

Sept. 1, 1942.

A. J. SORENSEN

2,294,485

RAILWAY TRACK CIRCUIT APPARATUS

Filed Oct. 26, 1940

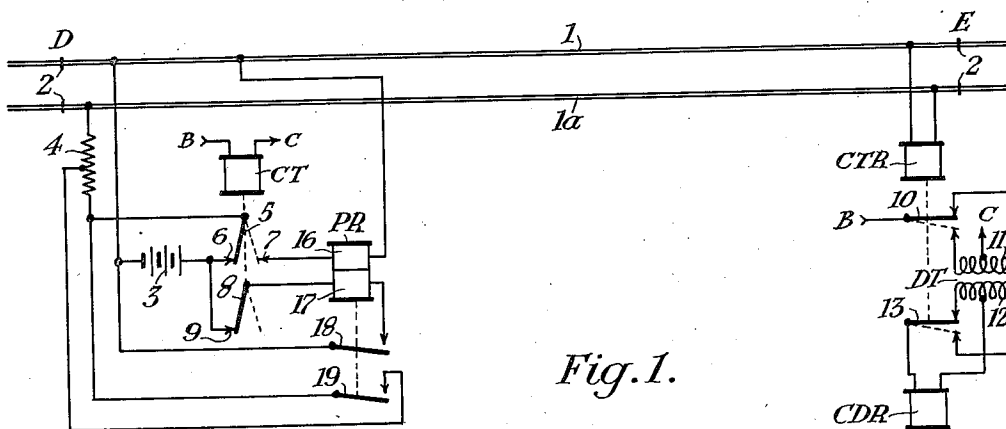


Fig. 1.

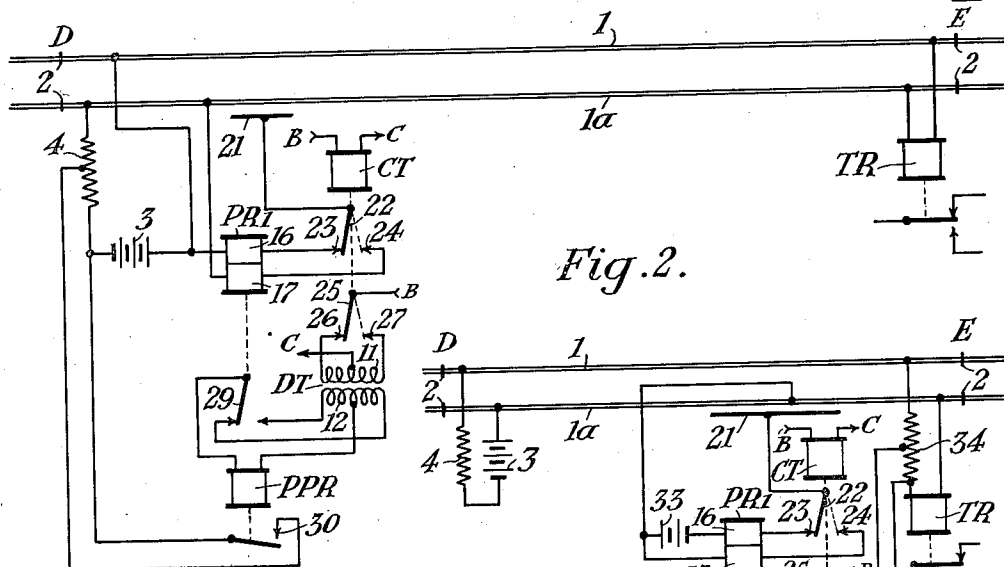


Fig. 2.

