

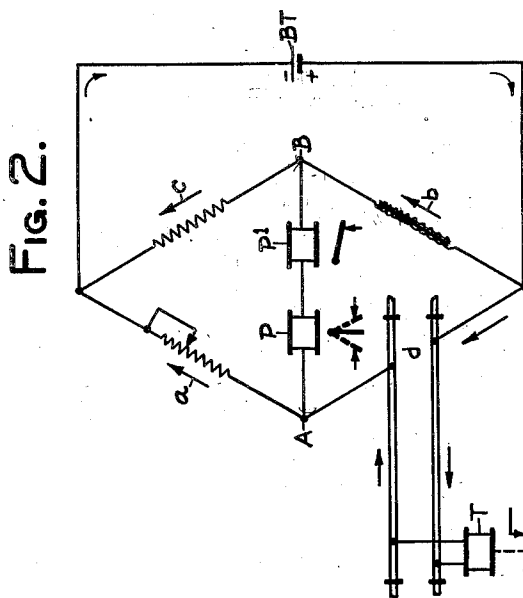
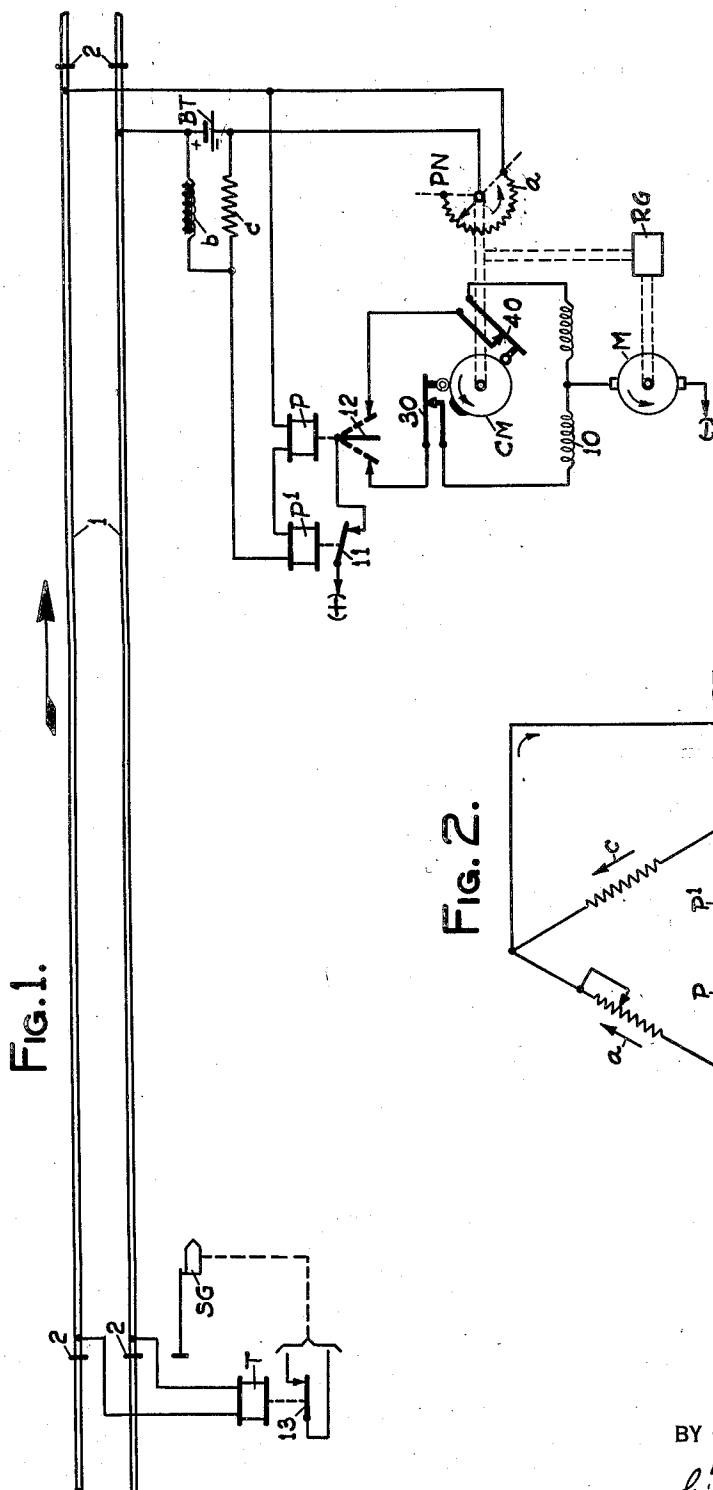
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RAILWAY TRACK CIRCUIT

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RAILWAY TRACK CIRCUIT

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This invention relates in general to track circuits such as used in railway signalling practice and it has more particular reference to means for maintaining current through a track relay associated with a stretch of railway track substantially constant, regardless of changes in ballast leakage between the rails of the track due to weather conditions.

