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ELECTRONIC SAFETY SWITCH

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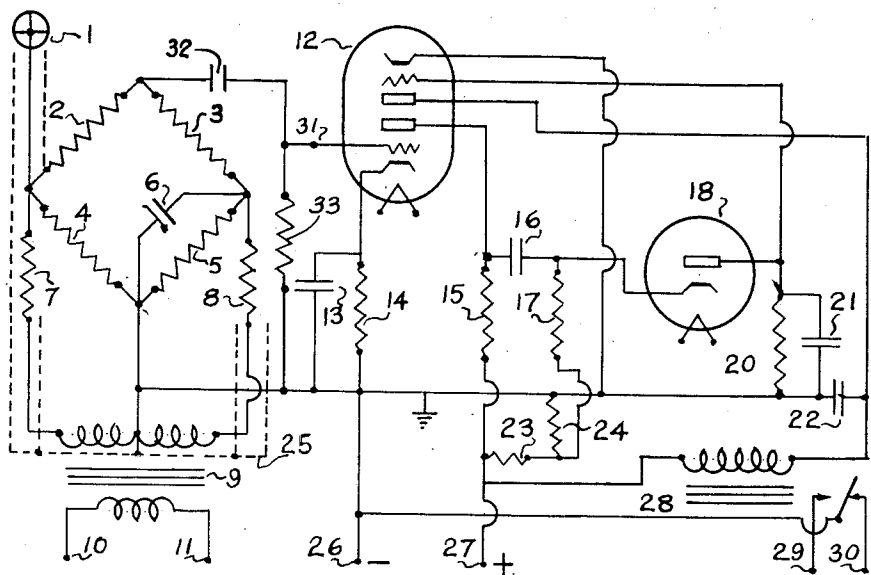


Fig. 1-

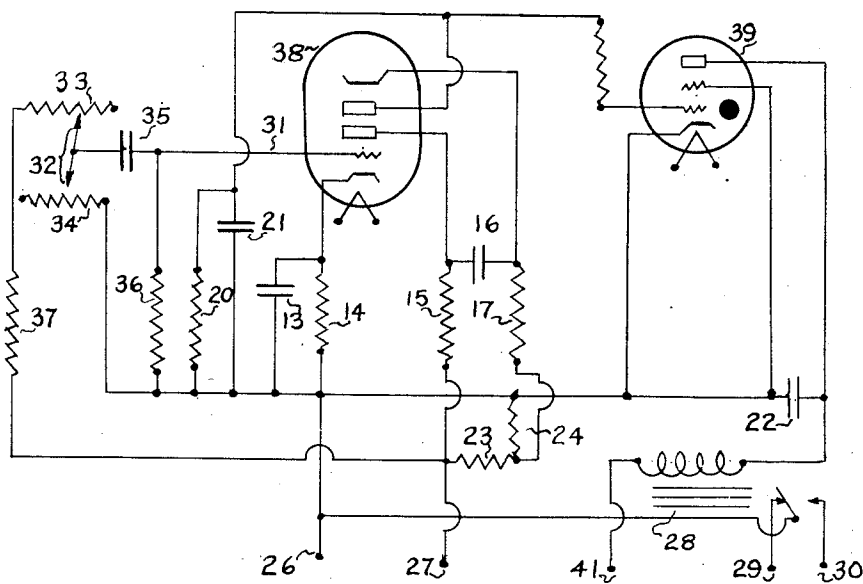


Fig. 2-

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2,695,402

ELECTRONIC SAFETY SWITCH

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8 Claims. (Cl. 340-258)

My present invention relates to relays, and more particularly to an improved relay or switching device operable by the capacity of the hand or body of a person.

The principal object of my invention is an improved relay.

Another object of my invention is an improved capacity relay having an operating circuit and a balanced bridge circuit associated therewith, and having a conducting element connected thereto, said balanced bridge circuit capable of being unbalanced by the mere presence or actual contact of the hand of a person approaching the conducting element, and whereby such operating circuit of the relay is controlled to operate the relay contacts.

