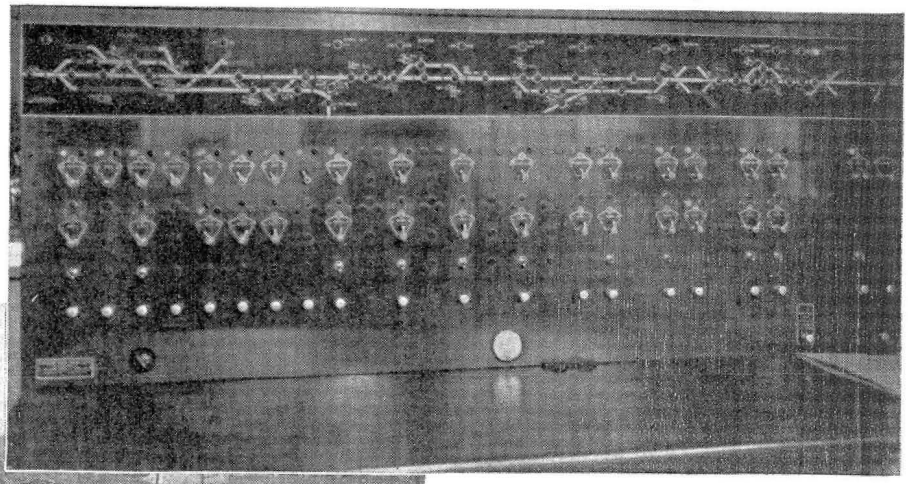
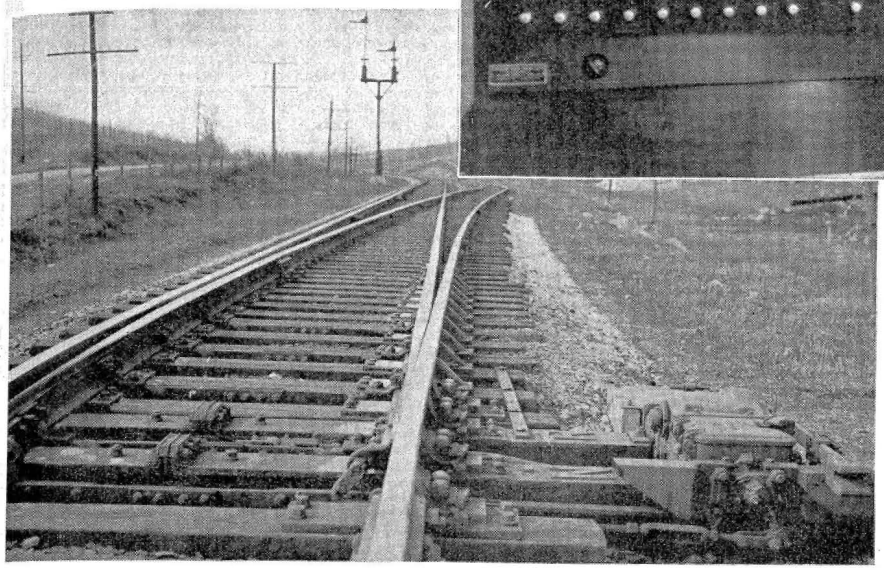


Right — The C.T.C. control machine in the office at Pulaski has 13 switch levers and 13 signal levers. Below — A typical power switch layout with semi-automatic signal at the end of one of the sidings



Installation based on a careful analysis of conditions decreases train delays, expands track capacity, and provides improved flexibility and precision of operations

Norfolk & Western Installs C.T.C. On 14 Miles of Single Track

As a means for improving safety and increasing track capacity, the Norfolk & Western has installed centralized traffic control on 14 miles of single-track main line between Radford, Va., and Pulaski, Va., which is a portion of a line extending from Bristol, Va., through Pulaski and Radford to Walton, Va., where connection is made with the Norfolk & Western through east-and-west route between Norfolk, Va., and Cincinnati, Ohio. At Bristol, connections are made with a line of the Southern, extending through Knoxville, Tenn., to Memphis, Tenn., and other points.