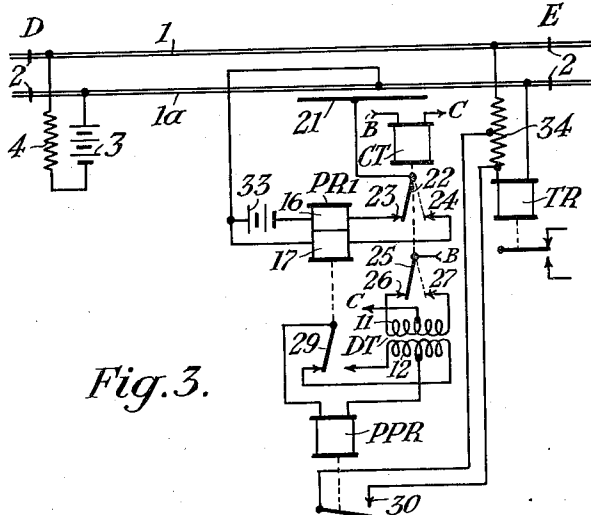


Fig. 3.

INVENTOR
Andrew J. Sorensen
BY *W. H. Wood*
HIS ATTORNEY

UNITED STATES PATENT OFFICE

2,294,485

RAILWAY TRACK CIRCUIT APPARATUS

Andrew J. Sorensen, Edgewood, Pa., assignor to
The Union Switch & Signal Company, Swiss-
vale, Pa., a corporation of Pennsylvania

Application October 26, 1940, Serial No. 362,996

17 Claims. (Cl. 246—34)

My invention relates to railway track circuit apparatus; and it has particular reference to the organization of such apparatus into railway track circuits incorporating means for regulating or adjusting the energization of track circuits in accordance with variations in ballast resistance.

In order to obtain proper operation of a railway track circuit, it is essential that the usual track relay connected to the rails at one end of an insulated section of track be energized at a value sufficient when the section is unoccupied to enable the relay to pick up. It is likewise essential that the energization of the relay be maintained within the limits which enable a train or vehicle occupying the section to shunt away from the relay a sufficient proportion of the track circuit current to reduce the energization of the relay to a point below its drop-away energy level. Thus, improper operation of a track circuit may result if the normal holding current is too high to permit effective shunting of the track relay, or if the current is too low to pick up and hold up the track relay when the section is unoccupied.

It is evident from a consideration of the above requirements that the usual variations in track ballast resistance encountered in practice, due primarily to differences in moisture content of the ballast caused by atmospheric conditions, may cause improper operation of a railway track circuit unless there is provided means for compensating the current ordinarily shunted away from the track relay through the ballast when the resistance of the ballast is low. For example, if a track circuit is adjusted to energize the track relay properly when the ballast is relatively wet, the proportion of current leaking across the ballast and hence shunted away from the relay under such conditions may be of such magnitude that when the ballast dries out and the proportion of current leaking through the ballast is greatly reduced, the relay may become over-energized and thus prevent a train in the section from effectively shunting the relay. Similarly, if the circuit is adjusted to permit shunting under dry ballast conditions, the current available to energize the relay under wet ballast conditions may be insufficient to pick up such relay.

I am aware that it has been proposed heretofore to control the energization of track circuits through the medium of relays or other control means connected in circuit, usually through ground rails or conductors, with representative portions of the track ballast and arranged to re-

spond to variations in current flow in the adjusting relays caused by variations in resistance of the track ballast. I propose, however, to utilize the so-called "storage current" in the track rails and ballast of a section to control the energization of the track circuit. This storage current is built up in the track rails and ballast due to the supply thereto of track circuit current, and the magnitude of current so built up over a predetermined short period of time is a function of track ballast resistance, increasing in magnitude when the ballast resistance decreases and decreasing when the ballast dries out to increase in resistance. Under certain conditions, particularly in coded track circuits, this storage current is undesirable and may cause improper operation of a track circuit by discharging through the track relay during the "off" periods of the coded track circuit current to hold up the track relay for an appreciable length of time. Coded track circuits heretofore proposed have therefore incorporated means for discharging the storage current away from the track relay by shunting the track rails during the "off" period of the code. My invention contemplates discharging the storage current from the track rails during the "off" periods of the track circuit code, and it provides means responsive to the magnitude of the discharged storage current to adjust or compensate the energization of the track relay for changes in resistance of the track ballast.

In view of the foregoing considerations, it is an object of my present invention to control or adjust the energization of a track circuit in accordance with the magnitude of storage current in the rails and ballast of the circuit.