Another object of my invention is an improved electronic relay having an operating circuit for opening and closing the relay contacts and in which relay a balanced circuit is associated with the operating circuit to control said operating circuit, to open and close the relay contacts, and in which the closing time of the relay contacts is measurably shorter than the opening time thereof.

A further object of my invention is an improved electronic relay having an operating circuit for opening or closing the relay contacts, and in which a balanced bridge circuit is associated therewith and controls the said operating circuit and in which a conductor, connected to said balanced bridge circuit, is controlled through the agency of the conductor by the mere presence of the hand or body of a person touching or approaching the conductor, to thereby operate the relay contacts.

I am aware that prior to this invention various forms of "capacity relays" have been used, but these devices have been primarily designed to operate at appreciable distances, and have been subject to instability and other objectionable characteristics which have made them unreliable over appreciable time intervals.

A principal object of this invention is to provide an improved electronic safety switch having an operating circuit for opening or closing relay contacts, and in which a modified form of balanced bridge circuit is associated therewith to control the said operating circuit, and in which a conductor or conductors connected to said balanced bridge circuit, is controlled through the agency of the conductor primarily by actual hand or switch contact, for example by the hand of a person touching or grasping the conductor, to thereby operate the relay contacts.

It is likewise a principal object of this invention to provide a simplified form of capacity relay that will remain reliable over appreciable time intervals.

It is also a purpose of the present invention to provide a simplified form of hand capacity relay, a conductor of which may be touched by a person's hand without any possibility of electrical shock.

Other objects and novel features of the construction and arrangement of parts comprising my improved relay will appear as the description of the invention progresses.

In the accompanying drawing;

Figure 1 is a schematic view of one form of my improved capacity relay.

Figure 2 is a schematic view of another form of my improved capacity relay.

Referring to the drawing, and particularly to Figure 1, there is shown a control electrode 1, that is well insulated from the ground. The electrode 1 may be a switch connecting capacitively or conductively to ground, or may be anything desired, as for example a conductor of any desired length, and located at a point or area that

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is to be protected or that is to be the source of control.

Good insulation from the ground, of the electrode or conductor 1, is important in order that the special Wheatstone bridge shown in Figure 1 may be made high impedance for increased sensitivity in order to reduce the necessary amplification, so that resistors 7 and 8 may be about 10 megohms each to eliminate the possibility of shock upon contact with the control electrode or conductor 1. The values for resistors 7 and 8 are chosen so that about 20 microamperes would flow through the person approaching or touching the control electrode or conductor 1 if such person is in good contact with ground. Such a small amount of current cannot be felt. Capacitor 6, shown adjustable, balances the capacity of the control electrode or conductor 1, or if the control electrode or conductor capacity to ground is sufficiently low, capacity 6 may be omitted. Resistors 2, 3, 4 and 5 should be 10 megohms each when electron discharge tube 12 is of a type similar to 6SN7. Resistors 4 and 5 may be omitted, although slightly greater stability is obtained by their use, because of the lowered grid to ground resistance. Resistors 2, 3, 4 and 5 form part of the Wheatstone bridge. These resistors 2, 3, 4 and 5 may be of the simple carbon or metalized type and the bridge balanced approximately by selection of resistor values, thus reducing its cost to a negligible value.

Transformer 9 is the relay's power transformer, obtaining current for the primary from an alternating current supply line through the terminals 10 and 11. The transformer 9 is standard, except for electrostatic shield 25. The electrostatic shield 25 and the shielded wires connecting the transformer secondary to resistors 4 and 5 are necessary to prevent unbalance due to out-of-phase capacity coupling, or leakage between the primary of the transformer and the bridge circuit. One of the most important features in the reduction of "90 degree" out-of-phase capacity or leakage coupling, is vested in the center-tap ground of the secondary. Without this ground, or even with excellent shielding, there is likely to be a few micromicrofarads capacity and/or several megohms leakage between the primary and the secondary. This capacity or leakage will supply essentially the same phase to each side of the bridge, across resistors 4 and 5, and a good balance will be impossible. But, with the transformer ground, any out-of-phase voltage is shunted to ground through the transformer's relatively low impedance. Transformer 9 has a secondary voltage of about 325 volts each side of the center tap. Terminals 10 and 11 connect to an alternating current supply line. Electron discharge tube 12 is a 6SN7. Cathode resistor 14 is 1200 ohms and capacitor 13 (used to prevent degeneration) is 25 microfarads. In the simplest form of this embodiment resistor 14 and capacitor 13 may be eliminated.

