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ELECTRICAL NETWORK AUTOMATICALLY RESPONSIVE TO A CHANGE IN CONDITION
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The present invention relates to electrical networks which are automatically responsive to a change in a condition, and, more particularly, to such networks which are responsive to the rate of change of such condition and are prevented from giving false indications in response to transient conditions.

The present invention, although useful for many other purposes, is primarily concerned with improving heat and flame detecting systems of the type shown in co-pending application for Letters Patent of the United States, Serial No. 624,074, now Patent No. 2,901,740, filed November 23, 1956, and assigned to the assignee of this application. Such systems include a thermistor element 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. The thermistor element forms one leg of a resistance bridge which is connected to circuitry for giving an alarm when the resistance of the element is such as to indicate the presence of an abnormal temperature condition.

The particular system disclosed in the above mentioned co-pending application also includes a rate circuit and therefore gives an indication not only when a given temperature is detected but also when a given rate of change of temperature is detected. This system is used in aircraft, and, while it is satisfactory in many respects, it has been found to be subject to false alarms due to various transient conditions which produce a sufficiently rapid change in the balance of the bridge to cause the rate circuit to actuate the alarm. Such transient conditions include the condensation of moisture on the element, and the discharge of static electricity through the element. These conditions have no relation to a fire hazard and therefore it is highly desirable that the resulting false alarms be eliminated.

Accordingly, an object of the present invention is to provide a network of this type which is not subject to the foregoing difficulties.

Another object is to provide such a network which is prevented from responding to a rate of change in the detected condition if the change is instantaneous.

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 the foregoing objects are accomplished by providing in a condition responsive system which includes a source of unidirectional current, first and second resistance elements connected in series across the source, third and fourth resistance elements connected in series across the source, the elements having resistance values to provide a voltage dividing bridge normally unbalanced in one direction and one of the resistance elements being constructed and arranged so that the resistance thereof changes in response to a predetermined condition to another value whereby the bridge goes towards unbalance in the opposite direction, an electronic valve having an input electrode connected to the junction of the first and second resistance elements and having another input electrode connected to the junction of the third and fourth resistance elements and having an output electrode connected for supply of current thereby, a capa
is located has a low resistance in comparison to that of the resistor 15. The base 20 of the transistor 19, therefore, is more positive than the emitter 21 and current flows from the conductor 11 both through the resistors 14 and 28 and through the resistor 30 to the base 20, and through the base emitter circuit of the transistor and the resistors 24 and 16 to the conductor 10. This flow places the transistor 19 in full conduction and allows current to flow from the conductor 11 through the load resistance 31, the collector emitter circuit of the transistor, and the resistors 24 and 16 to the conductor 10. With the transistor 19 in full conduction the collector 23 is less positive with respect to the base 20 (10) than the junction point of resistors 41 and 42 since a greater portion of the source voltage is dropped across resistor 31 than is dropped across resistor 41. The base 34 of transistor 32 is therefore less positive than the emitter 35 and the transistor 32 is held in a cutoff condition.

As the resistance of the thermistor 12 decreases in response to an increase in temperature, the potential of the point X decreases and the current supplied to the base 20 from the point X (through resistor 14) likewise decreases. The current flowing to the base 20 through the resistor 30, however, remains substantially constant until the point X becomes less positive than the base 20 allowing the diode 26 to conduct.

When the point X does become less positive than the base 20, some of the current flowing through the resistor 30 is shunted away through the diode 26 reducing the base current of the transistor 19. At some predetermined temperature the balance of the bridge will be such that sufficient current will be diverted from the base circuit to reduce the collector current to a point where the base 34 of transistor 32 will be more positive than the emitter 35 and the transistor 32 will begin to conduct.

The exact condition of the bridge with respect to balance which will reduce the collector current in the transistor 19 to the operating level is dependent upon the position of the tap 27 on the resistor 16 and upon the relation of the resistance of the diode 26 to the base-emitter resistance of the transistor 19. Since both the diode and the transistor are semi-conductors, their resistances vary with temperature in the same manner. Therefore, the point of operation does not vary appreciably with temperature.

