

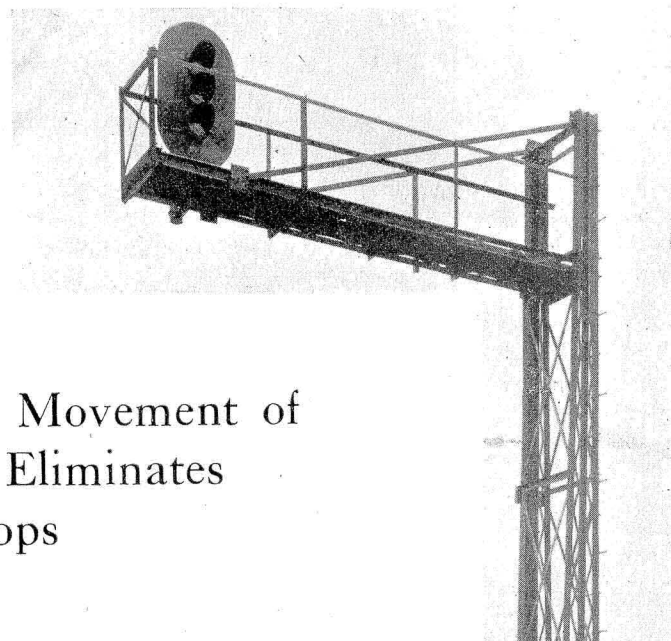
C. & O. Installs Signaling With Train Control

New Equipment Expedites Movement of Traffic at Sidings and Eliminates Unnecessary Stops

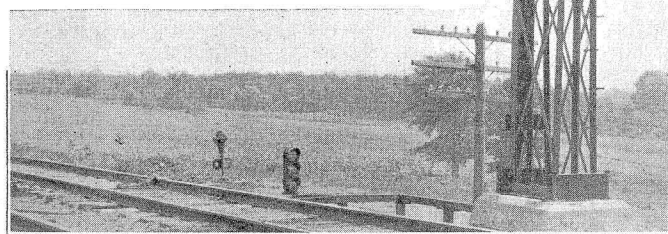
THREE-INDICATION color-light automatic block signals operated by alternating current together with the ramps and control equipment for automatic train control, have been installed on 40 miles of single track between Charlottesville, Va., and Staunton, on the Chesapeake & Ohio. This installation is a continuation of the section from Gordonsville to Charlottesville which was installed in 1919, and it is the intention to continue the installation from Staunton to Clifton Forge in the near future, making a complete signaled line of 96 miles from Gordonsville to Clifton Forge. Twenty-four locomotives have been equipped recently with automatic train control apparatus, which makes a total of 64 locomotives equipped with the device. The engine apparatus is provided with both direct and alternating current magnets to operate on both the older d. c. section, between Gordonsville and Charlottesville, and also on the new a. c. installation extending to Staunton.

Operating Difficulties on This Stretch of Single Track

In referring to the map of the C. & O. lines it may be seen that the C. & O. operates two lines between Richmond, Va., and Clifton Forge. Most of the traffic from the coal fields of West Virginia to tidewater is sent over



Absolute Signal on Lattice Bracket



the southern route through Lynchburg; however, the coal and other freight to and from Washington, Baltimore and northern connections is handled by way of Gordonsville. In addition to this rather heavy freight movement, the through passenger trains between the west and Washington are routed by way of Gordonsville to Clifton Forge and west. This line crosses through rough country with a continuous succession of curves and several long grades, some of which are from 1.13 to 1.42 per cent and from 1 mile to 14 miles in length. There are 5 tunnels totaling 1.5 miles in length in the 40 miles from Charlottesville to Staunton. On account of the physical characteristics, the high cost of constructing a second track was not considered to be justified by the present traffic. Therefore,

