Jan. 23, 1945. H. A. THOMPSON 2,367,742

RAILWAY TRACK CIRCUIT APPARATUS

Filed July 11, 1942 3 Sheets-Sheet 1

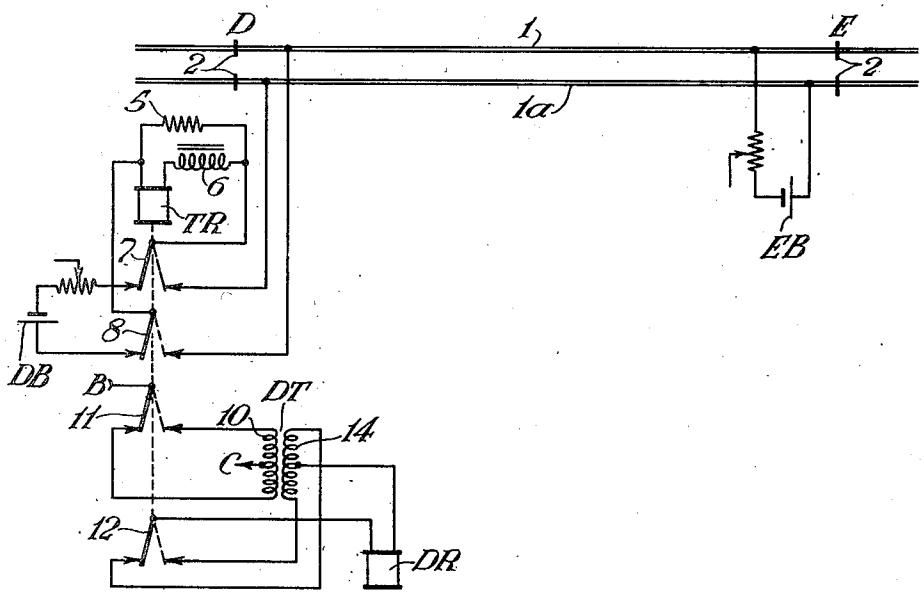

Fig. 1.

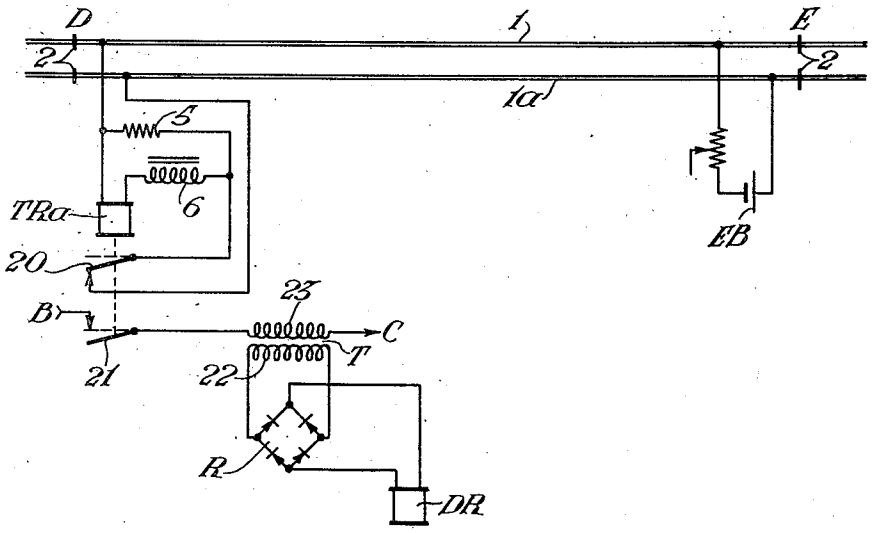

Fig. 2.

INVENTOR
Howard A. Thompson
BY
HIS ATTORNEY

Jan. 23, 1945. H. A. THOMPSON 2,367,742

RAILWAY TRACK CIRCUIT APPARATUS

Filed July 11, 1942 3 Sheets-Sheet 2

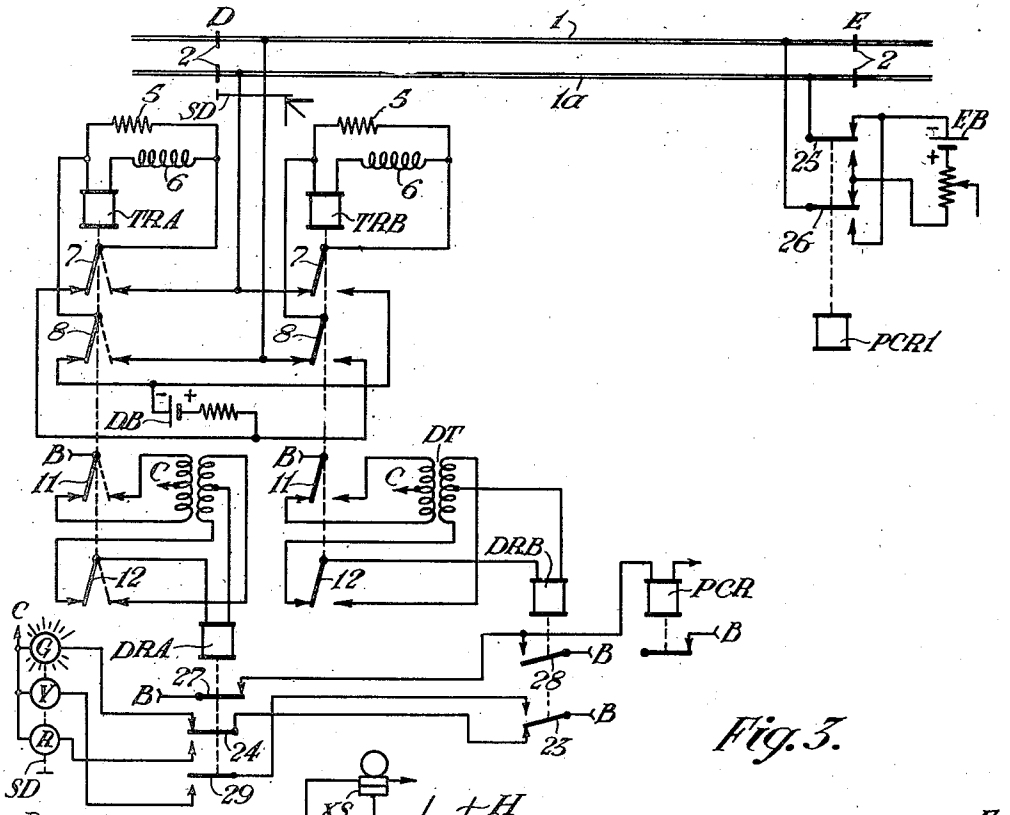

Fig. 3.

