(a) If the copper element is of a bright copper color it must not be short-circuited.

(b) If the copper element is of a brown color, short-circuit the cell for five minutes.

(c) If the copper element is of a very dark or black color, short-circuit the cell for 10 minutes (no longer).

Only those cells requiring short-circuit should be so treated, and where there is more than one cell in a set requiring such treatment, then connect the cells together in series, and short-circuit them as a battery, and not as individual cells. However, cells requiring five-minute treatment must not be included in the same short-circuiting with those requiring ten-minute treatment.

Any special instructions not in accordance with this section (4) should be disregarded.

5. TESTING. The battery while in service should be observed and tested frequently to ascertain its condition.

Test may be made with a voltmeter by connecting it in multiple (across the terminals) with the battery. If the potential of 16 cells in series falls below 7 volts while a current of 3 amperes is flowing, the battery should be watched closely.

The elements should also be observed to see the extent of consumption of the zincs, and that the copper oxide plates are changed to metallic copper. When the signal operations are very infrequent, the battery may safely be more nearly discharged, as there will be more time for it to recuperate between operations.

The depth to which the oxide plate has been changed to metallic copper may be best determined by digging a small hole into the plate near the center with a sharp instrument such as the blade of a knife.

6. RENEW BEFORE FAILURES. Care must be used to see that the battery is renewed before it has caused a failure and *still get the maximum life from it.*

7. RENEWAL RECORD. A record of consecutive renewals of all potash battery showing date and kind of renewal on prescribed form shall be kept in battery receptacles or other places designated by the signal maintenance foreman, and a report of all renewals made to the supervisor.

8. EXHAUSTED ELEMENTS. Whenever possible, and as instructed by the signal supervisor, exhausted elements should be carefully packed with excelsior in the same box in which new elements are received and shipped in that way to the general store. Before packing, however, the copper oxide plates must be washed thoroughly in clean water and well dried in the open air for not less than three days. Spontaneous combustion is almost sure to take place and fires result if this is not done. Exhausted elements, after being removed from the cells must never be taken inside of any building until after at least 24 hours exposure to the open air, unless placed in metal container.

9. REPORT SHIPMENTS. Report must be made to the signal supervisor of all exhausted elements shipped from each territory, stating of what the shipment consists, and from what the exhausted elements were taken, i. e., from what bell, automatic signals, interlocking, or other service, and accompanied by a copy of the bill of lading showing date shipped, car number, quantity, weight, and consignee.

10. MARKING SHIPMENTS. All boxes or packages shipped must be plainly marked, showing contents, quantity, and weight, place from where shipped, number of order covering shipment, to whom shipped, and destination.

English railways have done a great deal to educate employes in all departments in the rudimentary principles of the signal and interlocking systems in use. The London & Northwestern has had lectures given by its signal experts at regular intervals in its London station, which are open to all employes and which are made very interesting and instructive by the use of models of signal and interlocking installations, and of some of the standard apparatus used on the line. It is understood that this company will establish such classes at about twelve points on its system.

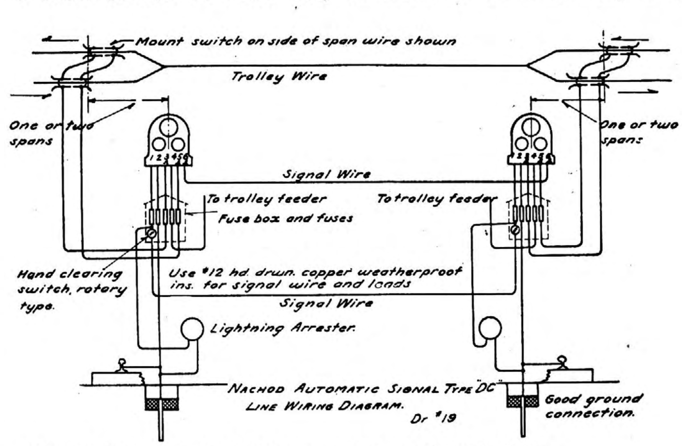
AUTOMATIC BLOCK SIGNAL SYSTEM FOR ELECTRIC RAILWAYS

A description of a trolley-contact block signal system which is in extensive use on interurban lines.

