Railway Signaling

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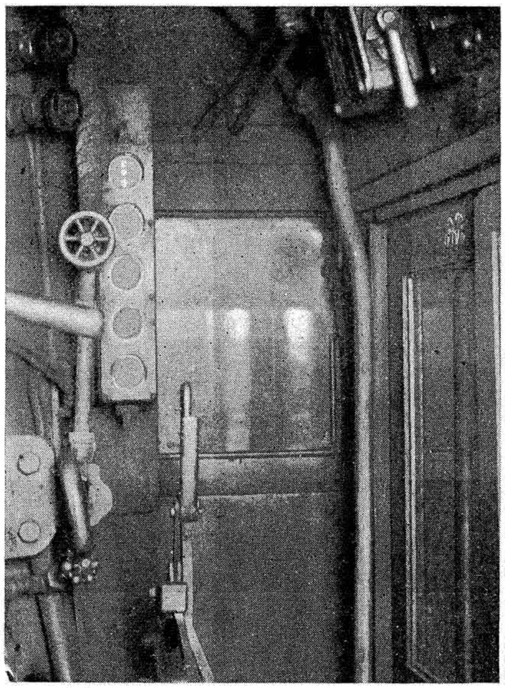
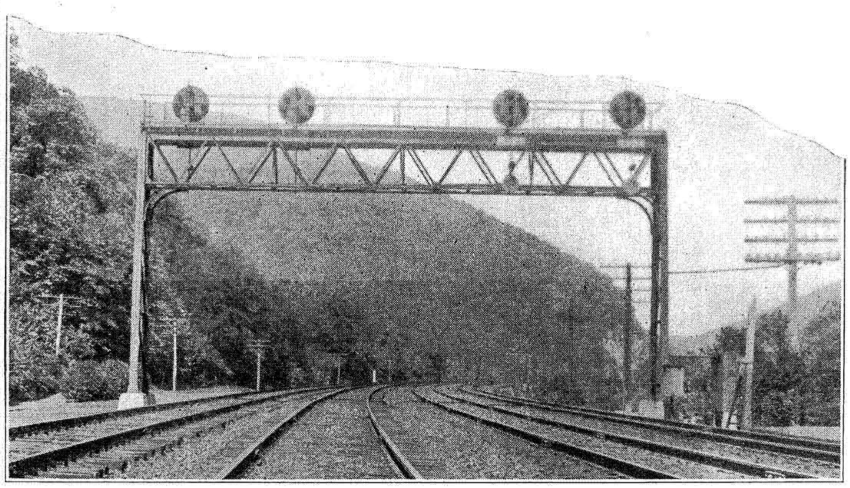
Pennsylvania Installs Code System of Train Stop with Signaling



Four-indication cab signals, power immune from foreign current and position-light signals included in installation on 1,492 track miles



The cab signal

The position-light wayside signal

IN compliance with the orders of the Interstate Commerce Commission the Pennsylvania has installed automatic train stop on five divisions, totaling 611.5 road miles and 1,492 track miles, with 1,159 locomotives equipped, as shown in detail in Table I. All of these installations include modern alternating current automatic block signaling, using position-light signals. On the four divisions placed in service during 1927, the new code system of train stop is used, in which the four indications of the cab signal are secured by a novel system of coded current, transmitted through the rails to an approaching locomotive. The wayside signal and train stop equipment, as well as that on the locomotives, was furnished by the Union Switch & Signal Company, and was installed by Pennsylvania forces.

Train Control Development on the Pennsylvania

Soon after the commission issued the first train control order in 1922, the Pennsylvania, for the purpose of test and development, made an installation of the Union three-speed continuous train control on 45 miles of its Sunbury division with 12 locomotives equipped. The continuously controlled cab signal used on this installation and forming an integral part of the continuous system, was a new development of considerable importance and utility. Having secured the desired results, this installation was dismantled in 1926.

In the meantime the commission had announced, in July, 1924, that the permissive or forestalling feature could be used with the simple train stop, which does not include the speed controller. The Pennsylvania, therefore, decided to install the continuous system with the permissive feature, in the belief that the cab signal, which it includes, was of great benefit in giving advance and continuously accurate information to the engineman irrespective of weather conditions.

Before starting on the installation of train stop on the territories specified by the commission, the Pennsylvania decided that modern a-c. automatic block signaling, using position-light signals, should be provided as the basis for the wayside apparatus. In order to eliminate the possibility of interference in the operation of the signal system, as well as of the train stop system, from 60 to 25-cycle commercial or power circuits, it was decided to use 100-cycle power for the wayside apparatus.

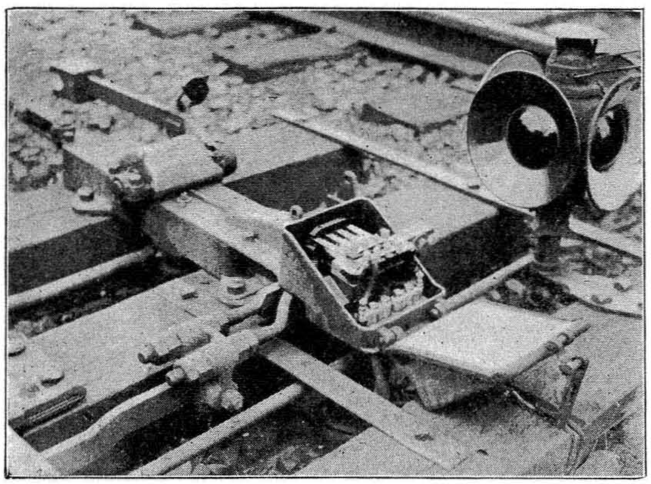
The first installation of this signaling with train stop was placed in service between Baltimore, Md., and Harrisburg, Pa., on July 17, 1926. At the time this installation was planned, the continuous train stop was chosen as the most highly developed system then available to meet the requirements, and three-indication cab signals were provided by means of track and loop circuits. In order to standardize the engine equipment, this installation is now being changed over to the new code system installed later on the other divisions.

