

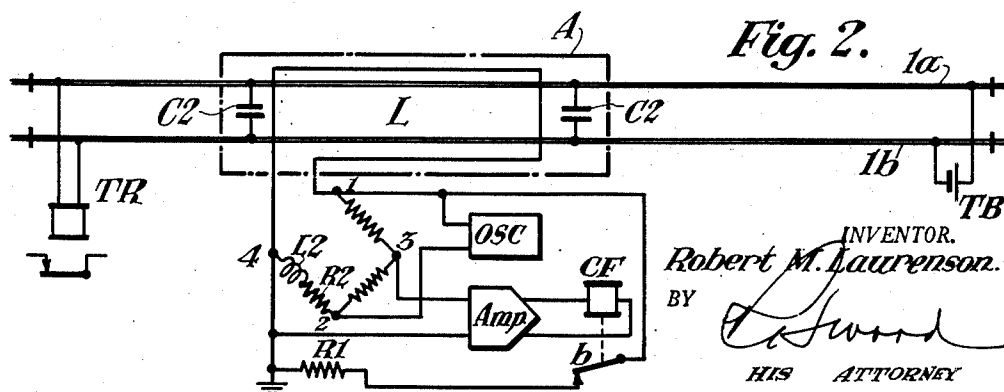
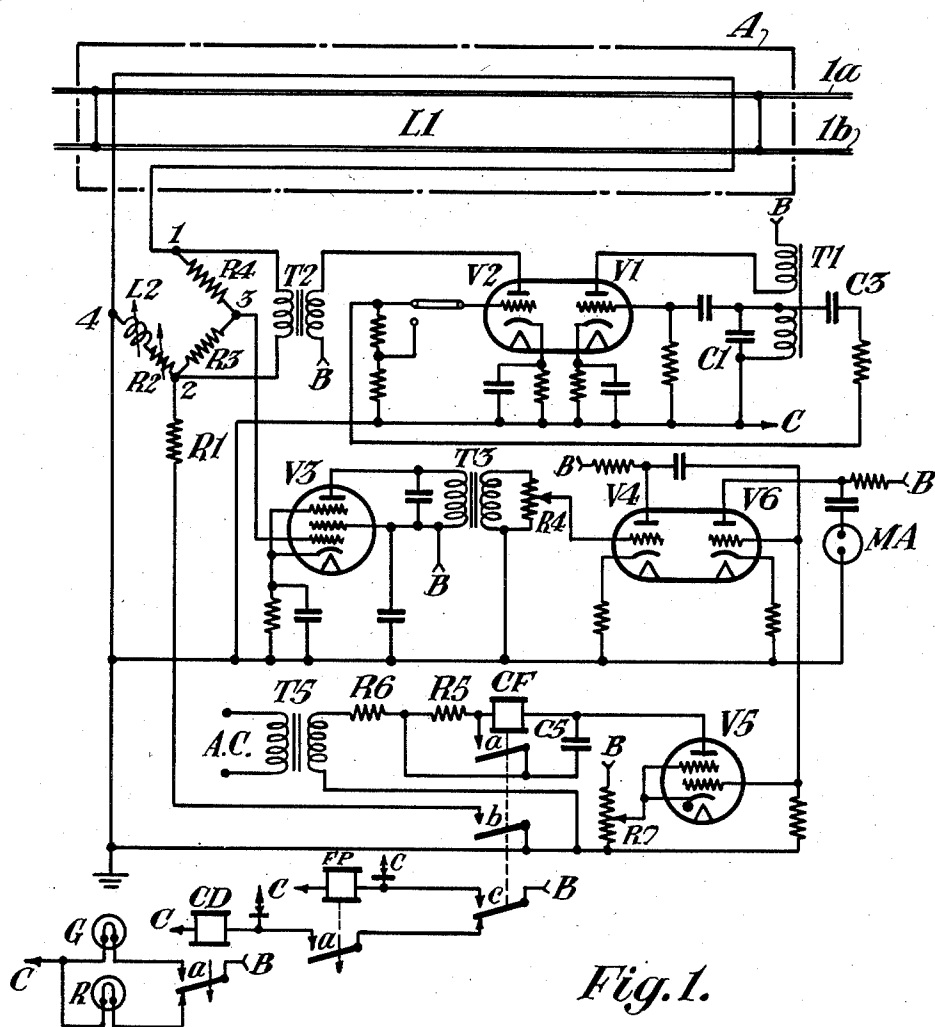
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2,558,445

