No. 13413

IN THE MATTER OF AUTOMATIC TRAIN-CONTROL DEVICES

No. 13413 (SUB-No. 21–2)

IN THE MATTER OF AUTOMATIC TRAIN-CONTROL DEVICE, CONTINUOUS-INDUCTION TYPE, OF UNION SWITCH & SIGNAL COMPANY ON SCRANTON DIVISION OF DELAWARE, LACKAWANNA & WESTERN RAILROAD

Inspection completed December 18, 1928. Decided March 22, 1929

1. After inspection and test, installation found to be in conformity with plans furnished by the carrier, and installation approved except as noted.
2. Certain features in connection with the requirements and specifications are brought to the carrier's attention for consideration and appropriate action.

REPORT OF THE COMMISSION

DIVISION 6, COMMISSIONERS EASTMAN, MCMANAMY, AND TAYLOR

BY DIVISION 6:

This report is made after inspection and test of the automatic train-control device installed on the Scranton division of the Delaware, Lackawanna & Western Railroad by the carried pursuant to our second order which was entered in this proceeding January 14, 1924, as modified July 18, 1924, *Automatic Train-Control Devices*, 91 I. C. C. 426. In that order we required, among others, the Delaware, Lackawanna & Western to install an automatic train-stop or train-control device on a designated portion of its line in accordance with specifications and requirements therein prescribed.

The device used in the installation under consideration is the automatic train-control device two-speed continuous-induction type, with forestalling feature and two-indication cab signal, manufactured by the Union Switch & Signal Company.

COST OF INSTALLATION

The cost of this installation, as reported by the carrier, covering roadway and locomotive equipment as hereinafter described, is as follows:

Roadway equipment:	
Total cost of roadway equipment of train-stop installation, less power lines and power apparatus, less cost of signals or cost of change in existing signal system, less salvage	$80,362.68
Total cost of power lines and power apparatus, less salvage	172,512.03
Total cost of signal system installed in connection with train stop; less salvage	158,888.01
Total cost of change in existing signal system made necessary by train stop; less salvage	188,406.55
Total cost of roadway installation	600,169.27
Locomotive equipment:	
Total cost of locomotive equipment	306,083.75
Total cost of installation	906,253.02

In addition to the above, $46,465.59 was expended for power line and power apparatus in connection with the signal installation, and $15,515.01 was expended for readjustment of locomotive and track circuits installed under our order of June 13, 1922, the alternating-current frequency being changed from 60 to 100 cycles so as to permit equipped locomotives to be operated interchangeably over both divisions.

DESCRIPTION OF ROADWAY EQUIPMENT

The roadway installation was completed and placed in service on July 1, 1928. The portion of the road equipped under this order extends westward from Scranton, Pa., to Elmira, N. Y., aggregating 115.55 miles of road and 264.48 miles of track adjoining the east end of the territory equipped under the commission's order of June 13, 1922. It is double track from Scranton passenger station to bridge 60, 0.94 mile; three track from bridge 60 to Nicholson tunnel, 14.84 miles; double track from Nicholson tunnel to New Milford interlocking, 20.96 miles, four track from New Milford interlocking to Hallstead interlocking, 9.27 miles, the two westward and the two eastward tracks of this four-track section, from milepost 172 to a point about 3.5 miles west thereof, being on different roadbeds separated a maximum distance of about 1,000 feet; and double track from Hallstead interlocking to Elmira, 69.54 miles. The tracks are constructed of 105, 118, and 130 pound rail and are ballasted with stone. The maximum grade is 1.537 per cent and the maximum curvature 5° 34′.

A normal-clear automatic block-signal system is in service. The signals between Scranton and Binghamton are of the two-arm lower-quadrant semaphore type with style B mechanisms and those between Binghamton and Elmira are of the color-light type.

There are 13 interlocking plants in this territory, all of which are equipped with approach, route, and detector locking. The interlocking signals are either of the color-light type or upper or lower-quadrant semaphores which are electrically, electropneumatically, or electromechanically operated.

