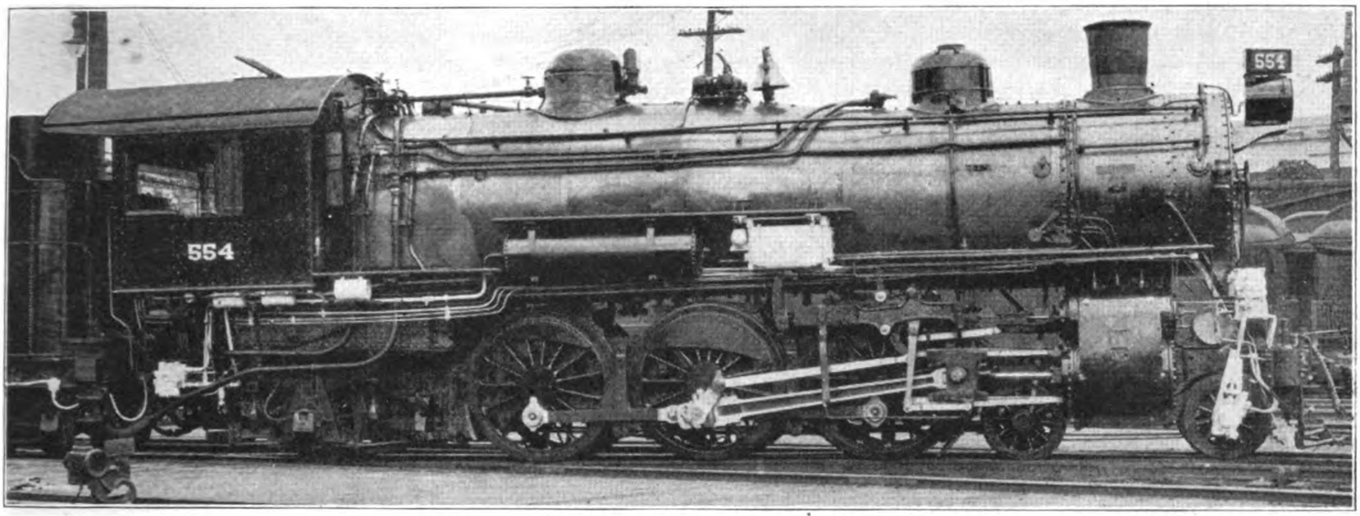
Railway Signaling, vol. 18, June 1925



Typical Locomotive With Train Control Equipment Painted White For Illustration

N. & W. Train Control In Service

Continuous System Incorporated With A. C. Position Light Signaling on an Engine Division of Single Track

By D. W. Richards
Signal Engineer, Norfolk & Western, Roanoke, Va.

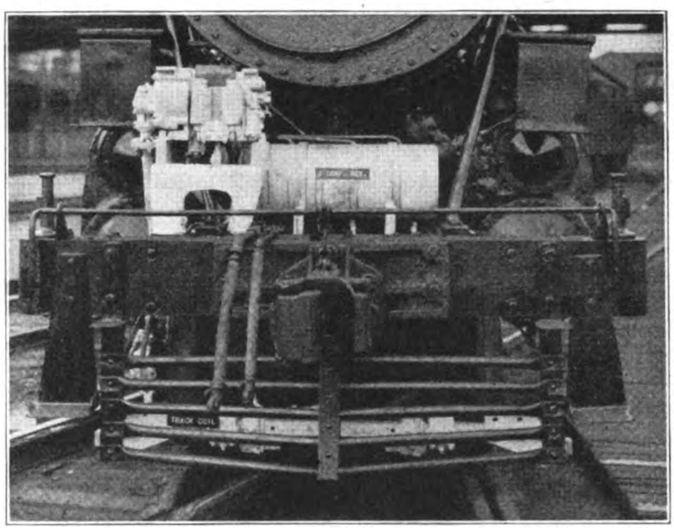
THE Norfolk & Western Railway has installed the three-speed continuous inductive train control system as manufactured by the Union Switch & Signal Company on its single track division of 108 miles, Hagerstown, Md., to Shenandoah, Va., the installation including a complete new system of automatic block signaling of the a. c. position-light type. This installation was made in compliance with the order No. 13413 of the Interstate Commerce Commission dated June 13, 1922, and construction is now under way to extend the installation from Shenandoah to Roanoke, 132 miles farther, in compliance with the order of January 14, 1924. The installation was commenced in December, 1923, and placed in service on November 10, 1924, with six equipped engines. Two additional passenger and 33 freight engines, making a total of 41, were put into service February 15, 1925.

