The North Western Installs Automatic Train-Stop System

Total of 235 miles on the high-speed route of the "400", now protected by device which stops train if engineman fails to observe a signal aspect that calls for reduction in speed or a stop

AN INTERMITTENT inductive automatic train-stop system has been installed by the Chicago & North Western, between Chicago, Ill., and Wyeville, Wis.; this 235 mi. being more than half of the 406 mi. on the high-speed route between Chicago and St. Paul-Minneapolis, via Milwaukee. The devices, installed on the locomotives, operate in conjunction with inductors at the wayside signals, so that, if a wayside signal is displaying an aspect which calls for a reduction in speed or a stop, the brakes will be applied automatically to stop the train if the engineman does not "acknowledge" by having his acknowledging lever in the acknowledging position as he passes over the inductor.

The additional protection provided was the reason for installing the new train-stop system on the Chicago-Wyeville territory where some of the trains are operated at high speeds. The streamliner "Twin Cities 400" makes the approximately 400 mi. between Chicago and St. Paul-Minneapolis in about 400 min., which was the reason for naming this train the "400". This train makes six scheduled stops, and three conditional stops. The speed is restricted within the limits of Chicago, Racine, Milwaukee, and other cities and towns, as well as on some curves. Therefore, in order to make the 400-mi. run in 400 min., fast speeds are required. On sections of track where speeds are not restricted, the maximum permissible speed, on the 85 mi. between Chicago and Milwaukee, is 100 m.p.h. for streamlined diesel-operated passenger trains. On the remaining 142 mi. between Milwaukee and Wyeville, the maximum is 95 m.p.h.

The train-stop project starts at Clybourn Junction, which is in Chicago about 2.5 mi. from the passenger terminal. The main line has two main tracks for ½ mi. between Clybourn Junction and Deering; three main tracks for 10.7 mi. from Deering to Wilmette; two main tracks for 122 mi. from Wilmette through Milwaukee to Clyman Junction; and one main track 102 mi. on to Wyeville.

The scheduled passenger traffic includes 47 trains between Clybourn and Evanston, 9.1 mi.; 40 trains between Evanston and Waukegan, 23.9 mi.; and 14 trains between Waukegan and Milwaukee, 49 mi. An average of five freight trains are operated daily over various sections of this main track between Chicago and Milwaukee. Most freight trains operate between Proviso and Milwaukee on a separate freight line. On the 50.5 mi. of double track between Milwaukee and Clyman Junction, the daily traffic includes the "400" streamliner each way, one other passenger train each way, and about eleven freight trains each way daily. On the 102.4 mi. of single track between Clyman Junction and Wyeville, the traffic includes the "400" streamliner each way and the Northwestern Limited each way, as well as an average of 12 freight trains.

Wayside Train-Stop Equipment

That part of the train-stop equipment installed on the wayside consists of an inductor unit at each automatic and interlocking main-

Maximum speed is 100 m.p.h. between Chicago and Milwaukee

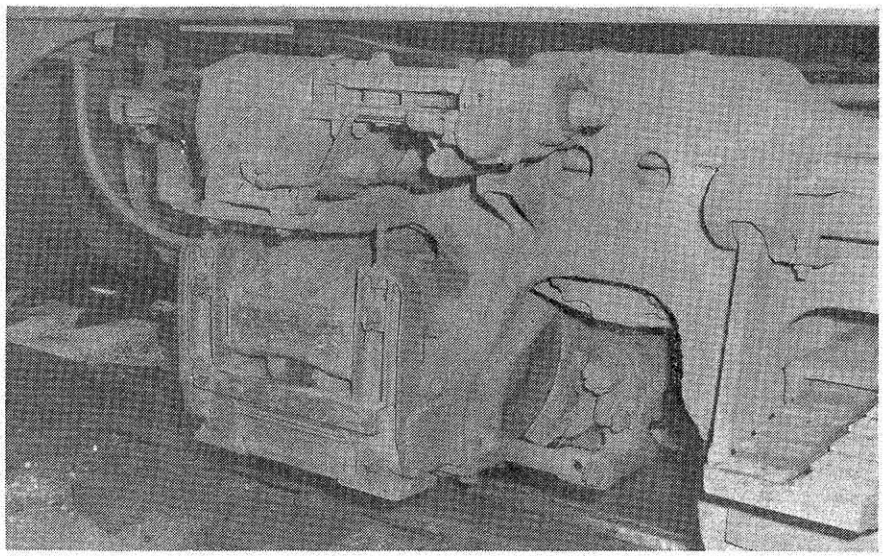
track signal. As shown in one of the pictures, each of these inductors is 7 in. wide and 45 in. long, and is mounted to the right of the track, in the direction of train movements. Two new 7-in. by 9-in. by 9-ft. 6-in. hardwood treated ties are spaced on 40-in. centers, with ends extending 3 ft. from gauge. Plates and adjustable washers are provided on which the inductor is mounted to bring its center line 19½ in. from gauge, and the top surface 2½ in. above the level of the top of the rail. The distance from the gauge of rail to the nearest part of the inductor is 16½ in. The assembly of plates, adjustable washers, nuts and bolts are coated with No-Ox-Id, consistency "A". The far ends of the three ties are kept in position by a ½-in. by 2½-in. iron strap held by lag screws.