Plate resistor 15 is 50,000 ohms; coupling capacitor 16 is 0.5 microfarad and diode input resistor 17 is 50,000 ohms. Electron discharge diode tube 18 is half of a 6H6 (or both halves in parallel). Diode load resistor 20 is 1.5 megohms and diode load reservoir capacitor 21 is in the order of 1.00 microfarad. Terminal 26 connects to ground and B. Terminal 27 connects to a 250 volt filtered power supply. Resistors 23 and 24 form a voltage divider to supply a positive voltage delay bias of about 12.5 volts to the diode input resistor 17, and resistor 23 should be 100,000 ohms and resistor 24 should be 5,000 ohms. In the simplest form of this embodiment resistors 23 and 24 may be eliminated.

With the other circuit values as above specified, relay 28 should be quiet in operation; should have a coil resistance of about 5,000 ohms, should close at about 4 ma., and open at about 3 ma. Capacitor 22 (used to prevent chattering of the relay contacts) is about .5 microfarad, and in the simplest form of this embodiment may be omitted. Terminal 29 may be used to operate a signal lamp, or other device, this with the relay in the position shown in the drawings. Terminal 30 connects to an alarm device, or other suitable signal device.

Again referring to Figure 1, the bridge is approximately balanced and only a slight residual A. C. signal is applied to the grid of the lower section of electron discharge tube 12. If resistors 23 and 24 are not used, the

amplified small residual signal subsequently developed across resistor 17 produces, after being rectified by diode 18, a small D. C. bias voltage across resistor 20 which is supplied as a negative bias to the grid of the upper section of electron discharge tube 12. This bias in turn reduces the normal current in relay 28 from about 9 milliamperes to perhaps 7 ma. In order to have a reliable circuit it is desirable to have the normal relay current, say twice the relay closing current, but from the point of view of economy of current and relay design the normal current should not greatly exceed that ratio. Now, rather than increase the normal current to compensate for the residual signal reduction, the residual effect may be removed by the use of resistors 23 and 24. The voltage delay thus introduced into the diode circuit prevents rectification of the residual signal and consequently the normal relay current is not reduced thereby.

When the hand or body of a person is near, or in contact with, the electrode control, or conductor, several factors operate, singly or together, to produce an unbalance in the bridge circuit, thus contributing to the reliability of operation of the relay.

One effect is the high resistance of the body to ground, 1,000 being sufficient to unbalance the bridge. In spite of this sensitivity it is easy to obtain reliable operation by mounting the bridge elements and the control electrode on a small insulator, such as polystyrene, with the junctions of 1, 2, 4 and 7, and 3, 5, 6 and 8 similarly placed with respect to ground. With this arrangement, humidity contributes equal leakage to both sides of the bridge and the normal unbalance stays below the voltage delay of diode 18. Another effect is the addition of the body capacity to ground, 50 microfarads being more than sufficient to unbalance the bridge even through a possible 10 megohms of hand resistance, or in series with a like amount of knob-to-hand capacity. Still another effect is the introduction of an out-of-phase hum pick up from the wiring of the room or between the power line and true ground, and random noise; anything over 3 volts through 5 megohms is sufficient to unbalance the bridge. In view of the relatively high voltage supplied to the bridge, and the bridge's high impedance, one or more of these said effects is very pronounced under all conditions of operation and humidity.

The bridge unbalance, due to the presence of the hand or body of a person causes a large A. C. signal to appear on the grid of the lower section of the electron discharge tube 12. This signal, after amplification, is applied through coupling elements 15, 16 and 17 to electron discharge diode 18. As this signal is large, compared to the diode voltage delay, rectification takes place and a relatively large D. C.-current flows into capacitor 21.

