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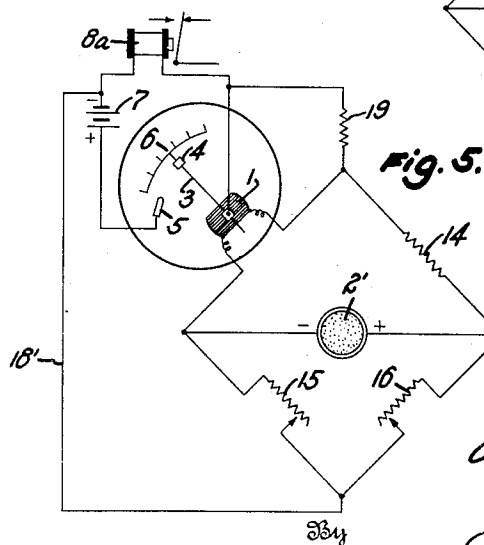
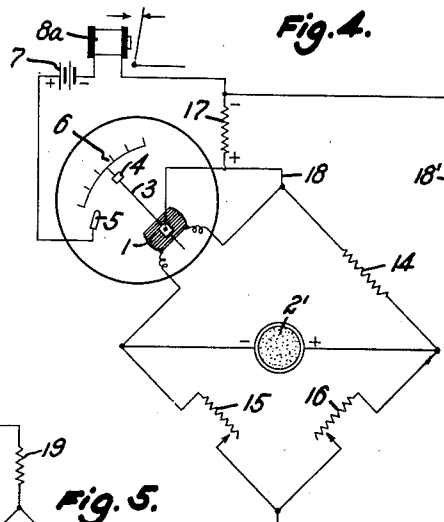
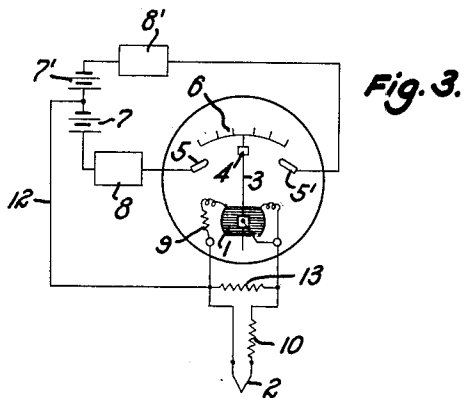
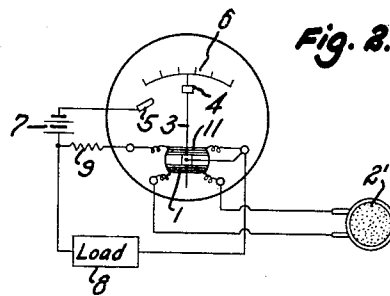
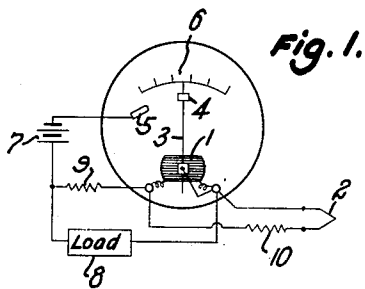
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2,346,589

