May 25, 1965 R. C. DOANE 3,185,974

FIRE DETECTION SYSTEM

Filed Dec. 1, 1961

FIG. 1

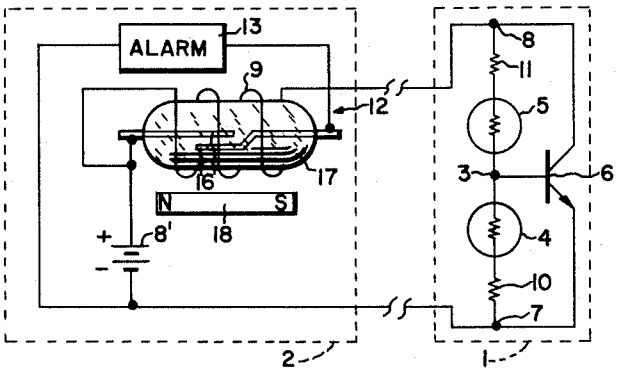


FIG. 2

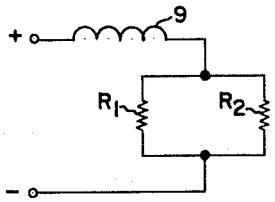


FIG. 3

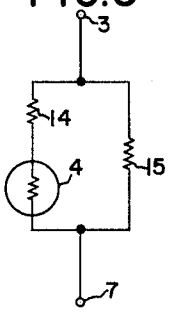


FIG. 4

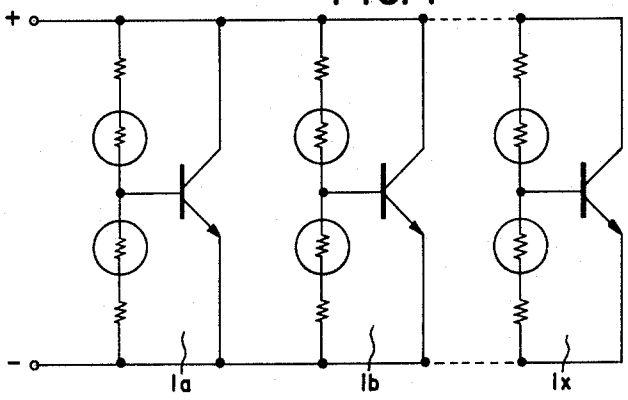
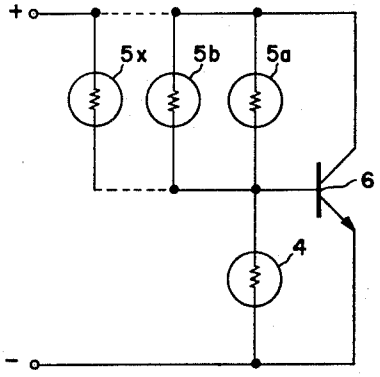


FIG. 5



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FIRE DETECTION SYSTEM

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This invention relates to fire detectors which respond to either an excessive change in temperature, or to an excessive temperature rise over a given time span.

It has been long known that fire detectors which respond to a given temperature of, say, 140° F. cannot be depended upon for reliable protection of life or property. In the home, a time lag of several minutes between the time at which a fire breaks out and that at which such an alarm would respond makes asphyxiation a serious threat. In a plant, where an even greater air mass must be heated, extensive damage can result.

To overcome this problem, a unit which responds to both an excessive temperature and an excessive rate of temperature rise is desired. Such a unit has been previously proposed using a pair of resistors with mutually different temperature coefficients and response times in a Wheatstone bridge, the bridge unbalancing for either an excessive temperature or rate of temperature rise. The principal disadvantage of this device is that with readily available temperature-sensitive resistors, for example thermistors with a temperature sensitivity of about −4% per degree centigrade, the alarm must be adjusted rather critically, resulting in an undesirably small margin of stability, and prohibiting the use of multiple sensors in different locations with a single alarm relay.

It is the principal object of the present invention to provide a reliable fire detection system which is highly stable and fast-acting, and yet inexpensive and simple to install. Generally speaking, this is accomplished by the provision of a novel temperature-sensitive transistor circuit.