Double track extends 4.6 miles between Walton and Radford, with single track 106.7 miles between Radford and Bristol. On the single-track territory between Radford and Pulaski, the daily through traffic includes 10 scheduled passenger trains, an average of about 2 extra passenger trains, and from 8 to 12 freight trains.

Straight a-c. semaphore automatic block signaling has been in service on the territory since 1918. In 1942, the C.T.C. was added on the 14 miles between Radford and Pulaski for several reasons. On account of the grades and curvature on a part of this section, the speeds of trains are limited, thus increasing the track occupancy time. In addition to the through traffic mentioned previously, additional transfer switching moves are made between Radford and Dublin as well as between other points. The solution of the problem, to increase track capacity and reduce train time, was to install centralized traffic control, including power switch machines and semi-automatic signals for directing train movements, thus superseding time tables and train orders.

Track Layouts

The double track from Walton to Radford ends at a crossover east of the station at Radford, the power switches and signals at this crossover

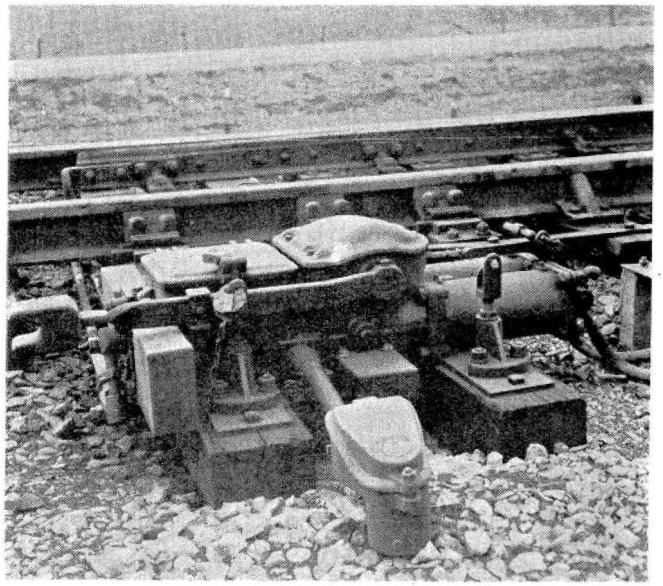
being controlled remotely from a machine in the office at Radford. A second track, formerly known as a running track for entering or departing from the yard, extended westward from Radford to M.P. 302. As a part of the C.T.C. project, a power switch machine was installed at the switch where this second track connects with the main line, so that the second track can be used as a westward main track or it can be used for passing trains as may be required. Likewise, power switch machines were installed at each of the two switches at the three passing tracks at Melborn, Wysor, Wurno and Pulaski.

At Wysor, there is a crossover between the main line and the passing track, and a single switch on the passing track leads to a new branch line. Power machines were provided at these crossovers and branch line switches. At Dora Junction, about two miles east of Pulaski, there is a single switch leading to the North Carolina Branch. This switch, which formerly was thrown by hand, is now equipped with a power machine.

Near the telegraph office at Pulaski, there are two crossovers between the main line and the North Carolina Branch. Power switch machines were installed at these crossovers. Also power machines were installed at the two switches of a passing track on the north side of the main line at Pulaski. Thus, in all, a total of 16 power switch machines were installed in the C.T.C. project. The turnouts at the ends of double track and at the ends of passing tracks are No. 15, good for speeds up to 30 m.p.h. for diverging moves. Insulated gage plates 1 in. by 8 in. are provided on the first two ties under each switch, and these plates extend and are attached to the switch machine, thereby eliminating chances for lost motion. Morden adjustable rail braces are used on a total of four ties at each switch.

Each of the power switches is operated by a Type A-20 dual control electro-pneumatic switch machine. When the selector lever is operated, the air supply to the switch machine is cut off, the valve control circuits are opened, and a code is sent to the office indicating an open switch and an occupied track circuit. Each selector lever is locked with a standard switch padlock in order to prevent unauthorized movement of this lever. The hand-throw lever is, of course, also padlocked. Each switch layout is equipped with the standard arrangement of lock rods and a point detector which is set to operate if the switch point is open more than 3/16 in.

