# Signaling the Union R. R. of Baltimore

## The Interlocking Plants and Automatics on 3.5 Miles of Line Handling 300 Movements Daily

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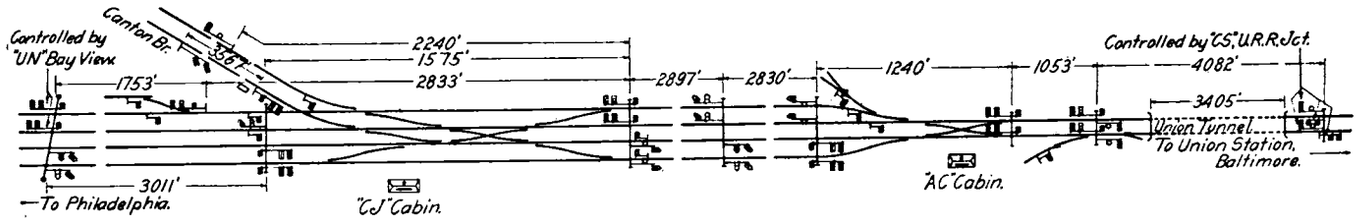
That portion of the Union Railroad of Baltimore referred to in this article extends from the Union station, Baltimore, Md., north to Bay View, a distance of 3.5 miles, and is used for all Pennsylvania freight and passenger movements between New York or Philadelphia and Baltimore or Washington, for all freight movements to the Canton piers via the Baltimore division, for all Baltimore & Sparrow's Point Railroad trains, and for all ergine movements to and from the enginehouse at Orangeville and the Union station for the make-up of trains leaving Baltimore, making an average total of 300 train movements in 24 hours.

Traffic on these tracks is governed by the rules of the Pennsylvania Railroad, through the Baltimore division, and was originally operated under the manual block system as two two-track railroads, with tracks 1 and 2 for freight and tracks 3 and 4 for passenger. The interlocking switches and the signals were operated by three S. and F. mechanical interlockings, which were also block stations. "KS" was a 4-lever plant controlling movements through the Union tunnel, "AC" a 32-lever plant operating switches and signals for the change from 4 tracks to 2 tracks, and "CJ" a 60-lever plant operating the 4-track layout at the junction with a 2-track branch.




Signal and Interlocking Layout on the Union Railroad of Baltimore.

In completing the program for continuous automatics from New York to Washington, it was decided to install automatics on this section of the main line and make it a standard 4-track road equipped with interlockings arranged for the high-speed movements of main-line trains. This necessitated the abandonment of No. 12 slips and turnouts and the installation of No. 20 crossovers and turnouts throughout. The various types of interlocking plants suitable for such an installation were considered, and on account of the great length of interlocking territory, the Union Switch & Signal Company's type "F" electric interlocking was chosen. This made possible the installation of one tower at Biddle street to take care of movements formerly governed by two plants "AC" and "KS." It also made possible the interlocking of an outlying switch at Canton Junction instead of the extension of a fifth track 1,500 ft., which would have been necessary to bring the switch within mechanical interlocking limits.

### "AC" TOWER AT BIDDLE STREET.

The Biddle street or "AC" tower has two stories and a basement, the machine being located on the top floor; the switchboard distributing panels, rectifier, relay rack and terminal board on the first floor, and the steam-heating plant and battery in the basement. The foundations are concrete and the floors are reinforced concrete. The walls of the first story are constructed of fire tile covered both inside and outside with a specially prepared plaster. The second story is made up of a copper-covered framework, and the roof is covered with slate shingles. Electric lighting is used throughout, the second story having indirect illumination. The interior arrangement follows three general ideas: Absolute fireproofing, accessibility of apparatus for maintenance and systematic arrangement to avoid confusion. Trouble can be localized very simply, and detentions to trains due to failures can thus be brought to a minimum.

