Sept. 24, 1940. B. E. O'HAGAN 2,215,910

RAILWAY TRACK CIRCUIT APPARATUS

Filed June 21, 1939

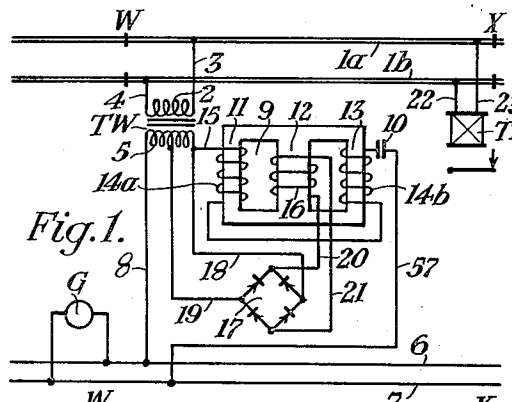


Fig. 1.

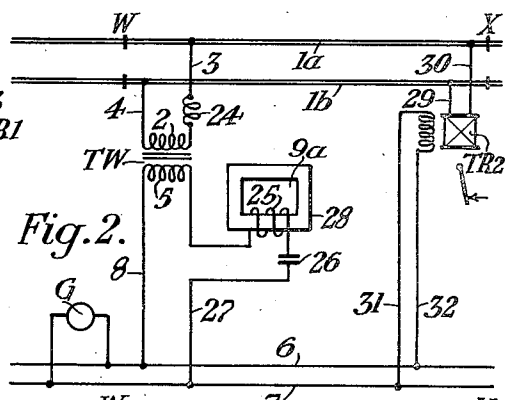


Fig. 2.

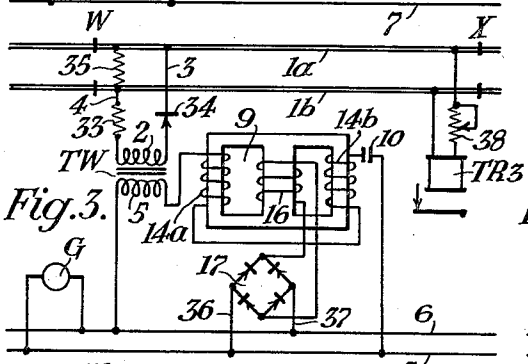


Fig. 3.

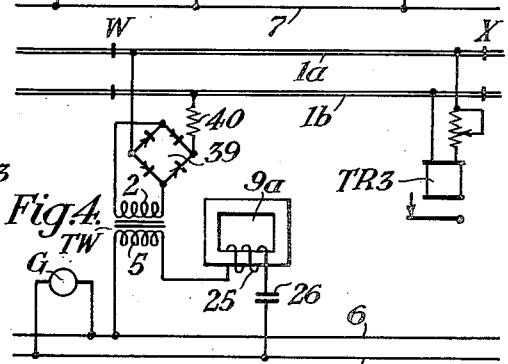


Fig. 4.

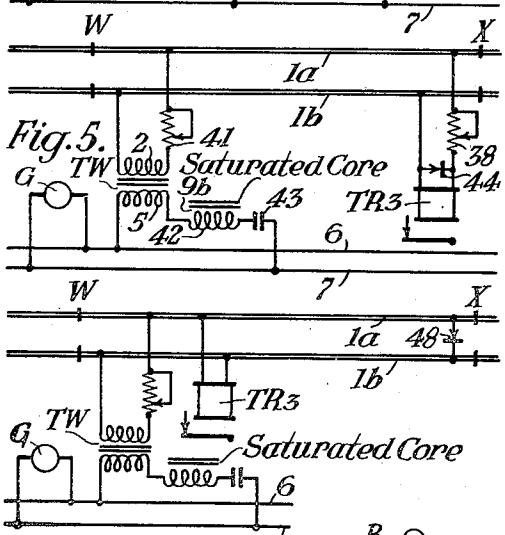


Fig. 5.

