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SELF-RESETTING ELECTRICAL NETWORK AUTOMATICALLY RESPONSIVE TO A CONDITION

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Fig. 1.

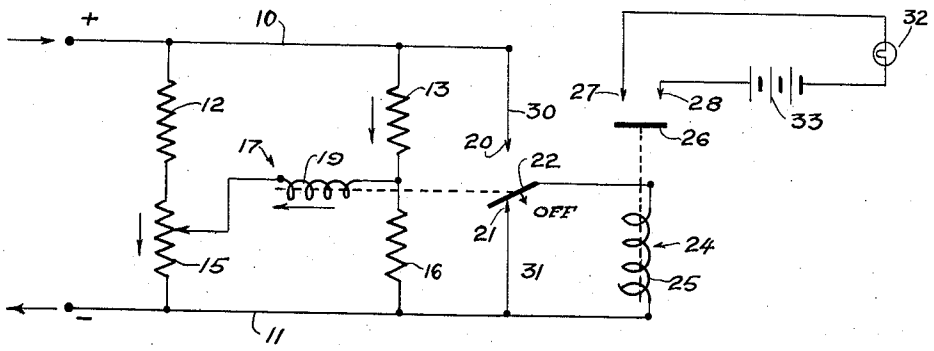


Fig. 2.

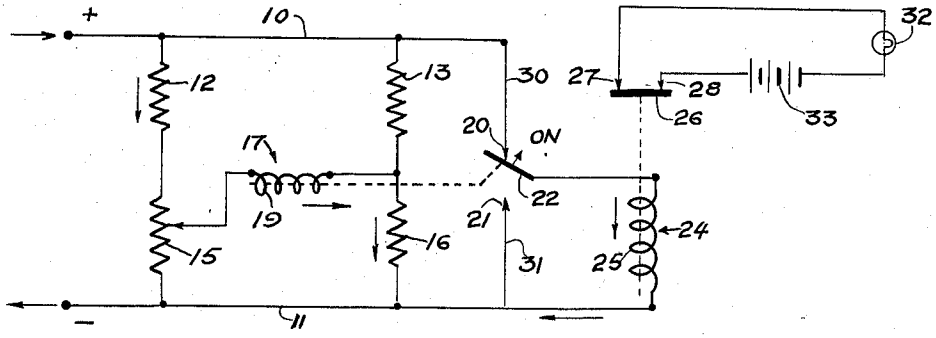
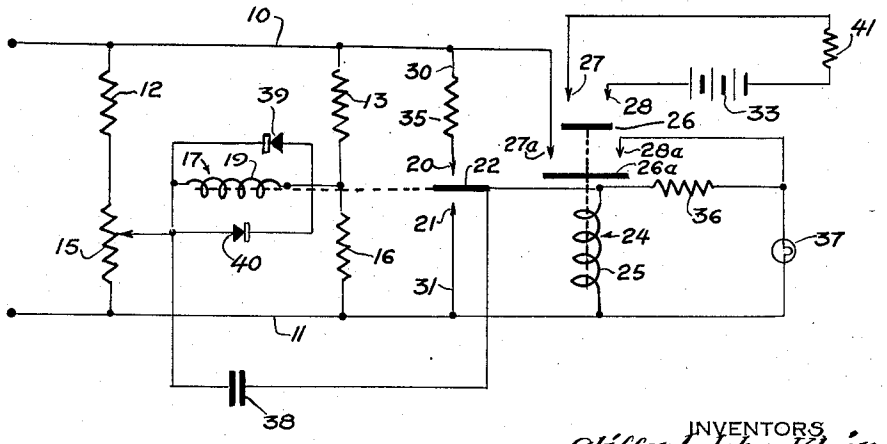


Fig. 3.



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SELF-RESETTING ELECTRICAL NETWORK AUTOMATICALLY RESPONSIVE TO A CONDITION

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3 Claims. (Cl. 317—153)

The present invention relates to electrical networks which are automatically responsive to a condition, and, more particularly, to such networks which are self-resetting.

