Aug. 10, 1937. P. N. MARTIN 2,089,836

RAILWAY TRACK CIRCUIT APPARATUS

Filed Nov. 8, 1934

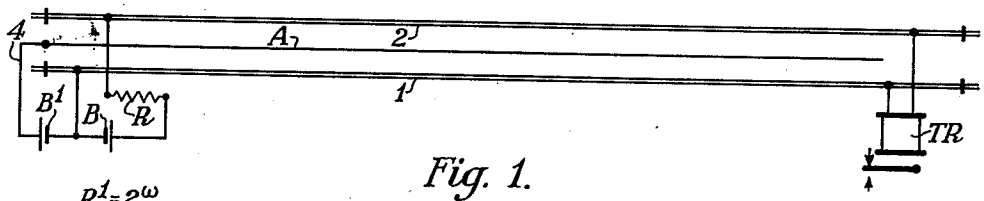


Fig. 1.

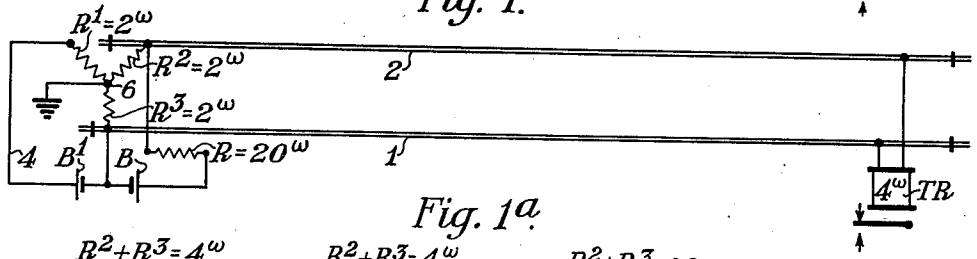


Fig. 1a

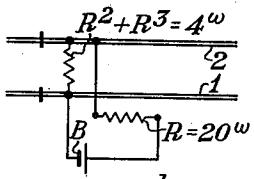


Fig. 1b

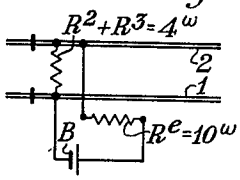


Fig. 1c

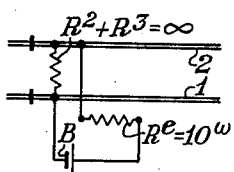


Fig. 1d

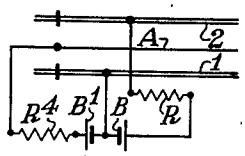


Fig. 2.

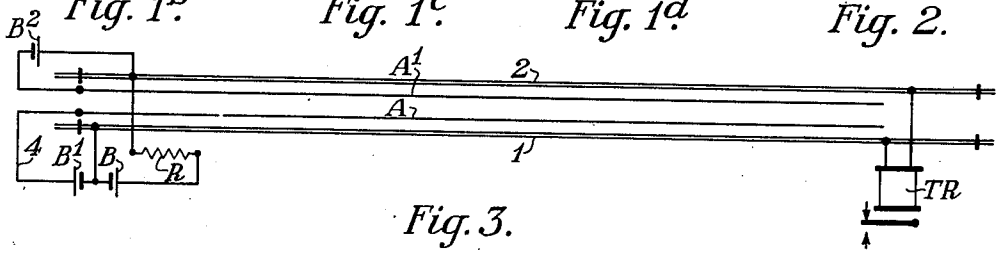


Fig. 3.

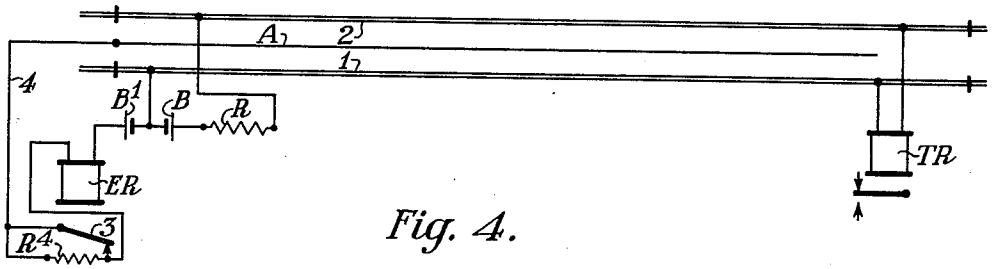


Fig. 4.