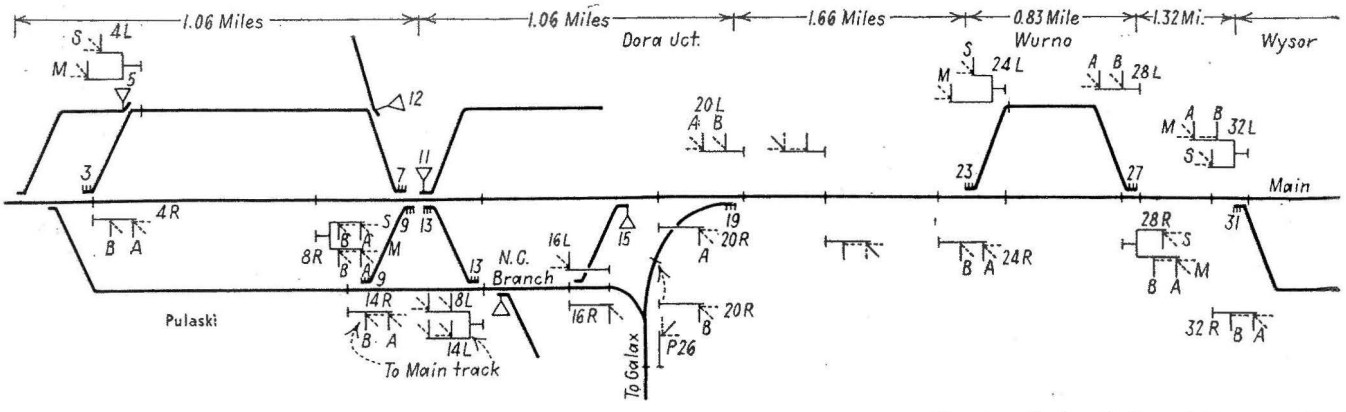
The compressed air for the operation of the switch machines is supplied by small-capacity motor-driven compressor sets. Duplicate compressors, each rated at 3.5 cu. ft. per min., are located at each single switch or crossover. The compressors are controlled automatically, the one in normal operation being set to cut in at 55 lb. and cut out at 70 lb., while the auxiliary compressor is set to cut in at 45 lb. and cut out at 60 lb. Each of the 3.5-cu. ft. compressors is driven by a 110-volt a-c. motor, rated at ¾ hp.



Each of the dual-control electro-pneumatic switch machines has two operating pistons

Electric Locks on Hand-Throw Switch

At various places, as shown on the diagram, house tracks or spurs leading to industries are connected to the main line with hand-throw switches. At each of these locations, the previous switch stand was replaced with a T-21 hand-throw switch-and-lock movement including an electric lock which locks the operating lever in the normal position. These layouts include lock and point-detector rods which lock the switches in the normal position. In each instance, a Hayes derail, located at the clearance point on the turnout, is pipe connected to and operated by the T-21 hand-throw switch and lock movement. A telephone is located near each switch.



Track and signal plan of the centralized

When a train is to use one of these switches, the conductor telephones to the C.T.C. operator, and if the switch is to be used, the operator sends out a control code to release the electric lock.

Signaling Arrangements

The three-position upper-quadrant semaphore signals, previously in service as automatic block signals were retained in the new C.T.C. system. On each station-entering signal a second arm was added to direct trains when entering the passing track.

A track circuit was installed on each passing track, and the controls are arranged so that the entering signal cannot be cleared if the passing track is occupied. With this track circuit protection, trains can pull in to a passing track at the speed for which the turnouts are designed. In order to permit trains to approach at this speed when making diverging moves, a second operative arm was installed on each signal in approach to a power switch in the facing direction. Such a distant signal displays an aspect of red-over-green when the station-entering signal displays red-over-yellow to direct a train to enter a passing track over a power switch in the reversed position. The signals previously in service are operated by Style-S mechanisms, and Style T-2 mechanisms were installed for operation of the additional semaphore arms.

