

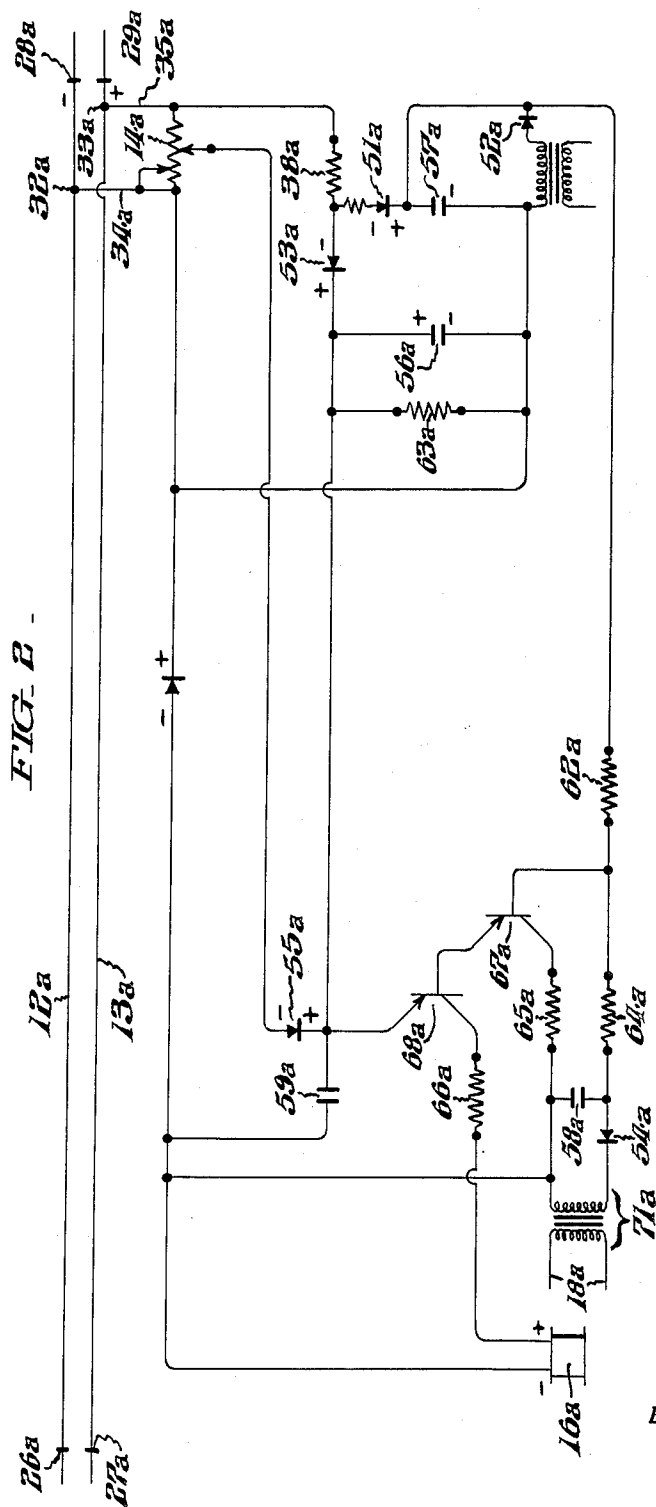
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RAILROAD TRACK CIRCUIT

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This invention relates to improvements in a railroad track circuit, and more particularly concerns a railroad track circuit for detecting the presence of a railroad car on a railroad track under adverse conditions.

In conventional track circuits, in both alternating current and direct current types, a source of energy is located at one end of the track section to provide an inter-rail potential. A track relay is located at the other end of the track section, with the rails serving as electrical conductors. A relay is normally closed while such inter-rail potential is present. When a train enters the track circuit, its wheels provide a shunt across the track rails which increases the current flow from the track energy source and creates a potential drop in the circuit formed by the track rails and limiting resistor which is usually included in series with the track energy source. This shunt decreases the inter-rail potential to such a value that the track relay releases its armature and the track relay is opened.

However, due to varying ballast conditions, for example, as between wet and dry weather conditions, it is difficult to maintain the inter-rail potential at a proper value. Accordingly, it is difficult to keep the track relay closed during wet weather conditions, and yet keep the inter-rail potential at such a value so that the train shunt will cause the relay to open. This is particularly so under the conditions surrounding operation of short track circuits involved in conjunction with freight classification yards where dependable shunts are required for a few cars, and even for a single car. Faulty operation of such track circuits is caused by lightweight cars, the character of the foreign material on the track rails, dirty wheels, and stray voltages, for example.

