Nov. 26, 1940. A. J. SORENSEN 2,222,804

RAILWAY SIGNALING APPARATUS

Filed April 29, 1939 2 Sheets-Sheet 1

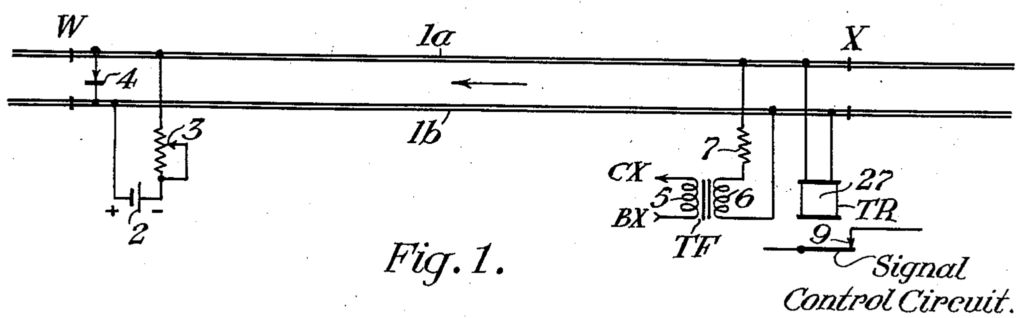

Fig. 1.

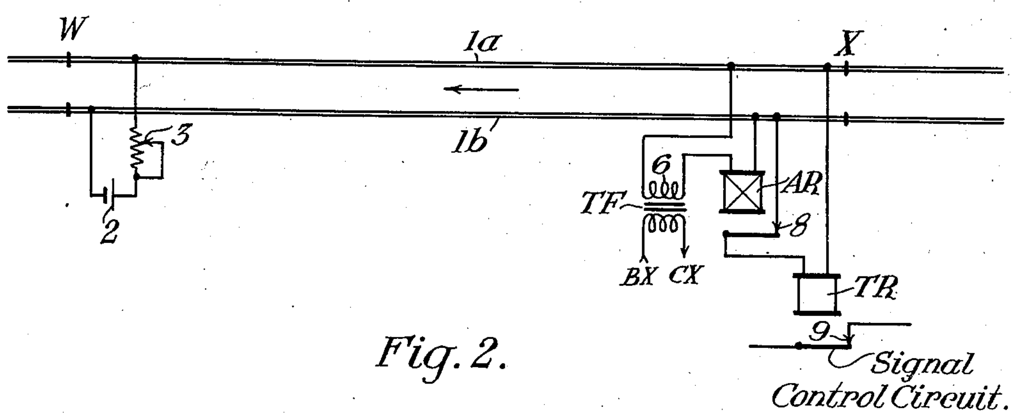

Fig. 2.

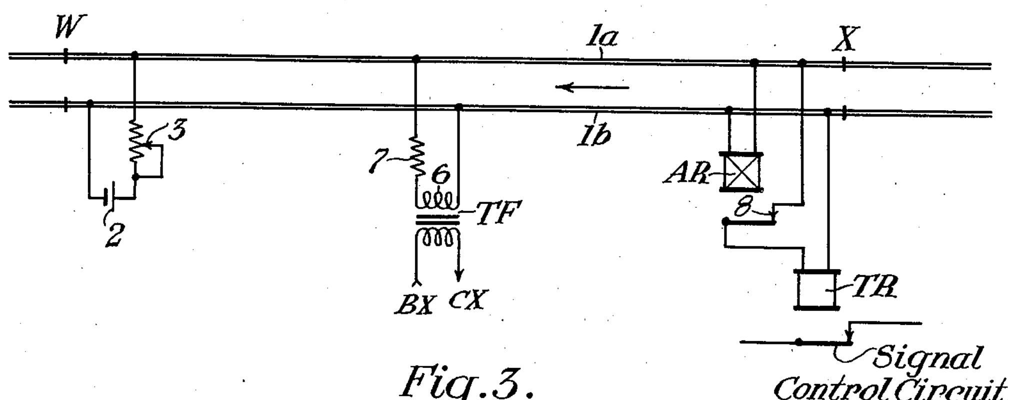

Fig. 3.

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RAILWAY SIGNALING APPARATUS

Filed April 29, 1939 2 Sheets-Sheet 2

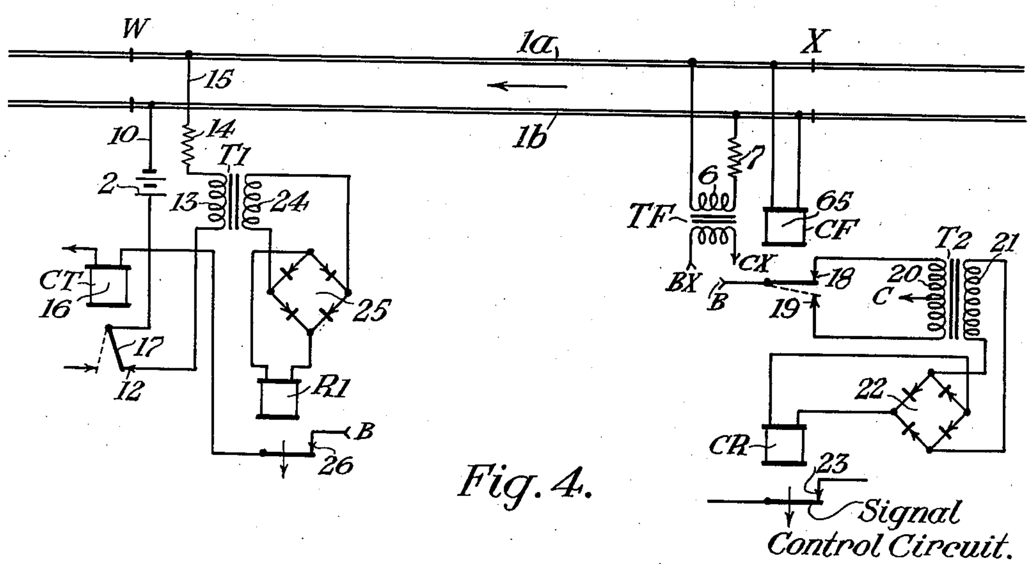

Fig. 4.