The train-stop equipment on each locomotive includes a receiver which is mounted so that it passes directly over each wayside inductor. On diesel locomotives, the receiver is on the rear journal box on the front truck. On steam locomotives, the receiver is on the rear journal box on the front truck of the tender. The leading wheels of any locomotive will shunt the track circuit beyond a signal, and thereby cause the signal to display a red aspect. Therefore, to prevent a long steam locomotive from thus setting up a condition to stop itself, the average wayside inductor is located 80 ft. in approach to each signal. In order to minimize damage to inductors, that might be caused by vibration of track at or near rail joints, the inductor is, in each instance, located at least 6 ft. from a rail joint, thereby lengthening the distance from the signal, in some instances to about 90 ft. Where a street crossing or a turnout to a siding is located directly in approach to a signal, the distance from the signal to its inductor may, in some instances, be as much as 140 ft.

Construction of Inductor

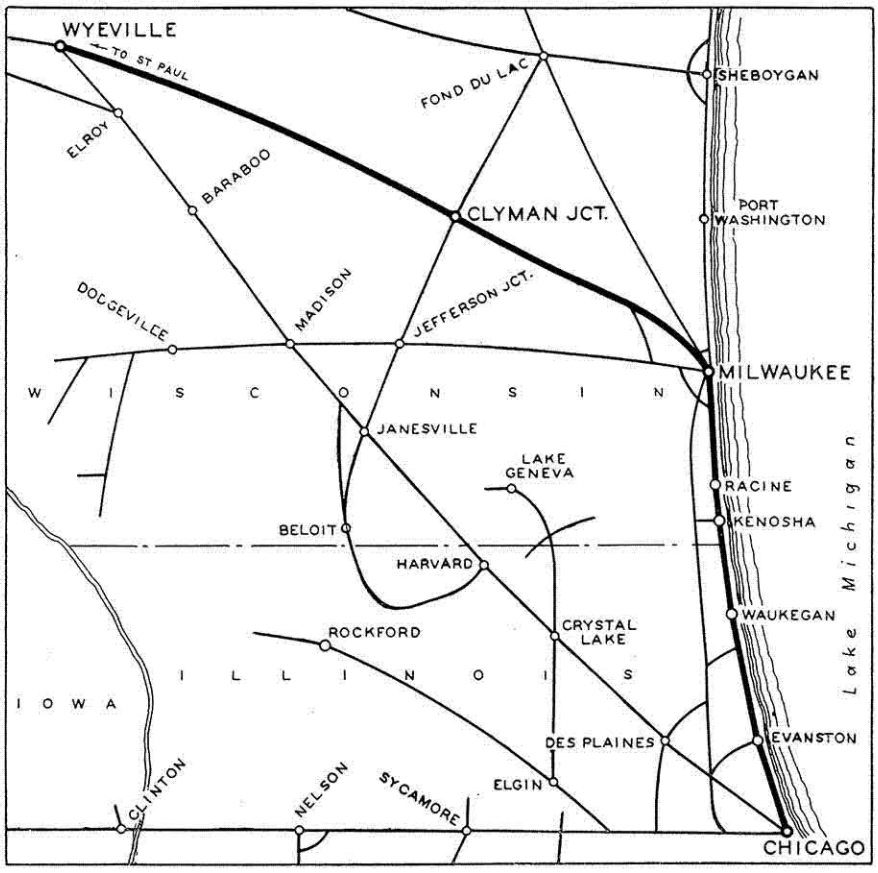
The outer casing of each inductor is made of bronze which is nonmagnetic. Inside this case is a laminated iron core, which is U-shaped with the two pole pieces extending through the top of the casing. Coils on the portion of the core within the case are connected to two No. 8 insulated flexible leads which extend to terminals in a junction box on top of a riser post near the inductor. A two-conductor No. 9 solid buried cable extends from this junction box to the housing for the relays at that signal location. No battery or other energy is required.