The Nachod signal system of automatic block signals for electric railways has been used continuously on a number of widely separated roads in the United States for more than two years.

It was the aim of the designers to produce at a moderate cost a safe signal that would be operative where the inspection and maintenance are reduced to the minimum. The problem is attacked from a new point of view, and the mechanical working out of the details has been particularly successful in practice.

The system herewith described, known as type CD, which is quite general in application, is for permissive signaling on single-track lines operating in both directions, with turnouts or sidings as passing points. It gives both facing and rear protection, though without distant signals. The signal indications are controlled not by a continuous track circuit, which may not be easily applied on account of the traction current in the rail, but by the passage of the car or train past a given point at which a contact device is located. This, without moving parts, may be a short section of third rail, an insulated track section, or a



Note - To indicate leads clearly only upper case of box is shown. Lightning arresters are required on signal wire #1 and feeder spaced every 1000 ft.

Fig. 1. Line Wiring Diagram for Through-Type Turnout.

trolley contactor, a type of the latter being shown herewith.

The system is adapted either for single-end sidings, for through type turnouts, or for curve protection in both directions, the arrangement of the signal apparatus on the right-of-way being shown approximately in Fig. 1 for a through type turnout. There is a distance of from one to two spans between the trolley contactor and the signal aspect, which is in advance. The signal is constructed to indicate affirmatively; that is, every passage of the car under the contactor must make some change on the aspect, visible to the motorman, to prove to him that his car has caused the mechanism to operate.

The apparatus for one block of single track, as shown in Fig. 1, consists of two signal boxes and four contactors—although two might be used—and two line wires connecting the stations.

The apparatus may be broadly divided into three parts: (1) the signal aspect, consisting of lights and color disks; (2) the intermediate mechanism, or relay, which converts the transient current impulses, caused by the passage of the car under the contactor, into signal indications, and (3) the controlling mechanism, as the trolley contactor.

The aspect is given by lights and color disks simultaneously, the three indications being *no light, no disk,* as in Fig. 3; a *white light* and a *white disk,* as in Fig. 2; a *red light* and a *red disk,* as in Fig. 4.

The signal box forming the aspect is a substantial weatherproof cast-iron case of compact and pleasing contour. The lower part is an oil tank which may be removed by three bolts so as to expose the relay, as in Fig. 3. The upper part is attached to the pole by hangers, and contains the lights and disks, as in Fig. 4, which are actuated by means of the relay magnets. The magnet connection is through a push rod so that there is no shock transmitted to the disk by the quick motion of the magnet plunger. These disks are of enameled aluminum, counterweighted to fall to indication by gravity. Only one lamp is lighted at a time, at which time the disk of the same color rises to an indicating position, and is viewed through the clear glass roundel in the hinged front of the box. Below this there are openings for a white and a red semaphore lens for the lamps.

Fig 2. Signal Box Indicating Proceed

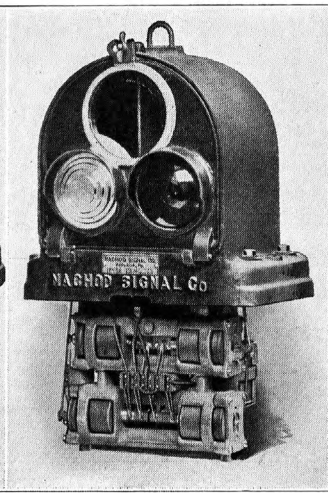


Fig. 3. Signal Box Indicating Neutral.

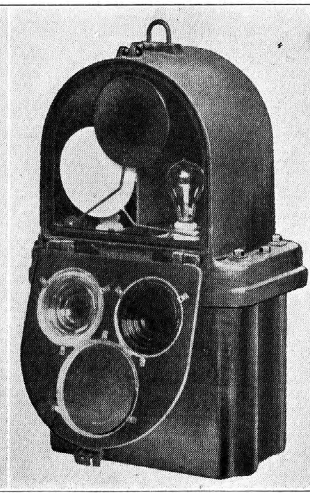


Fig. 4. Signal Box Indicating Stop.