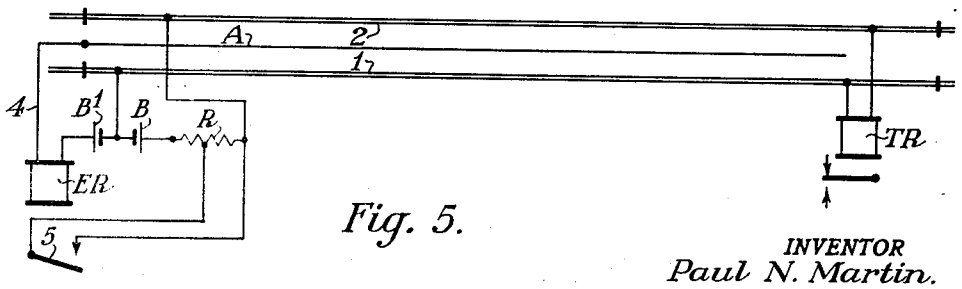


Fig. 5.

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RAILWAY TRACK CIRCUIT APPARATUS

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Application November 8, 1934, Serial No. 752,004

18 Claims. (Cl. 246—41)

My invention relates to track circuit apparatus, and more specifically to apparatus for increasing the shunting sensitivity of track circuits.

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

Fig. 1 of the accompanying drawing is a diagrammatic view showing one form of apparatus embodying my invention. Figs. 1a, 1b, 1c and 1d are diagrammatic views showing equivalent circuits which are used for explaining the operation of certain portions of the apparatus of Fig. 1. Figs. 2, 3, 4 and 5 are diagrammatic views showing modified forms of the apparatus of Fig. 1, each embodying my invention.

Similar reference characters refer to similar parts in each of the several views.

Referring to Fig. 1, the reference characters 1 and 2 designate the rails of a section of railway track. Connected across the rails at one end of the section is a source of current B which supplies current through a limiting resistor R, to a track relay TR which is connected across the rails at the other end of the section. In contact with the track ballast is a conductor A, to which, by means of a wire 4, is connected one terminal of a second source of current B^1. The other terminal of the source B^1 is connected to a rail of the same polarity which in this case is the rail 1. Conductor A is preferably a scrap rail of suitable length spiked to the same ties which support the rails 1 and 2 in a manner to simulate as closely as possible the type of junction which exists between the rails 1 and 2 and the supporting ties and ballast. That is, the connection of conductor A with the ballast should be such that a given length of this conductor will have a resistance to ground of approximately the same value as exists between a corresponding length of either rail 1 or rail 2, to ground. It is not essential that conductor A be in the form of a rail, as any suitable conductor, such for example, as a copper or iron wire making contact with the ballast through the ties, or in any other suitable manner, can be used. For example, an insulated wire bared at those portions which are spiked or otherwise fastened to the ties, can be used.

Experience with track circuit operation indicates that the major portion of the track ballast resistance is probably concentrated in a comparatively thin film which forms the junction between a rail and its supporting ties, as well as, to some extent, in a second film at the area of contact of a tie with the ballast in which it is imbedded. Based on this experience, the particular location of conductor A with respect to rails 1 and 2 is relatively unimportant, provided that substantial contact with the rail supporting ties is obtained for the purpose of establishing a film resistance condition at the conductor-tie junction which will closely approximate the film resistance condition at the rail-tie junction, under different conditions of ballast resistance. Ballast conductor A can be placed on the outside of rail 1 or rail 2 if desired, or it can take the form of a guard rail. If the ballast conductor is placed near to rail 2, trunking or other covering or insulation should be used in order to avoid accidental short circuits with rail 2 which might result in over-energization of the track relay.