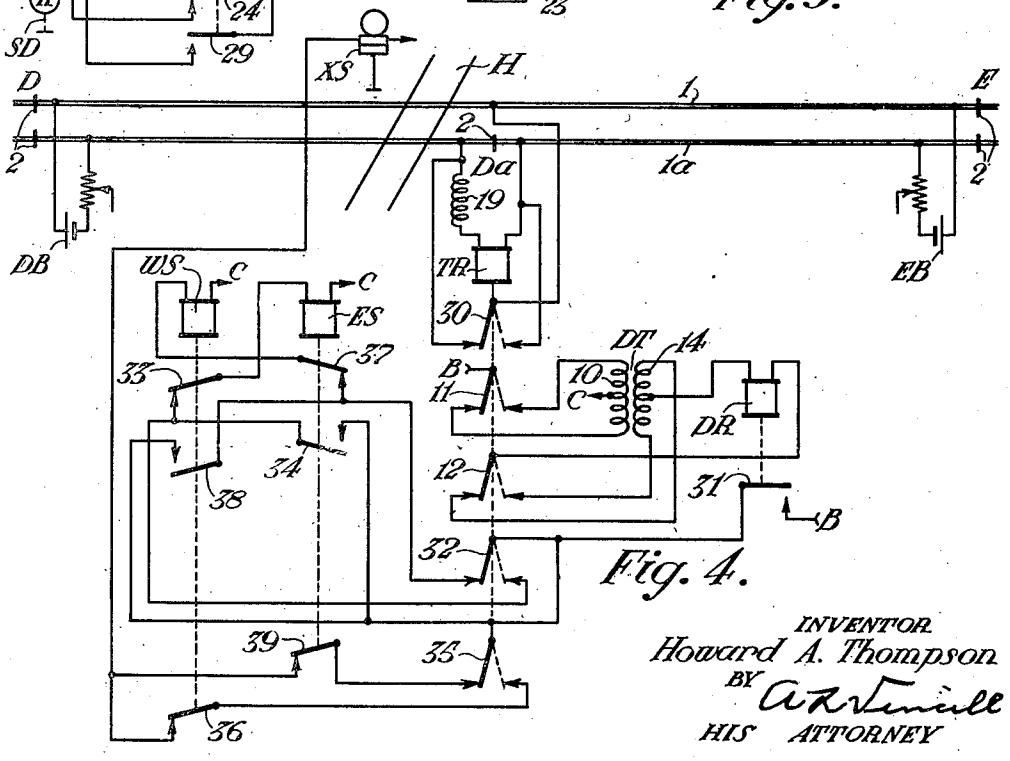

Fig. 4.

INVENTOR
Howard A. Thompson
BY
HIS ATTORNEY

Jan. 23, 1945. H. A. THOMPSON 2,367,742

RAILWAY TRACK CIRCUIT APPARATUS

Filed July 11, 1942 3 Sheets-Sheet 3

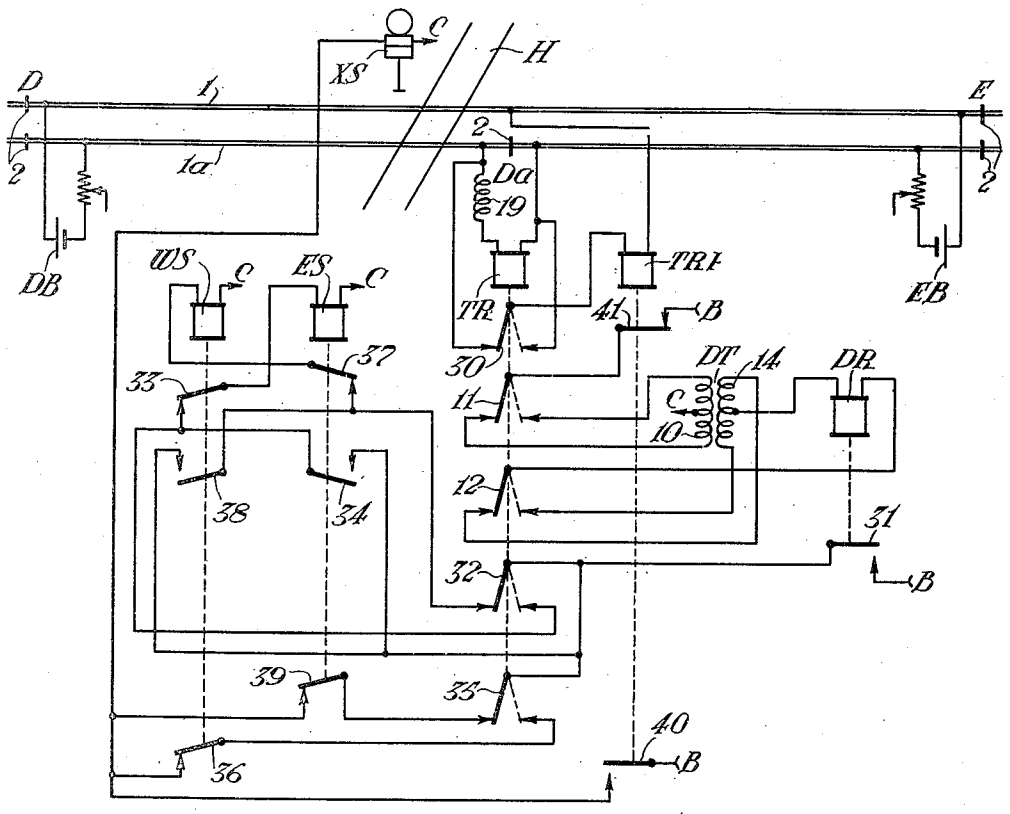

Fig. 5.

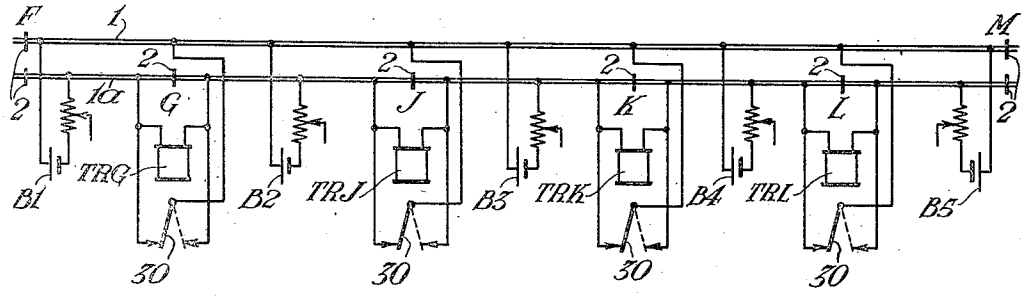

Fig. 6.