The invention also relates to means for automatically discriminating between current changes in the track circuit due to the occupied condition of the track and due to leakage currents resulting from poor ballast conditions.

In railway operation it is quite essential that the usual track relay connected across the track section at one end of a signalling block be sufficiently energized when the block is unoccupied to pick up and hold up with certainty. It is likewise essential that the occupancy of the track section will so effectively shunt or condition the relay that it will be positively released. For example, in the usual track circuits if the normal holding current is too high shunting may not be effective to drop the relay and if the normal holding current is so low that shunting is made more positive then it is possible that at times the holding current will be insufficient.

Taking the above into consideration it will be apparent that the usual variation in ballast resistance encountered in practice, due primarily to changes in weather conditions, may interfere with the proper operation of the track relay unless some means are provided to compensate for the current ordinarily shunted away from the track relay by extreme ballast leakage, or for discriminating between changes due to ballast resistance and track occupancy. The present arrangement is proposed as a means for regulating the potential applied to the holding winding or windings of a track relay under various ballast conditions and also for discriminating between slow changes in the shunting of the relay due to ballast changes and rapid changes in the shunting of the relay due to track occupancy.

It will be obvious that an increase in ballast resistance results in a decrease in the leakage current between the rails so that the voltage across the terminals of a track relay connected across these rails increases. Conversely, as the ballast resistance decreases the leakage current between the rails increases and the terminal voltage at the usual track relay decreases. The relay current will vary over a considerable range and cover a range at times which may prevent proper

response of the relay under occupied or unoccupied conditions of the track section.

It is therefore proposed in accordance with this invention to provide means automatically operable to permit a change in current in the track relay effected by the entrance of a train into the associated track section, but to automatically maintain a substantially constant current in the track relay regardless of changes in values of leakage current through the ballast from one rail to the other.

It is further proposed to improve the shunting efficiency of the track circuit and for this purpose a discriminating arrangement is included in the circuit of the track relay which discriminates between a slow change in track shunt due to track ballast and a rapid change in track shunt due to train occupancy.

Further objects, purposes and characteristic features of the invention will appear as the description progresses reference being made to the accompanying drawing showing by way of example one form which the invention may assume.

Fig. 1 illustrates in a diagrammatic and conventional manner one form of the present invention.

Fig. 2 illustrates the fundamental circuit scheme of Fig. 1 laid out in simplified manner for the purpose of more adequately describing the method of operation of the form disclosed in Fig. 1.

Apparatus.—Referring to Figs. 1 and 2, in which those parts of Fig. 1 which have been reproduced in Fig. 2 are given the same reference characters, a section of railway track including rails 1 is shown separated from the adjacent track sections by insulated joints 2. A track battery BT and a track relay T are shown connected to the track rails at opposite ends of the illustrated section.

As typical of the control exercised by the track relay, a semaphore signal SG is illustrated at the left end of the track section and in the present description it will be assumed that traffic moves from left to right over this section as indicated by the arrow appearing above the track.

The track relay and the track rails are connected to the track battery through the medium of an electrical network which is more clearly shown in Fig. 2. This network comprises various resistors, relays and an impedance coil laid out in the form of a Wheatstone bridge. It will be understood that the schematic circuit illustrated in Fig. 2 shows the same connection of this network which is illustrated in Fig. 1.

The upper ratio arms of the bridge comprise a

fixed resistor c and a variable resistor or potentiometer a . The arm of the bridge which is diagonally opposite arm a comprises an impedance coil b . The arm of the bridge which is diagonally opposite arm c comprises the track rails and the track relay T which make up arm d of the bridge.

Track battery BT is connected across one pair of conjugate points of the bridge. Connected across the other pair of conjugate points of the bridge are the detector relays P and P^1 .

The contacts of the detector relays are shown wired through contacts of a cam device CM to a motor M . This motor is of the reversible type and, through the medium of a reduction gear RG , it drives cam CM and the potentiometer PN in opposite directions as determined by the direction of rotation of the motor as will be explained in detail.