Table I—Train Stop Installation on the Pennsylvania

Road	From	To	Miles of Road	Miles of Track	Locomotives Equipped
Pennsylvania	Baltimore, Md.	Harrisburg, Pa.	81.5	163	152
Pennsylvania	Harrisburgh, Pa.	Altoona	130.4	490.2	443
W. J. & S.	Camden, N. J.	Atlantic City	56.2	112.4	136
P. C. C. & St. L.	Columbus, O.	Indianapolis, Ind.	187.0	351.5	122
P. C. C. & St. L.	Pittsburgh, Pa.	Newark, Ohio	156.4	374.7	306
			611.5	1,491.8	1,159

Code System Brought Out in 1926

Developments were being made for the purpose of producing a system that would not only be universally applicable to railroads of both steam and d-c. or a-c. electric propulsion but would also provide a continuous cab signal with four indications. The code system of continuous automatic train stop was the result. This system is a definite advance in the art of continuous control in that the currents used for transmitting "proceed" indications to the moving train, are of a distinctive character not heretofore employed in railway signaling or elsewhere. Immunity from interference is provided inherently, because the engine relay is designed to respond selectively to the 100-cycle track current periodically interrupted at the code frequencies and to this character of current only.

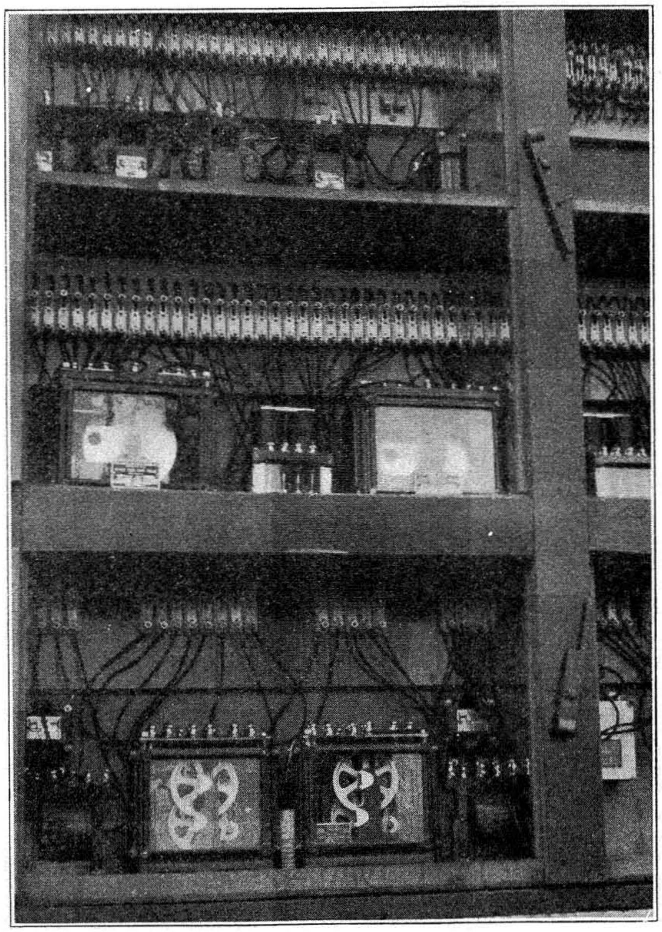


Main line switches in train stop territory are equipped with Union hand thrown switch and lock movements. View shows cover of circuit controller open

The locomotive equipment provides means for applying the brakes automatically after a more restrictive cab indication is given; means have also been provided for preventing such brake application, as well as for releasing the brakes after an automatic train stop application. This code system was installed first on the West Jersey & Sea Shore division of the Pennsylvania, where it was completed on March 20, 1927.

The wayside equipment is designed to operate on 100-cycle alternating current. Where a-c. power supply systems for the signaling were not already in service, a complete new a-c. distribution system was provided. Power is purchased at 60-cycle, and converted to 6,600-volts, 100-cycle, single-phase, for distribution to the wayside locations. Automatic switching equipment is provided at each substation, which will operate in case of a power failure, to cut the feed through from a live station. Therefore, under average conditions, interruptions of commercial power supply will not affect the operation of the signal and train stop system.

The master relay on the locomotive is controlled by energy from the track circuit in which a code transmitter is connected across the rails at the exit end of the block.



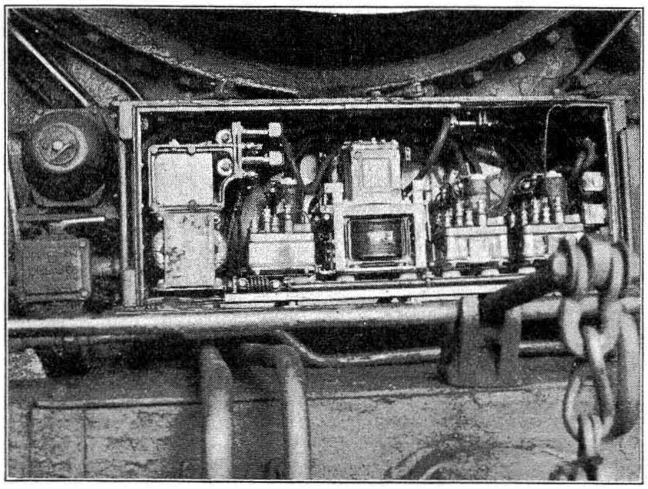
Typical wayside instrument case with code transmitters on bottom shelf

The code transmitter consists of two sets of three cam-operated circuit controllers (but one transmitter is required for two track circuits fed from the same location), the cams of which are driven through gears by a small induction motor. This motor runs at a constant speed and operates the cams and the contacts controlled by them at a constant predetermined speed. Whenever a train is in the block, the track relay opens, which starts the code transmitter, and the track current is then interrupted by means of the code transmitter, the prescribed number of times per minute, depending upon the conditions of the track in advance. This coded current, in turn, is transmitted to the master relay on the locomotive, which selectively energizes the proper decoding relays and, through a series of contacts, controls the cab signal indications. The codes used in this system display signals as follows:

Indications	Interruptions of 100-cycle current
Clear	180 per minute
Approach restricting	120 per minute
Approach	80 per minute
Caution—Slow speed	Steady current, or absence of current

Engine Equipment

Receiving coils are mounted on the locomotive just ahead of the leading pair of wheels, and so located as to have a clearance of from 4 in. to 7 in.