INVENTOR
Howard A. Thompson
BY
HIS ATTORNEY

Patented Jan. 23, 1945

2,367,742

UNITED STATES PATENT OFFICE

2,367,742

RAILWAY TRACK CIRCUIT APPARATUS

Howard A. Thompson, Edgewood, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application July 11, 1942, Serial No. 450,540

19 Claims. (Cl. 246—28)

My invention relates to railway track circuit apparatus and it has particular reference to the organization of such apparatus into novel and improved railway track circuits arranged to be highly sensitive to train shunts.

An ordinary track circuit, wherein the track circuit source and track relay are permanently connected in circuit with the track rails, is inherently characterized by the fact that the pick-up value of the relay is considerably higher than its release value. In order, therefore, to effect operation of such a circuit, the relay must be initially energized and caused to pick up in response to a relatively high energy level, and after the relay picks up, its energy level is considerably above that necessary to hold it up. It follows that in order for a train shunt to be effective to release such a relay, the shunt must be sufficiently low to by-pass the increment of energy above the release value of the relay, and this requires a shunt considerably lower in resistance than that required to prevent pick-up of the relay.

It has heretofore been proposed to utilize coded energy in the track circuit and means associated with the track relay to detect a code following operation of the relay, thereby to obtain a higher degree of shunting sensitivity due to the fact that the train shunt need be effective only to prevent pick-up or operation of the relay. In coded systems of the type heretofore proposed, it has been customary to code or periodically interrupt the supply of energy to the track rails by means of a coder or code transmitter having contacts interposed in the connection of the track circuit source to the track rails and effective alternately to open and close such circuit connection, thereby to cause periodically interrupted current to be transmitted through the rails of the circuit. An object of my present invention is the provision of novel track circuits having the sources of current permanently connected to the track rails and incorporating apparatus arranged in a novel and improved manner to obtain the advantages and shunting sensitivity heretofore obtained by periodically interrupting the connection of the sources to the track rails.

Another object of my invention is to provide track circuits incorporating novel and improved means for periodically connecting a track relay to and disconnecting it from the track rails, whereby to obtain a shunting sensitivity comparable to that obtained by periodically interrupting the connection of a track circuit source to the track rails.

A further object is to provide novel and improved track circuits incorporating apparatus arranged to code or periodically interrupt the connection of the associated track relays with the track rails.

An additional object is the provision of novel and improved track circuits arranged to obtain the operating advantages of a coded track circuit and in which use of a special device for coding the supply of current to such a circuit is obviated.

A still further object is the provision of novel and improved track circuits particularly well adapted for use in controlling highway crossing signals.

An additional object is the provision of novel and improved means for controlling highway crossing signals.

Another object is the provision of novel and improved railway 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 by providing in connection with a control circuit comprising a pair of conductors which are normally effective to transmit energy from either end of the circuit to the other but which at times are rendered ineffective to transmit such energy, two sources of energy one permanently connected across the conductors at one end of the circuit, a polar relay, and means including the conductors and contacts of the relay for connecting the winding of the relay alternately first through the conductors to the said one source and then to the other of the sources, the sources being poled to reversibly energize the relay.

I shall describe several 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 one form of apparatus embodying my invention. Figs. 2 and 3 are each diagrammatic views representing modified forms of the apparatus illustrated in Fig. 1, and also embodying my invention. Figs. 4, 5 and 6 are each diagrammatic views illustrating further modified forms of the apparatus represented in Fig. 1, and each also embodying my invention. In each of the several views, similar reference characters have been employed 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 the usual insulated joints 2 into a plurality of successive adjoining track sections of which only one section, D—E, is rep-

resented complete in the drawings. The rails 1 and 1a of section D—E comprise the transmission conductors of a control circuit of the track circuit type in which the conductors are normally effective to transmit energy from either end of the circuit to the other, but which conductors at times are rendered ineffective to transmit such energy.

The circuit of section D—E is provided with two sources of unidirectional current, designated by the reference characters DB and EB, respectively, and with a track relay designated by the reference character TR. Relay TR is of the polar stick type and has associated therewith a resistor 5, a reactor 6, a detector relay DR, and a decoding transformer DT.

In accordance with the invention, one battery EB is permanently or constantly connected across the rails of section D—E adjacent one end E of the section, while relay TR is alternately connected first to the rails of section D—E and then to a local source DB. The two sources DB and EB are poled in such manner as to reversibly operate relay TR. That is to say, when the apparatus is in the condition represented in Fig. 1 wherein polar contact members 7 and 8 of relay TR are in their normal or left-hand positions, as viewed in the drawings, the winding of relay TR is connected to battery DB in series with reactor 6 and in multiple with resistor 5, whereupon reactor 6 becomes charged and relay TR becomes energized with current supplied from battery DB and having a polarity such as to cause the relay to operate its contacts to their reverse or right-hand positions. When the armature of relay TR starts to move and the left-hand contacts are broken to disconnect relay TR from battery DB, the inductive effect of reactor 6 continues the flow of current through a closed circuit path including the winding of relay TR and resistor 5, thereby assisting in carrying the relay armature past its dead center position and to its right-hand position wherein the relay winding becomes energized and reactor 6 becomes charged with current supplied from battery EB over the track rails. Battery EB is poled so as to supply current of the opposite polarity whereupon relay TR operates its armature from its right-hand to its left-hand position. When the right-hand contacts are broken, reactor 6 discharges through the relay winding and resistor 5 to assist in carrying the armature past its dead center position to its left-hand position wherein the local battery DB is connected to the relay and reactor. This cycle of operation is repeated as long as section D—E is unoccupied, and this operation of relay TR is detected by means of relay DR which is energized in the usual manner through the medium of a decoding transformer DT. Transformer DT has its primary winding 10 energized by unidirectional current supplied from a suitable source of current, such as a battery not shown but having its opposite terminals designated by the reference characters B and C, alternately in first one direction over normal polar contact 11 of relay TR and then in the opposite direction over reverse polar contact 11 of relay TR, whereupon an alternating electromotive force is caused to be induced in secondary winding 14 of the transformer. This alternating electromotive force is rectified by means of polar contact member 12 of relay TR and is supplied to relay DR as unidirectional current to hold such relay energized as long as section D—E is unoccupied and relay TR is caused to reversibly operate.

When a train enters section D—E, the energy supplied from battery EB through the track rails is shunted away from the relay, hence such relay is caused to operate to its right-hand position due to energy from battery DB and remains in such position as long as the section is occupied. When relay TR ceases to operate, relay DR of course releases to indicate that section D—E is occupied, and relay DR remains released until the train vacates the section and removes its shunt from relay TR. When this happens, current from battery EB energizes relay TR and charges reactor 6, whereupon relay TR is caused to operate to its left-hand position and the reversible operation of relay TR is initiated. This in turn causes relay DR to pick up to indicate that the section is now vacant.

The provision of reactor 6 in circuit with relay TR not only results in assisting in operating the associated relay from either extreme position to the other, but also results in modifying the time constant of the circuit and tends to slow up the operation of the relay. The circuit constants preferably are selected to cause relay TR to operate at a rate of the order of, say, 180 cycles per minute.