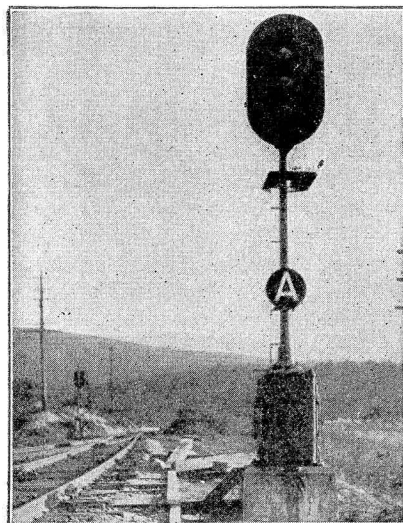


Fig. 1. Absolute Head-Block Signal

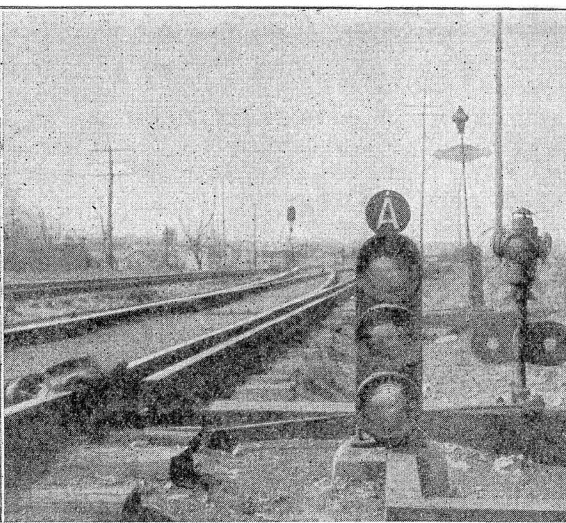


Fig. 2. Absolute Dwarf Signal



Fig. 3. Permissive Signal

the problem was to increase the track capacity of the single track line by the installation of signals. As it is the policy of the C. & O. to contribute its share to the development of automatic train control, it was also decided to extend the present installation of train control between Gordonsville and Charlottesville on through to Staunton.

Special Signal Indications Developed

The signal control circuits are of the Absolute Permissive Block system for single track signaling; that is, the head block advance signal at a siding gives an "ab-

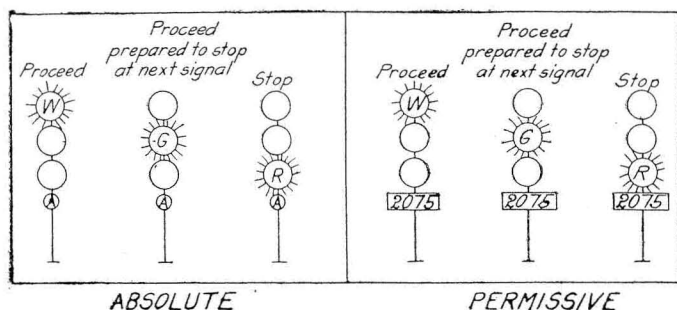


Fig. 4. Names and Aspects of Light Signal Indications

solite stop" indication for an opposing train movement between sidings, but a "permissive" indication for following train movements.

The absolute signals, either high-mast, bracket, or dwarf, are designated by a sign showing the letter "A" without any number (see Fig. 1 and 2) and are located at passing points, at the entrance to a block, and at tunnels. The permissive signals, either high-mast or bracket, are located at intermediate points (i. e.,) between stations, and are designated by number plates (see Fig. 3). All signal indications are given by colored lights arranged in a vertical row. On the high signals the indications are as follows:

Top light	White	Proceed.
Second light	Green	Proceed with caution.
Third light	Red	Stop.
Fourth light (displayed with red light only)	Amber	Proceed under Rule B-1.

Absolute dwarf signals, as shown in Fig. 2, are located at clearance points at the ends of passing sidings at

Rule B—"When a permissive signal indicates stop, a train will stop before reaching the signal and then proceed with caution, looking out for train ahead, car on siding fouling the main track, a misplaced switch, or a broken rail, regulating speed so that it can be stopped within the scope of the engineman's view; except that a train moving under flag protection from the absolute signal, as per Rule A, shall continue to proceed under flag protection until it has reached a signal which indicates caution or proceed.

Signal Layout Saves Minutes at Meeting Points

As with any single track installation the signaling at the sidings is the important factor, and it is difficult to lay out an arrangement which will allow flexible movements of trains under control and at the same time provide adequate head-on and trailing protection if the engineman should not be on the alert. The C. & O. has instituted several unique features that assist materially in expediting train movements at these points. A typical layout at a passing siding is shown at Crozet, Va., in Fig. 5. It will be noted that the layout consists of westward absolute signal A-1943, westward permissive signal 1941; eastward absolute signal A-1954 and eastward permissive signal 1952. Ramps are located braking distance in the rear of signals 1941 and 1952, i. e., the train passes the ramp previous to its arrival at the signal.

We will assume that westbound train W and eastbound train E are to meet at Crozet. When train W enters the east end of the block east of Crozet absolute signal A-1954 displays the "stop" indication, signal 1952 displays the "Restricted Speed" indication (red and amber), and ramp R in the rear of signal 1952 is de-energized. Likewise with train E approaching the absolute signal A-1943 and signal 1941 display the "Stop," and the "Restricted Speed" indications respectively, and the ramp R, in the rear of signal 1941 is de-energized. The rule covering this special restricted speed indication is as follows:

Rule B-1—"A permissive signal (i. e., signal 1941) indicating stop, when the amber light shows below the red light, may be passed at low speed. When the amber light is not burning the signal shall be regarded as a permissive signal. See Rule B."