The various features and advantages of the present invention will become apparent from the following description and accompanying drawings, wherein:

FIG. 1 is a circuit diagram of a fire detection system in accordance with the present invention,

FIG. 2 is an equivalent circuit diagram used to explain the operation of the system of FIG. 1,

FIG. 3 is a circuit diagram of a modification of the system of FIG. 1,

FIG. 4 is a circuit diagram of one embodiment of a multiple sensing unit fire detection system in accordance with the present invention, and

FIG. 5 is a circuit diagram of another embodiment of a multiple sensing unit fire detection system in accordance with the present invention.

Referring to FIG. 1, the fire detection system shown therein generally comprises a temperature sensing unit **1** connected to an alarm control unit **2**. Unit **1** comprises a center junction **3** to which are connected a pair of temperature-sensitive resistance branches including thermistors **4** and **5**, and the base of grounded-emitter, current-amplifying transistor **6**. The end junctions **7** and **8**, respectively connecting the branch of thermistor **4** to the emitter of transistor **6** and the branch of thermistor **5** to the collector of transistor **6**, are connected in series with the voltage source **8'** and relay coil **9** of control unit **2**. Transistors **4** and **5**, together with series resistors **10** and **11** which may be included for adjustment purposes if desired, form a base biasing network for the transistor **6**.

Thermistors **4** and **5** have substantially the same temperature sensitivity (for example −4% per ° C.), but different response times. For example, the resistance of thermistor **5** responds to a 5° C. temperature change in less than two seconds, whereas that of thermistor **4** fully responds after more than two minutes due to a greater heat insulation thereof.

The operation of this novel system may be understood by considering the equivalent circuit of FIG. 2 comprising the relay coil **9** in series with parallel resistances R_1 and R_2. R_1 consists of the series resistance of branches **4**, **10** and **5**, **11** in parallel with the leakage resistance of transistor **6**, and R_2 consists primarily of the emitter-collector resistance of transistor **6**. The resistance of the thermistors **4** and **5**, and hence the equivalent resistance R_1, continuously drops as the environmental temperature of unit **1** rises, regardless of the rate of temperature change. When a fast temperature change occurs, the resistance of the fast response time thermistor **5** drops while the resistance of the slow response time thermistor **4** remains substantially constant thereby effecting a rise in the transistor base bias voltage at junction **3**. As a result, the base current increases, causing a decrease in the emitter-collector resistance by an amount proportional to the transistor current amplification factor h_{fe}, and hence a corresponding decrease in R_2.

In a practical circuit, using readily available, inexpensive thermistors, resistance R_1 will drop approximately 90% of its reference value for an excessive temperature rise condition, for example from 80° F. to 140° F., and resistance R_2 can be adjusted to drop to a similar value for an excessive rate of temperature rise condition, for example a +5° F. change in less than one minute. Thus either condition effects an increase in the current through coil **9** to a value at which relay **12** is set to pull-in thereby closing the circuit from voltage source **8'** to actuate an alarm means **13**, for example a buzzer. In previous devices, a fast 5° F. change causes the resistance in series with the alarm relay to drop only about 10%, thereby requiring a much more critical adjustment for relay pull-in.

An enhancement in the sensitivity of the detector to excessive temperature rises may be accomplished by connecting the slow response thermistor **4** in the network of FIG. 3 comprising a series resistor **14** and a parallel resistor **15**. By proper selection of the values of these resistors, the temperature sensitivity of the network may be reduced to any desired fraction of the temperature-sensitivity of thermistor **4** alone. Thus a rise in temperature will cause an increase in the voltage of junction **3** whereby the effective resistance R_2 is decreased for this condition as well as for the excessive rate of change condition.

Referring now in greater detail to the relay **12**, this comprises a pair of spaced-apart ribbons or reeds **16** made of a silver-plated magnetic material and supported in a glass capsule **17**. The reeds **16** become magnetized with sufficient attractive force to close the alarm circuit (pull-in) when the current through relay coil **9** establishes a certain predetermined magnetism, for example 50 ampere-turns. Due to residual effects, the relay will not open (drop-out) until the coil magnetism drops considerably below the pull-in value, for example to about 30 ampere-turns for a pull-in value of 50 ampere-turns. By placing a small permanent magnet **18** near the reeds, a bias magnetism having a value intermediate between the pull-out and pull-in values is established, for example a bias of 40 ampere-turns for a pull-in value of 50 ampere-turns. In the example given, a relay coil magnetism of only 10 ampere-turns is required to pull in the relay, thereby increasing the relay sensitivity and reducing the voltage requirements and hence expense of the source **8'**. Further, once the relay is pulled in, it will remain

so even after the coil current is removed, the 40 ampere-turn bias magnetism alone being sufficient to hold the relay in. Thus, the relay remains pulled in regardless of what happens to the rest of the circuit which may, for example, be rendered inoperative by fire damage. When it is desired to open the relay contacts, the polarity of the coil magnetism can be reversed with a suitable switch to oppose the magnetism of bias magnet **18** and thus reduce the net magnetism to below the drop-out value.

