May 22, 1951 J. E. HILLIG ET AL 2,554,460

RAILWAY TRACK CIRCUIT APPARATUS

Filed Feb. 26, 1947 2 Sheets-Sheet 1

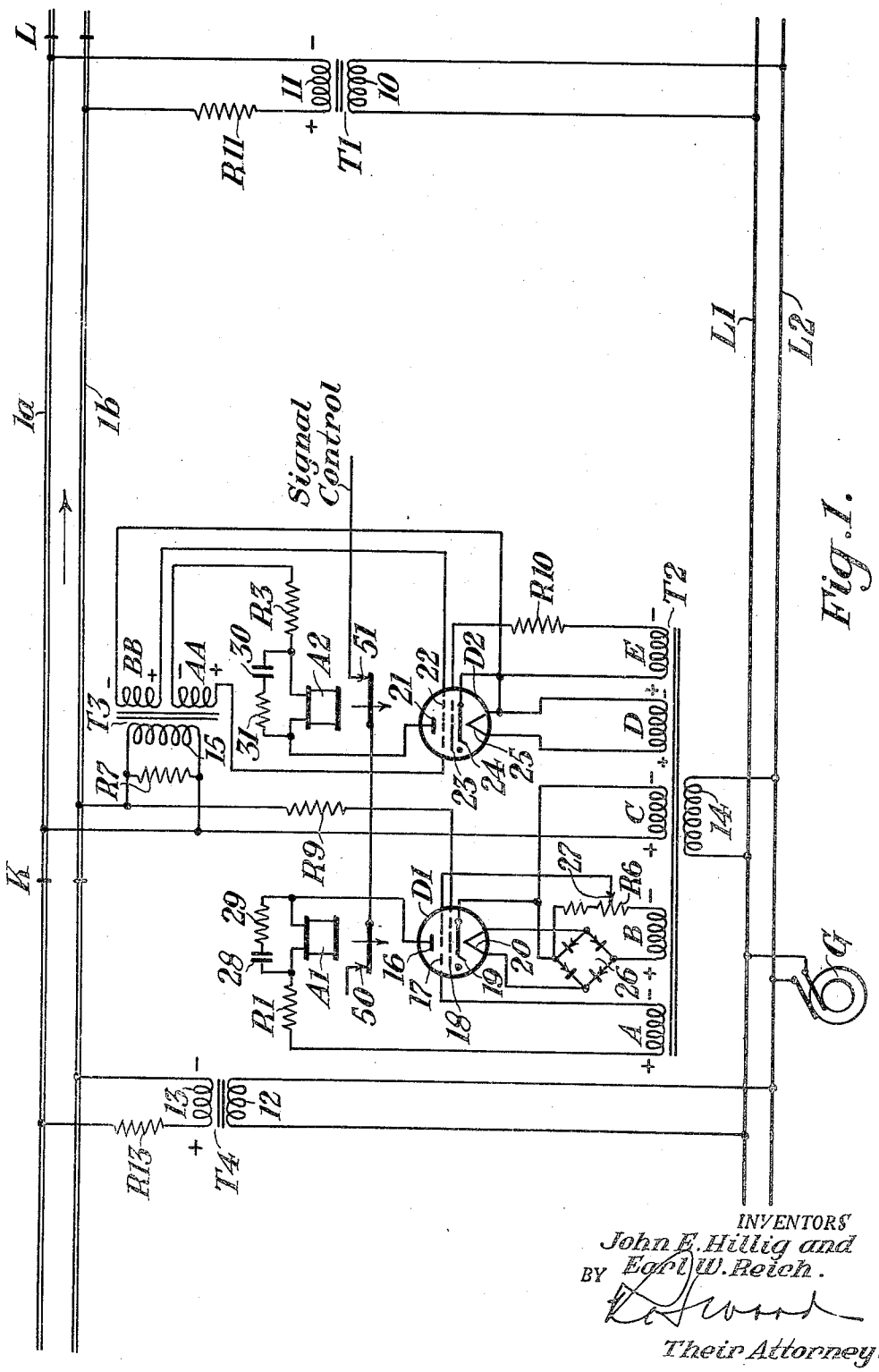

Fig. 1.