It is to be noted that while track battery EB is constantly and permanently connected across the rails of the section, whereby energy is constantly applied to such rails, a circuit is arranged to obtain the operating advantages and shunting sensitivity of a coded track circuit in that the train shunt need be effective only to prevent operation of relay TR from its right-hand to its left-hand position. Additionally, it is to be noted that since track circuit current is constantly applied to the track rails and no coding device is required to interrupt the supply of current to the rails, the track relay itself functions as a coding device in that it controls the connection of its winding to the rails and also the supply of energy to a detector relay DR. It follows, therefore, that I have provided a novel and improved form of track circuit wherein the apparatus is arranged to cause the track relay to code or periodically interrupt the supply of energy to a detector relay, in response to track circuit energy constantly supplied to the track rails.

Fig. 2 represents a modified arrangement of the apparatus of Fig. 1, wherein the local source DB is dispensed with, and track relay TR*a* is preferably of the polar biased neutral type responsive to current of but one relative polarity. Referring to Fig. 2, the winding of relay TR*a* is shown connected, in series with reactor 6 and in multiple with resistor 5, to the track rails 1 and 1*a* when back contact 20 is closed. Current from the track rails energizes relay TR*a* and charges reactor 6, and when the energy level in the relay reaches the pick-up level of the relay, relay TR*a* picks up to open its back contact 20. Reactor 6 now discharges through the relay winding and resistor 5 and causes the track relay to close its front contact 21. After the energy in reactor 6 is dissipated, relay TR*a* releases and again closes its back contact 20 to connect the relay winding and reactor in circuit with the track rails. This cycle of operation is repeated as long as the section remains vacant, and is detected by means of relay DR connected through a full-wave rectifier R to the secondary winding 22 of a transformer T which has its primary

winding 23 supplied with energy each time front contact 21 of relay TR*a* closes. It is readily apparent that relay TR*a* is shunted and becomes inactive whenever a train occupies section D—E, and relay DR accordingly releases and remains released until the train vacates the section and relay TR*a* again operates. It is also apparent that the apparatus of Fig. 2 provides a track circuit that is highly sensitive to a train shunt since the shunt need be effective only to prevent pick-up of the track relay, hence although the current source is constantly connected with the track rails there is attained a shunting sensitivity of a degree corresponding to that obtained when coded current is supplied to the track rails.

The circuit arrangements represented in Figs. 1 and 2 provide only a so-called two-position control, that is, the circuits are arranged to indicate either of the two possible conditions: (1) section vacancy or (2) section occupancy. Fig. 3 represents the apparatus of Fig. 1 modified to provide indication of three possible conditions, namely, (1) section occupancy, (2) section vacant but advance section occupied, and (3) both the associated and the advance section vacant. This three-position control is attained by providing pole-changing means for the track circuit battery whereby that battery may be caused to supply current of either polarity to the track rails, and by providing a local source and two track relays designated by the reference characters TRA and TRB, respectively, one relay arranged to be reversibly operated only when current of one polarity is in the track rails and the other relay arranged to be reversibly operated only when current of the opposite polarity is in the track rails.

Referring to Fig. 3, it is obvious that when pole changing relay PCR*f* (controlled by traffic conditions in the section in advance of section D–E, in a manner not shown but substantially corresponding to that hereinafter pointed out whereby relay PCR is controlled by traffic conditions in section D–E) closes its front contacts 25 and 26, current of one polarity is supplied from battery EB to the track rails, and that when back contacts 25 and 26 of relay PCR*f* are closed, then current of the opposite polarity is supplied to the rails.

When current of the one polarity is in the track rails, relay TRA is caused to be reversibly operated due to the local battery DB being arranged to supply current of the opposite relative polarity to such relay when it is connected with such source. At this time, the other track relay TRB is inactive since under the conditions assumed, both sources EB and DB are arranged to supply current of the same relative polarity to such relay. When, however, pole changing relay PCR*f* is released to cause battery EB to apply current of reverse polarity to the track rails, then relay TRB is reversibly operated due to being alternately energized first by current of one polarity derived from the track rails and then by energy of the opposite polarity supplied from local battery DB. At this time, relay TRA is inactive. Each relay TRA and TRB has associated therewith a detector relay DRA and DRB, respectively, and these relays control a pole changing relay PCR arranged to be energized whenever either relay TRA or TRB is picked up to close its front contact 27 or 28, as the case may be. Relay PCR may be employed, for example, as the pole changing means for the track section next in the rear of section D—E.

The specific operation of the apparatus of Fig. 3 is as follows: When relay PCR*f* is picked up, current of the one relative polarity is applied to the track rails, and as shown the upper rail *f* may at this time be considered as the positive rail since it is represented connected through front contact 26 of relay PCR*f* to the positive (+) terminal of battery EB. Both relays TRA and TRB, as shown, have their polar armatures positioned in the left-hand position, wherein the winding of relay TRB is connected to the track rails with the left-hand terminal of the relay connected through polar contact 8 to the upper or positive rail *f*. The winding of the other relay TRA is connected to battery DB with the right-hand terminal of the relay connected to the positive pole of the battery. These relays preferably are constructed so that when positive energy is applied to a relay terminal, the armature thereof will be attracted or swung to the corresponding position. That is, positive energy applied to the right-hand terminal of relay TRA causes its polar armature to swing to its right-hand position, and similarly positive energy applied to the left-hand terminal of relay TRA causes its polar armature to swing to its corresponding left-hand position. It follows, therefore, that with positive energy applied from battery DB to the right-hand terminal of relay TRA, that relay armature is caused to swing to its right-hand position, whereas positive energy applied to the left-hand terminal of relay TRB will not effect operation of its armature. When the armature of relay TRA is swung to the right, the winding of the relay is then connected to the track rails with the left-hand terminal of the relay being connected through contact 8 to the positive rail *f*, whereupon the relay armature is caused to swing back to its left-hand position. Reversible operation of relay TRA but not of relay TRB is thus effected when current of the one relative polarity is available in section D—E and that section is vacant.

When, however, the section in advance of section D—E is occupied so that relay PCR*f* is released to connect the lower rail *fa* through back contact 25 to the positive terminal of battery EB, then current of the opposite relative polarity is available in the rails of section D—E. Positive energy will now be applied to the right-hand terminal of relay TRB, which terminal is connected to the positive rail *fa* through contact 7, and will cause relay TRB to swing its polar armature to the right. Relay TRA likewise will swing its polar armature to the right in response to positive energy applied to its right-hand terminal from battery DB. With the polar armature of relay TRA to the right, the right-hand terminal of such relay is connected through contact 7 to the positive rail *fa*, hence no operation of the polar armature of the relay will be effected. Relay TRB, on the other hand, has its left-hand terminal connected through contact 8 (closed in the right-hand position) to the positive terminal of battery DB, whereupon the relay armature is caused to swing to its left-hand position to again connect the relay winding to the track rails with the positive rail *fa* connected to the right-hand relay terminal. It follows, therefore, that reversible operation of relay TRB but not of relay TRA is effected when current of the opposite relative polarity is available in section D—E and that section is vacant.

