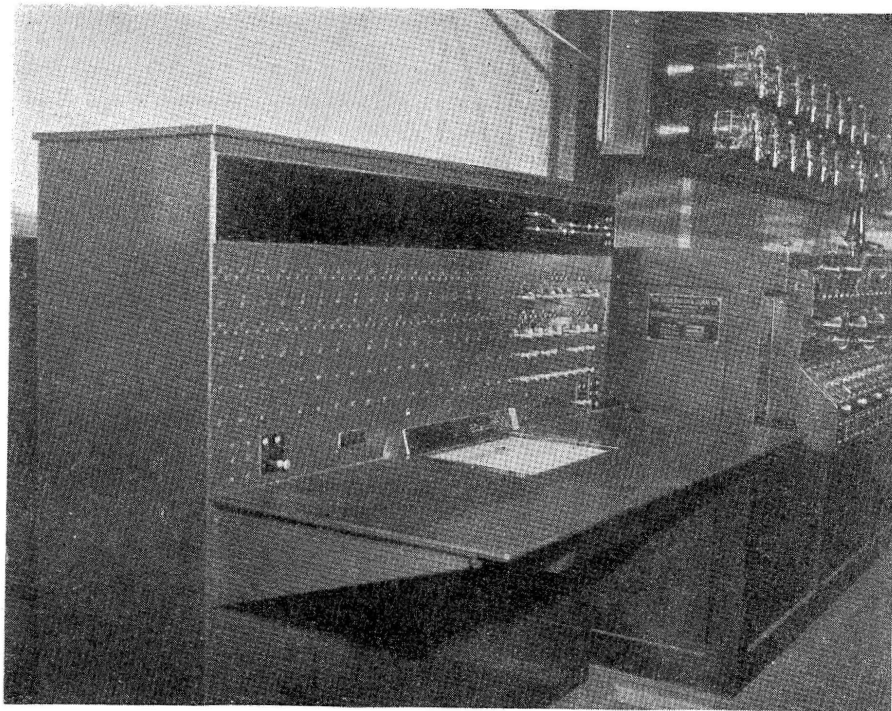
periods, was decided on when the plans for the signaling of Ridge Avenue subway were formulated. Thus, the entire subway, with the exception of terminal interlockings, will be C.T.C. controlled from the tower at Fairmount avenue. The first portion of this C.T.C. installation was placed in service when the Ridge avenue subway was opened to traffic as far as Eighth and Market streets on December 21, 1932.

The signal work involved in connection with the Delaware River Bridge Line consisted of alteration of the existing C.T.C. controlled E.P. interlocking facilities in the vicinity of Eighth and Market on the Ridge Avenue Line to include the junction of the Delaware River Bridge Line; installation of automatic block signals and automatic and semi-automatic train stops throughout; and the installation of a complete electro-pneumatic interlocking at City Hall Station on the Camden side of the Delaware river.

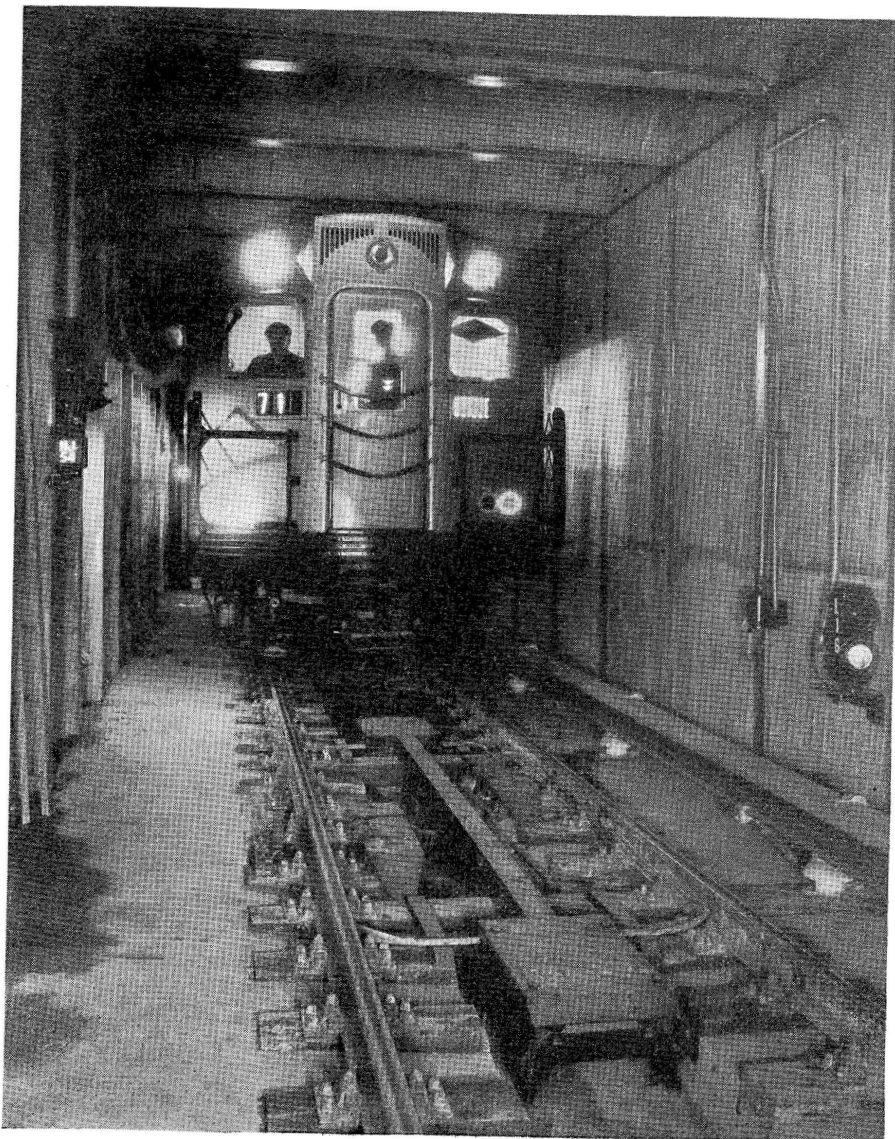
This installation is particularly interesting from an operating standpoint because of the exceedingly heavy traffic handled by the C.T.C. controlled facilities at Eighth and Market streets during rush hour periods when maximum length trains and minimum headways exist on both lines. In order to maintain four-minute headway on each line, and to allow for the necessary station stop time required to change ends, it was necessary to arrange the signaling so that a departure interval of less than 90 sec. be maintained. The present traffic requirements at this point are such that the layout undoubtedly constitutes the busiest single C.T.C. controlled group of signal appliances yet installed. Because of the fact that it is necessary to maintain this close headway with maximum length trains for several hours each day and there is practically no opportunity to make up the time lost if a delay should occur, it is imperative that delays chargeable to the signal system be practically non-existent.