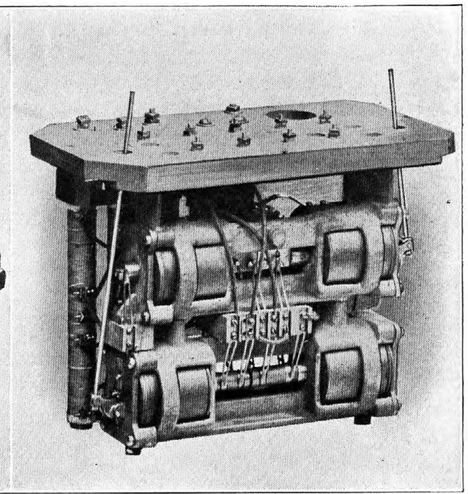


Fig. 5. Relay Unit.

It will be seen that the disk not indicating acts to screen from cross illumination the lens not indicating.

The relay is attached to the upper case by three bolts which, when removed, allow it to drop away, disconnecting automatically both the electrical contacts and the push rods from the color disks. This unit shown in Figs. 5 and 3 consists of 5 magnets, the upper pair of which count the cars by a ratchet and pawl mechanism; each entering car operating the left-hand magnet A, —lettering refers to Fig. 6,—to revolve the ratchet wheel and its attached revolving switch one notch in the counter-clockwise direction, and each leaving car actuating the right-hand magnet D to move the ratchet wheel one notch in the opposite direction. Thus if the signals are neutral or normal with no cars in the block, with the revolving switch in a certain position, they will be restored to neutral when the same number of cars have left the block as have entered. The latter magnet also operates the white color disk, and the left lower magnet H, the red color disk. The right-hand one C is the clearing magnet. Behind this magnet, and not visible in this view, is the no-voltage magnet N to prevent change of signals on failure of line voltage. To the left, in Fig. 5, will be seen the resistance rods vertically mounted with contact bands for adjustable taps. The entire unit depends from a contact board having terminal studs which impinge upon phosphor bronze spring contact strips in the upper case, these strips being plainly shown in Fig. 7. By this means a relay may be removed by taking out three bolts, and a spare one substituted without touching the wiring in any manner.

Some unusual features of this relay, which is in fact the heart of the signal system, are, in the first place, the use of partially iron-clad substantial plunger-type magnets instead of the delicate pivoted armature type, reducing wear and the possibility of sticking, since the power for operation is not minute, but may be as great as desired. Contacts are made and broken by the simple rectilinear movement of the plungers, without pivots or multiplying levers, there being phosphor bronze spring fingers pressing against brass rings separated by insulating material. The alignment of parts is through finished metal surfaces. The most novel feature of the design, however, is the immersion of the entire relay in a tank of transformer oil. By this means not only is continuous lubrication provided and corrosion prevented, but the relay is sealed against the entrance of foreign matter, dust, insects, etc. Moreover, the oil acts to cushion the variable magnet blows which might tend otherwise to loosen the screws. Furthermore, the high insulating power of the oil greatly reduces damage by lightning, which has always been a serious menace in connection with such signals, and it also permits parts of opposite polarity to be brought closer together than in air, thereby resulting in a more compact design. By the cool-