The apparatus represented in Fig. 3 may be employed, as shown, to control a three-position signal SD located at D and governing traffic entering section D—E at that end of the section. This signal may be of any desired type, but for the purposes of the present description, it will be assumed that the signal is of the color light type comprising three lamps G, Y and R effective when illuminated to display a green or "clear" aspect, a yellow or "approach" aspect, and a red or "stop" aspect. The various aspects signal SD are selected by means of relays DRA and DRB to reflect traffic conditions on the stretch. When section D—E and the section in advance are vacant, relay PCR1 is picked up and current of one relative polarity is available in the rails of section D—E so that relay TRA is reversibly operated and relay DRA is picked up while relay DRB is released. At such time, therefore, lamp G of signal SD will be illuminated over an obvious circuit extending from terminal B through back contact 23 of relay DRB, front contact 24 of relay DRA and the filament of lamp G of signal SD to terminal C. If, however, section D—E is vacant but the section in advance is occupied so that relay PCR1 is released, current of the opposite relative polarity is available in the rails of section D—E and relay TRB is reversibly operated. At such times, relay DRB is picked up while relay DRA is released, and lamp Y of signal SD is energized over an obvious circuit including terminal B, front contact 23 of relay DRB, back contact 29 of relay DRA, the filament of lamp Y of signal SD and the other terminal C. Whenever section D—E is occupied, both relays TRA and TRB are inactive and both relays DRA and DRB are released. Lamp R of signal SD is illuminated under such assumed conditions, over a circuit comprising terminal B, back contact 23 of relay DRB, back contact 24 of relay DRA, the filament of lamp R of signal SD and terminal C. It follows, therefore, that signal SD is controlled by the apparatus of Fig. 3 in accordance with traffic conditions on the stretch and such signal provides means for indicating traffic conditions on two successive sections of the stretch.

Other modifications of the apparatus represented in Fig. 1 are illustrated in Figs. 4, 5 and 6, respectively. In each of these modifications, two sources of current each connected to the rails of the section on either side of a track relay also connected to the section, cause such relay to be reversibly operated.

Referring to Fig. 4, section D—E is represented provided with two track circuit sources DB and EB connected respectively across the rails at opposite ends of the section, and with an insulated joint 2 interposed in the rail of section D—E at a point Da intermediate the two ends of the section. Track relay TR has its two terminals connected respectively to rail 1a on opposite sides of joint 2, and has a connection extending from the other rail to the heel of polar contact member 30 of the relay. The apparatus is arranged so that according to the position of contact member 30, one or the other of the two track circuit sources is shunted while relay TR is energized by current supplied from the non-shunted one of the two energy sources. For example, assuming the apparatus is in the condition represented in Fig. 4 of the drawings, relay TR is energized from battery EB over a circuit extending from one terminal of battery EB through rail 1a, the winding of relay TR, reactor 19, polar contact 30 of relay TR closed in the left-hand position, as viewed in the drawings, rail 1 and the other terminal of battery EB; while at the same time a shunt circuit is applied across the other battery DB through rail 1a, polar contact 30 of relay TR closed in the left-hand position, and rail 1 to the other terminal of battery DB.

The polarity of current supplied from battery EB to relay TR is selected to cause that relay to operate its armature to its opposite or right-hand position, wherein battery EB is shunted over an obvious circuit path including rails 1 and 1a and contact 30 of relay TR closed in its right-hand position; while relay TR is at this time energized by current of the opposite polarity supplied from battery DB over a circuit extending from one terminal of the battery through rail 1a, reactor 19, the winding of relay TR, polar contact 30 of relay TR closed in its right-hand position, rail 1 and the other terminal of battery DB. Relay TR is now caused to operate its polar contact members back to their left-hand positions. This cycle of operation is maintained as long as section D—E is vacant, and is detected by relay DR which is energized from decoding transformer DT.

When a train enters either end of section D—E, relay TR is caused to cease operating, while relay DR releases. The arrangement is such that relay TR positions its contact member 30 in accordance with the direction of traffic entering the section. That is to say, when a train enters section D—E at its western or left-hand (as viewed in Fig. 4) end D, current from battery DB is shunted from relay TR and that relay accordingly positions its contact member at its right-hand position in response to energy from the other battery EB, whereas when the train enters the section at its other end E, then current from battery EB is shunted from relay TR and that relay positions its polar contact member 30 in its left-hand position in response to energy from battery DB. This characteristic of the circuit arrangement provides a directional control feature which renders the track circuit arrangement adaptable for use in many schemes of signaling where it is essential to register the direction of train movement. The arrangement may be used, for example, in the short track sections that are provided at the ends of passing sidings for providing directional control of traffic movements in absolute permissive block (A. P. B.) or centralized traffic control (C. T. C.) systems; in unbalanced track circuits where the track relay and its insulated joint are located a short distance of, say, one or two hundred feet from one end of the circuit; or as shown in highway crossing signal control systems.

In the illustrative embodiment of my invention represented in Fig. 4, the track circuit arrangement just described is applied to the control of a highway crossing signal XS provided adjacent to the intersection of section D—E and a highway H. Associated with the crossing signal are two stick relays ES and WS arranged to cooperate with relays TR and DR in providing directional control of the signal.

When an eastbound train enters section D—E at its eastbound entrance end D, relay TR is positioned in its right-hand position, relay DR releases, relay ES is energized over a circuit extending from terminal B through back contact 31 of relay DR, polar contact 32 of relay TR closed in its right-hand position, back contact 33 of relay WS and the winding of relay ES to terminal C; and relay ES then picks up to complete for it-

self a stick circuit extending from terminal B through back contact 31 of relay DR, front contact 34 of relay ES, back contact 33 of relay WS and the winding of relay ES to terminal C. Signal XS is set into operation over a circuit extending from terminal B through back contact 31 of relay DR, polar contact member 35 of relay TR closed in its right-hand position, back contact 36 of relay WS and the operating element of signal XS to terminal C.

When the train passes insulated joint 2 disposed at Da adjacent to highway H, current from battery EB is shunted away from relay TR, but this action has no effect upon the apparatus at this time. When, however, the train clears joint 2 at Da, current from battery DB then operates relay TR to its left-hand position, whereupon contact 35 of relay TR operates away from its right-hand position and operation of signal XS is terminated. Then, after the train vacates section D—E, relay TR is reversibly operated and relay DR picks up to open its back contact 31 and thereby deenergize relay ES, whereupon relay ES releases to restore the apparatus to its normal condition.