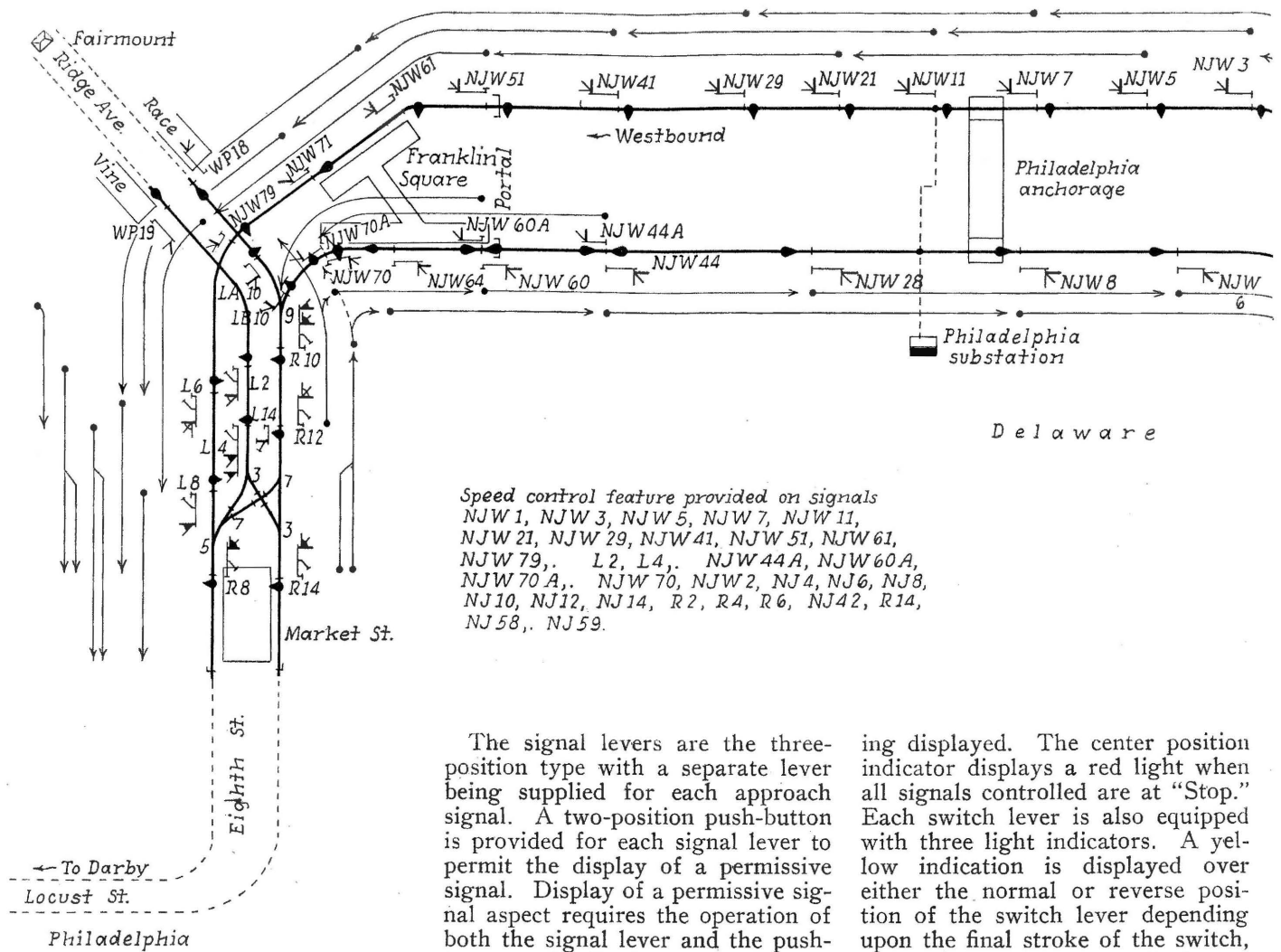
Features of the C.T.C. Installation

The C.T.C. system is the Union Switch & Signal Company's three-wire circuit-code type with the control machine located in Fairmount Tower at the junction of the Ridge Avenue and Broad Street subways. The C.T.C. machine is located adjacent to a standard Model 14 interlocking machine, which controls the electro-pneumatic interlocking at Fairmount avenue (see page 325 of December, 1933 issue, *Railway Sig-*



C.T.C. control machine at Fairmount Avenue
Below—L16 and NJ54 signal locations in the subway near City Hall station, Camden





ning), and has 4 levers for the control of 2 switches and 2 crossovers, 6 levers for the control of 19 signals, 1 lever for the control of 2 signals and 1 traffic control, 4 traffic control levers and 9 emergency release push buttons for the switches and traffic circuits at Market and Eighth streets.

