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[54] **RAILROAD TRACK CIRCUIT**
10 Claims, 2 Drawing Figs.

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[50] Field of Search 246/40, 125, 128

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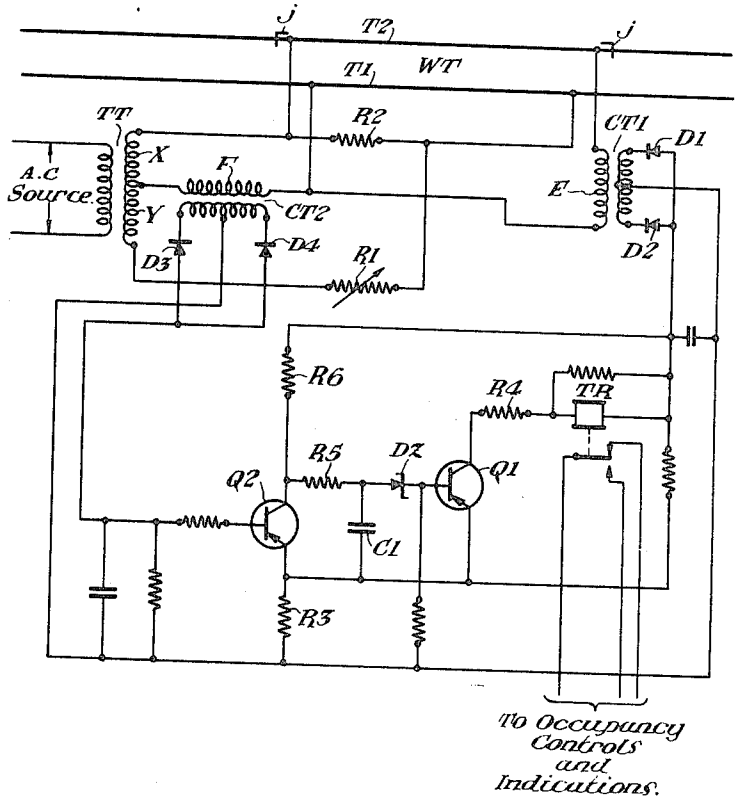
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ABSTRACT: Both portions of a center tapped track transformer secondary winding, a load resistor, and a balancing resistor are connected into a balanced bridge network, with the load resistor also connected across the track section rails. A first control transformer primary winding is connected in parallel with the load resistor and its rectified secondary output is applied to charge a timing capacitor which biases a first transistor to conduction to energize the track relay. The primary winding of a second control transformer is connected across opposite, voltage balanced terminals of the bridge to produce, when a track shunt unbalances the bridge network, a rectified output which is applied to fire a second transistor. When conducting, this second transistor discharges the capacitor, thus turning off the first transistor to deenergize the track relay. Removal of the rail shunt turns off the second transistor and the capacitor recharges over a predetermined timing period. The first transistor again fires when the capacitor charge exceeds a preset level. Reenergization of the track relay is thus delayed to avoid loss of train detection under erratic rail shunting conditions.