Before the hand or body of a person approaches control electrode or conductor 1, relay 28 will be drawing about 9 ma. with the charge across capacitor 21 zero. When the hand or body comes very close or in contact with terminal electrode or the coaxial cable, or pair of cables 1, capacitor 21 will rapidly change, and when at about 7 volts, the relay current will have dropped to about 3 ma. and relay 28 will have released. When the charge across capacitor 21 has reached about 15 volts, the relay current will have dropped to zero, the charge across capacitor 21 will continue to rise and at 5 RC time will stabilize at about 60 volts.

When the hand is removed, capacitor 21 will discharge slowly and when at about 6 volts, the relay current will have increased to about 4 ma. and relay 28 will have pulled down. When capacitor 21 finally discharges to zero, relay 28 will again be drawing about 9 ma.

Another embodiment of my invention is shown in Figure 2, and in this embodiment the capacity relay and control electrode or conductor 1 is replaced by a device that may be operated by means of a knob or handle. This device may take the form of a rotary commutator, coil, resistor, or capacitor, which generates or modulates a voltage to operate the controlling circuit for the relay.

One such arrangement is shown at the left section of the schematic diagram of Figure 2. Electron discharge tube 38 contains a medium μ triode and a diode. Elements 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30 and 31 answer the same description as the corresponding elements shown in Figure 1.

Control arm 32 is secured to and rotated by a conventional knob—not shown. Rotation of the control arm 32 causes the same to connect alternately to rheostats

33 and 34. Rheostat 34 connects to ground, and rheostat 33 connects, through limiting resistor 37, to the B terminal 27. As the control arm 32 is rotated, capacitor 35 is charged and discharged, and a pulsating voltage is applied across resistor 36 to the triode grid of electron discharge tube 38. The remainder of the circuit functions the same as that shown in Figure 1, except that a gas filled grid controlled electron discharge tube 39 is employed to operate relay 28. This arrangement conserves D. C. power, as relay 28 is supplied with A. C. current from terminal 41.

Resistor 40 is a grid current limiting device. In the simplest form of this embodiment of my invention capacitors 35, 13 and 22, and resistors 14, 40, 23 and 24 may be eliminated. Many other arrangements of the left section of the schematic diagram of Figure 2 will suggest themselves to those skilled in the art. For example, rheostats 33 and 34 may be replaced with two variable condenser stators 180 degrees apart, and arm 32 by a common condenser rotor.

It is to be understood that the left section of Figures 1 and 2 can be interchanged by breaking the connections at point 31.

What I claim is:

1. In an electronic relay; a normally balanced electrical bridge circuit system having two sets of junctions, the input set of junctions being symmetrical and the output set unsymmetrical with respect to ground, and with the said bridge system having at least six impedance elements; a transformed source of relatively high voltage alternating current, including electrostatic shielding and capacitive or conductive center-tap grounding means for essentially eliminating the primary out-of-phase coupling; means for supplying the said current source to the said bridge circuit through two of the said six impedance elements, to effectively provide a very high impedance across both said sets of junctions in spite of the center-tap-grounded voltage source; a control conductor connected to one junction of the said set of input junctions of the said bridge, a second conductor or capacitor connected to the other junction of the said input set, and adapted to maintain the said bridge system normally in balance; an electrically conductive element temporarily associated with the first-mentioned control conductor including a temporary external series impedance circuit provided by the said element's conductance, its contact resistance or capacity to the first-mentioned control conductor, and its conductance or capacity to ground, said temporarily associated element being in the form of a conductive article or the hand or body of a person, and adapted to have a very minute current passed from the said bridge through the said temporary external series impedance circuit to produce an unbalance in the said bridge system; switching means; amplifying, rectifying, and integrating means adapted to operate the said switching means when the said bridge system is unbalanced, whereby the said switching means is caused to respond to the presence or contact of the said temporarily associated element.