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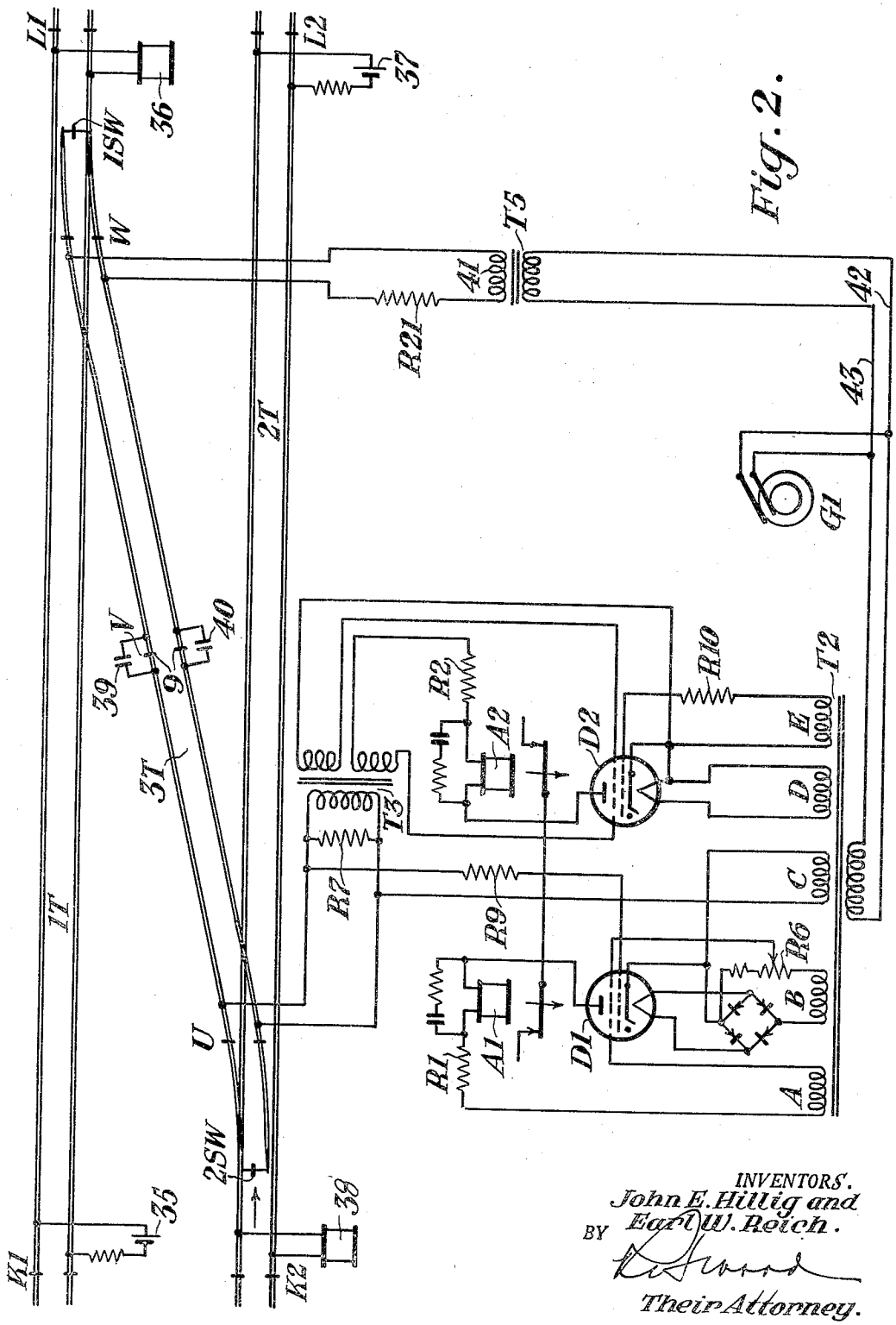

Fig. 2.

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RAILWAY TRACK CIRCUIT APPARATUS

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Application February 26, 1947, Serial No. 730,976

13 Claims. (Cl. 246—34)

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Our invention relates to railway track circuit apparatus, and more particularly to such apparatus using electron tubes.

In railway track circuits, shunting sensitivity, broken rail protection, broken down insulated rail joint detection, and reliability are important operating characteristics. Also, a closed circuit principle is essential to assure that a failure of a component of the circuit will cause a restrictive signal indication.

It is a main object of our invention to provide novel and improved railway track circuit apparatus which is characterised by high shunting sensitivity and which maintains the high shunting sensitivity over a wide variation of ballast resistance and under adverse shunting conditions due to a film of relatively high resistance on the rail surface.

A more specific object of our invention is the provision of railway track circuit apparatus using electron tubes in a novel and improved arrangement to provide high shunting sensitivity, broken rail protection to a high degree of safety, broken down insulated joint protection and to cause a restrictive signal indication when one or more components fail.

Again, a feature of our invention is the provision of track circuit apparatus of the form here contemplated for crossovers giving protection for the complete crossover and maintaining the insulation one from the other of the track circuits of the main tracks which the crossover joins.

Other features, objects and advantages of our invention will appear as the specification progresses.

To attain the foregoing objects, features and advantages of our invention, we provide a track circuit with an alternating current source and a track relay means including two electron tubes which control electromagnetic relays governing the conventional signal circuits. These tubes are preferably ionization tubes and tube conduction is controlled by phasing the alternating voltages applied to the anode and control electrodes as well as by the magnitude of such voltages.

For one of the tubes, a negative bias potential of a specific value is applied to a shield grid so that there is a critical positive value of the control grid potential to cause the tube to conduct during the positive half cycle of the alternating current wave applied to the anode. The critical voltage necessary to determine tube conduction is derived from the rail circuit. Thus this tube is fired alternate half cycles of the alternating track circuit current when the track circuit is

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unoccupied and the voltage across the track rails is not less than a given critical value. When the track rails are shunted even with a relatively high resistance shunt, the voltage applied to the control grid falls below the critical value and the tube fails to conduct. The tube and its circuits are characterized by steep control characteristics and a high circuit sensitivity is obtained.

A limiting impedance preferably comprising a resistor and an input or primary winding of a step-up transformer in parallel is connected across the rails of the track circuit. The value of this impedance limits the value of the maximum ballast resistance of the track circuit, that is, the resistance from one rail to the other. This limiting of the ballast resistance tends to maintain the shunting sensitivity obtained by the aforementioned tube substantially uniform over a wide variation of the leakage resistance of the ballast as caused by variations of weather conditions.