Train W upon approaching the meeting point receives the "Caution" indication (yellow) at signal 1931. On approaching signal 1941 if the engineman is alert and sees the restricted speed indication he can pass the ramp in the rear of signal 1941 without an automatic appli-

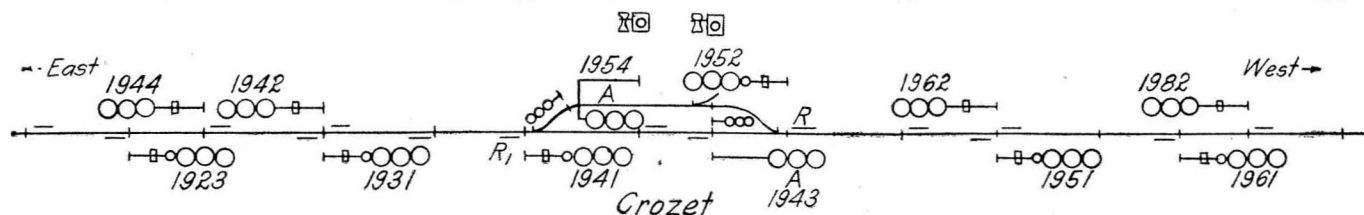


Fig. 5. Typical Track and Signal Layout at Siding

the entrance to a block, and control movements from the sidings to the main track.

For the dwarf signals, the indications are as follows:

Top light	White	Proceed.
Second light	Green	Proceed with caution.
Third light	Purple	Stop.

The several aspects are shown in sketches in Fig. 4. The rules governing train movements under these signal indications are as follows:

Rule A—"An absolute signal indicating stop must not be passed without authority from the chief train dispatcher, except, if unable to communicate with the chief train dispatcher, the train may, if time table or train order superiority permits, proceed under protection of a flag."

cation of the brakes providing he has reduced the speed to less than 12 m. p. h. and also providing the permissive lever on the engine is operated while passing over the ramp. The train then continues past signal 1941 at a speed not over 12 m. p. h. and enters the siding without coming to a full stop.

Train E approaching from the other direction receives similar indications and may proceed at restricted speed, past the ramp in the rear of signal 1952, and signal 1952, providing the engineman acknowledges these indications with the permissive lever. In case the train W is not yet in the clear on the siding then train E is brought to a stop at absolute signal A-1954. While if train W is in the clear the eastbound train E can proceed without

stopping providing the block is clear to the next station. Therefore, it will be seen that trains may meet without stopping unnecessarily, if the enginemen are alert, yet adequate head-on and trailing protection is afforded if the signal indications are not obeyed.

For example, assume that train E is on the siding at Basic, Va., Fig. 6, waiting for a westbound train W to pass, then both the eastbound head block absolute signal A and the absolute dwarf signal D give the absolute "Stop" indication. Both the high signal A and the dwarf D are located opposite the point of clearance for the siding. Therefore, there is no room for doubt on the part of the engineman as to where he must hold his train. Another advantage of this layout is that if westbound train W makes a station stop, train E can proceed east in the meantime on the clear indication of the dwarf signal which indicates "Proceed" as soon as the rear of westbound train W passes signal A. This movement of train E out of the siding is protected against any back-up move of train W by the signal A.

As a different example, assume that eastbound train E had been making its station stop on the main track

At certain stations where the absolute advance signal is in line with the permissive signal entering the station, the advance signal is burned at a reduced voltage to prevent a chance of mistaking one signal for the other.

Special Protection at Tunnels

Ordinarily the signals between sidings are permissive signals (see Rule B), however, the signals at the entrance of the tunnels are absolute signals, i. e., they have no number but have the marker A the same as the head block signals. Referring to rule A, it may be seen that such a signal cannot be passed without permission from the chief dispatcher or under flag protection. The purpose of requiring an absolute stop at the tunnel entrance is to prevent two trains from being in the tunnel at one time, or even for following moves. Referring to Fig. 6, it may be seen that after a proceeding train has actually cleared the tunnel, that there is no reason why signal A at the tunnel should not then be treated as any other intermediate permissive signal to allow the second train to proceed at minimum speed. Therefore, an amber light is added below the regular signal, which is illuminated in addition to the red indication as soon as the preceding