Fig. 7.

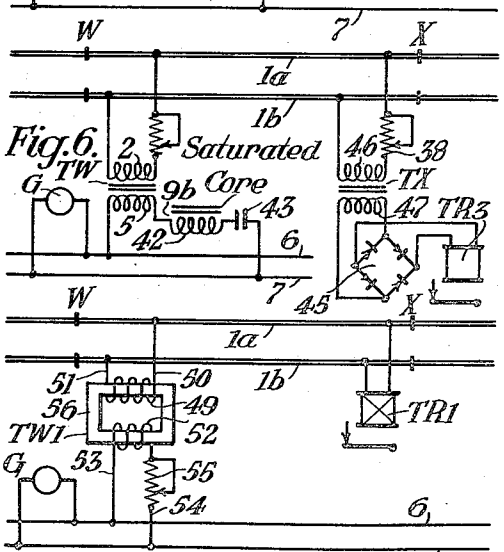


Fig. 6.

Fig. 8.

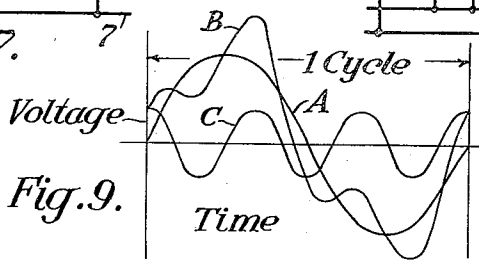


Fig. 9.

INVENTOR
Bernard E. O'Hagan.
BY
HIS ATTORNEY

Patented Sept. 24, 1940 2,215,910

UNITED STATES PATENT OFFICE

2,215,910

RAILWAY TRACK CIRCUIT APPARATUS

Bernard E. O'Hagan, Swissvale, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Application June 21, 1939, Serial No. 280,363

8 Claims. (Cl. 246—34)

My invention relates to railway track circuit apparatus.

Reliable operation of a track circuit of an insulated railway track section requires that the current source not only satisfactorily energize the track relay when the section is unoccupied but also requires that such current be effectively shunted away from the track relay when the section is occupied. It is well known that the train shunt through the wheels and axles of a train or car varies in its resistance because of the presence at times of a thin coating or film of relatively high resistance at the rail surface. For example, on tracks infrequently used or when light weight trains prevail, the coating or film at the rail surface may be of such nature as to form a high resistance path for the low voltages usually employed in track circuits because such low voltages are insufficient to break down or puncture such coating or film. Furthermore, on railways of relatively dense traffic, such rail film may at times seriously affect the shunting sensitivity of the present day track circuits using relatively low voltages. It is also well known that greatly increased shunting sensitivity of a track circuit is obtained by increasing the voltage impressed across the rails. The reason for this is that the high voltage breaks down the nonconductive film on the rails and permits the track circuit current to flow from rail to rail through the wheels and axles of the train. If a high voltage is steadily applied between the rails, however, the track circuit power input tends to become excessive, especially under wet weather conditions when the ballast resistance is relatively low. Again, under dry weather conditions, a high voltage impressed across the track rails tends to overenergize the track relay as well as to create other undesirable conditions.

It has been proposed to use for track circuits a current source means which supplies coded or time spaced current impulses, with each impulse of relatively high peak voltage and short duration, the high peak voltage being effective to break down the rail film resistance when the section is occupied as an aid to the shunting sensitivity of the track circuit, and the short duration of the impulse requiring but a relatively low energy input to the track circuit.

Accordingly, an object of my invention is the provision of novel and improved track circuit means for applying a high peak voltage across the track rails without increasing greatly the average power input to the track circuit and without requiring coding devices for periodically interrupting the circuit. More specifically, a feature of my invention is the provision of track circuit means for generating harmonic voltages of a sine wave or single harmonic voltage to obtain a resultant voltage having a high peak or maximum value for a portion of each cycle. Other objects and advantages of my invention will appear as the specification progresses.