The relay rack is built of ¾-in. and ¼-in. asbestos lumber, on a framework of angle iron. The door frames are iron, having the lower half filled with asbestos board and the upper half with glass, giving full view of all indicators. All relays rest on the asbestos shelves while all indicators are bolted to the angle iron, the space between angle irons being filled with asbestos board. The wires are brought through the back by drilling holes, one hole being used for each wire on the indicators, while on the switch indicating relays one large hole with a fiber bushing takes all the wires. All wires are brought directly to the binding posts of the instruments, thus avoiding unnecessary terminals and reducing chances for failures due to loose or broken connections. The only place where terminals are used in the tower is on the terminal board, which is part of the indicator rack. Here all wires that come to the tower from outside, which include No. 6, No. 9 and No. 12 B. & S. gage, are placed on R. S. A. porcelain terminals and from there are distributed with No. 16 wire to the various indicators and to the interlocking machine. R. S. A. porcelain terminals are also used in all the relay locations outside the tower.

The wire-way leading into the tower is lined with asbestos lumber and packed with asbestos sponge filling. The wire-way in the ceiling of the first story, directly under the machine, is also packed with asbestos sponge, thus stopping all chances for draught in case of a fire. All wires from the battery and from the transformer and rectifier are run through the floors in fireproof conduit, and so installed as to be easily accessible at all times. The relay rack being built in the shape of a hollow rectangle with one side blank and against the wall, permits easy access to the wires in the back. Entrance is obtained through an open panel in the terminal board. All track indicators are together and in regular numerical order; likewise all repeating indicators for track relays, and switch indicating relays. All terminals are arranged with the signal-control circuits, lock circuits, etc., grouped in numerical order. Each wire is marked with a red fiber tag having the wire number stenciled to agree with the circuit plans. To facilitate uniformity and prompt location of wires, working sheets were made in the office of the supervisor of signals at Baltimore for the entire relay rack, terminal board, and all outside locations. Blueprints of these sheets are posted at each location, enabling the maintainer to find any wire without having to look over the tags on the terminals.

### LOCAL POWER DISTRIBUTION.

Energy for the operation of the switches, signals, locks and indicators is furnished by duplicate sets of 96 cells of

Type A-4H, 150 ampere-hour Edison storage battery, one set being charged while the other is discharging. Charging is done by means of a 220-volt, 30-ampere G. E. mercury arc rectifier. The discharge is distributed by means of a special G. E. switchboard panel having six special, single-pole, double-throw, knife switches, so arranged as to make on one side before breaking on the other. When a switch is down, the discharge for that circuit is indicated on an ammeter located upstairs over the machine. These switches feed battery through fuses for separate circuits or groups of circuits as follows: Signal indication locks, switch circuit controllers, signal and indicator controls, switch-indicating relay bus for switch-indication locks, bus north of tower and bus south of tower. All switches are kept normally down, so that the men operating the machine can tell, by observing the ammeter, when any part of the plant

The Interlocking Tower at Biddle Street.

causes an unusual discharge. The ammeter can then be cut out of each circuit successively by raising the separate switches, thus locating the excessive discharge in a minimum amount of time. The battery charging switch, main charging switch, main discharging switch, voltmeter and voltmeter switch are also mounted on this panel. The voltmeter switch is the dial type, enabling voltages to be read across either set of batteries or across the bus by turning the dial to the different contact buttons.

Alternating current is distributed through a panel similar to the d. c. panel. There are two main switches, one for 55 volts and one for 110 volts. The 110-volt bus has three taps through fuses feeding to the relay rack and to the electric lights in the cabin. The 55-volt bus is arranged with six special switches for cutting the ammeter in or out as on the d. c. panel. The ammeter and voltmeter are mounted directly on the panel. Voltmeter readings across either bus are obtained by means of a plug switch. The transformer feeding the cabin is a 7.5-kv. a., Westinghouse Type, "S," single phase, 60-cycle, with 3,300-volt primary and three secondary taps providing 220, 110 and 55 volts.

### INTERLOCKING MACHINE.

The interlocking machine is a Union Switch & Signal Company's Type "F," electric, 19-lever machine, enclosed in an enameled, pressed-steel case, conforming to the general fireproof arrangement. Mounted over the machine is a model board, which was constructed by the Baltimore division signal department. All switches and signals are shown with their numbers, but no functions are operative. A light is placed in each track showing the approach of trains, and in addition two arrow lights show the direction of traffic through the Union tunnel. No indicators are located upstairs, all track conditions for the semi-automatic feature of signals and for electric detector locking being indicated by lights directly under the lever controlling the signal or switch.

