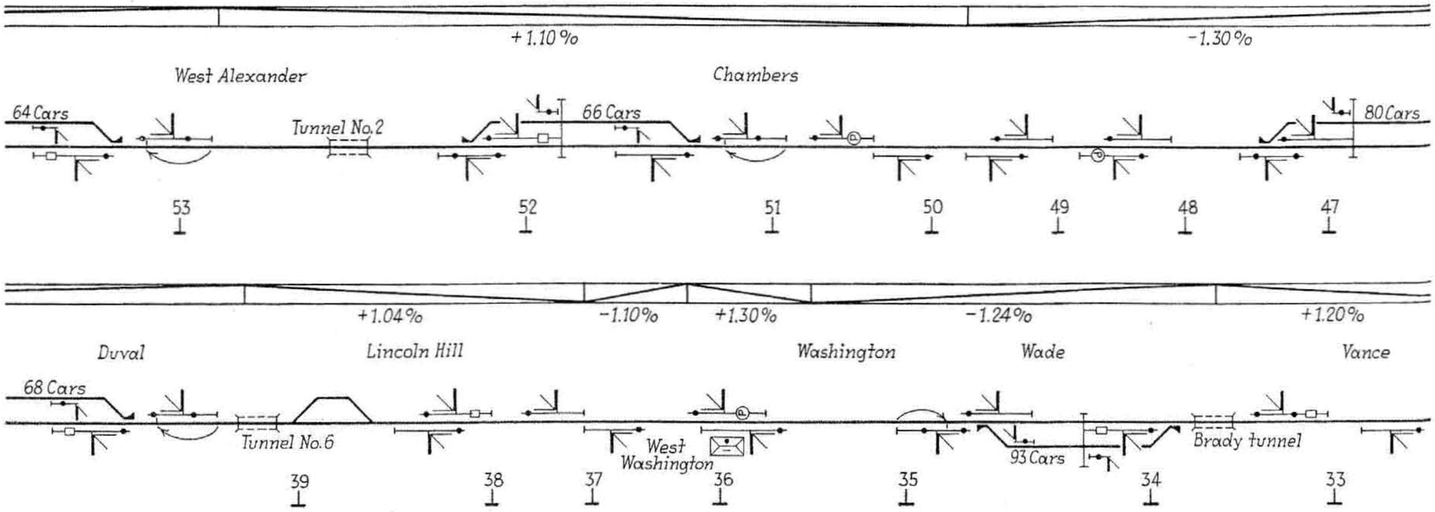
Centralized Traffic Control Installed on the Baltimore & Ohio

View of lap layout at Clokey looking west

Train operation by signal indication on 43 miles of single track reduces delays and effects saving in operating costs

THE Baltimore & Ohio has installed centralized traffic control on 43 miles of single track between Wheeling, W. Va., and Gilkeson, Pa., and, as a part of the project, has provided automatic signaling on 19 miles of double track from Gilkeson to Glenwood Junction (Pittsburgh). The centralized control installation includes the operation of the switches, at 11 passing tracks and at the end of double track, as well as the signals at these points for directing train movements, a total of 23 power-operated switches, 70 controlled signals and 38 automatic signals being involved in the project. The control machine is located at West Washington, 31 miles from Wheeling.

This subdivision traverses a mountainous territory passing over several minor divides, there being nine tunnels, ranging from 400 ft. to 1,700 ft. in length. Starting at Glenwood Junction a double track line ascends on a grade of about 1.7 to 1.9 per cent for five miles to the Whitehall tunnel, and then descends on a grade of 1.1 to 1.2 per cent for four miles, a rolling grade extending through Thomas tunnel and for 11 miles to Gilkeson, the end of the double track. On the single-track section be-



tween Gilkeson and Wheeling the line passes through seven tunnels, each of which marks the apex of grades descending for two to three miles in each direction, the maximum gradient eastbound being 1.7 and westbound 1.85 per cent. The grades most difficult to negotiate extend in each direction out of Washington, Pa., the condition being aggravated by the fact that all trains stop here for water and are required to run slowly through the city. The mallet-type locomotives assigned to freight service on this division have a tonnage rating of 2,300 tons eastbound and 2,200 tons westbound. On the average, a train of 40 loads constitutes a tonnage rating. The lading includes merchandise moved in either direction and considerable coal is handled eastbound. The traffic includes four passenger trains each way and from four to six freight trains each way daily, including the local freight operated each way daily. Considerable coal is mined in this territory and a turn-around pick-up train is operated from Pittsburgh to Elm Grove and return daily. Therefore, the total number of train movements ranges from 18 to 20 daily. In addition to the difficulties on account of grades, the line includes numerous curves, most of which range from 3 to 8 deg. but some are as high as 11 to 12 deg. The speed limit is 40 m.p.h. for passenger and 30 m.p.h. for freight trains.