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

In the accompanying drawing, Fig. 1 is a diagrammatic view of one form of apparatus embodying my invention when an alternating current track relay is used. Fig. 2 is a diagrammatic view of a modification of the apparatus of Fig. 1 also embodying my invention. Figs. 3, 4, 5, 6 and 7 are diagrammatic views respectively of apparatus embodying my invention wherewith alternating track circuit current is rectified for energizing a direct current track relay. Fig. 8 is a diagrammatic view of still another form of track circuit apparatus embodying my invention. Fig. 9 is a diagram illustrating characteristics of the track circuit current. In each of the several views like reference characters designate similar parts.

Referring to Fig. 1, the reference characters *1a* and *1b* designate the track rails of a stretch of railway and which rails are formed by the usual insulated rail joints with a track section W—X, and which section may be one of a series of successive track sections of a signal system. The track section W—X is provided with a track circuit consisting of a source of current connected across the rails at one end of the section and a track relay connected across the rails at the other end of the section, the rails being bonded in the usual manner to form continuous electrical conductors from one end of the section to the other. The immediate source of current for the track circuit of section W—X is a track transformer TW whose secondary winding 2 is connected across the rails *1a* and *1b* at the left-hand end of the section as viewed in Fig. 1, over wires 3 and 4. The primary winding 5 of transformer TW is supplied with current from a generator G by means of a transmission line consisting of line wires 6 and 7 and which transmission line may be that used to distribute power to the different track sections of the railway. As shown in Fig. 1, the left-hand terminal of primary winding 5 is connected directly with line wires 6 over wire 8, while the right-hand terminal of primary winding 5 is connected with line wire 7 over a saturable reactor 9 and a condenser 10.

The reactor 9 may take different forms and in Fig. 1 it consists of three magnetizable core legs 11, 12 and 13 which are connected together at each end to form an integral magnetic core structure having two magnetic paths to which the center leg 12 is common. For example, the core structure of reactor 9 would ordinarily at least be made up of laminated sheet steel. The reactor 9 is provided with a first or magnetizing winding consisting of two coils *14a* and *14b* mounted on

the outside legs 11 and 13, respectively. The coils 14a and 14b are connected in series so as to add their effects and the two coils are connected in series with the condenser 10 between the right-hand terminal of primary winding 5 of transformer TW and line wire 7, the connection consisting of right-hand terminal of primary winding 5, wire 15, coils 14a and 14b, condenser 10 and wire 57 to line wire 7.

The reactor 9 is further provided with a second or saturation winding 16 mounted on the center leg 12 and supplied with unidirectional current from any convenient source. In Fig. 1, winding 16 is supplied with unidirectional current from primary winding 5 of transformer TW through a full wave rectifier 17, the input terminals of rectifier 17 being connected across a portion of primary winding 5 over wires 18 and 19, and the output terminals of rectifier 17 being connected with winding 16 over wires 20 and 21. The parts are so proportioned that the undirectional current flowing in winding 16 creates unidirectional magnetic flux that substantially saturates the core structure of reactor 9.

It is well known that when an alternating flux is impressed on a ferric core structure which is substantially saturated by a direct magnetizing flux, the increase in magnetization during the positive half cycle of the alternating flux is relatively small while the decrease in magnetization during the negative half cycle of the alternating flux is relatively large, and that such non-linear condition gives rise to the third harmonic voltage of the alternating voltage producing the alternating flux.

The current flowing in magnetizing winding 14a—14b of reactor 9 is the load current plus the magnetizing current of transformer TW, and the parts are further so proportioned that the magnetizing current is relatively large as compared with the load current. Consequently the voltage impressed on the terminals of primary winding 5 of transformer TW rises and falls in step with the variations of impedance of reactor 9.