Double-arm two-position lower-quadrant normal-clear train-order signals are located at telegraph offices, but are not interconnected with the automatic signal or train-control circuits.

Green, yellow, and red in combination are the color-light signal indications and also the night indications of the semaphore signals. On the heavy ascending grade westward from Scranton to Clarks Summit automatic block signals Nos. 1347, 1369, 1377, 1385, 1393, and 1399 on westbound main track No. 1 and Nos. 1369, 1377, 1385, and 1393 on westbound freight track No. 3 display yellow upper blades and in horizontal position yellow lights instead of the usual stop-and-proceed signals. When a yellow blade is in the horizontal position, or a yellow light is displayed, a train may proceed with caution and without stopping, at a speed not exceeding 10 miles per hour and expecting to find the block occupied or obstructed.

Primary batteries, housed in concrete wells or creosoted wooden boxes, provide the current for the operation of track circuits, signals, and line relays east of Binghamton, while storage batteries furnish the current for the line relays and the emergency supply for the normally a. c. energized color-light signals.

The track leads are No. 6 Kerite, insulated, solid copper wire. Track joints are bonded with two galvanized-iron or two copper-clad or one cable bond per joint held in place with bolt clips. Insulated joints are of the Neafie, continuous, or Weber types.

Line relays are of 400, 500, or 600 ohms resistance and track relays are 2 or 4 ohms resistance. The leads to the track-relay coils and line wires are protected by lightning arresters. The track and line relays, terminals, arresters, and track transformers are housed in wooden boxes and iron cases. Stenciled fiber tags are used in these boxes to identify the wires. The signal and train control line wires are No. 9 bare, hard-drawn, solid copper or No. 9, double braid, weatherproof iron.

Passing track and siding switches are in some instances equipped with Hayes or point derails.

Turnout and crossover switches and derails are equipped with switch-circuit controllers which are adjusted to shunt the track

when the switch is open or the derail is in the nonderailing position. The controllers on the turnout and crossover switches are connected to shunt the main tracks through two No. 6 Kerite insulated solid copper wires bonded directly into each main-track rail and those on derails are connected to shunt the circuit to both the main track and turnout lead rails through two No. 6 Kerite, insulated, solid copper wires bonded directly into each of these rails.

Fouling protection at turnout and crossover switches consists of two or three No. 6, Kerite insulated, copper wires run in trunking and bonded directly into the outside main-track rail and the outside lead rail.

In this territory there are 35 noninterlocked crossover switches between main tracks, each of which is equipped with six insulated rail joints for insulating the two track circuits, and with fouling wires to minimize dead sections. The switch-circuit controllers are so wired that with either one or both switches open, both main tracks are shunted and a low-speed restriction imposed on an approaching train. It is possible to so locate a locomotive on a crossover between main tracks with both switches closed as to physically foul both tracks and only shunt the circuit on one main track. Such a condition would impose the low-speed restriction only on trains approaching on the shunted track. These crossovers have No. 10 frogs and the track centers do not exceed 14 feet. Rule 704 reads, "Both switches of a crossover must be open before a train starts to make a crossover movement, and the movement must be completed before either switch is restored to normal position."

Power for the train-control system is furnished at Scranton, East Binghamton, Johnson City, and Elmira. The power is transmitted at 575 volts, single phase, 100 cycle, from Scranton to Alford. At Alford the line is sectionalized by a switch (locked normally open) located in the interlocking tower. From Alford to a dead end at Court Street, Binghamton, the power is transmitted at 575 volts, single phase, 100 cycle. From a dead end at the west end of the Chenango Bridge, Binghamton, to Johnson City the power is transmitted at 575 volts, single phase, 100 cycle. From Johnson City to East Water Street, Elmira, the transmission line carries 6,600 volts single phase, 100 cycle, and from this point to the end of the territory 575 volts, single phase, 100 cycle. Normally power is supplied to the line through an automatic switchboard at the railroad power house at Scranton by the Scranton Electric Light & Power Company and the shop lines provide an emergency supply which will automatically come into service if the normal supply fails. The section between Alford and Court Street, Binghamton, is normally supplied through an automatic switchboard in the railroad power house near BY