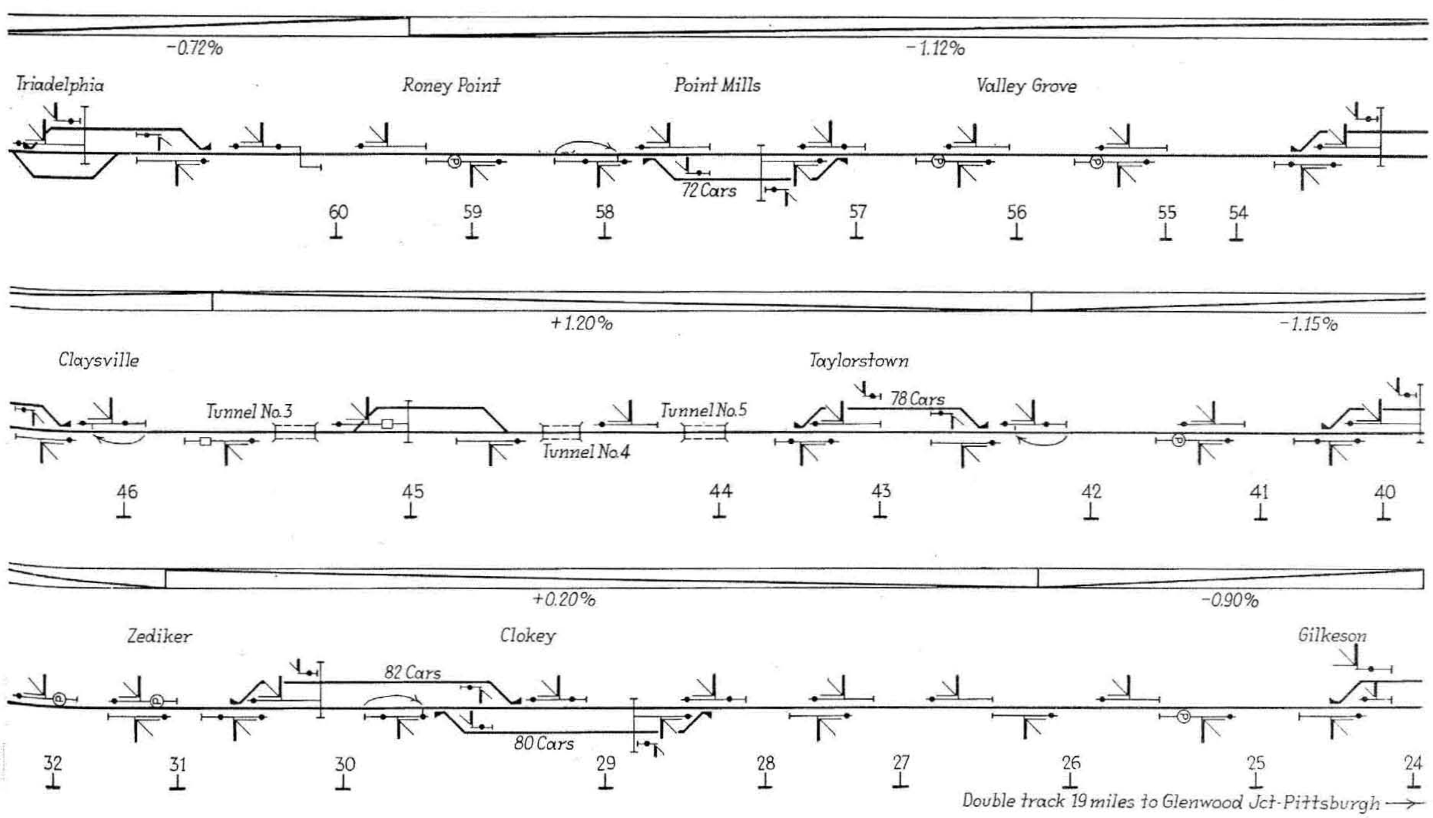
The Track Layout

Previous to the improvements recently completed, this line consisted of a single main track from Glenwood Junction to Rand, a distance of 2 miles; double track Rand to Bertha, 4.5 miles; single track Bertha to Finleyville, 6.6 miles; double track Finleyville to Gilkeson, 6 miles; and single track Gilkeson to Wheeling 43.2 miles, with 13 intermediate passing sidings having an average capacity of 65 cars.

It was decided to connect the short stretches of double track so as to provide continuous double track from the west end of the Monongahela River bridge at Glenwood Junction, to Gilkeson, a distance of 18.7 miles. The east end of the double track was connected with the interlocking plant at Glenwood Junction by a low-voltage remote control machine and the entire double track signaled with color-position-light automatic signals, 30 being used. The double track extensions released the three-trick manual block train order stations at Rand, Bertha and Finleyville and permitted more flexible operation of fill out and turn around service between interchange points at Bruceton with the Pittsburgh & West Virginia and at Snowden with the Montour Railroad.