Relay P is a biased-to-neutral polar relay of the sensitive type which operates its contact to the right or the left in response to current of a small degree flowing through its winding. Relay P^1 is a neutral relay of the marginal type so wound and adjusted that it is not picked up by current of a small degree which is effective to operate relay P . It requires a substantially greater amount of current flow between points A and B of the bridge to operate relay P^1 than relay P , which is effected in a manner to be presently explained.

The left hand field winding 10 of the motor is assumed to operate the motor, the cam device and the potentiometer in a clock-wise direction. When the potentiometer reaches the end of the resistance, cam device CM opens contact 30 so that the motor cannot drive the potentiometer any farther in a clock-wise direction. Similarly, when the potentiometer reaches the beginning of the resistance (indicated by the arrow in its lower position) cam device CM opens contact 40 which prevents the motor driving the potentiometer any farther in a counterclock-wise direction. It will be understood that potentiometer PN which is operated by motor M controls the resistor which is arm a of the Wheatstone bridge.

Operation of Fig. 1

Normal conditions.—With the circuit in its normal condition as illustrated in Fig. 1, track relay T is normally picked up over a circuit extending from the (+) terminal of battery BT , lower track rail, winding of relay T , upper track rail and potentiometer PN to the (—) terminal of battery BT . A multiple path is connected to the battery over which current flows from the (+) terminal of battery BT , impedance b and resistance c to the (—) terminal of battery BT .

As long as the product of the direct current resistances in arms ab equals the product of the direct current resistances in arms cd no current will flow between points A and B of the bridge in which relays P and P^1 are connected. It is assumed that there is a slight leakage due to track ballast which results in potentiometer PN connecting slightly less than all of its resistance in arm a of the bridge. Under these conditions the contacts of relays P and P^1 are in their de-energized positions and the contact of relay T is in its picked up position. Since the polar contact of relay P is in its neutral position neither winding of the motor is energized.

The operation of the invention depends essentially upon a well known property of the Wheatstone bridge. Fig. 2 of the drawing shows four resistances a , b , c and d interconnected to form

the four arms of the bridge. Devices BT and P — P^1 are connected in the diagonals of the bridge. It is a well known property of the bridge that, when the four resistances have the relation

$$\frac{a}{c} = \frac{d}{b},$$

whatever happens in one diagonal is entirely independent of what takes place in the other diagonal. If a source of E. M. F. acts in arm a , it will produce current in both of the diagonals, but any change in one diagonal will have no effect on what takes place in the other. If one of the diagonals contains a source of E. M. F., no current due to this source will flow in the other diagonal. Under these conditions the Wheatstone bridge is said to be balanced and the two diagonals constitute two conjugate branches.

Track occupancy.—It will now be assumed that a train enters the illustrated track section at the left end, thereby placing a sudden low resistance shunt across the track rails to which relay T is connected. This shunt causes relay T to open its contact 13 . This sudden shunt across the track rails also causes a sudden and a comparatively large flow of current from the (+) terminal of battery BT , lower track rail, through the wheels and axles of the train, upper track rail and potentiometer PN to the (—) terminal of battery BT . Since the resistance in arm d of the bridge is thus suddenly and substantially decreased (by the train shunt), the bridge is unbalanced to such an extent that considerably more current flows through arm d and thence through the windings of relays P and P^1 from left to right (of Fig. 2) and through arm c to the (—) terminal of battery BT .

This sudden increase of current operates relay P to the right and picks up the contact of relay P^1 . The picking up of back contact 11 of relay P^1 disconnects (+) potential from the motor circuit so that it is not operated under this condition. This has the effect of locking the regulator (comprising motor driven potentiometer PN) to prevent an attempt of the regulator to compensate for the shunt placed across the rails by the train. In the event that contact 12 of relay P operates before contact 11 of relay P^1 picks up, the gear reduction between the motor and the potentiometer is sufficient to prevent any substantial change in arm a of the bridge.

Contact 13 of relay T may be used to control the signal circuits of signal SG or for any other purpose required by the usual practice in connection with track relay circuits.

Track unoccupancy.—When the train leaves the track section, the removal of the shunt across the track rails restores arm d of the bridge to its previous condition which it is assumed balances arm a so that no current flows through relays P and P^1 . This causes the release of these two relays which is ineffective since contact 12 of relay P in its neutral position opens the circuit controlled by contact 11 of relay P^1 in its normal position.