The generator G supplies an alternating voltage of substantially a pure sine wave of, say for example, 100 cycles per second. That is, generator G supplies a simple harmonic voltage having a predetermined fundamental frequency of 100 cycles per second. In Fig. 9, curve A illustrates one cycle of the sine wave voltage supplied by generator G. This voltage is impressed on winding 14a—14b of reactor 9 with the result that the alternating magnetic flux created thereby gives rise to the third harmonic voltage of the fundamental frequency because of the saturation flux produced by winding 16. Such third harmonic voltage is illustrated by curve C of Fig. 9 and as a result the resultant voltage impressed on primary winding 5 of transformer TX4 has a non-sinusoidal wave as illustrated by curve B of Fig. 9. Consequently the voltage induced in the secondary winding 2 of track transformer TW and in turn impressed across the track rails of section W—X has a wave form substantially as illustrated by curve B of Fig. 9. The capacitance of condenser 10 is chosen so as to effect with reactor 9 series resonance at the frequency of the generator G and thereby reduce the voltage drop across the combination of reactor and condenser.

It will be understood of course that my invention is not limited to an alternating voltage of the frequency of 100 cycles per second and other frequencies may be used if desired.

It is to be noted from curve B of Fig. 9 that this resultant voltage has a high peak or maximum voltage at a small portion of each half cycle but that the average voltage of each half cycle of curve B is probably no greater than that of curve A.

In Fig. 1, an alternating current track relay TR1 is connected across the rails at the right-hand end of section W—X over wires 22 and 23. Track relay TR1 may be any one of the several well-known types of relays responsive to alternating current of 100 cycles per second.

Tests have shown that when a non-sinusoidal current such as impressed on the track circuit from the apparatus of Fig. 1 is used the peak voltage necessary to operate an alternating current relay of the usual construction is of the order of twice that necessary when a pure sine wave current is applied to the track circuit. However, due to the small peak voltage portion of the non-sinusoidal voltage wave, the power input to the track circuit is not greatly increased or at least is not increased at the same ratio as the peak voltage. Such peak voltage is effective to break down the rail film resistance when the section is occupied so that the track circuit is characterized by a relatively high shunting sensitivity. In other words, a track circuit of high shunting sensitivity is effected by the apparatus of Fig. 1 because of the non-linear characteristics of saturable reactor 9 giving rise to the third harmonic voltage of the sine wave voltage supplied by generator G and the resultant voltage supplied to the track rails is characterised by relatively high peak voltage during a portion of each cycle. And the power input to the track circuit may be only a little greater than the power input required by present day track circuits. Also, coding devices having moving parts are avoided.

In Fig. 2, the track rails 1a and 1b of a railway are formed with a track section W—X provided with a track circuit the same as in Fig. 1. In Fig. 2, the secondary winding 2 of track transformer TW is connected across the rails at one end of the section over wires 3 and 4 the same as in Fig. 1, except a current limiting impedance 24 is preferably interposed in wire 3. The primary winding 5 of transformer TW of Fig. 2 has its left-hand terminal connected directly with line wire 6 over wire 8 and its right-hand terminal connected with line wire 7 over a winding 25 of a saturable reactor 9a, a condenser 26 and wire 27.

The winding 25 of reactor 9a is mounted on a ferric core 28 and the parts are so proportioned that the magnetizing current flowing in winding 25, which current is the load current of the track transformer TW plus the magnetizing current of transformer TW, effects magnetic saturation of core 28. The capacitance of condenser 26 is so chosen as to resonate the circuit at the frequency of generator G. Because of the magnetic saturation of core 28 of reactor 9a the reactor is characterised by a non-linear condition and the third harmonic of the sine wave voltage supplied from generator G is created with the result that the voltage impressed across the primary winding 5 of track transformer TW has a non-sinusoidal wave form and possesses high peak or maximum voltages as illustrated by curve B of Fig. 9. Consequently the voltage induced in secondary winding 2 of transformer TW and in turn impressed across the rails of section W—X of Fig. 2 has a wave form corresponding to that illustrated by curve B of Fig. 9.