In view of the small number of wheels and axles available for obtaining a shunt for a single car, and the additional requirement in a classification yard, of knowing of the presence of a single car even when there is only one axle providing the shunt, it is an object of this invention to overcome the previously mentioned problems and to provide a railroad track circuit which responds to the presence of a single pair of wheels of a moving railroad car when within the precise limits of a designated track circuit.

It is another object of this invention to provide means for breaking down the deposits of foreign material on the head of the track rail.

It is another object of this invention to provide a railroad track circuit which is extremely sensitive, and yet which is of simple construction.

It is another object of this invention to provide a railroad track circuit which takes up very little space.

It is another object of this invention to provide a railroad track circuit which is self-compensating as to sensitivity so as to avoid having the track circuit fail during periods of rainfall, and so forth, when, because of ballast conditions, the inter-rail resistance is decreased.

It is another object of the invention to compensate as

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to sensitivity during periods when the inter-rail resistance is increased because of dry weather.

Other objects and advantages of this invention, including the ease with which it may be adapted to existing equipment, will further become apparent hereinafter and in the drawings, in which:

Fig. 1 is a diagrammatic view of a railroad track circuit constructed in accordance with this invention;

Fig. 2 is a diagrammatic view of an alternative embodiment of the invention;

Fig. 3 is a diagrammatic view of another alternative embodiment of the invention; and

Fig. 4 is a diagrammatic view of another alternative embodiment of the invention.

Although specific terms are used in the following description for clarity, these terms are intended to refer only to the structure shown in the drawings and are not intended to define or limit the scope of the invention.

Generally speaking, and without making any attempt to define the exact nature of the invention, this invention concerns a track circuit with a relatively high potential on the rails, and an organization of relay, transistor, amplifier and bias voltages of such sensitivity as to be able to detect small variations of inter-rail potential in order to detect wheels having a contact resistance on the order of 600 ohms from rail-to-wheel-wheel-to-rail.

Turning now to the specific embodiments of the invention selected for illustration in the drawings, there is shown a railroad track circuit which includes a transformer 11, a pair of spaced parallel rails 12 and 13, a limiting resistor 14, a control circuit 15, and a track relay 16 which is shown connected to an indicating mechanism such as the lamp 17. Track relay 16 prevents any switch located on the track section from being thrown until the track section is clear of railroad cars, and may also pass information to control other circuits, such as signal circuits, in the conventional manner of all track relays.

Transformer 11 is supplied with 117 volts A.C. by electrical energy source 18, a variable electrical resistor 21 is connected in series with the secondary of transformer 11, and the secondary of transformer 11 is connected across rails 12 and 13 at locations 22, 23 by electrical conductors 24, 25.

Rails 12 and 13 are provided at one end with insulated joints 26, 27, and at the other end with insulated joints 28, 29.

Resistor 14 is connected across rails 12 and 13 at locations 32, 33 by electrical connectors 34, 35, and is connected to connectors 34, 35 at junction points 36, 37.

It is to be noted that the secondary of transformer 11, variable resistor 21, rails 12, 13, and resistor 14 define a sensing circuit since it is this circuit which picks up the shunt caused by the presence of a railroad car traveling over tracks 12 and 13.

Control circuit 15 includes a resistor 38, full wave rectifier 41 with its diode rectifiers 42-45, transformer secondary 46 with its connecting posts 47, 48, diodes 51-55, capacitors 56-59, resistances 62, 66, transistors 67, 68, and transformer 71 with its primary 72, other secondary 73 and center tap 74.

Energy from power source 18 at 117 volts A.C. 60 cycles is applied to transformer 11, and the voltage from the secondary of transformer 11 is applied across locations 22, 23 to rails 12 and 13. The voltage of the secondary of transformer 11 is in the range of from about 10 to 75 volts, with a voltage drop of about 8 to 50 volts across current limiting resistor 21, so that approximately 2 to 25 volts R.M.S. (2.8 to 35.4 volts peak) is applied to rails 12 and 13. Selection of the approximate

voltage for the rails 12, 13 is a function of the length of the rails and prevailing interrail resistance.