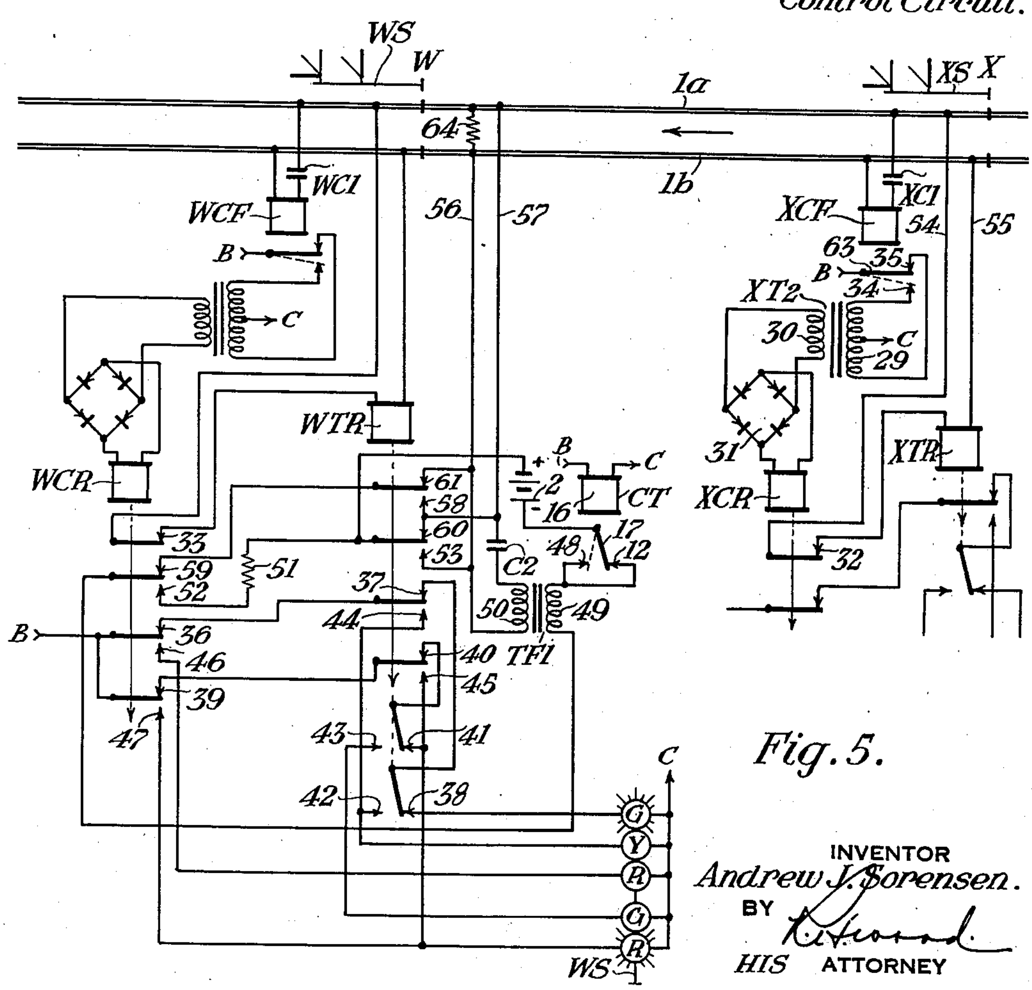

Fig. 5.

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UNITED STATES PATENT OFFICE

2,222,804

RAILWAY SIGNALING APPARATUS

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Application April 29, 1939, Serial No. 270,819

11 Claims. (Cl. 246—41)

My invention relates to railway signaling apparatus, and more specifically to railway track circuit apparatus.

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

A feature of my invention is the provision of novel and improved means for a track circuit of an insulated track section wherewith a substantially uniform voltage throughout the track section is obtained, and improved shunting sensitivity of the track circuit provided while the amount of power consumed due to leakage is relatively low. Another feature of my invention is the provision of novel and improved means for a track circuit of an insulated track section for applying to the track rails an electromotive force having two predetermined components to a particular one of which a track relay is responsive and the other of which is effective to break down the wheel-rail contact resistance when the section is occupied and a low resistance train shunt is assured. Again, a feature of my invention is the provision of novel and improved apparatus of the type here involved for control of signals of a wayside signal system. Other features and advantages of my invention will appear as the specification progresses.

In the accompanying drawings, Figs. 1, 2, 3 and 4 are diagrammatic views of four different forms of track circuit apparatus embodying my invention. Fig. 5 is a diagrammatic view of another form of track circuit apparatus embodying my invention when used with a three block four indication wayside signal system.

In each of the several views, like reference characters designate similar parts.