Instrument case, with door open, mounted on the front of locomotive

above the rail, and provide the means of receiving alternating current energy from the rails for energizing the train stop equipment, thus controlling its functions. An equipment box, mounted at the front of the locomotive, houses all of the electrical equipment required for the control and operation of the cab signal and the air brakes.

Cab signals of the position-light type are located within the cab on the engineman's side and also on the fireman's side and each displays four indications. An acknowledgment switch, by which automatic train stop brake applications may be forestalled, is located in the cab on the right side and convenient for the engineman to operate.

A reset switch, with which the electrical equipment may be reset to permit the release of brakes after an automatic train stop application of the brakes, is located beneath the right side of the cab so that it may be operated from the ground, after the locomotive has stopped.

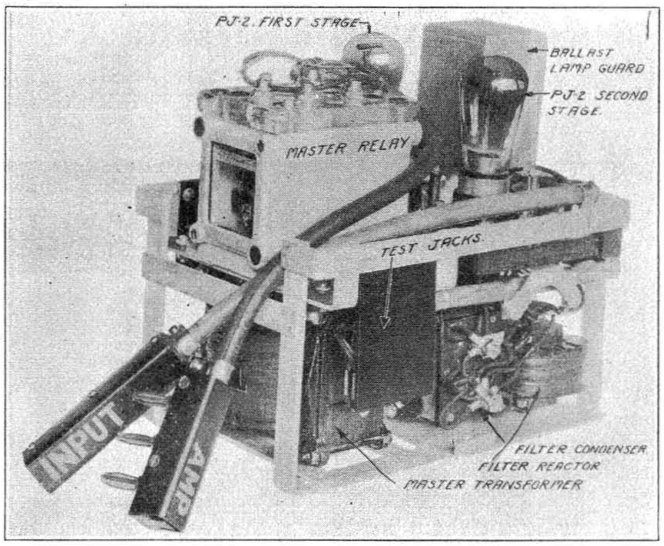
A timing valve with a warning whistle is located on the right side of the locomotive ahead of the cab. A new brake valve, known as the Type-HS2, replaces the standard brake valve. This valve has incorporated in it all of the standard air brake features, as well as the special features required by the automatic control of the brakes.

General Description of Operation

The principle of induction is used in transmitting the energy from the rails to the locomotive equipment. The receiver consists of a laminated iron core on which are mounted coil windings. The action between the rails and the receiver may be thought of as a transformer, in which the rails act as the primary and the coil windings as the secondary. The energy induced in the receiver is amplified and then passed through the master transformer to operate the master relay. The current for the cab signal lights, amplifying circuits and relays is taken from the headlight generator at 32 volts.

A brake application caused by the train stop equipment will result in about 35-lb. brake pipe reduction on locomotives when using 110-lb. brake pipe pressure, which is the usual pressure in passenger service, and about 22-lb. brake pipe reduction when using 70-lb. brake pipe pressure, which is the usual pressure in freight service. The automatic equipment makes only a service brake application. The engineman retains manual control over the brakes at all times, except that brakes cannot be released from the cab in case an automatic train stop application has been caused by failure to acknowledge a change to a more restrictive signal indication.

The indication of the cab signal is continuously determined by conditions in advance of the train. Any change in conditions occurring at any time in a clear block which calls for a reduction in speed, immediately operates to initiate an application of the brakes



Amplifier unit, a part of the apparatus in the engine equipment case

unless the change of cab indication is acknowledged by the engineman, who thereby indicates his alertness and ability to handle his train. Conversely, if after a restrictive cab indication is received, conditions ahead of the train change in such a way as to make a higher speed permissible, the change is immediately and visually indicated in the cab and this information can be utilized at once for accelerating the train.

Wayside Control Circuits

Diagram No. 1 shows the wayside circuits for the code system as applied to double or multiple track where trains are operated normally in one direction only on the track shown. The control of the signals as well as the code system is based on the track circuit. Three-position vane type a-c. relays are used for the track circuit, the three indications of the signal being controlled by this relay. However, in order to simplify the diagram the local controls for the signal lights are not shown.

With all signals at normal clear; when an eastbound train enters track circuit *A* at Signal *o*, the track relay at this signal is shunted, one contact of which completes the line circuit *IVIE* and relay *IV* at Signal *1* is picked up; the first contact of *IV* connects *110-V* to *1-2CT2* which starts the code transmitter. When the normally-

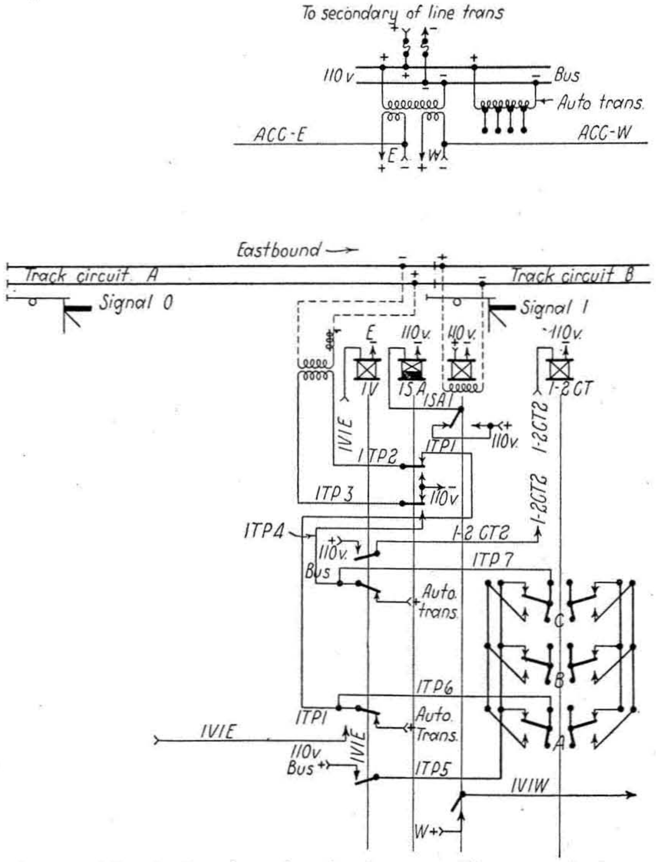


Diagram No. 1, showing circuits for wayside control of one track only on multiple track territory

closed back contacts of relay *IV* are opened, the auto-transformer feed is cut off from the primary of the track transformer so that as soon as the code transmitter starts, the code of 180 pulsations per minute is transmitted over wire *ITP6* and *ITP1* to the track transformer and in turn out over the rails to be picked up by the receiver coils on the approaching locomotive, thus giving a clear indication in the cab signal.