Resistor 14 provides a control voltage across the control circuit 15 at junction points 36, 37. Current flows in a path which includes the secondary of transformer 11, resistor 21, rails 12 and 13, and resistor 14.

Resistor 14 due to its low resistive value also masks from control circuit 15 any transient voltages that might otherwise exist since the magnitude of the transient voltages across the resistor 14 are small compared to the voltage normally impressed across resistor 14. Such transient voltages might be caused by leaks from adjacent track circuits caused by earth contacts to rails, by partially broken down insulated joints, or by interconnections between track circuits through car wheels, car trucks, or from car to car through a car coupler. Such leaks, although resulting in voltages that are of such magnitude as to influence conventional circuits, have a source path of relatively high impedance. Therefore, resistor 14 provides a load or path for these stray voltages to flow. With a relatively high impedance source, the resulting current change through resistor 14 is low, so that the influence of such voltage changes as seen by rectifier 41 at points 36 and 37 is a minimum.

Further, resistor 14 in drawing current, causes a pre-conditioning of the track circuit by causing a voltage drop across resistor 21 so that a shunt across rails 12, 13 draws additional current through the path made up of the secondary of transformer 11, resistor 21, the rails 12, 13 and the wheels and axle of the railroad car passing over the rails. Thus, when the rails are shunted, the additional current through resistor 21 causes the voltage drop across resistor 21 to increase, thereby decreasing the voltage on the rails 12 and 13. This in turn causes the voltage to drop across resistor 14, and this voltage drop is hereinafter referred to as the control or signal voltage. Voltage variations across resistor 14 caused by a change of interrail ballast resistance are minimized because of the relatively high impedance path between the rails through the rail ballast, and the relatively small impedance of resistor 14.

The voltage across resistor 14 is an alternating current voltage which is rectified to a direct current voltage by full wave rectifier 41 which is wired in a conventional bridge arrangement. A resistor 38 is inserted in series between rectifier 41 and resistor 14. Resistor 38 prevents any appreciable current flow into rectifier 38, and since resistor 38 is of relatively high resistance, it limits the loading effect of the control circuit 15 reflected on the track sensing circuit which includes rails 12 and 13, resistor 14, resistor 21, and the secondary of transformer 11. Resistor 38 also influences the recovery time of the RC circuit which includes capacitor 56 in parallel with resistor 63 as is explained hereinafter.

Control circuit 15, due to the long discharge time of capacitor 57 and the short discharge time of capacitor 56, distinguishes between rapid changes in voltage across resistor 14 (caused by a railroad car shunting across rails 12, 13), and gradual change in voltage across resistor 14 (caused by weather affecting the ballast resistance). Capacitor 57 is charged to a direct current voltage by the 5 volt R.M.S. alternating current winding 46 of transformer 71. This voltage appears at connecting posts 47, 48 and is rectified by diode 52 in a half wave manner with polarity as indicated. The 5 volt potential on winding 46 may be varied if desired, and may be set to approximately four and a half volts to accommodate minimum ballast resistance. The control or signal voltage from resistor 14 adds to the charge on capacitor 57 and diode 51 prevents charge or current flow from capacitor 57 from being superimposed upon the signal voltage from resistor 14 in an undesirable manner. Capacitor 57 has no appreciable load across it, and is of such size that it assumes a steady state stabilized voltage which

is a function of long period changes in wayside conditions.

Capacitor 56 has impressed across it the signal voltage from resistor 14 as rectified by rectifier 41. Diode 53 acts as a block to prevent the bias on capacitor 56 from being reflected backwardly in the circuit. Capacitor 56 has a short time charge period, and has a variable resistor 63 in parallel with it in such a manner as to place a constant discharge across capacitor 56. Capacitor 56 and resistor 63 together form a typical RC circuit which has a definite time period, a function of both the size of the capacitor 56 and of the resistor 63. The setting of resistor 63 determines the reaction time of control circuit 15 in operating in response to the signal across resistor 14.

The control or signal voltage is combined with the reference voltage to give a net combined-signal voltage across the connecting points 75, 76, and this combined signal voltage is the difference voltage between the relative charges on capacitors 56 and 57. The combined signal voltage across points 75, 76 is fed to a two-stage D.C. transistor amplifier 77 through variable resistor 62 which serves as a sensitivity control. The sensitivity control is set so that the track relay 16 is actuated in response to a predetermined change of resistance across the rails 12 and 13.