Referring to Fig. 1, the track rails 1a and 1b of a stretch of railway over which traffic normally moves in the direction indicated by the arrow are formed by the usual insulated rail joints with a track section W—X which section is provided with a track circuit having trackway sources of power connected across the rails at predetermined points in the section. A track battery 2 is connected across the rails at the exit end of section W—X over a resistor 3, the polarity of battery 2 being predetermined as indicated by the plus and minus signs. A track transformer TF whose primary winding 5 is constantly supplied with alternating current from any convenient source whose terminals are indicated as BX and CX has a secondary winding 6 connected across the rails at the entrance end of section W—X, a current limiting resistor 7 being preferably interposed in the connection. The alternating current supplied through the medium of track transformer TF may be of any convenient frequency such as the usual commercial frequency of 60 cycles per second, or it may be of the frequency of 100 cycles per second such as commonly used in railway cab signaling systems.

An asymmetric unit 4, such as, for example, a copper oxide rectifier unit, is connected across the rails at the exit end of the section W—X, the unit 4 being disposed with its high resistance direction to oppose the flow of current from track battery 2.

The track relay for the track circuit for section W—X is a direct current neutral relay TR whose operating winding 27 is connected across the rails at the entrance end of the section.

The electromotive forces created between the rails of section W—X by track battery 2 and track transformer TF produce a resultant electromotive force which at any given instant is the vector sum of the two. That is, the resultant electromotive force contains two components one predetermined by the power supplied by battery 2 and the other predetermined by the power supplied by transformer TF.

The electromotive force across the rails as effected by battery 2 is a maximum at the exit end of the section, gradually decreases and is of a minimum value at the entrance end of the section, whereas the electromotive force across the rails as effected by transformer TF is of a maximum value at the entrance end of the section, gradually decreases and is of a minimum value at the exit end of the section. As stated hereinbefore, the resultant electromotive force between the rails at any point in the track section is the vector sum of these two electromotive forces. The two sources of power, track battery 2 and track transformer TF, are so proportioned that such resultant electromotive force has a substantially uniform value throughout the track section, this resultant electromotive force having a recurrent maximum or peak value because of the alternating current component. The current sources are further so proportioned as to produce a resultant electromotive force of relatively high peak value.

The track relay TR which is a direct current relay is effectively energized only in response to the unidirectional component of the resultant electromotive force between the rails. Thus, the track relay TR is energized in part by power supplied by battery 2 and in part by power supplied by transformer TF. With section W—X unoccupied, the unit 4 forms a low resistance path for the half cycle of the alternating electromotive force which causes rail 1a to be positive and rail 1b to be negative, and forms a high resistance path for the half cycle of the alternating electromotive force which causes rail 1b to be positive and rail 1a to be negative with the result that rectified current supplied from track transformer TF aids the energization of relay TR effected by the direct current supplied from track battery 2. It should be noted that the ohmic resistance of resistor 7 and secondary winding 6 is made sufficiently high to avoid diverting any material amount of direct current supplied by battery 2. Hence, when the section W—X is unoccupied the direct current track relay TR is effectively energized and picked up closing front contact 9 which may be used to control a signal control circuit as desired.

When the section W—X is occupied by a train the maximum or peak value of the electromotive force produced by the sources of power breaks down the wheel-rail contact resistance and a relatively low train shunt is established so that the track circuit has a high shunting sensitivity and release of the track relay TR in response to occupancy of the track section is assured. Furthermore, because the electromotive force between the rails is substantially uniform throughout the section the shunting sensitivity of the track circuit is substantially uniform in all points of the section.

It is clear that the leakage power consumed by the track circuit of track section W—X is relatively low when compared with a track circuit having a single source of electromotive force at one end of the section. The voltage of such single source must be high to obtain the necessary voltage at the other end of the section to effectively energize a track relay and to effect a high shunting sensitivity so that the voltage through the greater part of the section is higher than required and excess leakage occurs.

In Fig. 2, the railway is formed with an insulated track section W—X having two sources of power connected across the rails at selected points of the section the same as in Fig. 1. The track battery 2 of the track circuit of track section W—X of Fig. 2 is connected in series with the resistor 3 across the rails at the exit end of the section. The secondary winding 6 of track transformer TF and the winding of an alternating current relay AR are connected in series across the rails at the entrance end of the section. The direct current track relay TR of Fig. 2 is connected across the rails at the entrance end of the section over a front contact 8 of relay AR. The alternating current relay AR is adjusted so that the leakage alternating current under dry ballast conditions is sufficient to effectively energize and pick up that relay closing front contact 8. Hence, relay AR is picked up at all times except in case of a failure of the alternating current power.

It is clear that the electromotive forces impressed on the rails by battery 2 and transformer TF produce a resultant electromotive force which is the vector sum of the two. The two sources of power of Fig. 2 are so proportioned as to effect a resultant electromotive force which is substantially uniform throughout the section, such resultant electromotive force having two predetermined components and also having recurrently high peak values.

When the section W—X of Fig. 2 is unoccupied the direct current track relay TR is effectively energized and picked up in response to the current supplied by battery 2, that is, relay TR is energized in response to the direct electromotive force component of the resultant electromotive force. When the section is occupied, the maximum or peak values of the resultant electromotive force breaks down the wheel-rail contact resistance and high shunting sensitivity of the track circuit is obtained. Furthermore, the shunting sensitivity is substantially uniform at all points of the section because of the resultant electromotive force being substantially uniform in value throughout the section. Also the power losses due to ballast resistance is relatively low. In the event there is a loss of alternating current power, the relay AR is deenergized and released to open the connection to track relay TR with the result that relay TR is released and such loss of power at once detected.