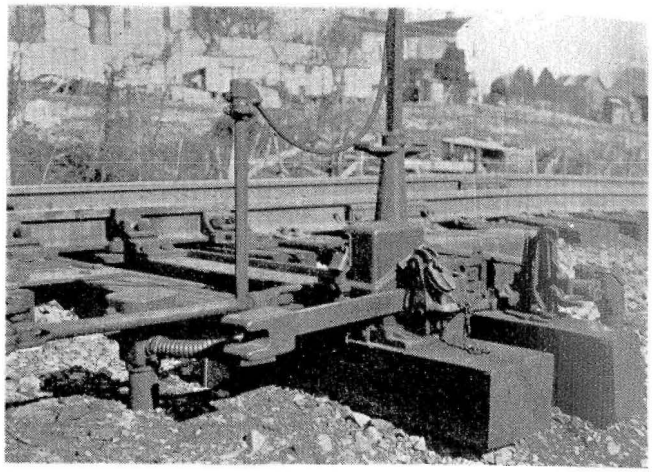
Track Circuits and Local Control

The a-c. track circuits were retained in service, except that conventional d-c. track circuits were provided for the detector O.S. sections at power switches. The 110-volt a-c. local line control circuits formerly included in the automatic signaling were retained in service as a part of the C.T.C. system. A double wire circuit is used for the control of signals for one direction, and a similar circuit is used for the control of signals for the other direction.

On the North Carolina Branch the annunciator track circuit in approach to the distant signal, P-26, is of a special type. The track is energized by alternating current from a conventional track transformer. At the same end of the track, a 4-ohm. d-c. track relay is connected. At the far end of the track circuit, a type RVM-9 half-wave copper-oxide rectifier is connected across the rails.

When the track circuit is unoccupied, one-half of the a-c. wave is shunted away from the relay by the rectifier. The other half of the wave cannot flow through the rectifier, and therefore flows through the relay, operating it on half-wave energy. When a shunt is placed across the track, the rectifying action of the rectifier is interfered with, and full-wave a-c. voltage is impressed across the relay. The d-c. relay offers such a high impedance to the 60-cycle energy that it cannot operate, even on the maximum voltage of the track transformer.

The use of this type of track circuit is especially desirable at this location because the track transformer and relay can both be located at the near end of the track circuit, thus eliminating the necessity of providing either control or power-supply line wires between the distant signal and the far end of the approach track circuit. The rectifier is housed in a weatherproof sealed metal case mounted on the ties between the rails. No other housing of any kind is required at that end of the track circuit.



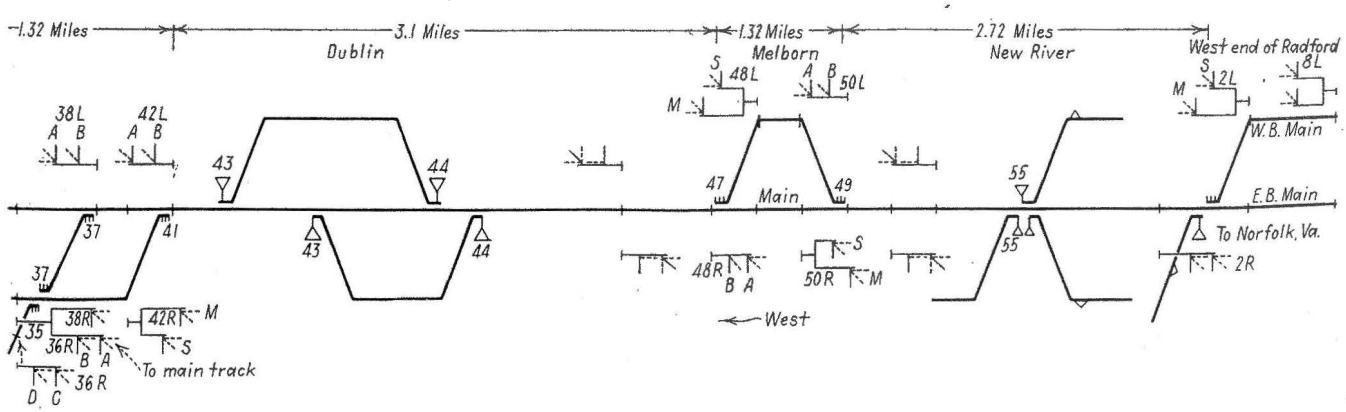
One of the new hand-operated switch and lock mechanisms with an electric lock

Time Locking

The C.T.C. system includes time locking. If a semi-automatic signal has been cleared, and is then taken away by lever control, the switch involved cannot be moved until the automatic time release has functioned, regardless of the condition of the approach track section.