In Fig. 1a, I have shown an equivalent circuit in which the resistances R^1, R^2 and R^3 represent the value of the resistance to ground, from conductor A, rail 2 and rail 1, respectively. It is assumed that the resistances R^1, R^2 and R^3 are equal and the rail resistance is neglected. When the resistances R^1, R^2 and R^3 are minimum, that is, when the ballast is wet, the voltage impressed across the rails 1 and 2 by battery B must be sufficient to operate the track relay TR. With the value of the voltage of battery B^1 chosen in such manner as to be equal to twice the value of the voltage drop across the rails 1 and 2 due to battery B, the value of the current flowing from auxiliary battery B^1, through resistance R^3, ballast resistance center 6 and resistance R^1 to connection 4, is equal to twice the value of the current which would normally flow from battery B through resistance R^3, ballast resistance center 6 and resistance R^2 to rail 2. This will be understood from the fact that if resistors R^1, R^2 and R^3 are all equal; and, if the voltage drop across resistors R^3 plus R^2, due to battery B, is equal to one-half of the voltage drop across the two resistors R^3 plus R^1, due to battery B^1, (i. e., is equal to the voltage drop across either one or the other of these resistors) then the point 6 and the point at which resistor R^2 is connected to rail 2 are at the same potential. In other words, the value of the drop in potential from rail 1 through resistor R^3 to the ballast resistance center 6 and due to battery B^1, is equal to the value of the drop in potential due to battery B from rail 1 to rail 2, and consequently, the ballast resistance center 6, and rail 2, are of equal potential so that no current flows from the ballast resistance center 6 to rail 2. The theory of operation of the equivalent circuit shown in Fig. 1a may also be explained in the following manner: If the circuit including battery B, resistance R^2 and resistance R^3 is con-

sidered to be the main circuit in which there exists a certain potential difference across resistance R^2 then the voltage of the battery B^1 of the auxiliary circuit including resistances R^3 and R^1 may be chosen of a value sufficiently greater than the voltage of battery B so that current from battery B^1 will tend to flow through battery B and resistance R^2, in the reverse direction, and thence through resistance R^1 back to battery B^1. If the potential of battery B^1 is properly chosen, then the potential difference across R^2 in the reverse direction due to battery B^1 will be equal and opposite to the potential difference across R^2 in the normal direction due to battery B. Consequently, point 6 and rail 2 will be at the same potential and no current will flow from battery B in resistance R^2. Since all of the ballast leakage current is supplied by battery B^1, it follows that battery B need only furnish such current to the track circuit as is required by track relay TR and resistor R will be of considerably higher resistance than it would have to be if battery B^1 and the auxiliary rail A were not present. Consequently, when the resistances R^1, R^2, and R^3 become high, that is, when the ballast dries out, the voltage across the rails 1 and 2 will not increase as it would in an ordinary track circuit, and it will be possible to release the track relay TR with a train shunt across the rails of comparatively high resistance.

In explaining the operation of the track circuit system shown in Fig. 1, I shall again make use of Fig. 1^a, and also Figs. 1^b, 1^c and 1^d. In Fig. 1^a, I have shown the resistance of relay TR to be 4 ohms, the resistance of R to be 20 ohms and the resistances of R^1, R^2 and R^3 to be 2 ohms each. Let it be assumed that under the condition of minimum ballast resistance, with the rail resistance neglected for convenience, the combination of the four resistances R, R^1, R^2 and R^3, with the values shown, is proper to cause battery B to supply the normal pickup current to relay TR. Conductor A is chosen of sufficient length to provide a resistance R^1 of 2 ohms from this conductor to ground, and to simplify the explanation, it is assumed that rails 1 and 2 each have a resistance of 2 ohms to ground, so that R^2 and R^3 are each 2 ohms. Under these conditions, it is apparent that if battery B^1 did not supply the ballast leakage current, the equivalent circuit is that shown in Fig. 1^b, wherein a 4 ohm resistance, consisting of resistances R^2 plus R^3, is connected across the rails 1 and 2, in multiple with the 4 ohm relay TR. Since the current from battery B is now divided between two 4 ohm resistances in parallel, it is also readily apparent that relay TR is not receiving sufficient current for pickup and in order for it to receive its normal pickup current. the resistor R would have to be reduced to a value of 10 ohms, shown as R^e in Fig. 1^c. The conditions existing when the ballast dries out are indicated in Fig. 1^d. Since the resistances R^2 and R^3 are now infinite, no current from battery B flows through the ballast, consequently, the relay TR is receiving more than its normal pickup current through the 10 ohm resistor R^e. It is now obvious, that, if the battery B^1 and the conductor A were not used, the value of the resistor R would have to be 10 ohms instead of 20 ohms, in the example illustrated, in order that relay TR would receive sufficient pickup current under the wet ballast condition, and necessarily, after the ballast became dry, the shunting sensitivity would be that corresponding to a 10 ohm battery resistor. Since the shunting sensitivity is largely determined by the amount of resistance in series with the track battery and the amount of current flowing through the track relay when the track is unoccupied, the marked advantage of the apparatus and method disclosed is obvious. A high resistance in series with the track battery tends to keep the current flow through the track relay from increasing to an excessive amount when the ballast resistance is high and also makes the train shunt more effective in reducing the current to release the relay, or in other words, increases the shunting sensitivity.