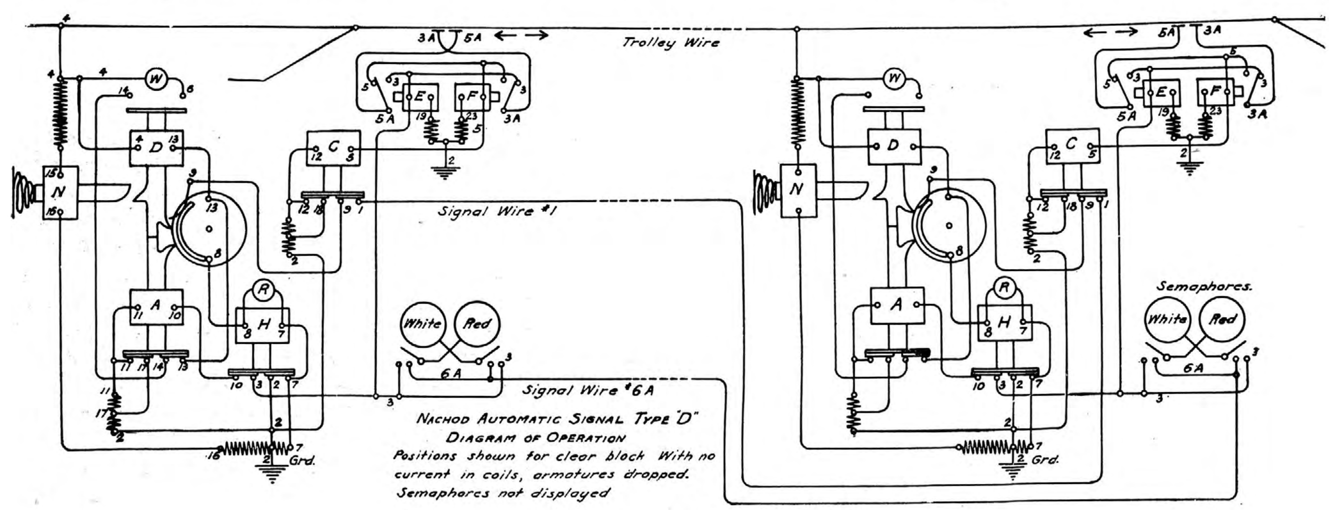


Fig. 6. Diagram of Operation.

ing properties of the oil, which transmits the local heat from the coil to the entire tank for radiation, the range of voltage operation is increased, since enough current for positive operation may be used for abnormally low voltages, and yet the coil

Fig. 7. Upper Case, Showing Spring Contacts.

will not be overheated with the normally high voltage. The life of the contact fingers is enormously increased by the quenching of the arc under oil, so that altogether the very great advantages

The change from neutral to proceed, a *white light* and a *white disk,* gives the first car the right-of-way to continue through the block; but a neutral signal is to be taken as a stop signal should the neutral remain after the car has passed the contactor. It indicates that the stop signal has not been set at the far end of the block.

The proceed signal notifies the second and following cars that the block is occupied by cars running in the same direction; and the "blinking" of the light, as the second and following cars run under the contactor, gives them the right-of-way to continue through the block.

The stop signal, a *red light* and a *red disk,* warns the motorman to stop and remain behind the contactor so long as it is exhibited.

The motorman must not pass the signal box to enter the block unless the white light and white disk are showing.

A car must not follow into a block already occupied unless the motorman sees the white light blink as he runs under the trolley contactor.

Motorman must not allow car to remain standing with the trolley on the overhead contactor.

The first car to enter the block in passing under the contactor sets a white light and a white disk, which is an indication that the red light and red disk are showing at the far end. Every successive car following in an occupied block indicates that it is registered by extinguishing the white light as it passes under the contactor, the light reappearing the next instant.

Fifteen cars may enter the block in succession and occupy it at once, or they may be continually entering and leaving, and they will all be protected.

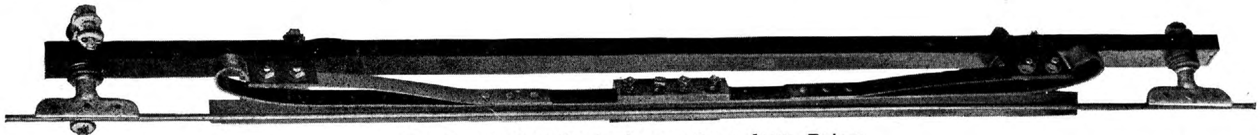


Fig. 8. Trolley Contactor as Seen from Below.