Increase in ballast leakage.—It will now be assumed that the condition of the ballast between rails changes so as to decrease the ballast resistance, that is, the leakage current between the rails is increased. This increase in current flow across the rails results in a small increase in current flow through arm d of the bridge. This current is of sufficient value to operate relay P to the right but it is not sufficient to pick up relay P^1 . The contact 12 of relay P in its right hand position

closes a circuit for energizing the motor which extends from (+), back contact 11 of relay P¹, contact 12 of relay P in its right hand dotted position, contact 40 of cam device CM, right hand field winding and the armature of the motor to (-). It is assumed that current in the right hand field winding drives the motor in a counter-clock-wise direction.

This operates potentiometer PN in a counter clock-wise direction to remove some of the resistance in arm *a* of the bridge. In other words, it increases the conductance of arm *a* until the conductances of arms *a* and *d* are substantially equal when the bridge will again be in balance for de-energizing relay P. This restores contact 12 to its neutral position which stops the motor with the potentiometer in a position for balancing the conductance of arm *d* of the bridge with that of arm *a*. This increase in conductance of arm *a* permits more current to flow through arms *a* and *d* so that the potential across the terminals of relay T is stepped up. If the leakage across the track rails is further increased by an amount sufficient to again operate relay P to the right, the motor will again operate to cut out more resistance of arm *a* thus further increasing the current flow through arms *a* and *d* to maintain the potential across the terminals of relay T substantially constant.

If the track ballast dries out and the resistance increases, the conductance of arm *d* decreases with respect to that of arm *a* so that current flows between points B and A from right to left, which actuates relay P to the left to close a circuit for the motor extending from (+), back contact 11 of relay P¹, contact 12 of relay P in its left hand dotted position, contact 30 of the cam device CM, left hand field winding and armature of the motor to (-). This drives the motor in a clock-wise direction for decreasing the conductance of arm *a* by increasing its resistance by means of potentiometer PN. When the balance is reached, relay P will restore contact 12 to its neutral position for stopping the motor.

It will be clear from the above description that the invention of Fig. 1 provides means for automatically maintaining the potential across the track relay substantially constant irrespective of slow leakage current between the track rails due to ballast conditions. Therefore arm *a* which is controlled by potentiometer PN, comprises a compensating circuit for automatically compensating for ballast changes in arm *d* by maintaining a substantially fixed ratio of resistances between *a* and *d*. Furthermore, a sudden change in conductance across the track rails due to a train shunt is effective to lock the regulator device so that it will not attempt to compensate for an extreme shunt across the rails by abnormally stepping up the current from the track battery.

It will be clear from the above description that this invention provides means whereby there is an increased shunting efficiency of the track relay and whereby there is a check in the way of a positive discrimination between track circuit conditions due to track occupancy and due to ballast leakage.

The above rather specific description of one form of the present invention has been given solely by way of illustration and is not intended in any manner whatsoever in a limiting sense. It will be obvious that the general principles therein disclosed may be embodied in many other organizations widely different from those illus-

trated without departing from the spirit of the invention defined in the following claims.

What I claim is:—

1. In a Wheatstone bridge, a potentiometer included in one ratio arm of said bridge, a railroad track included in another ratio arm of said bridge, a track relay connected to said track, a detector comprising an electro-responsive device connected across diagonally opposite points of said bridge, means controlled by said device for operating said potentiometer, and means controlled by the operation of said potentiometer for varying the resistance value of said one ratio arm whereby said device is operated.

2. In a Wheatstone bridge, a potentiometer included in one ratio arm of said bridge, a railroad track included in another ratio arm of said bridge, a track relay connected to said track, a detector comprising an electro-responsive device connected across a first pair of diagonally opposite points of said bridge, a source of current connected across a second pair of diagonally opposite points of said bridge, means controlled by said device for operating said potentiometer, and means controlled by the operation of said potentiometer for varying the resistance value of said one ratio arm whereby said device is operated to maintain a substantially uniform electrical potential from said source across said relay irrespective of leakage across the rails of said track.

3. In a track circuit, in combination with an insulated stretch of track, a source of current connected across one end and a track relay connected across the other end of said track, detecting means, a regulating device, means including said detecting means for detecting a small percentage change in current flow in said track and acting to cause said regulating device to operate to provide a complementary flow of current in said track, means responsive to said complementary flow of current and acting to stop the operation of said device, and means including said detecting means for detecting a large percentage change in current flow in said track and acting to lock said regulating device.