Selection of Type of Train Control

This district was selected for the installation of train control because it was not equipped with automatic block signals and it was thought preferable to protect the train movement on this district and also increase the track capacity, rather than to add the train control system to a district already provided with automatic block protection.

A careful study was made in deciding on the train control system to be used, the basic selection being between intermittent and continuous control devices. In the intermittent field there is a choice between ramp and inductive types. It was found that on account of the fundamental requirement that the wayside ramp and the train carried shoe must overlap each other, one or the other must encroach on clearance. Dragging equipment, loose track obstructions, banked snow and ice and even authorized structures, such as station platforms, have little respect for the clearance diagram so that one or both of these essential parts is subject to potentially and dangerous derangements.

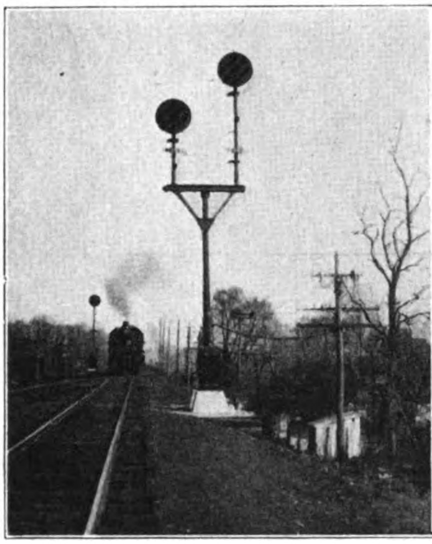
In studying the ramp type intermittent system, in comparison with continuous speed control system, we found that the latter system utilizes the running rails



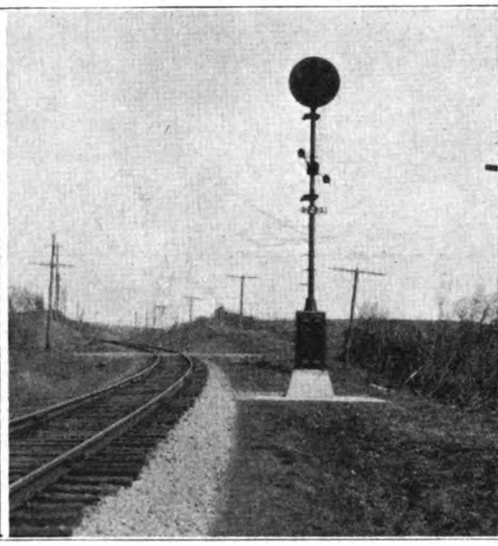
Front View Showing Governor and Track Coil Supports

themselves for the roadside device and that the engine carried receiver is well within the clearance lines. It was therefore apparent that there was an encroachment which might render the system inoperative.

Intermittent systems are designed to cause brake applications only at certain control points usually at fixed signal locations, but always separated by several thousand feet of track in which train control is nonexistant. After once passing a clear control point a



Signaling at End of Passing Track at Shenandoah Jct.