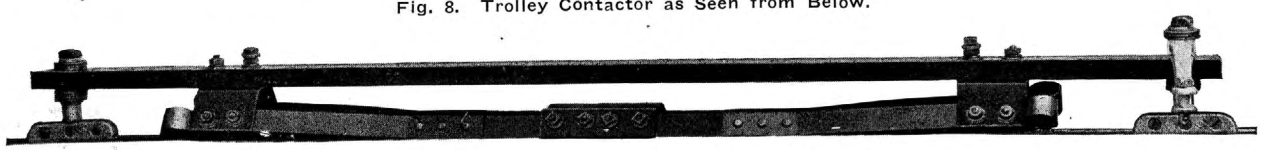


Fig. 9. Trolley Contactor as Seen from Above.

due to oil cooling and oil insulating, so long used in transformers, together with that of the oil-break switches, are obtained.

Instances are on record where signals with such relays have operated for a year at a time with no attention whatever.

The trolley contactor shown in Figs. 8 and 9 consists of two flexible longitudinal steel contact strips supported by a rigid member near the trolley wire, but insulated from the latter, so that the wheel running on the wire,—which it does not leave,—touches in passing one or both of the contact strips, which are electrically connected. These strips are inclined outwardly at the bottom, flared at the ends to receive the wheel easily, and mounted by flexible phosphor bronze suspenders. The deflection of the strips, however, is positively limited by steel brackets shown. Each strip is divided into halves electrically and reunited through insulation so as to obtain a sense of direction without the use of moving parts. The insulation between the contact strips and trolley wire is through hickory, impregnated under vacuum and pressure with a weather-proofing compound. The entire contactor, which is about four ft. long and weighs 18 lbs., is hung by a double-curve suspension at one end, and clamped to the wire by the usual trolley ears. This contactor receives the various size wheels without shock, and operates the signals very successfully at car speeds of 55 miles an hour. The position of the car controller handle does not in any way affect its action.

The neutral signal, *no light* and *no disk,* presumes that the block is clear, and gives the first car the right-of-way to run under the contactor, but no further.

If the motorman should accidentally overrun the entering contactor when the signal shows red he will not visibly affect the

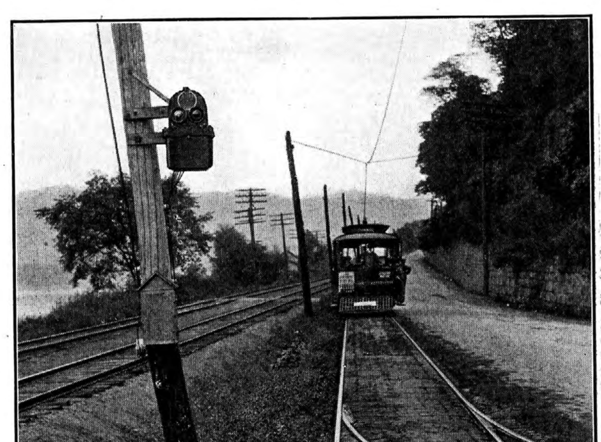


Fig. 10. Showing the Signal in Service on the Mahoning & Shenango Railway & Light Company's Line, Youngstown, Ohio.

signals, but will count in the car on the relay; and this change will be canceled when he backs out of the block again under either contactor to wait.

If the motorman should enter a clear block, under either contactor, setting the signals, and back out on either track at the same end of the block, as he might in using the single track as a Y or cross-over, the signals will be automatically cleared on leaving.

If a motorman should enter a block, setting the signals, and remain there, then cars for any reason entering and backing from either end in any manner, whether against the red or white signals, will not disturb the signals as set by the first car; and only when all the cars have vacated the block will the signals be restored to neutral.

The trolley contactors have a sense of direction so as to count cars into or out of the block, according to the end of the contactor first reached by the trolley wheel. The operation is perfectly general and cars may enter and leave by any one or by all the contactors.