The circuit is simple. If the signal is displaying a "top-arm" high green aspect, contacts in the signal relay (or repeater) are closed to connect the two wires from the inductor, thereby making a closed circuit including the coil of the inductor. When thus connected, the receiver, of a passing locomotive, inductively receives a "clear." On the other hand, if the signal is being controlled to display other than a "top-arm" high green, the wires from the inductor are on open circuit, and the receiver of a passing locomotive effects controls to apply the brakes, unless the engineman properly acknowledges.



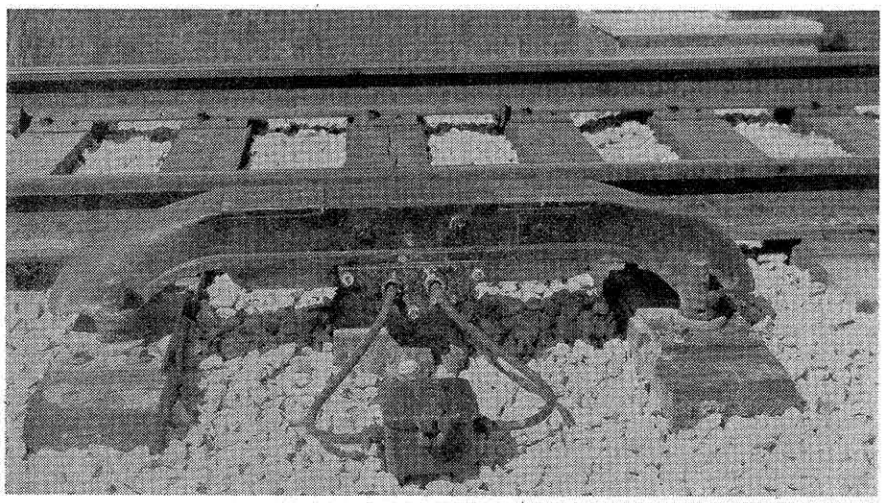
Receiver is mounted on journal box on locomotive truck

At each signal where a conventional colorlight signal is in service, a new 8-point, 100-ohm retained-neutral polar relay was installed to replace the existing 6-point relay. The inductor circuit is through a polar contact and a front neutral contact. At each searchlight-type signal, there was previously a yel-



Heavy line indicates train-stop territory

Traffic includes 47 passenger trains daily



An inductor is located at each signal

low-green repeater relay. A new 50-ohm 2-point green-repeater relay was added. The semaphores are the top-post mechanism type. At each such signal, the inductor circuit checks through a front contact of the signal control relay and a contact, in the signal circuit controller, closed when blade is in the clear position.

The total cost for materials and field construction of the wayside portion of this train-stop system was approximately $375,000, and the additional signaling maintenance costs are estimated at $22,500 annually.

Train-Stop Equipment on the Locomotives

The train-stop equipment on each locomotive functions to apply the air brakes automatically if the engineman does not acknowledge as he approaches any wayside signal which is displaying other than a high green. When the brakes are thus applied, the train is thereby brought to a stop. After a penalty brake application is received, the engineman can operate the lever of his reset device, which includes a clock-work time-release that introduces a delay period, at the termination of which the brakes are released. The time delay period is 1 min. on passenger trains and 2 min. on freight trains, which is sufficient to stop the train.

The automatic train-stop system is in service on all passenger trains, including the numerous suburban passenger trains operated in the train-stop territory. Likewise, train-stop equipment is in service on all diesel freight locomotives. Steam freight locomotives are not equipped because it is expected that they will be replaced with diesels in the near future.

For passenger-train service, train-stop equipment has been applied on 89 steam locomotives, 56 diesel locomotives and 2 rail cars. For freight service, train-stop equipment has been applied on 115 diesels and 19 diesel switchers. These locomotives are in a pool, and are operated not only in train-stop territory but also in other territories. The cost of installing train-stop equipment on the 279 locomotives and 2 rail cars is approximately $1,400,000, and the estimated annual maintenance of this equipment is $85,000.