TRAFFIC CONTROLLING APPARATUS

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TRAFFIC CONTROLLING APPARATUS

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My invention relates to traffic controlling apparatus, and more particularly to an electronic proximity detector of an improved type for detecting the presence of a movable object in a protected space.

The principal object of my invention is to enable the presence of a movable object such as a vehicle or airplane in a stretch of roadway or track or in an airport zone to be detected without dependence upon physical contact between the detecting system and the object the presence of which is to be detected.

A further object is the provision of a proximity detector system which is adapted for use for traffic control purposes in safety control systems by reason of its operation upon the closed circuit principle, and which is suitable for use for any of the purposes for which closed track circuits are ordinarily used in railway signaling systems, and which is adapted to supplement or to serve as a substitute for a track circuit in traffic control systems.

My invention is an improvement upon that disclosed in an application for Letters Patent of the United States, Serial No. 625,561, filed October 30, 1945, by George W. Baughman, for Traffic Controlling Apparatus, now Patent Number 2,537,298 issued January 9, 1951.

I shall describe one form of apparatus embodying my invention and a modification of a portion thereof, and shall then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 illustrates a preferred form of the apparatus of my invention arranged for the detection of the presence of a vehicle or other movable object in a protected area A, which may, for example, comprise a stretch of highway or a portion of an airfield, but which as shown comprises a stretch of railway track not equipped with a track circuit, the reference characters 1a and 1b representing the track rails. Fig. 2 shows a stretch of railway track in which the rails 1a and 1b are included in a closed track circuit having a track battery TB and a track relay TR, a portion of which constitutes the protected area A in which the presence of a vehicle is detected by a modified form of the apparatus of Fig. 1.

Referring to Fig. 1, the reference character L designates a conductor arranged in the form of a loop surrounding the major portion of the protected space A, so disposed that when supplied with alternating current a magnetic field is created which is subject to a detectable variation

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in the presence of a vehicle within the perimeter of the space A, as indicated by the broken line.

To detect variations in the impedance of the loop L from the value which it normally presents when the area A is unoccupied, the loop is arranged to form one arm of a Wheatstone bridge, the other arms of which comprise a balancing impedance network comprising a resistor R1 and in parallel therewith, an adjustable reactor L2 and adjustable resistor R2, in series, and two ratio arms comprising fixed resistors R3 and R4. The loop conductor, and also the conductors which form the other bridge arms consist of wires having a substantially zero temperature coefficient so as to stabilize the operation of the bridge under wide variations in ambient temperature.

The input terminals 1 and 2 of the bridge are supplied with alternating current generated by an electronic oscillator comprising the triode V1, through a buffer amplifier triode V2, these triodes being for convenience in the same bulb, comprising a twin tube as shown. The tubes are supplied with energy by connections to the positive terminal B and the negative terminal C of a suitable source of direct current, tube V1 being arranged in a conventional manner to generate alternating current having a frequency determined by the constants of a resonant circuit comprising a transformer T1 and tuning condenser C1, this frequency being preferably of the order of 50 kilocycles per second, the circuit components being so proportioned as to provide a substantially constant frequency under conditions involving variations in temperature and in the supply voltage.

The voltage across condenser C1 by which the grid circuit for tube V1 is energized is applied through a blocking condenser C3 to the grid circuit for the amplifier tube V2, the plate circuit of which supplies amplified alternating current through a transformer T2 to terminals 1 and 2 of the bridge, whereby the loop L1 is maintained normally energized.