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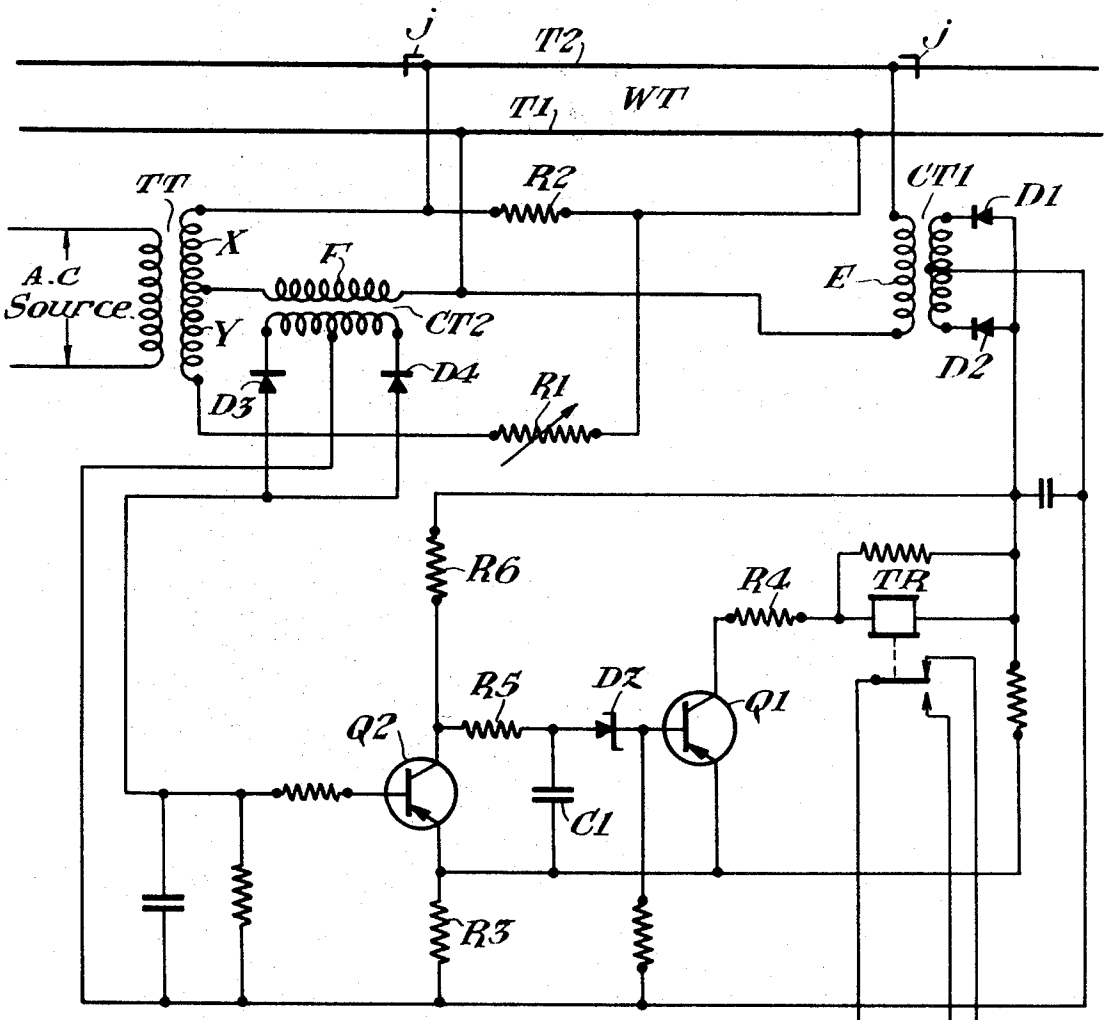


Fig. 1.

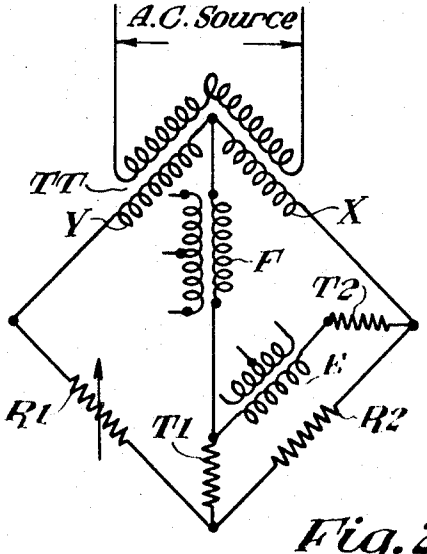


Fig. 2.

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RAILROAD TRACK CIRCUIT

This invention relates to a railroad track circuit. More specifically, my invention pertains to a track circuit for the continued detection of the presence of a train or railroad car within a short track section where shunting conditions between the car wheels and track surface may be poor or erratic.