A break in a rail, which inserts the additional resistance of a leakage path through the ballast and ground around the break in series in the rail circuit, will reduce the voltage applied to the input of the tube and it will fail to conduct. This arrangement provides broken rail protection because steep operating characteristics of the tube can be provided so that a relatively small increase in the rail resistance results in a non-conductive condition of the tube. A ballast resistance lower than the maximum value will lower the voltage applied to the tube and the broken rail protection is not decreased by a low ballast resistance.

The voltages applied to an anode and shield grid of a second electron tube are obtained from secondary windings of the step-up transformer. A control grid of this second tube is provided with a fixed potential and the control grid potential is selected to permit the tube to conduct when the anode and shield grid voltages are of values resulting from the voltage applied to the input winding of the step-up transformer under normal ballast resistance of the track circuit.

This second tube serves to check the integrity of the limiting impedance which maintains a uniform high shunting sensitivity for the first electron tube.

The track transformers of adjacent track circuits are connected to supply currents of opposite instantaneous polarities so that a broken down insulated rail joint which permits current to be fed to the track relay means for one track circuit from the track transformer of the adjacent track circuit through the insulated rail joints will apply

to the tubes of the track relay means potentials out of phase and the tubes will fail to conduct with the result a restrictive signal indication is displayed as a detection of the defective insulated rail joint.

The tube circuits are arranged in such a manner that the bias voltages are checked and a loss of a bias voltage due to a broken connection or poor contact results in the tube being non-conductive corresponding to a restrictive traffic condition of the associated track circuit.

We shall describe two forms of apparatus embodying our invention, and shall then point out the novel features thereof in claims.

In the accompanying drawings,

Fig. 1 is a diagrammatic view showing one form of track circuit apparatus embodying our invention, and Fig. 2 is a diagrammatic view showing track circuit apparatus embodying our invention when applied to a crossover.

In each of the two views like reference characters are used to designate similar parts.

Referring to Fig. 1, the reference characters 1*a* and 1*b* designate the track rails of a railway over which traffic normally moves in the direction indicated by the arrow, and which rails are divided by the usual insulated rail joints into consecutive track sections of a signaling system, and of which sections only the one section K—L and the adjoining end of an adjacent section are shown, since these are sufficient for a full understanding of our invention. Each section is provided with track circuit apparatus embodying our invention and which apparatus comprises a source of alternating current connected across the rails at one end of the section and an electron tube track relay means connected across the rails at the other end of the section. The source of supply for the track circuits is a generator G connected to a pair of line wires L1 and L2 extending along the railway. The generator G supplies alternating current preferably of a frequency of the order of 100 cycles per second, but other frequencies can be used.

Power is supplied to the track circuits through track transformers of the usual construction. For example, a track transformer T1 for the track circuit of section K—L has a primary winding 10 connected across the line wires L1 and L2 and a secondary winding 11 connected across the track rails at the exit end L of the section, a current limiting resistor R11 being interposed in the connection to the rail 1*b*. Similarly, a track transformer T4 for the track circuit of the section next to the left of section K—L as viewed in Fig. 1, has a primary winding 12 connected across the line wires and a secondary winding 13 connected across the rails through a resistor R13. For reasons to be explained hereinafter, the connections of the track transformers T1 and T4 are arranged so that currents of reverse instantaneous polarity are supplied to the adjacent track circuits, the plus and minus signs placed at the track transformers indicating the polarity of the currents at a given instant.

The track relay means for the track circuits are alike and only that for the circuit of section K—L is shown. This track relay means includes a supply transformer T2, a step-up transformer T3, a limiting resistor R7, two electron tubes D1 and D2 and two relays A1 and A2, together with associated tube circuits.

The supply transformer T2 is provided with a primary winding 14 receiving power from the line wires L1 and L2 and with a group of independent secondary windings A, B, C, D, and E to be referred to from time to time. To aid in the understanding of the apparatus, the polarity of the voltages of the several secondary windings of transformer T2 at a given instant is indicated by plus and minus signs placed at the secondary windings.

The step-up transformer T3 has an input or primary winding 15 connected in parallel with resistor R7 across the track rails to provide a limiting impedance, and transformer T3 receives power from the track circuit. Transformer T3 is provided with two secondary windings AA and BB, to be referred to later.

The electron tubes D1 and D2 are preferably alike and as here shown they are four-element "Thyratrons" of the indirectly heated cathode type, but other types of tubes can be used. Tube D1, for example, is provided with an anode 16, a shield grid 17, a control grid 18 and a cathode 19, together with a heater or filament 20. Similary, tube D2 has an anode 21, a shield grid 22, a control grid 23 and a cathode 24, together with a filament 25. Each of the tubes D1 and D2 is so constructed that its shield grid (17 of tube D1 and 22 of tube D2) is provided with two terminals. With this construction, the connection to the shield grid is made to include the two terminals and the grid element in series. This series arrangement assures that any break in the connection or the grid will open the associated circuit and detect the loss of the shield grid control.

The relays A1 and A2 are neutral magnetic relays of standard construction and each is equipped with contacts to govern conventional signal circuits in the usual manner.