When the transistor 32 begins to conduct, the potential of the emitter 35 (with respect to the conductor 10) increases due to the increased current flow through the resistor 42. This increase in potential is fed back to the emitter 35 of the transistor 19 through the resistor 16 making the emitter 21 more positive than the base 20, cutting off the transistor 19. The transistor 32 then goes into full conduction energizing the relay coil 39 to close the switch 40 and give an indication in the external circuit that a fire or dangerous heat condition is present.

In order that a flash or rapid fire may be detected before it reaches dangerous proportions difficult to extinguish, the rate portion of the network 25 operates when the element is exposed to a rapid increase in temperature, to give an indication before the thermistor is heated to a temperature sufficient to balance the bridge.

The potential at the base 20 controls the conduction of the transistor 19 and is at all times equal to the source voltage minus the IR drop across the resistor 30. The rate portion of the network 25 affects the conduction of the transistor 19 by influencing the voltage drop across the resistor 30 as follows.

When the resistance of the thermistor element is high and constant, the diode 26 is not conducting, the transistor 19 is conducting, the capacitor 27 is charged to the voltage drop across the resistor 28, and the voltage drop across the resistor 30 is constant and proportional to the current flowing therethrough to the base 20.

As the element 12 decreases in resistance slowly in response to a normal increase in ambient temperature, the capacitor 27 discharges through the resistor 28 at a rate sufficient to maintain its charge equal to the IR drop across the resistor 28. Under these conditions the voltage drop across the resistor 30 remains constant holding the potential at the base 20 constant.

However, when the resistance of the element 12 drops rapidly, the capacitor 27 cannot discharge through the resistor 28 at a constant rate. At a certain point in time a preicable discharge current also flows from the positively charged plate of the capacitor through the element 12 and the power supply, and through the resistor 14 in parallel with the element and the power supply, to the conductor 11 and through the resistor 30 to the negatively charged plate. This discharge current increases the IR drop across the resistor 30 thereby decreasing the positive potential on the base 20. It may be seen that if the discharge of the capacitor 27 increases the current through the resistor 30 to a point where the IR drop across the resistor is greater than the source voltage, the base 20 will be driven negative with respect to ground.

This circuit is arranged so that when the resistance of the element 12 decreases rapidly to a value of 30,000 ohms or less, the rate capacitor 27 causes the transistor 19 to be cut off.

The network described so far in detail is disclosed in the aforementioned application. It has been found that the transient conditions mentioned hereinabove cause instantaneous changes in the balance of the bridge of sufficient magnitude to cause the rate circuit to drive the transistor 19 to cut off. In the network of the aforementioned application, the transistor 32 is placed in conduct by this action and continues to conduct until the capacitor 27 discharges sufficiently to allow the transistor 19 to conduct once again. In the network described hereinabove in detail, an instantaneous change in the balance of the bridge causes the capacitor 27 to hold the transistor 19 cutoff for a period of about three seconds.

In accordance with the present invention, this network is prevented from giving an alarm in response to such transient conditions by the addition of a 100 microfarad capacitor 44 connected in series with a 1,000 ohm resistor 45 between the collector 37 and the base 34 of transistor 32, and a diode 46 connected between the emitter 21 and the base 29 of transistor 19 in a manner such that its conductive direction is opposite to that of the base-emitter circuit of the transistor. Then, in standby operation when the transistor 19 is conducting, holding the transistor 32 cutoff, the diode 46 is biased against conduction, and the capacitor 44 is charged to a potential in opposition to the potential of conductor 10. Under these conditions, the transistor 19 is held at the collector 22. When the transistor 19 is driven to cutoff by a rapid change in the balance of the bridge, the collector 22 is temporarily prevented from rising to the line potential by the charge on the capacitor 44. The transistor 32, therefore, is prevented from conducting for a period of time dependent on the rate of discharge of the capacitor 44. In the illustrative embodiment described hereinabove this time period is one second.

During the above operation, when the rate network drives the transistor 19 to cutoff, the voltage biasing the diode 46 against conduction is removed and the capacitor 27 discharges rapidly through the low resistance path provided by the element 12, the collector 10, the resistors 16 and 24, and the diode 46. The rate network is thereby prevented from holding the transistor 19 cutoff for a period exceeding the delay provided by the capacitor 44 when the change in the balance of the bridge is instantaneous. In the preferred embodiment described hereinabove the resistance of this discharge path is such that any instantaneous change in the balance of the bridge will not cause the capacitor 27 to cut off the transistor 19 for a period exceeding 0.75 second.