The use of short detector track sections is common in all types of railroad signal and control systems. Normally such sections are track circuited to detect the presence of a train or railroad car within the section limits in order to inhibit the operation of some type of apparatus, the operation of which would create a dangerous condition for the movement of that train or car. Specific examples may be taken from railroad classification yard control systems in which detector track sections are used at switches and within car retarders in order to insure that, respectively, a track switch does not change position during the passage of a car and that a car is not prematurely released from, or stalled within, a retarder due to the loss of an indication of the presence of a car. Continuing this specific example, in the operation of classification yards, as a result of the necessary inspection of the cars and/or measures taken to expedite car movement, poor rail shunting conditions are frequently created at various locations throughout the yard. For example, oil and dirt become deposited on the rails, creating a film which prevents a good, or at times any, contact between the wheels and the rails. Also brine drippings and other lading spills from the cars may cause corrosion and dirt on the rail surfaces. Such conditions frequently cause erratic shunting of the rails by cars moving within the short detector track sections. Such loss of shunt may cause a nonoccupied indication to actuate a control function which produces a dangerous condition which may result in an accident and damage. Many arrangements, some lacking economy, effectiveness, or efficiency, have been proposed to cure, alleviate, or avoid this problem. However, the need still exists for a track circuit which will initially detect and then maintain the detection of the presence of a car within a short track section even under erratic shunting conditions.

Accordingly, an object of my invention is a railroad track circuit with improved shunting characteristics.

Another object of the invention is an alternating current track circuit having improved detection characteristics for installation in short sections of railroad track where the rail surface conditions frequently result in erratic shunting of the track circuit by the car wheels.

A further object of my invention is a railroad track circuit arrangement which will immediately detect the initial rail shunt by car wheels and release the track relay, then delay track relay reenergization for a selected period of time if intermittent shunting occurs.

Still another object of my invention is a railroad track circuit comprised of a balanced bridge circuit network which assures the release of the track relay immediately upon the initial rail shunt by car wheels and also establishes a delay period which must expire prior to the reenergization of the track relay upon subsequent loss of the shunt condition even if due to erratic rail shunting by the car resulting from poor contact between the wheels and the rail surface.

A still further object of this invention is an alternating current track circuit which includes a balanced bridge network connected to the rails of the track section to be responsive to rail shunts by cars and including a transistorized circuit arrangement which will immediately release the track relay upon the initial shunt condition and delay subsequent pickup of the track relay in order to avoid the loss of the occupancy indication under erratic shunting conditions.

Other objects, features, and advantages of my invention will become apparent from the following description when taken in connection with the accompanying drawings.

In practicing my invention, the alternating current energy for the track circuit is provided from the commercial power source through a track transformer having a center tapped secondary winding. This secondary winding, a balancing resistor, and a load resistor are connected into a balanced bridge circuit network with each half of the secondary winding forming a separate leg of the bridge circuit. The load resistor is also connected across the rails of the track section. In the specific form shown, the track section is insulated to define specific limits for the detection of railroad cars. Also connected across the rails is the primary of a first control transformer, connected in such a manner that this primary winding is in parallel with the load resistor. The rectified output from the secondary winding of this control transformer is applied to a series circuit including the track relay winding and the current conducting path of a first transistor. This transistor is so biased as to normally be in its conducting state, i.e., switched on, when no car is occupying the track section. This bias is applied by a capacitor which is connected into a resistor-capacitor timing circuit also supplied by the rectified output from the secondary of the first control transformer.