tower, East Binghamton, from the Binghamton Light, Heat & Power Company and an emergency supply is provided by a steam-driven generator automatically controlled by the switchboard at this power house. The section between Binghamton and Elmira is normally supplied from a substation at East Water Street, Elmira, to which the Elmira Water, Light & Railroad Company's Riverside plant furnishes power through an automatic switchboard at the plant. The emergency supply for this section is provided through an automatic switchboard in the plant of the Binghamton Light, Heat & Power Company's Westover Plant at Johnson City.

A specially constructed pole line carries the two No. 4 bare stranded copper wires for the 6,600-volt section. The 575-volt sections consist of two No. 4 triple-braided weatherproof copper-stranded conductors carried on distinctive light-yellow porcelain insulators on the two field pins of a cross-arm located on the Western Union pole line. The signal and train-control line wires are also carried on these pole lines.

At each signal location, a line transformer is mounted on the transmission-line cross-arm and its secondary furnishes energy at 110 volts for the system. Lightning arresters and cut-outs are provided at these transformer locations.

This 110-volt energy is selected through the signal-circuit controller and line and track relays and then impressed on the primary of the track transformer located at the exit end of each track section in the rear of and within braking distance of the entrance to the block. Taps on the secondary of the track transformer are connected to the track rails at the leaving end of the track section so as to provide an alternating current of proper value in the rails, this alternating current for train-control operation being superimposed upon the direct-current track circuit.

On this installation the stop operation is initiated at a point, termed the B point, located at the approach-restricting signal in three-block indication territory or the approach signal in two-block indication territory, which are in the rear of the stop signal and governed by it. The stop signal and the approach-restricting or approach signals which it governs mark the braking-distance limits.

Hence, as installed, the track sections in the rear of an occupied section or stop signal or an open outlying switch, are devoid of train-control current to a point braking distance in the rear of the signal located at the entrance to the obstructed block. In an occupied section the shunt imposed by the first train deprives a following train of train-control current. The shunt imposed by the circuit controllers connected to outlying switches and derails decreases the train-control current in the rear of such shunt in the section in which the

switch is located. Within interlocking limits train-control current is present in the track rails only when a clear home signal governing a high-speed route is properly displayed.

A track circuit energized with normal train-control current when the track is occupied is provided on the Ithaca branch at Owego, and a combined track circuit and loop continuously energized with normal train-control current is provided on the westward pull-out track from the Keyser Valley branch at Cayuga. These circuits are designed to cause the equipment on locomotives operating cut out electrically to cut in automatically when they enter train-control territory.

The guard rails of the river bridge at Owego are bonded and are energized by train-control current of high value to serve as a cut-out section for trains entering the Ithaca branch. A short track circuit energized with train-control current of high value serves as a cut-out section for trains entering the Bloomsburg branch near bridge 60, Scranton. These sections are provided to enable the enginemen to electrically cut out the equipment when trains leave equipped and enter nonequipped territory. Appropriate signs mark the locations of these cut-in and cut-out loops.

Permanent test loops are provided at East Buffalo, Elmira, Binghamton, Hampton, and Scranton, to permit maintainers to test the equipment on arrival and enginemen to make departure tests.

DECRIPTION OF LOCOMOTIVE EQUIPMENT

One hundred and twenty-eight locomotives were equipped under this order. One hundred and seven of these locomotives operate in freight service and 21 in passenger service.