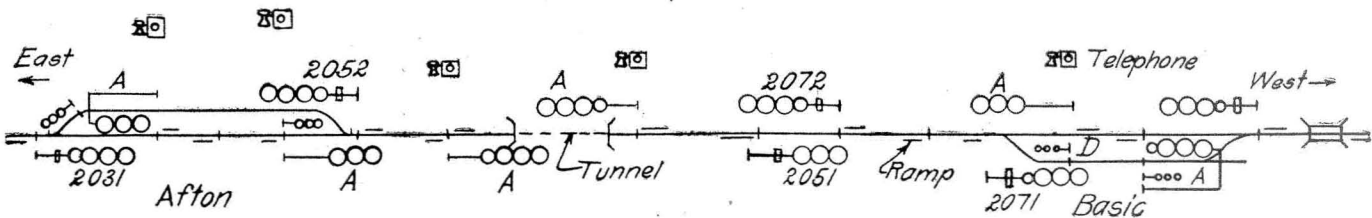


Fig. 6. Typical Signal Layout Between Sidings Including Tunnel Protection

at Basic, while westbound train W had been approaching, then train W would have found the permissive signal 2071 giving the "Restricted Speed" indication. Under this condition the westbound train W would have been permitted to proceed into the passing track without coming to a full stop at the signal 2071. (See Rule B-1).

With the westbound train W making this move into the passing track the eastbound absolute block signal A will not indicate proceed for eastbound train E until the train W was in the clear on the siding and the switch and derail lined up. The same layout is applied at each end of every siding. Therefore it may be seen that every move at sidings is protected; that there is no chance for an engineman on a siding to pull by the clearance point and cause delays, and also that a train on a siding can go immediately as soon as the block is clear.

Where passing tracks are long and the ramps located in the rear of the signal governing the entrance to the passing tracks are too far out to enforce restricted speed, then a second ramp is located between the ends of passing tracks so as to shorten the restricted speed zone and allow trains to close in and do station work when waiting on a meet. An example of this layout is shown at Afton.

An interesting case developed at Fisherville, where the station was so located that a train making the station stop did not clear the passing track switch so that a train could not enter or leave the siding. This kind of an arrangement did not fit in with the new signal layout and operating scheme and it was planned to extend the passing track approximately 500 ft. However, it was suggested that the train control ramp could be placed alongside the station platform and that the signal could be supported from a bracket that would clear the platform. The ramp is shown in Fig. 7. Therefore, the station platform was merely extended 200 ft. east and the same result accomplished as if the passing track had been extended 500 ft. west.

train has cleared the tunnel. This amber light can be seen readily up to 1,000 ft. Under this condition the second train may proceed, being governed by a special rule as follows:

"An absolute signal indicating stop, when the amber light shows below the red light may be passed at low speed. When the amber light is not shown, the signal shall be regarded as an absolute signal."

In the several uses of this additional amber light, it should be noted that if in any case the amber light should fail to be illuminated that the indication is more restrictive, thus requiring a stop; therefore no hazard is introduced by the new indication.

In the locomotive cab are mounted small color-light signals that repeat the indication of the wayside signals. These cab signals indicate either the white or the green indications of the wayside signal. However, the red wayside indication is not repeated in the cab but such indication is evidenced by the automatic stop.

How Train Control Is Incorporated With the Signaling

The intermittent electrical contact type of train control including speed control and cab signals as furnished by the American Train Control Company, is installed with this new signaling. Ramps are located alongside the track in the rear of each main line signal, i. e., a train approaching a signal will arrive at the ramp previous to its arrival at the signal. Ramps are also located at a few other special points as will be explained later. In brief, the operation of this train control system is as follows:

As the locomotive proceeds past one of these ramps the shoe on the locomotive rides up and down the incline. If the block is clear and the signal at proceed the current on this ramp is carried to the electrical apparatus on the locomotive that functions to prevent any exhaust of air from the train line while the shoe is passing over the ramp. If the immediate block is occupied and the

signal is at danger there is no energy on the ramp, and providing the engineman does not take certain precautionary measures, the exhaust of the air in the train line as the shoe passes over the ramp will cause the brakes to be set. A detailed description of the construction of the American Train Control Company's equipment was published on page 846, of the *Railway Signal Engineer* for March, 1921.

On approaching a permissive signal giving a stop indication, the engineman, if alert and by reducing speed to less than 12 m. p. h., can pass the signal without a stop providing he pulls the permissive lever while the shoe is passing over the ramp. He may then proceed through the block without interference from the train control, expecting to find a train in the block, a broken rail or a switch open. In view of the fact that there are many long grades on this line, the ability to pass a permissive signal at minimum speed without an absolute stop eliminates the necessity of stopping heavy trains on a grade for a permissive signal but they may be kept moving at a minimum speed until the preceding train has time to clear the advance block. Further benefits are derived

the track capacity by keeping trains moving when there is no need for a tonnage train to come to a stop at a signal indicating "stop," when that indication is caused by a preceding train that may soon clear the block. The train control ensures safety by enforcing a train stop for all conflicting train movements and at all signals indicating stop when the engineman is not alert and does not have his train under control at a specified speed.