From the above explanation, it is clear that when the ballast resistance is high, a train shunt of much higher resistance will be effective in causing relay TR to release if battery B^1 and conductor A are used, than if the usual type of track circuit is employed. It is understood that the resistance values of R, R^1, R^2 and R^3 need not be equal to the values used in this example, nor need the resistance value of R^2 plus R^3 be equal to the resistance of relay TR, these values being merely explanatory and being determined, in actual practice, by the physical characteristics of the particular track circuit, character of rail traffic, degree of shunting sensitivity required, as well as other practical considerations.

In Fig. 2, a resistor R^4 is inserted in connection 4, between battery B^1 and ballast conductor A. The resistor R^4 may be added to the ballast conductor circuits shown in Figs. 1, 3 and 5, if it is desired to limit the flow of current from the battery B^1 or the battery B^2, or to limit the flow of current upon the occurrence of an accidental short circuit between the ballast conductor and the running rails. Also a fuse may be used in place of resistor R^4, or in addition thereto.

The resistor R^4 may be of the type in which the resistance varies in accordance with the amount of current flowing through it, such for example, as a resistor having a high positive temperature coefficient of resistivity. With this arrangement, an increase in the temperature of the resistor brought about by increasing the current flowing through it would cause an appreciable increase in the resistance of the resistor. If a resistor of this type is connected between the battery B^1 and the ballast conductor A and is so proportioned as to have a relatively high temperature under low ballast resistance, that is, when the ballast is wet, so that the resistance of the resistor will be relatively high, it will be seen that the shunting sensitivity of the circuit will be improved under wet ballast conditions because the current which might flow from battery B^1 through the ballast and rails to relay TR will be somewhat less than would flow under similar conditions if a resistor of the ordinary type were used.

In Fig. 3, I have shown a track circuit similar to the track circuit shown in Fig. 1, with the exception that a second ballast conductor A^1, with a battery B^2, has been provided. The polarity of the connection of battery B^2 between rail 2 and ballast conductor A^1 is the opposite of that of battery B and ballast conductor A. I will not make a detailed explanation of apparatus shown in Fig. 3, since it is obvious that if a single battery can be provided, such as described for Fig. 1^a, to furnish the ballast leakage current of a track circuit, such leakage current can be divided between two batteries. Since batteries B^1 and B^2 provide the ballast leakage current, it follows that battery B need only furnish the current required by the track relay TR, and in all other respects the track circuit shown in Fig. 3, operates in the

same manner as previously described for the track circuit shown in Fig. 1. It is readily apparent that the arrangement shown in Fig. 3 has the advantage of flexibility in that the voltage of batteries B^1 and B^2 can be varied independently, and likewise the size, resistance and other characteristics of ballast conductors A and A^1 can be varied independently, as conditions may require.