2. In an electronic relay; a normally balanced electrical bridge circuit system having two sets of junctions, the input set of junctions being symmetrical and the output set unsymmetrical with respect to ground, and with the said bridge system having four ungrounded resistive elements; a transformed source of relatively high voltage alternating current, including means for eliminating the out-of-phase coupling; means for supplying the said current source to the said bridge circuit through two of the said four resistive elements, to effectively provide a very high impedance across both said sets of junctions in spite of the center-tap-grounded voltage source; a control conductor connected to one junction of the said set of input junctions of the said bridge, a second conductor or capacitor connected to the other junction of the said input set, and adapted to maintain the said bridge system normally in balance; an electrically conductive element temporarily associated with the first-mentioned control conductor including a temporary external series impedance circuit provided by the said element's conductance, its contact resistance or capacity to the first-mentioned control conductor, and its conductance or capacity to ground, said temporarily associated element being in the form of a conductive article or the hand or body of a person, and adapted to have a very minute current passed from the said bridge through the said temporary external series impedance circuit to produce an unbalance in the said

bridge system; amplifying, rectifying, and switching means adapted to operate when the said bridge system is unbalanced by the presence or contact of the said temporarily associated element.

3. In an electronic relay; a normally balanced electrical bridge circuit system having two sets of junctions, the input set of junctions being symmetrical and the output set unsymmetrical with respect to ground, and with the said bridge system having six resistive elements; a transformed source of relatively high voltage alternating current, including electrostatic shielding and capacitive or conductive center-tap grounding means for essentially eliminating the primary out-of-phase coupling; means for supplying the said current source to the said bridge circuit through two of the said six resistive elements, to effectively provide a very high impedance across both said sets of junctions in spite of the center-tap-grounded voltage source; a control conductor connected to one junction of the said set of input junctions of the said bridge, a second conductor or capacitor connected to the other junction of the said input set, and adapted to maintain the said bridge system normally in balance; an electrically conductive element temporarily associated with the first-mentioned control conductor, said element being in the form of a conductive article or the hand or body of a person, and adapted to have a very minute current passed through the said temporary element to produce an unbalance in the said bridge system; switching means; amplifying, rectifying and integrating means adapted to operate the said switching means when the said bridge system is unbalanced, whereby the said switching means is caused to respond to the presence or contact of the said temporarily associated element.

4. In an electronic relay; a normally balanced electrical bridge circuit system having two sets of junctions, the input set of junctions being symmetrical and the output set unsymmetrical with respect to ground and with the said bridge system having at least six impedance elements, four of which are resistive and ungrounded; a source of alternating current; means for supplying the said current source to the said bridge circuit through two of the said six impedance elements, to effectively provide a very high impedance across both said sets of junctions regardless of the current supply conditions; a control conductor connected to one junction of the said set of input junctions of the said bridge, an adjustable capacitor connected to the other junction of the said input set and adapted to allow the said bridge system to be periodically balanced; a conductive element temporarily associated with the first-mentioned control conductor, in the form of a conductive article or hand or body of a person, operable to cause an unbalance in the said bridge system; an electron discharge tube A.-C. amplifier, having its input connected to the said output set of junctions of the said bridge system, and operable from an unbalance of the said bridge system; a rectifier having its input connected to the output of the said A.-C. amplifier, including a voltage-delay bias adapted to reject any small A.-C. signal caused by any residual unbalance of the said bridge system, and including a resistor and a capacitor adapted to integrate a rectified signal caused by a control unbalance of the said bridge system, said integration being appreciably faster than the subsequent discharge of said capacitor; an electron discharge tube D.-C. amplifier, or relay tube, having its input connected across the said resistor and capacitor of the said rectifier and having a relay or other switching means in its plate circuit, and adapted to operate the contacts of the said switching means when the integration voltage across its input circuit resulting from an unbalance of the said bridge system has reached a predetermined value, said value being consistent with the characteristics of the aforementioned temporarily associated element, whereby the said switching means is caused to respond to the presence or contact of the said temporarily associated element.