4. In a normally energized track circuit, a track relay connected to said track circuit, a detector device in said circuit automatically maintaining itself substantially de-energized under various conditions of track leakage, an equalizer controlled by said detector device for equalizing the current flow in said track relay under various conditions of track leakage, and means responsive to the presence of a train on said track circuit for maintaining said detector device energized by disabling said equalizer.

5. In a track circuit, in combination with an insulated stretch of track, a source of current connected across one end and a track relay connected across the other end of said track, detecting means, a regulating device, means including said detecting means and controlled over said track by current from said source for detecting a slow change in current flow in said track relay and acting to cause said regulating device to operate to provide a complementary flow of current from said source in said track relay, and means including said detecting means and controlled over said track by current from said source for detecting a quick change in current flow in said track relay and acting to lock said regulating device.

6. In a track circuit wherein the track relay

and the track current supply are connected together through an electrical network, a detector relay connected to said network and operated to distinctive positions in response to variations in ballast leakage between the rails of the track during its unoccupied condition, adjusting means controlled by the operation of said detector relay for automatically adjusting said network so that the detector relay winding will be placed at points in said network having a potential below the operating value of the detector relay, and means responsive to the occupancy of said track by a train for disabling said adjusting means while permitting the operation of said detector relay.

7. In a track circuit wherein the track relay and the track current supply are connected together through an electrical network, a detector relay connected to said network and operated to distinctive positions in response to variations in ballast leakage between the rails of the track during its unoccupied condition, and adjusting means controlled by the operation of said detector relay for automatically adjusting said network so that the detector relay winding will be placed at points in said network having a potential below the operating value of the detector relay.

8. Compensating means for compensating for variable ballast conditions in a section of railroad track comprising, a compensating circuit including a potentiometer and the rails of said section of track, an electrical network including said compensating circuit, and automatically controlled means for causing said potentiometer to vary the conductance of said compensating circuit to establish a predetermined ratio of conductances between the portions of said network which include said rails and said potentiometer.

9. Compensating means for compensating for variable ballast conditions in a section of railroad track comprising, a compensating circuit including a potentiometer and the rails of said section of track, an electrical network including said compensating circuit, automatically controlled means governed by variations in ballast conditions in said section for causing said potentiometer to vary the conductance of said compensating circuit to establish a fixed ratio of conductances between the portions of said network which include said rails and said potentiometer, and means responsive to the presence of a train in said section for locking said potentiometer whereby a change in conductance of said compensating circuit is prevented.

10. In a track circuit for railroads; a normally balanced Wheatstone bridge comprising, track rails connected in one arm of said bridge; a potentiometer connected in another arm of said bridge; a source of current and a first and second electro-responsive device connected across conjugate points of said bridge, said first device being operated by the unbalance of said bridge due to a change in ballast leakage across the rails in said one arm and said second device being operated by the unbalance of said bridge due to a train shunt across the rails in said one arm; means controlled by the operation of said first device for causing said potentiometer to effect a rebalance of said bridge and the subsequent release of said first device; and means controlled by the operation of said second device for preventing the rebalance of said bridge and the subsequent release of said first device.

11. In a track circuit for railroads; a normally balanced Wheatstone bridge comprising; track rails connected in one arm of said bridge; a potentiometer connected in another arm of said bridge; a source of current and a first and second electro-responsive device connected across conjugate points of said bridge, said first device being operated by the unbalance of said bridge due to a change in ballast leakage across the rails in said one arm and both of said devices being operated by the unbalance of said bridge due to a train shunt across the rails in said one arm; means controlled by the operation of said first device for causing said potentiometer to effect a rebalance of said bridge and the subsequent release of said first device, and means controlled by the operation of said second device for preventing the rebalance of said bridge and the subsequent release of said first device.

12. In a track circuit for railroads; a normally balanced Wheatstone bridge comprising; track rails connected in one arm of said bridge; a potentiometer connected in another arm of said bridge; a source of current and a first and second electro-responsive device connected across conjugate points of said bridge, said first device being operated by the unbalance of said bridge due to a change in ballast leakage across the rails in said one arm and both of said devices being operated by the unbalance of said bridge due to a train shunt across the rails in said one arm; means controlled by the operation of said first device for operating said potentiometer; and means controlled by the operation of said second device for preventing the operation of said potentiometer by said first device.

13. In combination with a railway track circuit provided with a source of track circuit voltage and a track relay; a voltage relay device connected to said track circuit so as to be substantially unaffected by variations in the voltage of said source but being operated by the varying voltage applied to its winding from said source due to variations in ballast leakage current across the rails of said track; and means controlled by said operation of the relay device for varying the voltage applied to said track from said source, whereby the voltage applied to said track relay from said source is automatically maintained substantially constant under varying track ballast leakage conditions.