In Fig. 4, I have shown the same apparatus as is shown in Fig. 1, with the addition of a relay ER and the resistor R^4 connected in series between battery B^1 and ballast conductor A, with a back contact 3 of the relay ER connected in parallel with the resistor R^4. The relay ER is adjusted so that an increase in current flowing from battery B^1, such as for example might occur when the ballast is wet, will energize relay ER thus opening contact 3 and causing resistance R^4 to be effective in the circuit for limiting the flow of current from battery B^1. Consequently, the shunting sensitivity of the track circuit under wet ballast conditions is improved because any current which might flow from ballast conductor A to relay TR through the ballast and the rails is limited to a small amount. Otherwise the apparatus shown in Fig. 4 operates in the same manner as the apparatus shown in Fig. 1.

In Fig. 5, I have shown all of the apparatus shown in Fig. 1 with the addition of the relay ER connected between battery B^1 and ballast conductor A, and a front contact 5 of relay ER which shunts out a portion of resistor R when relay ER is energized. Relay ER is adjusted to pick up when the ballast resistance is low and to release when the ballast resistance increases to a predetermined value with a consequent decrease or increase in the value of the resistor R, thus increasing the flow of the current from battery B when the ballast resistance is low and decreasing the flow of current from battery B when the ballast resistance is high. The decrease in the flow of current from battery B when the ballast resistance is high reduces the energization of relay TR and consequently improves the shunting sensitivity of the track circuit under dry ballast conditions. Otherwise, the apparatus shown in Fig. 5 operates in the same manner as the apparatus shown in Fig. 1.

Although I have shown only one relay ER in Figs. 4 and 5, it is understood, that if it is desired to vary the value of the resistances R or R^4 gradually, more than one relay or one relay having a series of contacts each adjusted to operate at a different value, can be used.

It is further understood that any source of current can be used with my invention, such as direct current, pulsating current or alternating current, although I have shown only batteries, as a source of current. The principal requirement with respect to the source of current is that the relative polarities must be as shown herein.

I wish to also point out that any failure of the ballast conductor and its source of current to function properly would tend to reduce the amount of current flowing in the track relay, and so my invention does not introduce any additional hazards into the usual track circuit.

While I have herein shown and described my invention as being employed for controlling the ballast leakage current of railway track circuits, it is understood that the use of my invention is not so limited but may also be applied to other types of electrical circuits which are subject to leakage between conductors, such for example, as a cable comprising two or more conductors of a circuit which is subject to leakage currents from one conductor to another through the insulation of the conductors. It is apparent that my invention may be applied to such circuit to compensate for the leakage currents, by placing an extra conductor in contact with the insulation between two conductors leading from a main source to a load, and connecting an auxiliary source between the extra conductor and one of the other two conductors. The resulting arrangement would function in substantially the same way as the track circuit described above.

Although I have herein shown and described only a few 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. The combination, with a section of railway track provided with a main source of current connected across the rails; of means for governing the amount of current flowing between the rails of said section through the ballast from said main source of current including a first ballast conductor in contact with the track ballast, a second source of current connected between said ballast conductor and one rail of said section for controlling the potential difference between the ballast and the rails of said section, a second ballast conductor also in contact with the track ballast, and a third source of current connected between said second ballast conductor and the other rail of said section also for controlling the potential difference between the ballast and the rails of said section.

2. In combination with a track circuit including a section of railway track, a ballast conductor in contact with the track ballast, a source of current connected in an auxiliary circuit including said ballast conductor and one rail of said section for substantially neutralizing the ballast leakage current of said track circuit, a relay connected in said auxiliary circuit, and means controlled by said relay for varying the effective resistance of said auxiliary circuit with changes in the ballast resistance to govern the amount of current flowing therein.

3. The combination, with a section of railway track provided with a track circuit including the two rails of said section, a main source of current connected across the rails of the section, and a track relay connected across the rails of the section; of means for supplying the ballast leakage current of said track circuit including a first ballast conductor in contact with the track ballast, a second source of current connected between said ballast conductor and one rail of said section for supplying a portion of the ballast leakage current from said main source, a second ballast conductor also in contact with the track ballast, and a third source of current connected between said second ballast conductor and the other rail of said section for supplying the remaining portion of the ballast leakage current from said main source.