Intermediate Location With Grade Signal

Signal With Lower Arm For Siding Indication

subsequently developed dangerous condition ahead of a train cannot affect the brakes before reaching, at unlimited speed, the next control point which will, in most cases, be too late. In continuous control systems such a condition would instantly affect the train control device to apply the brakes regardless of the location of the train. This is because the rails themselves, which must be continuous, constitute the wayside element of the system. There were other desirable features peculiar to the continuous system which also affected our choice, of which the following are a few examples:

Changed conditions calling for a more restricted speed are instantly reflected on a train, and vice versa, changed conditions, favorable for an increase in speed, are also instantly reflected on a train and may be taken advantage of by the engineman. This immediate response to changed conditions was of immense importance to us when it is remembered that we were contemplating the installation of train control on a single track line. Expeditious handling requires that opposing trains approaching a meeting point should not delay each other beyond the requirements of safety. It was found that in the continuous system opposing trains could be advanced much nearer a passing siding than in an intermittent system. To put it another way, in the continuous system, opposing trains could be advanced, until they reached a distance relation to each other that might be dangerous if high speed were continued regardless of their respective relations with the passing siding. On the contrary, with intermittent control the braking must be effected with regard to the passing sidings, even though the trains themselves may be at enormous distances apart. This would have caused serious delays at meeting points which would have been felt still more when more than two trains were involved in a meet.

With the continuous system we could take advantage of the facilities afforded by speed control in which high speed could be permitted under favorable conditions, medium speed in a caution or medium speed block and low speed in an occupied or low speed block.

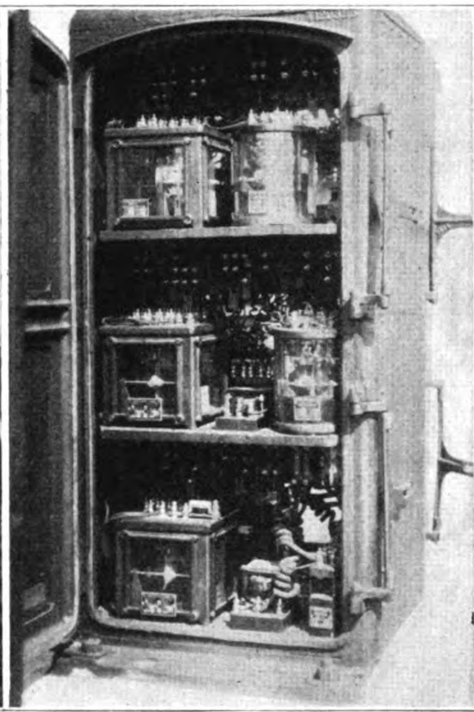
An all important consideration in a comparison between systems of train control is safety. The interlocking system in its crude beginning consisted of a grouping of several switch operating levers at a single location. Such an arrangement was simply a convenience. Experience, probably expensive, taught that signals, locking between levers, detector bars and

A Telephone Is Located at Each Passing Track

An Intermediate Double Location With a Grade Signal in One Direction

Typical Pole Equipment at Signal Location facing point locks were necessary. Further experience showed the desirability of caution distant signals, approach locking, route locking and section locking, all of which additions are solely for safety. Even the signaling aspects have progressed from the crude (and now totally inadequate) early forms, so that modern

Switch Lamps Are Lighted Electrically



Typical Relay Case at Double Signal Location

Braking Point Location Feed Box Showing Terminals

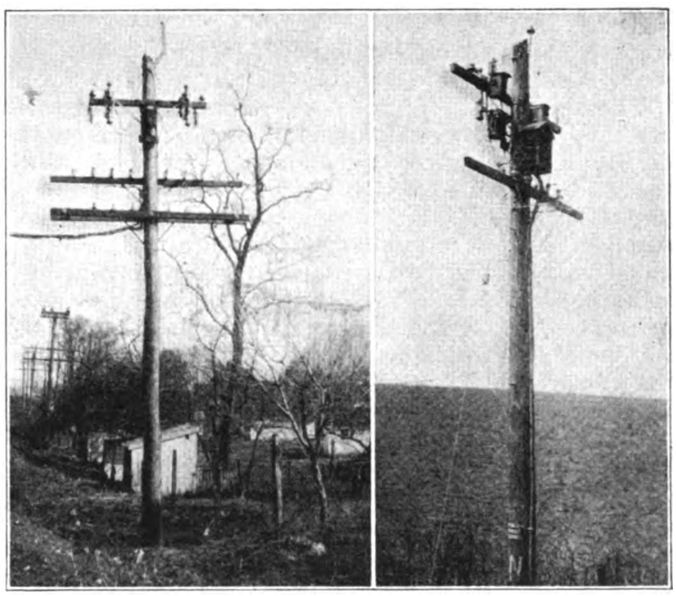
signaling provides for a variety of indications for the guidance of the engineman in controlling his train. Thus we usually have, amongst others, indications for high speed and for medium speed; for proceed prepared to stop; for low speed into an obstructed block, and for stop. Such requirements are met with by our train control system.