Three of these freight locomotives are equipped as described in the commission's report No. 13413, Sub-No. 21, 115 I. C. C. 270, 279 with the following exceptions:

A type 832 dual Keystone turbo-generator, 800 watt, 32 and 300 volts, is used in place of the Pyle National type E–3 turbo-generator, and the dynamotor is not used. The use of the protection governor has been discontinued. The electrical equipment on these locomotives as well as those equipped under the first order has been changed to function with 100-cycle track current. The track-circuit current on the first order installation has also been changed from 60 to 100 cycle. Consequently, locomotives equipped under either order operate over both the first and second order installations.

The apparatus on the remainder of the locomotives equipped under the second order comprises the following:

A type 832 dual Keystone turbo-generator 32 and 300 volts, 800 watt, 3,100 r. p. m., furnishes current for the operation of the train-control apparatus on the locomotive. The necessary compressed air is supplied by the air-brake compressors.

A *receiver* for receiving the induced current from the track rails. It consists of a laminated iron structure extending transversely across the track, carried between the pilot and the front locomotive truck wheels, suspended from the pilot beam, from 8 to 10 inches above the top of the rails. It has a receiving coil mounted near each end just inside the rails. The receiving coils are connected so that the induced currents are supplementary if alternating current flows in opposite directions in the two rails, and hence current flowing in the same direction in both rails induces equal and opposing currents, which are neutralized.

An *equipment box* mounted on the right side of the locomotive boiler, above the hand rail, houses the various electrical units. These units consist of (*a*) a two-stage amplifier by means of which the voltage induced in the receiving coils is amplified and delivered to the primary of a transformer, the output from the secondary of this transformer being rectified by a static rectifier and the current thus obtained being employed to energize a train-control relay; (*b*) a 16-ohm relay of the usual type, except as modified to overcome the objectionable effects of vibration, this modification consisting of an armature latch which can be released to allow the relay contacts to close only when energy is applied to the magnet coils; (*c*) an acknowledging stick relay for energizing the governor magnet following the acknowledgment of a restrictive indication when the speed has been reduced to less than 20 miles per hour; and (*d*) an electropneumatic cut-out relay, used only on passenger locomotives, for the purpose of permitting the engineman to cut out electrically the train-control system when passing from train-control equipped territory to nonequipped territory.

A *cab-signal indicator* mounted above the boiler on the gauge board within convenient view of the engineman and equipped for displaying two colored lights, a green and a yellow, as well as the letters H and L, denoting respectively high and low speed. The green light is displayed when the device is in operative condition and the block ahead is clear, while the yellow light is displayed for restricted track conditions. When the device is cut out electrically, both lights are extinguished. An audible warning is sounded when the cab indication changes from green to yellow or H to L.

A *cut-out switch* mounted on the side of the cab within easy reach of the engineman, to be operated when passing over a cut-out loop to render the device inoperative while running in non-train-control ter-

ritory, and also to impose the low-speed restriction when switching or taking siding.

A *governor* which operates electrical contacts for enforcing the low-speed restriction is mounted on an extension of the end of the axle of the leading truck wheels and is driven through gears from the axle.

A modified *engineman's brake valve* having two rotary valves, and, contained in its pipe-bracket base, three train-stop valves, namely, an application valve for controlling the automatic application, a brake-pipe cut-off valve which prevents feed-valve air from being supplied to the brake pipe during an automatic application, and a vent valve which permits an emergency application to be made manually during an automatic application. A sealed cut-out cock is also provided so that the train-control pneumatic apparatus may be cut out of service when necessary. A broken seal constitutes evidence that the cut-out has been used.

An *application-control group* comprising the governor magnet which controls the flow of air from the timing reservoir to atmosphere and also to the warning whistle; and the timing valve and timing reservoir which operate in combination to regulate the delay time of the automatic application. A safety valve set at 65 pounds is connected to the timing reservoir to insure against excess pressure. Air pressure for the control of the pneumatic system is supplied from the reducing valve of the independent brake valve and train-signal system adjusted to a pressure of 60 pounds. This group is located on the boiler head above and to the left of the fire-box door.