In case Signal *1* is at danger, Signal *o* would indicate "approach" and we will now see how this indication is repeated in the cab. In this case the track relay for track circuit *B* is de-energized so that the slow-action relay *ISA* is de-energized, thus closing its back contacts so that when the relay *IV* is picked up and the code transmitter started, the wires *ITP7* and *ITP4* will be connected to the primary of the track transformer. Wire *ITP7* comes from the contact of the code transmitter that operates 80 times a minute so that the 80 pulsations are sent out on the rails, which, when picked up by the receiving coils of the approaching locomotive causes an approach indication to be shown in the cab signal.

The slow-acting relay *ISA* controls the polarity of the track circuit feed which determines the position of the track relay at the entering end of the track circuit *A*. A slow-acting relay is required for this purpose to tide over the interval while the track relay *ITR* is reversing. When track circuit *B* is occupied, the track relay is de-energized, therefore, the slow-acting relay *ISA* is de-energized so that the back contacts are closed, thus reversing the feed to the track circuit *A*. In case the Signal *o* at the entering end of track circuit *A* is at danger, due to a train in the block, a second locomotive attempting to pass the signal would receive no pulsations because the track is shunted by the preceding train, therefore, the indication of the cab signal in the second locomotive would change to "caution-slow speed" and a brake application would result unless forestalled.

Where the signals are less than braking distance apart the "approach restricting" indication is used. In this case another line control relay is employed, through the contacts of which the circuit for the code to the track transformer is so selected as to connect to the middle cam of the transmitter which operates at 120 interruptions per minute.

When a track circuit is cleared by the train passing out of the block, the first impulse of coded current over the rails picks up the track relay, de-energizes the *IV* relay, and stops the code transmitter, thus restoring the track circuit to the normal alternating current feed from the auto-transformer

Control for Single Track

In view of the fact that the code current must be fed toward an approaching locomotive, the wayside control circuits for single track are more complicated in that the relay end and the feed end of the track

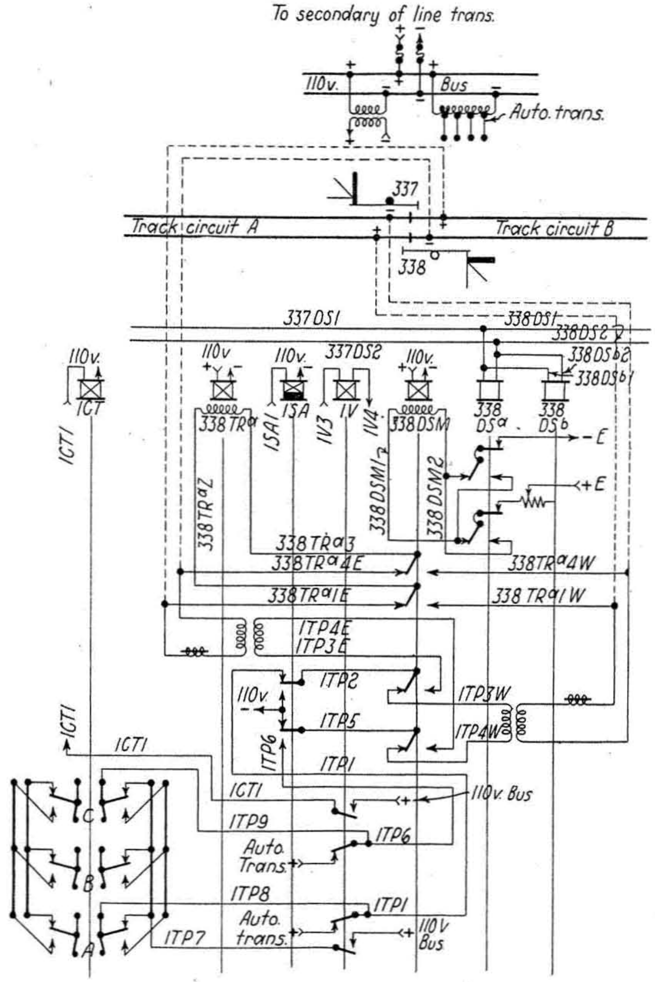


Diagram No. 2, showing circuits for wayside control on single track territory

circuit must be transferred to meet conditions for trains in either direction. The circuits as shown in Diagram No. 2 are for single track, from which it may be seen that the direction in which traffic is to move is established first by the line circuit on wires *338DS1* and

338DS2 which control the three-position polar relay *338DSa;* and in the position as shown, the set up is for eastbound traffic with Signal *338* indicating clear. This circuit *338DS* for the control of the relays such as *338DSa* at each location, extends from interlocking to interlocking, at which points interlocked desk levers are used to establish and lock up the direction in which traffic is to move betwen any two towers.

Relay *338DSa* controls relay *338DSM* which has four polar contacts through which circuits are so connected that, in the position shown, the track relay *338TRa* is connected to track circuit *B* and the auto-transformer is connected to feed track circuit *A*. Reversing the position of relay *338DSa* would reverse relay *338DSM* which would change the connections so as to connect track relay *338TRa* to track circuit *A* and the track circuit feed to track circuit *B*.