Another object is to regulate or control the energization of a track circuit by novel and improved means utilizing energy stored in the rails and ballast of the circuit.

A further object is to provide novel and improved means for regulating or controlling the energization of a track circuit and a track relay.

Another object is to improve the operation of coded track circuits.

The above-mentioned and other important objects and characteristic features of my invention which will become readily apparent from the following description, are attained in accordance with my invention by intermittently impressing a source of current across a portion at least of the ballast of a track circuit and by utilizing means responsive to energy stored by the source in the trackway for controlling the energization of the track circuit. In certain forms of my in-

vention hereinafter described, the regulating apparatus is arranged to respond only to current stored in the trackway, while in other forms of my invention the regulating apparatus responds in part to current stored in the trackway and in part to current leaking across the ballast.

I shall describe three forms of apparatus embodying my invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a diagrammatic view illustrating a preferred form of apparatus embodying my invention. Figs. 2 and 3 are diagrammatic views illustrating modified forms each also embodying my invention, of the apparatus represented in Fig. 1. Similar reference characters have been employed in each view to designate corresponding parts.

Referring to Fig. 1, the reference characters 1 and 1a designate the track rails of a stretch of railway track divided by insulated joints 2 into a track section D—E. Section D—E is provided with a track circuit comprising a suitable source of track circuit current, such as a battery 3, intermittently connected through the usual current limiting resistor 4 to the rails at one end of section D—E at such times as contact 5—6 of a coding device CT, to be referred to hereinafter, is closed; and a code following track relay designated by the reference character CTR, connected to the rails at the other end of the section.

The reference character CDR designates a control relay associated with relay CTR and energized in the usual manner through a decoding transformer DT whenever relay CTR, in response to coded current received from the track rails, operates its contact 10 to supply unidirectional current from a suitable source, such as a battery not shown but having its terminals designated by the reference characters B and C, alternately to first one and then the other portion of a center-tapped primary winding 11 of transformer DT. Relay CDR has one terminal connected to a center-tap of winding 12 of transformer DT and has its other terminal connected through contact 13 of relay CTR to first one and then the other portion of winding 12, whereby substantially unidirectional current is supplied to relay CDR when relay CTR is following code, due to the action of contact 13 of relay CTR rectifying the alternating current induced in winding 12.

The code transmitter or coder CT may be of any suitable type and is represented conventionally in the drawing as comprising a constantly energized operating element controlling two movable members 5 and 8 alternately to an extreme left-hand position, in which they are illustrated in the drawing, and to an extreme right-hand position indicated by a dotted line in the drawing. In the left-hand position of member 5, contact 5—6 is closed to complete an easily traced circuit which connects battery 3 to the rails of section D—E, this circuit passing from one terminal of battery 3 to rail 1 and from the other terminal of the battery through contact 6—5 of coder CT and resistor 4 to the other rail 1a. As will be made clear presently, battery 3 at times is connected to the track rails through only a portion of resistor 4, thereby permitting the energization of the track rails to be increased to compensate for excessive ballast losses when conditions are such that such excessive losses exist.

The reference character PR designates a two-winding compensating relay which at times com-

pletes at its front contact 19 an obvious shunt path around a portion of resistor 4 whereby the energization of the track circuit of section D—E is adjusted in response to variations in the track ballast resistance. This control of the energization of the track circuit of section D—E is effected by connecting one winding 16 of relay PR across the rails of section D—E at such times that contact 5 of coder CT is in its right-hand position wherein contact 5—7 is closed, the circuit connection of winding 16 passing from rail 1a through resistor 4, contact 5—7 of coder CT and winding 16 of relay PR to rail 1. It follows that winding 16 of relay PR is energized by current stored in the rails and ballast of section D—E, inasmuch as this winding is connected to the rails only when contact 5—6 of coder CT is open to disconnect battery 3 from the rails. When relay PR picks up due to the effective energization of winding 16 by storage current in the section, front contact 19 closes to complete the previously mentioned shunt path around a portion of resistor 4, and front contact 18 also closes to prepare for the other winding 17 of relay PR an energizing circuit completed when contact 8—9 of coder CT closes, this circuit path passing from one terminal of battery 3 through contact 8—9 of coder CT, winding 17 of relay PR and its front contact 18 to the other terminal of the battery.