As indicated in Rule A a train must not proceed past an absolute stop signal except under flag protection without permission from the chief dispatcher, therefore some ready means of communication is necessary. A separate metallic telephone circuit of two No. 10 bare copper wires was installed through the 40 mile section, with special telephones at all absolute signals, viz., at the ends of sidings and at the entrance to tunnels.

Economies Effectuated by the Signaling

The cost of operation of this signaling system amounts to approximately \$4.13 per mile per month, which includes the a. c. current supply, the oil and gas for motor cars and incidentals. The maintenance charges for signal

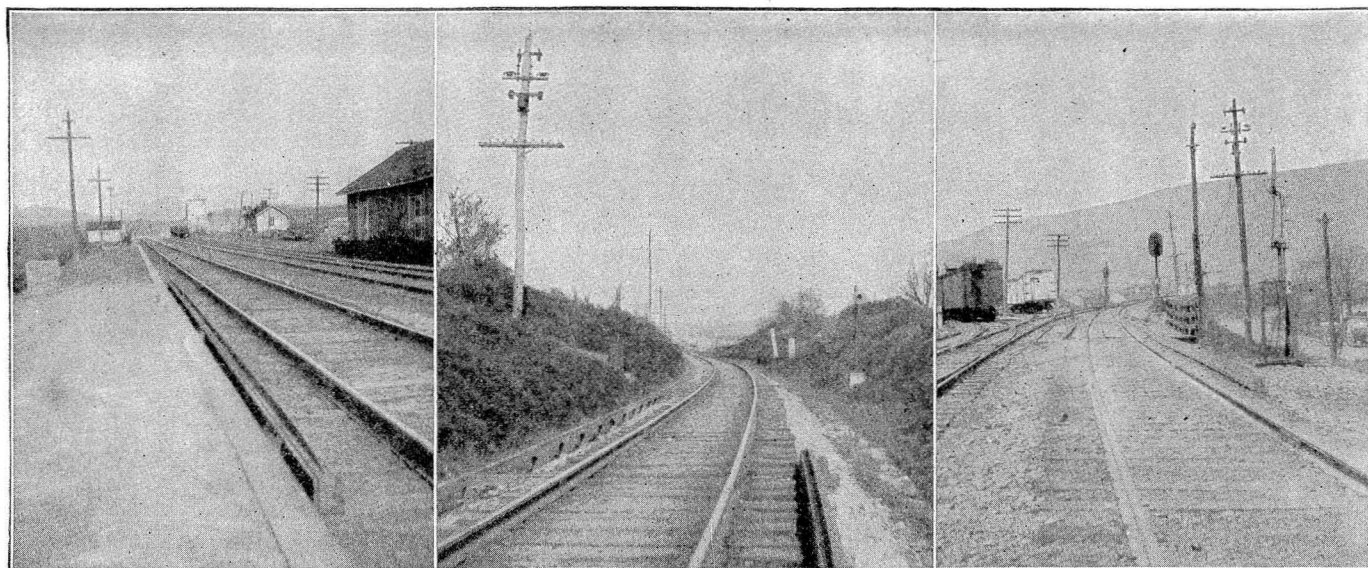


Fig. 7. Ramp Located Along Platform Fig. 8. Intermediate Ramp Location Fig. 9. Absolute Signal and Ramp Location

by allowing trains to close in at stations under control, as described heretofore.

At any point where a ramp is located between signals it is distinguished by a special marker as shown in Fig. 8. The ramp marker consists of a standard R. S. A. cast iron electric lamp case with No. 18 gage sheet metal background, 18 in. in diameter, on an R. S. A. adjustable lamp bracket, the whole being supported on a standard cable post. The background is painted white and serves as the marker. It is illuminated at night by reflected light. The reflection is obtained by placing a small disc directly in front of the lens and about 6 in. away. The side of the small disc toward the engineman is painted black and the side toward the lamp white, to assist in the reflection of light on the large disc. The engineman is shielded from all direct light from the lamp and observes only the large white disc with the black spot in the center both day and night. If the first train clears the block before the second train reaches the intermediate ramp, energy is supplied to this ramp so as to operate the control equipment on the locomotive in such a way as to remove the minimum speed control restriction.