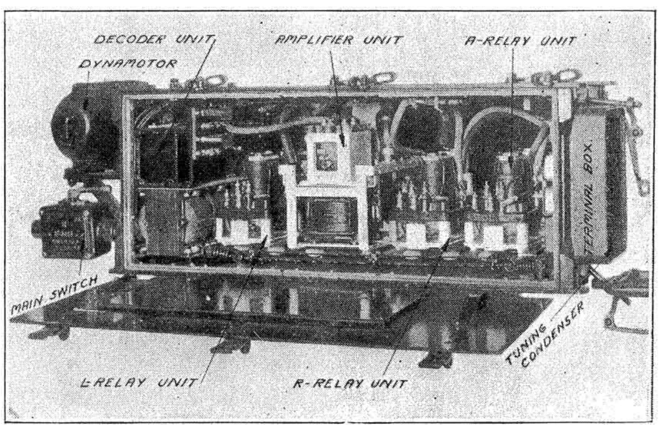
The principles of the operation of the remainder of the relays is the same as that previously discussed for the double track, i.e., a train entering the distant end of the track circuit causes relay *IV* to be picked up, thus cutting off the normal a-c. track circuit feed from the auto-transformer and starting the code transmitter which sends out the coded current towards the approaching locomotive.

Description of Locomotive Circuits

The Diagram No. 3 shows the locomotive circuits and apparatus in the normal running position with a clear cab signal. The receiver, with its coils, constitutes the core and the secondary of a transformer of which the rails are the primary, so that when alternating current flows in the rails, a voltage is induced in the receiver coils above them. The receiver coils are so connected that the voltage induced by the current flowing in the opposite directions in the two rails is additive. One terminal of the receiver coil is connected to the filter, which serves the purpose of choking out current at all frequencies, except 100 cycles, plus or minus five per cent, and thence to the grid of the first stage amplifying tube. The other terminal of the receiver coil is connected through the filter to the common wire. The coded 100-cycle current induced in the receiver coils, is amplified and converted to low-frequency current to control the master relay. The master relay is a direct current polarized relay and repeats the code as furnished by the wayside code transmitting relay. Normally, headlight generator current feeds from *B-32,* to the dynamotor, (which supplies plate voltage), to the contact fingers of the master relay, to the contact fingers of the *A* relay and the *RP* relay, to the vacuum tube filaments, to the ballast lamp, to the resistances, and returns over the *C* wire.

The master relay is operated by the increase and decrease of the plate current from the amplifying tube *PJ2*. This change of plate current is caused by the interrupted current which is induced in the receiver coil and in turn is applied to the grid. The plate current is at a minimum value when no voltage is being induced in the receiver coils, and at a maximum value when voltage is induced. As the clear signal is received when the track current is interrupted 180 times per minute, this means that track current is off and on, 180 times and, consequently, the plate current decreases and increases 180 times per minute. Each time the plate current is decreased, the current in the primary of the master transformer flows in one direction, and when the plate current is increased, the primary current of the transformer flows in the opposite direction. The flow of the induced current in the secondary of the master transformer reverses coincident with the flow in the primary, and thus actuates the master relay contacts. The operation of the master relay contacts, connects 32-volt direct current, alternately to one end or the other of the primary of the decoding transformer, inducing low-frequency alternating current in the secondary.

Selective operation of the three decoding relays is accomplished by an arrangement of selective circuits so that the *A* relay will be picked up only when 180 interruptions per minute are received, and so that the *R* relay will be picked up only when 120 interruptions are received, and so that the *L* relay will be picked up when 80 interruptions are received. Due to the fact that the *L* relay circuit is not tuned, the *L* relay will be energized for all code interruptions. This selection is accomplished by a resonant circuit for the *A* relay, comprising a reactor and condenser tuned to 180 interruptions and connected across the terminals of the decoding transformer secondary. The reactor is used as a step-down transformer, the rectifier connected to the *A* relay being tied to a low-voltage tap on the reactor winding. By this means, sufficient current to pick up the *A* relay will be flowing in the *A* resonant circuit only when the frequency is approximately 180 interruptions per minute. Similarly, the *R* relay is energized through a resonant circuit comprising a reactor and condenser, tuned to respond to approximately 120 interruptions per minute only, connected in parallel with the *A* circuit across the decoding transformer. The circuit



Close-up view of locomotive instrument case

for the *L* relay is not tuned but the *L* rectifier is connected to the decoding transformer directly, with a reactor in series, to cut down the current flow through the *L* circuit at the higher code frequencies.

When the 180 code is in effect, the master relay will make 180 reversals per minute and the *A, R* and *L* decoding relays will assume the positions as shown. Current supplied by the headlight generator will then flow through wire *B-32* to No. 1 contact finger of *A* decoding relay, wire *A1* lighting the clear cab signal, returning over wire *NA1,* No. 2 contact finger of *A* decoding relay to wire *C*. A tap from wire *A1* to contact of *RP* acknowledging relay through No. 2 contact finger, wire *H2* through lower arm of reset switch to *H1,* through bottom arm of acknowledging switch, wire *H,* magnet of timing valve, wire *NH* to No. 3 contact finger of *RP* acknowledging stick relay, wire *NA1* and back to wire *C*.

When the 120 code is in effect in the rails, the master relay will make 120 reversals per minute and the *R* and *L* decoding relays will be energized and the *A* decoding relay will be de-energized, and its contact fingers assume the down position. Current will then flow from wire *B32* to No. 1 contact finger of *A* decoding relay, wire *A2* to No. 1 contact finger of *R* decoding relay, wire *R1* and lighting the "approach-restricting" cab signal, returning over wire *NR* to No. 2 contact finger of *R* decoding relay, wire *NA2*, to No. 2 contact finger of *A* decoding relay and back to wire *C*.