The apparatus of Fig. 4 functions to control the operation of signal XS for a westbound train in a manner believed to be obvious from an inspection of the drawings taken in connection with the foregoing description of the operation for an eastbound train, and further detailed explanation is believed to be unnecessary except to point out that when a westbound train enters section D—E, at its westbound entrance end E, relay TR is positioned in its left-hand position, relay DR releases, and relay WS becomes energized over a pick-up circuit extending from terminal B through back contact 31 of relay DR, polar contact member 32 of relay TR closed in its left-hand position, back contact 37 of relay ES and the winding of relay WS to terminal C. Relay WS then picks up to complete for itself a stick circuit extending from terminal B through back contact 31 of relay DR, front contact 38 of relay WS, back contact 37 of relay ES and the winding of relays WS to terminal C. Operation of signal XS is now attained over an obvious circuit which extends from terminal B through back contact 31 of relay DR, polar contact 35 of relay TR closed in its normal or left-hand position, back contact 39 of relay ES and the operating element of signal XS to terminal C. This operation of the signal is maintained until the train clears joint 2 at Da and energy from battery EB causes relay TR to reverse its contacts. Then, after section D—E becomes vacant and relay TR reversibly operates, relay DR picks up, relay WS releases, and the apparatus is restored to its normal condition.

If it is desired to provide protection for following trains, the apparatus of Fig. 4 may be modified as shown in Fig. 5 to incorporate a relay TRP interposed in the connection of contact 30 of relay TR to rail 1. Relay TRP is energized at all times except when current from both batteries DB and EB is shunted away from relay TR, and relay TRP is effective to provide an alternate energizing circuit for the highway crossing signal that effects operation of the signal should a first train in section D—E clear joint 2 at Da prior to a second following train entering section D—E. If relay TRP were not provided, the reversal of the polar armature of relay TR caused by the first train clearing joint 2 at Da would interrupt the operation of signal XS and would prevent operation of that signal until the first train vacates the section, even though a second train might be following the first through the section. The second train in approaching the intersection would therefore have no crossing protection until the first train vacates the entire section. However, when relay TRP is employed, it is effective after the first train clears joint 2 at Da and the polar contact member 35 is reversed to terminate operation of signal XS, to restore operation of the signal should a second train follow the first into the section prior to the first train vacating the section. When this happens, current from both batteries will be shunted away from relay TR, and relay TRP accordingly will release to close its back contact 40 and thereby complete an obvious energizing circuit for signal XS, which circuit restores or initiates again the operation of signal XS. When the first train vacates section D—E, relay TRP picks up to open the alternate energizing circuit of signal XS, but operation of the signal at this time is maintained due to energy from battery EB causing relay TR to operate its contact 30 to its right-hand position, thereby causing the apparatus of Fig. 5 to assume the condition corresponding to that established when the first train entered the section. It follows, therefore, that relay TRP is effective to provide crossing protection when a second train follows a first train through section D—E.

In Fig. 6, I have represented how an extremely long section F—M of track may be provided with a highly sensitive track circuit of the type embodying my invention. The section is defined at either end by a par of insulated joints 2, one in each track rail, and such section is divided, by joints 2 in one track rail, such as for example, rail 1a, into as many subsections as is desired for a proper operation of the circuit. At each single joint location there is provided a track relay, designated by the reference character TR with a suitably distinguishing suffix, arranged as described in detail in connection with the apparatus of Fig. 4. Each track relay has associated therewith two track circuit sources. The sources connected to the rails intermediate the section ends are each common to the two track relays disposed on either side thereof, while the track batteries at the two ends of the section cooperate only with the adjacent track relays.

As pointed out in detail in connection with the description of the operation of the apparatus of Fig. 4, in Fig. 6 the battery at one side of an insulated joint will energize the relay connected across that joint with current which will cause that relay to operate its polar armature to its other position whereupon the battery located on the opposite side of the joint will energize the relay with current which causes that relay to operate its armature back to its original position, and this reversible operation of the armature of the relay will continue as long as a train does not shunt energy from either of the two sources away from that relay. This operation of the relays shown in Fig. 6 is effected even though each battery (except the two batteries located respectively at the ends of section F—M) is at all times provided with two circuit paths, one completed through the winding of the relay connected across one of the adjacent insulated joints, and the other completed through the polar contact of the relay connected across the other of the two adjacent insulated joints. For example, consider bat-

tery B2 shown in Fig. 6. In the condition of the apparatus shown in the drawings, battery B2 energizes relay TRG over an obvious circuit which extends from one terminal of battery B2 through rail 1a, the winding of relay TRG, contact 30 of relay TRG and rail 1 back to the other terminal of battery B2. At the same time, battery B2 is provided with a circuit path which extends from one terminal of battery B2 through rail 1a, contact 30 of relay TRJ and rail 1 to the other terminal of battery B2. The joints located at points G and J are so spaced that the current division between the two paths provided for battery B2 is such that in the absence of a train between the joints at G and J, relay TRG is effectively energized and caused to operate its armature from the position shown to its other position. When a train enters subsection G—J at, say, end G, current from battery B2 will be shunted away from relay TRG but relay TRJ will continue to be effectively energized from battery B2 until the train in moving toward battery B2 causes the current division between the two paths available for the battery to reach the value such that the current through relay TRJ is ineffective to operate that relay. The relays shown in Fig. 6 obviously will become successively inactive as a train proceeds through the section, and will in turn become successively active as the rear of the train moves through the section. Each relay will, of course, be provided with a detector relay, not shown but similar to relay DR associated with relay TR of Fig. 4, and a line circuit carried through contacts of each of the detector relays may be employed to detect a train on any portion of the section.

A circuit arrangement of the type represented in Fig. 6 is characterized by the fact that a train shunt need be effective only to prevent operation of a relay, hence such an arrangement provides a means for obtaining a highly sensitive track circuit for a relatively long track section with a minimum of apparatus and with the fewest number of insulated joints.

From the foregoing description, it is readily apparent that I have provided novel and improved track circuits of the type wherein a track circuit source is constantly connected across the track rails, and which circuits incorporate means whereby a highly sensitive track circuit is provided.

Although I have herein shown and described only a few forms of railway 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, an insulated section of railway track having a source of unidirectional energy permanently connected across the rails at one end of said section, a polar relay, circuit means including contacts closed in one position of said relay for connecting the winding of said relay across said track rails at a point remote from said one section end for energization effective to operate said contacts to another position, another source of unidirectional energy, and circuit means including contacts of said relay closed in said other position for connecting the winding of said relay to said other source of energization effective to operate said contacts to said one position.

2. In combination, an insulated section of railway track, two sources of unidirectional current one permanently connected to the rails at one end of said section, a polar relay, and means including said section rails and contacts of said relay for connecting the winding of said relay alternately first to said one source through a connection with said track rails at a point remote from said one section end and then to the other of said sources, said sources being poled in such manner as to reversibly energize said relay.