Transformer 71 furnishes operating voltages to operate transistors 67 and 68, and furnishes a reference voltage to capacitor 57. Diode 54 acts as a half wave rectifier to charge capacitor 58 with a negative voltage to a junction point 78, and this negative voltage appears at a point 81 in the circuit. Point 81 is connected to the center tap 74 of transformer 71, and approximately 12.5 volt R.M.S. appear across the secondary of transformer 71 between the point 82 and center tap 74. The negative voltage is impressed upon transistor 67 as a bias through resistor 64 which is in parallel with the D.C. bias from resistor 62. The voltage from resistor 62 appears as a negative bias at the base of transistor 67 to faithfully follow the signal voltage from the circuit going back to resistor 14.

Transistor 67 with a negative voltage on its base causes an amplified voltage to appear at its emitter which is conducted to the base of transistor 68. The envelope of the amplified voltage is a faithful reproduction of the combined signal voltage which appears across points 75, 76.

A positive direct current bias is developed and placed upon the emitter of transistor 68 from the secondary winding 73 of transformer 71. This bias is rectified in a half wave manner by diode 55 and is impressed upon capacitor 59 with polarity as indicated, this bias being directly connected to the transistor emitter at point 83. The transistor 68 causes current to flow in the coils of track relay 16 in such a manner as to cause track relay 16 to close or to open depending on whether or not there is a railroad car on rails 12, 13.

With transformers 11 and 71 both being connected to the same alternating current source of power, any minor voltage change (increase or decrease) is reflected in both ends of the circuit in such a manner as to cancel out, with no undesirable effects on track relay operation. When the voltage decreases in transformer 11, there is a decrease in the voltage across tracks 12 and 13 and this is reflected in a change on the bias of capacitor 57. The voltage on winding 46 of transformer 71 is also proportionately decreased. The bias voltage on transistors 67, 68 are not so critical as to cause malfunction of the track circuit even though the voltage on capacitor 57 is changed. An increase of the voltage from the power source 18 results in the same compensating effect, but in the opposite sense.

In operation, a railroad car provides a shunt across rails 12 and 13 which creates a signal voltage across re-

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sistor 14. This signal voltage is passed into control circuit 15 and is amplified therein to operate track relay 16 to illuminate the lamp 17. The sensitivity of the apparatus is controlled by adjusting the variable resistor 62. It is to be noted that the voltage of capacitors 56, 57 drift with the change in ballast conditions and are thus self-compensating since the track relay 16 is triggered by the difference between the voltage across capacitors 56, 57 when such difference voltage is rapidly changed by a railroad car shunting the rails 12, 13.

The alternative embodiment of the invention shown in Fig. 2 is similar to the embodiment shown in Fig. 1. Accordingly, the same numbers have been used to designate the same elements except that a suffix "a" has been added for more convenient reference. The apparatus of Fig. 2 operates on half-wave rectification, and the bridge rectifier has been eliminated. This makes the apparatus less expensive and more compact in size. Additionally resistors 63a and 62a are fixed resistors instead of variable resistors. It is to be noted that the voltage across capacitor 59a (which is used for energizing track relay 16a) is picked off from the tracks 12a, 13a across resistor 14a, thus making the circuit fail safe.

The alternative embodiment of the invention shown in Fig. 3 is similar to that shown in Fig. 2, and similar elements have been designated by the same reference number with the addition of the suffix "b." In the embodiment of Fig. 3, the bias voltages from coils 46 and 73 are eliminated, since the circuit is biased by the voltage on the track 12b, 13b. All voltages required to operate the circuit are taken from the track 12b, 13b, thus making the circuit totally inert and fail safe. This is of particular advantage when the apparatus is located at a remote point, for example at a remote railroad crossing.

In the embodiment of the invention shown in Fig. 4, there is shown a single-rail track circuit, with the lower rail 13c being grounded. The bias voltage is here supplied by a transformer 85, which gives the apparatus more stability and increases its sensitivity. This apparatus tolerates a wider range of interrail resistance changes caused by such external influences as weather, ballast, and so forth.

It is to be noted that when a railroad car shunts the rails 12, 13 the voltage across the capacitor 57 bleeds off slowly, while the voltage across the capacitor 56 drops sharply, and the different voltage overcomes the bias of the transistors which thereupon stop conducting to de-energize the track relay 16.