Therefore, since the transistor 19 will conduct only if the transistor 19 remains cut off for a period of more than one second, the network responds to a rate of
change in the balance of the bridge only if this rate of change continues for a predetermined time.

It will be seen that the operation of the rate network is not appreciably affected by the addition of the diode 46 since the diode is biased against conduction when the transistor 19 is conducting and therefore has no function until the bias is removed when the transistor 19 is cut off.

The resistor 45 is provided to limit current flow through the relay coil 39 when the capacitor 44 is charging, thereby preventing the coil 39 from being energized momentarily, giving a false indication, when the network is initially energized or is reset after giving a fire indication.

From the foregoing description, it will be seen that the present invention provides a condition responsive network which is prevented from responding to a rate of change in the detected condition if the change is instantaneous.

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 a condition responsive system including a source of unidirectional current, first and second resistance elements connected in series across said source, third and fourth resistance elements connected in series across said source, said resistance elements having resistance values to provide a voltage dividing bridge normally unbalanced in one direction and one of said resistance elements being constructed and arranged so that the resistance thereof changes in response to a predetermined condition to another value whereby the bridge goes towards unbalance in the opposite direction, an electronic valve having an input electrode connected to the junction of said first and second resistance elements and having another input electrode connected to the junction of said third and fourth resistance elements and having an output electrode adapted to be connected for supply of current thereto, a capacitor providing at least in part the connection between the junction of said first and second resistance elements and the first mentioned input electrode for detecting the rate of change of the condition of the bridge with respect to balance, an electrically operable device adapted to be connected for supply of current thereto and connected to be controlled by the output of said electronic valve: the improvement which comprises means connected to said device for delaying the operation of said device after the output of said electronic valve is such that its operation of said device, and means providing a low resistance discharge path for said capacitor so that said device will not operate in response to the rate of a change in the condition of the bridge when the change is instantaneous.

2. A system according to claim 1, wherein said last mentioned means is a diode connected between the input electrodes of said valve in a manner such that its conductive direction is opposite to the conductive direction of the input circuit of said valve, whereby a low resistance discharge path is provided for said capacitor.

3. A system according to claim 1, wherein said electrically operable device includes a second electronic valve having a pair of input electrodes one being connected to the output electrode of said first valve and having an output electrode adapted to be connected for supply of current thereto and said delaying means includes a capacitor connected between said output electrode of said first valve and said output electrode of said second valve.

4. A system according to claim 3, wherein a relay coil is connected to said output electrode of said second valve, and a resistor is connected in series with said delaying means capacitor to limit the charging current flowing to said capacitor through said relay coil.

5. In a condition responsive system including a source of unidirectional current, first and second resistance elements connected in series across said source, third and fourth resistance elements connected in series across said source, said resistance elements having resistance values to provide a voltage dividing bridge normally unbalanced in one direction and one of said resistance elements being constructed and arranged so that the resistance thereof changes in response to a predetermined condition to another value whereby the bridge goes towards unbalance in the opposite direction, an electronic valve having an input electrode connected to the junction of said first and second resistance elements and having another input electrode connected to the junction of said third and fourth resistance elements and having an output electrode adapted to be connected for supply of current thereto, a capacitor and a resistor connected in parallel between the junction of said first and second resistance elements and the first mentioned input electrode for detecting the rate of change of the condition of the bridge with respect to balance, a second electronic valve having a pair of input electrodes one being connected to the output electrode of said first electronic valve and having an output electrode adapted to be connected for supply of current thereto: the improvement which comprises a capacitor connected between said output electrodes of said first valve and said output electrode of said second valve for delaying the operation of said second valve after the output of said first electronic valve is such as to cause said second valve to conduct, and a diode connected between said input electrodes of said first valve in a manner such that its conductive direction is opposite to the conductive direction of the input circuit of said first valve thereby providing a low resistance discharge path for said first capacitor so that said second valve will not conduct in response to the rate of a change in the condition of the bridge when the change is instantaneous.

6. A system according to claim 5, wherein a relay coil is connected to said output electrode of said second valve, and a resistor is connected in series with said delaying means capacitor to limit the charging current flowing to said capacitor through said relay coil.

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