If two cars from opposite ends enter at exactly the same instant, the white disks will not remain set, but will disappear immediately, leaving neutral signals when the car leaves the contactor, and before it passes the box. Each car should back out

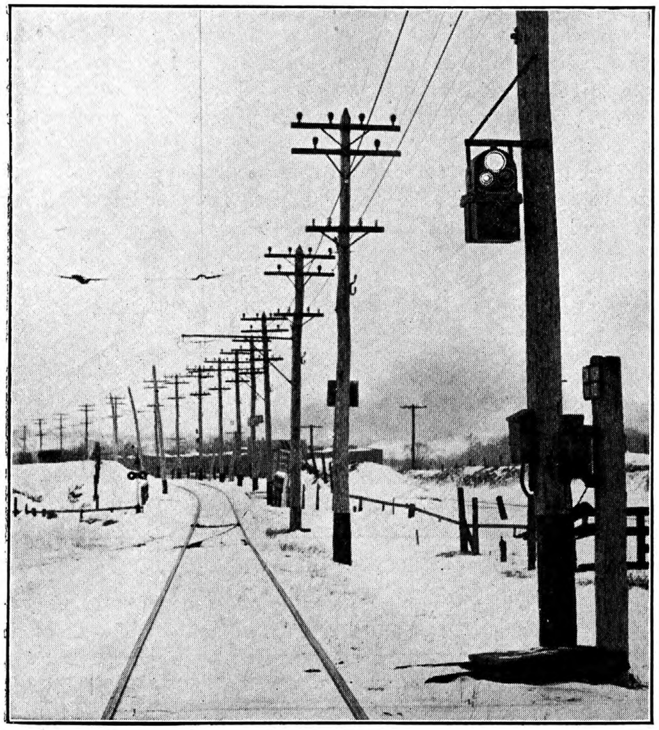


Fig. 11. Signal in Service on the Ohio Valley Scenic Route.

of the block, and the one having the superior right should go forward, setting the signals against the other car.

In Fig. 10, which shows the signal in service on the Mahoning & Shenango Railway & Light Company's lines, Youngstown, O., the car has entered the block of single track and is still in it, having disappeared beyond the bend, leaving the signal permissive for another car to follow. The clearing contactor for this end of the block may be seen over the turnout at the left. The box on the stub pole is a telephone system for emergencies.

In Fig. 11, on the Ohio Valley Scenic Route, the car is approaching the observer to leave the block, the signals being set red.

In Fig. 12 on the same road the bunched leads are brought through enclosed fuses before passing to the relay, these fuses acting also as disconnecting switches. A lightning arrester may be seen below the open fuse box.

Fig. 6 shows the operation of the electrical system, the apparatus being alike at both stations, and in the normal position with no car in the block.

The directional trolley contactor 3A, 5A, is divided into halves, reached in succession by the trolley wheel. These are interconnected by means of the directional magnets E and F, so that a car entering from the end 3A will close the signal-setting circuit through coil A in the relay, and hold it closed even after it reaches the second strip 5A. But should a car reach the end 5A first, then the directional magnets will close the circuit through the clearing magnet C in the relay, and hold it even after it reaches the second strip 3A.

The circuits through the directional relay are described herewith once for all, and not each time they are mentioned. A car