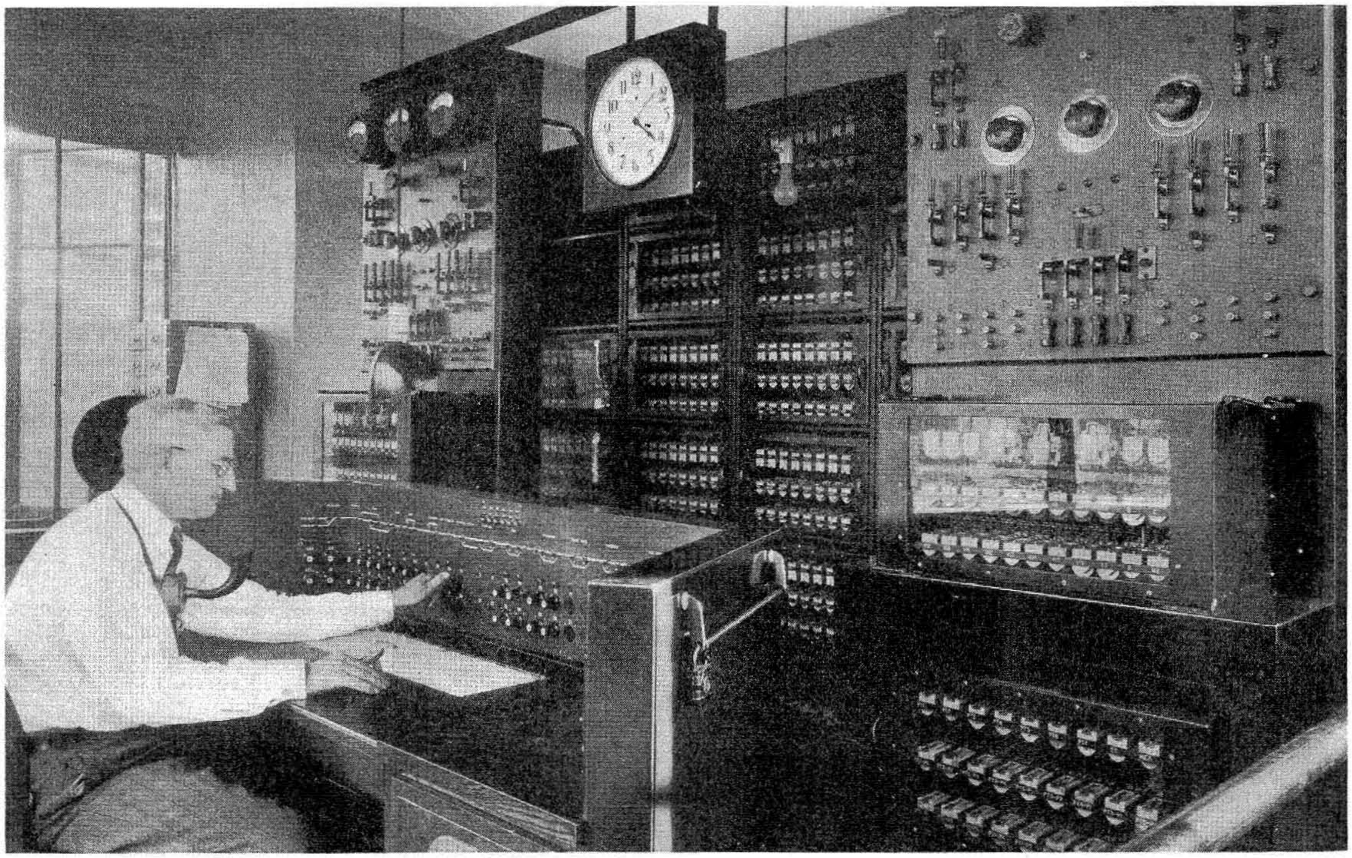
The topography of the single track territory between Gilkeson and Wheeling is such that the cost of constructing second track was prohibitive, there being seven tunnels varying in length from 400 ft. to 1,700 ft., 58 bridges and numerous heavy cuts and fills. Therefore it was decided to increase the track capacity of this section by providing centralized traffic control and re-arranging the passing sidings and increasing the capacity in each instance to 80 or more cars. The north siding at Clokey was extended and a new south siding constructed so as to make a lap layout. The sidings at Wade, Taylorville, Claysville, West Alexander and Elm Grove (NA Tower) were extended. The sidings at Duval, Bell Siding, Point Mills, and Triadelphia were left as they were, while those at Wylandville and Vance were retired.

The switches for the passing tracks, as well as the switch at the end of double track at Gilkeson, are all equipped with power-operated switch machines, the control of which is included in the centralized machine at Washington. This control machine, of course, also includes the control of all the absolute signals for directing train movements at the various switches where power machines are used as mentioned above. The west end of the centralized traffic control ties in with the interlocking located at the east end of the yard at Wheeling. The control office was located at Washington because this point was centrally located on the division and because this is a good sized town where living conditions are



desirable for the dispatchers and other employees. A new fireproof brick and concrete tower was provided to house the control facilities, this building being located about a mile west of the station at Washington.

All turnouts to industry tracks and to sidings not equipped with power switch machines are equipped with switch circuit controllers so as to afford automatic signal protection. Furthermore, a Hayes derail is located at the clearance point on each of the turnouts and a switch circuit controller is connected to each of these derails. The automatic block signals are controlled on the A.P.B. principle.