The switch levers are of the two-position type, one lever being used to operate a single switch or the two switches of a crossover. Normally-sealed emergency switch release buttons for the two crossovers and two turnouts at Market street are provided in the lower center portion of the control machine. Release of a switch requires the simultaneous operation of the proper button by the operator and by a motorman or the signal maintainer, acting under the operator's instructions, of an emergency spring-return push-button type releasing device located at each home and dwarf signal. The detailed steps involved in the operation of this release feature are described elsewhere in this article.

The signal levers are the three-position type with a separate lever being supplied for each approach signal. A two-position push-button is provided for each signal lever to permit the display of a permissive signal. Display of a permissive signal aspect requires the operation of both the signal lever and the push-button. Traffic levers provide for setting up reversal of traffic on any track within the sole control of the C.T.C. and for the reversal of traffic on the bridge tracks in co-operation with the interlocking at City Hall Station, Camden. A special push-button, sealed in the normal position, is provided in connection with each traffic lever for the purpose of effecting emergency release of the traffic locking circuits.

C.T.C. Indication System

The indication system on the C.T.C. machine gives the operator a complete picture of the position of signals and switches at all times and complete information as to the occupancy of track circuits. Indications are provided showing the traffic route set-up, low air pressure, and loss of third-rail propulsion energy. In addition an automatic train graph is in service.

Each signal lever on the C.T.C. machine is equipped with a light-type indicator directly over each position of the lever. The right or left position indicator displays a yellow light depending upon whether the right or left "Proceed" signal is be-

ing displayed. The center position indicator displays a red light when all signals controlled are at "Stop." Each switch lever is also equipped with three light indicators. A yellow indication is displayed over either the normal or reverse position of the switch lever depending upon the final stroke of the switch, while the third indicator displays a green indication when the condition of the electric locking in the field is such as to permit movement of the switch in response to a lever movement.

Traffic lever indications are provided on the track model portion of the machine by two light indicators for each track controlled by traffic locking, one showing a set-up providing for movements in the normal direction and the other indicating that the set-up is for reverse movements. Each of the traffic lever indicators is painted with an arrow pointed in the direction of the traffic line-up as an aid to the operator in visualizing conditions at all times. Track occupancy indicators over the traffic levers show the usual information as to the occupancy of all track section in the control of the traffic locking.

Indicators showing the occupancy of all track sections between Fairmount avenue and Eighth and Market streets, as well as for each of the three blocks in approach to the approach signal and each of the first three blocks beyond the interlocked territory on the bridge line, thereby giving ample indications for the op-