The secondary winding B of power transformer T2 is connected to the input terminals of a full wave rectifier 26 in series with a potentiometer resistor R5, and the output terminals of the rectifier are connected to the heater 20 of tube D1. That is, the voltage supplied by secondary winding B serves to heat the tube D1 and to provide an alternating voltage drop across resistor R6, and which voltage drop is used to bias the shield grid 17 of the tube as will shortly appear.

An anode-shield grid circuit for tube D1 can be traced from the left-hand terminal of secondary winding A of transformer T2, through resistor R1, winding of relay A1, anode 16 and tube space to cathode 19 of the tube D1, resistor R6 to an intermediate terminal 27, one terminal of shield grid 17 and the grid element to the other terminal of the grid and thence to the other terminal of secondary winding A. The voltage of secondary winding A modified by the voltage drop of a portion of resistor R6 is impressed across the anode and cathode of tube D1 tending to fire the tube. Also, the voltage drop across a portion of resistor R6 as determined by the setting of the intermediate terminal 27 serves to bias the shield grid 17. With instantaneous polarity of the voltages of secondary windings A and B as indicated by the plus and minus signs, then during the half cycle of the voltage that the anode 16 is positive in potential with respect to the cathode 19, the shield grid 17 is negative in potential with respect to the cathode by a voltage, the specific value of which is determined by the setting of terminal 27 of resistor R6. The parts are so proportioned that the tube D1 fails to conduct at the voltage supplied to the anode from the secondary winding A without suitable voltage on the control grid due to the negative bias of the shield grid. Fur-

thermore, the bias potential applied to the shield grid is made such that a definite control grid potential is required to create a conductive condition of the tube.

The tube D1 is provided with a control grid circuit that can be traced from rail 1b through a resistor R9 to control grid 18, and from cathode 19 through the secondary winding C of transformer T2 to rail 1a. Thus a voltage derived from track transformer T1 through the rail circuit and a voltage from secondary winding C of the power transformer T2 are applied to the control grid of tube D1 in series. The connections of secondary winding 11 of transformer T1 and secondary winding C of transformer T2 are such that the polarities of their voltages at a given instant are indicated by the plus and minus signs and the two voltages are additive as applied to the control grid 18. Furthermore, the winding 11 and the winding C are connected so that the voltage applied to the control grid 18 causes the grid 16 to be positive in potential with respect to the cathode 19 during the half cycle of the alternating current the anode 16 is positive with respect to the cathode. The parts are so proportioned that the voltage from winding C alone is insufficient to cause the tube to conduct, but that the voltage resulting from the addition of the voltage of winding C and the voltage derived from the track circuit is sufficient to fire the tube and current flows to energize the relay A1 interposed in the anode circuit. By making the voltages of secondary windings C and 11 additive, it is not necessary to impress a high voltage across the rails, yet it allows for a critical voltage to be applied to the control grid of tube D1 from the rail circuit before the tube is fired. During the negative half cycle of the alternating current, the negative voltage applied to the anode 16 stops the conduction of current so that the tube D1 becomes deionized and the control grid 18 regains control. That is, the tube D1 is made conductive during alternate half cycles of the alternating current and relay A1 is energized with periodic impulses of current. A capacitor 28 and a resistor 29 in series are connected across the winding of relay A1 and relay A1 thereby is made slow releasing in character and is retained picked up during the half cycle of the alternating current that the tube D1 is non-conductive. Relay A1 governs at its front contact 50 a conventional signal circuit in the usual manner.

It follows that tube D1 is provided with a specific bias voltage for its shield grid to assure that the tube is not conductive at the voltage applied to the anode without suitable voltage on the control grid and the series arrangement of the anode and shield grid checks the presence of this shield grid bias. The control voltage applied to the control grid of the tube is derived in part from a local source and in part from the track circuit so that the track circuit voltage can be measured with great accuracy. Thus, even a relatively high resistance shunt across the track rails will lower the voltage applied to the control grid sufficiently for the tube to fail to conduct and relay A1 will be deenergized to control the signal circuit. Also, proper shunting of the track circuit will be effected when the track is infrequently used and a film of relatively high resistance is present on the rail surfaces. Furthermore, a break in the electrical continuity of the rails 1a and 1b will lower the voltage applied to tube D1 and the tube will fail to conduct and thereby detect the broken rail condition.

The limiting impedance provided by resistor R7 and the input winding 15 of transformer T3 serves to limit the maximum ballast impedance of the track circuit, that is, the rail to rail impedance, and consequently a more nearly uniform shunting sensitivity of the track circuit is maintained for a relatively wide variation of the leakage resistance as caused by changes in weather conditions. Although we prefer to use a resistor R7 and an input winding of transformer T3 in parallel as the limiting impedance, it is clear that the resistor R7 may be omitted and the input winding of the transformer made to have the desired impedance.

