battery 0.010 amp.; occupied, current from battery 0.015 amp. Three Columbia high-voltage cells are on this circuit.

Track circuit "B": Unoccupied; voltage at battery terminals 0.71; current from battery 0.016 amp.; occupied, current from battery 0.068 amp. Three standard-voltage primary cells are on this circuit.

The advantages of using the rectifiers are relative. To be of value these automatic rectifiers must reduce track-circuit operation costs sufficiently to more than pay for the interest and depreciation charges on the investment cost. Offhand, it does not appear that we can afford to spend very much money for a rectifier for the average track circuit, because the annual cost of operating the circuit direct from primary battery is relatively small. Therefore, the reduction in dollars and cents is comparatively small.

Economy in Operation of Track Circuits

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Continuous automatic train control is in service on 511 mi. of double-track line on the Chicago & North Western between Council Bluffs, Iowa, and Chicago. The track circuits in this territory are direct current, with low-voltage 60-cycle alternating current superimposed for train-control purposes, of which Fig. 1 shows a typical circuit. In that portion of the territory between Council Bluffs and Clinton, Iowa, the train control was installed with track circuits fed by primary battery. However, in the section between Clinton and Chicago, floating storage battery was used for the d-c. track circuits.

In the storage-battery district it was thought necessary to provide two cells of storage battery, connected in multiple, as insurance against possible false-clear indications from the pulsating current of the rectifier, in case a battery jar should happen to break. It was thought unlikely that both jars would be broken at the same time. This circuit is illustrated in Fig. 2.

When the Bettison track-circuit feed, using a rectifier across a set of primary cells, as shown in Fig. 3, was developed, it was found to be especially suitable for use in this train-control territory. The fact that the half-wave rectifier unit could be fed from the track transformer, which is used to feed the train control current to the track, eliminated the objection to the use of a rectifier in connection with the d-c. track circuits, because the rectifier is in use only when the alternating current is applied to the track, that is, when the block is clear.

The greater portion of the track circuits in the territory between Council Bluffs and Boone, Iowa, have gravel ballast and require five or six primary cells in multiple, for good operation. A few track circuits in this district were equipped according to the Bettison scheme and rendered satisfactory operation. It was then decided to apply this scheme to a 10-mile section including 43 track circuits. On the track circuits in this test section the number of primary cells was reduced to two, except on the track circuits operating highway-crossing protection and at interlocking plants, which were left as they originally were to assure proper operation in case of an interruption of the a-c. feed to the track. It should be understood that all trains operate under continuous speed control with cab signals, and as there are no roadside block signals, the d-c. track circuits, in general, are for the purpose of controlling the a-c. train-control circuits only.

The addition of these rectifiers, with adjustments of the train-control track circuits, resulted in an addition of only approximately 16 watts to the load on the train-control power line in this test section. The application of this scheme indicated an improvement in the power-factor characteristics of the power line, which was further improved by the installation of capacitors.

At the time the installation was made, the track ballast was moist, owing to recent rains, and it was thought best to adjust the circuits to allow the primary battery to discharge at 20 to 30 m.a., with the track circuits unoccupied. This arrangement eliminated the necessity for considerable re-adjustment during dry-weather periods. A comparison of the number of primary-battery renewals required before and after the change, indicated that approximately 5.5 renewals are being saved per track circuit annually, on this particular section. Giving consideration to the labor saved and deducting the cost of power, the annual saving per track circuit is found to be approximately $10.

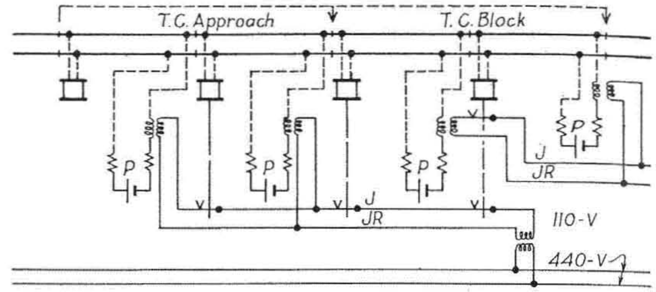

Fig. 1

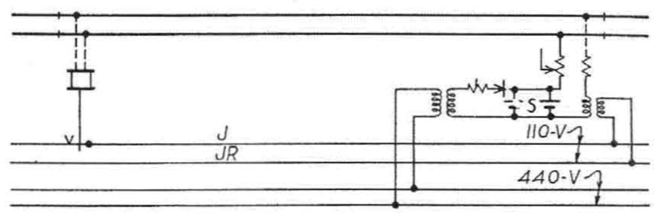

Fig. 2

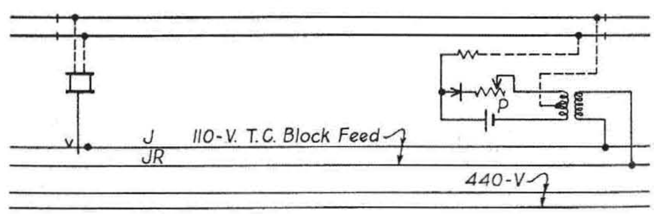

Fig. 3

Fig. 1. Typical wayside train-control circuits on the C. & N.W.
Fig. 2. Track circuit with floated storage battery
Fig. 3. Bettison floating primary battery arrangement

The results obtained from this primary-battery circuit proved so satisfactory that we have decided, eventually, to equip the remaining primary-battery fed track circuits in this territory, and the same system will be extended on the Clinton to Chicago territory, when the storage batteries on the track, which are approaching the end of their guaranteed life, are due for replacement. It was found that the Bettison primary-battery circuit could be installed for approximately what it would cost to replace the two cells of storage battery on each track circuit.

The change has also resulted in considerable reductions in our power bills where entire sections have been equipped, because of better power-factor characteristics. Also the train-control system is safeguarded because in emergencies longer power-feed sections are practical.