5. In an electronic relay; a normally balanced electrical bridge circuit system having two sets of junctions and including preferably a minimum of six resistive elements; a source of alternating current at the power frequency, and including means for reducing the primary out-of-phase coupling; means for supplying the said current source to the said bridge circuit through two of the said six resistive elements; a control conductor connected to one junction of the said set of input junctions of the said bridge, a capacitor connected to the other junction

of the said input set, and adapted to maintain the said bridge system normally in balance; a hand or other portion of a person's body, or a conductive article, temporarily associated with the said control conductor to produce an unbalance in the said bridge system; switching means; amplifying, rectifying, and integrating means adapted to operate the said switching means when the said bridge system is unbalanced, whereby the said switching means is caused to respond to the presence or contact of the said temporarily associated element.

6. In an electronic relay; a normally balanced electrical bridge circuit system having two sets of junctions, the input set of junctions being symmetrical and the output set unsymmetrical with respect to ground, and with the said bridge system having four ungrounded impedance elements; a transformed source of relatively high voltage alternating current, including electrostatic shielding and capacitive or conductive center-tap grounding means for essentially eliminating the primary out-of-phase coupling; means for supplying the said current source to the said bridge circuit through two of the said four impedance elements, to effectively provide a very high impedance across both said sets of junctions in spite of the center-tap-grounded voltage source; a control conductor connected to one junction of the said set of input junctions of the said bridge, a second conductor or capacitor connected to the other junction of the said input set, and adapted to maintain the said bridge system normally in balance; an electrically conductive element temporarily associated with the first-mentioned control conductor including a temporary external series impedance circuit provided by the said element's conductance, its contact resistance or capacity to the first-mentioned control conductor, and its conductance or capacity to ground, said temporary associated element being in the form of a conductive article or the hand or body of a person, and adapted to have a very minute current passed from the said bridge through the said temporary external series impedance circuit to produce an unbalance in the said bridge system; an electron discharge tube A.-C. amplifier, having its input connected to the said output set of junctions of the said bridge system, and operable from an unbalance of the said bridge system; a rectifier having its input connected to the output of the said A.-C. amplifier, including a voltage-delay bias adapted to reject any small A.-C. signal caused by any residual unbalance of the said bridge system, and including a resistor and a capacitor adapted to integrate a rectified signal caused by a control unbalance of the said bridge system, said integration being appreciably faster than the subsequent discharge of said capacitor; an electron discharge tube D.-C. amplifier, or relay tube, having its input connected across the said resistor and capacitor of the said rectifier and having a relay or other switching means in its plate circuit, and adapted to operate the contacts of the said switching means when the integration voltage across its input circuit resulting from an unbalance of the said bridge system has reached a predetermined value, said value being consistent with the characteristics of the aforementioned temporarily associated element, whereby the said switching means is caused to respond to the presence or contact of the said temporarily associated element.

7. In an electronic relay; a bridge circuit system having at least four impedance elements; high resistive balanced means for supplying an alternating current voltage to said bridge circuit system; electrostatic shielding means for reducing the out-of-phase capacity coupling from the A.-C. line to the said bridge; at least one control conductor conductively connected to the bridge circuit system to produce a state of unbalance in said bridge upon the approach or contact therewith of a person's hand or body; electron discharge tube amplifying and rectifying means actuated by the unbalance of said bridge system; and electrical switching means operable by said electron discharge tube means.

8. In an electrical system to be actuated by a temporarily associated conductive element; a normally balanced bridge circuit system having three sets of junctions, a voltage source set, an input set, and an output set, and including six resistive elements; a transformed source of alternating current balanced to ground, and adapted essentially to eliminate all 90-degree currents; at least one control conductor connected to one of the input junctions, and the bridge system adapted to be normally in

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balance; a hand or other portion of a person's body arranged to be temporarily associated with the said control conductor to produce an unbalance in the said bridge system; switching means; amplifying, rectifying and integrating means adapted to operate the said switching means when the said bridge system is unbalanced, whereby the said switching means is caused to respond to the presence of the said temporarily associated element.

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