14. In combination with a railway track circuit provided with a source of track circuit voltage and a track relay; a voltage relay device connected to said track circuit so as to be substantially unaffected by variations in the voltage of said source but being operated by the varying voltage applied to its winding from said source due to variations in ballast leakage current across the rails of said track; means controlled by said operation of the relay device for varying the voltage applied to said track from said source, whereby the voltage applied to said track relay from said source is automatically maintained substantially constant under varying track ballast leakage conditions; and means controlled by a train shunt across the rails of said track for rendering said relay device ineffective to vary the voltage applied to said track from said source.

15. In a circuit network comprising, a source of railroad track current and an electro-responsive device connected to said network in conjugate relation, a potentiometer and the rails of the track connected to said network in direct series relation with said source of current, and

means responsive to current flow in said rails and including said electro-responsive device for causing said potentiometer to vary the current flow in said rails.

5 16. In combination; a section of railway track having two spaced rails; a source of current for supplying an electric potential across said rails at one end of said section; electro-responsive means at the other end of said section con-
10 nected across said rails and responsive to change its condition in accordance with the interrail potential at said other end; a polar relay at said one end of said section operated to normal and reverse positions in response to a decrease and
15 an increase respectively in track ballast leakage between said rails; and a reversible motor at said one end of said section operated in normal and reverse directions by said polar relay in corresponding positions for decreasing and increas-
20 ing respectively the potential supplied across said rails from said source, whereby the potential applied to said electro-responsive means is main-
tained substantially constant.

17. In combination; a section of railway track
25 having two spaced rails; a source of current for supplying an electric potential across said rails at one end of said section; electro-responsive means at the other end of said section connected
30 across said rails and responsive to change its condition in accordance with the interrail potential at said other end; a polar relay at said one end of said section operated to normal and reverse
35 positions in response to a decrease and an increase respectively in track ballast leakage between said rails; a reversible motor at said one end of said section operated in normal and re-
40 verse directions by said polar relay in corresponding positions for decreasing and increasing respectively the potential supplied across said rails
45 from said source, whereby the potential applied to said electro-responsive means is maintained substantially constant; and means responsive to the application of a train shunt across said rails for disabling the normal and reverse operating
50 circuits of said motor controlled by said polar relay.

18. In an electrical circuit network made up in the form of a Wheatstone bridge, a variable resistance in one ratio arm of the bridge, a motor,
50 a railroad track in another ratio arm of the bridge, a track relay connected to said track, a detector comprising a relay connected across di-

agonally opposite points of said bridge, means controlled by said relay for operating said motor, and means controlled by the operation of said motor for effecting a change in said variable resistance whereby said relay is operated.

19. In an electrical circuit network made up in the form of a Wheatstone bridge, a variable resistance in one ratio arm of the bridge, a motor, a railroad track in another ratio arm of the bridge, a track relay connected to said track, a
10 detector comprising a relay connected across a first pair of diagonally opposite points of said bridge, a source of current connected across a second pair of diagonally opposite points of said
15 bridge, means controlled by said relay for operating said motor, and means controlled by the operation of said motor for effecting a change in said variable resistance whereby a substantially uniform electrical potential from said source
20 across said relay is maintained irrespective of leakage across said track.

20. In a Wheatstone bridge electrical circuit network; a variable resistance in a first ratio arm of the bridge, a section of railroad track in a second ratio arm of the bridge, fixed resistances in the other two ratio arms of the bridge whereby
25 diagonally opposite points of the bridge are at equal potential when the bridge is balanced; a motor for controlling said variable resistance; a relay connected across said diagonally opposite
30 points of the bridge and operated in response to a substantial unbalance of the bridge for operating said motor; and means controlled by the operation of said motor for so controlling said variable resistance that the bridge is brought into
35 balance whereby current in said section of track is maintained substantially uniform during its unoccupancy by a train irrespective of track ballast leakage.

21. In combination with a section of railway track provided with a source of track circuit voltage and a track relay, a first auxiliary relay responsive to variations in the resistance of the track ballast, circuit means controlled by a contact of said first auxiliary relay for varying the
40 voltage applied to the rails of the track, a second auxiliary relay responsive to a shunt applied to the rails of the track by a train, and means controlled by a contact of said second auxiliary relay for rendering said circuit means ineffective.

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