# An Improved Track Circuit for Light-Weight Equipment

## Peak voltage of half-wave rectifier utilized to effect shunt under adverse rail conditions

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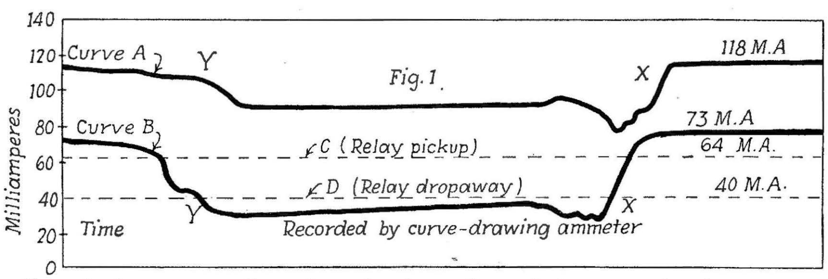
AN IMPROVED track-circuit arrangement has recently been developed on the New York Central to provide greater safety and reliability for use on steam railroads. The track circuit, while a basic and essential part of the signal system, is subject, under unfavorable conditions, to greater variation in its margin above reliable working than any other circuit used in signaling.




Record of current readings through relay coils made by curve drawing ammeter—Curve-A made by battery fed circuit and Curve-B made by rectifier fed circuit

This is largely due to relatively low insulating resistance from rail to rail. This factor, which is known as the ballast resistance, varies widely on account of conditions of the weather, ties, drainage and ballast. The electrical leakage through the ballast, around broken rails and across insulated joints has forced the use of relatively low voltages, and has prevented the use of voltage and current values desirable for more positive train shunting and correct working of the track circuit relay.

### Reliable Operation Needed

These limitations tend toward a still lower factor of reliable operation where light equipment, such as gas-driven passenger cars, is operated, largely limiting the use of such cars in signal territory to rails kept bright by constant use. These characteristics have also, to an extent, restricted the use of track circuits on English and continental European railroads where the average equipment is much lighter than that used in regular service in North America.

The track-circuit problem has become more acute during the last few years on slightly-used branch lines and on some station tracks and switches on account of their less frequent use, permitting the rails to become rusty and the car-wheel shunts less reliable. On the other hand, economic conditions have caused the railroad managements to become more critical of derailments which may be caused by track-circuit failures. It has, therefore, been necessary to give greater study to the problem, and both railroad and signal company engineers have been working to improve the situation.

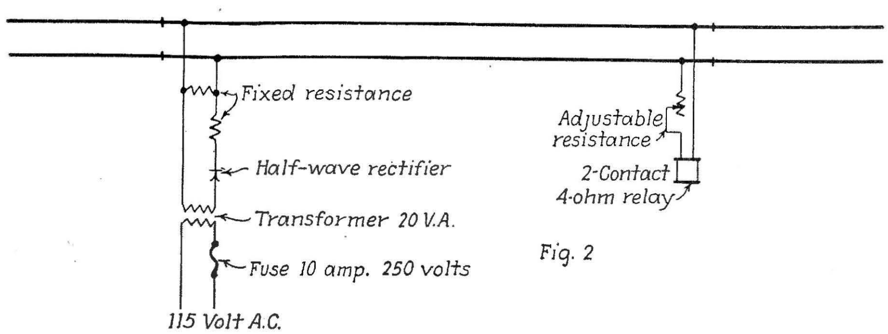
A solution of this problem, or at least a definite improvement, has been discovered by taking advantage of a high instantaneous voltage to establish current flow through the rail-wheel contact surfaces.

In making tests, in cases of trouble experienced with poor shunting, it was found that by inserting resistance in the relay leads, which required increased track voltage, a car-wheel shunt could be made more effective through a rusty rail surface. However, it was impractical to use higher track voltages where ballast resistance was low.

### Half-Wave Solves Problem

In seeking to avoid the objectionable results caused by higher track voltage, recourse was made to the use of a half-wave rectifier in the output of which the peak voltage was sufficient to establish the car-wheel shunt through the rusty rail surface, and the average voltage not sufficiently high to be objectionable. The instantaneous peak voltage impulses occur at frequencies corresponding to the cycle of the a-c. supply, and are several times higher than the voltage as read on a voltmeter. On account of the compensating feature of the circuit, a practically uniform track voltage between the rails and uniform current through the track relay is provided regardless of weather and ballast conditions. With this arrangement primary or storage battery must not be connected to the rail circuit.

Fig. 1 illustrates the greater reliability afforded by a track circuit energized from a half-wave rectifier without a battery connection as compared with the standard track circuit energized from primary battery or storage battery with the floating arrangement. Curves *A* and *B*, Fig. 1,




Circuit diagram of track circuit with half-wave rectifier feed were recorded by a curve-drawing ammeter from a test of an existing track circuit at a terminal interlocking where the rails, owing to their not being used constantly, are coated with rust.