The track relay TR2 of Fig. 2 is a two-element

alternating current relay, one element of which is connected across the rails of section W—X over wires 29 and 30, and the other element of which is connected across line wires 6 and 7 over wires 31 and 32.

It is clear that the track circuit of section W—X of Fig. 2 is characterized by high shunting sensitivity because of the high peak voltage attained during a portion of the positive and negative half cycles of the track circuit current, the power input to the track circuit being not greatly increased over the power required by present day track circuits.

In Fig. 3, the track section W—X of a railway is provided with a track circuit the immediate source of the current of which is track transformer TW the same as in Fig. 1. The secondary winding 2 of transformer TW of Fig. 3 is connected across the rails over wires 3 and 4, a current limiting resistor 33 being interposed in wire 4 and a half-wave asymmetric unit or rectifier 34 being interposed in wire 3. Also a stabilizing resistor 35 is preferably connected across the rails at the same end of the section as transformer TW.

The primary winding 5 of transformer TW of Fig. 3 is connected with line wires 6 and 7 over winding 14*a*—14*b* of reactor 9 and condenser 10 the same as in Fig. 1. However, in Fig. 3 the saturation winding 16 of reactor 9 is supplied with unidirectional current directly from line wires 6 and 7 through rectifier 17, the input terminals of rectifier 17 being connected across line wires 6 and 7 over wires 36 and 37.

Consequently, the track circuit of section W—X of Fig. 3 impresses across the rails a non-sinusoidal voltage as illustrated at curve B of Fig. 9, except for the fact that rectifier 34 serves to pass to the rails only a particular half cycle of the voltage supplied from secondary winding 2 thereby providing a single unidirectional current impulse in the track circuit each cycle of the alternating voltage.

A track relay TR3 of the direct current type is connected across the rails at the right-hand end of section W—X of Fig. 3 over a resistor 38.

It follows that when section W—X of Fig. 3 is unoccupied, the track relay TR3 is effectively energized by the rectified or unidirectional current supplied to the track circuit through the apparatus located at the left-hand end of the section. When the section is occupied the high peak voltage attained during a portion of each unidirectional current impulse is effective to break down the rail film resistance so that high shunting sensitivity of the track circuit obtains. The resistor 35 serves in the well-known manner to effect a substantially uniform power requirement for both wet and dry ballast conditions and overenergization of track relay TR3 under dry ballast conditions is avoided.

Again it is to be noted that the non-linear characteristics of reactor 9 gives rise to the third harmonic voltage of the sine wave voltage of generator G so that the voltage impressed across the track rails has a high peak voltage to effect high shunting sensitivity for the track rails, and such high peak voltage is obtained without materially increasing the power input to the track section and without coding devices.

In Fig. 4, the track circuit of section W—X is supplied with current from transformer TW whose secondary winding 2 is connected across the rails 1*a* and 1*b* over a full wave rectifier 39 and a resistor 40 as will be readily understood by an inspection of Fig. 4. The primary winding 5 of transformer TW of Fig. 4 is connected across line wires 6 and 7 over a reactor 9*a* and a condenser 26 the same as in Fig. 2. Consequently, the voltage supplied by secondary winding 2 of transformer TW is the resultant of the simple harmonic voltage of generator G and the third harmonic voltage created by the non-linear characteristics of reactor 9*a*. The rectifier 39 serves to rectify both half cycles of the current supplied from secondary winding 2 so that the track circuit is supplied with two unidirectional current impulses each cycle, and each unidirectional current impulse is characterized by a relatively high peak voltage for a portion of the impulse.

The track relay TR3 of Fig. 4 is the same as in Fig. 3 and is effectively energized by the unidirectional current supplied to the track circuit when the section W—X is unoccupied. When the section is occupied the recurrently high peak voltages of the current impulses are effective to break down the rail film resistance so that a high shunting sensitivity of the track circuit obtains.