To detect when the bridge is balanced, its output terminals 3 and 4 are connected to the grid circuit of a pentode amplifier V3, the plate circuit for which is supplied with energy from terminals B and C of the direct current source and is coupled through a transformer T3 and an adjustable resistor R4 to the grid circuit of a triode V4, the plate circuit for which is supplied with energy from the same source and is directly coupled to the grid circuits for the electron tubes V5 and V6.

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The tube V5 is a tetrode of the gas filled or controlled ionization type having its plate circuit supplied with alternating current from the secondary winding of a transformer T5. The primary of transformer T5 is connected to an alternating current source such as the local lighting circuit, the frequency of which is generally 60 cycles per second, as indicated by the legend "a.c." adjacent the primary terminals of transformer T5.

A sensitive direct current relay CF is included in the plate circuit for tube V5 in series with resistors R5 and R6. Relay CF assumes its energized position when the potential applied to the grid circuit for tube V5 is sufficiently positive to render the plate circuit conducting, and a condenser C5 provides energy storage to maintain relay CF energized during the periods when a negative potential is applied to the plate of tube V5 due to the alternations in polarity of the alternating current supply voltage and the plate circuit for tube V5 is rendered non-conducting.

The triode V6 together with the triode V4 constitute a twin tube like the triodes V1 and V2. The triode V6 has its grid circuit energized in parallel with the grid circuit for tube V5 and its plate circuit energized from terminals B and C of the direct current source. The triode V6 provides means by which a meter, as indicated by the legend MA, may be included in the output circuit to aid in balancing the bridge or for test purposes, without disturbing the adjustment of relay CF.

It will be seen that relay CF is energized as long as the bridge is unbalanced so as to create an A. C. potential difference across terminals 3 and 4. This is amplified by tubes V3 and V4 and applied to the grid circuit of tube V5, and renders tube V5 conducting during the positive half cycles of the alternating current voltage supplied to its plate circuit. Relay CF releases when the bridge is sufficiently close to the point of balance where terminals 3 and 4 are at the same potential, that the amplified A. C. voltage is reduced to a point where the firing point of tube V5 is not reached. The sensitivity of the system, that is to say, the amount of unbalance at which relay CF operates is subject to control by manual adjustment of resistor R1, which resistor applies an adjustable direct current voltage to the cathode of tube V5 in series with the alternating current voltage derived from the bridge.

Since the balanced condition as manifested by the release of relay CF corresponds to the safety condition to be detected, means are provided for making the indication of this condition dependent upon the periodic energization of relay CF rather than upon its mere deenergization, in order to conform with the closed circuit principle which is a necessary requisite for traffic control systems. This is accomplished in the form of the apparatus shown in Fig. 1 by including a front contact b of relay CF in the circuit for the resistor R1 and by adjusting the reactor L2 and resistor R2 so that the bridge is balanced only when the loop L is unoccupied and then only when resistor R1 is connected across terminals 2 and 4, in parallel with L2 and R2.

Assuming now that relay CF releases due to the fact that the bridge is balanced, the opening of its front contact b removes resistor R1 from the circuit and thereby unbalances the bridge so that relay CF becomes reenergized. The closing of its front contact b then restores the balance, provided the loop is unoccupied, rendering tube

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V5 non-conducting and causing relay CF to release to repeat the cycle of operation, while, if the loop is occupied so that a balance is not attained when relay CF picks up, relay CF remains steadily energized. When a balance is attained, the release of relay CF is retarded by the discharge period of condenser C5 which is connected directly across the terminals of relay CF over the front contact a of that relay.

Following the release of relay CF, its reenergization is retarded because condenser C5 is charged through resistor R6, and in parallel with resistor R5 and the relay winding in series therewith. These components are so chosen as to cause relay CF to operate periodically at a fixed rate of 3 cycles per second, or less, with substantially equal periods of energization and release, its operation being preferably similar to that of the code following relays now in wide use in railway signaling systems so as to enable the detection of its periodic operation to be effected by conventional apparatus.

As shown, a slow release detector relay CD is maintained in its energized position by periodic energization over the back contact c of relay CF and a front contact a of a slow release repeating relay FP, the latter relay being maintained in its energized position by periodic energization over the front contact c of relay CF.