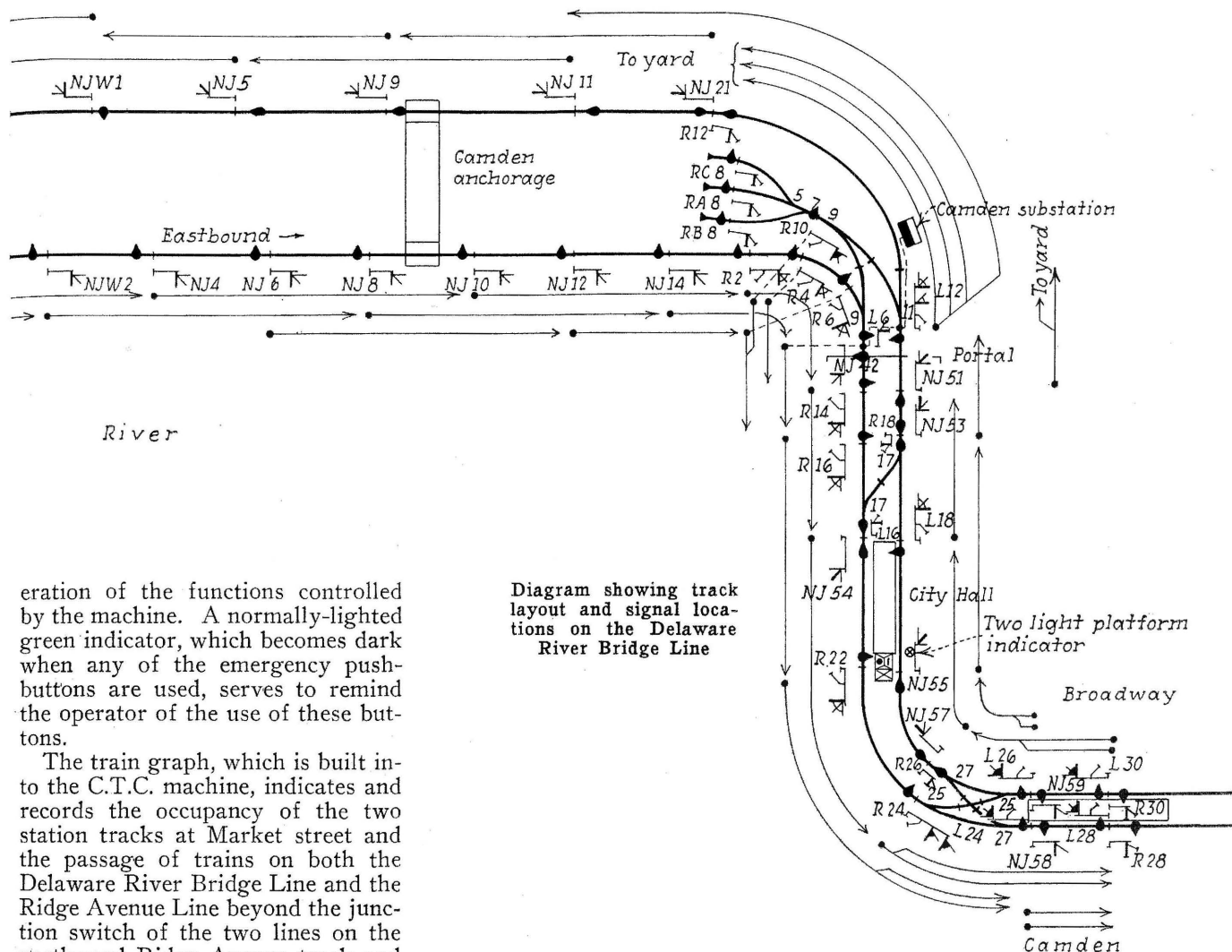


Diagram showing track layout and signal locations on the Delaware River Bridge Line

eration of the functions controlled by the machine. A normally-lighted green indicator, which becomes dark when any of the emergency push-buttons are used, serves to remind the operator of the use of these buttons.

The train graph, which is built into the C.T.C. machine, indicates and records the occupancy of the two station tracks at Market street and the passage of trains on both the Delaware River Bridge Line and the Ridge Avenue Line beyond the junction switch of the two lines on the northward Ridge Avenue track and the eastward Delaware River Bridge track. It is also used to record the passage of trains at Fairmount avenue, on each of the four tracks of the Broad Street subway.

Emergency Release Operation

The following outlines the steps to be taken in the operation of the emergency release of a switch in the C.T.C. controlled facilities at Market street:

1. Operator must code all signals governing over the switch, to the stop position.
2. Operator must be advised by trainman that all trains in the vicinity have stopped and that no trains are occupying the switches.
3. Operator must then break seal on the emergency release button and hold the button depressed while he pushes the code starting button.
4. The normally-lighted green emergency release indicator is automatically darkened.
5. The operator instructs the trainman to depress the emergency release button at the home or dwarf signal at which the train is standing. (This is done without the necessity

of leaving the cab.) This action, in conjunction with the emergency release relay controlled by the operator, by-passes the detector locking circuit.

6. The indication showing that the switch is free to be moved appears on the control panel over the switch levers involved and the operator then reverses the switch.

7. After the switch has responded, the operator pushes the code-starting button under the release button without depressing the release button. This action again locks the switches and restores the emergency release circuit to its normal condition in the field.

8. The proper signal may then be displayed to allow the train to proceed.

Code System Designed for Speed

The code system for the control and indication of all switch and signal functions is arranged so that there will in no case be a delay of more than 20 sec. in the delivery of any code and that each code line will, at all times, be working at less than 50 per cent of capacity. Three code

lines are used between the C.T.C. machine at Fairmount avenue and the facilities at Eighth and Market, one of which will be extended to handle some of the emergency crossovers contemplated in the plans for the extension of the Ridge Avenue subway.

E. P. Interlocking Machine Installed at Camden

In order to provide facilities for the control of trains at the Camden terminal of the bridge line, a Union Switch & Signal Company Model 14 interlocking machine controlling a standard electro-pneumatic interlocking was installed at City Hall Station, Camden. This machine has 27 working levers and 12 spare spaces. There are 7 levers for the control of 3 single switches and 4 crossovers; 14 levers for the control of 40 signals; and 6 levers for controlling traffic on both tracks between Market street, Philadelphia, and City Hall Station, between the yard and City Hall Station, and be-

tween City Hall Station and Broadway. The spare spaces in the machine were provided primarily to take care of proposed future additions when the line is extended eastward from Broadway, Camden.

Indication lights were provided in this machine, having the same colors and indications as the corresponding indications on the C.T.C. control machine at Fairmount Station, Philadelphia. The illuminated track diagram is mounted on pipe supports over the machine. The pipe supports serve as conduits for the incoming wires. The board itself consists of $\frac{1}{8}$ -in. steel plates mounted on an angle iron frame, with sectional doors at the rear to provide ready access to the interior wiring. The rails are represented by $\frac{1}{8}$ -in. chromium plated brass strips fastened in place by flush machine screws and the area between the two strips representing a track is painted in color. A track circuit indicator for each section indicates, when lighted, the occupancy of that particular track section. The air gage, clockwork time releases, and manipulation chart are in the center of the model board directly below the track diagram.

At one end of the operating room, facing the end of the interlocking machine, is a sheet-steel dead-front enclosed type switchboard, upon which are mounted the necessary switches and meters used in the operation of the plant. Switches are of the fuseless circuit-breaker type. Indicating lights and control switches for ground-detector apparatus are mounted on this switchboard.

An item of particular interest which may be noted in the illustration of the City Hall interlocking machine is the specially constructed steel desk which houses an automatic train graph. This recorder is built as a unit and is similar to the graphic recorder used in connection with the C.T.C. installation on the Philadelphia side in the Ridge Avenue subway. Indications of the operation of certain track relays are recorded on this time chart and thus a record of train movements is obtained throughout the Camden subway portion of the line.