Highly satisfactory results have been obtained in the embodiment of Fig. 1 where the elements of the circuit are as follows: resistance 14, 30 ohms; resistance 38, 2 w., 2.2K; diode rectifiers 42-45, 1N91; diodes 51-53, 1N600; capacitor 57, 100 mfd., 150 v.; resistance 63, 5 meg.; resistor 62, 5 meg.; capacitor 56, 50 mfd., 150 v.; resistor 64, 1 w., 1500 ohms; resistor 65, 1 w., 1000 ohms; resistor 66, 5 w., 200 ohms; transistor 67, 2N217 or 2N109; transistor 68, 2N301; diodes 54, 55, 1N91; capacitors 58, 59, 100 mfd., 150 v.; track relay 16, 1300 ohms.

Similar satisfactory results have been obtained in the embodiment of the invention of Fig. 3 where the elements of the circuit are as follows: resistance 14b, 120 ohms; resistance 21b, 40 ohms; diodes 53b, 51b, 3BS1; diode 52b, 1N91; capacitor 57b, 100 mfd., 150 v.; capacitor 56b, 50 mfd., 150 v.; resistance 63b, 1 w., 100K; resistance 62b, 42K, 1 w.; resistance 64b, 200K, 1 w.; resistance 65b, 50K, 1 w.; transistor 67b, 2N109; transistor 68b, 2N301; resistor 66b, 150 ohms, 2 w.; track relay 16b, 800 to 1000 ohms.

Similar satisfactory results have been obtained in the embodiment of the invention of Fig. 4 where the elements of the circuit are as follows: diodes 51c, 53c, 97, 92, 3BS1; voltage across the secondary of transformer 11c, 45b; resistor 95, 55 ohms; resistor 94, 30 ohms; re-

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sistor 96, 30 ohms; capacitor 57c, 1000 mfd.; capacitor 56c, 50 mfd.; resistance 63c, 2400 ohms, 1 w.; capacitor 98, 200 mfd., 3 v.; resistor 65c, 500K, 1/4 w.; resistor 66c, 150 ohms, 1 w.; capacitor 93, 40 mfd.; transistor 67c, 2N109; transistor 68c, 2N301; resistor 99, 25K, 2 w.; track relay 16c, 800 ohms, 8.5 v. (D.C.); and the setting of milliammeter 91 at 11 ma.

With use of an alternating current applied to the rails as a source of energy, in lieu of a direct current source, advantage is taken of the difference between effective and peak voltage to assist in the breakdown of deposits of foreign material on the head of the rails. Also, with the use of alternating current as a source of energy, protection is afforded against any "storage battery" effect in the rails.

The apparatus of this invention is self-compensating in sensitivity so that the track circuit does not fail during periods of rainfall when, because of ballast conditions, the interrail resistance is decreased. The integrity of the track circuit is not jeopardized under these circumstances, because the rail-wheel-rail contact resistance also decreases under wet rail conditions.

The shunting sensitivity of the apparatus of this invention increases as ballast resistance increases because of dry weather, and the shunting sensitivity decreases as ballast resistance decreases because of wet weather. This is desirable since during periods of dry weather when the circuit has maximum shunting sensitivity, the general rail surface conditions are at their worst due to oil and other foreign material deposits which increase the resistance across the rails. The conventional track circuit exhibits the opposite trait, an undesirable one, in that its shunting sensitivity decreases as the ballast resistance increases.

It is to be understood that the form of the invention herewith shown and described is to be taken as a preferred embodiment. Various changes may be made in the shape, size, and arrangement of parts. For example, equivalent elements may be substituted for those illustrated and described herein, parts may be reversed, and certain features of the invention may be utilized independently of the use of other features, all without departing from the spirit or scope of the invention as defined in the subjoined claims.