Details of Equipment

The train-stop equipment on each locomotive includes a receiver which is mounted on the rear journal box on the front truck of each diesel locomotive and on rear journal box of front tender truck on steam locomotives. These journal boxes have special integral cast side lugs for attaching the brackets of the receiver. Adjustments can be made to set the bottom pole faces of the receiver 4 in. above the level of the top rail. The center line of the receiver is 19½ in. from the gauge of rail, so that the receiver passes directly over the center line of the wayside inductors. The vertical clearance between the locomotive receiver and wayside inductor is 1½ in.

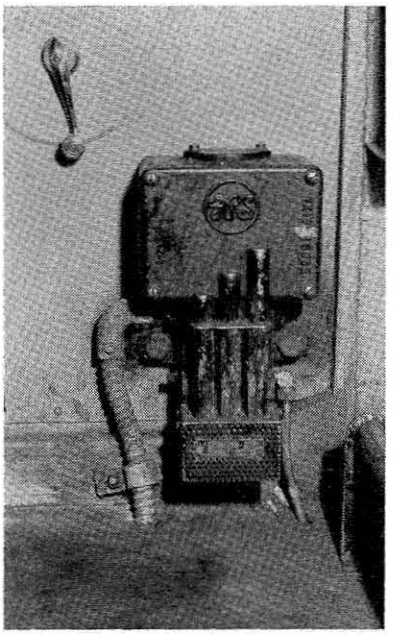
Each of these locomotive receivers has two coils wound on a laminated core, which is connected to flat pole pieces on the bottom of the receiver. The coil toward the front of the locomotive is the primary coil, and the other one is the secondary coil. Both coils are normally energized by 32-volts direct-current energy from sources on the locomotive, such as the turbo-generator on a steam locomotive or the motor-generator sets on a diesel locomotive.

Operation

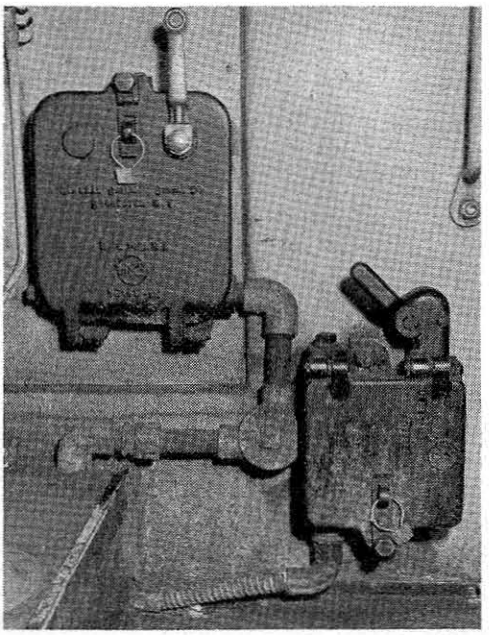
When the receiver passes over a wayside inductor whose coil is closed (high green), there will be no material change in the engine apparatus, although a slight variation will take place in the flow of current in the primary relay.

When the engine receiver passes over a track inductor with an open coil, on account of the signal displaying other than a top-arm green aspect, the sequence of operations is as follows:

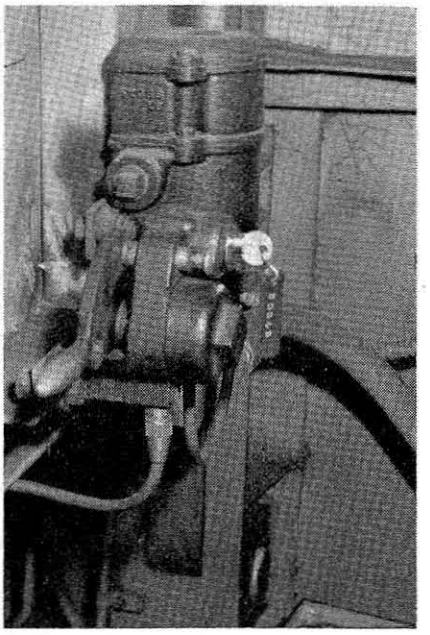
(1) The passage of the receiver over the inductor causes a surge of magnetic flux to build up in the secondary coil, thus producing a negative current in the primary relay, R1,



Whistle in cab



Acknowledger (left) and reset



Cut-in valve and key

thereby causing that relay to release.