RELAY CIRCUIT

Filed Jan. 30, 1942

2 Sheets-Sheet 1



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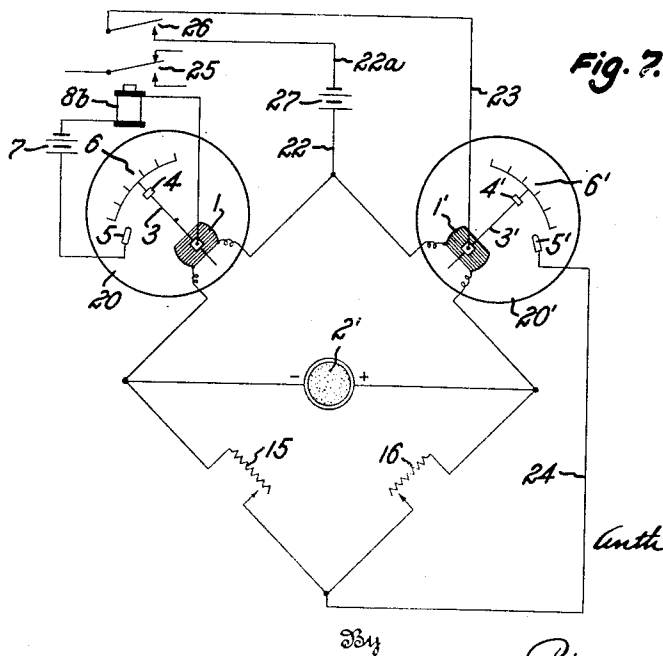
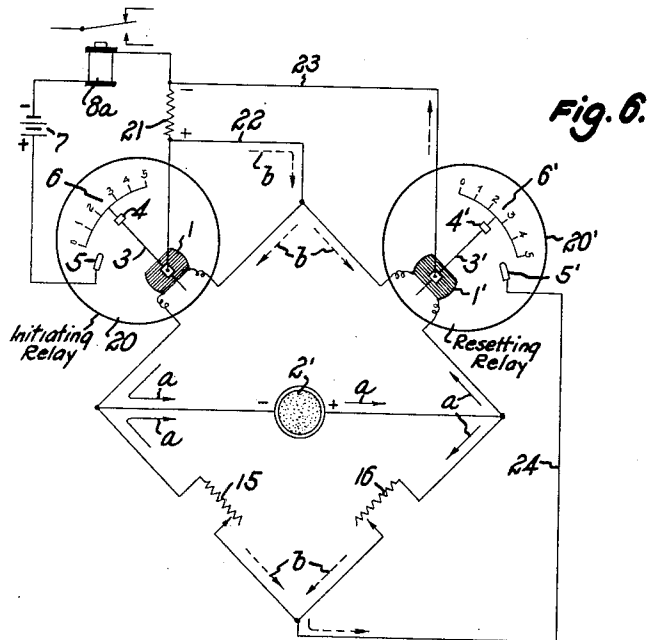
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RELAY CIRCUIT

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,346,589

RELAY CIRCUIT

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Application January 30, 1942, Serial No. 428,956

19 Claims. (Cl. 175-320)

This invention relates to relay circuits that include magnetic contact relays, and more particularly to relay circuits employing highly sensitive magnetic contact relays that are reset without the use of mechanical resetting mechanisms.

Magnetic contact relays such as disclosed in my prior Patents 2,014,385 and 2,014,386 have been used to control heavy load circuits in response to predetermined changes in a measured quantity or factor (such as temperature, illumination, voltage or current) that is too small to develop a reliable closure of non-magnetic contacts or to separate the magnetic contacts. As described in my prior patents, the moving system of the relay displaces the movable pointer and contact freely in the usual manner until the measured factor reaches the critical value at which the magnetic attraction between the contacts displaces the moving system, and the contacts then engage under magnetic attraction to afford a reliable non-chattering contact closure. Some form of mechanical resetting mechanism has been required to separate the magnetic contacts when the subsequent changes in the measured factor were incapable of developing a force sufficient to separate the magnetic contacts, and these mechanical resetting mechanisms have imposed some limitations upon the design of the sensitive relays and upon the fields of use of the same.

An object of this invention is to provide a relay circuit that includes one or more sensitive relays of the magnetic contact type, and circuit elements for resetting the relays without resorting to mechanical resetting mechanisms. An object is to provide a relay circuit including a sensitive instrument relay of the magnetic contact type with a moving system that responds to variations in a relatively minute control current, the magnetic attraction between the engaged contacts being substantially greater than any resetting force developed by the control current fluctuations, and a resetting circuit including a current source for momentarily establishing in the moving system a heavy current flow to overcome the magnetic attraction between the contacts. An object is to provide a sensitive relay circuit including an instrument relay with magnetic contacts, a current source for imposing upon the relay moving system a relatively minute current flow that varies with a control factor or quantity, and a resetting circuit for automatically sending a heavy current flow through the relay moving system upon an engagement of the magnetic contacts, whereby the load circuit of the relay is intermittently energized and de-energized