In simple words, this train control system increases

maintainers wages are \$17.78 per mile per month. Thus the total cost of operation and maintenance is \$21.80 per mile per month. These costs are based on a new installation and do not include any heavy repair charges. The automatic train control in connection with the signal installation, as included in the above figures, increased the cost of maintenance and operation over that for a simple automatic signal system. The estimated saving in cost of operation of the line includes:

5 telegraph operators.....	\$ 745.20
120 train hours	678.95
	<u>\$1,414.15</u>

which amounts to \$35.35 per mile per month. Therefore the saving in operating expenses is \$35.35—\$21.90=\$13.45 per mile per month.

Signal Construction Features

The signals, instruments, cases, relays, track transformers, switch circuit controllers, etc., for this installation were furnished by the Union Switch & Signal Company. The high signals are the L-14 type with an inner lens that has the color and proper optical characteristics so that when arranged with the outer 8-3/8 in. clear lens that a doublet is formed which gives the proper

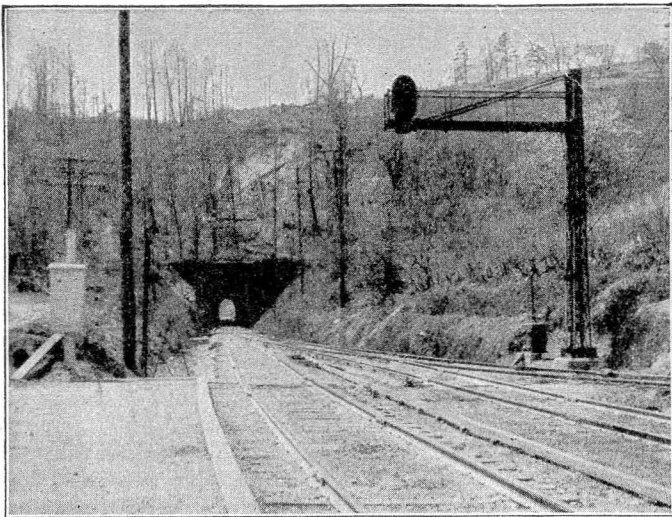


Fig. 10. Absolute Signal on Bracket, Telephone Box Shown at Left

range. Provision is made for the mounting of a 10 or 20 degree deflecting prism in order that the angular spread may be increased where signals are located on curves.

Each lens unit is equipped with two lamp receptacles, the front receptacle being of the single contact bayonet candelabra type and so located as to bring the filament of the lamp at the exact focal point of the lens system. The rear or secondary lamp is a standard medium screw base type and a spherical mirror is provided so as to throw the light from the rear or secondary lamp onto the inner lens of the lens system and is so located as not to produce phantom indications.

The front or focal lamp is a 6-volt, 18-watt bulb, with a concentrated filament. It is based accurately so that the lamps can be interchangeable in the field without requiring readjustment in order to maintain the previously established range of the signal. The rear or secondary lamp is a 55-volt, distributed mazda filament, 25-watt bulb, medium screw base. These signals have a

the siding, it was necessary to place the signal on a bracket at one end of every passing track, as shown in the illustrated heading and also in Fig. 10. These brackets are made of special light steel lattice work and were furnished by the Bates Expanded Truss Company. At the regular high signals the relays, track transformers, etc.,

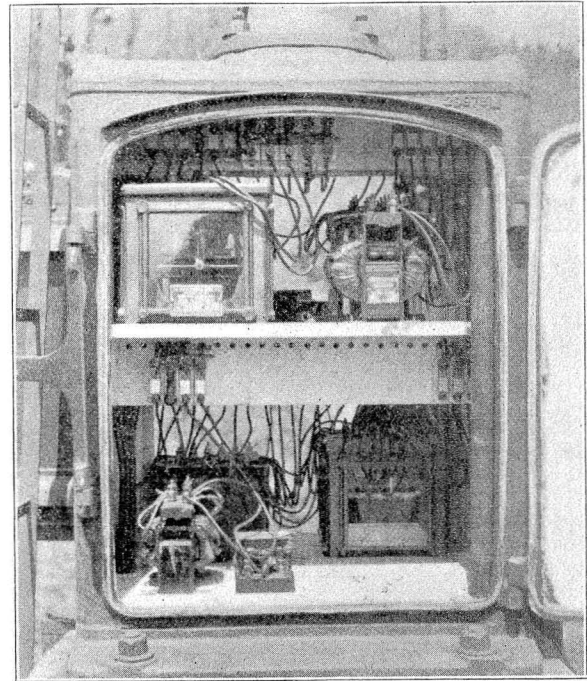


Fig. 11. Interior of Instrument Case

are housed in double door cases which support the signal mast. At bracket pole locations the relays are located in a signal case on a separate foundation. The interior of one of these instrument cases is shown in Fig. 11.