Acknowledgment having been made, acknowledging stick relay *RP* will become energized and the contact fingers will assume the up position, the No. 1 contact

When there is no code in effect, the master relay will be at rest with the result that the three decoding relays will be de-energized and their contact fingers will assume the down position. Energy is then fed from *B32*, No. 1 contact finger of *A* decoding relay, wire *A2* to *R* decoding relay, to No. 1 contact finger, wire *R2* to No. 1 contact finger of *L* decoding relay, wire *S1* lighting the "caution slow-speed" cab signal returning via wire *NS* to No. 2 contact finger of *L*

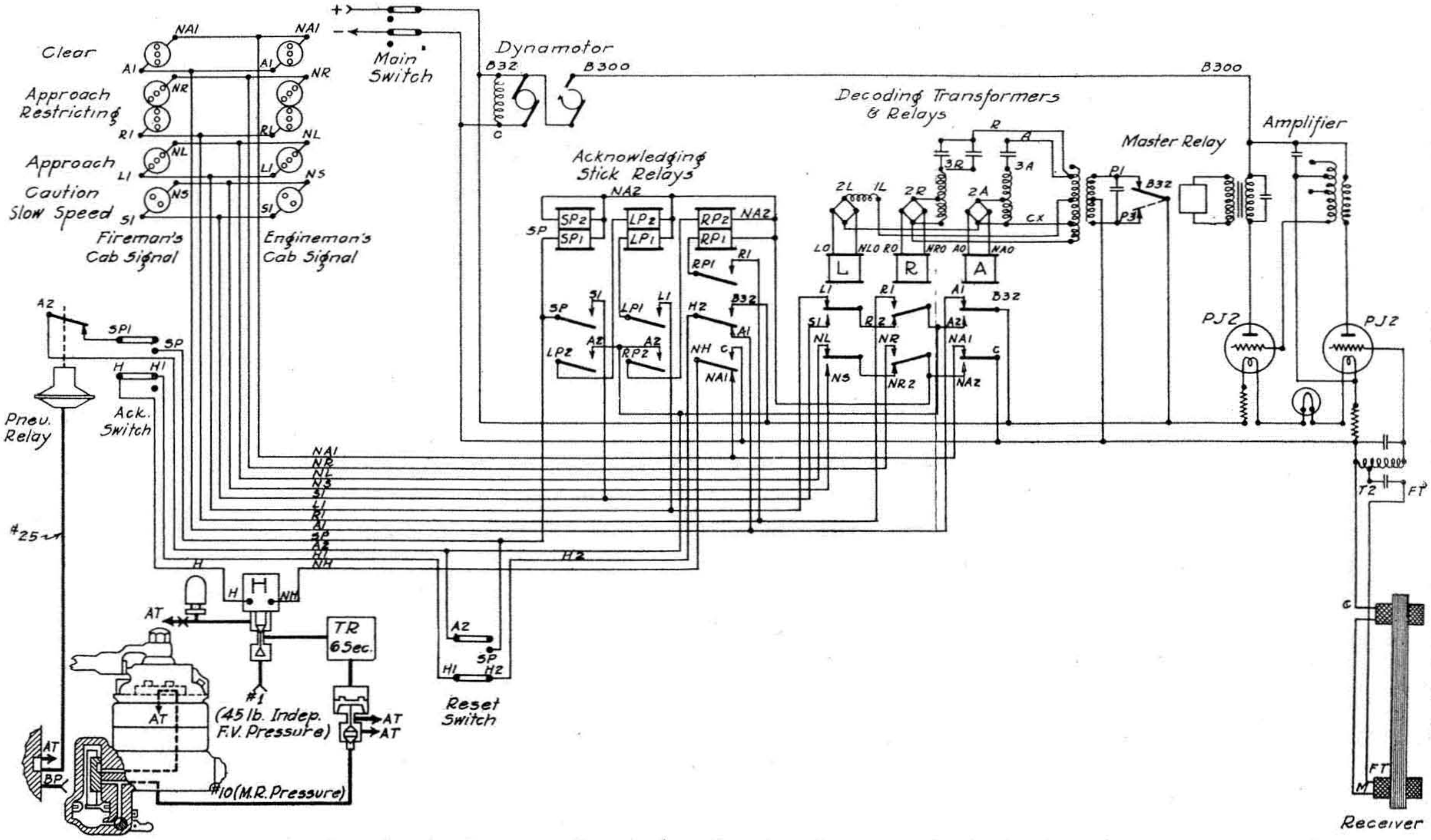


Diagram No. 3, showing circuits for control and operation of train stop and cab signal equipment on locomotive

finger completing the stick circuit for holding up the contact fingers. Energy from *B32* will then flow through No. 2 contact finger, wire *H2* to bottom arm of reset switch, wire *H1* to bottom arm of acknowledging switch, wire *H* to magnet valve, wire *NH* to No. 3 contact finger of *RP* acknowledging stick relay to wire *C*.

When the 80 code is in effect, it will be repeated by the master relay and the *L* decoding relay will be energized and the *R* and *A* decoding relays will be de-energized and their contact fingers will assume the down position. Energy is then fed from *B32*, No. 1 contact finger of *A* decoding relay, wire *A2* to No. 1 contact finger of *R* decoding relay, wire *R2* to No. 1 contact finger of *L* decoding relay, wire *L1* and lighting the "approach" cab signal, returning over wire *NL* to No. 2 contact finger of *L* decoding relay, wire *NR2* to No. 2 contact finger of *R* decoding relay, wire *NA2*, to No. 2 contact finger *A* decoding relay and back to wire *C*. Acknowledgment having been made, acknowledging stick relays *RP* and *LP* will become energized and their contact fingers will assume the up position, the No. 3 contact finger of *LP* acknowledging stick relay furnishing energy to acknowledging stick relay *RP* which holds its contact fingers in the up position, and the No. 2 contact finger of relay *LP* completes the stick circuit for holding its own contacts in the up position. Under this arrangement, the magnet valve will be energized over the same circuit as previously described.

decoding relay, wire *NR2* to No. 2 contact finger of R decoding relay, wire *NA2* to No. 2 contact finger of *A* decoding relay and returning to wire *C*.

Acknowledgment having been made, acknowledging stick relay *SP* is energized and the contact fingers assume the up position, the No. 2 contact finger furnishing the stick circuit and the No. 3 contact finger energizing relay *LP* and holding its contact fingers in the up position, which in turn holds relay *RP* contact fingers in the up position and the magnet valve will be energized over the same circuit as previously described.

Manual Service Application

The engineman may, in this system, apply the brakes at any time to any degree permissible in usual air brake practice. The application of the train brakes is effected by reducing the air pressure in the brake pipe, accomplished, as usual, through the medium of the engineman's brake valve by moving the brake valve handle to the service or emergency position.