The line-control switchboards and relay cabinets are located at the rear of the control machine

Train Movements Directed by Signals

Under the previous method of operation train movements over the single track, Gilkeson to Wheeling, were governed by time-table, train orders and manual block. Block offices were located at eight points, Gilkeson, Wylandville, Washington, Taylorstown, West Alexander, Point Mills, "NA" Tower and Wheeling. About 40 train orders were issued during each trick, when traffic was equivalent to what it is now. Under the new centralized traffic control system of operation, train movements are directed by signal indication without written orders and without superiority. On account of this change in the method of operation seven of the former block offices were closed and 16 operators were transferred for duty at other points thus making a saving in operating costs of $30,000 for wages alone, the remaining operators being retained for station work.

On the double track from Glenwood Junction to Gilkeson the trains are operated by regular double-track rules, automatic block signal protection being provided. However, space is available in the new control machine to add the necessary levers for signals to control train movements by signal indication in either direction on both tracks of this double-track section.

The double-track extensions and automatic signals were put in service as far as Gilkeson, on March 17, 1931. The C.T.C. system was put in service in sections, as follows: Gilkeson to Washington, June 17, 1931; Washington to West Alexander, July 15, 1931; West Alexander to Wheeling, August 1, 1931. No changes have as yet been made in the passenger train schedules; the principal benefit so far as these trains are concerned is that any lost time can be made up more readily without delaying other trains. Under the manual block system all freight trains were required to clear the main line one block ahead of a passenger train. No permissive movements were permitted in which any passenger train was involved either for following a passenger train or for a passenger train following a freight train. With the new system, including automatic signal protection, the meeting points can be arranged according to the circumstances so that very little time need be wasted while waiting for a meet, and as a matter of fact non-stop meets are not at all unusual. The elimination of train stops which were made in order to pick up orders or to enter or leave a siding not only saves time but reduces the fuel and water consumption.

Therefore, although the system has been in service but a few months, it is already quite evident that the factors mentioned above are contributing to the safety of train operation and are expediting the movement of trains. For example, the former schedule for the fast through merchandise freight trains between Glenwood Junction and Wheeling was 3 hr. 20 min. eastbound and 3 hr. 30 min. westbound. These trains are now being operated over this territory in three hours regularly and in some cases even better time is made. Likewise the time between terminals for the tonnage trains has been reduced one hour. The turnaround run from Pittsburgh to Elm Grove and return, which formerly required about 11 hr., is now being made regularly in 9 hr.

Under the previous method of operation there was a heavy penalty in overtime, which was brought about primarily by two factors. In the first place the business on this line required frequent set-offs and fill-outs, and this condition together with the manual block rules resulted in considerable overtime. Freight train overtime for the first 11 months of 1931 showed a decrease of 72 per cent under the corresponding period of 1930, the average time per train having decreased 22 per cent. However, consideration must be given to the fact that the C.T.C. was in service for only the latter four months of the period and also that throughout the 11 months there was a decline of 24 per cent in the number of trains as compared with the corresponding period in the previous year. Therefore it is difficult to determine how much of the decrease in overtime is due to the decrease in traffic and how much to the new system.

Centralized Traffic Control System

The centralized traffic control equipment is of the type manufactured by the General Railway Signal Company, known as the Duplex System, which, as the name infers, provides for the simultaneous transmission of controls to, and the receipt of indications from, the same or different stations.

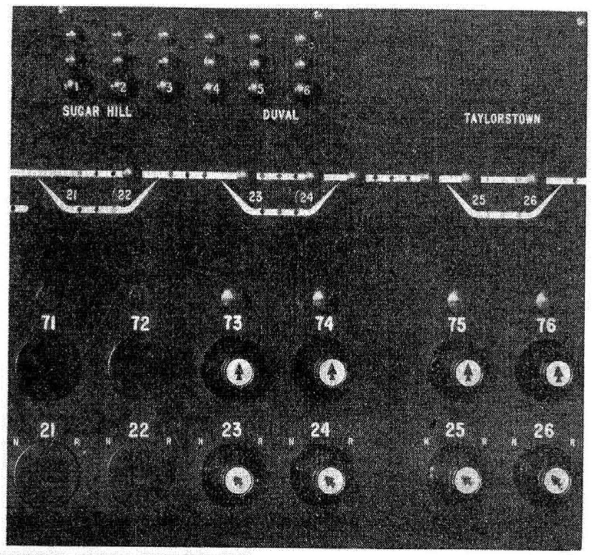
Two circuits, one for outgoing controls and stepping and the other for incoming indications, are employed in each direction from the control office, those running east being separate from those running west. The wires are No. 12 copper, rubber-covered, carried in cables along with the wires used for signaling. In an emergency these circuits can be sectionalized manually at each location.