The present invention, although useful for many other purposes as described hereinafter, is primarily concerned with improving heat and flame detector systems of the type wherein an element is utilized which comprises two conductors spaced apart by a material having an infinitely high resistance at a normal temperature to render it substantially non-conductive to electricity and having the characteristic of being rendered conductive at an abnormal temperature. In such systems, suitable means indicate or operate various devices when the abnormal temperature condition has been detected.

Accordingly, the primary object of the present invention is to provide an improved network of such type which is extremely accurate in responding to the condition to be detected, which is unaffected by vibrations, and which rapidly resets itself the instant the condition no longer exists.

Another object is to provide such a network which is constructed of a minimum number of relatively inexpensive, lightweight components adapted to be arranged in a compact manner.

Another object is to provide such a network which has a long useful life and requires a minimum of maintenance or repair.

Another object is to provide such a network within the essential components are protected against excessive voltages.

A further object is to provide such a network which has utility in a great many fields of application.

Other and further objects of the invention will be obvious upon an understanding of the illustrative embodiment about to be described, or will be indicated in the appended claims, and various advantages not referred to herein will occur to one skilled in the art upon employment of the invention in practice.

In accordance with the present invention, it has been found that the foregoing objects can be accomplished by the use of an ultra-sensitive polarity indicator having no perceptible deflection gradient and thereby having no steady-state-intermediate-position between its contacts. Such an indicator includes a winding and switch means having a pair of spaced apart contacts and a torqueless, freely deflectable switch element movable between the contacts. This indicator is arranged in a voltage dividing bridge type network which essentially comprises a source of unidirectional electrical current, first and second resistors connected in series across the source, third and fourth resistors connected in series across the source, the first and third resistors having resistance values and the second and fourth resistors having resistance values to provide a voltage dividing bridge normally unbalanced in one direction, the fourth resistor being constructed and arranged so that the resistance thereof changes in response to a predetermined condition to another value whereby the bridge is unbalanced in the opposite direction, the winding being connected between the junction of the first and second resistors and the junction of the third and fourth resistors and one contact thereof being connected to one side of the source and the other contact thereof being connected to the other side of the source, and a relay adapted to control electrically operated means, the relay including a winding connected between the indicator switch element and the last mentioned side of the source.

A preferred embodiment of the invention has been chosen for purposes of illustration and description, and is shown in the accompanying drawing, forming a part of the specification, wherein:

Figs. 1 and 2 are circuit diagrams illustrating the essential components arranged in a network, in accordance with the invention, under normal and detecting conditions, respectively.

Fig. 3 is a circuit diagram illustrating a more practical application of the essential network.

Referring to Fig. 1 of the drawing, a network is shown which essentially comprises a source of unidirectional electrical current represented by conductors 10 and 11, a pair of fixed resistors 12 and 13 (first and third resistors), a variable resistor 15 (second resistor), a condition sensing resistor 16 (fourth resistor), a polarity meter 17 including a winding 19, a pair of contacts 20 and 21 and a switch element 22, and a relay 24 having a winding 25 and a switch element 26 for connecting contacts 27 and 28.

The source of current may be direct current from a battery or generator, rectified alternating current or pulsating direct current. The conductor 10 is illustrated as being connected to the positive side of the source, and the conductor 11 is illustrated as being connected to the negative side of the source.

The resistors 12 and 13 act as balancing resistors and may have equal resistance values. These resistors are of the type which do not vary appreciably in resistance with ambient temperature changes and consequently remain in balance when subjected to temperatures ranging from −65° F. to 160° F.

The variable resistor 15 is shown herein as a voltage divider and is adapted to provide a wide range in which the network may be accurately adjusted. This resistor also is practically immune to ambient temperature changes.

The condition sensing resistor 16 may be any element subject to changes in its resistance in response to the particular condition to be detected. For example, such an element may be sensitive to heat, light, humidity, or mechanical force. In the illustrative embodiment of the invention described herein, such an element is utilized to detect heat or flame on aircraft or other craft or vehicles, and comprises two conductors of electricity spaced apart by a thermistor-like material having an infinitely high resistance at a normal temperature to render it substantially non-conductive to electricity and having the characteristic of being rendered conductive at an abnormal temperature caused by the heat of flame or fire. Such elements are well known in the art as illustrated by U. S. Patent No. 2,586,252 and need not be described in detail herein.