so long as the control factor magnitude remains within a range corresponding to energization of the relay. An object is to provide a self-resetting relay circuit that includes a sensitive relay with magnetic contacts, a control current source connected across the moving system of the relay but developing forces insufficient to reset the relay, and a resetting current source for supplying a heavy, short-duration current pulse to the relay moving system to reset the same upon an engagement of the magnetic contacts. More specifically, an object is to provide a relay circuit including a pair of magnetic contact relays, a load or load circuit controlled by the relay contacts, and a resetting circuit also controlled by said contacts to establish a current surge of relatively high value through the relays to reset the same. An object is to provide a self-resetting relay circuit including a pair of magnetic contact relays that operate in opposite sense in response to changes in the value of the control factor, a load controlled by the magnetic contacts of the relays, and a resetting circuit including a power source and circuit connections such that the closure of either set of magnetic contacts establishes a momentary current pulse of high magnitude through the relays to reset the same. More particularly, an object is to provide a self-resetting relay circuit including a Wheatstone bridge network having magnetic contact type relays in two side arms, a fluctuating source of control current in a conjugate arm of the network, a load circuit including a power current source and a load in series with the magnetic contacts of one relay, and a resetting circuit connected across the bridge as the other conjugate arm, the resetting circuit including the magnetic contacts of the second relay and a voltage drop resistor in the load circuit.

These and other objects and advantages will be apparent from the following description when taken with the accompanying drawings in which:

Figs. 1 and 2 are schematic circuit diagrams illustrating different embodiments of the invention;

Fig. 3 is a schematic diagram of a relay circuit in which the relay contact arm carries a magnetic contact cooperating with a pair of angularly spaced magnetic contacts, load devices selectively energized in accordance with the magnetic contacts that are closed, and a relay resetting circuit energized by a closure of the relay contacts.

Fig. 4 is a diagram of a relay circuit in which the power current source for resetting the relay

is electrically isolated from the control current source that is connected to the moving system of the relay;

Fig. 5 is a diagram of a modification of the relay circuit of Fig. 4;

Fig. 6 is a schematic diagram of a relay circuit of the on-off control type that includes two self-resetting sensitive relays of the magnetic contact type; and

Fig. 7 is a schematic diagram of an alternative arrangement that includes current sources individual to the load circuit and to the resetting circuit.

This application is a continuation-in-part of my copending application Serial No. 388,516, filed April 14, 1941, "Relay circuits."

In Fig. 1 of the drawings, the sensitive instrument relay is of the known direct current type including a pivoted coil 1 movable in the gap of a permanent magnet, not shown, and connected to a control current source 2 that develops only a small current flow through the coil 1, for example a current flow of the order of a few microamperes. For purposes of illustration, the current source 2 is shown diagrammatically as a thermocouple but it is to be understood that the control current source may be a photoelectric cell, a potentiometer, or the potential drop across a temperature-variant resistance, according to the character of the factor or quantity that is to control the relay circuit. The pointer 3 is secured to the coil 1 and carries a small rider or contact 4 of magnetic material for cooperation with a relatively stationary magnetic contact 5. The magnetized contact 5 is so positioned that the contact 4 is drawn into engagement with the contact 5 when the pointer 3 is moved to a preselected graduation of the scale 6 by the flow of control current through the coil 1. A load circuit including a current source 7 and a load device 8 is connected between the relay contacts 4, 5.

The elements so far described are, or may be, of any desired type and relative arrangement. The load device 8 may be a visual or an audible signal, a motor, or a power relay according to the desired control or relay action. According to this invention, a heavy current is automatically supplied to the relay moving system at each contact closure to develop a torque greater than that required to overcome the magnetic attraction of the engaged contacts.