In Fig. 5, the track section W—X is provided with a track circuit receiving current from track transformer TW whose secondary winding 2 is connected across the rails 1*a* and 1*b* over wires 3 and 4 with a current limiting resistor 41 interposed in wire 3. The primary winding 5 of transformer TW of Fig. 5 is connected with line wires 6 and 7, over winding 42 of a reactor 9*b* and a condenser 43. Reactor 9*b* comprising, as shown conventionally, a winding 42 mounted on a ferric core structure in the well-known manner for such reactors, the parts being so proportioned that the core structure is magnetically saturated by the current flowing in winding 42. Consequently, the non-linear characteristic of reactor 9b gives rise to the third harmonic voltage of the sine wave voltage of generator G and a resultant voltage is impressed on primary winding 5 of transformer TW and in turn on the track rails whose wave form is substantially as illustrated by curve B of Fig. 9.

In Fig. 5 direct current track relay TR3 is connected across the rails over a resistor 38 the same as in Figs. 3 and 4 except a rectifier or asymmetric unit 44 is connected across the terminals of relay TR3 and serves as a short circuit for the relay TR3 during, say, the positive half cycle of the track circuit current so that track relay TR3 is effectively energized and picked up when section W—X is unoccupied, in response to the alternating voltage impressed across the rails at the other end of the section.

When section W—X of Fig. 5 is occupied the peak voltages which occur for portions of each cycle of the track circuit current are effective to break down the rail film resistance and effect a high shunting sensitivity for the track circuit.

In Fig. 6, the apparatus for supplying current to the track circuit of section W—X is the same as in Fig. 5 and consequently the wave form of the voltage supplied across the rails is the resultant of the sine wave voltage of generator G and the third harmonic voltage thereof as created by reactor 9*b*.

The direct current track relay TR3 of Fig. 6 is energized by unidirectional current in response to the alternating track circuit current by means of a relay transformer TX and a full wave rectifier 45. The primary winding 46 of transformer TX is connected across the rails over resistor 38 and the secondary winding 47 is connected with the input terminals of rectifier 45 the output terminals of rectifier 45 being in turn connected

with the winding of relay TR3. Thus when section W—X of Fig. 6 is unoccupied the track relay TR3 is effectively energized by the unidirectional current supplied thereto in response to the alternating current supplied to the rails at the opposite end of the track section. When section W—X is occupied the peak voltages of the track circuit current are effected to break down the rail film resistance and effect a high shunting sensitivity of the track circuit, the same as in the former cases.

In Fig. 7, the means for supplying current to the track circuit of section W—X is the same as in Fig. 5 and consequently the wave form of the voltage applied across the rails is characterized by high peak voltages.

The direct current track relay TR3 of Fig. 7 is connected across the track rails at the same end as the track transformer TW and an asymmetric unit 48 is connected across the rails at the other end of the section.

When section W—X of Fig. 7 is unoccupied, track relay TR3 is effectively energized and picked up in the well-known manner in response to the alternating voltage impressed across the rails. When the section is occupied, the track relay TR3 is shunted at relatively high shunting sensitivity because the high peak voltages of the current supplied to the rails through track transformer TW effectively breaks down the rail film resistance.

In Fig. 8, a track transformer TW1 has its secondary winding 49 connected across the rails 1*a* and 1*b* at the left-hand end of the section W—X over wires 50 and 51. The primary winding 52 of transformer TW1 is connected with line wires 6 and 7 over wires 53 and 54, a resistor or impedance element 55 being interposed in wire 54. The parts of track transformer TW1 are so proportioned that its ferric core structure 56 is worked at, or very close to, magnetic saturation so that the magnetizing current of the transformer is a relatively high percentage of the total current. It is evident that the non-linear operating characteristics of transformer TW1 gives rise to the third harmonic voltage of the sine wave voltage of generator G and as a result the voltage impressed on the track rails has a wave form similar to that illustrated by curve B of Fig. 9.