3. In combination, an insulated section of railway track, two sources of current one for each end of said section and one permanently connected to the rails at one end of said section, a polar track relay at the opposite end of said section, and means governed by contacts of said relay for connecting the relay winding alternately first to said one source through a connection with said rails at the opposite end of said section and then to the other source, said sources being poled in such manner as to reversibly energize said relay.

4. In combination, an insulated section of railway track, a source of unidirectional energy permanently connected across the rails at one end of said section, another source of unidirectional energy and a polar track relay at the opposite end of said section, and circuit means including contacts of said polar relay for connecting the winding of said relay alternately first to said first-mentioned source through a connection with said track rails at said opposite section end and then to said other source, said sources being poled in such manner as to reversibly energize said relay winding.

5. In combination, an insulated track section, a first source of current constantly connected across the rails at one end of said section, a polar track relay, a circuit including contacts of said relay closed in one position of the armature thereof for connecting the relay winding to said track rails at the opposite section end for deriving from said section rails energy having one relative polarity effective to cause said relay to operate said armature to another position, a second source of energy, and a circuit including said relay contacts closed in said other armature position for connecting said relay winding to said second source for deriving therefrom energy having the opposite relative polarity effective to cause said relay to operate its armature to its said one position.

6. In combination, an insulated track section, a first source of current constantly connected across the rails at one end of said section, a polar track relay, a reactor and a resistor, a circuit including contacts of said relay closed in one position of the armature thereof for connecting the relay winding in series with said reactor and in multiple with said resistor to said track rails at the opposite section end for deriving from said section rails energy having one relative polarity effective to cause said relay to operate said armature to another position, a second source of energy, and a circuit including said relay contacts closed in said other armature position for connecting said relay winding in series with said reactor and in multiple with said resistor to said second source for deriving therefrom energy having the opposite relative polarity effective to cause said relay to operate its armature to its said one position.

7. In combination, an insulated track section, a first source of current constantly connected across the rails at one end of said section, a polar track relay, a reactor and a resistor, a circuit including contacts of said relay closed in one position of the armature thereof for connecting the relay winding in series with said reactor and in multiple with said resistor to said track rails at the opposite section end for deriving from said section rails energy having one relative polarity effective to cause said relay to operate said armature to another position, a second source of energy, a circuit including said relay contacts closed in said other armature position for connecting said relay winding in series with said reactor and in multiple with said resistor to said second source for deriving therefrom energy having the opposite relative polarity effective to cause said relay to operate its armature to its said one position, and means controlled by contacts of said relay for detecting reversible operation of said relay armature.

8. In combination with a track section and a first source of track circuit energy and means for supplying from said first source to the rails at one end of said section energy having one relative polarity or the other, two polar track relays, circuit means including contacts of each of said polar relays closed in a predetermined position of the armature thereof for connecting the winding of the respective relay to the track rails at the opposite end of said section, a second source of energy, and circuit means also including said contacts of each of said relays closed in another position of the armature thereof for connecting the winding of the respective relay to said second source, said first and second sources being poled to cause current to flow alternately in opposite directions through the winding of one of said two track relays when energy of said one polarity is constantly supplied from said one source to said track rails and to cause current to flow in opposite directions through the winding of the other of said track relays when energy of said other polarity is constantly supplied from said one source to said track rails.

9. In combination, a track section, a first source of energy, means for reversibly connecting said first source to the rails at one end of said section for supplying such rails with current of one relative polarity or the other, a second source of energy, a first polar relay, circuits means governed by contacts of said first relay and effective when the armature of said relay is in a predetermined position for connecting the winding of said relay to the track rails at the opposite end of said section for deriving therefrom energy effective when of one relative polarity to operate the armature of said first relay to another position, circuit means governed by contacts of said first relay and effective when the armature thereof is in said other position for connecting said winding of said first relay to said second source for deriving therefrom energy effective to operate the armature of said first relay to said predetermined position, a second polar relay, circuit means governed by contacts of said second relay and effective when the armature thereof is in a predetermined position for connecting the winding of said second relay to the rails at said opposite section end for deriving therefrom energy effective when of the said other relative polarity to operate the said second relay armature to another position, and circuit means governed by contacts of said second relay and effective when the armature thereof is in its said other position for connecting the said second relay winding to said second source for deriving therefrom energy effective to operate the said second relay armature to its said predetermined position.

10. In combination, a track section, a first source of energy, means for reversibly connecting said first source to the rails at one end of said section for supplying such rails with current of one relative polarity or the other, a second source of energy, a first polar relay, circuit means governed by contacts of said first relay and effective when the armature of said relay is in a predetermined position for connecting the winding of said relay to the track rails at the opposite end of said section for deriving therefrom energy effective when of one relative polarity to operate the armature of said first relay to another position, circuit means governed by contacts of said first relay and effective when the armature thereof is in said other position for connecting said winding of said first relay to said second source for deriving therefrom energy effective to operate the armature of said first relay to said predetermined position, a second polar relay, circuit means governed by contacts of said second relay and effective when the armature thereof is in a predetermined position for connecting the winding of said second relay to the rails at said opposite end of said section for deriving therefrom energy effective when of the said other relative polarity to operate the said second relay armature to another position, circuit means governed by contacts of said second relay and effective when the armature thereof is in its said other position for connecting the said second relay winding to said second source for deriving therefrom energy effective to operate the said second relay armature to its said predetermined position, and means for detecting a reversible operation of either of said two track relays.

11. In combination, a stretch of railway track including an insulated track section, a first source of current, means governed by traffic conditions on said stretch beyond one end of said section for connecting said first source to the track rails at said one section end for supplying thereto at times energy of one relative polarity and at other times energy of the other relative polarity, a second source of energy, a first polar relay, circuit means governed by contacts of said first relay and effective when the armature of said relay is in a predetermined position for connecting the winding of said relay to the track rails at the opposite end of said section for deriving therefrom energy effective when of one relative polarity to operate the armature of said first relay to another position, circuit means governed by contacts of said first relay and effective when the armature thereof is in said other position for connecting said winding of said first relay to said second source for deriving therefrom energy effective to operate the armature of said first relay to said predetermined position, a second polar relay, circuit means governed by contacts of said second relay and effective when the armature thereof is in a predetermined position for connecting the winding of said second relay to the rails at said opposite section end for deriving therefrom energy effective when of the said other relative polarity to operate the said second relay armature to another position, circuit means governed by contacts of said second relay and effective when the armature thereof is in its said

other position for connecting the said second relay winding to said second source for deriving therefrom energy effective to operate the said second relay armature to its said predetermined position, and means governed by said two track relays for controlling traffic operating over said stretch.