The resetting current may be drawn from the power current source 7 of the load circuit by shunting the relay coil 1 across the load device 8, a resistor 9 being included in the coil branch of this parallel circuit network to limit the resetting current flow to a magnitude that will not damage the coil 1. In general, the resetting current flow may be of the order of milliamperes when the relay is designed for a control current input of the order of several microamperes. The control current source 2 is in shunt with the coil 1, so far as concerns current flow from the power source 7, and a current limiting resistor 10 is placed in series with the source 2 to restrict the flow of power current through the source 2.

An engagement of the magnetic relay contacts 4, 5 closes the load circuit to energize the load device 8 from the battery 7, and also completes the resetting circuit through the resistor 9 and coil 1. The polarity and magnitude of the resetting current flow through the relay coil 1 are such that the coil rotates clockwise to separate the magnetic contacts, thereby automatically

separating the relay contacts 4, 5 to open the load circuit and the resetting circuit. The flow of resetting current is thus limited to a relatively short current pulse, and the resetting current may therefore be of a value substantially higher than the maximum current that could be passed through the coil 1 for an appreciable period without damage to the winding.

The Fig. 1 relay circuit is of the pulsing or periodic closing type as the energization of the load device 8 and the resetting of the relay moving system take place alternately so long as the current output of the control source 2 is within the range corresponding to a closure of the relay contacts.

The flow of power current through the control source during the resetting operation may be objectionable in some cases, for example when the control current source 2' is a photoelectric cell. The control current source may be effectively isolated from the resetting current source by providing the moving system of the sensitive relay with a control winding 1 and a separate resetting winding 1', as shown schematically in Fig. 2. The remaining elements of the Fig. 2 circuit are, or may be, substantially identical with the corresponding elements of the Fig. 1 relay circuit.

The resetting system may be incorporated in a double contact or "high-low" relay circuit, such as shown in Fig. 3, in which the load devices 8, 8' are selectively energized by power current sources 7, 7' respectively in accordance with the engagement of the movable contact 4 with the magnet contact 5 or 5'. The load devices 8, 8' are connected between the outer terminals of the power sources 7, 7' and the respective magnet contacts 5, 5', and the midpoint of the serially connected power sources is connected to the movable contact arm through a lead 12 and series resistor 13. The resistor 13 is shunted across the control current circuit that connects the variable current source 2 to the relay moving coil 1, and current limiting resistors 9, 10 are arranged in the control circuit between the shunt resistor 13 and, respectively, the coil 1 and the current source 2.

The relatively heavy current that may be required for operation of the load devices 8, 8' flows through the resistor 13 to establish a potential drop that is impressed across the moving coil 1 for resetting. The direction of load current flow through the resistor 13 depends upon the contact 5 or 5' that is engaged by the movable contact 4, and the polarity of the resetting potential drop across resistor 13 therefore reverses in accordance with the required direction of rotation of coil 1 for a resetting operation. The reversed polarity of current flow from the power current sources 7, 7' to the load devices 8, 8' is not material as the current source and return circuit connections may be made to the proper terminals of each load device when a particular direction of current flow through the device is required.

The double contact control circuit is of the pulsing type and is similar to the Fig. 1 circuit in that the moving system of the relay has a single coil 1 that is traversed by both the control current and the resetting current. The separate control and resetting windings of the Fig. 2 circuit may be employed in the double contact relay system when an electrical isolation of the control and resetting circuits is desirable.

A bridge circuit arrangement, as shown in Fig. 4, may be employed to obtain an electrical isolation

tion of the control and resetting currents without resorting to a double winding on the moving system of the relay. The relay winding 1 and resistors 14, 15, 16 are arranged as the side arms of a bridge network, and one or more of the resistors are preferably adjustable for a balancing of the bridge network. A fluctuating control current source, for example a photocell 2', is connected across one set of opposed terminals of the bridge, and the load circuit includes the magnetic contacts 4, 5, a current source 7, a power relay 8a, and a voltage drop resistor 17 that is connected across the other set of opposed bridge terminals by leads 18, 19.