The successful operation of the network in accordance with the present invention depends chiefly on the use of the ultra-sensitive polarity indicator 17 which is adapted to detect the change of polarity of the bridge error when the resistance of the sensing resistors 16 reaches a predetermined value. The switch element 22 of this indicator is pivotally mounted for free, torqueless movement thereof and has no appreciable mass. The switch element is under the control of the winding 19, as indicated by the broken line, whereby when current flows through the

winding in one direction, the switch element engages the contact 20, and, when current flows through the winding in the opposite direction, the switch element engages the contact 21. The indicator has no deflection gradient to speak of and thereby does not have any steady-state-intermediate-position between the contacts 20 and 21.

The relay 24 may be of any common type wherein the switch element 26 is moved into engagement with the contacts 27 and 28 under the influence of the winding 25 to complete a circuit or is moved out of such engagement to break the circuit.

The foregoing components are arranged in the network in the manner about to be described. The resistors 12 and 15 (first and second resistors) are connected in series across the conductors 10 and 11 (source of current), and the resistors 13 and 16 (third and fourth resistors) are likewise connected in series across the conductors 10 and 11. One end or terminal of the winding 19 of the polarity indicator 17 is connected to the effective junction of the resistors 12 and 15, that is, in voltage dividing relation with respect to the resistor 15, and the other end or terminal of the winding 19 is connected to the junction of the resistors 13 and 16. The contact 20 of the meter is connected to the conductor 10 (one side of source) by a conductor 30, and the contact 21 is connected to the conductor 11 (other side of source) by a conductor 31. One end of the relay winding 25 is connected to the switch element 22, and the other end of this winding is connected to the conductor 11.

The relay switch element 26 and contacts 27 and 28 are adapted to control a subsidiary circuit, herein illustrated as an alarm circuit including an indicator, such as a lamp 32, and a source of electrical current, such as a battery 33. Alternatively, the battery could be dispensed with by connecting the relay switch (26, 27, 28) in series with the lamp 32 across the conductors 10 and 11.

It will be understood that the relay 24 could operate a number of switch elements 26 adapted to close circuits for accomplishing other desired functions. Also it will be apparent that such switch elements may be arranged to normally close or open a circuit or that certain switch elements may close a circuit while others may open a circuit. Furthermore, the relay switches could function as double-throw switches to close separate circuits in both positions of the relay.

In the operation of the network just described, assuming that it is used as a heat or flame detector, the resistance of the resistor 15 is adjusted so that the network is in balance just before the resistor 16 is subjected to the temperature condition it is designed to detect. The network then is out of balance at normal temperatures, and current flows through the winding 19 and the other components as illustrated by the arrows, whereby the switch element 22 is held in engagement with the contact 21, as shown in Fig. 1. The relay 24 is de-energized while the network is in this state, and accidental operation thereof, due to vibrations or movement of the craft tending to cause the switch element 22 to move and touch the contact 20 is prevented, because the indicator 17 is energized to retain the switch element in the position shown.

When the sensing resistor 16 is subjected to heat or flame and its resistance is lowered so that it becomes more conductive than the resistor 15, the bridge is unbalanced in the opposite direction with current flowing through the meter winding 19 and the other components as illustrated by the arrows, whereby the switch element 22 is moved into and held in engagement with the contact 20, as shown in Fig. 2. The relay 24 is then connected across the conductors 10 and 11 and is energized to cause its switch element 26 to engage the contacts 27 and 28 and close the alarm circuit. While the network is in this state, accidental de-energization of the relay, due to vibrations and the like tending to cause the switch element to leave the contact 20 is prevented, because the indicator is energized to maintain the switch element in this position. This eliminates blinking of the lamp 32 because on and off operation of the relay 24 is prevented.