Relay CD may control indication or traffic controlling means of any suitable type, as illustrated typically by a green lamp G which is lighted only when the apparatus is in working order with the loop L unoccupied, and a red lamp R which is lighted when the loop L is occupied, or in the event of a fault.

It will be seen that relay CF provides a "self-coding" action which makes it unnecessary to provide a code transmitter or other auxiliary device for periodically unbalancing the bridge as in the system of the Baughman application hereinbefore referred to. In respect to this feature, my invention is an improvement upon the bridge circuits disclosed in the applications for Letters Patent of the United States, Serial No. 611,289, filed August 18, 1945, now abandoned, and Serial No. 657,402, filed March 27, 1946, now Patent Number 2,478,000 issued August 2, 1949, by Alfred B. Miller, for Hot Bearing Alarms.

The apparatus of Fig. 1 is preferably placed in operation by adjusting it in the following manner: The bridge is first balanced, with the oscillator V1 supplying current of normal voltage and frequency, by means of the meter MA, in order to measure the impedance presented by the loop under the unoccupied condition, and is then rebalanced to measure its impedance when occupied by an object of the minimum size which it is desired to detect. For example, in the application of the system to a stretch of railway track, the second measurement may be made with a car standing with only one pair of wheels within the area enclosed by the loop.

It is to be understood that the effect of occupancy of the loop by a vehicle is to decrease the loop impedance and consequently to lower the potential across terminals 1 and 4 of the bridge, due to the distortion and decrease in the volume of the field by the shielding effect of currents induced in the metallic parts of the vehicle and due to energy losses due to such currents.

The bridge is then balanced for service operation by adjustment of the impedance network connected across the bridge terminals 2 and 4, with resistor R1 of such a value that its removal

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unbalances the bridge by increasing the potential across terminals 2 and 4 by an amount which is equal to or slightly less than the reduction in potential across the opposite terminals 1 and 2 due to the occupancy of the loop by an object of minimum size, as determined by the measurements above referred to. It will be seen that the impedance between terminals 2 and 4 is increased due to the removal of resistor R1, and the resulting unbalance is in the same direction as when the impedance between terminals 1 and 4 is decreased due to the occupancy of the loop, and the two effects are additive.

Finally, the detector tube V5 is adjusted so that relay CF operates when the unbalance is substantially one-half that due to the removal of resistor R1 from the circuit, this value providing the maximum margin of operation with varying conditions as will be readily apparent.

Assume now that the operating point of tube V5 gradually increases in service due to aging of the tubes or to other causes until relay CF fails to pick up in response to the increase in potential applied to tube V5, due to the removal of resistor R1 from the circuit. Relay CD will release, lighting lamp R and indicating the fault before it had progressed to a point where the apparatus is rendered incapable of detecting the greater amount of unbalance caused by the presence of a vehicle in the area A. It will be seen, therefore, that resistor R1 is a measure of the minimum change in loop impedance which the apparatus is adapted to reliably detect and that the apparatus is self-checking with respect to a loss of sensitivity which renders it incapable of detecting a change of loop impedance of the specified amount.

Referring now to Fig. 2, it is to be understood that the detecting apparatus in this form is similar to that of Fig. 1, with the exception that the balancing resistor R1 is connected across the bridge terminals 1 and 4 over a back contact b of relay CF while in Fig. 1 it is connected across the opposite terminals 2 and 4 over a front contact b of relay CF. In Fig. 2, the impedances L2 and R2 are adjusted to balance the loop when unoccupied and with resistor R1 disconnected. In this form of the apparatus, when relay CF releases due to the fact that the bridge is balanced, the closing of its back contact b connects resistor R1 across the loop causing a reduction in potential across terminals 1 and 4 of the bridge corresponding to that due to the occupancy of the loop L by an object of minimum size. If the apparatus is in working order, this causes relay CF to be reenergized to restore the balance, as in Fig. 1.

It will be seen, therefore, that resistor R1 may be applied to either side of the bridge with appropriate change in the connections to its control contact.