The control current from the photocell 2' and the resetting current from the power source 7 both flow through the relay coil 1 but the control and resetting circuits are effectively isolated when the bridge network is balanced. The polarity of the potential drop across the resistor 17 is of course such that the coil 1 is turned clockwise by the resetting current pulse. The polarity symbols +, - adjacent the terminals of the photocell 2' and the resistor 17 indicate that the relay contacts engage when the photocell current falls to a selected low value, and that the resetting current pulse is in the same sense as the low value photocell current. If the relay contacts close upon an increase of the photocell current to a critical value, the leads 18, 19 must be reversed to pass the resetting current pulse through the coil 1 in opposition to the photocell current.

The self-resetting relay circuit of Fig. 5 is similar to the described Fig. 4 circuit, and corresponding parts are identified by like numerals but are not described in detail. These alternative circuit arrangements are distinguished from each other by the particular circuit connections for introducing the resetting current pulse into the bridge network. In the Fig. 5 relay circuit, the opposed terminals of the bridge network are connected across the load circuit relay 8a through the current-limiting resistor 19 and the lead 18'. The resistor 19 will be of a relatively high value when the power current source 7 has a high voltage to establish a heavy current flow through the auxiliary relay 8a. The magnitude of the resetting current pulse is thus reduced to a safe value by the resistor 19 that is a series element of the resetting circuit. In Fig. 4, the voltage drop resistor 17 will have a relatively low ohmic resistance to reduce the potential across the bridge network to a safe value.

The relays of the described circuits will pulsate continuously so long as the control current has a value corresponding to a closure of the relay contacts. The invention may be applied to "on-off" relay circuits by employing separate magnetic contact relays for the "high" and "low" contact closures. A typical relay circuit of this type, as illustrated in Fig. 6, may be generally similar to the described photoelectric relay circuit of Fig. 4 but differs therefrom in that the pivoted coil 1' of a sensitive instrument relay 20' replaces the resistor 14 (Fig. 4) as one balancing arm of the bridge network. For convenience of description, the relay 20 which includes the moving coil 1 will be identified as the "initiating relay," and the relay 20' will be identified as the "resetting relay." The relays may be of identical design, although this is not essential, and the resetting relay includes a pointer 3' that carries a magnetic material contact 4' for cooperation with a magnetized contact 5', the pointer moving along

a graduated scale 6' to indicate the instantaneous value of the measured factor or current flow established through the coil 1' by the control current source or photocell 2'.

The relays 20, 20' are so designed or connected into the network that an increased current output from the photocell 2' moves the contact arm 3 of the initiating relay away from the contact 5, and moves the contact arm 3' of the resetting relay 20' towards the associated fixed contact 5'. The direction of current flow from the control current source 2' is indicated by the solid line arrows a, and inspection of the circuit diagram shows that the magnetic contacts 4, 5 of the initiating relay 20 close when the illumination at the photocell 2' drops to a selected critical value, and that the contacts 4', 5' of the resetting relay 20' close when the photocell illumination rises to a preselected critical value.

The controlled or load circuit between the relay contacts 4 and 5 includes, in series, the power current source 7, the auxiliary relay 8a, and the voltage drop resistor 21. The lead 22 extends from the positive terminal of the voltage drop resistor to one junction of the bridge network, and lead 23 extends from the other terminal of resistor 21 to the contact arm 3' of the resetting relay 20', the contact 5' of relay 20' being connected to the opposite bridge terminal by a lead 24.

Inspection of the circuit diagram shows that a voltage drop will be established across resistor 21 by the current source 7 when the contacts 4, 5 of relay 20 are closed, and that this voltage drop will establish a current flow in the bridge network when the contacts 4', 5' of relay 20' are closed. The direction of this current flow is indicated by the dotted line arrows b. The method of operation of the relay circuit will be explained with respect to a photoelectric relay system for controlling lights by the relay 8a in accordance with the illumination at the photocell 2'.