The heater of tube D2 is energized from secondary winding D of transformer T2 and control grid 23 of tube D2 is provided with a control potential from secondary winding E of transformer T2, a resistor R10 being preferably included in the connection of grid 23. An anode-shield grid circuit for tube D2 can be traced from the top terminal of secondary winding AA of transformer T3, through resistor R3, winding of relay A2, anode 21 and tube space to cathode 24 of tube D2, secondary winding BB of transformer T3, one terminal to the other of shield grid 22, and to the other terminal of secondary winding AA. Since the input winding 15 of transformer T3 is connected across the rails, the voltages induced in secondary windings AA and BB of transformer T3 are determined by the current flowing in the rails from the track transformer T1. The connections are such that the instantaneous polarity of the voltages of secondary winding 11 of track transformer T1 and secondary windings AA and BB of transformer T3 are as indicated by the plus and minus signs placed on the windings. This means that during the half cycle of the alternating current the tube D1 is made conductive as explained hereinbefore, the voltage applied to tube D2 causes the anode 21 to be negative in potential with respect to the cathode 24 and the tube D2 is non-conductive. During the next half cycle of the alternating current the anode 21 is made positive tending to fire the tube D2. It is noted that during the half cycle that anode 21 is positive, the shield grid 22 is driven negative in potential with respect to the cathode by the voltage of secondary winding BB. The parts are so proportioned that the negative bias of the shield grid is sufficient to keep the tube D2 non-conductive without suitable potential applied to the control grid. However, the secondary winding E is poled so that the control grid 23 is positive in potential with respect to the cathode during the half cycle anode 21 is positive and such positive bias voltage for the control grid 23 serves to counteract the negative bias of the shield grid 22 and the tube D2 is fired. With tube D2 made conductive, the relay A2 is energized by an impulse of anode current. A capacitor 30 and resistor 31 in series are connected across the winding of relay A2, and relay A2 is retained energized and picked up during the half cycle of the alternating current that tube D2 is non-conductive. Relay A2 controls the conventional signal circuit at its front contact 51.

The control grid voltage for tube D2 as derived from secondary winding E is selected to permit conduction of the tube when the voltage applied to the input winding 15 of transformer T3 is that created under normal or maximum ballast resistance of the track circuit with the resistor R7 intact and the track circuit unoccupied.

Preferably, the parts are proportioned so that

the tube D2 is operated on a range of its characteristic curves where an increase in the negative shield grid potential is more effective than a corresponding increase in the positive anode potential and where a decrease in the negative shield grid potential is less effective than a corresponding decrease in the positive anode potential. This means that a given increase in the voltage applied to the input winding 15 of transformer T3 to cause corresponding increases in the voltages of secondary windings AA and BB will make the tube D2 non-conductive, and also a given decrease in the voltage applied to input winding 15 to cause corresponding decreases in the voltages of windings AA and BB will make the tube non-conductive.

Thus the tube D2 serves to check the integrity of the limiting impedance made up of resistor R7 and input winding 15, and which limiting impedance assures a substantially uniform shunting sensitivity of the track circuit as provided by tube D1. If winding 15 is open circuited, tube D2 becomes inactive and relay A2 is deenergized. If resistor R7 is open circuited, the voltage applied to input winding 15 is materially increased and the voltages induced in secondary windings AA and BB are correspondingly increased and tube D2 becomes non-conductive to deenergize relay A2.

Furthermore, a decrease in the voltage applied to input winding 15 of transformer T3 due to a train shunt or a broken rail will lower the voltages induced in secondary windings AA and BB and tube D2 becomes non-conductive to detect the train shunt or broken rail, this detection effected by tube D2 being supplemental to the detection obtained by tube D1.

With the track transformers T1 and T4 connected to supply currents of reverse relative polarity for the track circuits, it is clear that if an insulated rail joint at location K fails and current from track transformer T4 is fed to the tubes D1 and D2, such current would cause the tubes to be non-conductive and the relays A1 and A2 to be released. This is so because the voltage applied to control grid 18 of tube D1 from transformer T4 through a defective insulated rail joint will be out of phase with the voltage applied to anode 16, and the voltage applied to anode 21 of tube D2 from transformer T4 through the insulated rail joint will be out of phase with the voltage applied to control grid 23. Consequently the tubes D1 and D2 provide broken down insulated rail joint protection.

Referring to Fig. 2, two main tracks 1T and 2T are joined by a crossover 3T, the two switches 1SW and 2SW of the crossover being indicated as of the hand throw type although they can be power operated. The track 1T is formed with a track circuit K1—L1 including track switch 1SW and having a track battery 35 and a track relay 36. Similarly, the main track 2T is formed with a track circuit K2—L2 including track switch 2SW and having a track battery 37 and a track relay 38. The track circuit K1—L1 controls signals governing traffic on the main track 1T and the track circuit K2—L2 controls signals governing traffic on track 2T in any of the well-known arrangements. These two track circuits should be insulated one from the other so that traffic moving on track 1T through the track circuit K1—L1 will not interfere with the signals controlling traffic on track 2T and vice versa.

The crossover 3T is formed by insulated rail joints with two sections U—V and V—W. The insulated rail joints 9 at the junction of the two sections of the cross-over are by-passed by capacitors 39 and 40.

The two sections of crossover 3T are included in series in a track circuit, the apparatus of which is substantially the same as that described in connection with Fig. 1. A track transformer T5 has a secondary winding 41 connected across the rails at one end of section V—W and an electron tube track relay means is connected across the rails at one end of the section U—V. The track relay means includes electron tubes D1 and D2 and relays A1 and A2, together with associated circuits the same as in Fig. 1, and the description need not be repeated. The crossover track circuit apparatus of Fig. 2 receives power from the track transformer T5 due to the insulated joint 9 being by-passed by the capacitors 39 and 40.