4. The combination, with a section of railway track provided with a track circuit including the two rails of said section, a main source of current connected across the rails of the section, and a track relay connected across the rails of the section; of means for improving the shunt-

ing sensitivity of said track circuit including a first ballast conductor in contact with the track ballast, a second source of current connected between said ballast conductor and one rail of said section for neutralizing a portion of the ballast leakage current from said main source, a second ballast conductor also in contact with the track ballast, and a third source of current connected between said second ballast conductor and the other rail of said section for neutralizing the remaining portion of the ballast leakage current from said main source.

5. In combination with a track circuit including a section of railway track, an auxiliary circuit including a ballast conductor in contact with the track ballast as well as a source of current and one rail of said section for substantially neutralizing the ballast leakage current of said track circuit to improve the shunting sensitivity of the track circuit, and a resistor having a high positive temperature coefficient introduced into said auxiliary circuit for varying the resistance of the auxiliary circuit when the current flowing therein varies in response to changes in ballast resistance.

6. In combination with a section of railway track provided with a source of current connected across the rails and a track relay receiving current from the rails, a circuit including a ballast conductor in contact with the track ballast as well as a second source of current and one rail of said section for regulating the ballast leakage current to maintain the current received by said track relay at a substantially constant value regardless of changes in ballast resistance, and a resistor the resistance of which varies in accordance with the amount of current flowing therein introduced into said circuit for varying the resistance of the circuit when the current flowing therein changes in response to changes in ballast resistance.

7. In combination with a section of railway track provided with a track circuit including a track relay connected directly across the rails of said section and a main source of energy supplying current to said rails, said track circuit being subject to leakage current flowing from said main source through the ballast between the rails, means for producing an auxiliary flow of current between the rails and ballast of said section of such polarity and magnitude that the leakage current from said main source is opposed and substantially reduced under a given ballast resistance, and means for varying the value of said auxiliary current in accordance with subsequent changes in ballast resistance.

8. In combination with a section of railway track provided with a track circuit including a track relay connected directly across the rails of said section and a main source of energy supplying current to said rails, said track circuit being subject to leakage current flowing from said main source through the ballast between the rails, means for producing an auxiliary flow of current between the ballast and rails of said section of such polarity and magnitude that the leakage current from said main source is opposed and substantially neutralized under a given ballast resistance, and means for varying the value of said auxiliary current in accordance with subsequent variations in ballast resistance, thereby maintaining at a substantially constant value the current flowing through said track relay.

9. In combination with a section of railway track provided with a track circuit including a track relay connected directly across the rails of said section and a main source of energy supplying current to said rails, said track circuit being subject to leakage current flowing from said main source through the ballast between the rails, means including a path for producing an auxiliary current flow between the rails and the ballast of such polarity and magnitude that said leakage current is opposed and substantially neutralized, and means for controlling the impedance of said path in accordance with the current flowing through such path.

10. In combination with a section of railway track provided with a track circuit including a track relay connected directly across the rails of said section and a main source of energy supplying current to said rails, said track circuit being subject to leakage current flowing from said main source through the ballast between the rails, means including a path for producing an auxiliary current flow between the rails and the ballast of such polarity and magnitude that said leakage current is opposed and substantially neutralized, another relay controlled by said auxiliary current, and means for controlling the impedance of said path by said other relay.

11. Track circuit apparatus for a section of railway track comprising a main source of current connected across the rails at one end of the section, a track relay, circuit means the resistance of which is independent of any changes in ballast resistance connecting said track relay across the rails at the other end of the section, a ballast conductor for said section in contact with the track ballast, a second source of current, and means connecting said second source between the ballast conductor and only one rail of the section to supply thereto a potential difference of such magnitude and polarity that variations in the current supplied from the main source to the relay due to changes in ballast resistance are substantially eliminated by the current resulting from said potential difference.