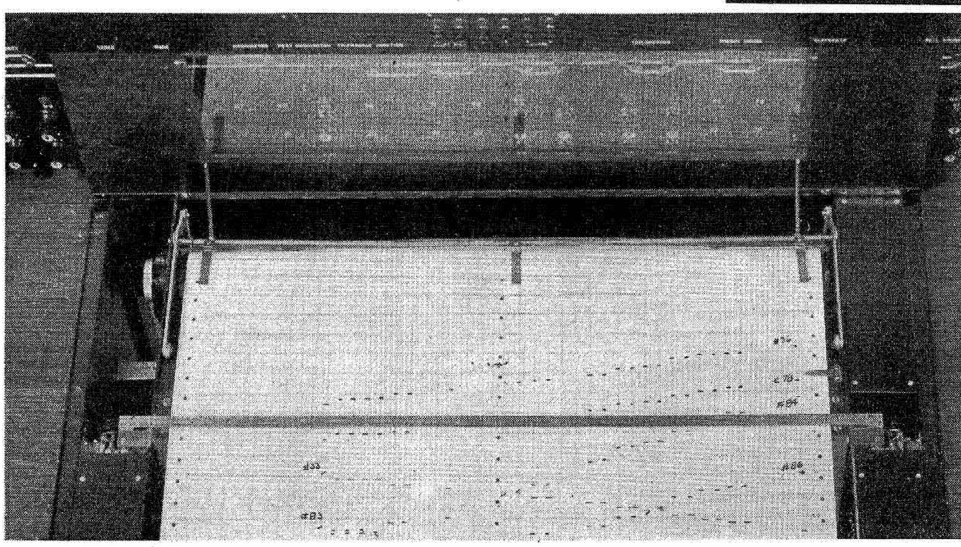
In operation, the dispatcher moves his levers as desired, paying no attention to the order in which stations are called, which occurs automatically one at a time, in a predetermined order until all, that are required to carry out the changes set up by the new position of the levers, have been reached. This preference of stations is not necessarily geographical and can be made in any order desired at the time when the apparatus is wired and can be revised by making a change in the wiring.

Independently or simultaneously with the calling of a station from the control office, any station, including the one being called, can send in its call and record its indications. If more than one station desires to call in for the purposes of recording changes in indications, they follow each other in predetermined order.

System Employs Relays

The system employs relays exclusively. An operating cycle consists of a succession of steps, the first few of which are assigned to selecting the stations in and outbound, and the succeeding ones for control and/or for indications. The relays are grouped in cabinets which are interchangeable within their own classification and are provided with plug boards so that a cabinet can be substituted for another very readily. The relays and switch boards at the control office are located in the operating room. The relay cabinets are supported on steel racks or shelving, at the rear of which there is a large wiring compartment where all the wires are brought up from the conduits in the floor and carried to conveniently located terminals. This wiring cabinet is equipped with tight-fitting sheet-steel doors. All wiring between these cabinets and the control machine is run in steel ducts laid in the concrete floor. There are no relays on the lever machine. In addition to the field station cabinets there are function relay units of two relays each used to receive and store the controls at the field stations.





Above—Close-up of a typical section of the control machine. Left—Recorder with cover lifted showing train graph sheet

Control Machine

The control machine is in the form of a flat top desk with the control panel mounted on the top at the back.

On account of the length of the control panel the ends are brought forward at an angle of 45 degrees so that the levers are readily reached by the dispatcher. The machine has been made large enough to add, at a later date, the necessary equipment to control the double track east of Gilkeson arranged for running in both directions on both tracks, as well as for several sidings on the single track not equipped at present.

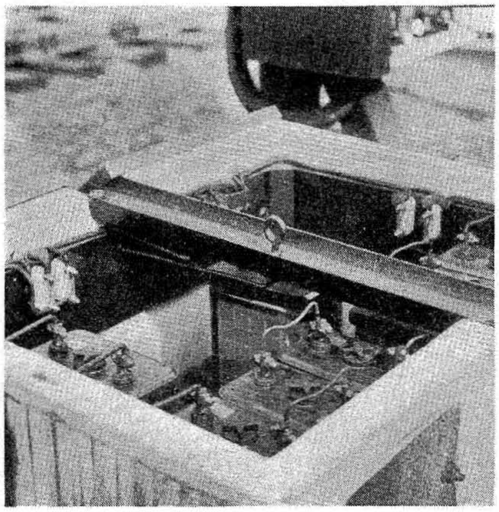
Along the top of the panel extends a track diagram with the signal and switch levers located directly below the corresponding switches on the diagram, the signal levers being in a row above the switch levers. The levers are in the form of rotating knobs with indication lamps in the centers. The switch levers have two positions, with normal to the left, while the signal levers have three positions, the normal position being with the arrow pointing vertically up, while to the left clears the signals governing eastward and to the right clears the signals governing westward. The switch points on the diagram are mechanically operated by the switch levers showing the line up as a white line.

The switch indication is in the form of a light located in the center of the switch lever which is illuminated from the moment the lever is moved until the switch itself is locked up in the corresponding position. It will be illuminated also when the switch is moved by hand either by the use of the dual-selector or hand crank. The signal indication is in the form of a lamp located in the center of the signal lever, which becomes illuminated when a signal is clear—no light showing for a signal at Stop. An arrow which becomes clearly defined by the indication lamp shows the direction in which the cleared signal governs. Above each signal lever is a push button for starting the system in operation under special conditions to be described later.