Below the model board and over the machine are mounted clockwork time releases, for use in connection with approach locking. The d. c. ammeter showing the discharge of the plant, an electric light which will burn only when a short circuit develops on the high-tension power line, and a voltmeter ground detector are also mounted with the time releases. The ground detector, having a zero center, will indicate either a positive or a negative ground in volts, thus telling what wire is grounded and how badly grounded it is.

Two hand levers are provided on the operator's table for the controlled manual block operation which governs all movements through the tunnel. Traffic is in either direction on both tracks.

On either side of the tower, at the second story, are Klaxon automobile horns wound for 110 volts, and controlled by a push button over the machine. The intensity of their blast makes them very serviceable as a substitute for the air whistle at locations where air is not available. One blast stops all trains immediately, two blasts mean proceed after having proper interlocking signals, three blasts call the maintainer, and four blasts are for tests at 7 a. m. and 7 p. m.

"CJ" interlocking at Canton Junction was installed in the same manner as "AC" and at the same time. They differ, however, in the cabin construction. "CJ" being originally of brick was not abandoned. The new machine, a 23-lever, type "F," U. S. & S. electric machine, was installed on temporary supports over the locking bed of the old 60-lever mechanical machine, and when the new plant went in service, the old machine was torn out, the floor closed up and the new machine set in its permanent place.

### SIGNALING.

Standard speed signaling, as adopted by the Pennsylvania, is installed throughout the interlockings. In this system the top arm indicates authorized speed, which is 60 miles per hour on the Union Railroad, the second arm permits 30 miles per hour and the low-speed arm permits 15 miles per hour. Where the distance between signals is less than braking distance, the caution indication is repeated at the next signal in the rear.

Approach locking of signals, route locking of switches and electric detector locking of switches are included in the design of circuits. Dwarf and low-speed signals are three-position, semi-automatic to repeat the signal in advance when they lead up to a high signal on a main running track, and are used regularly by scheduled trains, and also where such indication will facilitate prompt movements. Dwarf signals when less than 100 ft. from a switch point are provided with a mercury type slow release, attached to the lever of the machine, which prevents the lever being returned to the normal position to release the locking until a pre-determined length of time is consumed. All signal levers controlling semi-automatic signals are provided with a mechanical stick push button for the control of the low-speed arm when it is desired to use this as a closing-in signal with the track occupied. This push button can be used only when the signal lever is pulled and is restored automatically when the lever is restored to the normal position. All of the automatic signals in this territory are two-arm distant interlocking signals except two advance signals at "AC" and two advance signals at "CJ." These are one-arm with marker light, and are three-position, upper-quadrant.

### SWITCHES AND SIGNALS.

All switch movements are U. S. & S. style "B-3," with 110-volt d. c. motors. The switch mechanism operates the switch through a worm gear, which is direct-connected to the motor through a set of reduction gears, rated at 25 to 1 for single points and 45 to 1 for slips and movable-point frogs. The motor is protected from shock by the insertion of a friction cone clutch in the shaft between the reduction gear and the

armature. The motor receives its energy over a pole-changing circuit through a master circuit controller mounted on a concrete foundation at each switch. This controller is of the shuttle armature type, having both the field and armature energized at all times, the field over a pole-changing set of bands on the lever of the interlocking machine and the armature directly from the 110-volt d. c. bus, which has taps at each controller. Both field and armature are wound to 600 ohms, with 2,500 ohms inserted in the circuit controlling each element, thus making a total of approximately 3,100 ohms in each single switch circuit. For crossovers and slips, the fields of the controller are connected in series. When a switch lever is reversed in the tower the polarity of the field circuit in the controller is reversed, causing the armature to reverse its rotation and operate the pole-changing circuit which feeds battery to the switch motor, thus reversing the

General View of the "CJ" Interlocking.

switch. The switch motor circuit goes through an additional set of contacts, which open as soon as the switch movement is completed and at the same time close the circuits for the indication and for the reverse operation.