In Fig. 3, the track circuit of an insulated track section W—X differs from that of Fig. 2 in that the secondary winding 6 of transformer TF is connected across the rails at approximately the mid point of the section, a resistor 7 being preferably interposed in the connection. The alternating current relay AR is connected across the rails at the entrance end of the section and controls at its front contact 8 the connection of the direct current track relay TR with the rails. It will be understood, of course, that the ohmic resistance of the winding of relay AR as well as the ohmic resistance of the path including resistor 7 and secondary winding 6 of transformer TF is in each case high enough to avoid diverting any material amount of direct current supplied by battery 2.

In Fig. 3, the two sources of power and the associated elements are so proportioned and adjusted that a resultant electromotive force is produced for the track circuit of the section which has characteristics similar to those described by the track circuits of Figs. 1 and 2.

Referring now to Fig. 4, the rails 1a and 1b are formed with a track section W—X having a track circuit provided with two sources of power connected with the rails at predetermined points of the section. In Fig. 4, a track battery 2 is connected across the rails at the exit end of the section by having one of its terminals connected with rail 1b over wire 10 and its other terminal connected with rail 1a over contact 12 of a code transmitter CT and a primary winding 13 of a transformer T1, both of which will be described hereinafter, and thence over a resistor 14 and wire 15. The track transformer TF of Fig. 4 has its secondary winding 6 connected across the rails at the entrance end of the section in the same manner as in Fig. 1.

The code transmitter CT may be of any of the several well-known types and as here shown it is of the relay type. It is sufficient for this application to point out that when winding 16 of transmitter CT is energized a contact member 17 is operated to periodically engage a contact 12 at a predetermined rate, such as, for example, 75 times per minute, the contact 17—12 being closed for substantially one-half of each operating cycle of code transmitter CT and being opened for substantially one-half of each operating cycle. Furthermore, contact member 17 is normally biased so that it is held in engagement with contact 12 when the winding 16 is deenergized. It follows that as long as the code transmitter CT is operated, a direct electromotive force is periodically impressed upon the rails of section W—X and when transmitter CT is inactive, non-interrupted direct electromotive force is applied to the rails.

In Fig. 4 the track relay for the track circuit is a direct current quick acting code following relay CF whose operating winding 65 is connected across the rails at the entrance end of the section. Hence, the track relay CF is operated in response to the direct electromotive forces periodically produced across the track rails by battery 2 when the code transmitter CT is active and is inactive when the code transmitter is inactive, and furthermore it is non-responsive to the alternating electromotive forces supplied from the transformer TF. That is to say, the code following relay CF is operated in response to a particular one of the components of the resultant electromotive force and is non-responsive to the other component of such resultant electromotive force. When track relay CF is operating to alternately close its front contact 18 and back contact 19, direct current from a source whose terminals are designated B and C is alternately supplied to two portions of the primary winding 20 of a transformer T2 to induce an alternating electromotive force in the secondary winding 21 of transformer T2. The secondary winding 21 is connected with a winding of a control relay CR through a full wave rectifier 22. Consequently, relay CR, which is preferably slightly slow releasing in character, is energized and picked up closing a signal control circuit at its front contact 23 when periodic impulses of direct electromotive force are supplied to the track circuit from track battery 2 and the track relay CF is operated at a corresponding frequency.

When contact 17—12 of code transmitter CT is closed the alternating electromotive force produced across the track rails by track transformer TF causes an alternating current to flow in the circuit which includes wire 15, resistor 14, primary winding 13 of transformer T1, contact 17—12 of transmitter CT, battery 2 and wire 10, and an alternating electromotive force is induced in the secondary winding 24 of transformer T1. Secondary winding 24 of transformer T1 is connected with the winding of a slow release relay R1 through a full wave rectifier 25 with the result that relay R1 is picked up closing front contact 26 when the section W—X is unoccupied. Front contact 26 is interposed in a simple energizing circuit for the operating winding 16 of the code transmitter CT as will be readily understood by an inspection of Fig. 4.

It follows that when section W—X of Fig. 4 is unoccupied, the alternating current supplied through transformer T1 during the periods the contact 17—12 of transmitter CT is closed causes relay R1 to be picked up and energy is supplied to the operating winding 16 of transmitter CT causing the transmitter to be operated. With transmitter CT operated, the direct current code following relay CF is operated in response to the direct electromotive force periodically applied across the rails from track battery 2 and the signal control relay CR is picked up.

It is apparent that the two sources of power for the track circuit of Fig. 4 create a resultant electromotive force which is the vector sum of the two, the same as described for Figs. 1, 2 and 3, except for the fact that the direct electromotive force is periodically interrupted. Again the two sources of power are so proportioned as to create a resultant electromotive force which is substantially uniform in value throughout the section and has a high peak value.

When section W—X of Fig. 4 is occupied, the high peak value of the resultant electromotive force is effective to break down the resistance of the wheel-rail contacts of the train and a high shunting sensitivity for the track circuit prevails, the shunting sensitivity being substantially uniform throughout the section. Due to the low resistance train shunt, the direct current is effectively shunted away from the code following relay CF and the alternating current is shunted away from the primary winding 13 of transformer T1. Hence, relay CF ceases to operate and the control relay CR in turn is deenergized and released to govern the signal control circuit. Also, the relay R1 is deenergized and released causing the code transmitter CT to be inactive, its contact member 17 remaining stationary in engagement with contact 12 due to the bias of the code transmitter. When the train moves out of section W—X, the alternating current flowing in primary winding 13 causes relay R1 to be picked up closing front contact 26 and code transmitter CT is in turn operated at a corresponding frequency for operating track relay CF to control relay CR and in turn close the signal control circuit.