When confronted by the necessity for a large expenditure for additional train protection, the Norfolk & Western chose the system which, in its judgment, gave the greatest degree of safety and that at little, if any, extra cost over systems installed to meet operating conditions. The single track line between Shenandoah and Hagerstown has 22 passing sidings. The maximum curvature is 9 degrees and the maximum grade 2 per cent. The train movement was formerly operated under the telegraph block system. In this district, there are two interlocked grade crossings, at Riverton and Charlestown, and numerous highway crossings which had to be protected.

The A. C. Signaling System

Alternating current track circuits were installed so as to make the automatic signal system immune from the effect of possible d. c. foreign current, and also because the same transmission line could be utilized economically for the operation of water softening plants, automatic electrically driven pumps, station lighting, switch lighting, etc. Transmission is effected at 4,400 volts, 3-phase, 60-cycle and is furnished at three different points, Hagerstown, Berryville, and Shenandoah. The system is so arranged that Berryville will transmit in both directions to Shenandoah and to Hagerstown while the substations at the two latter points can transmit to Berryville in case of a power failure there. As an additional precaution the substations at Hagerstown, Berryville and Shenandoah are each supplied from two or more sources. All the various sources of supply at each station will eventually be arranged so that they can switch in automatically, when normal power fails.

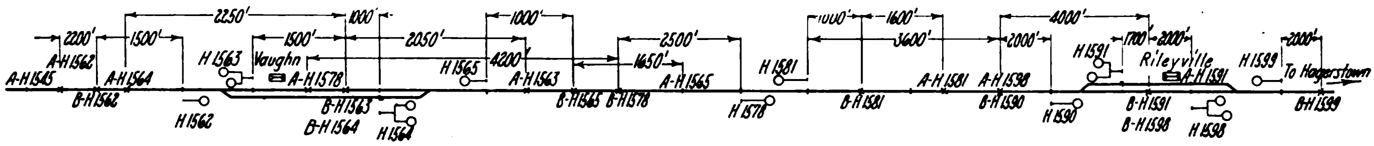
The automatic block signal installation consists of 118 ground signals, 41 bracket signals and 282 a. c. track circuits. The A. P. B. system of signal control



Typical Transformer Poles at Signal Locations—Note the Parkway Running Down Pole From Arrester Box

circuits is used. This system provides head on protection from siding to siding but permits following trains to run one block apart between passing sidings.

The accompanying photographs show the position-light signals as installed on this district. The signals are designed to use three lights in a row for each indication, the arrangement of lights corresponding to the position of the semaphore type of signal. If the horizontal row of lights is lighted, the indication is "Stop." If the diagonal row of lights is lighted, the indication is "Proceed under control prepared to stop at next signal." If the vertical row of lights is lighted, the indication is "Proceed."



Track and Signal Plan Between Sidings Showing Automatic Signals and Location of "A" and "B" Points For Each Signal, in Which Case "A" Is the High-to-Medium Speed Braking Point and "B" Is the Medium-to-Low Speed Braking Point

Special Signaling at Interlockings and On Grades

At interlocking plants and also at some passing sidings two-arm signals are used. The additional indication is provided by two rows of lights located six feet below the top signal lights, one row horizontal and the other row inclined at an angle at 45 degrees corresponding to the 0 and 45 degree indication of a semaphore arm.