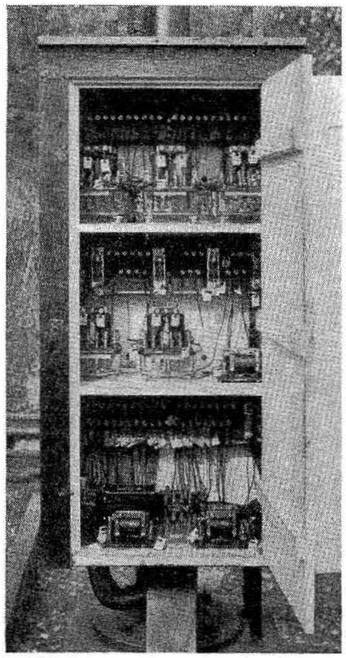
The track occupancy information is given by red lamps in the track diagram, which are normally out and which become lighted upon the presence of a train. There is a light for each track section in which a controlled switch is located and one for each approach annunciator used where controlled points are a considerable distance apart. The track model is provided with holes for tokens to be used as desired by the dispatcher for switch engines, work trains, motor cars, etc., to indicate their location.

Above the diagram is located a row of red lights, one of which will indicate a failure of the corresponding source of power for charging storage batteries. At the time a red light shows up, a vibrating bell rings, which can be stopped by pushing the button below the red light.

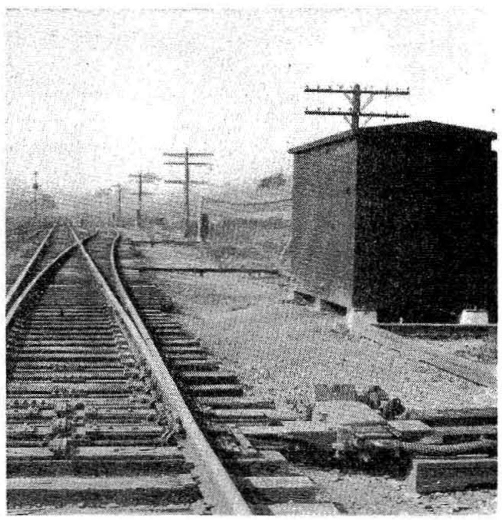
Inserted in the desk is the automatic recorder which records the position of trains by impressions on the graph sheet made by metal type striking through to a typewriter ribbon. These impressions also indicate whether the train is continuing on the main or is entering or leaving a siding, the impressions being a horizontal dash — for a main track move and a diagonal dash, / or \ when the switch is reversed. The record therefore is complete and can be read at any time thereafter. It is the habit of the dispatcher to connect the impressions with lines so that the record may be read more easily by others. The paper is moved forward by a mechanism controlled by a clock.



Batteries are housed in concrete boxes



Left—Relay case at an automatic block signal location



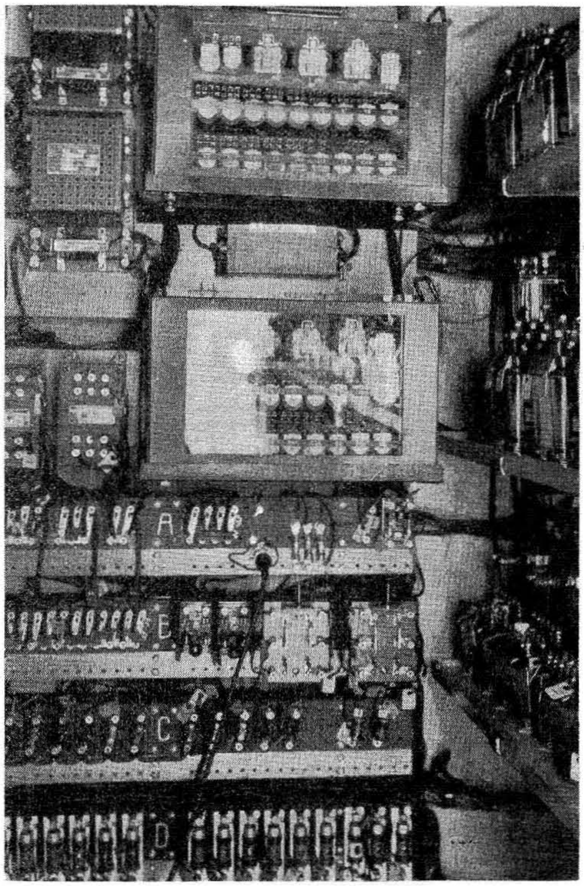
Below—Power switch and sheet metal instrument house at Clokey

Operation of the System

The movement of a signal lever to right or left automatically starts the system and the switch and signal controls are sent out to the field station. The movement of a switch lever does not start the system if moved alone, the push button mentioned above being used for this purpose. All signals are stick signals and will not clear for a following train unless the operator clears the signal lever a second time. When it is desired to put to Stop a signal which has not been passed by a train, the push button must be pushed in addition to placing the signal lever in the normal position as the movement of the signal lever to Stop will not cause a start of the code.