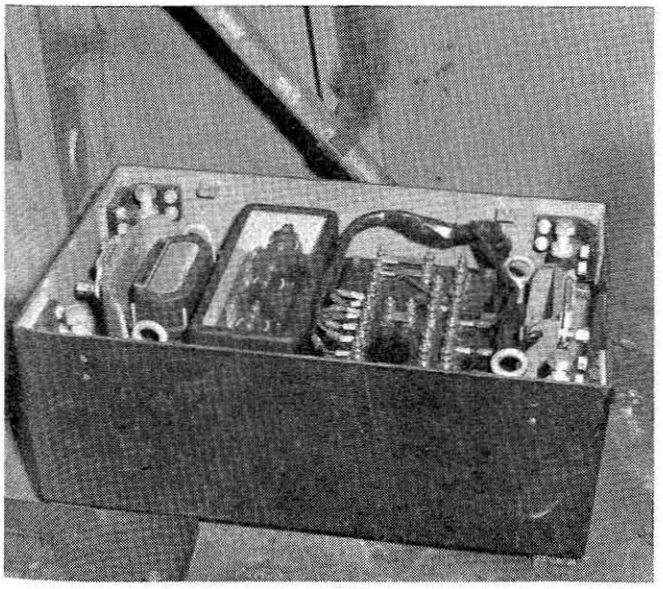
(2) The de-energizing of the primary relay, opens the circuit to the secondary relay, R2, which causes its armature to drop.

(3) The third relay, R3, being deprived of current by the opening of the armature of the second relay, thus opens the circuit to the electro-pneumatic valve.

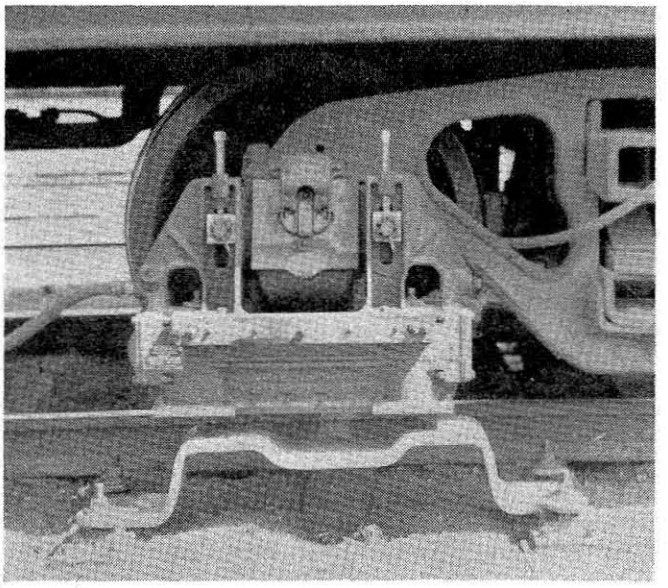
(4) The electro-pneumatic valve being opened, air is exhausted to cause a service application of the brakes.

The brakes having been applied, they may only be released by operating the reset contact, which applies current directly to the relay controlling the electro-pneumatic valve.

If the engineer is alert, and desires to avoid a stop at a signal displaying other than top-arm green, he may operate the acknowledging contactor. This puts into operation a timing element, and, at the same time, through the circuit provided for that purpose, cuts the control of the valve-controlling relay out of the influence of the inductor, although the other two relays are momentarily opened as the inductor is passed. At the same time, by another circuit through the contactor, the primary relay is re-energized, which causes the coils of the secondary relay to be re-energized. Since the first of these circuits controls the whistle valve, a blast is caused, but of very short duration, since the secondary relay is de-energized only momentarily in this operation, and upon being re-energized immediately provides a circuit around this whistle valve. Thus, this whistle blast is an indication that proper acknowledgement has been made. The acknowledging contactor should be put normal after the whistle has stopped blowing. The acknowledging time element operates for 15 sec., and, if the contactor has been operated more than that period before reaching an inductor, a brake application will ensue. This feature was incorporated in the system so that an engineman cannot defeat the purpose