An *acknowledging switch* located in the cab which may be operated by the engineman to acknowledge a change to a more restrictive indication.

A *reduction-insuring valve* for insuring that a predetermined manual reduction must be made and maintained to effect a permanent suppression of an automatic application until the train speed is retarded to low speed. This portion is secured to a bracket on the boiler in the cab.

A *split-reduction portion* consisting of a reduction timing valve and a reduction hold-back valve operating in combination to cause a split reduction in an automatic application of the brakes if the brake valve is in lap position.

Reservoirs, a timing, stop, suppression, supply, split-reduction timing, and a double-chamber reservoir for limiting the first and second reductions during a split reduction, are all mounted on brackets located on top of the boiler, some of them being inside and the others outside of the cab.

A modified *double-heading cock*, for the purpose of nullifying the action of the train control while double heading and for cutting out the brake valve from the brake pipe.

A *suppression valve* for preventing an automatic brake-pipe reduction while a manual application is being made. This portion is secured to a bracket on the boiler in the cab.

An *air gauge* mounted on the regular gauge-group bracket for indicating the pressure in the train-control pneumatic system.

A *pneumatic circuit controller* located at the equipment box functions to prevent acknowledgment after an automatic application has been started.

The necessary *piping* to insure the intended operation of the pneumatic portion of the device.

The necessary *wiring* in conduit to provide for the intended operation of the electrical portion of the device.

OPERATION

The operation of the system is as described in the commission's report No. 13413, Sub-No. 21, 115 I. C. C. 270, for the three freight locomotives equipped with pneumatic acknowledging valve and with the governor which operates pneumatic valves.

The device on locomotives equipped with governors which operate electrical contacts operate as follows between the B point and the stop signal.

When the train passes the B point and enters a track section in which there is no alternating current flowing in the track rails, no voltage is induced in the receiver coils. The train-control relay is deenergized and the cab indication changes from green to yellow (H to L). The governor magnet valve becomes deenergized and vents the timing-reservoir air by a restricted port to atmosphere through the warning whistle and a port in the body of the valve. This restricted port is so proportioned that after approximately six seconds, if the downward change of indication has not been acknowledged during this period the timing valve will be moved downward by its spring. This movement of the timing valve connects the spring chamber of the brake-application valve to the stop reservoir and to atmosphere through a port in the upper rotary of the brake valve.

Normally main-reservoir pressure on both sides of the brake-application valve piston is balanced by virtue of the feed port through the piston so that the piston is maintained in normal position by its spring. The venting of the spring chamber reduces the pressure faster than it can be replenished through the feed port. Therefore,

when sufficient reduction has been made, the air pressure in the valve chamber overcomes the combined spring and air pressure in the spring chamber and moves the brake-application valve to application position. By this movement the spring chamber is provided with a second connection to atmosphere through the brake-application slide valve and the upper rotary of the brake valve.

When the brake-application valve is in application position it also disconnects the feed-valve supply of air to the chamber above the equalizing discharge piston and connects this chamber through a restricted port to the first reduction reservoir. This restricted port is of such size that automatic train-control equalizing-reservoir reductions are made at the same rate as manual reductions from the same brake-pipe pressures. The first reduction reservoir is of such volume relation to the equalizing reservoir that a reduction of approximately 7 pounds based on 70 pounds brake-pipe pressure is made in the equalizing reservoir and in the chamber above the equalizing discharge piston. This reduction vents the brake pipe to atmosphere approximately an equal amount. During this period the split-reduction valve functions to interrupt the reduction. When the reduction is resumed equalizing-reservoir air is discharged into the second reduction reservoir, which is connected through the upper rotary valve to atmosphere with the brake valve in release, running, holding, and service positions. Therefore, if the engineman takes no action, this reduction will be unlimited. However, if the brake valve is moved to lap position before the beginning of the equalizing-reservoir reduction, the split reduction will be limited to a total of about 22 pounds from an initial brake-pipe pressure of 70 pounds.