I shall assume that the apparatus of Fig. 1 is in its normal condition as represented in the drawing when the ballast resistance of section D—E is relatively high. In this condition of the apparatus, relay CDR is energized in response to operation of relay CTR by coded current supplied from battery 3 to the rails of the section over intermittently closed contact 5—6 of coder CT. Relay PR is, however, deenergized since under the assumed ballast conditions, the storage current built up in the rails and ballast of the section each time contact 5—6 of coder CT closes to connect battery 3 to the track rails, is insufficient in magnitude to pick up relay PR when contact 5—7 of coder CT connects winding 16 to the track rails. The entire resistor 4 accordingly is effective to limit the current supplied from battery 3 to the track rails to its normal value sufficient to pick up relay CTR under the assumed ballast conditions but enabling a train in the section to establish an effective shunt on the relay.

If, however, the ballast conditions change and the resistance of the ballast decreases, the magnitude of storage current built up in the track rails increases. Preferably, winding 16 is proportioned to create in relay PR its pick-up energy level only when relatively low resistance ballast conditions exist in section D—E so that the proportion of current leaking across the ballast causes the amount of energy available to energize relay CTR to be reduced to a value only slightly above that required to pick up relay CTR, and under such assumed ballast conditions, the intermittent supply of current to the rails of section D—E over contact 5—6 of coder CT causes energy stored in the rails and ballast of the section to reach a value sufficient to effectively energize relay PR. When relay PR picks up due to storage current received from the rails of section D—E, front contact 19 closes to shunt a portion of resistor 4 and thereby increase the energization of section D—E to compensate for the current shunted from the track relay CTR due to the relatively low track ballast resistance. Front

contact 18 of relay PR also closes to prepare the previously mentioned circuit for its other winding 17, which winding becomes energized in multiple with the track rails when coder CT reverses to disconnect winding 16 from and connect battery 3 to the track rails. Relay PR remains energized due to the alternate energization of its two windings until such time as the ballast conditions change and the storage current in the section decreases in value to such an extent as to be insufficient to effectively energize winding 16. When this happens, relay PR releases to open its front contacts 18 and 19, the former contact opening the energizing circuit of winding 17 and the latter contact opening the previously mentioned shunt path around a portion of resistor 4.

From the foregoing, it is evident that I have provided novel means for regulating the current supplied to a track circuit in such manner that under dry ballast conditions the current is limited to a value that permits effective shunting of the track relay and under wet ballast conditions the current is increased to insure sufficient current to pick up the track relay despite relatively large current losses through the ballast. It is further apparent that the regulating means is operative in response to storage current in the track rails and ballast of the section, and functions not only to regulate the energization of the track circuit but also to discharge the storage current during the "off" periods of the trackway code.

A modified arrangement of the apparatus of Fig. 1 is shown in Fig. 2, wherein track battery 3 is constantly connected to the track rails and is intermittently impressed across a portion of the track ballast through the medium of an auxiliary rail or ground conductor 21.

Referring now to Fig. 2, battery 3 is constantly connected to the rails at one end of section D—E over an obvious circuit including resistor 4, and a track relay TR is connected to the rails at the other end of the section. In contact with the ballast of the section is conductor 21, which preferably is a scrap rail of suitable length spiked to the same ties which support rails 1 and 1a, in a manner to simulate as closely as possible the type of junction which exists between rails 1 and 1a and the supporting ties and ballast. That is, the connection of conductor 21 with the ballast is such that a given length of this conductor will have a resistance to ground approximately the same value as that existing between the ground and a corresponding length of either rail or 1 or 1a. It is to be understood, of course, that while a scrap rail is to be preferred, any suitable bared conductor, such, for example, as a copper or iron wire making contact with the ballast through the ties, or in any other suitable manner, may be used as the auxiliary or ground conductor 21.