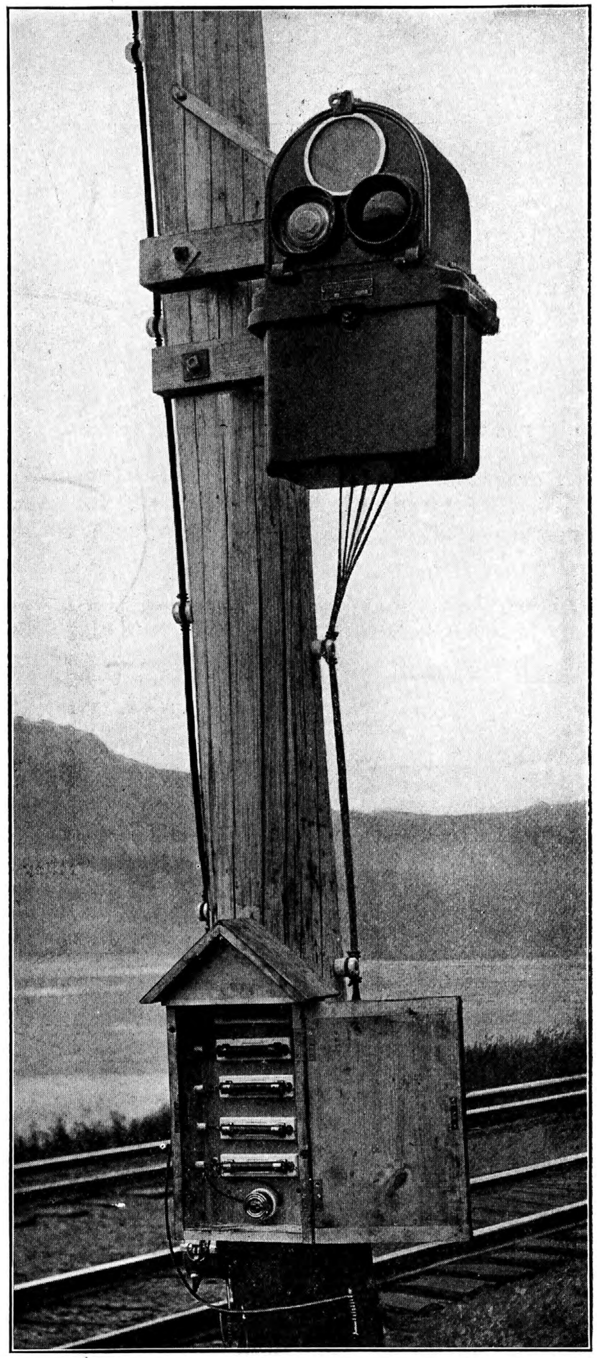


Fig. 12. Signal Mounting, Fuse Box Open.

reaching the trolley contactor from the end 3A diverts a current from the trolley wire 4 through 3A, 3, coil E, 19, to ground 2. Coil E attracts its armature, breaking the contact at 5 and making that at 3, so that when the car reaches the second part 5A, the circuit still includes coil E, being made from 4, 5A, 3, coil E, 19, 2, ground. The setting magnet A is in multiple with coil E, and is, therefore, energized with it. In an exactly similar manner, if 5A is reached first, then the circuit is through magnet F, which will attract its armature and maintain current in it even when the car has reached 3A. The clearing magnet C in the main relay, being in multiple with magnet F, is therefore continuously energized while the car is on the contactor, having approached it from the end 5A. The divided contact strips and the directional relay magnets E and F thus act selectively, to actuate coils A or C according to the direction of the car.

In the clear block both ends of the signal wire are grounded through the circuit, 1, 9, 8, 7, 2, ground, including coil H, and the red lamp.

A car entering from the left temporarily connects contact strip 3A of trolley contactor with trolley wire, forming a circuit, 4, 3A, 3, 10, 11, 17, 2, ground, passing through coil A. This impulse of current in A moves its plunger to revolve the two-way switch, transferring the end of the signal wire 9 from contact 8 to contact 13. Current then flows from trolley wire, 4, 13, 9, 1, signal wire to other relay to ground as described. When the car leaves the contactor, plunger A drops back into the position shown, while plunger D remains in the retracted position on account of the current in coil D. The white light now burns, since it is in shunt across D by the path 4, W, 6, 14, 13; and the red light also burns in the other relay because of the current in the signal wire. The retracted position of plunger D in the one relay, and that of plunger H in the other, permit the display of the white and red disks, respectively. So long as the red signal continues the circuit of magnet A is held open at 3, 10, preventing change in the left relay by cars entering at contactor 3A against the red signal. The effect of successive entering cars is to revolve the switch so that the contacts overlap further, but not to cause any electrical change in the signal circuit, except that each entering car actuates magnet A so as to break the lamp circuit at switch 13, 14, causing the white light to blink.

When the car leaves the block at the right end it runs under contactor 5A, completing the circuit, 4, 5A, 5, 12, 18, 2, ground. The plunger of magnet C opens the signal line wire circuit at 1, 9, breaking the circuit of magnet D in the entering relay. The plunger of D is restored to its original position, revolving the switch in the reverse direction, one notch at a time for each leaving car. When there have been as many breaks of current in coil D as impulses of current in A, the revolving switch will be in its original position, and the signals will be cleared.