A. C. Transmission Line

A separate pole line for the signal feeder and control circuits was constructed from Charlottesville, Va., to

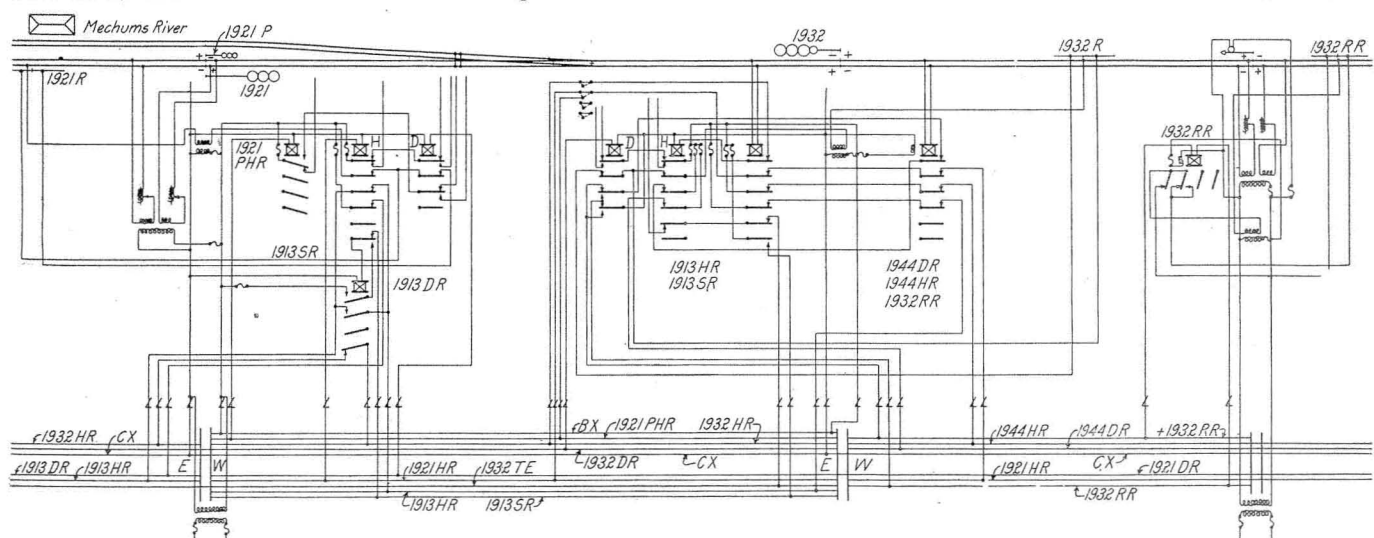


Fig. 12. Typical Wiring Diagram for Head Block and Dwarf Signals

minimum range of 4,500 ft. under adverse conditions of bright sunlight. The dwarf signals have a 6-3/8 in. lens illuminated by two single filament lamps, giving a minimum range of 1,000 ft.

In order that the absolute signal can be located adjacent to the main track opposite the point of clearance of

Staunton. The three conductors for the 3-phase, 6,600-volt a. c. feeder circuit are bi-metallic reinforced stranded aluminum equivalent to No. 6, copper, and two of which are carried on the short top arm and one wire on the pinnacle pin. Splices are made with McIntyre sleeves. All low tension wires are No. 10 B. & S. copper clad,

hard-drawn, double braided, slow-burning weather-proof.

Sectionalizing switches are installed in the line at intervals of 5 miles. This enables the signal department to sectionalize the line in making repairs without killing the entire line and also enables it to have one or more sections dead in case of trouble, i. e., if the line should break 10 miles out of Charlottesville they will be able to feed from Charlottesville and from Staunton to the point of trouble and keep all signals working except those in the block where the trouble exists. Power is purchased from the local power companies at Charlottesville and Staunton.

Chestnut poles not less than 35 ft. in length, spaced 175 ft. apart were used on the signal line. Cypress crossarms were installed and all bolts and braces are of galvanized iron. All insulators were porcelain made by the R. Thomas & Sons Company, Pittsburgh, Pa. The

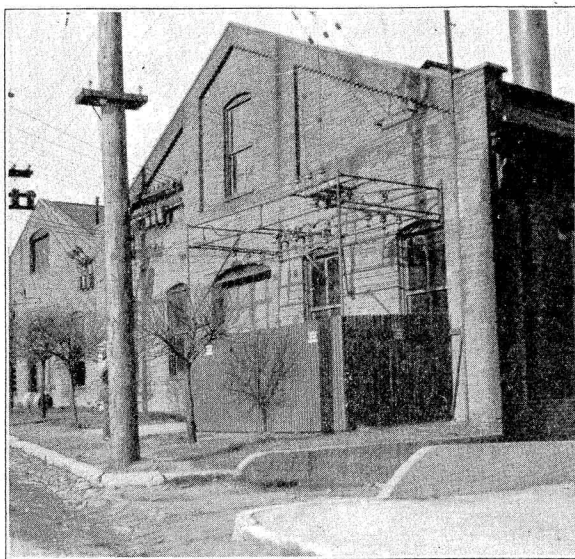


Fig. 13. Open Air Substation Outside Powerhouse at Staunton

high tension insulators were the Cat. No. 1009, and the low tension were the Cat. No. 7019.