Special Train Indication Unit at City Hall Station

A special train indication unit is used on the platform at City Hall Station to advise the platform man of the departure of a train westward from Broadway Station. This is a two indication unit made up of two single units of the type used for per-

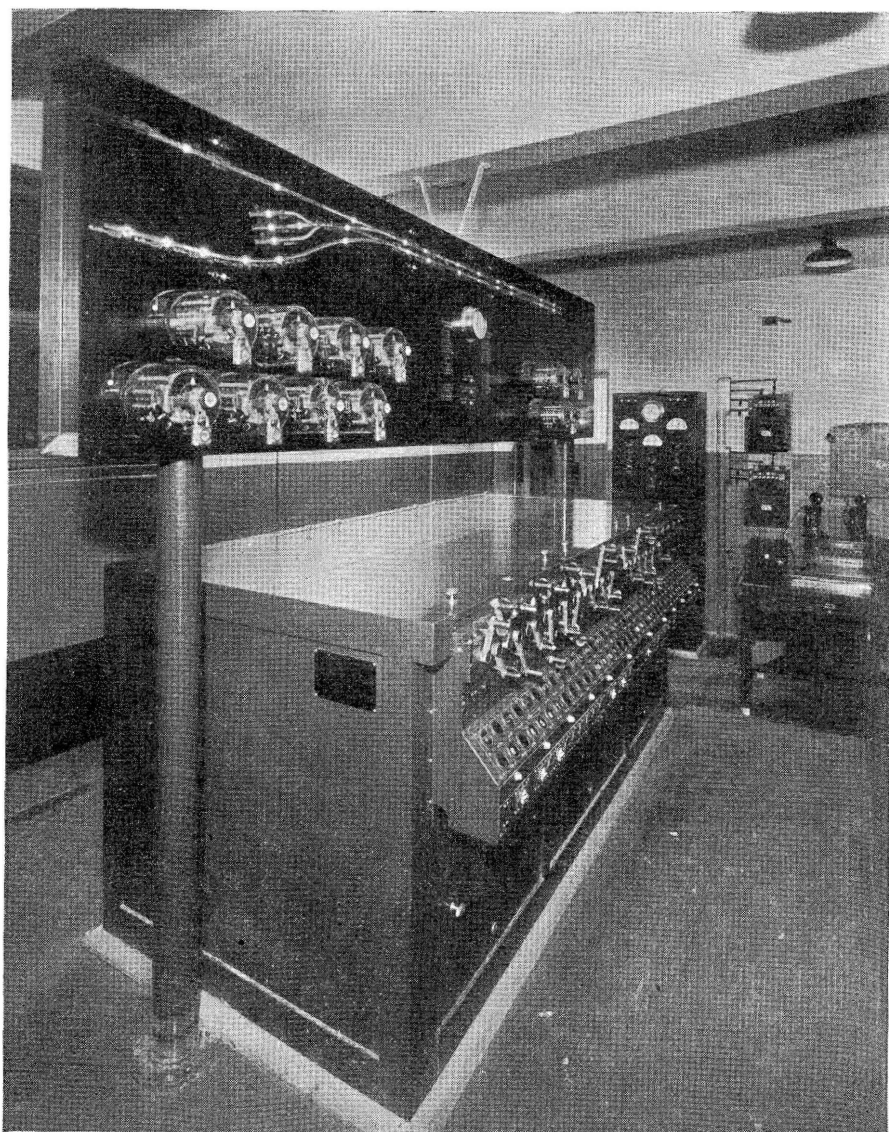
missive aspects on three-arm signals and is mounted on top of the westward automatic signal unit but facing against the current of traffic so as to be visible from the platform. One unit is equipped with a yellow lens, which is normally lighted, but becomes dark when the other, with a red lens, is lighted after a train has left Broadway Station and is approaching City Hall Station. Both units are extinguished when traffic is set up for the reverse direction, in order that the aspects of the indicator will not be mistaken for automatic signal indications.

Switches Are Electro-Pneumatic

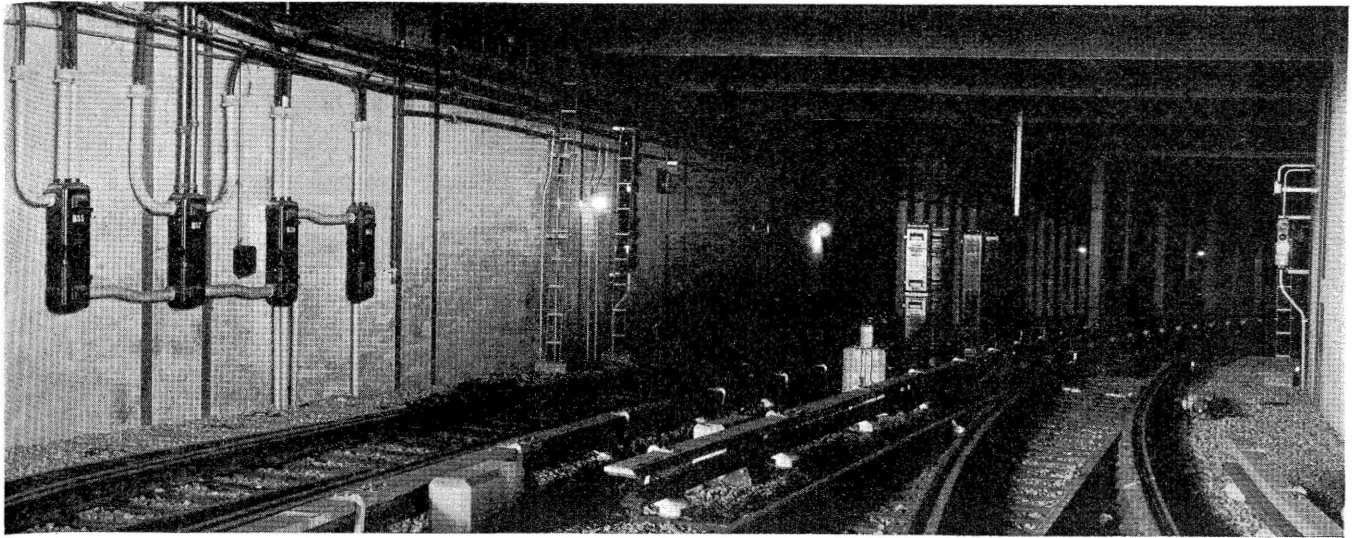
All switches of the C.T.C. controlled interlocking at Market street, Philadelphia, as well as those of the standard electro-pneumatic interlocking at City Hall Station, Camden, are controlled by Union Style