The indication circuit is alternating and was developed by the Pennsylvania to eliminate false indication possibilities. Alternating current at 55 volts is taken from the bus wires running through the interlocking to a pole-changing set of contacts, which close after the switch movement is completed and locked. From there it goes to the primary of an adjustable air gap transformer in the same box as the master circuit controller and is stepped up to 125 volts on the secondary, which goes direct to the switch indicating relays in the cabin. These are three-position polyphase, wound for 55 volts and 125 volts. The battery, 110-volt d. c. current, at the indication locks feeds through these relays, as do all signal circuits. The relays are extremely sensitive, a variation of 2.5 volts between the 55-volt bus on the relay and the 55-volt bus at the indication transformer being sufficient to destroy the phase displacement required for the closing of the contacts. False indication protection is furnished by means of the air gap in the transformer. Adjustment is made so that the closed circuit voltage of the secondary is just sufficient to close the contacts of one relay. Should a cross develop on the secondary leads of the transformer, the increased load current will produce an increase of secondary magnetism, and on account of the magnetic leakage and the magnetization of the primary failing to be exactly equal and opposite to that of the secondary, the secondary voltage is dropped so low that the relay opens.

All signals are U. S. & S., type T-2. Interlocking signals are 110-volt d. c., and automatic signals are 110-volt a. c. All track circuits are alternating current, with two No. 6 copper-clad bond wires. The tunnel circuits have two No. 6 copper bond wires instead of copper-clad. Interlocking track circuits are of the vane relay type and automatic sections are of the radial polyphase, three-position type.

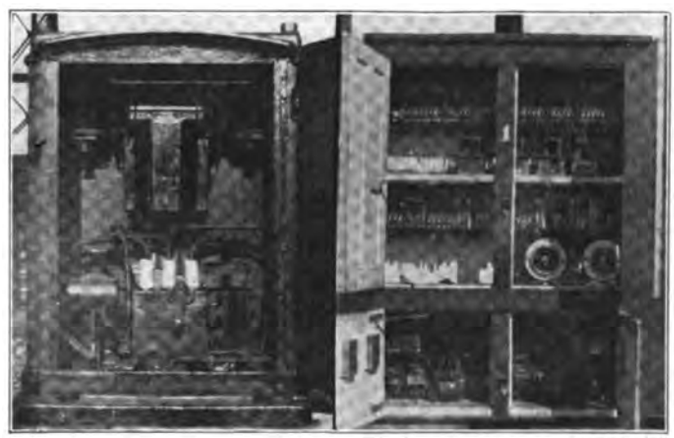
All indicators are U. S. & S., eight-point, semaphore type, having 1,000-ohm coils, with an additional 7,000-ohm resistance tube inserted in the circuit for 110-volt operation. Stick indicators for the semi-automatic control of signals have a slow-acting relay connected in multiple with their control, so designed as to hold up for two seconds after the circuit is broken. Their purpose is to restore the indicator if the power supply is momentarily interrupted while a signal lever is pulled. All relay and indicator contacts are carbon to carbon for the high-voltage circuits.

General Electric Company's three-terminal vacuum tube lightning arresters are used on all track circuit wires at relay end and on all pole-line circuits.

### POWER SUPPLY.

The Pennsylvania power plant at Mt. Vernon furnishes all the power for this installation. The single-phase a. c. is transmitted through the Union station and Baltimore terminal at 2,200 volts and just before it reaches the Union tunnel is stepped up to 3,300 volts through a 35-kv. a. transformer. The 3,300-volt line extends from this point underground through the tunnel to the Orangeville power plant of the Pennsylvania, just beyond Canton Junction. No. 4, B. & S., flexible, single-conductor cable is used throughout, except in the tunnel, and is placed in cypress conduit two feet underground. The conduit is filled with pitch, so as to surround both wires completely.