The conductor 21 may be located on the outside of either rail 1 or 1a, or may be located between the two rails 1 and 1a, experience indicating that the particular location of the conductor is relatively unimportant since it appears that the major portion of the track ballast resistance is apparently concentrated in a comparatively thin film which forms the junction between a rail and its supporting ties, as well as, to some extent, in a second film at the area of contact of a tie with the ballast in which it is imbedded. As shown, conductor 21 is located on the outside of rail 1a.

Coder CT intermittently impresses battery 3 across a portion of the ballast of section D—E

when contact 22—23 of the coder is closed, over a circuit passing from one terminal of battery 3 through resistor 4, rail 1a, intervening ballast, conductor 21, contact 22—23 of coder CT and winding 16 of relay PR to the other terminal of battery 3. In this position of coder CT, energy stored in rail 1, conductor 21 and the intervening ballast also is supplied to winding 16 of relay PR over an obvious circuit which may be traced from conductor 21 through contact 22—23 of coder CT, winding 16 of relay PR, rail 1 and intervening ballast to conductor 21. The battery 3 is impressed across another portion of the ballast when contact 22—24 of coder CT closes to complete a circuit extending from battery 3 through resistor 4, rail 1a, winding 17 of relay PR, contact 24—22 of coder CT, conductor 21, intervening ballast, and rail 1 to the other terminal of battery 3; and when contact 24—22 of coder CT is closed, current stored in rail 1a, conductor 21 and the intervening ballast is supplied to winding 17 over an obvious circuit which extends from rail 1a through winding 17 of relay PR, contact 24—22 of coder CT, conductor 21 and intervening ballast to rail 1a.

Relay PR of Fig. 2 is provided with a polar contact member 29 which is operated to its left-hand position, in which it is illustrated in Fig. 2, when winding 16 of the relay is effectively energized and is operated to its right-hand position when winding 17 is effectively energized. When contact 29 is alternately operated by the two windings of relay PR, it functions to cause substantially unidirectional current to be supplied to a repeater relay PPR, which relay is energized through the medium of a decoding transformer DT which has its two portions of center-tapped primary winding 11 supplied alternately with unidirectional current through contacts 25—26 and 25—27 of coder CT, and which has its center-tapped secondary winding 12 connected to relay PPR by contact 19 of relay PR in an obvious manner such that the alternating current induced in winding 12 is supplied to relay PPR as substantially unidirectional current. Relay PPR when energized in response to the operation of relay PR, closes its front contact 30 to close an obvious shunt path around a portion of resistor 4 interposed between one terminal of battery 3 and rail 1a.

The windings 16 and 17 of relay PR of Fig. 2 are preferably so proportioned that under relative high resistance ballast conditions, the energization of the windings by the current leaking across the ballast between conductor 21 and rails 1 and 1a, respectively, is insufficient to cause contact member 29 to be operated. Under such assumed conditions, therefore, relay PPR is released and all of resistor 4 is effective to limit the energization of the track circuit. When, however, the ballast resistance decreases and the current leaking across the ballast correspondingly increases, more energy is stored in the rails, auxiliary conductor 21 and intervening ballast, and this increased storage current, together with the increased leakage current supplied through the ballast to windings 16 and 17 of relay PR causes relay PR to be effectively energized and operate its contact 29 to energize in turn relay PPR. Contact 30 of relay PPR accordingly picks up to close the previously mentioned shunt circuit around a portion of resistor 4 to increase the energization of the track circuit to compensate for the increased leakage current due to the lowered ballast resistance.

It is, of course, readily apparent that when the ballast dries out and the rail-to-rail ballast resistance increases, the leakage current and storage current both decrease, and when a predetermined ballast resistance is reached, the energization of relay PR1 again becomes ineffective to operate polar contact member 29 and relay PPR accordingly is released to interpose the full value of resistor 4 in circuit with battery 3 to limit the energization of the track circuit.