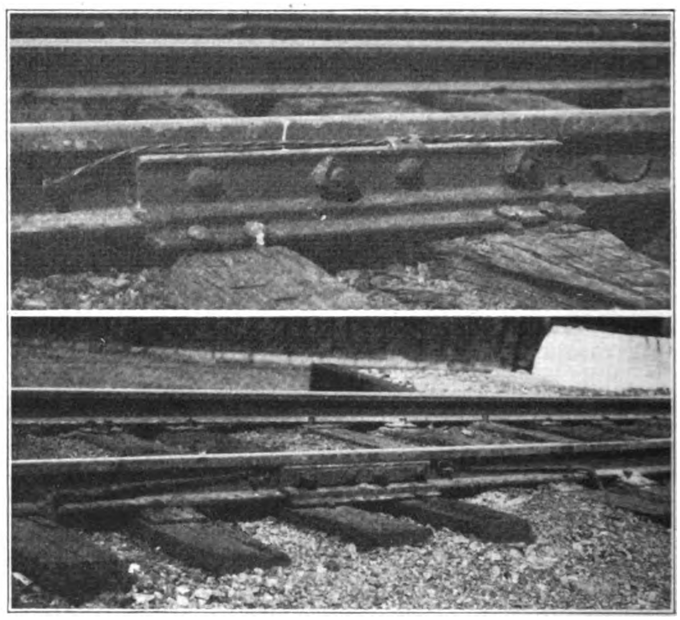
Typical Installation of 110-volt A. C. Magnetic Autoflag

The signals, as described, are what are designated as "Stop and Proceed" Signals, but at various points on the district between Shenandoah and Hagerstown there are a number of heavy grades where it is almost impossible to start a tonnage train after once being stopped. At these points, grade indications are provided which consist of a row of three lights inclined at an angle of 45 degrees opposite to the angle used for a two-arm signal, and located on the signal mast six feet below the lights above described, as shown in the illustrations. A train approaching a "Stop and Proceed" signal at "Stop," having a grade indication, may proceed, without stopping, at a slow rate of speed and under full control, prepared to stop short of train or other obstruction.

The Problem of Fixing Speeds and Braking Distances

The addition of train control to our single track automatic block system brought in new problems to be solved. In the first place, it was necessary to choose the high, medium and low speed limits. Because of the curvature and grades encountered, it was decided that 60 miles an hour for passenger trains and 40 miles an hour for freight trains was a safe maximum and would satisfy our traffic conditions. On other divisions where higher speeds are desirable and safe, higher speed limits would be used. The low speed of 20 miles an hour was selected because it had been found difficult, at lower speed limits, to keep heavy tonnage trains moving without either exceeding the low limit or stalling on grades. The medium speed limit was arbitrarily fixed midway between the respective high and low speed.

Having fixed the speed limits, the stopping distances of trains under varying conditions of grade and curvature could be determined and the signaling laid out, wherever possible, in accordance with the stopping distance. In connection with this work it must be remembered that an engineman can usually see a restrictive signal before reaching it and, knowing the speed and weight of his train and other conditions affecting stopping distance, perhaps apply the brakes before passing the signal. He also has the option of making an emergency brake application if, in his judgment, the rate of train retardation is not sufficient. A train control system cannot anticipate a caution signal and, as it is not always safe to make a direct emergency application, the automatic application is restricted to the full service.



Upper—Standard Bonding
Lower—Parkway Cable Terminating at Rail

The train control system is, amongst other things, intended to function to control safely the speed of a train or stop it should an engineman become incapacitated. It is therefore necessary to provide adequate stopping distances in the rear of all signals. Since heavy freight trains at their maximum speed require greater distances than passenger trains, stopping distances are based on the former and the signaling was laid out accordingly.

Another consideration in single track signaling is the double stopping distances required where high speed opposing trains may approach each other at passing sidings. In studying this phase, it was found that, due to the continuous control system chosen, neither of such trains need affect the other until they were within double stopping distance of each other. This always allows the first arrival to proceed at full speed until within stopping distance of the far end (from him) of the passing siding while the second arrival is allowed to proceed unchecked up to stopping distance from his near end. I have already mentioned this in connection with comparisons between continuous and intermittent control.