Having thus described our invention, we claim:

1. Apparatus for sensing the entrance of a railroad vehicle into an electrically isolated railroad track section, said apparatus comprising: a high-impedance current source; a shunt resistance connected between the rails of said track section for receiving current from said high-impedance source, thereby to develop a control voltage between said rails, said shunt resistance having a value small relative to that of the total distributed shunt resistance between rails offered by the track ballast; first and second resistance-capacitance circuits the discharge time constant of one of said resistance-capacitance circuits being long relative to that of the other; means for applying the control voltage developed across said shunt resistance to the capacitors of each of said first and second resistance-capacitance circuits in opposing relation thereby to develop a difference voltage; control means; and means for utilizing said difference voltage to trigger said control means.
2. Apparatus as claimed in claim 1 characterized in that said control means includes a normally conducting amplifier and a normally energized relay for receiving current from said amplifier; and further characterized in that said means for utilizing said difference voltage to control said control means includes means for applying said difference voltage to said amplifier in a polarity tending to cut off said amplifier.
3. Apparatus as claimed in claim 2 further characterized in that said means for applying said control voltage to said capacitors includes a full-wave rectifier.
4. Apparatus for sensing the entrance of a railroad vehicle into an electrically isolated railroad track section,

said apparatus comprising: a high-impedence current source connected to the rails of said section; a shunt resistance connected between the rails of said section for receiving current from said high-impedence source and developing a control voltage between said rails, said shunt resistance having a value which is small relative to that of the resistance between rails offered by the track ballast, whereby changes in track-ballast resistance due to changes in weather conditions cause but little change in the voltage between said rails; first and second resistance-capacitance circuits coupled between said rails in bucking relation for developing a difference voltage, the discharge time constant of one of said resistance-capacitance circuits being long relative to that of the other, the parameters of said circuits being such that the capacitors of both circuits are able to follow the relatively slow changes in voltage between rails resulting from changes in track-ballast resistance, one of said capacitors being able but the other of said capacitors being unable to follow the sudden drop in voltage between rails occurring when a railroad vehicle enters said track section, whereby said difference voltage increases suddenly; control means and means for utilizing said sudden increase in difference voltage to trigger said control means.

5. Apparatus as claimed in claim 4 characterized in that said control means includes a normally-conducting amplifier and a normally-energized relay receiving current from said amplifier.

6. Apparatus as claimed in claim 5 further characterized in that said means for utilizing said sudden increase in difference voltage includes means applying said difference voltage to said amplifier in a polarity tending to cut off said amplifier.

7. Apparatus as claimed in claim 6 further characterized in that said first and second resistance-capacitance circuits are coupled between said rails by way of a full-wave rectifier.

8. Apparatus for detecting the entrance of a railroad vehicle into an electrically isolated track section, said apparatus comprising: a high-impedence current source connected to the rails of said section; a shunt resistance connected between the rails of said track section, the value of said shunt resistance relative to that of the track ballast being low and such that said shunt resistance determines the voltage between said rails except when a railroad vehicle is present in said section; a pair of resistance-capacitance circuits the parameters of which are such that the discharge time constant of one of said

circuits is long relative to that of the other; means for coupling the capacitors of said circuits across the rails of said track section in opposing relation to develop a difference voltage; control means; and means for utilizing said difference voltage to trigger said control means.

9. Apparatus as claimed in claim 8 characterized in that said control means includes a normally-conducting transistor amplifier and a normally energized relay receiving current from said amplifier; and further characterized in that said means for utilizing said difference voltage to trigger said control means includes means for applying said difference voltage to said transistor amplifier in a polarity tending to turn off said amplifier.

10. Apparatus as claimed in claim 9 further characterized in that said high-impedence current source is an alternating-current source; and still further characterized in that said coupling means includes a full wave rectifier for rectifying the voltage developed between said rails before application to the said capacitors of said resistance-capacitance circuits.

11. Apparatus as claimed in claim 10 further characterized in that said means for applying said difference voltage to said transistor amplifier includes a potentiometer for controlling the sensitivity of said detecting apparatus.

12. Apparatus as claimed in claim 11 further characterized in that the discharge path of the capacitor in the resistance-capacitance circuit having a short discharge time constant includes a potentiometer for adjusting the response time of said detecting apparatus.

13. Apparatus for detecting the entrance of a railroad vehicle into an electrically isolated track section, said apparatus comprising: means for developing between the rails of said section a voltage which changes but slowly as a result of changes in track ballast resistance due to changes in weather conditions but which changes rapidly when a vehicle enters said section and shunts said rails; and differentiating means, including a pair of RC circuits the capacitors of which are connected in voltage bucking relation and have substantially different discharge times, coupled between said rails for detecting the sudden change in track voltage which occurs when a railroad vehicle enters the section.

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