In Fig. 2 the source of alternating current is a generator G1 having its terminals connected to conductors 42 and 43 for supplying alternating current to the track transformer T5 and to a power transformer T2. The generator G1 provides alternating current of a suitable frequency such as, for example, of the order of 60 or 100 cycles per second. An alternating current of a relatively high frequency of the order of 1000 cycles per second or higher can be used, such high frequency serving to reduce the size of the capacitors 39 and 40 which are proportioned to pass the alternating current from generator G1 and to block the current used for the track circuits for the main tracks 1T and 2T. Under these circumstances, the track circuit for sections U—V and V—W has operating characteristics the same as those described for the apparatus of Fig. 1.

It is clear that the arrangement of Fig. 2 provides protection for the complete crossover 13 and the track circuits for the main tracks 1T and 2T are in effect electrically insulated one from the other.

Track circuit apparatus here disclosed has the advantage of providing a high shunting sensitivity for a wide differential between low and high ballast resistance, that is, the resistance of the ballast, ties, etc., from one rail to the other. The limiting impedance comprising resistor R7 and winding 15 stabilizes the rail-to-rail impedance so that ballast resistance variations do not greatly vary the rail-to-rail impedance. The tube D1 is characterized to require but a small control grid voltage variation to change the tube D1 from a conductive to a non-conductive condition. Thus, a relatively high train shunt resistance will decrease the rail-to-rail voltage sufficiently to switch the tube D1 to a non-conductive condition. This assures that a train or even a single car, occupying a track circuit infrequently used and with a high resistance film present on the surface of the rails, will be detected. In other words, the tube D1 functions as a track relay having a release voltage only slightly less than the pick-up voltage. The track circuit apparatus here disclosed also has the advantage of providing broken rail protection of a high degree of safety between maximum and minimum values of ballast resistance, because a relatively small resistance interposed in series in the rail circuit will lower the rail current sufficiently for the voltages applied to tube D1 to be varied enough to change that tube to a non-conductive condition. Again, the track circuit apparatus here disclosed assures broken down insulated rail joint detection and checks the components of the circuits. Furthermore,

when the apparatus is applied to a crossover, protection is provided for the complete crossover and the track circuits of the associated main tracks are electrically insulated one from the other.

We have disclosed track circuit apparatus which includes two electron tubes, one tube D1 arranged to provide shunting sensitivity and broken rail protection and one tube D2 arranged to check the component parts of the circuit, and we prefer such a two-tube arrangement because each tube can be adjusted to perform its particular function with a high degree of efficiency. However, it is apparent that tube D2 will respond to a train shunt and broken rail and consequently the track circuit apparatus here disclosed can be arranged to use only tube D1 or only tube D2, and our invention contemplates such modifications.

Although we have herein shown and described but two forms of railway track circuit apparatus embodying our 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 our invention.

Having thus described our invention, what we claim is:

1. In a railway track circuit for a stretch of track, a source of alternating current having connections to the rails of said stretch to power the track circuit, a pair of controlled ionization electron tubes, means to excite an anode-cathode circuit of a first one of said tubes but normally ineffective to fire the tube, a control grid-cathode circuit for said first tube receiving voltage from said track circuit to fire the tube on alternate half cycles of the alternating current when the section is unoccupied, a transformer having an input winding connected across the rails of said section to limit the rail-to-rail impedance of said track circuit and to be energized by the track circuit current, said transformer having a secondary winding connected to an anode-cathode circuit of a second one of said tubes to fire the second tube alternate half cycles of the alternating track circuit current to check the limiting impedance, and signaling means controlled by the current impulses thus caused to flow in the anode-cathode circuits of said tubes.

2. In a railway track circuit for a stretch of track, a source of alternating current having connections to the rails of said stretch to power the track circuit; a first and a second controlled ionization electron tube each having an anode, a cathode and at least one control grid; means to energize an anode-cathode circuit of said first tube from said current source, a control grid-cathode circuit for said first tube connected to the rails of said stretch to fire the tube in response to alternate half cycles of the track circuit current when the stretch is unoccupied, a transformer having an input winding connected across the rails of said stretch to be energized by the track circuit current, an impedance unit connected in multiple with said input winding to predetermine in conjunction with the input winding a maximum limit for the rail-to-rail impedance of said track circuit, a control grid-cathode circuit for said second tube excited by said current source, an anode-cathode circuit for said second tube including a secondary winding of said transformer to fire the tube in response to alternate half cycles of the track circuit current to check the impedance predetermined by said unit and input winding, and signaling means controlled by said anode-cathode circuits.

3. In a railway track circuit for a stretch of track, a source of alternating current having connections to the rails of said stretch to power the track circuit; a first and a second controlled ionization electron tube each having an anode, a cathode and at least one control grid; means to energize an anode-cathode circuit of said first tube from said current source but ineffective to fire the tube, a control grid-cathode circuit for said first tube connected to the rails of said stretch to fire the tube in response to alternate half cycles of the track circuit current when the stretch is unoccupied, a resistor, a transformer, said resistor and an input winding of said transformer in parallel connected across the rails of said stretch to limit the rail-to-rail impedance to maintain substantially uniform the shunting sensitivity of the said track circuit as provided by said first tube, a control grid-cathode circuit for said second tube excited from said current source, an anode-cathode circuit for said second tube including a secondary winding of said transformer to render the second tube conductive in response to alternate half cycles of the voltage induced in said secondary winding due to track circuit current flowing in said input winding to check the continuity of said resistor, and signaling means controlled by the anode-cathode circuits of said tubes.