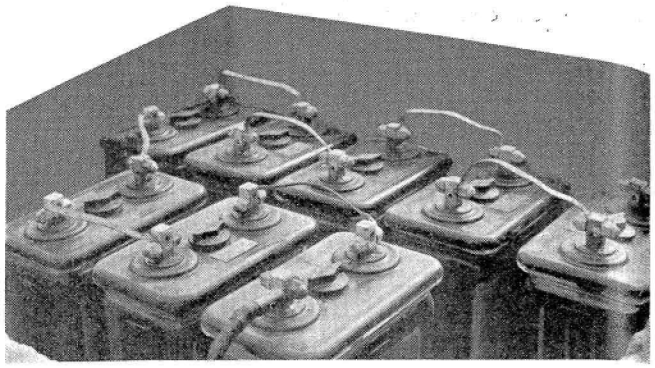
The C.T.C. Control Machine

The C.T.C. control machine, located in the yard office at Pulaski, is

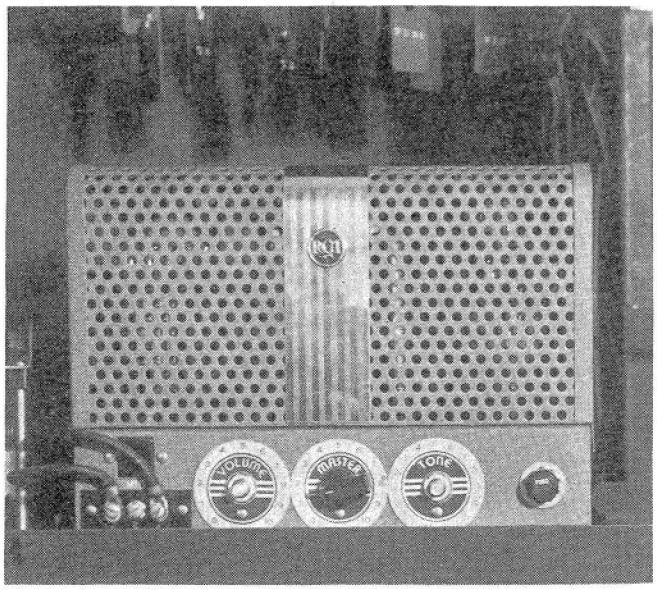


traffic control territory between Pulaski and Radford

handled by an operator who works under the direction of the dispatcher. Thirteen levers control 10 single switches and 3 crossovers. Thirteen levers control 54 operative semi-automatic signal arms. The power switch and signal 2R, 2L, 6L and 8L, at the west end of Radford, are controlled directly by the operator in the office at Radford, but in order for him to clear signal 2L, a release must be given through the C.T.C. line code system by the operator in charge of the C.T.C. machine at Pulaski. This release is effected by setting the traffic-direction lever No. 57 to the left position and then pushing the code starting button. The operator at Pulaski has control of the eastward signals at Melborn, but before he can clear such a signal, the traffic direction must be set up eastward between Melborn and the west end of Radford. The operator at Radford must place signal 2L at Stop if it is not already at such a position, and then advise the operator at Pulaski accordingly. Then the operator at Pulaski positions his traffic lever for eastward traffic and sends out a control code. The direction in which traffic is thus established between the west end of Radford and the east end of Melborn, is indicated by a lamp in an arrow on the panel of the control machine.