The increased stability of the basic circuit of FIG. 1 advantageously permits the use of multiple sensing units with but a single relay, the relay being a relatively costly item. One such arrangement is shown in FIG. 4 wherein a plurality of sensing units **1***a*, **1***b* . . . **1***x*, positioned in different monitoring locations, are connected in parallel. If a dangerous fire condition exists at only one of the sensing units, the current increase available to actuate the alarm is smaller the greater the number of such units. As previously discussed, the novel circuit of the present invention enables an enhanced condition-responsive decrease in the effective sensor resistance and thus permits an increased number of sensing units. An alternative multiple sensing unit arrangement is shown in FIG. 5 wherein the fast response timer thermistor comprises a plurality of parallel-connected thermistors **5***a*, **5***b* . . . **5***x*, each positioned in a different monitoring location. The system of FIG. 5, requiring fewer thermistors and transistors, is considerably more simple and less expensive than that of FIG. 4, but permits a fewer number of sensing units. The multiple sensing units of both FIGS. 4 and 5 are further advantageously characterized by a minimum number of wires interconnecting the control unit and the various sensing units.

This application is a continuation-in-part of Serial Number 148,100, filed October 27, 1961 and now abandoned.

What is claimed is:

1. A fire detection system comprising an alarm actuating means in series with at least one transistor circuit, said circuit comprising a transistor which is controlled from the junction of a pair of temperature sensitive resistance branches, and the response time of the resistance of one of said branches to a change in temperature being substantially shorter than that of the other of said branches, said circuit establishing two parallel current paths, the resistance of one of said paths decreasing with an excessive temperature rise condition and the resistance of the other of said paths decreasing with an excessive rate of temperature rise condition to establish a current through said alarm actuating means which rises above a predetermined alarm level for either of said conditions.

2. A fire detection system according to claim 1 wherein each resistance branch includes a thermistor, said thermistors having substantially the same temperature sensitivities but substantially different response times.

3. A fire detection system according to claim 2 wherein the longer response time thermistor is connected in a temperature sensitivity reduction circuit comprising a first resistance in series with said thermistor and a second resistance in parallel with the series combination of said thermistor and said first resistance.

4. A fire detection system according to claim 1 wherein each temperature-sensitive resistance is connected between said control junction and a contact in series with one terminal of a single voltage source, said transistor being operated as a grounded-emitter current amplifier with the emitter and collector thereof each connected to one of said series contacts and the base thereof being biased by connection to said control junction, said voltage source being the sole source of energization for said resistance branches and said transistor.

5. A fire detection system according to claim 1 wherein said alarm actuating means includes a relay coil in series with said transistor circuit.

6. A fire detection system according to claim 5 further comprising a pair of magnetic reed elements adapted to open and close an alarm circuit, said relay coil being disposed in magnetic coupling relation to said reed elements, and a permanent magnet means also disposed in magnetic coupling relation with said reed elements for maintaining said alarm circuit in a closed state after an initial closing thereof.

7. A fire detection system according to claim 1 comprising a plurality of said transistor circuits connected in parallel, each circuit being positioned in a different temperature monitoring location.

8. A fire detection system according to claim 1 wherein said shorter response time resistance branch includes a plurality of temperature sensitive resistances connected in parallel and positioned in different temperature monitoring locations.

9. A fire detection system comprising an alarm actuating means in series with at least one sensing circuit, said sensing circuit comprising a transistor connected in a network with two temperature-sensitive resistances having substantially different response times to temperature changes, said network establishing two parallel current paths, the resistance of one of said paths decreasing with an excessive temperature rise condition and the resistance of the other of said paths decreasing with an excessive rate of temperature rise condition to establish a current through said alarm actuating means which rises above a predetermined alarm level for either of said conditions.

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