A-1 electro-pneumatic switch movements with CP valves. Mechanisms and covers are so mounted that no part of the switch operating mechanism or cover extends more than $\frac{1}{4}$ in. above the plane of the top of the track rails. The subway track at switch locations is of channel construction, the ties being bolted to channels which are imbedded in concrete. The yard track switches are on rock ballast. Long ties were framed for mounting the switch-operating mechanisms. Switch valves are separately housed and are mounted in the jack-arches, between columns or on concrete pedestals.

Covers, or other suitable protection, are provided for the ends of lock rods and operating rods, where they extend beyond the switch machine, to prevent injury to persons and to prevent interference with proper operation caused by obstructions which might lodge between the



City Hall interlocking machine—sheet steel enclosed type switchboard, and train graph desk, against far wall



Arrangement of signals, relay boxes, stop valves, junction boxes on wall, and application of cable runs just inside the Camden portal

rods and some part of the subway structure. All switch mechanism covers are marked with numbers corresponding to the control machine lever number, and, in the case of two switches of a crossover being operated from a single lever, the number is followed by the letter "N," "S," "E," or "W," depending upon whether the switch is the north, south, east, or west switch of the crossover. The marking consists of cast iron numbers or letters, securely fastened to the sheet metal cover, which have been painted white for quick identification.

Signals

All signals on this installation are of the Union subway type, those used in the subway proper being the standard subway light signal with signal lens using 14-volt, 5-watt bulbs, and those used outside of the subway being adapted to the different conditions of visibility by the use of hoods, doublet lenses and 30-volt, 30-watt bulbs. The type of signal used throughout the installation employs duplicate lamps for the illumination of each lens of the signal.

Automatic signals are of the three-indication type with a green, yellow and red lens, one lens being blanked out if less than three indications are required. Each automatic signal is equipped with an illuminated number plate on the front and back of the case using duplicate lamps as in the signal aspects. All signals are located on the right side of and adjacent to the track they govern and, with the exception of the signals on the suspended spans and bridge approaches are located approximately opposite the insulated joint in the track rail. The signals on the suspended spans and bridge

approaches are located approximately 11 ft. from the insulated joints because the releasing device for the train stop, which is described elsewhere, is mounted on the signal head rather than 11 ft. ahead of the signal as in the subway structure. Signals on the suspended spans and bridge approaches are also equipped with a side opening in the red lens unit so that a red indication is visible to the motorman at the time of operating the releasing device to clear the automatic train stop. Operation of the releasing device for the automatic train stop from the motorman's compartment makes necessary this special arrangement on the bridge because suitable mounting for the release could only be secured at the signal unless a separate upright support were installed.

Signals are mounted on convenient portions of the subway or bridge structure where possible, or on relay cases, pipe supports or concrete foundations, depending upon the type of track structure involved, so that a clear view of the signal is provided.

Interlocking Signals

Home signals at interlockings consist of two three-indication units with the same lens and lamp equipment as the automatic signals and, where required, a single-indication unit mounted below these to be used as a permissive signal. The indication displayed by a home interlocking signal consists of two or three lights in a vertical row to indicate which route is set up, and whether the track ahead is occupied. The top three-indication unit of an interlocking signal governs the right-hand route and the bottom unit the

left-hand route. Where there is no diverging route, the single permissive signal unit is omitted and lenses in the top and bottom position of a three-position unit are used, the upper lens being red and the bottom yellow. Dwarf signals consist of a two-indication unit with a yellow lens and a normally lighted red lens.

All signals bear an illuminated number plate. The illuminated number plates for interlocking home and approach signals are located under the bottom lens of the upper unit and bear the signal lever number. An additional illuminated plate bearing the letter "T" to designate a tower controlled signal is placed immediately below the bottom lens of the second unit. Each dwarf signal has the number of the corresponding lever in the control machine attached to the side of the signal case nearest the track.

Speed Control Signals

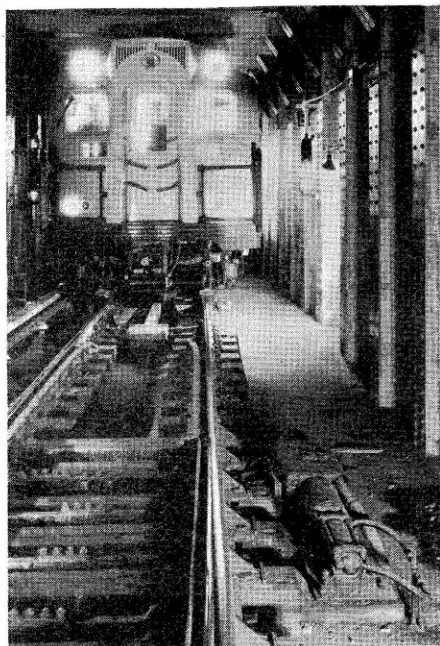
An interesting feature of this installation is the provision of "speed control" in connection with a large number of home, approach and automatic block signals. These signals, in addition to their normal controls, have a special time-element control which operates so as to require the train to consume a pre-determined time in the block or blocks approaching the signal in order to receive a clear or approach indication. Because of the relatively heavy grades (as much as five per cent) involved in descending from the bridge approaches to subway construction on both sides, it was deemed desirable to equip a large portion of the signals on the entire installation with this speed control feature in order to keep trains within

a range of speeds consistent with the braking distances upon which the signal system was based. Each section of speed controlled territory is marked by an illuminated speed sign which is located near the approach to the territory. This sign does not function in connection with the signals, but serves merely as a marker to advise the motorman that he is entering speed control territory and is lighted by a 110-volt, 25-watt lamp.