It is to be observed that in the event of a loss of alternating current power, the relay R1 is deenergized and the code transmitter CT is inactive with the result that the code following relay CF is inactive and the control relay CR is deenergized and released to detect such loss of power.

In Fig. 5, the track circuit for an insulated track section W—X is provided with two distinctive electromotive forces both of which are applied across the rails at the exit end of the section. The resultant electromotive force is therefore the vector sum of the two forces and this resultant electromotive force is in turn characterized by recurrently high peak values which break down the rail film resistance when the section is occupied so that a high shunting sensitivity for the track circuit prevails.

The track circuit for section W—X of Fig. 5 is used to control a wayside signal system. Hence, the railway would, of course, be formed with consecutive track sections each of which is provided with a track circuit similar to the track circuit for section W—X. The apparatus for the track circuit of section W—X and a portion of the apparatus for the track circuit for the section next in advance of section W—X only are shown for the sake of simplicity since such is sufficient for a full understanding of this form of apparatus embodying my invention and how it can be used to control a wayside signal system.

The means for applying two electromotive forces to the track circuit of section W—X of Fig. 5 consists of a track battery 2, a code transmitter CT and a track transformer TF1 together with the necessary circuits.

The code transmitter CT is preferably of the relay type the same as in Fig. 4 and its operating winding 16 is permanently connected with the source of current whose terminals are B and C and is hence continuously active to operate its contact member 17 between contacts 12 and 48 at a predetermined rate which rate I have assumed hereinbefore for illustration to be 75 times per minute. The contacts 12 and 48 are connected in multiple and are interposed in any one of a plurality of different circuits to be later described. Hence, the circuit in which contacts 12 and 48 are interposed under a specific condition is periodically interrupted during each time that contact member 17 is in transit between its two positions, the circuit being closed when either contact 17—12 or 17—48 is closed and hence is closed during the major portion of each operating cycle of the transmitter. Each of the different circuits in which the contacts 12 and 48 of the code transmitter are included also includes the track battery 2 and the primary winding 49 of transformer TF1 as will be pointed out hereinafter. Hence, the current flowing in primary winding 49 from battery 2 through contact 17—12 or 17—48 is momentarily interrupted during each interval the contact member 17 is in transit and an electromotive force is induced in the secondary winding 50 of transformer TF1. That is to say, when either contact 17—12 or 17—48 is closed and direct current flows in the primary winding 49, magnetic energy is stored in the transformer TF1 so that when contact member 17 is moved from one contact to the other and the circuit is momentarily interrupted an electromotive force is induced in the secondary winding 50 of transformer TF1. The secondary winding 50 is connected across the rails 1a and 1b over wires 56 and 57, a condenser C2 of relatively large capacity being interposed in wire 57. The complete circuits and manner whereby two electromotive forces are applied to the rails, one from track battery 2 and one from transformer TF1, will be explained when the operation of the apparatus of Fig. 5 is described.

The relay means for the track circuit of section W—X of Fig. 5 includes a direct current polarized track relay XTR, a code following relay XCF, a transformer XT2 and a control relay XCR. The code following relay XCF is connected across the rails at the entrance end of the section W—X through a blocking condenser XC1 and is preferably of the quick acting type. With relay XCF operated in a manner to later appear to alternately close its contacts 63—34 and 63—35, direct current is alternately supplied to two portions of the primary winding 29 of transformer XT2 to induce an electromotive force in the secondary winding 30 of that transformer. The secondary winding 30 is connected to the winding of relay XCR through a rectifier 31. Hence, the electromotive force induced in the secondary winding 30 is rectified and applied to the winding of control relay XCR. Relay XCR governs at the front contact 32 the connection of direct current track relay XTR with the track rails as will be readily understood by an inspection of Fig. 5.

Looking at the left-hand end of Fig. 5, a code following relay WCF and a direct current polarized track relay WTR are associated with the track circuit for the section next in advance of section W—X and are connected across the rails of the section next in advance in the same manner that relays XCF and XTR are connected with the rails of section W—X. That is to say, relay WCF is connected with the rails of the section next in advance through a blocking condenser WC1 and when operated causes a control relay WCR to be energized and picked up while the direct current polarized relay WTR is connected across the rails of the section in advance over front contact 33 of relay WCR.

Wayside signals XS and WS which govern traffic through track section W—X and the section next in advance, respectively, are provided. The signals XS and WS may be of any of the standard types and in this instance are color light signals capable of displaying four different indications. Looking at signal WS, it comprises two groups of lamps, the top group having a green lamp G, a yellow lamp Y and a red lamp R; and the bottom group having a green lamp G and a red lamp R. The operating circuits for signal WS are controlled by relays WTR and WCR associated with the track circuit for the section next in advance. These operating circuits may be of any of the standard types since their specific arrangement forms no part of my present invention.