At each end of the tunnel, at each signal bridge, and at each cabin the 3,300 volts are stepped down to 110 volts through oil switches and oil-cooled transformers connected for sectionalizing. The 110 volts are further stepped down by air-cooled track transformers to 10 volts for signal lighting and to the necessary voltage, ranging from 3 to 15, for the track circuits. All track circuits are provided with a reactance in the positive lead. A relay in series with the power line, located in the transformer case, can be adjusted to pick up for different values of current. It picks up whenever the line carries an excessive amount of current, such as develops with a short circuit, and thus serves as an indicator of the condition of the line. Emergency power can be obtained from the Consolidated Electric Light & Power Com-



Transformer and Sectionalizing Case for 3,300-Volt Line. Relay and Terminal Location at "CJ" Interlocking.

pany, Baltimore, by means of a connection at "CS" interlocking, and in the event of this supply failing also, the Union Railroad can be supplied with power from the Orangeville power house of the Pennsylvania, located close to "CJ" interlocking.

### UNION TUNNEL.

A feature of the installation was the method of carrying wires through the tunnel. On account of the smoky and wet condition of the tunnel, some thought was given to running the wires in the ducts of the city of Baltimore, located in the street overhead, but the extra length of wire required, together with the annual rental of the ducts, made the cost prohibitive. It was finally decided to run ducts through the tunnel for this purpose.

For the power line, twin conductor, No. 4 stranded, lead-covered cable was used, and for the signal and lock and

block circuits between "AC" and "CS," 20-conductor, lead-covered cable was used, having four No. 9 wires and 16 No. 16 wires. Each cable was placed in Orangeburg fiber conduit. The joints of the conduit were covered with pitch and wrapped with friction tape, and then the entire conduit was covered with concrete, giving at least 6 in. of concrete protection to the fiber on all sides. The line of conduit was laid between the outer edge of the ties and the wall of the tunnel with the top level with the top of the ties. The cables came in four sections, necessitating three manholes, in which splices were made. Copper sleeves were sweated to the wires for splicing and wrapped with pure gum and taped. The lead sheath was then filled with hot Ozite, driving out all air, and the joint wiped. Sheet-iron covers for the manholes were set in the concrete and bolted down. While the conduit was being placed, a No. 9 fish wire was pulled in, and with this a 7-16-in. stranded steel cable was pulled in to serve as a fish wire for pulling in the lead-covered cable. A series of scrapers, the same diameter as the inside of the conduit, were attached to the fish cable and served to clean the conduit of all foreign material before the lead-covered cable entered.

All work was done at night on account of the lighter traffic making less smoke. It was practically necessary, on account of the smoke inside the tunnel, to have all concrete mixed outside. To obtain a safe working condition, the use of one track was obtained and all material carried in on this track by a flat hand-truck built up so as to carry large batches of concrete. The use of the truck was preferred to a work train on account of the engine smoke that would have been present. While one gang was busy with the truck carrying concrete, another gang was removing the forms of the night before and advancing them for the fresh concrete. About 50 special acetylene marine lights, giving 400 cp. each for two hours, were used for illumination. Considerable difficulty was experienced with dripping water from the walls of the tunnel and with the smoke of traffic. Rock was encountered also at intervals, which required extra labor for breaking a path for the ducts. The work was finished with eight consecutive night shifts of eight hours each and a gang of fifteen men, using 550 bags of cement and 200 tons of stone for the concrete.

The total length of power line installed was 28,000 ft., excluding 3,500 ft. through the tunnel. All wire used was manufactured by the Kerite Insulated Wire & Cable Company and amounted to 150 miles. Six miles of this was No. 16 wire for interior wiring, 15 miles was No. 12 copper-clad line wire and the rest was 20-conductor cable, 6-conductor cable, 4-conductor cable and No. 4, No. 6, No. 9 and No. 12 single-conductor.

This entire work was handled by the Baltimore division forces of the Pennsylvania, under direction of the supervisor of signals, with plans furnished by the signal engineer. All apparatus was thoroughly tested by the division forces and checked by inspectors from the signal engineer's office before going in service. Two general orders, one week apart, were issued to place the entire installation in service. The complete change of traffic on all tracks was made without a failure or detention of any kind.