The manual service application of the brakes will be described first. Main reservoir pressure supplies air to the chamber of the rotary valve of the engineman's brake valve. In running position (see Drg. No. 4) it passes through the feed valve, pipe *FV*, a port in the bottom rotary valve seat, port *18*, cut-off valve to the brake pipe *13* to the lower chamber of the equalizing piston, and through the double heading cock to the brake pipe.

A branch through the rotary valve seat also connects feed valve pressure through ports *21* and *8* to the equalizing reservoir and to the upper chamber *8* of the equalizing piston. Since these connections are the same, except in physical arrangement, as in the existing engineman's brake valve, manual brake application can be made exactly as before. Another branch of port *18* passes through a port in the application valve and port *11* to the operating chamber of the cut-off valve, holding this latter valve to the right.

When the engineman's brake valve is moved to the service position, port *18*, and the feed valve pressures are disconnected from the upper chamber of the equalizing piston and from the equalizing reservoir and the two latter volumes are vented to atmosphere through ports *8* and *21* and the usual preliminary exhaust until a desired pressure reduction is accomplished, after which the engineman's brake valve is moved to lap, stopping further reduction, but maintaining the reduced equalizing reservoir pressure. The brake pipe pressure below the equalizing piston then raises the equalizing piston and then the equalizing discharge valve, connecting the brake pipe through port *16* to atmosphere. When the pressure in the brake pipe and the lower chamber of the equalizing piston is reduced to slightly below that of the equalizing reservoir and the upper chamber of the piston, the piston is forced downward, closing the equalizing discharge valve and preventing further brake pipe reduction.

The manual emergency brake pipe reduction is not made entirely through the brake valve rotary valve as in the H6 brake valve, but a brake pipe vent valve is included in the brake valve pipe bracket and operated via the sand port. When the brake valve handle is moved to the emergency position, main reservoir pressure is admitted to the sand port and to the operating chamber of the vent valve and opening the large brake pipe vent to atmosphere, so that emergency brake applications are always effective, even on long freight trains after a manual or automatic service brake application has been started or if made immediately following release. Furthermore, its connection below the double-heading cock permits helper engines to make emergency brake application if the need arises.

Automatic Train Stop Application

When the magnet valve becomes de-energized on account of not acknowledging a change to a more restrictive indication, it vents the timing reservoir to atmosphere through a restricted port No. *51*, to the small warning whistle which sounds continuously for several seconds. This port is so proportioned that at the end of approximately six seconds, the timing valve will move downward by its spring. This movement of