Features of Signaling

The Baltimore & Ohio standard color-position-light signals are used throughout this installation. The signals consist of a main unit with one or more markers. The main unit is equipped with two red lights in a horizontal line, two yellow lights in a row diagonally upward to the right and two green lights in a vertical line. Red is for stop, yellow for "caution, proceed prepared to stop at the next signal," and green for "proceed." These indications are modified by the use of white markers. The absence of a marker with the red indication means "stop and stay," but with a marker either above or below, it indicates "stop and proceed." The failure of a marker-light will result in a more restrictive indication being given. The indication of any signal can be displayed either as "stop and stay" or as "stop and proceed." This facility is taken advantage of by making all intermediate signals indicate "stop and stay" against opposing moves and "stop and proceed" for following moves. In addition a marker above the main unit is used for all main routes and the marker below for all medium-speed routes. No marker is used for low-speed routes but inasmuch as the siding turnouts have No. 16 frogs and all sidings are track circuited, medium-speed indications are given gov-



View of interior of steel instrument housing

erning into a siding. The signals governing into the sidings indicate "proceed, prepared to stop at the next signal" when the siding is unoccupied and "stop and proceed" when occupied. Dwarf signals are used governing movements out of sidings and are equipped with lower markers.

When desired, the main unit can be equipped with a permissive indication displaying two lunar white lights in a row diagonally upward to the left and this indication is used to govern trains against traffic at Gilkeson. The use of this signal is safeguarded by requiring the dispatcher to operate two levers to clear it and in addition the train must have orders to accept the signal.

The a-c. floating system of power supply is used for this entire installation. Power is purchased at 8 points, at each of which a small switch-board is provided so that power can be fed each way or the station can be cut out and the feed circuit cut through. Each switchboard is equipped with a General Electric overload circuit-breaker and a G.E. ammeter with range of 0 to 15 amp. and a G.E. voltmeter with a range of 0 to 750 volts. The line feed at 460 volts is carried on two No. 4 weatherproof copper wires on porcelain insulators. At each location a G.R.S. line transformer, the capacities ranging from 50 va. to 250 va., depending on the load, is used, protected by G.E. lightning arresters, in connection with a 3/4 in. by 10 ft. Copperweld ground rod. The maximum resistance of the ground connection is 15 ohms. The signals are lighted normally from the a-c. supply with a d-c. reserve cut in by power-off relays.

At each location including a power switch, a battery of 12 cells of EMGO-7 Exide storage battery of 120-a.h. capacity is provided for the switches and the signals. At the intermediate signal locations 6 cells of EMGO-5, 80-a.h. capacity Exide battery is used for the signals and control circuits. One cell of EMGO-7 120-a.h. capacity is used for each track circuit. At the control office a 24 volt 120-a.h. EMGO-7 Exide battery is used for the local requirements of the CTC system and two 160 volt 6-a.h. battery (BTM) for the line requirements. All cells are charged by G.R.S. dry-plate rectifiers. The rail joints are bonded with No. 2 A.W.G. 7½ in. gas-welded bonds.

Line Cable a Feature

All line control circuits, including the code control, are carried in a cable made up of No. 14 conductors for signal circuits and No. 12 for the C.T.C. line circuits with 4/64-in. insulation, with tape and braid on each conductor and with a braided covering over all. The number of conductors in each section of the cable ranges from 12 to 27, about 20 per cent being spares with a minimum of 4 spare conductors. The cable was ordered in lengths to meet the conditions for each section. This cable is suspended from a 3/8 in. stranded Copperweld messenger wire using C.-W. never-slip cable rings.

At each switch layout a welded sheet-metal house, lined with Celotex, is provided for housing all the relays, coder units, batteries, rectifiers, etc. With the exception of the house at Clokey lap which is 6 ft. by 12 ft., each house is 6 ft. by 8 ft., and includes a separate compartment used as a telephone booth. The relays are the shelf type mounted on springs. Incoming line wires terminate on Railroad Supply Co.'s triple-path neon arresters mounted on a board near the floor, in the end of the house. General Electric carbon-gap signal type lightning arresters are in use on the C.T.C. wires. Various other terminals, resistors and knife-switches are located just above. All jumpers between terminals, arresters and relay posts are No. 14 insulated flexible wire except for switch operating circuits which were all No. 9. These houses were all wired up with the apparatus in place at the works of the General Railway Signal Company at Rochester, N. Y.

The switch machines are the G.R.S. Model-5D equipped for dual control. Morden adjustable rail braces with 1 in. by 8 in. gage plates are used on the first three ties. Two of these plates extend and are bolted to the switch machine. Baltimore & Ohio standard adjustable front rods are used and the switch adjustments are the Bossert type. The point detectors are adjusted to a 1/8-in. opening.