Alternating current track relay TR1 is connected across the rails at the right-hand end of section W—X of Fig. 8 the same as in Fig. 1. Consequently when section W—X of Fig. 8 is unoccupied the track relay TR1 is effectively energized by the non-sinusoidal voltage applied to the rails from transformer TW1 and when the section is occupied the high peak voltages effected during the portion of each cycle serves to break down the rail film resistance and provides a high shunting sensitivity for the track circuit.

It is to be noted that although the reactor having a saturated core is interposed in the circuit connection to the primary winding of the associated track transformer, such reactor may be interposed in the connection between the secondary winding of the track transformer and the track rails with similar results obtained in respect to giving rise to the third harmonic voltage of the sine wave voltage of the generator G.

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

Having thus described my invention, what I claim is:

1. In combination with an insulated railway track section, a source of simple harmonic voltage of a predetermined frequency, a track transformer having its secondary winding connected across the rails of said section, circuit means including a winding mounted on a constantly saturated ferric core to connect the primary winding of said transformer with said voltage source to induce in said secondary winding a voltage which is the resultant of said single harmonic voltage and the relatively large third harmonic voltage thereof as created by said winding mounted on said core, said circuit means effective to produce a resultant voltage of substantially the same value for both unoccupied and occupied conditions of said track section, and a track relay connected across the rails of said section effectively energized in response to said resultant voltage impressed on said rails when the section is unoccupied and effectively shunted when the section is occupied due to the high peak voltage which occurs, each cycle of said resultant voltage breaking down the rail film resistance.

2. In combination with an insulated railway track section, a source of simple harmonic voltage of a predetermined frequency, a track transformer having its secondary winding connected across the rails of said section, circuit means including a winding of a saturable reactor and a condenser in series to connect said source across the primary winding of said transformer to supply current to the rails, said circuit means proportioned to produce a magnetizing current for said reactor which is relatively large as compared with said rail current to assure constant saturation of said reactor and to give rise to a relatively large third harmonic voltage of said simple harmonic voltage to create across the rails a resultant voltage having a high peak value which is of substantially the same value for both unoccupied and occupied conditions of said track section, and a track relay connected across the rails of said section effectively energized by such rail current when the section is unoccupied and effectively shunted when the section is occupied by a train because of said peak value of the resultant voltage breaking down the rail film resistance.

3. In combination with an insulated railway track section, a source of alternating current having a predetermined fundamental frequency, a track transformer having a secondary winding connected across the rails at one end of said section for supplying current to the rails, a saturable reactor normally conditioned for magnetic saturation, a condenser, a circuit means including a winding of said reactor and said condenser in series to connect said current source with a primary winding of said transformer, said reactor winding and condenser proportioned for series resonance at said fundamental frequency to cause the magnetizing current of said transformer to contain a large third harmonic component so that the rail current has a high peak voltage which is of substantially the same value under both unoccupied and occupied conditions of said track section, and a track relay connected across the rails at the other end of said section effectively energized by said rail current when the section is unoccupied and effectively shunted when the section is occupied by a train because

of said peak voltage breaking down the rail film resistance.

4. In combination with an insulated railway track section, a source of simple harmonic voltage of a predetermined fundamental frequency, a track transformer having a secondary winding connected across the rails at one end of said section, a saturable reactor having a first and a second winding mounted on a ferric core, a condenser, circuit means including said condenser and said first winding of the reactor to connect said voltage source with a primary winding of said transformer, means including a rectifier to connect a portion of said primary winding with said second winding of the reactor to create unidirectional saturation flux in said core to give rise to the third harmonic voltage of said simple harmonic voltage to impress across the rails a resultant voltage having a relatively high peak value during a portion of each cycle and which value is substantially the same for both unoccupied and occupied conditions of said track section, and a track relay connected across the rails at the other end of the section effectively energized in response to said resultant voltage when the section is unoccupied and effectively shunted when the section is occupied by a train because of said peak value of the resultant voltage breaking down the rail film resistance.