When the loop is applied to a stretch of railroad track, as in Fig. 1, the track rails 1a and 1b provide a circuit inductively coupled to the loop and completed through the track ballast, the effective resistance of which may vary widely with changes in ballast resistance due to weather conditions, and to stabilize the operation of the detecting system it is desirable to minimize the effect of this variation. Since the current which flows through the ballast is due to the induced potential from rail to rail, it has been found practicable to reduce the ballast current to a negligible value by connecting the rails together at the ends of the loop through low resistance conductors as shown in Fig. 1, or through con-

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densers of large capacity as in Fig. 2, when the loop extends over a portion of a track circuit as shown. This evidently will reduce the potential difference from rail to rail substantially to zero not only at the ends but throughout the length of loop L, the current induced in the rail being practically equal to that in the loop, so that the ballast leakage current becomes substantially zero. The loss of energy in the rail circuit is relatively small due to its low resistance, and since this is substantially constant, it can be readily compensated for by adjustment of the balancing impedances L2 and R2.

Although I have herein shown and described only one form of apparatus embodying my invention and one modification thereof, 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. A system for detecting the presence of a movable object in a protected space comprising a conductor arranged in the form of a loop surrounding at least a portion of said space, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of an object in said space, a balancing impedance comprising another arm of said bridge, a sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, means for causing said balancing impedance to have a first value when said relays is energized and a second value when said relay is released, said first value being effective to balance the bridge to effect the release of said relay, provided the space is unoccupied and said second value being such as to cause said sensitive relay to assume its energized position irrespective of the condition of said space, a detector relay, and means controlled by said sensitive relay for energizing said detector relay so arranged that the detector relay is maintained in its energized position only in response to the continued periodic operation of said sensitive relay.

2. A system for detecting the presence of a movable object in a protected space comprising a conductor arranged in the form of a loop surrounding at least a portion of said space, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of an object in said space, a sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, a balancing impedance in said bridge having at times a first value such that the bridge is substantially balanced provided said space is unoccupied and having at other times a second value such that the bridge is unbalanced by a predetermined amount which is less than the unbalance due to a selected object in said space, means for recurrently changing said balancing impedance from said first to said second value to effect the intermittent energization of said sensitive relay in the event said space is unoccupied, a detector relay for indicating the con-

dition of occupancy of said space, and detecting means responsive to the periodic operation of said sensitive relay for energizing said detector relay, said detecting means becoming ineffective when such periodic operation ceases.

3. A system for detecting the presence of a movable object in a protected space comprising a conductor arranged in the form of a loop surrounding at least a portion of said space, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of an object in said space, a sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, a balancing impedance in said bridge by which the bridge is adjusted to cause the release of said relay when said space is unoccupied, means controlled by said relay and rendered effective upon the release thereof for unbalancing said bridge to effect the reenergization of said relay even through said space is unoccupied, and detecting means governed by said sensitive relay and arranged to distinctively indicate the periodic operation of said sensitive relay.

4. A system for detecting the presence of a movable object in a protected space comprising a conductor arranged in the form of a loop surrounding at least a portion of said space, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of an object in said space, a sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, a balancing impedance in said bridge by which the bridge is adjusted to cause the release of said relay when the space is unoccupied, means controlled by said relay and rendered effective upon the release thereof for unbalancing said bridge by an amount which corresponds to the unbalance due to an object of predetermined size which is less than that of any object which it is desired to detect in said space, said relay being thereby caused to operate periodically as long as the unbalance due to its release is sufficient to cause it to assume its energized position and the unbalance remaining when this is removed is not sufficient to maintain the relay in such position, and detecting means governed by said sensitive relay arranged to distinctively indicate the periodic operation of said sensitive relay.

5. A system for detecting the presence of a movable object in a protected space comprising a conductor arranged in the form of a loop surrounding at least a portion of said space, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of an object in said space, a slow acting sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, a balancing impedance in said bridge the value of which is dependent upon the position of said sensitive relay, said

balancing impedance having a value such that the bridge is substantially balanced when said relay is in its energized position provided said space is unoccupied and having a different value when said relay is released, such that the bridge is unbalanced by a predetermined amount which is less than the unbalance due to a selected object in said space but which is sufficient to cause said sensitive relay to assume its energized position, and detecting means arranged to distinctively indicate the periodic operation of said sensitive relay.