4. In a railway track circuit including the track rails of a stretch of track, a source of alternating current having connection to the rails of said stretch to supply alternating current to said track circuit; a first and a second gas tube each having an anode, a cathode and a control electrode; means to excite an anode-cathode circuit of said first tube but ineffective to fire the tube, means to connect said control electrode and cathode of said first tube across the rails of said stretch to render the tube conductive alternate half cycles of the track circuit current when the stretch is unoccupied, said first tube being non-conductive in response to a relatively high resistance shunt of the rails due to the operating characteristic of the tube, a transformer having an input winding connected across the rails of said stretch to be energized by said track circuit current, an impedance unit connected to said winding, said unit and input winding proportioned for a given impedance to preselect the maximum rail-to-rail impedance of the track circuit, control means to energize the control electrode of said second tube, an anode-cathode circuit for said second tube including a secondary winding of said transformer to fire that tube alternate half cycles of the track circuit current, said control means and said secondary winding proportioned to render the second tube nonconductive in response to a given variation in the impedance above or below said given impedance of said unit and input winding, and signaling means controlled by said anode-cathode circuits of said tubes.

5. In a track circuit including the track rails of a stretch of track, a source of alternating current having connections to the rails at one end of said stretch to supply current to said track circuit; a controlled ionization electron tube having an anode, a cathode and a control electrode; a transformer having an input winding connected across the rails at the other end of the stretch to be energized by said track circuit current, a control electrode-cathode circuit connected across the control electrode and cathode

of said tube and excited by a current source to establish a sensitivity for the tube preselected by the voltage of the exciting current source, an anode-cathode circuit connected across the anode and cathode of said tube and including a secondary winding of said transformer to fire the tube in response to alternate half cycles of the voltage induced in said secondary winding due to the track circuit current flowing in said input winding, and a control relay energized by the current impulses created in said anode-cathode circuit.

6. In a track circuit including the track rails of a stretch of track, a source of alternating current connected across the rails of said stretch to supply current to said track circuit; a gas tube having an anode, a cathode and a first and a second control electrode; a transformer having an input winding connected across the rails of said stretch to receive energy from the track circuit, a circuit including said first control electrode and cathode to excite the first control electrode from said alternating current source; another circuit including in series a first and a second secondary winding of said transformer, said anode, said cathode and said second control electrode; said first and second secondary windings poled for said anode to be positive in potential and said second control electrode negative in potential with respect to said cathode the half cycle of the alternating current that said first control electrode is positive in potential with respect to the cathode whereby said tube is fired alternate half cycles of track circuit current of a given value, and a relay having a winding interposed in said another circuit to be energized by the impulses of current thus caused to flow in said another circuit.

7. In a track circuit including the track rails of a stretch of track, a source of alternating current connected across the rails of said stretch to supply current to said track circuit; a gas tube having an anode, a cathode and a first and a second control electrode; a resistor, a transformer, said resistor and an input winding of said transformer in parallel connected across the rails of the stretch to provide a limiting rail-to-rail impedance for the track circuit; a first circuit to connect said current source to said first control electrode and cathode to excite the first control electrode; a second circuit including in series a first secondary winding of said transformer, said anode, said cathode, a second secondary winding of said transformer and said second control electrode to excite the anode and second control electrode by track circuit current flowing in said input winding; said first and second secondary windings poled for said anode to be positive in potential and said second control electrode negative in potential with respect to said cathode the half cycle of the alternating current that said first control electrode is driven positive in potential with respect to the cathode to fire the tube alternate half cycles of current received from the track circuit of a given range of values, and said tube and said first and second circuits selected to operate the tube for the tube to be non-conductive when the current flowing in said input winding is decreased or increased beyond said given range of values.

8. In a track circuit including the track rails of a stretch of track, a source of alternating current connected across the rails of said stretch to supply alternating current to said track circuit; an indirectly heated gas tube having an anode, a cathode and a first and a second control electrode; a power transformer having its primary winding receiving power from said current source, a first secondary winding of said transformer connected in series with a resistor to the input terminals of a full wave rectifier the output terminals of which rectifier are connected to a heater element of said tube; an anode circuit including a second secondary winding of said transformer, anode to cathode space of said tube, at least a portion of said resistor and said second control electrode; said first and second secondary windings poled for said anode to be positive in potential and said second control electrode negative in potential with respect to said cathode during a given half cycle of said alternating current to normally render the tube non-conductive, a control circuit including a third secondary winding of said transformer to connect said first control electrode and cathode across the rails of said stretch to drive said first control electrode positive in potential with respect to the cathode said given half cycle of the alternating current to fire the tube when said stretch is unoccupied, and a control relay having a winding interposed in said anode circuit to energize the relay in response to the impulses of current passed by the tube.