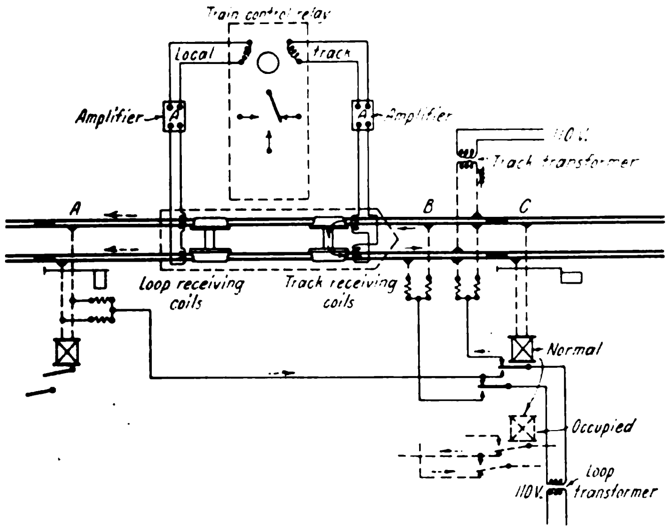


Diagram 1—Typical Train Control Circuits as Tied in With Signaling

Detailed Operation of Continuous System

The wayside portion of the system consists of alternating currents in the rails, one, the usual track current, flows down one rail, through the track relay or the axles of an occupying train and back in the other rail as shown in Diagram 1. Another train control circuit called the "loop circuit" flows through all or a part of a track circuit through both rails in multiple and returns on a line wire. This latter circuit is polarized, that is, when the next block ahead is clear the current at a given instant will flow through the rails in one direction, but if the next block is occupied, the current at that instant will flow in the opposite direction. The track current flow, Diagram 1, is shown by the solid arrows and the loop current by the dotted arrows. It will be noticed that when the next block is occupied the loop current is not only reversed in direction but part of the track circuit, between the *B* point and the stop signal, is deprived entirely of loop current. There are, therefore, three different conditions of loop curent relative to the track current, that is, loop current of one relative polarity, loop current of the other relative polarity and no loop current.

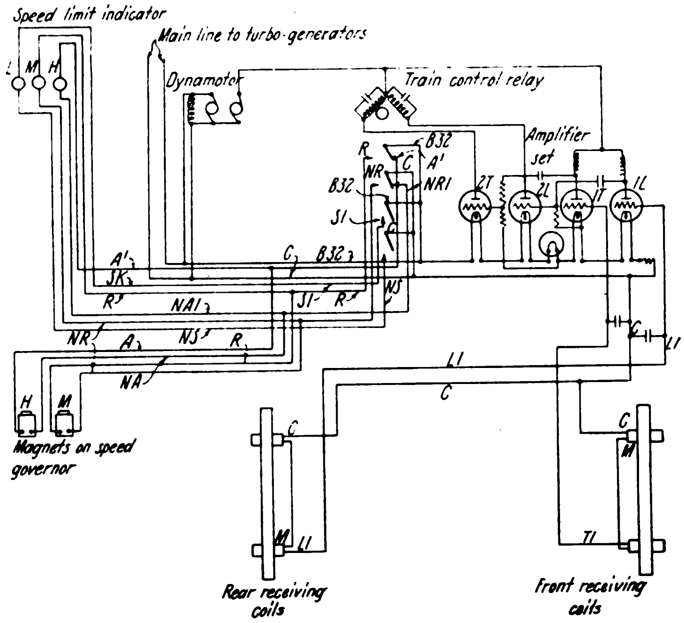
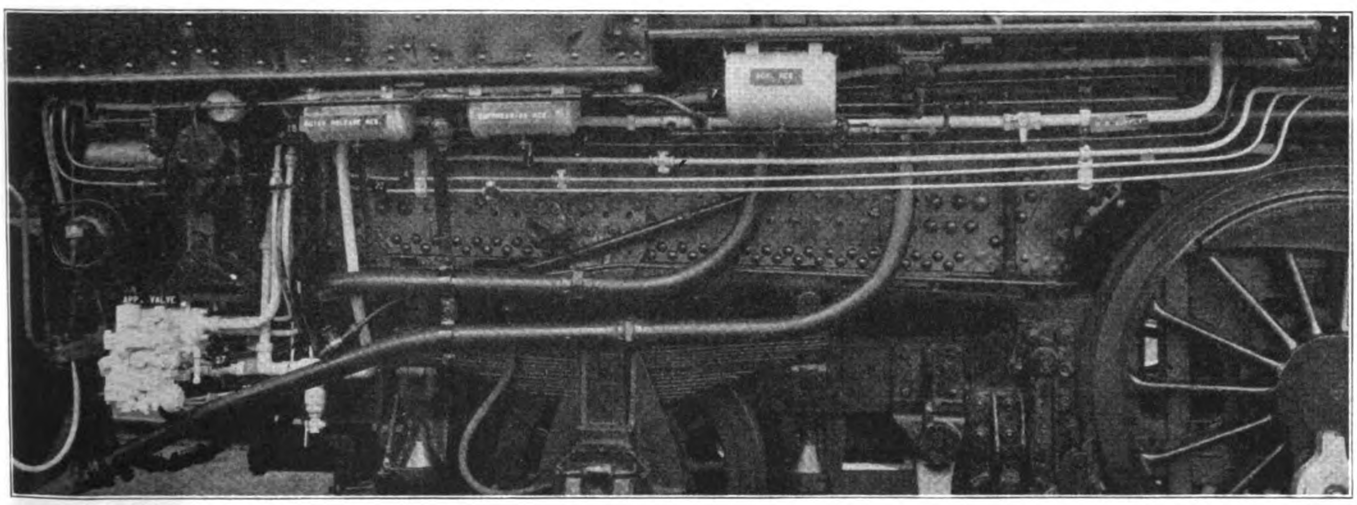