If the car enters the block by contactor 3A, 5A, it will energize magnet A and set the signals; while if it backs out under the same contactor, it will energize magnet C to clear them. If a car should accidentally overrun the contactor against a red signal, then current would flow through signal wire 6A to the distant relay, and through setting coil A there, by means of the color disk switches, one of which will be closed in each signal box. But there would be no effect on the signal showing red, since the circuit of the setting magnet A would be held open at contacts 10, 3, as stated. The second signal wire 6A is, therefore, a means for enabling a car running against the red signal to count in on the distant relay, that it may count out again in backing. It is in use only at such rare instances.

The function of magnet N is to prevent change of signals should the power fail with cars on the block. It is permanently connected across the line in series with a high resistance, 4, 15, 16, 2. Should the current fail while the plunger of D is drawn up, the plunger of N will catch that of D to prevent it from rotating the ratchet.

All the magnets are arranged so that after the stroke is partly completed, the current in the coil is reduced either by insertion of resistance or by shunting current around them. For instance, before the plunger of C moves the current passes through the resistance 18, 2 only, but after it has moved it passes through the additional length 12-18 and is, therefore, reduced in strength. By this means the magnet is operative over a very large voltage range; and is also protected from burn-out should the car remain under the trolley contactor. Magnet C is provided with a dash-pot, to retard its return motion and allow magnet D to act during the breaking of its circuit.

SUMMARY OF RECENT PROGRESS IN SIGNALING

BY A. H. RUDD.*

In the past five years electric traction has been rapidly developed, telephones have been substituted for telegraph in many sections, locomotives of higher power and cars of larger capacity and increased strength built, air brake efficiency improved, greater attention than ever before given to the manufacture of rails, the improvement of fastenings, preservation of ties, and the general betterment of the permanent way, but in no branch of railway engineering and operation, except in government regulations, has such a revolution been accomplished and such progress made as in the signaling of the trunk lines of America.

The development of the motor signal operating at low voltages, and particularly of the top-post mechanism applying the power directly at the point required, has enabled us to place our distant signals at a sufficient distance to give proper advance warning to approaching fast trains, while removing the danger of maladjustment inherent in the old wire-connected signals; while electric back locks insure against dangerous complications in the rare event of false clear failures. Approach locking insures against errors of practice, in the event of an attempt on the part of a signal operator to change a route after clear signals have been displayed. In the automatic field improved apparatus has reduced failures, and notably, the development of alternating-current apparatus has practically eliminated that class of false clear indications, due to stray currents closing the track relays (which are the basis of operation of all improved automatic work), at the same time providing more rugged mechanism, probably cutting down operating expenses considerably, if the same energy is used to operate and light signals, dispensing as it does with the care of oil lamps and storage or primary batteries.

The development of manual controlled block systems has enabled us to operate entirely by signal, without the use of train orders, on single track, with practically the same safety as is insured by the employment of the staff, or staff and tablet system, but without the delays made necessary by these cumbersome methods.

The perfecting of electric and electro-pneumatic interlocking has made possible the control of signals and switches a mile or more from the center of operation, and this has required in turn the development of electric route locking, so that not only are switches prevented from moving immediately under trains, but are locked by the approach of a train throughout its entire route to the next signal, and are released in turn immediately on its passage. If a signal is cleared for an eastbound train, the entrance of such a train upon such a route will hold all switches in front of it and release them as it passes, and the clearing of a signal for a westbound train will lock all switches in the route, and the train will release them in reverse order on its passage. This development has added tremendously to the safety of our large terminals, and, incidentally, as the track circuits are installed, they have been utilized to introduce the semi-automatic feature in terminal stations, by which all signals are restored to the normal position by the passage of the train, a still further safeguard, utterly out of all question ten years ago, and attempted with trepidation first, I believe, on the Pennsylvania some four years ago.

It is not my intention, however, to enlarge upon the engineering features of the profession, but rather to set forth a few of the problems involved in the indications to be given and the aspects to be displayed to the engineman.

The disk signal was the first type of automatic signal. Broadly, it consisted of two kinds, the simple magnet and

*Signal engineer, Pennsylvania Railroad. From a paper recently read before the Canadian Railway Club, Montreal.