It follows from the foregoing that the apparatus of Fig. 2 may be adjusted in such manner that relay PR1 is caused to operate its polar contact member 29 when the increment of current supplied to windings 16 and 17 of the relay in response to energy stored in conductor 21, the ballast, and rails 1 and 1a, respectively, reaches a substantial value. This increment of current due to storage energy in the rails, auxiliary or ground conductor 21, and ballast cooperates with the leakage current through the ballast to cause operation of the control relay PR1, thereby enabling closer regulation of the track circuit energization to be maintained since operation of relay PR1 may if desired be effected prior to the ballast resistance condition being reduced to the value where leakage current alone causes such relay to operate.

In another modification of the apparatus of Fig. 1 represented in Fig. 3, an auxiliary battery 33 is intermittently impressed across a portion of the track ballast through ground conductor 21, and relay PR1 is arranged in such manner that one winding 16 responds to the leakage current between conductor 21 and the adjacent track rail 1a while winding 17 responds to current stored in rail 1a, conductor 21 and the intervening ballast.

Referring now to Fig. 3, battery 3 is shown constantly connected through resistor 4 to the rails at one end and relay TR is represented connected through a resistor 34 to the rails at the other end of section D-E.

Ground conductor 21 is represented located outside rail 1a adjacent the relay end E of the section, and an auxiliary battery 33 is intermittently impressed across the ballast between conductor 21 and rail 1a over a circuit including winding 16 of relay PR1 and extending from one terminal of battery 33 through rail 1a, intervening ballast, conductor 21, contact 22-23 of coder CT and winding 16 of relay PR1 to the other terminal of the battery when coder CT operates to open contact 22-23 and close contact 22-24, battery 33 is disconnected from conductor 21 and winding 17 of relay PR1 becomes energized by storage current over a circuit extending from rail 1a through winding 17 of relay PR1, contact 24-22 of coder CT, conductor 21 and intervening ballast to rail 1a. Relay PR1 and coder CT cooperate in controlling repeater relay PPR in a manner substantially similar to that explained in connection with the apparatus of Fig. 2, whereby relay PPR is energized and closes its front contact 30 to shunt a portion of resistor 34 when and only when relay PR1 causes its polar contact member 29 to operate.

The apparatus of Fig. 3 is arranged and proportioned in such manner that when the ballast is relatively dry so that its resistance is relatively high, the current leaking across the ballast from conductor 21 to rail 1a when contact 22-23 of coder CT is closed, is insufficient to effectively energize winding 16 of relay PR1. Under such assumed conditions, the energy stored in rail 1a,

conductor 21 and the intervening ballast is likewise ineffective to effectively energize winding 17 of relay PR1 when contact 22-24 of coder CT is closed. As a result, therefore, contact 29 of relay PR1 is inactive and relay PPR is released so that its front contact 30 is open and the full value of resistor 34 is effective to limit the energization of relay TR.

In the event that the resistance of the ballast decreases, a higher leakage current is permitted to flow between conductor 21 and rail 1a, and when the ballast resistance decreases to an extent such that the ballast losses become relatively large, the current leaking between conductor 21 and rail 1a also assumes a value sufficient when contact 22-23 of coder CT is closed to effectively energize winding 16 so that contact member 29 is operated to its left-hand position. With this large leakage current available, the energy stored in rail 1a, conductor 21 and the intervening ballast also assumes a value sufficient when contact 22-24 of coder CT closes, to effectively energize winding 17, thereby causing contact member 29 to swing back to its right-hand position. This operation of contact 29 of relay PR1 continues as long as the ballast resistance remains relatively low, and relay PPR accordingly is caused to pick up and close its front contact 30 to shunt a portion of resistor 34 and thereby increase the energization of relay TR to compensate for the relatively large leakage current losses through the ballast of section D-E due to the low resistance ballast conditions.

When the ballast again dries out and its resistance increases, the leakage current available for energizing winding 16, and the storage current available for energizing winding 17 of relay PR1, both decrease in value so that relay PR1 is ineffective to operate its contact member 29. Relay PPR accordingly is caused to release and its front contact 30 opens to render the full value of resistor 34 effective to limit the energization of relay TR and thereby compensate for the decreased leakage losses through the ballast of the section.