Diagram 2—Locomotive Train Control Circuits

The appearance of the train control devices on the engine is shown in an illustration. The locomotive equipment consists of the track receiver coils between the pilot and the front wheel; the speed control valves and centrifuge, above the pilot, driven from the outer end of the front axle; the instrument case just ahead of the main reservoir; the brake application valve group below the cab; and the loop receiving coils at the rear of the tender. Diagram 1 includes briefly the electric control elements of the system, while Diagram 2 shows this in complete detail.



Application Valve, Quick Release and Acknowledging Reservoirs Under Cab

The alternating currents in the rails generate voltages in the receiver coils by induction, which are so connected that the track receiver coils are affected only by the track current flowing in opposite directions in the two rails while the loop receiver coils are only affected by the loop current which flows through both rails in the same direction. These voltages are amplified through audion amplifiers and conducted to the train control relay which they operate.

The train control relay is so designed that when the polarity relation exists, as in approaching a clear block, its contacts are swung to the right, or normal position, as shown in the diagrams. With the polarity relation which exists between *A* and *B* in the rear of an occupied block, the contacts are swung to the left or reverse posi-

Form S. E. 30

NORFOLK AND WESTERN RAILWAY COMPANY

OFFICE OF SIGNAL ENGINEER

Roanoke, Va., May 2nd, 1925

Report of Automatic Train Control Performance

From Hagerstown, Md. To Shenandoah, Va.

April 1st, 1925 To April 30, 1925, inclusive

NUMBER OF ENGINES IN SERVICE MONTH OF April, 1925 ..... Passenger 7, Freight 26, Total 33

NUMBER OF ENGINES IN STORAGE MONTH OF April, 1925. ..... Passenger 1, Freight 8, Total 9