Set of battery in a concrete box at an intermediate signal



The amplifier for the loudspeaker in the Pulaski office

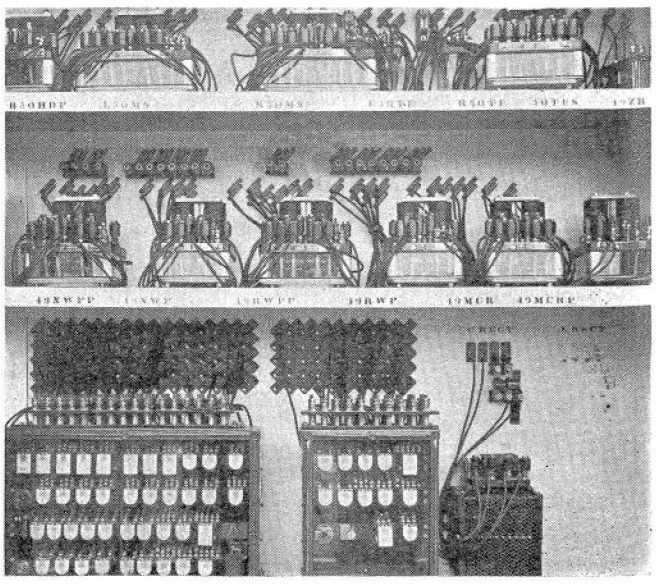
Track Diagram

The illuminated track diagram on the control panel includes lamps to indicate occupancy of all sections of the main line as well as the passing tracks. The lamps are normally extinguished, being lighted when a train occupies the corresponding track section. A lamp above the normal position of a switch lever is lighted white when the corresponding switch is in the normal position, or an amber lamp above the reverse position is lighted when the switch is reversed. A red light above the center position of a signal lever is lighted when the signals controlled by the lever are all displaying the Stop aspect, and a green lamp above the left or right position of the lever is lighted when the signal being controlled displays a Proceed aspect. A lamp above the normal position of an electric lock lever is lighted white when the corresponding switch is locked in the normal position, or an amber lamp is lighted above the reverse position of the lever when the switch is unlocked. The code controls are sent from the office to the field station nearest to an electric lock location, local line wire circuits being provided between the field station and the switch.

Electric Locks

An electric lock cannot be immediately released if a train is occupying any section of the main track of the station-to-station block, or if any station leaving signal for that block is not displaying the Stop aspect. When a block is occupied, as is the case when a train on the main line wishes to use a spur or industrial siding, the release can be effected only after the operation of a thermal time-element relay.

When the air pressure in the reservoir at an electro-pneumatic switch falls below 45 lb., an indication is sent



Relays and the line code apparatus in sheet metal case at a new power switch

to the control office to cause a lamp to be lighted so that the operator can call the maintainer.

Control System

The power switch at the west end of Radford as well as the signals at this location are controlled by direct-wire circuits from the office at Radford. Likewise, the two crossovers, the single switch and the signals near the yard office at Pulaski are controlled by direct-wire circuits from the C.T.C. machine. The remainder of the power switches and semi-automatic signals are controlled by the Union Switch & Signal Company time coding system using two line wires, with the code-following relays connected in multiple across the line.

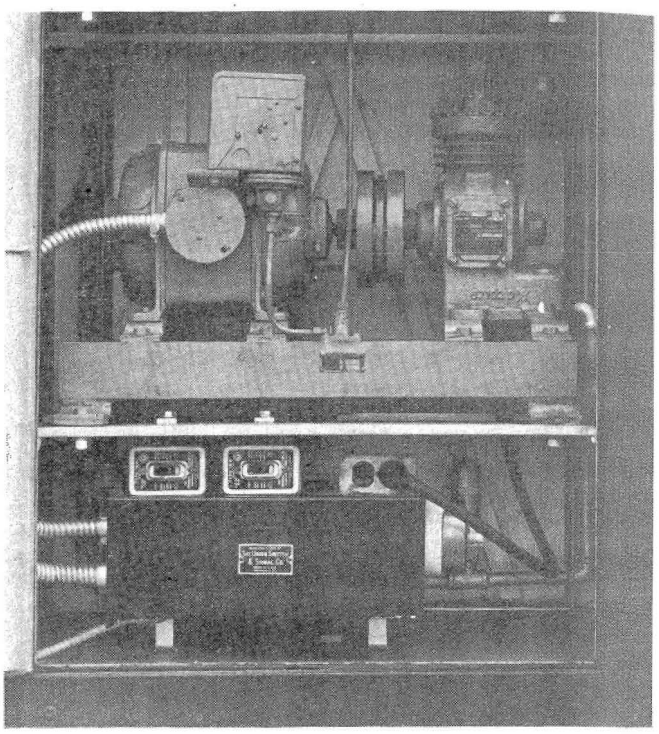
The two new line wires for the code system are No. 6 hard-drawn bare copper. These wires also handle a local telephone circuit with telephones at each switch location. The circuit is connected through an amplifier to a loud speaker on the C.T.C. control machine at Pulaski. When a maintainer or a trainman speaks into a telephone at any of the field locations, the operator hears the voice on the loud speaker.