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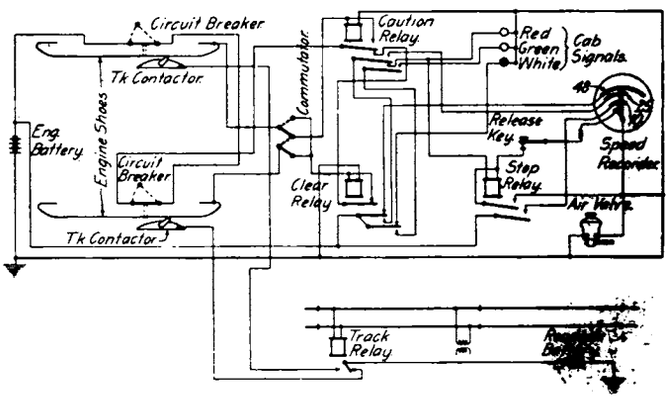
A New York Central Maintainer's Record.—W. G. Shipman, maintainer on Section 14 of the Mohawk Division of the main line of the New York Central, east of Buffalo, with the help of three assistants, maintained the following apparatus for the five months, ending May 31, with only two failures, which were classed as unavoidable, not being due to defective maintenance: Seventy miles of bonded track; 830 batteries, comprising 380 Edison, 160 gravity, and 290 storage; 2 interlocking plants of 32 and 38 levers, respectively; 190 lamps; 7 crossing bells; 12 Hayes derails and 10 bolt-locked crossovers. The traffic on this division is very heavy.

## JULIAN TRAIN CONTROL DEMONSTRATION

The first public demonstration of the automatic train control and cab signal system of the Julian-Beggs Signal Company, Terre Haute, Ind., was given on the Queen & Crescent, on May 18, to officers of that road and a number of invited guests. The demonstration also covered the speed-control system which this company has developed, an installation on the private car of General Manager H. Baker being used for this test.

The automatic speed control is effected by a speed recorder belt-connected to the car axle, to which is attached a series of contact segments arranged for any predetermined speeds, and a dial switch on which is set the desired limiting speed. A series of platinum points are moved up and down over the contact segments by the points of the recorder, which is raised as the speed increases. As these platinum points rise above the segment corresponding to the speed indicated on the dial switch, the normally closed circuit through a solenoid magnet holding closed a valve in the train line or in a connection from the




**Track and Engine Circuits of the Julian Train Control System.**

equalizing tank, is broken, allowing this valve to open and the air to escape to the atmosphere, thereby setting the brakes and reducing the speed of the train until the platinum point again makes contact with the segment, completing the circuit, energizing the magnet, and closing the valve.

The train control and cab signal system utilizes a similar speed recorder and air valve in connection with a roadside contactor and side rail to control the speed of the train automatically, depending on the condition of the track ahead, and also to give the engineer distinctive proceed, caution and stop signals in the cab. This system, as developed at present, requires the following equipment: On the locomotive, a 12-volt storage battery, three standard relays, a light signal with three lenses, a speed recorder mounted on the pilot and belted to the axle of the leading truck, an electro-pneumatic valve connected in the line from the equalizing tank, a push-button release for closing the engine circuit after the train has been automatically stopped, a commutator on the reverse lever to change the wiring connection for reverse movements of the engine, and an armored conduit with the necessary junction boxes for connecting the wiring on the cab and the tender; on the tender, two curved shoes attached to the journal boxes of the forward truck on each side, and mechanical circuit breakers with horizontal arms also attached to the truck on each side; and on the roadside, a contactor box attached to the ends of the ties on each side of the track, one side rail supported by steel brackets from the ends of the ties at a proper height to engage the circuit breakers on the tender, a 16-volt battery at the signal location and the necessary line wire and trunking to connect the battery, track relay and track contactor boxes. The section between Erlanger, Ky., and Crittenden, 18 miles, on which this train-control system is installed, is protected by three-position, a. c. upper-quadrant signals, controlled by three-position, polarized track relays. As these relays have one