Relays in case in locomotive



Receiver being tested over "dead" inductor

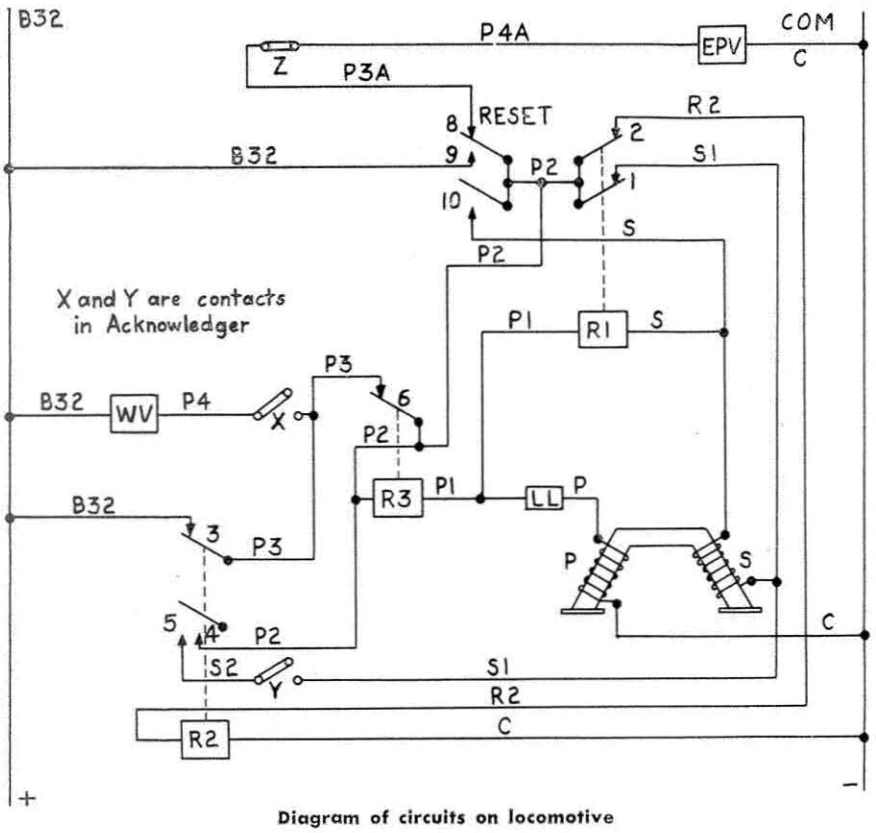


Diagram of circuits on locomotive

of the system by holding or tying the acknowledging lever in the "acknowledging" position.

Description of Circuits

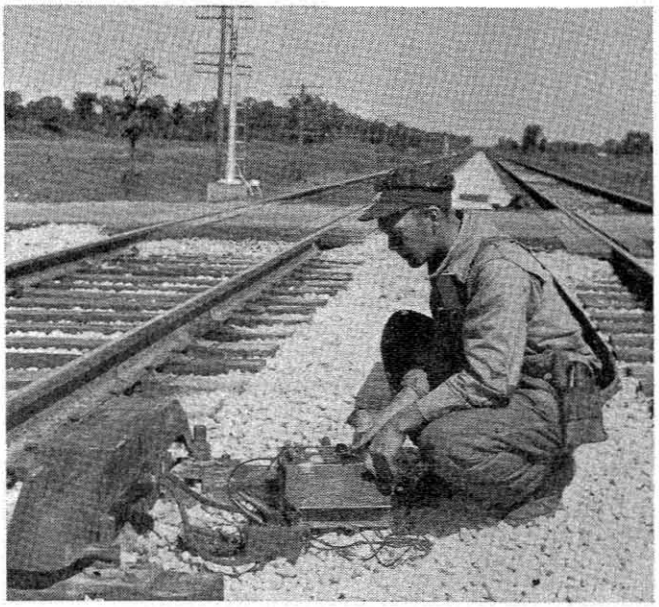
Having described the principles upon which the operation of the circuits are based, the purpose of the following paragraphs is to describe actual application of typical circuits in the operation of the system.