For clarity, it will be assumed that the contacts of both relays are initially open. Such a balanced condition is obtained when the quantity of light falling upon the photocell 2' causes said cell to generate sufficient energy to deflect the movable coils 1, 1' of the sensitive relays so that the movable arms 3, 3' each occupy a position between graduated values "1" and "5" on the illustrated scales 6, 6'. This deflection may be predetermined for a given quantity of light by proper choice of the bridge resistors 15, 16 with respect to the resistance of the movable coils and the sensitivity of the relays. With the contacts of the initiating relays open, the power relay 8a is de-energized and no potential is impressed across the bridge network other than that generated by the photocell 2'.

The current output of the photocell decreases with approaching darkness and the movable coils of both relays rotate in a counterclockwise direction as explained hereinabove. A sufficient decrease in cell output causes contacts 4, 5 of the initiating relay 20 to close, thereby energizing the power relay 8a which may be provided with suitable contacts to turn on artificial illumination as is well known in the art. Further decrease in the current output of the photocell is ineffective, tending only to move the movable arm 3' of the resetting relay toward the zero point on the scale. Inasmuch as the battery circuit is completed by the closure of contacts 4,

3 of relay 20, a definite voltage drop exists across the resistor 21.

With the approach of daylight the photocell generates an increasing current that tends to rotate the movable coils of the sensitive relays in a clockwise direction. Contacts 4, 5 of the initiating relay remain closed as the photocell current does not produce sufficient torque in the movable coil 1 to overcome the magnetic attraction between the contacts. However, movable coil 1' of resetting relay 20' is free to move and the contacts 4', 5' therefore engage when the photocell current reaches the value for which the relay is calibrated. The closure of contacts 4', 5' impresses the potential which exists across the drop resistor 21 across the bridge network producing a flow of current as indicated by the broken line arrows b. This current is employed to reset the relay contacts and its magnitude depends upon the constants of the electrical circuit, being in the order of milliamperes as compared to the microampere output of the photocell. Such a relatively large current develops sufficient torque in the movable coils to cause separation of the relay contacts. Upon the opening of the contacts of the initiating relay 20, the power relay 8a is de-energized and the potential drop across the resistor 21 is removed. The movable contact arm 3 of the initiating relay 20 now assumes an upscale position indicative of the current generated by the photocell. On the other hand, the movable arm 3' of the resetting relay 20' immediately re-engages with the magnet contact 5' without further effect upon the circuit.

As darkness again approaches, the current output of the photocell 2' decreases, thereby tending to produce counterclockwise rotation of the movable coils 1, 1'. The contacts 4', 5' of the resetting relay 20' remain closed as current flow through the movable coil 1' is not sufficient to overcome the magnetic attraction between the contacts 4', 5'. The coil 1 of the initiating relay 20 is now free to rotate however, and the contacts 4, 5 close when the output of the photocell decreases to the value for which the relay is calibrated. Closure of these contacts completes the power circuit, thus energizing the power relay 8a and establishing a voltage drop across the resistor 21. As the contacts of the resetting relay have remained closed during this part of the operating cycle, the voltage now appearing across drop resistor 21 is immediately impressed across the bridge network and both relays consequently are reset, as explained hereinabove. Movable arm 3' of the resetting relay therefore assumes a low scale position indicative of the reduced photocell current flowing through coil 1' and the contacts of the initiating relay 20 reclose immediately to keep the power relay 8a energized but the bridge network is unaffected because of the open contacts 4', 5' of the resetting relay 20'.

It will be apparent that by proper choice of the values of the resistors 15, 16 and the use of sensitive relays, properly calibrated, the desired on and off control of a load, signal, recorder or the like may be obtained for any desired variation in photocell output. Further, the photocell may be replaced by any voltage or current source developing an output that varies with a preselected control factor.

It will also be apparent that the power current source 7 may be replaced by an alternating current power source and a rectifier or, if the load

or power relay 8a is designed to operate on alternating current, it is preferable to insert a conventional rectifier in one of the leads 22, 23 or 24 of the conjugate bridge arm through which the resetting current impulse is impressed upon the relays 20, 20'. Further, sensitive relays may be inserted in any two or more arms of the bridge network. These relays may be of any desired sensitivity, all alike or each different, to obtain various types of multiple control.