The primary winding of a second control transformer is connected across opposite terminals of the bridge network, that is, across balanced voltage terminals and specifically between the center tap of the track transformer secondary winding and a terminal of the first control transformer primary which is equivalent to the common connection of the load and balancing resistors. The control input terminals of a second transistor, normally biased to its nonconducting condition, are connected to receive the rectified output of the secondary winding of the second control transformer. The shunting of the rails of the track circuit by car wheels causes an unbalanced condition in the bridge network which activates the second transistor to conduct current. This completes a shunting path for the timing capacitor so that it is discharged and thus turns off the first transistor, which deenergizes the track relay to immediately release. When the rail shunt is removed for any reason from the track circuit, the second transistor becomes nonconducting so that charging current flows through the timing capacitor. The charging circuit has a predetermined timing period established by the resistance-capacitance circuit parameters. In other words, when the second transistor conducts to shunt the timing capacitor, it establishes a delay period which must expire before the capacitor is recharged after the second transistor again is nonconducting. During the period that the timing capacitor is charging, the first transistor is held nonconducting until the normal voltage level of the capacitor charge is reached. When this occurs, the first transistor again conducts and reenergizes the track relay. Thus, the track relay is not reenergized until the timing period necessary to recharge the capacitor is completed. This timing period, that is, the parameters of the R-C circuit network, are selected so that intermittent and erratic shunting will not cause the track relay to pick up and incorrectly indicate an unoccupied condition of the track circuit.

I shall now describe in greater detail the track circuit arrangement of my invention referring from time to time to the accompanying drawings in which:

FIG. 1 is a diagrammatic circuit showing one form of track circuit embodying the invention as applied to a track section.

FIG. 2 is a schematic illustration in conventional arrangement of the portion of the apparatus and circuits of FIG. 1 which form the balanced bridge circuit network embodied in the track circuit invention.

In each of the figures of the drawings, similar reference characters are used to designate equivalent parts of the apparatus or circuit arrangement.

Referring now to FIG. 1, across the top is shown a stretch of railroad track comprising the track rails T1 and T2. In the stretch, a detector track section WT is set off by insulated joints *j*. These joints are shown only in one rail in the specific illustration but obviously may be installed in both rails at each end of the track section if desired. Either type of insulated track sections are used for detector track circuits. At the left of the drawing is shown a track transformer TT which has a

center tapped secondary winding, the halves of which are designated as winding X and winding Y. The primary of transformer TT is connected across a source of alternating current energy which for convenience will normally be the commercial power supply available at the installation. Output voltages of windings X and Y are equal, that is, at the same voltage level, and have the same instantaneous polarity. Transformer TT is also shown in schematic form in FIG. 2 with the primary again connected to an alternating current source and the two halves X and Y of the secondary winding forming separate legs of the bridge circuit network which will be described shortly.

Returning to FIG. 1, the upper terminal of winding X is connected to rail T2 and also to one terminal of a load resistor R2. The other terminal of resistor R2 is connected to rail T1 in a diagonal manner, that is, at the opposite end of section WT. Resistor R2 is thus a load across the rails of the track section although it need not necessarily be connected in the diagonal manner. In other words, both terminals of resistor R2 may be connected to the opposite rails at the same end of the track section if so desired. The lower terminal of winding Y is connected to one terminal of a balancing resistor R1, and adjustable resistor, the other terminal of which is connected to rail T1 and also to the second terminal of resistor R2. The windings X and Y and the impedances or resistors R1 and R2 are thus connected into a bridge network as schematically illustrated, for convenience, in FIG. 2. It is to be noted that the rails T1 and T2 are illustrated as resistors in the FIG. 2 network in order to specifically set them off from the other apparatus or circuit connections in the schematic illustration. The rails do have a low resistance which is, however, relatively immaterial in the operation of the track circuit embodying my invention.

Also connected across rails T1 and T2, at the opposite diagonal points of section WT, is the primary winding E of a first control transformer CT1. However, if resistor R2 is connected across the rails at one end of section WT rather than the diagonal connection shown, winding E will then be connected directly across the rails at the other end of section WT. For either arrangement, winding E in series with rails T1 and T2 provides a circuit path in parallel with resistor R2 in the bridge network, as schematically illustrated in FIG. 2. A primary winding F of a second control transformer CT2 is connected between the center tap or common terminal of windings X and Y and the connection from winding E to rail T1. Winding F is thus connected across the opposite terminals or equivalent voltage points of the balanced bridge network in series with rail T1, as shown specifically in FIG. 2. Said in another way, when the bridge network is balanced, there is no differential between the voltage potentials at the center tap terminal and the common connection of resistors R1 and R2. An equivalent balanced voltage connection for winding F is also obtainable if the second terminal of this winding is connected to the common point between resistors R1 and R2, as will be obvious from an inspection of the schematic illustration of the bridge network in FIG. 2.