After the fire or other cause which heated the sensing resistor 16 no longer exists and the resistance of the resistor 16 increases as this resistor cools, the network is unbalanced in its original direction (Fig. 1), whereby the switch element 22 engages the contact 21. This short-circuits the relay winding 25 to quickly de-energize the same and causes the alarm circuit to be opened.

A unique feature of the maner of operation of the network in accordance with Figs. 1 and 2 is that the detection of a reversal in polarity is relied upon, rather than a magnitude of error or value of unbalance existing in the network between normal and abnormal conditions. This feature greatly simplifies the entire network and enables the same to operate reliably on a source of electricity wherein the voltages may vary between as much as plus or minus 50% without appreciably affecting the accuracy with which the sensing resistor 16 will detect the condition for which adjustment has been made.

In Fig. 3, a network is shown which basically is the same as that shown in Figs. 1 and 2, with like reference numerals applied to like components, but which includes refinements serving to enhance the utility of the essential network. In this network, the relay 24 includes an additional switch element 26*a* and contacts 27*a* and 28*a* adapted to connect the relay across the conductors 10 and 11 directly and retain the relay self-energized without relying on the flow current through the switch element 22, whereby the indicator 17 is maintained energized to hold the switch element 22 against the contact 20. When the conductor 31 short circuits the relay winding, as previously descibed, the relay breaks its holding circuit.

In order to further protect the switch element 22 and its contacts 20 and 21 against excessive current, a limiting resistor 35 (fifth resistor) is connected in the conductor 30, and a limiting resistor 36 (sixth resistor) is connected in series with the relay switch (26*a*, 27*a*, 28*a*) and the relay winding 25 across the conductors 10 and 11. These resistors also limit the flow of current through the relay winding. An indicator, such as a lamp 37, may be connected in series with the relay winding 25 and the resistor 36.

In order to assure operation of the polarity indicator 17, a condenser 38 is connected between the end of the winding 19 connected to the junction of the resistors 12 and 15 and the switch element 22. This condenser is charged at a polarity dependent upon the on or off position of the switch element 22 and when the bridge is at or near balance, this condenser provides a transient voltage which modifies the voltage drop across the polarity indicator in the manner described hereinafter to augment a change in the direction of current flow through the indicator.

The condenser is charged to a polarity and magnitude depending upon the voltage drop across either the lower portion of the resistor 15 or the resistor 12 plus the upper portion of the resistor 15 depending upon the position of the switch element.

The resistance of the sensing resistor 16 is changing rapidly as the bridge approaches balance, therefore, the current values flowing through the arms of the bridge will also be changing rapidly causing a rapid change in the voltage drop across the bridge resistors. If the rate of resistance change of the resistor 16 is great enough, the rate of change in the voltage drop across the bridge arms will be greater than the discharge rate of the condenser and therefore the condenser will hold the left end of the coil 19 at a potential which will cause the current flow through the coil 19 to reverse its direction before such a reversal would occur if the condenser was not provided. After the switch element has been moved from one contact (due to a current reversal in coil 19) and while it is in transit to the opposite contact, the con-

denser continues to discharge through the relay coil **25** increasing the flow through the coil **19** and the force acting on the switch element **22**. The motion of the switch element is very rapid and therefore a substantial charge remains on the condenser when the switch element contacts the opposite contact. When this contact is made, the voltage then connected across the condenser is opposite in polarity to the charge on the condenser, therefore, the condenser rapidly discharges and recharges to the opposite polarity causing a surge in the current flow through coil **19** increasing the force on the switch element to drive it against the contact and hold it against vibrational displacement.

The winding **19** is protected against high voltage surges by a pair of varistors **39** and **40** arranged in opposite directions and connected in parallel across the winding. These elements decrease in forward resistance with an increase in voltage, whereby high voltage current flows through these elements to short-circuit the winding **19** and eliminate the effect of such surges thereon.

The network in accordance with the invention could be arranged to normally maintain the relay **24** energized to close a circuit including a heater **41** (Fig. 3) which is to be shut off when a predetermined temperature is attained, whereby the network serves as an industrial heater control rather than a fire detector. The network can be so modified by either reversing the polarity of the source, as shown, or by reversing the connections to the terminals of the meter winding.