The power relay 8a may advantageously be of the time delay type in certain applications to prevent interruption of the load circuit during the interval within which the sensitive relays are reset. Such a time delay action is particularly desirable when the circuit is used as a photoelectric light control, thereby preventing false operation of the load circuit when clouds or smoke pass over the photocell.

The resetting current pulse is supplied by the load circuit power source in each of the above described relay circuits, but a separate current source may be employed for resetting the relay automatically at each contact closure. The manner in which a separate current source for resetting may be incorporated in the several relay circuits will be apparent from Fig. 7 which is similar to the Fig. 6 circuit except the auxiliary relay 8b has a switch section 25 for control of the load circuit and a normally open switch section 26 in the resetting circuit that includes the battery or other direct current source 27. The positive terminal of the battery 27 is connected to one bridge terminal, and the other battery terminal is connected through the relay switch 26, lead 23, the contacts of the resetting relay 20', and lead 24 to the opposite bridge terminal. The method of operation of the Fig. 7 circuit will be apparent from the description of operation of the Fig. 6 circuit.

It will be apparent that the resetting current pulse must be a direct current when, as is usual, the sensitive instrument relay is of the direct current type. Direct current of appropriate polarity may be obtained from batteries, or from alternating current source through rectifiers. Alternating current may be employed in the load circuit or circuits of relay systems, such as shown in Fig. 7, in which a separate current source is provided for resetting, and also in relay circuits of the single power source type where rectifiers are included in the load circuit to provide a direct current for resetting.

The stated modifications of the apparatus will be apparent to those skilled in the art and are pointed out to indicate the scope of the invention. It will be understood that further modifications and variations fall within the scope and spirit of the invention as defined in the following claims.

I claim:

1. A relay circuit comprising a current source having an output that varies with changes in a control factor, a sensitive instrument relay having a pointer carrying a contact of magnetic material for cooperation with a relatively fixed contact of magnetic material, a moving system including a coil connected to said current source for displacing said pointer in accordance with changes in the magnitude of the control factor, a load circuit controlled by the contacts of said instrument relay and including a power source of current, and a resetting circuit including means energized by an engagement of said contacts to deliver a relatively heavy current pulse to said

moving system to develop a high torque to overcome the magnetic attraction of and separate the engaged magnetic material contacts.

2. A relay circuit as recited in claim 1, wherein said resetting circuit includes said power current source and a resistor for limiting the current flow established in said resetting circuit by said power current source.

3. A relay circuit as recited in claim 1, wherein said resetting circuit includes a source of current independent of said power current source.

4. A relay circuit comprising a current source having an output that varies with changes in the magnitude of a control factor, a sensitive relay having a pointer carrying a contact of magnetic material for cooperation with a relatively fixed contact of magnetic material, a moving system including a coil connected to said current source for displacing said pointer, a load circuit including a source of power current in series with said relay contacts and a load device, and a resetting circuit for establishing a current flow of relatively high value through said moving system to separate the relay contacts upon an engagement of the same; said resetting circuit including said relay contacts in series with said power current source, said moving system, and a resistor for limiting the current flow established through said moving system by said power current source.

5. A relay circuit as recited in claim 4, in combination with means electrically isolating said first current source from said power current source.

6. A relay circuit as recited in claim 4, in combination with means electrically isolating said first current source from said power current source, said means comprising a second coil on said moving system and included in said resetting circuit.

7. A relay circuit as recited in claim 4, in combination with means electrically isolating said first current source from said power current source, said means comprising a balanced bridge network having said first current source and said resetting circuit as the conjugate arms thereof, said coil of the moving system of the relay being in one side arm of the bridge network.