The output of the secondary winding of transformer CT1 is rectified by diodes D1 and D2 and, with the waveform slightly smoothed, is applied to a series circuit which includes the emitter-collector circuit path of a first transistor Q1 and the winding of track relay TR. This series circuit may be specifically traced from the center tap terminal of the secondary winding of transformer CT1 through resistor R3, the emitter-collector path of transistor Q1, resistor R4, the winding of relay TR, and diodes D1 and D2 to the end terminals of the secondary winding. A carefully selected resistor will be connected in parallel across the winding of track relay TR in order that the pickup and release characteristics of the relay will be relatively unaffected by the parameters of the circuit in which the relay winding is connected. Transistor Q1 and a second transistor Q2 are both shown as PNP-type transistors. Obviously, NPN-type transistors may be used, if desired, by proper arrangement of the potentials applied to the various circuits. It will also be apparent, as the description progresses, that various other types of semiconductor switching devices may be substituted for transistors Q1 and Q2, if desired. The charging circuit for a timing capacitor C1 is also connected across this secondary winding of transformer CT1, the circuit including resistor R3, capacitor C1, resistor R5, resistor R6, and diodes D1 and D2. The various operating conditions for these two circuits will be described shortly. It will be noted that the bias potential on the base of transistor Q1 is chiefly applied from the upper terminal of capacitor C1 through a Zener diode DZ with a further bias connection being applied through a resistor in a conventional manner from the positive potential bus from transformer CT1.

The output from the secondary winding of transformer CT2 is also rectified, by diodes D3 and D4, and the rectified waveform is smoothed by a resistor, capacitor network. This rectified voltage, when available, is applied as a bias signal across the base-emitter circuit path of transistor Q2, which is normally held in a nonconducting condition by a bias potential from the positive bus from transformer CT1. The emitter-collector path of transistor Q2 is also connected across the rectified output of the secondary winding of transformer CT1 so that the transistor conduction path is directly parallel to the circuit path including capacitor C1 and resistor R5, as will be obvious from an inspection of the circuit diagram of FIG. 1.

I shall now describe the operation of the track circuit embodying my invention. With no car occupying section WT, that is, no shunt across rails T1 and T2, the bridge circuit network shown in FIG. 2 is in a balanced condition. This condition is obtained by properly adjusting resistor R1 when the track circuit is initially installed. The balanced condition is, of course, the normal situation upon which operation is based. With the bridge network in a balanced condition, the equal outputs of windings X and Y of transformer TT result in the opposite terminals of the bridge having equal potential. In other words, the voltage potentials at opposite terminals of the series circuit through winding F and rail T1 are at the same level and no current flows through winding F. The parallel circuits including resistor R2 and winding E of transformer CT1 each carry a portion of the current flowing in that leg of the balanced bridge. As previously mentioned, the actual resistance of rail T1 is so small that it does not materially affect the balanced condition of the bridge so that it may be assumed that no current is flowing in winding F under this normal situation. With no current flowing in winding F, there is no output from the secondary winding of transformer CT2 and thus transistor Q2 will be in its nonconducting condition since a positive bias signal appears on the base of this transistor under this normal situation.