It will also be understood that the sensing resistor **16** may have a positive coefficient of resistivity rather than a negative coefficient of resistivity, that is, the resistor becomes more conductive as the temperature decreases. With such an arrangement, the network serves to detect abnormally low temperatures and has utility as a control for turning on a heating system or shutting off a refrigerating system.

From the foregoing description, it will be seen that the present invention provides a simple, practical, highly reliable and economical condition responsive network which is entirely automatic in operation and is self-resetting.

As various changes may be made in the form, construction and arrangement of the parts herein, without departing from the spirit and scope of the invention and without sacrificing any of its advantages, it is to be understood that all matter herein is to be interpreted as illustrative and not in any limiting sense.

We claim:

1. In an electrical network subject to external vibration and automatically responsive to a condition external of the network other than vibration, the combination of a source for supplying unidirectional electrical current at a steady voltage, first and second resistors connected in series across said source, third and fourth resistors connected in series across said source, said first and third resistors having resistance values and said second and fourth resistors having resistance values to provide a voltage dividing bridge normally unbalanced in one direction, said first, second and third resistors being immune to temperature changes and only said fourth resistor being of the type whose resistance changes in response only to a predetermined condition external of the network to another value whereby the bridge is unbalanced in the opposite direction, a polarity indicator including an armature and a winding connected between the junction of said first and second resistors and the junction of said third and fourth resistors and including switch means having a pair of contacts and a freely deflectable switch element movable by said armature instantaneously from one contact to the other, one of said contacts being electrically connected to one side of said source and said other contact being electrically connected to the other side of said source, a condenser connected between the junction of said first and second resistors and said switch element to provide a transient voltage modifying the voltage impressed upon said polarity indicator when the bridge changes its direction of unbalance, and a relay including a winding connected between said switch element and the last mentioned side of said source, said polarity indicator being characterized in that it only has a steady state position when said switch element engages one contact or the other, whereby said switch element is positively held in engagement with one contact or the other.

2. In an electrical network automatically responsive to a condition, the combination of a source of unidirectional electrical current having positive and negative sides, first and second resistors connected in series across said source from positive to negative, third and fourth resistors connected in series across said source from positive to negative, said first and third resistors having resistance values and said second and fourth resistors having resistance values to provide a voltage dividing bridge normally unbalanced in one direction, said fourth resistor being of the type whose resistance changes in response to a predetermined condition to another value whereby the bridge is unbalanced in the opposite direction, a polarity indicator connected between the junction of said first and second resistors and the junction of said third and fourth resistors and including switch means having a pair of contacts and a freely deflectable switch element movable between said contacts, a fifth resistor connected between one of said contacts and the positive side of said source, a conductor of electricity connecting said other contact to the negative side of said source, a relay including a winding connected between said switch element and the negative side of said source and a switch operable thereby, a sixth resistor connected in series with said relay switch and said relay winding across said source, and electrically operated means controlled by said relay.

3. In an electrical network automatically responsive to a condition, the combination of a source of unidirectional electrical current, first and second resistors connected in series across said source, third and fourth resistors connected in series across said source, said first and third resistors being balancing resitors having resistance values and said second and fourth resistors having resistance values to provide a voltage dividing bridge normally unbalanced in one direction, said second resistor being variable and said fourth resistor being of the type whose resistance changes in response to a predetermined condition to another value whereby the bridge is unbalanced in the opposite direction, a polarity indicator connected between the junction of said first and second resistors and the junction of said third and fourth resistors and including a winding and switch means having a pair of contacts and a freely deflectable switch element movable between said contacts, two varistors arranged in opposite directions and connected in parallel with said indicator winding, a condenser connected between the junction of said first and second resistors and said switch element, a fifth resistor connected between one of said contacts and one side of said source, a conductor of electricity connecting said other contact to the other side of said source, a relay including a winding connected between said switch element and the last mentioned side of said source and a switch operable thereby, a sixth resistor connected in series with said relay switch and said relay winding across said source, and electrically operated means controlled by said relay.

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