6. A system for detecting the presence of a movable object in a protected space comprising a conductor arranged in the form of a loop surrounding at least a portion of said space, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of an object in said space, a sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, a balancing impedance in said bridge by which the bridge is adjusted to cause the release of said relay when the space is unoccupied, an impedance element connected across one of the arms of said bridge over a contact of said relay for unbalancing the bridge whenever said relay assumes its released position irrespective of the condition of said space, and detecting means arranged to distinctively indicate the periodic operation of said sensitive relay.

7. Traffic controlling apparatus for detecting the presence of a car in a stretch of railway track comprising, a conductor arranged in the form of a loop extending along the track rails, a Wheatstone bridge having said loop as one of its arms, means for supplying alternating current to the input terminals of said bridge to effect the energization of said loop and thereby render its impedance subject to a measurable variation in the presence of a car in said stretch, a sensitive relay, means for supplying said relay with energy in accordance with the potential difference at the output terminals of said bridge due to unbalance, a balancing impedance in said bridge for adjusting said potential difference to cause the release of said relay when said loop is unoccupied and to effect its energization due to unbalance when a car enters said stretch, and means comprising a low impedance connection from rail to rail at each end of said loop to provide a low resistance circuit for current induced in the track due to its inductive coupling with said loop, whereby the effect of such coupling upon the measured impedance of said loop is rendered substantially independent of variations in the resistance from rail to rail through the track ballast.

8. Self-checking apparatus for detecting a change in the impedance of an electric circuit element by a predetermined amount comprising a Wheatstone bridge having two ratio arms, a third arm which includes said circuit element and a fourth arm which includes a balancing impedance, a source of current connected to two opposite terminals of said bridge for supplying energy thereto, a sensitive relay, an electronic amplifier for supplying said relay with energy in accordance with the potential difference at the other two terminals of said bridge due to unbalance, means governed by said relay for un-

balancing the bridge by an amount less than said predetermined amount whenever said relay assumes its released position, to cause said relay to return at least temporarily to its energized position in the event its release is due to the balanced condition of said bridge and not due to a fault or to a loss in sensitivity of said electron tube, and detecting means arranged to respond distinctively to the periodic operation of said sensitive relay for indicating said balanced condition.

9. Self-checking apparatus for comparing the impedance of two electric circuit elements comprising a Wheatstone bridge having four arms comprising said two circuit elements and two fixed impedances, a source of current connected to two opposite terminals of said bridge, a sensitive relay deriving its energization from said source in accordance with the potential difference at the other two terminals of said bridge and which releases when the bridge is substantially balanced, means including a contact of said relay for connecting an additional impedance of a relatively high value across one of the bridge arms, whereby said bridge is unbalanced whenever the relay releases to cause said relay to return to its energized position and remove the unbalance caused thereby, a detector relay, and means controlled by said sensitive relay for energizing said detector relay which requires the periodic operation of said sensitive relay in order to maintain said detector relay energized.

10. Self-checking apparatus for detecting a change in the impedance of an electric circuit element by a predetermined amount comprising

a Wheatstone bridge having two ratio arms, a third arm which includes said circuit element and a fourth arm which includes a balancing impedance, a source of alternating current connected to the opposite terminals of said bridge for supplying energy thereto, a sensitive relay, an electron tube controlling said relay having its input terminals connected across the other two terminals of said bridge, means controlled by said relay for changing the impedance of one of said bridge arms whereby said bridge is unbalanced by an amount less than said predetermined amount whenever the relay releases, such unbalance being effective to cause said relay to return to its energized position in the event its release is due to the balanced condition of the bridge and not due to a fault or loss in sensitivity of said electron tube, and detecting means arranged to respond distinctively to the periodic operation of said sensitive relay for indicating said balanced condition.

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