The output from the secondary winding of transformer CT1, resulting from the flow of current through winding E under the balanced bridge network condition, holds capacitor C1 fully charged over the previously traced circuit. The potential at the upper terminal of this charged capacitor is sufficiently negative in potential to exceed the breakdown voltage of diode DZ so that a negative bias signal is applied to the base of transistor Q1 to hold this transistor in its conducting condition. Current thus flows in the emitter-collector path of transistor Q1 and through the winding of relay TR to hold this relay in its picked up condition. With relay TR picked up, a nonoccupancy indication for section WT is recorded by the closing of a front contact of relay TR. This is conventionally shown by the partially illustrated circuit network which records the condition of relay TR into the occupancy controls and indication apparatus as the front or back contact of this relay is closed. Any one of various and well known arrangements for recording and using the track occupancy indication may be used with the track circuit arrangement of my invention and it is not necessary to further discuss such arrangements. Simply then, it is accepted that, when the illustrated front contact of relay TR is closed, a nonoccupancy indication or control is applied to whatever system is in use and when the corresponding back contact is closed, a track occupied indication or control is recorded and applied to the system.

When a car enters section WT, its wheel and axle units shunt the rails of the section and the bridge circuit network of the track circuit becomes unbalanced. In other words, the resistor R2, winding E parallel paths in that leg of the network are substantially shunted by the car occupying the section. This reduces the output from transformer CT1 so that the current flowing through relay TR will be insufficient to hold that relay picked up. Further, since the opposite terminals of the bridge no longer have equal potential, current flows through winding F. The resulting output from transformer CT2 activates transistor Q2 into its conducting condition by applying a negative biasing signal to the base of this transistor. With transistor Q2 conducting, its emitter-collector circuit path shunts and rapidly discharges timing capacitor C1. This changes the bias signal at the base of transistor Q1 and switches off conduction by this transistor. With transistor Q1 no longer conducting, current through the relay circuit is completely halted, thus assuredly deenergizing relay TR which immediately releases. As previously explained, release of relay TR to close its back contact records an occupied indication for section WT by the passing car. These actions within the circuit network occur rapidly following the initial shunt across the rails of the section. In addition, the common emitter coupling between transistors Q1 and Q2 aids in this rapid response.

When the car leaves section W2, the shunt across the rails is removed and the bridge is again in its balanced condition. With no current passing through winding F, the negative bias signal at the base of transistor Q2 is removed and it becomes nonconducting. Track voltage also reappears at the output from the secondary of transformer CT1. This output is applied to the previously traced charging circuit for timing capacitor C1 which gradually recharges during a timing period established by the resistance, capacitance parameters of the circuit. Thus the discharge of capacitor C1 when transistor Q2 becomes conducting, as a result of the entry of the car into the section, establishes a predetermined timing period for the reactivation of the track circuit. Capacitor C1 gradually recharges until its voltage exceeds the break down limit of diode DZ when a negative bias signal is again applied to the base of transistor Q1. This transistor again conducts and reenergizes relay TR so that it picks up, thus recording a nonoccupied indication for track section WT. The timing period which is enforced prior to the reenergization of relay TR is predetermined by selecting values for the resistors in the charging circuit and for capacitor C1 which will give the delay period characteristics desired.

If, during the passage of the car through section WT, contact between the wheels and the rails is lost due to poor shunting conditions, that is, oil, dirt, or corrosion on the rails, the bridge network will again become balanced since no shunt is evident. This causes transistor Q2 to be switched off since no signal is applied from the secondary of transformer CT2. Capacitor C1 immediately begins to charge from the track voltage which reappears through transformer CT1. It is characteristic of such detector track sections that this loss of shunt with the car still within the section limits is an intermittent action, that is, the shunting is erratic. Therefore, prior to the completion of the charging time for capacitor C1, that is, prior to the expiration of the established delay period, the wheel shunt will be restored. Said in another way, during the charging time of capacitor C1, the shunt across the rails will at least occur intermittently. With each intermittent shunt condition, transistor Q2 immediately conducts and again discharges capacitor C1. Each discharge action for this capacitor renews the predetermined delay period. Transistor Q1 cannot conduct to reenergize relay TR until a delay period completely expires. In other words, transistor Q1 cannot be switched on to conduct current until capacitor C1 reaches a charging voltage which exceeds the breakdown limit of diode DZ. Therefore, relay TR does not pick up to incorrectly record a nonoccupied indication or control under these erratic shunting conditions. Since the occupancy indication control is not interrupted, the apparatus controlled by relay TR cannot be restored or operated in a manner dangerous to the passage of the cars moving through section WT.