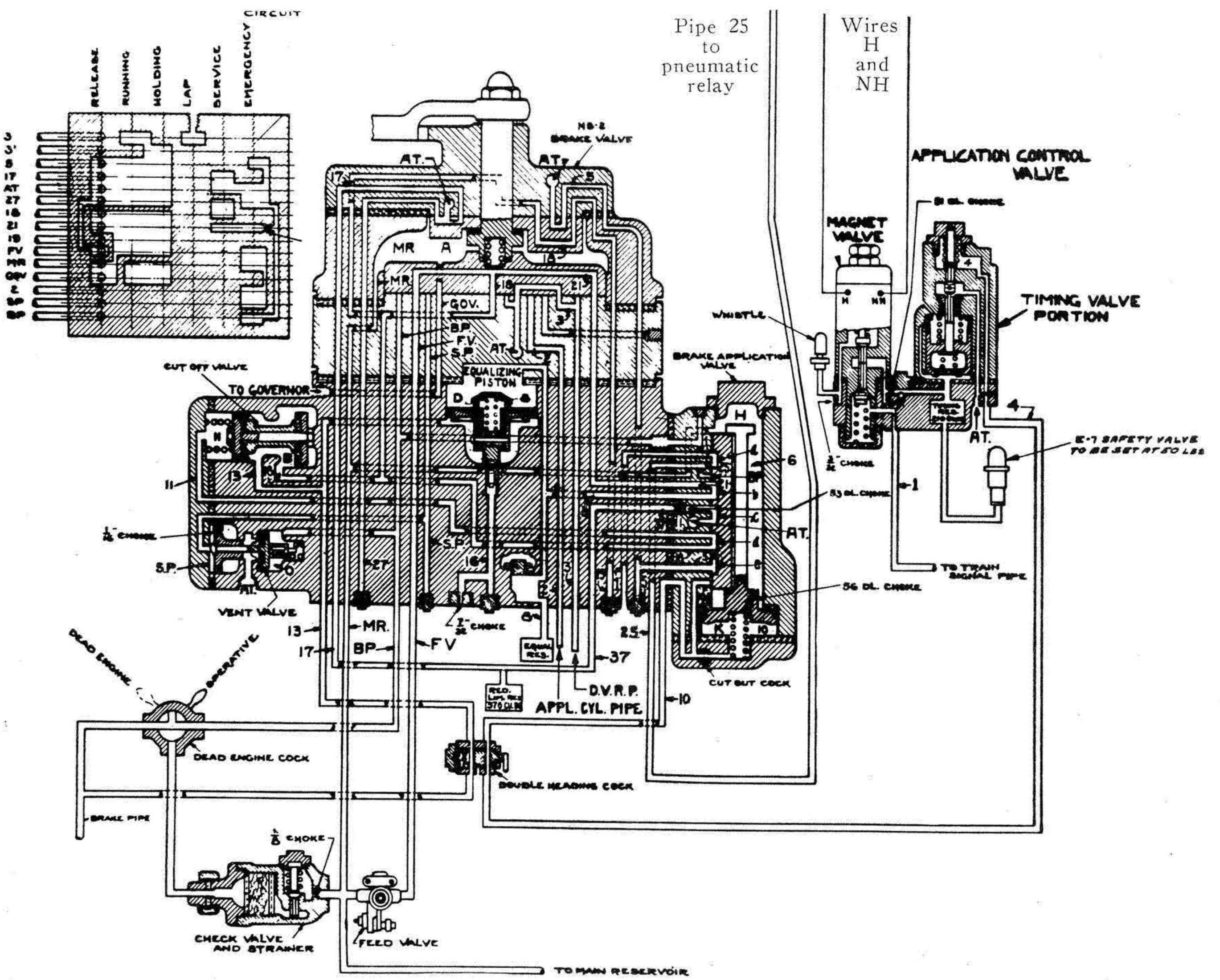


Diagram No. 4, showing pneumatic equipment on locomotive the timing valve connects chamber *10* of the brake application valve to atmosphere. Normally, the main reservoir pressure on both sides of the brake application valve piston is in equilibrium by virtue of the restricted feed port *56* through the piston of the valve, and it assumes the normal position as shown because of the spring in chamber *10*. The venting of chamber *10* to atmosphere reduces the pressure faster than it can be replenished through the feed port, and when sufficient reduction has been made, the air pressure in the upper chamber is able to overcome the combined spring and air pressure in chamber *10*, and move the piston and valve downward. By this movement chamber *10* is, also, connected directly to atmosphere through the brake application valve via the lower port *5* in the brake valve.

The brake application valve, as its name indicates, is the direct means of controlling the functions involved in automatically applying the train brakes.

The operation of the brake application valve also vents the equalizing reservoir by disconnecting port *8* from port *21* and connecting the former through a restricted port *53* to pipe *37* and to the reduction limiting reservoir. This restricted port is of such size that automatic train stop equalizing reservoir reductions are made at the same rate as manual equalizing reservoir reductions from the same brake pipe pressure. The reduction limiting reservoir is of such volume relation to the equalizing reservoir that a reduction of about 22 lb. based on 70-lb. brake pipe pressure, or about 35 lb. based on 110-lb. brake pipe pressure, is made in the equalizing reservoir and in the top chamber of the equalizing piston. This reduction will vent the brake pipe to atmosphere. A branch pipe, *17*, from the reduction limiting reservoir is run to the engineman's brake valve, where it is open to atmosphere when the engineman's brake valve is in the service, holding, running and release positions. The engineman may, therefore, cause a further service reduction after the brake application valve has reversed. Since pipe *17* is connected to atmosphere in the service, holding, running and release position, the engineman is required to move his brake valve handle promptly to lap (before the beginning of the equalizing reservoir reduction) to prevent the reduction being greater than the 22 or 35 lb. measured by the reduction limiting reservoir. If the brake valve handle is not moved to lap, the equalizing reservoir and brake pipe will be completely vented.

In order that the brake may not be released by acknowledgment, following an automatic train stop application, brake pipe pressure is connected to the pneumatic relay through a port in the brake application valve to pipe *25*, so that when the brake application valve is in the application position, brake pipe pressure will operate the contact finger in the pneumatic relay and open the circuit to the acknowledging switch, so that the magnet can only be re-energized by operating the reset switch.

Forestalling Automatic Train Stop Application

The functioning of the system automatically to initiate a brake application may be forestalled by the engineman operating the acknowledging switch. When this switch is operated, current flows from wire *SP1* to wire *SP* and energizes one or more of the acknowledging stick relays, depending upon the cab signal displayed, which, in turn, will re-energize the magnet valve and stop the venting of the timing reservoir.

The operation of the acknowledging switch must be accomplished before the timing valve operates, which is six seconds after a change to a more restrictive signal. In event the acknowledging switch is held in the acknowledging position after the blow down of timing reservoir is completed, the brakes will be automatically applied on account of the magnet valve circuit being broken through the acknowledging switch. This insures that the operating handle of the switch is left in the correct position.

Preventing Release

When the timing valve and brake application valve function in response to a change to a more restrictive signal, the latter cuts off feed valve pressure, via ports *18* and *11* of the cut-off valve, and vents chamber *11* to the atmosphere. The cut-off valve, therefore, operates to the left, closing the passage between charging port *18* and brake pipe *13*, so that the engineman is powerless to release the brakes until the train is stopped.

Release After Automatic Train Stop Application

The automatic brake valve must be placed in the lap position to close the atmosphere vent of pipe *10* through port *5* in the brake valve. Pipe *10*, however, is still connected to atmosphere via pipe *4* to the timing valve. When the train stops, the engineman, having lapped his brake valve, descends to the ground and operates the reset switch, which energizes the acknowledging stick relay in accordance with the cab signal displayed and this, in turn, re-energizes the magnet valve, when the reset switch is returned to the normal position, and closes the final vent to pipe *10* to atmosphere as soon as the timing valve moves up. The reset switch is provided with a spring return in order to return it to the normal running position as soon as released. Port *5* and pipe *10* will then become charged through the restricted port in the piston of the brake application valve, the spring back of this piston returning it to the normal position when the pressure in pipe *10* approaches that in the upper chamber. This movement of the brake application valve disconnects ports *10* and *5*, and will be followed by the restoration of the cut-off valve connecting ports *13* and *18*. The brakes can then be released in the usual way. The return of the reset switch to running position is guaranteed, since the circuit to the magnet valve is not closed until the reset switch and acknowledging switch are in their normal positions. (If, however, the cab indication goes to clear, the brakes can be released by lapping the brake valve and returning to release position.)

Pneumatic Cut-out Cock and Dead Engine Feature

A pneumatic cut-out is provided for use in case of train stop equipment failure. The engineman may cut out the train stop equipment pneumatically by breaking a seal, releasing a small lever, which, when reversed, prevents the venting of chamber *10* when pipe *10* is vented and renders the brake application valve inoperative. When the pneumatic lever has been reversed, and the conditions which required it is rectified, the lever may be returned to the cut-in position and the train stop equipment will thereafter be effective.

This equipment is provided with a "dead engine" feature which is made operative by closing cut-out cock on the brake valve, closing the double-heading cock and moving the dead engine cock to the dead engine position. In the dead engine position, the brake pipe is connected through the ⅜-in. check valve and strainer to the main reservoir, so that the pressure-maintaining feature of the distributing valve will be operative. The brake valve handle is to be clamped in running position for such an operation.

[Other articles on the power supply system, substations, etc., will follow in an early issue.—EDITOR.]