In Fig. 5, the operating circuits for signal WS are as follows: when relay WCR is picked up and relay WTR is picked up at its normal polar or right-hand position, the G lamp of the top group of lamps and the R lamp of the bottom group of lamps of signal WS are illuminated so that signal WS displays a green light over a red light for a clear signal indication. The circuit for lamp G of the top group can be traced from terminal B over front contact 36 of relay WCR, front contact 37 of relay WTR, normal polar contact 38 of relay WTR, lamp G and terminal C. The circuit for the R lamp of the bottom group of lamps extends from terminal B over front contact 39 of relay WCR, front contact 40 of relay WTR, normal polar contact 41 of relay WTR, lamp R and terminal C. When relay WCR is picked up and relay WTR is picked up at its reverse polar position, the Y lamp of the top group of lamps and the G lamp of the bottom group of lamps are illuminated so that signal WS displays a yellow light above a green light for an approach medium signal indication. The circuit for the Y lamp extends from terminal B over front contacts 36 and 37 of relays WCR and WTR, respectively, reverse polar contact 42 of relay WTR, lamp Y and terminal C. The circuit for the G lamp of the bottom group of lamps includes terminal B, front contacts 39 and 40 of relays WCR and WTR, respectively, reverse polar contact 43 of relay WTR, lamp G and terminal C.

Again, when relay WCR is picked up and relay WTR is released, the Y lamp of the top group of lamps and the R lamp of the bottom group of lamps are illuminated and the signal WS displays a yellow light over a red light for an approach signal indication. The circuit for the lamp Y includes terminal B, front contact 36 of relay WCR, back contact 44 of relay WTR, lamp Y and terminal C; and the circuit for the R lamp involves terminal B, front contact 39 of relay WCR, back contact 45 of relay WTR, lamp R and terminal C.

When relay WCR is released, the R lamp of each of the two groups of lamps is illuminated and signal WS displays a red light over a red light for the stop signal indication. The circuit of the top lamp R includes terminal B, back contact 46 of relay WCR, lamp R and terminal C; and the circuit for the lamp R of the bottom group of lamps includes terminal B, back contact 47 of relay WCR, lamp R and terminal C.

The operating circuits for signal XS are controlled by relays XCR and XTR in the same manner as the circuits for signal WS are controlled by relays WCR and WTR and only certain portions of the circuits for signal XS are shown for the sake of clarity since this much of the circuits is sufficient for a full understanding of the invention.

In describing the operation of the apparatus of Fig. 5, I shall first assume the section next in advance of section W—X is occupied so that relay WCF is made inactive causing relay WCR to be deenergized and released as well as relay WTR being deenergized and released. With relays WCR and WTR both released, the wayside signal WS displays the stop signal indication as explained hereinbefore. Also, current now flows from the positive terminal of battery 2 over a resistor 51, back contact 52 of relay WCR, primary winding 49 of transformer TF1, either contact 17—12 or 17—48 of code transmitter CT and to the negative terminal of battery 2. Since this circuit including primary winding 49 is momentarily interrupted each time the contact member 17 is in transit between contacts 12 and 48, the magnetic energy stored in transformer TF1 decays and produces an electromotive force in the secondary winding 50 of that transformer, the wave form of such electromotive force in effect consisting of a single half-cycle of short duration. The parts are so proportioned that each such impulse of electromotive force is of relatively high peak voltage as well as of short duration. This electromotive force induced in secondary winding 50 is applied across the rails of section W—X through condenser C2, causing an impulse of current to flow in the winding of relay XCF through condenser XC1 with the result that contact 63—35 of relay XCF is momentarily closed. Consequently, the relay XCF is operated at a frequency corresponding to the frequency at which the code transmitter CT is operating and in turn causes the control relay XCR to be picked up closing the connection of track relay XTR with the track rails at front contact 32. It should be noted that the impedance of track relay XTR, due to its construction, is high and that relay therefore does not divert an appreciable amount of power of the impulse which operates relay XCF as well as not being responsive to such impulses of electromotive force. It follows that with the section next in advance occupied, impulses of electromotive force from transformer TF1 only are applied to the rails of section W—X with the result relay XCR is picked up and relay XTR is released. With relay XCR picked up and relay XTR released the associated signal XS is caused to display an approach signal indication, the operating circuits for signal XS being the same as described for signal WS.

I shall next assume that the section next in advance of section W—X is unoccupied and the second section in advance is occupied so that relay WCR is picked up but relay WTR is released. Under this condition, current flows from the positive terminal of battery 2 over back contact 53 of track relay WTR, wire 56, rail 1b, wire 55, winding of relay XTR, front contact 32 of relay XCR, wire 54, rail 1a, wire 57, back contact 58 of relay WTR, front contact 59 of relay WCR, primary winding 49 of transformer TF1, either contact 17—12 or 17—48 of transmitter CT and to battery 2. Direct current flows in this circuit during each interval either contact 17—12 or 17—48 is closed, which intervals it will be recalled are relatively long with the result that the direct current track relay XTR is effectively energized thereby and picked up. The polarity of such current which is effective to close the reverse polar contacts of relay XTR, I shall term reverse polarity. Such direct current is substantially blocked by condenser XC1 and does not affect the code following relay XCF. This circuit is momentarily interrupted each time contact member 17 of transmitter CT is in transit between its two positions and an electromotive force impulse is induced in the secondary winding 50, the same as described hereinbefore, and which impulse of electromotive force is applied from secondary winding 50 to the rails of the section W—X causing an impulse of current to flow through condenser XC1 to momentarily pick up the code following relay XCF with the result that the control relay XCR is energized and picked up. With relay XCR picked up and relay XTR picked up at its reverse position, the signal XS is caused to display an approach medium indication.