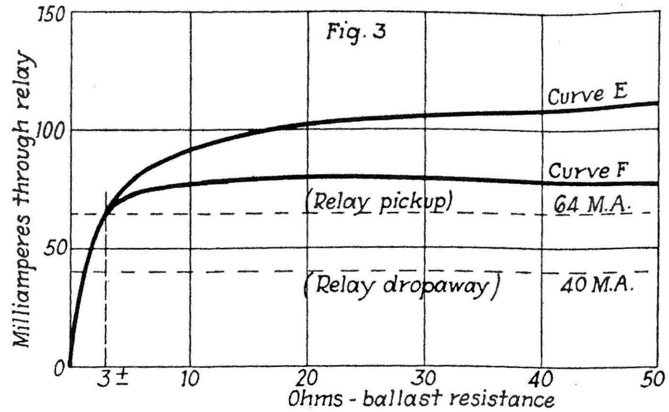
Curve *A* shows that with the standard battery-fed circuit in service there was sufficient current through the track relay to hold the relay contacts closed while the track was occupied by two pairs of car wheels. Curve *B* shows the same circuit operated from a half-wave rectifier connected as shown in Fig. 2. Curve *B* was recorded before curve *A*, so that the new arrangement would have the less favorable rail-rust conditions. In the diagram *X* and *Y* indicate when the car wheels passed on and off the track circuit. The horizontal portion between *X* and *Y*, of curves *A* and *B*, show where car wheels were stationary on the track circuit. Lines *C* and *D* indicate in vertical measurement the relay pick-up point (64 milliamperes) and the relay dropaway (40 milliamperes) of the track relay which is a two-contact, four-ohm relay of the improved type.

Curves *A* and *B*, Fig. 1, were taken under normal ballast conditions and indicate, at the right of the figure, the service current necessary through the relay under this condition to permit the track circuit to work properly with wet or dirty track, that is, low ballast-resistance conditions.

## Safer Operation

A considerable number of circuits, which would operate per curve *A* on various railroads, are protected by placing reminders or blocks on the switch levers to be locked by the track circuit. Instructions are posted that the levers so marked must not be operated until the leverman is assured, either by personal observation or by message, that a train has passed off the track circuit.

Curves *E* and *F*, Fig. 3, show the reason for the difference in normal service current as shown at ends of curves *A* and *B*. Curve *E* shows the degree that the current through the relay of a standard circuit increases from minimum ballast resistance to maximum ballast resistance, as the track ballast dries or is cleaned out. Curve *F* shows that the current through the relay of a circuit operated from a half-wave rectifier is more uniform with similar changes in ballast resistance.




Curves showing comparison of relay current and ballast resistance in typical track circuit

## Photographic Record

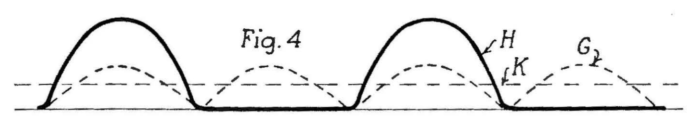
The curves on Fig. 4 were traced from actual photographs of the instantaneous lines as appearing on the screen of an oscillograph. Curve *G* shows the uniform sine curve as distorted by the full-wave rectifier to supply all current in one direction. Curve *H* shows the high instantaneous voltage which is produced by a half-wave rectifier when the transformer is adjusted so that the rectifier will give the same average voltage (Line *K*) as a full-wave rectifier or a battery operating the track circuit.

The half-wave rectifier track circuit is applicable where emergency ac. energy can be instantly provided to take over the track-circuit load automatically in case of a momentary failure of commercial current, as at a terminal interlocking. It is also applicable where the momentary failure of the track circuit is less objectionable than the possibility of the track circuit being improperly energized, as at an automatic highway-crossing-signal installation. At such a point the operation of the highway signal unnecessarily for a short time would not be as objectionable as the failure of the signal to operate with a light car or train approaching the crossing.

## Application of Principle

The use of this type of track circuit would not be practicable for the control of an automatic signal system without emergency apparatus to assure track circuits being at all times supplied with electric current. This condition is readily overcome at an interlocking by providing a small d-c.—a-c. dynamotor to be operated from the signal station standby battery. The saving in installation, maintenance and operating costs of individual track batteries are in excess of the cost of emergency apparatus, thereby effecting an economy in favor of the more reliable track circuit. An equivalent system may be provided for automatic signaling by extending the emergency supply throughout the territory.

The present standard track circuits are generally sufficiently reliable for automatic signaling on American railroads where the rails are bright and traffic is heavy enough to justify the maintenance of signals. It is likely that the arrangement here described will be useful in countries where the installation of automatic signaling has lagged on account of the unreliability of the track circuit for the weight of equipment in general use. The proposed track circuit may be used to provide more reliable shunting where rubber-tired equipment, using brushes to establish rail contact, is to be operated.




Curves traced from oscillogram showing instantaneous values of current output

The track-circuit arrangement, with the half-wave rectifier, was conceived and developed by F. X. Rees, circuit engineer. After preliminary field work in connection with trouble experienced from rusty rail on batfed circuits, the problem was transferred to the laboratory, and the principles developed on an artificial track circuit. Tests were then conducted in the field on track circuits, where rust conditions were severe, and the conclusions reached were checked and corroborated by W. B. Nicol, signal inspector.