12. In combination, a section of railway track, means for applying to the rails at one end of said section energy having one relative polarity or the other in accordance with predetermined conditions, a second source of current, a first polar relay connected in circuit over its own contacts alternately first to said second source and then to the track rails at the opposite section end when current of said one relative polarity is applied to said rails, and a second polar relay connected in circuit over its own polar contacts alternately first to said second source and then to said track rails at said opposite section end when current of said other relative polarity is applied to said rails.

13. In combination, a section of railway track, two sources of current connected respectively across the track rails at opposite ends of said section, an insulated joint in one of said rails intermediate the ends thereof, a polar relay having its two terminals connected to said one rail on opposite sides of said joint respectively, and a circuit connecting the other of said rails to one terminal or the other of said relay through a polar contact of said relay according as the polar armature of said relay is in one position or the other, whereby to complete the circuit connection of the relay winding to one or the other of said sources respectively, said sources being poled to cause current from each of said sources when connected in circuit with the relay to flow in the relay in a direction to cause the relay to operate its armature from its then existing position to its opposite position.

14. In combination with a section of railway track, two sources of current connected respectively to the rails at opposite ends of said section, an insulated rail joint in one of said rails intermediate the ends thereof, a polar track relay having its two terminals connected respectively to said one rail on opposite sides of said joint, a polar contact member operated by said relay and connected to the other of said rails, a connection from one of said relay terminals to a fixed contact engaged by said polar contact in one position of the polar armature thereof for completing the circuit connection of one of said sources to the winding of said relay for deriving from said one source energy having a polarity effective to cause said relay to operate its polar armature member to its other position, and a connection from the other of said relay terminals to another fixed contact engaged by said polar contact in said other position of the polar armature thereof for completing the circuit connection of the other of said sources to the winding of said relay for deriving from said other source energy having a polarity effective to cause said relay to operate its polar armature to its said one position.

15. In combination with a section of railway track, two sources of current connected respectively to the rails at spaced points along said section, an insulated rail joint in one of said rails intermediate said spaced points, a polar track relay having its two terminals connected respectively to said one rail on opposite sides of said joint, a polar contact member operated by said relay and connected to the other of said rails, a connection from one of said relay terminals to a fixed contact engaged by said polar contact in one position of the polar armature thereof for completing the circuit connection of one of said sources to the winding of said relay for deriving from said one source energy having a polarity effective to cause said relay to operate its polar armature member to its other position, and a connection from the other of said relay terminals to another fixed contact engaged by said polar contact in said other position of the polar armature thereof for completing the circuit connection of the other of said sources to the winding of said relay for deriving from said other source energy having a polarity effective to cause said relay to operate its polar armature to its said one position.

16. In combination with a stretch of railway track, a plurality of sources of current connected respectively at spaced points to the rails of said section, a plurality of insulated rail joints respectively interposed in one of said track rails intermediate the connections of each two successive sources to the track rails, a plurality of polar relays one for each insulated joint and each having its two terminals connected to said one track rail on opposite sides of the associated insulated joint, each of said relays having a polar contact member operated by said relay and connected to the other of said rails at a point adjacent to the associated joint in the said one rail, each of said relays having a connection from one of that relay's terminals to a fixed contact engaged by said polar contact of that relay in one position of the polar armature thereof for completing the circuit connection of one of the adjacent two sources for that relay to the winding of that relay for deriving from said one source energy having a polarity effective to cause that relay to operate its polar armature member to its other position, and each of said relays having a connection from the other of that relay's terminals to another fixed contact engaged by said polar contact of that relay in said other position of the polar armature thereof for completing the circuit connection of the other of the adjacent two sources for that relay to the winding of that relay for deriving from said other source energy having a polarity effective to cause that relay to operate its polar armature to its said one position.

17. In combination with a section of railway track, two sources of current connected respectively to the rails at opposite ends of said section, an insulated joint interposed in one of said rails intermediate the two ends of said section, a polar relay having its two terminals connected to said one rail on opposite sides of said joint respectively, a circuit connecting the other of said rails through a polar contact of said relay to one terminal or the other of said relay according as the polar armature of said relay is in one position or the other, whereby to complete the circuit connection of the relay winding to one or the other of said sources respectively, said sources being poled to cause current from each of said sources when connected in circuit with the relay to flow through the relay winding in a direction to operate the polar armature from its then existing position to its opposite position, and directional control means governed by said polar relay effective when a train enters either end of said section to establish a directional control dependent upon the direction of the train movement.

18. In combination with a section of railway track, two sources of current connected respec-

tively to the rails at opposite ends of said section, an insulated joint interposed in one of said rails intermediate its two ends, a polar relay having its two terminals connected to said one rail on opposite sides of said joint respectively, a circuit connecting the other of said rails through a polar contact of the relay to one terminal or the other of said relay according as the polar armature of said relay is in one position or the other, whereby to complete the circuit connection of the relay winding to one or the other of said sources respectively, said sources being poled to cause current from each of said sources when connected in circuit with the relay to flow through the relay winding in a direction to operate the polar armature from its then existing position to its opposite position, means for detecting operation of said polar relay armature alternately between its said one and said other position caused by said two sources, and directional control means controlled by said polar relay and said detecting means.

19. In combination with a section of railway track intersected intermediate the ends thereof by a highway, a highway crossing signal adjacent to said intersection, an insulated joint in one of the rails of said section adjacent to said intersection, two sources of current connected to the rails at opposite ends respectively of said section, a polar track relay having its two terminals connected respectively to said one rail on opposite sides of said joint, a polar contact member operated by said relay and connected to the other of said rails, a connection from one of said relay terminals to a fixed contact engaged by said polar contact in one position of the polar armature thereof for completing the circuit connection of one of said sources to the winding of said relay for deriving from said one source energy having a polarity effective to cause said relay to operate its polar armature member to its other position, a connection from the other of said relay terminals to another fixed contact engaged by said polar contact in said other position of the polar armature thereof for completing the circuit connection of the other of said sources to the winding of said relay for deriving from said other source energy having a polarity effective to cause said relay to operate its polar armature to its said one position, a detecting relay, means controlled by said polar relay when reversibly operated for energizing said detecting relay, two directional stick relays, a pick-up circuit for one of said two directional stick relays comprising a back contact of said detecting relay, the winding of said one stick relay, a back contact of the other stick relay and a polar contact of said polar relay closed in said one position of said polar armature; a stick circuit for said one stick relay comprising its own front contact and a back contact of said detecting relay; a pick-up circuit for the other of said stick relays comprising a back contact of said detecting relay, the winding of said other stick relay, a back contact of said one stick relay and a polar contact of said polar relay closed in said other position of said polar armature; a stick circuit for said other stick relay comprising its own front contact and a back contact of said detecting relay; and an operating circuit for said warning signal comprising the operating element of said signal, a back contact of said detecting relay, and a polar contact of said relay closed in said one position of the armature thereof and a back contact of said other stick relay or a polar contact of said polar relay closed in said other position of the armature thereof and a back contact of said one stick relay.

HOWARD A. THOMPSON.