Signaling Circuits

A few special features are embodied in the A.P.B. signaling circuits. Each line circuit for signal control is a loop circuit with double control. Each HD (Home and Distant) control circuit passes through a back contact of the second opposing home signal's HD relay—considering a signal at the same location as the first opposing signal—to provide that all opposing signals must be

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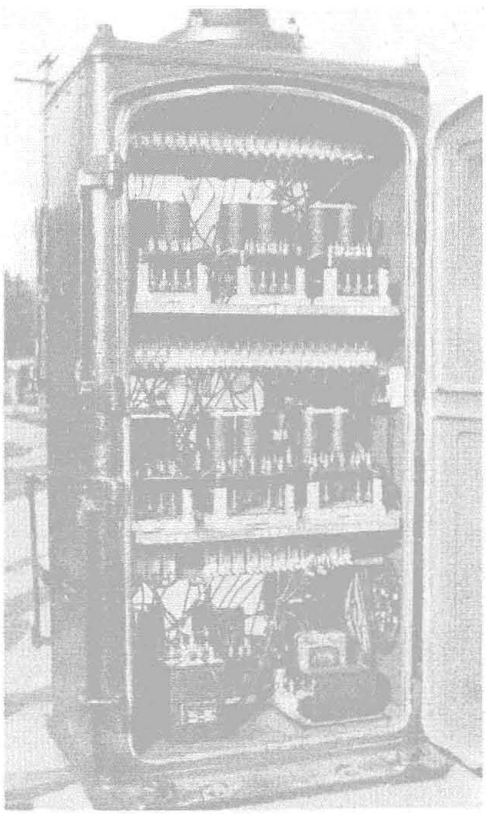
lamp. Between the reflector and the cover glass of each unit is a metal stencil having one of the letters in the word STOP cut out. Normally, the sign is dark. Upon the approach of a train the lamps are illuminated and a distinctive STOP warning is dipslayed in bright red letters.

Mounted also on each post is a sign indicating the number of tracks at each crossing. This sign "1 Track", or "2 Tracks", as the case may be, is of the reflector-button type, and is mounted on the posts so that the numeral is between the light units with the word, "Track", directly below. The crossbuck sign, "Railroad Crossing" is also of the reflector-button type. The beams of automobile headlights are reflected by these signs in such a manner as to make the signs visible and legible.



Interior view of relay case at Clinton street, showing relays and power equipment

All line wires are No. 10 W.P. solid copper and are carried on the railroad's pole line throughout the installation. Cabled drops are No. 14, and are carried from the pole line to mechanism cases in "made up" form on No. 8 messenger wire. The track wires, which are run in trunking to standard Union bootlegs, are No. 10 copper. All field relays are of the Union DN-11 type, shelf mounted, and are housed in relay cases, while the relays in the control cabin are of the L type, similar to those used in the Union centralized traffic control machine.

All track circuits are fed from primary battery located in battery chutes, and all relay and flashing-light circuits are controlled from a battery of five lead storage cells floated across copper-oxide rectifiers. The lamps are normally lighted directly by a-c. power and, in the event of a power failure, by a d-c. standby, in connection with ANL-30 power-off relays. The a-c. power is obtained from the local power company. Approach bells, with manual push-button cut-out controls, are used for both north and south approaches.

G. N. to Discontinue A. T. C.

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results from the maintenance and operation of this installation. There is considerable inconvenience and interference with the economical operation of the railroad, particularly in the reassignment of runs of locomotives. Some of the longer engine runs that the Great Northern desires to establish are interfered with because of the necessity of operating only train-stop equipped engines between New Rockford and Williston. For example, the railway company has some heavy locomotives that ordinarily run between Minot and Grand Forks which are not equipped with train-stop devices. On account of the poor crop conditions in that part of North Dakota there has not been much use for these locomotives in that territory and in the interest of economy the railway company would like to use these heavy locomotives between Minot and New Rockford for several months but can not do so because they are not equipped.

If the use of the automatic train-stop devices is discontinued between New Rockford and Williston, that territory will still be protected by the most modern type of automatic block signals, using the three-position semaphore signals between Williston and Minot and the color-light type of signals between Minot and New Rockford.

The report in its summary of reasons reviews the statement of principles which was set forth by the commission when it made its general report on automatic train control (148 I. C. C. 188) calling attention to the fact that accidents which are preventable by automatic train control are relatively few in comparison with the railroad accident record as a whole. It states that the Great Northern has more than 6,000 miles of track not yet equipped with automatic block signals; and 5,874 grade crossings not yet protected, except by signs. The cost of equipping a grade crossing with an automatic signal is about $1,500. The road strongly contends that it should not be required to provide super-protection on this short district, less than three per cent of the railroad, while more than 72 per cent remains without block signals. The commission is on record as requiring generous expenditures for the protection of human life, with the money so distributed as to provide the greatest possible measure of protection; and therefore the decision, in favor of the Great Northern, is as quoted above.

B. & O. Installs C. T. C. on 43 Miles

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at stop before a leaving signal can clear. The control machine is wired so that a signal control cannot be sent out while an opposing conflicting lever is reversed. All directional stick relays are prevented from picking up, and if up, are dropped, by an open switch leading to a siding which will hold a train. Standard approach, time, route, and indication locking is provided for protection against the movement of switches when it is unsafe for such switches to be moved.

In addition to the telephones located in the booths in the steel houses at the control points, telephones are located conveniently to all hand-operated switches and the dispatcher is equipped with a loud speaker.

The apparatus for the signaling as well as for the centralized traffic control on this installation was furnished by the General Railway Signal Company, and was installed by the Baltimore & Ohio signal construction forces under the direction of the signal engineer and under the supervision of the engineer maintenance of way.