Percentage of perfect trips to total trips - April - 97.76%

" " " " " " " - March - 96.00%

ENGINE	Total Number of Trips	No. of Trips with A. T. C. Cut Out	No. of Perfect Trips	FAILURES: Engine Elec.	FAILURES: Engine Pneu.	Wayside	Other Causes	Undetermined	Total Failures per Engine
Passenger									
546	40	0	40	0	0	0	0	0	0
547	37	0	37	0	0	0	0	0	0
551	29	0	29	0	0	0	0	0	0
554	30	1	29	1	0	0	0	0	1
557	37	0	37	0	0	0	0	0	0
576	41	0	41	0	0	0	0	0	0
579	35	0	35	0	0	0	0	0	0
Freight									
431	35	0	35	0	0	0	1	0	0
433	10	0	10	0	0	0	0	0	0
434	31	0	30	1	0	0	0	0	1
448	41	0	41	0	0	0	0	0	0
449	34	0	34	0	0	0	0	0	0
466	30	0	30	0	0	0	0	0	0
1100	25	0	25	0	1	0	0	0	1
1103	8	0	6	0	2	0	0	0	2
1114	10	0	9	1	0	0	0	0	1
1116	31	0	30	0	1	0	0	0	1
1119	31	0	31	0	0	0	0	0	0
1123	3	0	3	0	0	0	0	0	0
1126	3	0	3	0	0	0	0	0	0
1127	2	0	2	0	0	0	0	0	0
1131	29	0	29	0	0	0	0	0	0
1135	4	0	4	0	0	0	0	0	0
1139	19	0	19	0	0	0	0	0	0
1145	17	0	17	0	0	0	0	0	0
1146	19	0	19	0	0	0	0	0	0
1148	1	0	1	0	0	0	0	0	0
1149	2	0	1	0	1	0	0	0	1
1151	12	0	11	0	1	0	0	0	1
1152	30	0	30	0	0	0	0	0	0
1153	11	0	10	0	1	0	0	0	1
1155	4	0	4	0	0	0	0	0	0
1159	14	0	12	0	2	0	0	0	2
	664	1	652	3	9	0	1	0	12

Engine Failures - - - - 12
Other Causes " " - - - - 1
Total " 13

The Record of Operation For April Shows Only 13 Failures, 12 of Which Were Engine Failures, 3 Being Electrical and 9 Pneumatic

tion. When the loop circuit is absent, as between *B* and *C*, in the rear of an occupied block or when the track current is absent, as in an occupied block, the relay is de-energized and the contacts are moved by gravity to the middle position. These three relay positions respectively set up the high, medium and low speed limits and illuminate corresponding indications in the cab.

How Train Control Affects the Air Brakes

The centrifuge, which is driven by the front axle, has several small poppet valves, one opened at each of the speed limits and, when open, act to initiate a brake application if the speed of the train exceeds the speed limit set up by the train control relay as determined by traffic conditions in advance. This automatic brake application may, however, be suppressed if the engineman previously makes a proper and sufficient manual application. He may then release the brakes when the train is retarded to the proper speed.

The automatic brake applications are always split, the first reduction being from 7 to 8 lb., followed automatically, when this reduction is completed, by a further reduction of about 13 lb. This is an important feature of this system because of the well know smoothness of stops and the absence of destructive shocks throughout the train when the slack is run in too violently as occurs in a continuous service reduction.

When the brakes are automatically applied they cannot release themselves. It is always necessary for the engineman to lap the brake valve until the proper speed limit is reached. The automatic brake application valve then restores and then, but not until then, can the handle be returned to the running or release position.

Failure of any wire or part of the apparatus will restrict the train to either medium or low speed. In such an event a sealed cutout cock may be operated, permitting the train to run without train control, but the breaking of the seal will have to be accounted for. The speed limit indicator may still be operative so that the engineman may control the train manually.

The work of installing both the automatic signals and the wayside train control apparatus was handled by the signal department forces with the co-operation of the telegraph department and the Shenandoah division officials and organization. The plans were prepared by the signal department in co-operation with the Union Switch & Signal Company's engineers.

In conclusion, I would say that we have had an excellent record since the system was placed in service and tuned up. It took some little time to clear up adjustments and minor faults which are always necessary after a large construction job, but since then the performance has been very satisfactory, and as the maintenance men become familiar with the system, further improvement in operating results will be realized.

Exhibition of Highway Crossing Protection Apparatus at Berlin Railway Exposition