This operation of the novel arrangement here provided improves over the specific prior art systems in which a capacitor only is used to provide slow pickup characteristics for the track relay. For example, assume that an initial good shunt period is followed by a period of poor shunting interrupted by very brief intervals of good shunting. In the prior art arrangements, the capacitor starts to charge at the beginning of the poor shunting period. Each brief good shunting interval is too short to discharge the capacitor. The applied track relay voltage is therefore smeared by the capacitor as it builds to its full charging level. In order to further protect against incorrect track relay pickup, a long time constant must then be designed into the R-C charging circuit. This delays pickup of the track relay when the car does clear the track section. In the presently disclosed arrangement, each period of good shunting turns on transistor Q2 to completely discharge capacitor C1. Thus, a shorter R-C time constant may be used for the capacitor charging circuit with full assurance that the track relay voltage applied during successive loss of shunt periods will not be smeared by capacitor C1 to result in an improper pickup of relay TR. When the car clears the section, there is then less delay in the proper energization of relay TR so that more time is available between successive cars for the operation of the controlled apparatus.

A track circuit arrangement embodying my invention thus insures the continued detection of the presence of a car within the detector track section even under erratic shunting conditions. This result is accomplished in an effective and efficient manner without requiring an excessive amount of apparatus. A safe operation of the associated control system, for example, track switch or car retarders, may thus be assured.

Although I have herein shown and described but one form of a track circuit arrangement embodying the principles of my invention, it is to be 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.

I claim:

1. Track circuit apparatus for a stretch of railroad track traversed at times by railroad cars, comprising in combination,
   a. a source of alternating current energy having an additional center tap connection,
   b. a load impedance connected across the rails of said track stretch,
   c. a balancing impedance,
   d. said source and said load and balancing impedances being connected in a bridge circuit network, balanced when a no-rail shunt condition exists, each portion of said source, as divided by said center tap, and each impedance forming a separate leg of said bridge circuit,
   e. indication means coupled to said load impedance and responsive to shunt and no-shunt rail conditions for indicating the occupancy or nonoccupancy, respectively, of said stretch by a car,
   f. delay means coupled across opposite balance points of said bridge network and responsive to each shunt condition across said rails for establishing a predetermined delay period,
   g. said delay means also coupled to said indication means for enforcing the full predetermined delay period after each rail shunt condition, prior to the subsequent response of said indication means to a no-rail-shunt condition.

2. Track circuit apparatus as defined in claim 1 in which,
   a. said load impedance comprises a load resistor connected across said rails and the primary winding of a first control transformer connected in parallel with said resistor through said rails, said parallel circuits together forming one leg of said bridge network,

b. said indication means comprises a track relay and a first transistor, series connected across the secondary winding of said first control transformer,

c. said first transistor controlled by said delay means for completing the energizing circuit for said relay to provide a nonoccupied indication only when said predetermined delay period has expired after a no-rail-shunt condition exists.

3. Track circuit apparatus as defined in claim 2 in which the combination further includes,

a. a second control transformer having its primary winding connected between said center tap terminal of said source and the opposite terminal of said bridge network, and in which,

b. said delay means comprises a second transistor and a timing capacitor,

c. the secondary winding of said second control transformer coupled to said second transistor for actuating that transistor to its conducting condition when a rail shunt condition occurs,

d. said capacitor connected in a charging circuit across the secondary of said first control transformer for charging to a selected voltage level during said predetermined delay period,

e. said second transistor having connections for discharging said capacitor when that transistor is in its conducting condition,

f. said capacitor coupled to said first transistor for actuating that transistor to complete said energizing circuit for said track relay only when said selected voltage level of capacitor charge is reached.