The primary coil, P, of the receiver is energized by current flowing from the positive side of the generator through wire B32, contact 3 of relay R2, wire P3, contact 6 of relay R3, wire P2, the coils of relay R3, wire P1, the ballast lamp LL, wire P through the primary coil of the receiver and wire C to the negative side of the generator. The relay R3 is energized by the circuit last described. The relay R1 is energized by the drop in voltage across the coils of the relay R3, due to current flowing in the circuit last described. The circuit is as follows: Starting from the left-hand side of the coils of relay R3, wire P2, contact 1 of relay R1, wire S1, secondary coil of the receiver, wire S, coils of the relay R1, wire P1, back to the right-hand side of the coils of relay R3. The secondary coil, S, of the receiver is energized by the circuit described above for relay R1. The circuit which supplies current to the coils of relay R2 is traced as follows: Starting from the positive side of the generator through wire B32, contact 3 of relay R2, wire P3, contact 6 of relay R3, wire P2, contact 2 of relay R1, wire R2, the coils of relay R2, and wire C to the negative side of the generator. The electro-pneumatic valve, EPV, is receiving current through the following circuit: Starting from the positive side of the generator, wire B32, contact 3 of relay R2, wire P3, contact 6 of relay R3, wire P2, contact 8 of reset contactor, wire P3A, contact Z of the acknowledging contactor, wire P4A, the coils of the electro-pneumatic valve and wire C to the negative side of the generator.

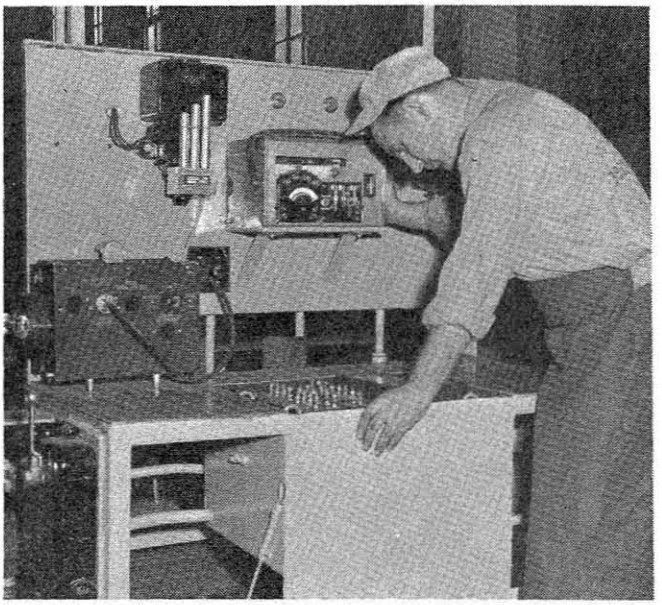
The operation of the circuits is as follows: When the receiver passes an inductor whose coils are closed, the current through the relay R1 is not materially changed, but, when the receiver passes over an inductor whose coils are open, the current through relay R1 is decreased, so that its contacts are opened. The opening of contact 2 of relay R1 deprives relay R2 of current and the opening of contact 3 of relay R2 deprives relay R3 of current. The opening of contact 6 of relay R3 deprives the electro-pneumatic valve of current and a full service brake application results. The E.P. valve cannot then be supplied with current until relay R3 is again energized. Relays R3, R1 and R2 are re-energized by the operation of the reset contactor as follows: When contact 9 of the reset contactor is closed, relay R3 will receive current through the following circuits: From the positive side of the generator, wire B32, contact 9 of the reset contactor, wire P2, coils of relay R3, wire P1, ballast lamp LL, wire P, primary coil of receiver, wire C back to the negative side of the generator. This produces a drop in voltage across the coils of the relay R3 so that the relay R1 will be energized by the following circuit: Starting from the left-hand side of the coils of relay R3, wire P2, contact 10 of reset contactor, wire S, coils of relay R1, wire P1 back to the right-hand side of coils of relay R3. Having thus closed contact 2 of relay R1, relay R2 will be energized so that contact 3 will be closed and the reset contact returns to its normal position, thereby closing contact 8 which re-energizes the electro-pneumatic valve.

If, at the time the receiver passes over an inductor whose coils are open, contact X on the acknowledging contactor is closed, relay R3 will not be opened, consequently the electro-pneumatic valve will not be deprived of current. The circuit which holds relay R3 energized at this time is as follows: From the positive side of the generator, wire B32, the coils of the whistle valve WV, wire P4, contact X of the acknowledging contactor, wire P3, contact 6 of relay R3, wire P2, the coils of relay R3, wire P1, the ballast lamp LL, wire P, the primary coil of the receiver and wire C back to the negative side of the generator. With contact X of the acknowledging contactor closed and contact 3 of relay R2 open, energy passes through the audible signal WV, causing a blast of the whistle. The blast, however, is of short duration because contact 3 of relay R2 is opened only momentarily and, when closed, short circuits the coils of the whistle valve WV. When the receiver passes over an inductor under these conditions, i.e., with contact X of the acknowledging contactor closed, the impulse received will cause relay R1 to open but since relay R3 is energized, relay RI will immediately pick up.