12. Track circuit apparatus for a section of railway track comprising a main source of current connected across the rails at one end of the section, a track relay, circuit means the resistance of which is independent of any changes in ballast resistance connecting said relay across the rails at the other end of the section, a ballast conductor for said section in contact with the track ballast, an auxiliary source of current, and means connecting said auxiliary source between the ballast conductor and only one rail of the section to supply thereto a potential difference of such magnitude and direction that the flow of ballast leakage current from said main source is substantially eliminated due to the current resulting from said potential difference, thereby maintaining the energization of said track relay at a substantially constant value regardless of changes in ballast resistance.

13. Track circuit apparatus for a section of railway track comprising a main source of current connected across the rails at one end of the section, a track relay, circuit means the resistance of which is independent of any changes in ballast resistance connecting said track relay across the rails at the other end of the section, a ballast conductor for said section in contact with the track ballast, an auxiliary source of current, and means connecting said auxiliary source between the ballast conductor and only one rail of the section to supply thereto a potential difference of a greater magnitude than the potential

difference across the rails due to the main source and in such direction that the flow of ballast leakage current from said main source is reduced due to the current resulting from the potential difference supplied by said auxiliary source, thereby preventing wide variations due to changes in ballast resistance in the current received by said track relay from said main source.

14. Track circuit apparatus for a section of railway track comprising a main source of current connected across the rails at one end of the section, a track relay, circuit means the resistance of which is independent of any changes in ballast resistance connecting said track relay across the rails at the other end of the section, a ballast conductor for said section in contact with the track ballast, an auxiliary source of current, and means connecting said auxiliary source between said ballast conductor and only one rail of the section to supply thereto a potential difference of approximately twice the potential difference across the rails due to the main source and in such direction that the flow of ballast leakage current from said main source is substantially eliminated due to the current resulting from the potential difference supplied by said auxiliary source, thereby maintaining the energization of said track relay at a substantially constant value regardless of changes in ballast resistance.

15. Track circuit apparatus for a section of railway track comprising a main source of current connected across the rails at one end of the section, a track relay, circuit means the resistance of which is independent of any changes in ballast resistance connecting said track relay across the rails at the other end of the section, a ballast conductor for said section in contact with the track ballast, an auxiliary source of current, and means connecting said auxiliary source between said ballast conductor and only one rail at said one end of the section to supply thereto a potential difference of such magnitude and direction that the flow of ballast leakage current from said main source is substantially eliminated due to the current resulting from said potential difference, thereby maintaining the energization of said track relay at a substantially constant value regardless of changes in ballast resistance.

16. Track circuit apparatus for a section of railway track comprising a main source of current connected across the rails at one end of the section, a track relay, circuit means the resistance of which is independent of any changes in ballast resistance connecting said track relay across the rails at the other end of the section, a ballast conductor for said section in contact with the track ballast, the resistance between said ballast conductor and the ballast being substantially the same value as the resistance between the track rails and the ballast, a second source of current, and means connecting said second source between the ballast conductor and only one rail of the section to supply thereto a potential difference of such magnitude and polarity that variations in the current supplied from the main source to the relay due to changes in ballast resistance are substantially eliminated by the current resulting from said potential difference.

17. In combination, a pair of conductors having a leakage path of variable resistance therebetween, a main source of current connected across the conductors at one end, a load, means the resistance of which is independent of changes in the resistance of said leakage path connecting said load across the conductors at the other end, a ballast conductor in contact with said leakage path, a second source of current, and means connecting said second source between the ballast conductor and only one conductor to supply thereto a potential difference of such magnitude and polarity that variations in the current supplied from the main source to the load due to changes in the resistance of said leakage path are substantially eliminated by the current resulting from said potential difference.

18. In combination, a section of railway track, a main source of energy for supplying current to the rails at one end of the section, an impedance connected between said main source and one rail at said one end of the section, a track relay connected across the rails at the other end of the section, a ballast conductor in contact with the track ballast, an auxiliary source of energy, a circuit responsive to changes in ballast resistance connecting said auxiliary source between said ballast conductor and only one rail at said one end to supply thereto a potential difference to control the ballast leakage current of said main source, an auxiliary relay connected in said circuit, and means controlled by said auxiliary relay for varying the value of said impedance in accordance with changes in ballast resistance.

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