4. Track circuit apparatus as defined in claim 3 in which, said timing capacitor is coupled to said first transistor by a Zener diode having a preset breakdown voltage equal to said selected charging voltage level.

5. Track circuit apparatus as defined in claim 4 in which,

a. said balancing impedance is an adjustable resistor,

b. said alternating current source is a track transformer having its primary winding connected across a source of alternating current energy and a center tapped secondary winding providing equal output from each portion of that winding.

6. Track circuit apparatus as defined in claim 1 in which, said indication means comprises a track relay and a first switching semiconductor device, the winding of said relay and the conducting path of said first device connected in a series circuit which is coupled to said load impedance for at times energizing said track relay,

b. said delay means coupled to said first semiconductor device for switching on said series circuit to energize said track relay only when said predetermined delay period has been completed after a no-rail-shunt condition begins,

c. said track relay having connections for controlling the display of a nonoccupied and an occupied indication as said relay is energized and deenergized, respectively.

7. Track circuit apparatus as defined in claim 6, in which said delay means comprises,

a. a timing capacitor,

b. a charging circuit for said capacitor coupled to said load impedance for charging said capacitor to a preset voltage level during said predetermined delay period,

c. a second switching semiconductor device coupled to said bridge network and responsive to the occurrence of a rail-shunt condition for switching its conducting path to its on condition,

d. said second device having connections for discharging said capacitor when said second device is in its on condition,

e. said timing capacitor coupled to said first device for switching on said series circuit only when said preset voltage charging level is reached.

8. A balanced bridge track circuit arrangement for a stretch of railroad track, comprising in combination,

a. first and second equal secondary track transformer windings having a common connection and forming two legs of said bridge circuit,

b. a balancing impedance connected to form a third leg of said bridge circuit,

c. a load impedance connected to form a fourth leg of said bridge circuit and also connected across the rails of said track stretch,

d. a primary winding of said track transformer connected to a source of alternating current energy,

e. a first control transformer having a primary winding connected across the rails of said track stretch for forming a parallel path in the fourth leg of said bridge circuit,

f. a second control transformer having a primary winding connected between said common connection of said track transformer secondary windings and the opposite terminal of said bridge circuit formed by the common connection of said third and fourth legs,

g. indication means coupled to the secondary winding of said first control transformer and responsive to the flow of current in said bridge circuit during a nonshunted condition of the rails of said track stretch for recording a nonoccupied indication of said track stretch, and

h. delay means coupled to the secondary winding of said second control transformer and responsive to the flow of current in said bridge track circuit when the track rails of said stretch are initially shunted for controlling said indication means to record a stretch occupied indication,

i. said delay means being further responsive to a nonshunted rail condition subsequent to a rail shunt for establishing a predetermined delay period and coupled to said indication means for delaying the recording of a nonoccupied indication until the expiration of said delay period.

9. A track circuit arrangement as defined in claim 8 in which said delay means comprises,

a. a timing capacitor,

b. a semiconductor device having its control elements coupled to the secondary winding of said second control transformer for triggering to its conducting condition when a rail shunt condition exists, and having connections for discharging said timing capacitor when said device is in its conduction condition, and

c. a charging circuit for said timing capacitor having connections to the secondary winding of said first control transformer for charging said capacitor to a selected voltage level during said predetermined delay period,

d. said capacitor further coupled to said indication means for delaying the response to a nonshunted rail condition until said selected voltage level is obtained.

10. A track circuit arrangement as defined in claim 9 in which said indication means comprises,

a. a track relay having connections for providing when energized a nonoccupied indication for said stretch and when deenergized an occupied indication,

b. another semiconductor device,

c. the winding of said relay and the conduction path of said other device being connected in series across the secondary winding of said first control transformer for energizing said relay when said other device is in its conducting condition and a nonshunted rail condition exists, and in which,

d. said timing capacitor is coupled to the control elements of said other device for triggering said other device to its conducting condition only when said capacitor is charged to said selected voltage level.

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