It is, of course, to be understood that the compensating apparatus of Fig. 3 may be employed at the battery end of the section to limit or increase the supply of energy supplied to the track rails of the section by opening or closing, respectively, a shunt path around a portion of resistor 4 interposed between battery 3 and one track rail. However, the use of the regulating apparatus at the relay end of the section enables the regulating action to be obtained while maintaining a relatively high energy level in the track rails at all times, this high energy level assisting a train or vehicle in the section in puncturing the rail film and establishing an effective train shunt.

From the foregoing description of the operation of the apparatus of Figs. 1, 2 and 3, it is readily apparent that I have provided means for regulating the energization of track circuits in response to energy stored in the rails and ballast of the section. In Fig. 1, the regulating apparatus is controlled solely in response to the magnitude of the energy stored in the track circuits; in Fig. 2 the regulating apparatus is arranged to respond to the increment of current added by the stored current to the current leaking across the ballast; while in Fig. 3 the regulating apparatus responds alternately to leakage and to storage current, each form of current being required for operation of the regulating apparatus.

Although I have herein shown and described only three forms of track circuit apparatus embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination with a stretch of railway track supported on ballast and provided with a track circuit comprising a track relay connected to the rails of the track, a source of electrical energy, means for intermittently impressing said source across a portion at least of the track and ballast of said stretch, and means responsive to energy derived from said source and stored in said track and ballast for varying the energization of said track circuit.

2. In combination with a stretch of railway track supported on ballast and provided with a track circuit comprising a track relay connected to the rails of the track, a source of electrical energy, means for intermittently impressing said source across a portion at least of the track and ballast of said stretch, and means operable by energy caused to be stored in said track and ballast in response to the supply thereto of energy from said source for varying the energization of said track circuit.

3. In combination with a stretch of railway track supported on ballast and provided with a track circuit comprising a track relay and a track circuit source of energy connected respectively to the rails of said track, means responsive to energy caused to be stored in said track and ballast by the supply of energy from said source to the track rails, and other means controlled by said first-mentioned means for varying the energization of said relay by said source.

4. In combination, a stretch of railway track supported on ballast and provided with a track circuit comprising a track relay and a track circuit source of electrical energy connected respectively to the rails of said stretch, and means connected to the rails of said stretch and responsive to energy caused to be stored in said track and ballast by the supply to the rails of energy from said source, for varying the energization of said track relay.

5. In combination, a stretch of railway track supported on ballast and provided with a track circuit comprising a track relay and a track circuit source connected respectively to the rails of said track, control means responsive to energy stored in said track and ballast by the supply of current to the rails of said track, and other means controlled by said control means for varying the energization of said track circuit.

6. In combination, a stretch of railway track supported on ballast, a track relay connected to the rails of said track, a source of current intermittently connected to said rails, control means connected to said rails during the intervals that said source is disconnected therefrom and responsive to energy stored in the rails and ballast of said track, and means governed by said control means for varying the energization of said track rails.

7. In combination, a stretch of railway track supported on ballast, a track relay connected to the rails of said track, a source of current, a coding device alternately connecting said source to and disconnecting it from said track rails for supplying coded current to said track relay, an-

other relay connected by said coding device to said track rails during the intervals that said source is disconnected from said rails, and means controlled by said other relay in response to energy stored in said track and ballast for controlling the magnitude of energization of said track rails.

8. In combination, a stretch of railway track supported on ballast, a track relay connected to the rails of said track, a source of current and another relay, a coding device, means controlled by said coding device for alternately connecting first said source and then said other relay to said rails, said other relay responding to energy caused to be stored in the track and ballast when said source is connected to said rails, and means controlled by said other relay for varying the current supplied from said source to the track rails.

9. In combination, a stretch of railway track supported on ballast, a track relay connected to the rails of said track, a source of current and a two-winding relay, a coding device, means controlled by said coding device for alternately connecting first said source and then one winding of said two-winding relay to said rails, other means controlled by said coding device and including a front contact of said two-winding relay for energizing the other of its two windings during the intervals that said one winding is disconnected from said rails, and means controlled by said two-winding relay for adjusting the current flow from said battery to the track rails in accordance with track ballast conditions.