The momentary opening of relay R1 opens relay R2 which immediately picks up again. Immediately after the relay R2 is opened, with the acknowledging contactor operated so that contact Y is closed, relay R1 will be energized by the drop in voltage across the coils of relay R3, the circuit being as follows: Starting from the left-hand side of relay R3, through wire P2,



Signal maintainer tests a wayside inductor



Locomotive train-stop equipment is tested in shop

to contact 4 of relay R2, contact 5 of relay R2, wire S2, contact Y of the acknowledging contactor, wire S1, secondary coil of receiver, wire S, the coils of relay R1, wire P1 back to the right hand side of the coils of relay R3. Energizing relay R1 closes contact 2 of this relay which again energizes relay R2 so that all of the circuits are restored to normal. It should be noted that if the contacts X and Y of the acknowledging contactor are closed for more than 15 seconds, contact Z will open. This will deprive the EPV of current and cause an automatic brake application. It should also be noted that if the acknowledging contactor is not operated at the time an inductor is passed whose coils are open, circuits cannot be restored to normal until contacts 9 and 10 of the reset contactor are operated.

Conductor's Responsibility

A special Chicago & North Western feature is that the conductor of a train has joint responsibility, with the engineman, to know that the train stop is in service on the locomotive during a run. This result is accomplished by a special cylinder-type lock. The cut-in valve, which feeds air through the train stop electro-pneumatic valve, EPV, must be in the "train stop" position to withdraw the key. Rules require that this key be in the possession of the conductor, during the run of the train between terminals.

Entrance Tests

When on the road, the train-stop equipment on a locomotive must go through a test when approaching and entering train-stop territory. For example, a test wayside inductor is located braking distance in approach to the westward home signal at Clybourn Junction. This test inductor is "unwound," i.e., in all instances it will operate to apply the train brakes unless the engineman acknowledges. The location of these test inductors are designated by special "T" signs, made with Scotchlite reflectorized material.

Departure Tests

Just before each locomotive leaves the enginehouse tracks, preparatory to making a run, the train-stop equipment is given a departure test. The first test is to check the 15-sec. timing limit for the holding of the acknowledging lever. The engineman operates this lever and holds it. When the time exceeds 15 sec., the brakes should be automatically applied. The 15-sec. feature is included on the system so that an engineman cannot tie the acknowledging lever in the acknowledging position and "ride by" signals, without a stop. The next two tests are made by operating over two "dead" inductors spaced 50 ft. apart. A "dead" inductor, as shown in one of the pictures, is made of ¾-in. by 8-in. iron plate, and this iron has the same effect on the receiver on the locomotive at slow speed as a regular inductor with an open-circuit coil.

As the receiver on the locomotive passes over the first departure test inductor, the engineman operates his "acknowledger" until the whistle blows. This proves that the circuits, relays, whistle, etc., are operating correctly. When the receiver passes over the second test inductor, the engineman does not acknowledge, and, as a consequence, the air brakes should be applied automatically, and the locomotive, and train if coupled, is brought to a stop. The engineman then operates the reset lever and, after one minute for passenger locomotives or two minutes for freight locomotives, the air brakes can be released. The tests discussed above will indicate if the train-stop equipment on the locomotive is in proper operating condition.

Tests of Wayside Inductors

Every 30 days a special gauge is used to check the position of each wayside inductor. At 6-mo. intervals, an electrical test is made to check the coil in each inductor and the circuit from the inductor to the case and through the contacts. This electrical test is made by means of a special test set, which includes dry-cell battery and a vibrator-generator to produce 110-volt a.c. for testing.

This train-stop project was planned and installed by Chicago & North Western forces. The wayside portions of the system were installed under the direction of S. E. Noble, assistant chief engineer, communications and signals, and under the supervision of E. W. Horning, assistant engineer. The equipment on the locomotives was installed under the direction of J. C. Stump, chief mechanical officer, and under the supervision of L. E. Legg, electrical engineer. The train-stop equipment and new relays at the signals were furnished by the General Railway Signal Company.