The 15-amp. 6,600-volt expulsion type fuses and compression chamber type high tension lighting arresters, General Electric No. 79220 were mounted on extra cross arms. Ground rods are made of 6 ft. galvanized iron pipe fence posts made by the American Steel & Wire Company. These posts have a row of holes punched up one side with lips used for attaching fence wire. When the ground post is driven the pipe is filled with charcoal and salt, and the dampness coming through the holes assists in making a satisfactory ground. The ground wire is attached to the ground pipe by one of the Ohio Brass welded bonds.

High tension choke coils were made up of 23 turns of No. 10 hard drawn rubber covered wire, the turns being 5 in. in diameter. A 0.75 kv.a. oil cooled line transformer 6,600 volt to 110 volt was located at each signal location. Typical pole line construction is shown in Fig. 8. All signal cables and conductors between signals and instrument cases is No. 14 solid copper rubber covered single conductor. Track wires are No. 9 solid rubber covered. All insulated wire on this installation is Okonite.

On the entire 40 mile section the rails are bonded with Ohio Brass Company gas welded copper bonds. The use of these bonds has eliminated the necessity for cut-sections between signals. In the Blue Ridge tunnel, the ballast leakage is excessive, and it would have been

necessary to locate a cut section in the middle of the tunnel which is 4,620 ft. in length, if channel pin bonding had been used. With the welded bond using a feed of 2 volts, there is 0.8 volt at the relay end of the circuit.

This signal and train control installation was made under the supervision of Chas. Stephens, signal engineer of the C. & O.

Disregard of Signals Causes Death of Six on Lehigh Valley

ON February 20, 1923, there was a rear-end collision between an express train and two light engines on the Lehigh Valley, at Rummerfield, Pa., which resulted in the death of six employees. A summary of the report of the Bureau of Safety is as follows:

This accident occurred on a double-track line over which trains are operated by time-table, train orders, and an automatic block-signal system. The signals in the vicinity of the point of accident are of the three-position, upper-quadrant type, normally displaying stop indications. The signals involved in this accident are signal 2431, located about 800 ft. east of the point of accident, and signal 2411, located about 1½ miles farther east.

Westbound freight train extra 2109 was being delayed on account of the engine not steaming well, and when it stopped with its rear-end in the vicinity of signal 2431, extra 2108, which consisted of engine 2108, dead engine 1147 and a caboose, coupled to it for the purpose of assisting it. After pushing extra 2109 until its rear-end was in the vicinity of the station it was brought to a stop and extra 2108 then backed eastward on the main track to a waterspout about 700 ft. east of the station, or 880 ft. west of signal 2431. The evidence indicates that extra 2108 stopped at this waterspout at about 6:45 a. m., and while it was standing at this point its rear end was struck by train No. 17.

Westbound express train No. 17 consisted of 16 mail and express cars and 1 combination car, hauled by engine 2016, passed Laceyville, the last open office, 18.9 miles from Rummerfield, at 6:37 a. m., and collided with extra 2108 while traveling at a speed variously estimated by the employees at between 25 and 45 miles an hour. The

Flagman Lynch, of extra 2108, stated that after his train coupled to the rear of extra 2109 and started to assist it, he boarded the caboose and rode on it until extra 2109 stopped near the station. He then got off and started back to flag, carrying with him a red and white lantern and a red flag, reaching a point about 10 car lengths east of the waterspout when he heard the whistle of train No. 17, which was not yet in sight, and he said he continued back until he reached a point about six car lengths east of signal 2431, which was displaying a stop indication, and that from that point he gave a stop signal with his white lantern.

There is nothing to indicate that Engineman Shellenberger saw the stop indications displayed by signal 2431, and there is a dispute as to whether he acknowledged the flagman's stop signals. But regardless of this latter fact, the testimony of the train crew of train No. 17 indicates that the brakes were not applied until the engine was within a few car lengths of the caboose of extra 2108.

This accident again calls attention to the necessity for some form of automatic train control for the prevention of accidents when for any reason an engineman fails to observe or obey signal indications; had such a device been in operation at this point this accident undoubtedly would not have occurred.