10. In combination, a stretch of railway track supported on ballast, a track circuit for said stretch comprising a track relay and a current source connected respectively to the rails of said track, means for intermittently impressing said source across a selected portion of the rails and ballast, control means responsive to energy stored in said selected portion of the rails and ballast, and means controlled by said control means for varying the energization of said track rails.

11. In combination, a stretch of railway track supported on ballast, a track circuit for said stretch comprising a track relay and a current source connected respectively to the rails of said track, a coding device, an auxiliary conductor in contact with said ballast, means controlled by said coding device for intermittently connecting said source across said auxiliary conductor and at least one of said track rails, and means responsive to current caused to be stored in said track and ballast by said intermittent connection of said source for varying the energization of said track circuit.

12. In combination, a stretch of railway track supported on ballast, a track circuit for said stretch comprising a track relay and a current source connected respectively to the rails of said track, a coding device, an auxiliary conductor in contact with said ballast, means controlled by said coding device for intermittently connecting said source across said auxiliary conductor and at least one of said track rails, another relay intermittently connected across said auxiliary conductor and said one track rail during the intervals that said source is disconnected therefrom and responsive to current caused to be stored in said track and ballast by said intermittent connection of said source, and means controlled by said other relay for controlling the energization of said track circuit.

13. In combination, a stretch of railway track

supported on ballast, a track circuit for said stretch comprising a track relay and a current source connected respectively to the rails of said track, a coding device, an auxiliary conductor in contact with said ballast, means controlled by said coding device for intermittently impressing an electromotive force across said auxiliary conductor and at least one of said track rails, another relay connected by said coding device across said auxiliary conductor and said one track rail and responsive to current caused to be stored in said track and ballast by said intermittent impression of said electromotive force, and means controlled by said other relay for controlling the energization of said track circuit.

14. In combination, a stretch of railway track supported on ballast, a track circuit for said stretch comprising a track relay and a current source connected respectively to the rails of said track, an auxiliary conductor in contact with said ballast, a coding device, another source of current and another relay, means controlled by said coding device for alternately connecting said other source and said other relay across said auxiliary conductor and at least one of said track rails, and means controlled by said other relay for controlling the energization of said track circuit.

15. In combination, a stretch of railway track supported on ballast, a track circuit for said stretch comprising a track relay and a current source connected respectively to the rails of said track, an auxiliary conductor in contact with said ballast, a coding device, two contacts alternately closed by said device, another source of current and a two-winding relay, a circuit completed through one of said contacts for connecting said other source in series with one winding of said two-winding relay across said auxiliary conductor and one of said track rails, a circuit completed through the other of said contacts for connect-

ing the other winding of said two-winding relay across said auxiliary conductor and said one track rail, and means controlled by said two-winding relay for varying the energization of the track relay in accordance with track ballast conditions.

16. In combination, a stretch of railway track supported on ballast, a track relay connected to the rails of said track in a track circuit including a source of track circuit energy, a contact operating device, two contacts recurrently closed alternately by said device, a first circuit including a source of energy and one contact of said device for impressing energy across a portion at least of the track and ballast of said stretch, a control relay connected across the track and ballast of said stretch over a circuit including the other contact of said device, said control relay being responsive to energy caused to be stored in such track and ballast when said first circuit is completed, and means governed by said control relay for varying the energization of said track relay by energy from said track circuit source.

17. In combination, a stretch of railway track supported on ballast, a track relay connected to the rails of said track in a track circuit including a source of track circuit energy, a contact operating device, two contacts periodically closed alternately by said device, a first circuit connected across a portion at least of the track and ballast of said stretch for impressing energy on said portion of the track and ballast, a control relay connected across said portion of the track and ballast over a circuit including the other contact of said device, said control relay being responsive to energy caused to be stored in said portion of the track and ballast when said first circuit is completed, and means controlled by said control relay for governing the magnitude of energy received by said track relay from said track circuit source.

ANDREW J. SORENSEN.