8. A relay circuit comprising a current source having an output that varies with the magnitude of a control factor, a sensitive instrument relay having a pointer carrying a contact of magnetic material for cooperation with a relatively fixed contact of magnetic material, a moving system including a coil connected to said current source for displacing said pointer, a load circuit including a source of power current in series with the relay contacts and a load device, a resistor in said load circuit, and a relay resetting circuit including said resistor and circuit elements connecting the same across said coil to establish a current flow through the coil when the load circuit is completed by a closure of the relay contacts.

9. A relay circuit comprising a current source having an output that varies with the magnitude of a control factor, a sensitive instrument relay having a pointer carrying a contact of magnetic material for cooperation with a relatively fixed contact of magnetic material, a moving system including a coil connected to said current source for displacing said pointer, and a load circuit and relay resetting circuit each including a source of power current in series with said relay contacts; said load circuit including a load device,

and said resetting circuit including said moving system of the relay.

10. A relay circuit as recited in claim 9, wherein said load circuit and said resetting circuit have a common source of power current.

11. A relay circuit as recited in claim 9, wherein said load circuit includes a series resistor, and said resetting circuit is connected across said resistor.

12. A relay circuit comprising a current source having an output that varies with changes in a control factor, a pair of relays each having a moving system carrying a contact of magnetic material for cooperation with a relatively fixed contact of magnetic material, circuit elements connecting said current source to the moving systems of said relays to displace the same in opposite sense with reference to the respective fixed contacts, a load circuit controlled by the contacts of one relay and including a power current source and a load, and a resetting circuit including the moving system and contacts of at least one of said relays in series with a source of resetting current.

13. A relay circuit as claimed in claim 12, wherein said source of resetting current comprises a voltage drop resistor in said load circuit.

14. A relay circuit comprising a current source having an output that varies with changes in a control factor, a sensitive relay including an operating coil connected to said current source, said relay having cooperating magnetic contacts controlling a load circuit, and a resetting circuit for said sensitive relay; said resetting circuit including a resetting relay connected to said current source and having a coil controlling the engagement of a pair of contacts, and circuit elements connecting the contacts of the resetting relay in series with the coils of both relays and with a resetting current source, the polarity of said resetting current source being such that current flow therefrom actuates both relays to separate the contacts thereof.

15. A relay circuit comprising a pair of magnetic contact type relays and impedances serially connected in a bridge network, a variable current source connected across one pair of opposite terminals of the bridge network, the relays having moving systems that are displaced in opposite sense with reference to the fixed contacts thereof upon a given change in the output of said source, a load circuit including the contacts of one relay in series with a load and a power current source, and a resetting circuit connected across the other pair of opposite terminals of the bridge network; said resetting circuit including the contacts of the resetting relay in series with a source of resetting current.

16. A relay circuit as claimed in claim 15, wherein said source of resetting current has an output of an order substantially higher than that of said variable current source.

17. A relay circuit as claimed in claim 15, wherein said source of resetting current comprises a voltage drop resistor in said load circuit.

18. A relay circuit comprising a pair of magnetic contact type relays and impedances serially connected in a bridge network, a variable current source connected across one pair of opposite terminals of the bridge network, the relays having moving systems that are displaced in opposite sense with reference to the fixed contacts thereof upon a given change in the output of said source, a load circuit including the contacts of one relay in series with a load and a power current source,

and a resetting circuit connected across the other pair of opposite terminals of the bridge network; said resetting circuit including the contacts of both relays in series with a source of resetting current.

19. A relay circuit comprising a pair of sensitive relays connected to a control current source having an output that varies with a control factor, impedances cooperating with said relays to form a bridge network across which said current source is connected as one conjugate arm, the first relay having magnetic contacts that engage when the output of said current source falls to a

selected value and the second relay having magnetic contacts that engage when said output rises to another preselected value, a power current source and a load in series with the contacts of one relay to form a controlled circuit, and a resetting circuit connected as the other conjugate arm of the network and including the contacts of both relays in series with each other and with a source of resetting current, the polarity of said resetting current source being such that the control and resetting currents are additive in the first relay and opposed in the second relay.

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