9. In a track circuit including the track rails of a stretch of track, a source of alternating current connected across the rails of said stretch to supply current to said track circuit; an indirectly heated gas tube having an anode, a cathode and a first and a second control electrode; a power transformer having a primary winding receiving power from said current source, a first circuit including a resistor to connect a first secondary winding to a heater element of said tube; an anode circuit including in series a second secondary winding of said transformer, anode-to-cathode space of said tube, at least a portion of said resistor and said second control electrode; said first and second secondary windings poled for said anode to be positive in potential and said second control electrode negative in potential with respect to the cathode during a given half cycle of the alternating current to normally maintain the tube non-conductive, a control circuit including a third secondary winding of said transformer to connect said first control electrode and cathode across the rails of said stretch, said third secondary winding and the track circuit poled to add their voltages as applied to the first control electrode to fire the tube when the stretch is unoccupied, and a relay having a winding interposed in said anode circuit to energize the relay in response to the impulses of current passed by said tube.

10. In a track circuit including the rails of a stretch of railway track and having a source of alternating current connected across the rails at one end of the stretch for energizing track relay means connected across the rails at the other end of the stretch; said track relay means comprising, a pair of gas tubes, a pair of electromagnetic relays, a step-up transformer and a power transformer; said power transformer having a primary winding powered from said current source, an anode-cathode circuit for a first one of said tubes and including a first secondary winding of said power transformer and a winding of a first one of said relays, a control grid-cathode circuit for said first tube connected across the rails of said stretch and including a second secondary winding of said power transformer,

said track circuit and second secondary winding of the power transformer poled to add their voltages to fire the tube alternate half cycles of the alternating current and energize said first relay when the stretch is unoccupied, said step-up transformer having an input winding connected across the rails of the stretch to receive energy from said track circuit, said input winding of a preselected impedance to predetermine the maximum rail-to-rail impedance of the track circuit, an anode-cathode circuit for a second one of said tubes and including a second one of said relays and a secondary winding of said step-up transformer, a control grid-cathode circuit for said second tube including a third secondary winding of said power transformer to fire the second tube alternate half cycles of the alternating current and energize said second relay when said step-up transformer is energized by the track circuit current, said second tube anode-cathode and control grid-cathode circuits preselected for the second tube to remain non-conductive in response to a given variation in the impedance of said input winding with respect to said preselected impedance and signaling means controlled jointly by said relays.

11. In a track circuit including the track rails of a stretch of track, a source of alternating current having connections to the rails at one end of said stretch to supply current to the track circuit; an electron tube having an anode, a cathode and at least one control electrode; a control electrode-cathode circuit including a current source and connected across said control electrode and cathode of said tube to predetermine the operating characteristic of the tube, an anode-cathode circuit for said tube connected across said anode and cathode and having connections for receiving current from the rails at the other end of said stretch to effect either a first or a second value of conduction current through the tube solely in response to the current received from the track circuit, said conduction current being of said first or said second value according as the stretch is unoccupied and said track circuit current flows in the rails at said other end or said stretch is occupied and the track circuit current is shunted, and a control relay means having an element interposed in said anode-cathode circuit and operated to a first or a second position according as said conduction current is of said first or second value.

12. In a railway track circuit for a stretch of track, a source of alternating current having connections to the rails of said stretch to supply alternating current to the track circuit; a first and a second controlled ionization electron tube each having an anode, a cathode and at least one control electrode; an anode-cathode circuit for said first tube to excite the tube but normally ineffective to fire the tube, a control electrode-cathode circuit for said first tube having connections to the rails of said stretch to fire the tube on alternate half cycles of the alternating current when the section is unoccupied, an impedance means having connections across the rails of said stretch and of a value preselected to predetermine the maximum rail-to-rail impedance of the track circuit to govern the response of said first tube to a rail-to-rail shunt of the track circuit, an anode-cathode circuit for said second tube to excite the tube, a control electrode-cathode circuit for said second tube having connections for receiving a voltage from said impedance means in response to the track circuit current flowing therein, said anode-cathode and control electrode-cathode circuits of the second tube effective to fire the tube only when the impedance means is of approximately said preselected value, and signaling means controlled jointly by the anode-cathode circuits of the two tubes.

13. In a railway track circuit for a stretch of track, a source of alternating current having connections to the rails of said stretch to supply alternating current to the track circuit; a pair of controlled ionization electron tubes each having an anode, a cathode and at least one control electrode; a first circuit means having connections to the anode and cathode of a first one of said tubes to excite that tube, a second circuit means receiving power from said track circuit and having connections to the control electrode and cathode of said first tube, said first and second circuit means operable to fire the first tube on alternate half cycles of the alternating track circuit current when the stretch is unoccupied and to retain the tube nonconductive when the stretch is occupied by a train to shunt the rails, a transformer having a primary winding connected to the rails of said stretch to predetermine by its impedance the maximum rail-to-rail impedance of the track circuit and govern the shunting sensitivity of the track circuit as provided by said first tube, said primary winding being energized by the alternating track circuit current, means including a voltage source having connections to the anode and cathode of a second one of said tubes to excite that tube, means including a secondary winding of said transformer having connections to the control electrode and cathode of said second tube to govern the firing of that tube by said voltage source according to said energization of said primary winding by the track circuit current to check the impedance of the primary winding, and signaling means governed jointly by the anode-cathode circuits of said tubes.

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