Next I shall assume that the first two sections in advance of section W—X are unoccupied and the third section in advance is occupied so that relay WCR is picked up and relay WTR is picked up at its reverse position. A circuit can now be traced from the positive terminal of battery 2 over front contact 60 of relay WTR, wire 57, rail 1a, wire 54, front contact 32 of relay XCR, winding of relay XTR, wire 55, rail 1b, wire 56, front contact 61 of relay WTR, front contact 59 of relay WCR, primary winding 49 of transformer TF1, either contact 17—12 or contact 17—48 of code transmitter CT and to the negative terminal of battery 2. The direct current flowing in this circuit during each interval either contact 17—12 or 17—48 is closed is effective to energize and pick up the relay XTR. The polarity of the current is now of normal polarity so that relay XTR is closed at its normal polar position. The circuit is momentarily interrupted each time the contact member 17 is in transit with the result that an impulse of electromotive force is induced in secondary winding 50 of transformer TF1 which impulse of electromotive force is applied across the rails and causes a current impulse to flow in the winding of relay XCF to operate that relay so that the control relay XCR is energized and picked up. With relay XCR picked up and relay XTR picked up at its normal position the signal XS is caused to display a clear signal indication.

Again assuming that the three sections next in advance of section W—X are unoccupied so that relay WCR is picked up and relay WTR is picked up at its normal position, current of normal polarity is again supplied to the track circuit for section W—X and relay XTR is energized at its normal polar position. Again each time the contact member 17 of transmitter CT is moved from one position to the other an impulse of electromotive force is induced in the secondary winding 50 of transformer TF1, which electromotive force is applied across the rails causing a current impulse to flow in the winding of relay XCF to operate that relay. Again it is to be noted that relay XCR is picked up and relay XTR is picked up at its normal position and the signal XS is caused to display a clear indication.

It is to be noted that the electromotive force effected between the rails by battery 2 and that effected from secondary winding 50 of transformer TF1 are distinctive in character and cooperate to create a resultant electromotive force which is characterized by periodically high peak values. Hence, when the section W—X is occupied the peak value of the resultant electromotive force breaks down the resistance of the wheel-rail contacts and a high shunting sensitivity for the track circuit is provided with the result that both relays XCF and XTR are deenergized causing signal XS to display a stop indication, relay XTR being also disconnected from the rails when relay XCR is released.

In order to stabilize the track circuit of Fig. 5 and avoid too great a variation of the current flowing in the primary winding **49** of transformer TF**1** between dry and wet ballast conditions, a resistor **64** is preferably connected between the rails. Resistor **64** is so chosen as to cause approximately the same peak values of the electromotive force induced in the secondary winding **50** under dry and wet ballast conditions with the result that a satisfactory shunting sensitivity of the track circuit is effected for all ballast conditions within the usual operating limits. It should be pointed out that resistor **64** if broken does not cause a dangerous failure. At low ballast resistance, the resistor **64** is high enough to make little or no appreciable difference in the operation of the track circuit. If resistor **64** becomes disconnected at high ballast resistance, the current flowing in primary winding **49** is reduced and the electromotive force induced in secondary winding **50** correspondingly reduced so that the current impulses operating relay XCF are materially reduced in magnitude and should relay XCF fail to respond then both relays XCR and XTR become deenergized and released and the most restrictive indication of signal XS is displayed.

Although I have herein shown and described only certain forms of railway signaling 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, an insulated track section, a source of unidirectional current connected across the rails at one end of said section, a direct current track relay connected across the rails at the other end of said section effectively energized by said unidirectional current when the section is unoccupied, a source of alternating current connected across the rails of the section to supply to the rails current of relatively high instantaneous voltages for breaking down the rail film resistance when the section is occupied to aid the shunting of said track relay, another relay having connection with the rails of said section effectively energized by said alternating current, and means including a contact of said other relay for controlling the supply of unidirectional current to said track relay.

2. In combination, an insulated track section, a track battery connected across the rails at one end of said section, a track transformer having a primary winding supplied with alternating current, an alternating current relay, means to connect a secondary winding of said transformer and a winding of said relay in series across the rails at the other end of said section, and a direct current track relay having its winding connected across the rails at said other end of said section over a front contact of said alternating current relay.

3. In combination, an insulated track section, a track battery, a normally active code transmitter, a first transformer, means including a contact of said transmitter and a primary winding of said transformer to connect said battery across the rails at one end of said section to supply recurrent impulses of direct current to the rails, a control relay, means including a rectifier to connect a winding of said control relay across the secondary winding of said first transformer for energizing said relay when alternating current flows in the primary winding of said transformer, means including a front contact of said control relay to energize said code transmitter, a track transformer having its primary winding supplied with alternating current and its secondary winding connected across the rails at the other end of said section for energizing said control relay when the section is unoccupied, a direct current code following relay connected across the rails at said other end of the section effectively operated by said recurrent impulses of direct current when the section is unoccupied, and signaling means controlled by said code following relay.

4. In combination, an insulated track section, a track battery, a normally active code transmitter, a track transformer, means to connect said battery in series with a primary winding of said transformer across the rails at the exit end of said section over a contact of said transmitter to effect a direct electromotive force across the rails which is periodically interrupted, means including a condenser to connect a secondary winding of said transformer across the rails at the exit end of said section to periodically effect across the rails an impulse of electromotive force of relatively short duration and high peak voltage, a code following relay having its winding connected in series with another condenser across the rails at the entrance end of the section effectively operated in response to said impulses of electromotive force, a direct current relay having its winding connected across the rails at the entrance end of said section effectively energized by said direct electromotive force, and a signal circuit jointly controlled by said two relays.