The feed-valve supply of air to the brake-pipe cut-off valve is also disconnected and the spring chamber of the brake-pipe cut-off valve is vented to atmosphere; hence, the cut-off valve is reversed and prevents the feed-valve air supply from replenishing the brake pipe, so that the engineman is unable to recharge the brake pipe to release the brakes while an automatic application is in effect.

In order to effect a release of the brakes after an automatic application, the brake valve must be placed in lap position to close the vent from the spring chamber of the brake-application valve through a port in this valve and the upper rotary to atmosphere. The acknowledging switch must also be reversed to pick up the acknowledging relay and then allowed to return to normal to cause the governor magnet to become energized, thereby charging the timing reservoir and actuating the timing valve to close the vent from the spring chamber of the brake-application valve. The pressures in this valve then equalize and the spring returns it to normal position. The brakes may then be released in the usual manner.

In order to prevent acknowledgment after the brake-application valve has moved to application position, brake-pipe pressure is connected to the pneumatic relay through a port in the brake-application valve when in the application position and operates the contact fingers in the relay to open the circuit to the acknowledging relay so that this relay can not be energized by operating the acknowledging switch until the pressure in the pneumatic relay has been reduced to less than 20 pounds, this reduction being effective when either the brake-pipe pressure has reduced to this amount, or the application valve has returned to normal position and the air in the pneumatic relay has been vented to atmosphere.

If the engineman on passing a B point acknowledges the downward change of indication by operating the acknowledging switch and makes a manual brake-pipe reduction of more than 10 pounds, the automatic application will be suppressed and the brakes may be manually released when the speed is less than 20 miles per hour. If the train is running below the low-speed limit of 20 miles per hour and a downward change of indication occurs and is acknowledged, no automatic application will result.

The reduction-insuring valve and timing reservoir are provided to insure that during the actual discharge of the brake pipe, and for a sufficient time interval thereafter to permit split-reduction braking, an automatic application will be suppressed through the operation of the suppression valve.

Another means of suppressing an automatic application is effective when a 10-pound manual reduction has been made by one or more reductions. This is accomplished by the functioning of the reduction-insuring valve and suppression limiting reservoir, and is effective until the brake valve is moved either to running or release positions.

If a suppression of the automatic application is maintained by one of these methods until the train has decelerated to the low-speed limit of 20 miles per hour and the low-speed contacts of the governor are closed, after the acknowledging switch is operated the brakes may be manually released without an automatic application. However, should the train while proceeding under a restrictive indication be accelerated to a speed above the low-speed limit, the low-speed contacts of the governor will open and initiate an automatic application unless again suppressed by a manual application.

TRAFFIC

Traffic over train-control territory as shown by the train dispatcher's record of movement for the period 12.01 a. m. to 11.59 p. m., Friday, November 23, 1928, consisted of 14 westward first-class

trains; 28 westward freight and work extras; 14 eastward first-class trains; and 29 eastward freight and work extras. In addition, six helping locomotives assisted six of the eastward trains and there were 35 eastward movements of helping locomotives running light. Thirty-seven helping locomotives assisted 31 of the westward trains and there were 11 westward movements of helping locomotives running light. These helping locomotives are equipped with train control and ordinarily are operated with normal current of traffic. When headed with traffic and running light they are limited to 20 miles per hour by time-table restriction. When backing with current of traffic the train-control device restricts speed to 20 miles per hour.

The speed of the light engines is checked daily on the dispatcher's record of train movements, with disciplinary action in cases where speed of 20 miles per hour is exceeded. These locomotives are operated light over distances of from 4 to 20 miles.

Passenger locomotives operate between Scranton and Elmira, between Scranton and Binghamton, between Binghamton and Ithaca via Owego, and between Minoka Junction and Binghamton via Cayuga or Hyde Park wye. Freight locomotives are operated between Hampton and Buffalo, between Scranton and Buffalo, and between Scranton and Syracuse. Helping locomotives in service between Scranton or Hampton and Factoryville are operated from the engine terminal at Scranton or Hampton, and those between Hallstead and New Milford are operated from the engine terminal at Binghamton. Nonequipped locomotives are used for switching within yard limits at Elmira, Binghamton, Scranton, and Owego.