5. In combination with an insulated railway track section, a source of current having a simple harmonic wave of a predetermined frequency, a track transformer having a secondary winding connected across the rails at one end of said section, a reactor having a ferric core structure with a first and a second winding mounted thereon, a condenser, circuit means including said first winding and said condenser in series to connect said current source with the primary winding of said transformer for supplying current to the rails through said secondary winding, other circuit means including a source of unidirectional current connected to said second winding of the reactor to create saturation flux for the core of the reactor to give rise to the third harmonic of said predetermined frequency to cause the current supplied to the rails to have a predetermined high peak voltage for a portion of each cycle which high peak voltage is substantially the same for both unoccupied and occupied conditions of said track section, and a track relay connected across the rails at the other end of said section effectively energized by such rail current when the section is unoccupied and effectively shunted when the section is occupied by a train due to said peak voltage breaking down the rail film resistance.

6. In combination with an insulated railway track section, a source of current having a simple harmonic wave of a predetermined frequency, a track transformer, circuit means to connect a secondary winding of said transformer across the rails of the section, a reactor having a ferric core structure with a first and a second winding mounted thereon, a condenser, other circuit means including said first winding of the reactor and said condenser in series to connect said current source with a primary winding of said transformer to supply current to the rails through said first mentioned circuit means, means connected with said second winding of said reactor to constantly create unidirectional saturation flux in said core to give rise to the third harmonic component of said simple harmonic current to cause the current supplied to the rails through said first mentioned circuit means to have a relatively high peak voltage which is of substantially the same value under both unoccupied and occupied conditions of the track section, a track relay connected across the rails effectively energized by said current when the section is unoccupied and effectively shunted when the section is occupied because of the breaking down of the rail film resistance by said high peak voltage of the current, and a stabilizing resistor connected across the rails adjacent said transformer to avoid overenergization of said relay under dry ballast conditions.

7. In combination with an insulated railway track section, a track circuit comprising, a source of current having a simple harmonic wave of a predetermined frequency, a track transformer, circuit means to connect a secondary winding of said transformer across the rails of the section, other circuit means including a winding of a saturable reactor and a condenser to connect said current source with a primary winding of said transformer to supply current to the rails through the first mentioned circuit means, said other circuit means proportioned to work said reactor at magnetic saturation for a portion of each current cycle to effect resonance of the circuit means at said predetermined frequency so that the voltage impressed on said primary winding rises and falls in accordance with the variations of impedance of said reactor and the current supplied to the track rails has a relatively high peak voltage, and a track relay connected to the rails of said section effectively energized by said current when the section is unoccupied and effectively shunted when the section is occupied in response to the high shunting sensitivity of the track circuit as effected by said peak voltage.

8. In combination with an insulated railway track section, a track circuit comprising a source of current having a simple harmonic wave of a predetermined frequency, a track transformer having a secondary winding connected across the rails of the section, a saturable reactor, a condenser, a circuit means including said reactor and said condenser to connect said current source with a primary winding of said transformer to supply an alternating current to the rails through said secondary winding, said circuit means proportioned to work said reactor at magnetic saturation so that the voltage impressed on said primary winding rises and falls in accordance with the variations of impedance of said reactor and the alternating current supplied to the rails has a predetermined high peak voltage during a portion of each cycle, a direct current track relay connected across the rails of the section, and an asymmetric unit connected across the rails to form a short circuit path for a particular one of the half cycles of the alternating current to cause effective energization of said track relay when the section is unoccupied, and said relay effectively shunted when the section is occupied by a train due to the high shunting sensitivity of the track circuit as effected by said peak voltage.

BERNARD E. O'HAGAN.