Train Stops

Electro-pneumatic train stops of the Union Style S type are provided to operate in connection with all high signals and all dwarf signals, except one, on the entire installation. An automatic train stop has the same control as the signal in connection with which it operates, except that the trip arm is held in the clear position until the entire train has passed over it. The train-stop mechanisms are housed in weather-proof cast-iron cases located between the track rails. The center line of the trip arm is $8\frac{1}{2}$ in. outside the gage line of the nearest track rail. In the tripping position the arm extends $2\frac{1}{2}$ in. above the top of the rail, and in the clear position not less than $\frac{1}{2}$ in. below the top of the rail.

Each automatic train stop is provided with a spring return push-button type releasing device which can be used when it is necessary for a train to pass an automatic signal in the "Stop" position. In the subway,



Train approaching east end of crossover No. 17, City Hall interlocking. CP valve (not shown) is located on the center columns

the push-button is mounted in a cast-iron box mounted on the second column preceding the one supporting the signal, and so placed that it can be operated by the motorman from his cab. This push-button is located approximately 11 ft. from the train stop so that the motorman can observe the train stop assuming the clear position. On the bridge approaches and suspended spans, the push-button is mounted on the signal head and the train stop is located at the insulated joints which are located approximately 11 ft. beyond the signal. The latter arrangement is made for convenience of mounting the push-button and makes it necessary that the train stop be located beyond the signal so that its clearance can be observed by the motorman when keying-by the automatic train stops.

Semi-automatic train stops, which are located at all interlocked signals, are controlled in the same manner as the automatic train stops, except that a push-button release is not provided. Provision is made for the automatic depression of all train stops when traffic is reversed.

Circuits

Both single- and double-rail 60-cycle a-c. track circuits, using Union Switch & Signal Company Model 15 two-position vane relays, were installed. The track transformers were, in most cases, also equipped with a lighting secondary equipped to deliver secondary voltage in steps of one volt each, while the track voltage is adjustable in steps of two volts.

Impedance bonds for the double-rail track circuits are of the laminated core type and are petrolatum filled, with an adjustable air gap for varying the impedance drop in the bond. They have a continuous current-carrying capacity of 1,000 amp. per rail. The bonds are set on malleable-iron legs imbedded in concrete, or are supported on ties either between or outside of the rails. Impedance bonds located on the suspended spans are supported beneath the walkway gratings in cradles. Connections between bonds and between a bond and the rail are made by means of bare stranded cables, except on the suspended span where copper straps protected by wood strips and insulated stranded cables are used. All insulated joints are of the Union modified Keystone type.

Automatic block signal circuits are so arranged that a signal will display the "Stop" indication when any portion of the track within its control limits is occupied, or when the auto-

matic train stop operating in connection with the signal is in the tripping position. A signal indicates *Proceed with caution, prepared to stop at the next signal* when the portion of track within its control limits is unoccupied, the automatic stop is in the clear position, but the next signal is in the "stop" position. A signal indicates *Proceed* when its control limits are unoccupied, the train stop is in the clear position, and the next signal indicates *Proceed* or *Proceed with Caution*. The control limits of a signal generally include an overlap beyond the next signal so as to provide 150 per cent emergency braking distance at maximum speed.

Interlocking home signals are controlled by track and line circuits and train stops in the same manner as the automatic block signals and, in addition, by their respective levers in the control machine in such a manner that the correct position of all switches in the route is assured before the signal can be cleared. A home signal will not clear if its permissive signal push-button is not in the normal position. A dwarf signal will clear when its control lever is reversed, the switches in the route properly aligned and locked and the route clear. In C.T.C. territory, the control circuits for all interlocking signals check the opposing code repeater relays for all routes in the de-energized position. A permissive signal is so controlled that it cannot be cleared unless the corresponding home signal lever is cleared, all switches in the route are locked, and the home or approach signals indicate *Stop*. Interlocking approach signals are controlled in the same manner as the interlocking home signal.

Speed control of automatic and interlocking signals does not affect the other controls of the signal, but merely imposes an additional control, that of the operation of the time-element relay, upon the factors involved in the clearing of the signal. Automatic and semi-automatic train stops have the same control limits as the signal with which they are associated.

Signal indication and approach locking are provided in the interlocking machine for each signal lever. The electrical equivalent of this locking is provided for all switches controlled by the C.T.C. machine. Time-element relays are used for the release of such locking in the C.T.C. territory and manual clock-work time releases in the interlocking territory.

Approach locking is automatically released after a train has passed the

respective home or approach signal.

Detector and sectional route locking is provided for all switches. Where a route involves more than one track circuit, including switches, the locking circuits are arranged to provide for automatic release of each successive electric switch locking, immediately upon the passage of a train out of the track circuit in which the switch is located. Emergency release of detector and route locking on the interlocking machine is accomplished by means of a manual clock-work release mounted on the track model. Emergency release of detector and route locking in the C.T.C. controlled territory is accomplished by means of co-operation of the operator and the motorman, the former operating a releasing push-button on the control machine and the latter operating a push-button located at the signal. The steps involved in effecting this release have been previously described.