Movements against the current of traffic are made in emergency cases only, and then under train orders with the train-control device cut out. The time-table restricts the maximum speed of passenger trains to 70 miles per hour and of freight trains to 40 miles per hour; greater restrictions are imposed at certain points and with certain equipment. The traffic is handled by operating rules, time-table, special bulletins, train orders, automatic block signals, and automatic train control.

CONCLUSION

Our order in *Automatic Train-Control Devices*, *supra*, provides that each installation made pursuant to the order shall, when completed, be subject to inspection by and to the approval of the commission or any division thereof to which the matter may be referred. Accordingly, the purpose of this inspection and test was to determine whether or not the installation was made in accordance with the plans furnished by the carrier and the specifications and requirements of our order.

As a result of this inspection and test, it is found that the installation is made in conformity with the plans furnished, and the installation is approved except that with respect to compliance with the requirements of the specifications and order in *Automatic Train-Control Devices*, *supra*, certain features were disclosed which require further consideration by the carrier, as follows:

1. The fouling protection provided at turnouts and crossovers, and the switch-circuit controller shunt used for protection at open outlying crossover or turnout switches and derails are designed on the open-circuit principle, their effectiveness being dependent upon a high degree of maintenance.

2. It was demonstrated during the inspection that on locomotives equipped with the type of governor operating pneumatic valves and safety valve would not, under certain conditions, perform its intended function to regulate or limit the air pressure of the train-control system. Since any increase in train-control pressure results in an increase in the delay time of automatic application of the brakes, steps should be taken by the carrier to insure that the pressure shall be so regulated that the initiation of an automatic brake application will occur within the period prescribed.

3. Automatic applications of the brakes could not be obtained on certain locomotives immediately after they had been inspected and tested by the carrier's forces; this was in one case due to a stuck piston ring in the application valve of locomotive 1234, and in another case to the brake-pipe cut-off valve being bound in its cage by an accumulation of rust on locomotive 1257. Sufficient care should be exercised in maintaining and testing both the electric and pneumatic portions of the train-control equipment on the locomotives to insure that it is in proper operative condition.

4. As designed and installed the pneumatic circuit controller for preventing acknowledgment after an automatic brake application has been initiated may fail to operate as intended if for any reason air pressure is not supplied to the controller when the application valve is in application position.

5. The automatic cut-in feature, as designed, operates on the open-circuit principle, dependence being placed solely upon the cab indication to apprise the engineman of failure of the device to be cut in automatically.

6. The governor drive is designed and operates on the open-circuit principle. On locomotives equipped with the type of governor which operates pneumatic valves, should the governor-driving mechanism fail the governor would assume the zero-speed position regardless of the locomotive speed; in the event of a downward change of cab-signal indication the intended speed restriction would not be imposed

and if the change in cab-signal indication was not acknowledged an automatic brake application would not occur until after the expiration of a delay period of about 35 seconds, under which conditions the distance, within which a train travelling at a speed in excess of 20 miles per hour would be brought to a stop, would be materially increased. On locomotives equipped with the type of governor which operates electrical contacts, should the governor-driving mechanism fail these contacts would not function as intended, and although the cab signal would continue to reflect the track conditions in advance, and acknowledgement of a restrictive cab-signal indication would be required within about 6 seconds after the downward change in order to prevent an automatic brake application, the intended speed restriction would not be imposed. The governor-driving mechanism is of rugged and substantial construction, but should it be found as a result of more extended service that the present design and construction are not adequate for the purpose, other means must be provided for insuring reliability of operation of the device in this respect.

The Delaware, Lackawanna & Western is expected promptly to inform us as to the measures which it will take in respect to the matters noted above.