5. In combination, an insulated track section, a track battery, a normally active code transmitter, a track transformer, means controlled by traffic in advance of said section to connect said battery in series with a primary winding of said transformer across the rails at the exit end of said section over a contact of said transmitter to effect periodically interrupted direct electromotive force of either positive polarity or negative polarity in response to two different traffic conditions in advance, means including a condenser to connect a secondary winding of said transformer across the rails at the exit end of the section to effect periodic impulses of electromotive force of relatively short duration and high peak voltage due to operation of said transmitter, a code following relay having its winding connected in series with another condenser across the rails at the entrance end of the section effectively operated in response to said impulses of electromotive force, a direct current polarized relay having its winding connected across the rails at the entrance of said section effectively energized in response to said direct electromotive force, and two signaling circuits jointly controlled by said two relays one closed when the polarized relay is energized at normal polarity and the other closed when the polarized relay is energized at reverse polarity.

6. In combination, an insulated track section, a track battery, a normally active code transmitter, a track transformer, means including a condenser to connect a secondary winding of

said transformer across the rails at the exit end of said section, means controlled by three different traffic conditions in advance of said section to connect said battery in series with a primary winding of said transformer over a contact of said transmitter to effect periodic impulses of electromotive force across the rails in response to a first one of the traffic conditions and to connect said battery in series with said primary winding across the rails at the exit end of the section over said transmitter contact to effect direct electromotive force of either normal polarity or reverse polarity in response to either a second or a third one of said traffic conditions respectively, a code following relay having its winding connected in series with another condenser across the rails at the entrance end of the section effectively operated in response to said impulses of electromotive force, a direct current polarized relay having its winding connected across the rails at the entrance end of the section over a front contact of said code following relay effectively energized in response to said direct electromotive force, and three different signaling circuits selectively controlled by said two relays.

7. In combination, an insulated track section, a transformer, a code transmitter, a source of direct current connected across the rails at one end of said section through a primary winding of said transformer in series with a contact of said code transmitter for supplying coded direct current to the rails when said code transmitter is operated, a code following track relay connected across the rails at the other end of said section effectively operated by such coded direct current when the section is unoccupied, a signaling circuit controlled by said track relay and closed when the relay is operated, a control relay having connection to a secondary winding of said transformer effectively energized and picked up when an alternating current flows in said primary winding, a source of alternating current connected across the rails at said other end of said section to energize said control relay when the section is unoccupied and which alternating current is effectively shunted to deenergize said control relay when the section is occupied, and an operating circuit including a front contact of said control relay for operating said code transmitter to discontinue operation of the code transmitter when the section is occupied as an aid in rendering said code following relay responsive to occupancy of the section.

8. In combination, an insulated track section, a normally active code transmitter, a transformer, a source of direct current connected in series with a primary winding of said transformer across the rails at one end of said section over a contact of said code transmitter to supply periodically interrupted direct current to the rails, a direct current track relay having connection to the rails at the other end of the section for energization thereof by said interrupted direct current when the section is unoccupied, signaling means controlled over a contact of said track relay, means including a condenser to connect a secondary winding of said transformer across the rails at the other end of the section to supply a current impulse of relatively short duration and high peak voltage each time said direct current is interrupted as an aid in breaking down the rail film resistance when the section is occupied, a code following relay having a winding connected in series with another condenser across the rails at said other end of the section effectively operated by such current impulses when the section is unoccupied, and a contact governed by said code following relay interposed in said connection of said track relay to the rails to complete such connection only when the code following relay is operated.

9. In combination, an insulated track section, a normally active code transmitter, a transformer, a source of direct current, means including a contact of said code transmitter to connect said current source and a primary winding of said transformer across the rails at one end of said section to supply periodically interrupted direct current to the rails, a direct current track relay having connection to the rails at the other end of the section effectively energized by said interrupted direct current when the section is unoccupied, and a secondary winding of said transformer connected in series with a condenser across the rails at said one end of the section to supply a current impulse of relatively high peak voltage each time said direct current is interrupted as an aid in breaking down the rail film resistance and shunting said track relay when the section is occupied.

10. In combination, an insulated track section, a trackway source of power having connection to the rails at one end of the section to supply a direct electromotive force to the rails, a track relay having connection to the rails at the other end of the section effectively energized by said supply of direct electromotive force when the section is unoccupied, another trackway source of power having connection to the rails of the section to supply a periodic electromotive force across the rails which is incapable of effectively energizing said relay and which periodic electromotive force is of relatively high peak voltage to provide a high shunting sensitivity for said track relay by breaking down the rail film resistance when the section is occupied, and another relay receiving energy from said other trackway source of power and having a contact which controls the supply of said direct electromotive force to permit energization of said track relay only when said other trackway source of power is supplying said periodic electromotive force to the rails.

11. In combination, an insulated track section, a track battery connected to the rails at one end of the section to supply unidirectional current to the rails, a direct current track relay connected to the rails at the other end of the section effectively energized by said supply of unidirectional current when the section is unoccupied, other means connected to the rails of the section to supply a periodic current to which said track relay is non-responsive and which periodic current serves to break down the rail film resistance and aid the shunting of said track relay when the section is occupied, and another relay energized by such periodic current received from said other means and having a front contact which controls the supply of said unidirectional current to cause release of said track relay when said other means fails to supply said periodic current.

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