When the operator wants to call a maintainer, he sends out a code which causes a short blast on an air whistle, and a lamp to be lighted on the track side of the case at the given field station. When the maintainer hears the whistle or sees one of these lamps lighted, he calls on the nearest telephone. Filters are provided between the line and the coding units so that the conversation and the line coding do not interfere.

Power Supply

The 4400-volt, three-phase, 60-cycle power line, previously in service, was continued in use. A new line transformer rated at 3000 watts was provided at each new power switch location, to feed the compressor motors and for other additional requirements. At each field station a set of eight cells of Exide EM-7, 120-a.h. storage battery is provided to operate the line coding apparatus, and one cell of the same type feeds the O.S. switch detector track circuit. At the control office, the code line is fed by a set of 9 cells of 60 a.h. Exide storage batteries, and a set of eight cells of 120 a.h. capacity feeds the coding apparatus.

Aerial cable is used for drop wires between the cases and the line poles, a 5/16-in. strand Copperweld messenger being used with Raco cable straps spaced 18 in. A strain type porcelain insulator is located in the messenger about 2 ft. from the mast in order to prevent the messenger acting as a ground. The line cable terminates on Raco lightning arresters, which are mounted in a Raco cast-iron box attached to the pole below the crossarm.

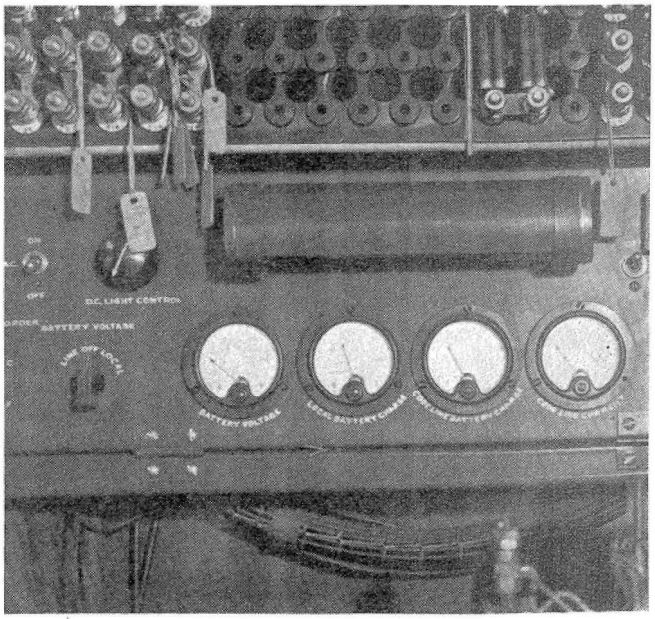


One of the new motor-driven air compressors at an electro-pneumatic switch

Track Circuit Connections

Track circuit connections were installed between the cases and the rails, using single-conductor No. 9 stranded underground cable, Raco bootleg outlets and stranded Copperweld connections to ⅜-in. plugs in the rails. The connections under the track, between signals, are in No. 14 solid wire underground cable. These underground cables are protected with non-metallic covering and with mummy finish coating. The insulated wires and cables are of Kerite manufacture.

This signaling project was planned and installed by the signal forces of the Norfolk & Western, under the direction of J. A. Beoddy, superintendent telegraph and signals. The major items of equipment were furnished by the Union Switch & Signal Company.



Panel of meters for checking the charging rate of batteries and the line voltages