Traffic locking is provided. The circuits require that the entire territory under the control of the traffic lever must be unoccupied before the lever in the interlocking machine can be changed. A complete equivalent of this locking is provided in the field in the territory controlled by the C.T.C. machine. Code-repeating relays controlling signals leading into traffic controlled territory are checked in the de-energized position before opposing signals may be cleared. For emergency release of traffic locking, if it is desired to reverse traffic when a train is occupying a section or when a track circuit has failed, a sealed emergency release button in the C.T.C. machine is depressed which will by-pass the track circuit portion of the electric locking following the operation of a time-element relay.

Transmission Systems

The electrical energy required for the signaling and interlocking may be supplied from either the Philadelphia or Camden substations. The 110-volt a-c. signal mains are fed at six transformer locations by 4,150-volt, 60-cycle duplicate transmission cables.

The 110-volt a-c. signal mains are divided into sections at points approximately midway between adjacent transformers. Signal mains in the subway structures are run on messenger wire fastened to the walls on either side of the subway, those on the bridge approaches and suspended spans are run in Everdur metallic tubing, and those in the yards are run in Everdur metallic

tubing carried on concrete pedestals in conjunction with the main air runs.

Low-voltage d-c. mains are carried in the same multiple conductor cable with the a-c. mains. They are divided into sections at points approximately midway between adjacent rectifiers.

Compressed Air Equipment

Two motor-driven air compressors, each capable of delivering 100 cu. ft., are located in each of the two compressor rooms. One compressor room is located at the west end of Franklin Square Station on the Philadelphia side and the other at the south end of City Hall Station in Camden. Compressors are of the Westinghouse Air Brake Company's 2-VSW-8 type with a directly connected 220-volt, 3-phase induction motor. Compressor motor starters are the Cutler-Hammer Company's Type A. The motor and compressor are supported on the same casting which is bolted to a concrete foundation. An after cooler is provided between the compressor and the main reservoirs. An I.T.E. Company sheet-steel dead-front enclosed type switchboard is located in each compressor room.

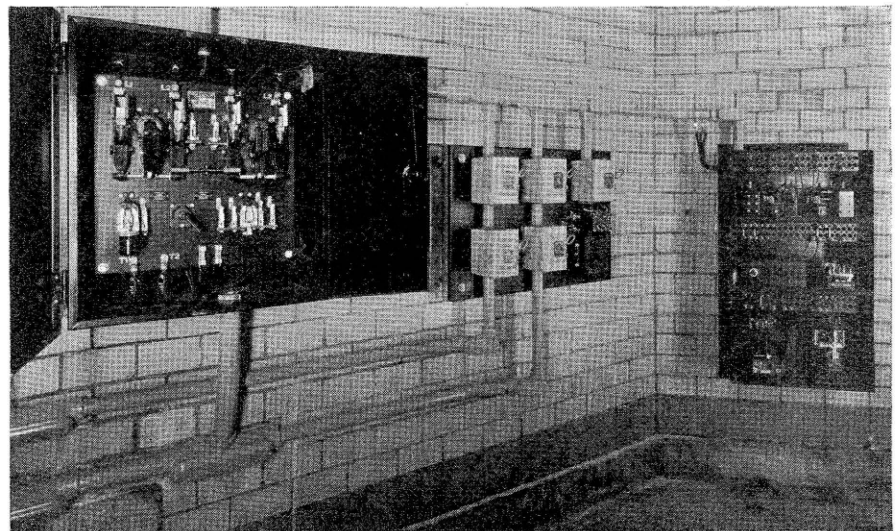
Two 1½-in. main air pipes, carrying air at 90-lb. pressure, connect to existing 2-in. main signal air pipe lines in the Ridge Avenue subway and continue across the bridge, one paralleling each track, merging at the east end to form a 2-in. line which is installed on the east and north walls of the subway in Camden. A 1½-in. line at the center of the bridge ties the two lines together. Slip expansion joints providing 14-in. travel are installed at the bridge

towers. Branch lines are of ¾-in. diameter where switches are supplied and of ½-in. diameter where train stops only are supplied. Service taps have been provided in the main air lines approximately every 200 ft. for the operation of track tools and ejector equipment.

In the subway portions of the installation, the main air pipe line is supported by guides fastened to alternate subway columns so that the pipe is approximately 11 ft. 6 in. above the top of the rail. Support for the main air lines on the bridge approaches and suspended spans is provided by clamps on the fascia angles which form a part of the walkway railings. In the yard the main air line is supported on concrete pedestals with about 11-ft. spacing.

A gate valve is placed in the main air line at each overhead crossing, tie line and compressor plant connection; at intervals of approximately 1,000 ft. in automatic territory; and at various points through interlocking territory so that local repairs can be made without interrupting air service in the rest of the territory.

The block signaling and interlocking system was designed by the Delaware River Joint Commission and the Union Switch & Signal Company, and the major signaling items were supplied and installed by the Union Switch & Signal Company. Cable was furnished by the Okonite Company and the Hazard Insulated Wire Works, while the single-conductor wire was supplied by the J. A. Roebling Sons Company. Everdur pipe for the air lines and conduits on the suspended spans and bridge approaches and for the air lines in the subway was supplied by the American Brass Company.



Transfer panel, square D switches for a-c. and d-c. control, and ground detector apparatus at transformer location T4, Camden anchorage