United States Patent [19]

Hunter

[11] **3,845,440**

[45] **Oct. 29, 1974**

[54] **TIME DELAY RELAY**

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[22] Filed: **Dec. 4, 1973**

[21] Appl. No.: **421,552**

[52] **U.S. Cl.** **337/341,** 337/3, 337/298, 337/401

[51] **Int. Cl.** **H01h 37/62**

[58] **Field of Search** 337/401, 299, 304, 335, 337/336, 341, 343, 362, 298, 3; 60/528, 529

[56] **References Cited**

UNITED STATES PATENTS

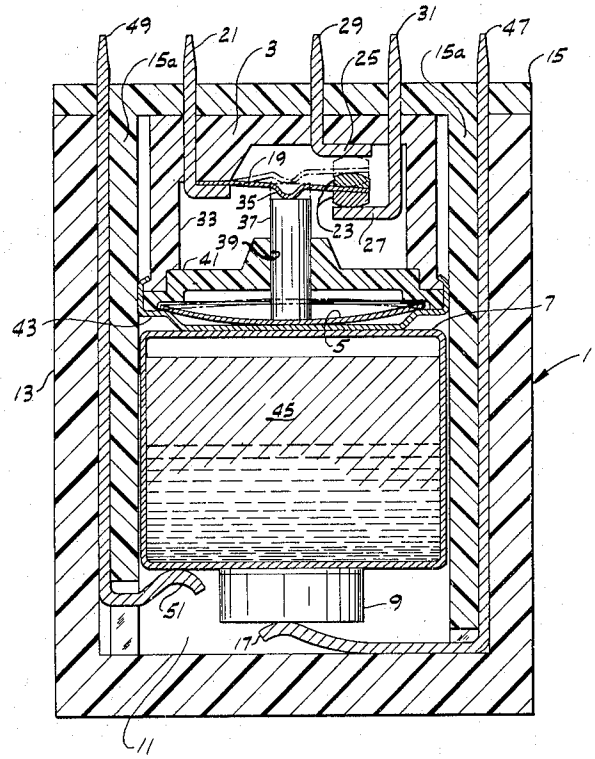
3,575,645	4/1971	Doversberger et al.	337/3
3,624,578	11/1971	Stocker et al.	337/299

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Attorney, Agent, or Firm—John A. Haug; James P. McAndrews; Edward J. Connors, Jr.

[57] **ABSTRACT**

A time delay relay comprising a set of electrical contacts movable between circuit-making and circuit-breaking positions and thermally responsive means for actuating the contacts to move them from one to the other position at a predetermined temperature. The relay includes thermal storage means in heat exchange relationship with the thermally responsive actuating means. The thermal storage means comprises a body of material which will change from a first to a second physical state at a temperature intermediate that of the ambient of the relay and the predetermined temperature. Heatable means is positioned in heat exchange relationship with the thermal storage means so as to effect a transfer of heat therebetween and cause the body of material to change states so that the transfer of heat between the heatable means and the thermally responsive means is delayed and the period of time required for the thermally responsive means to reach the predetermined temperature is extended.

10 Claims, 2 Drawing Figures



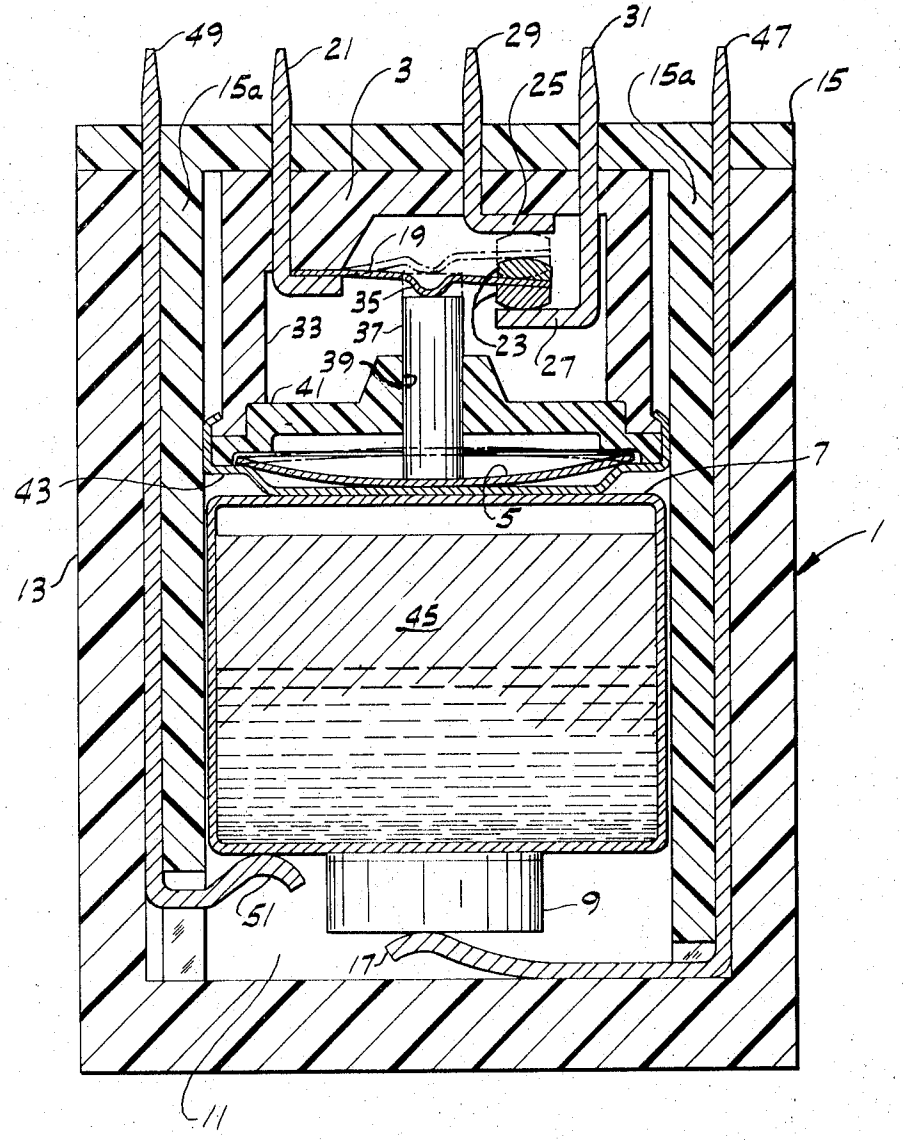

49
21
3
29
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15a
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FIG. 1

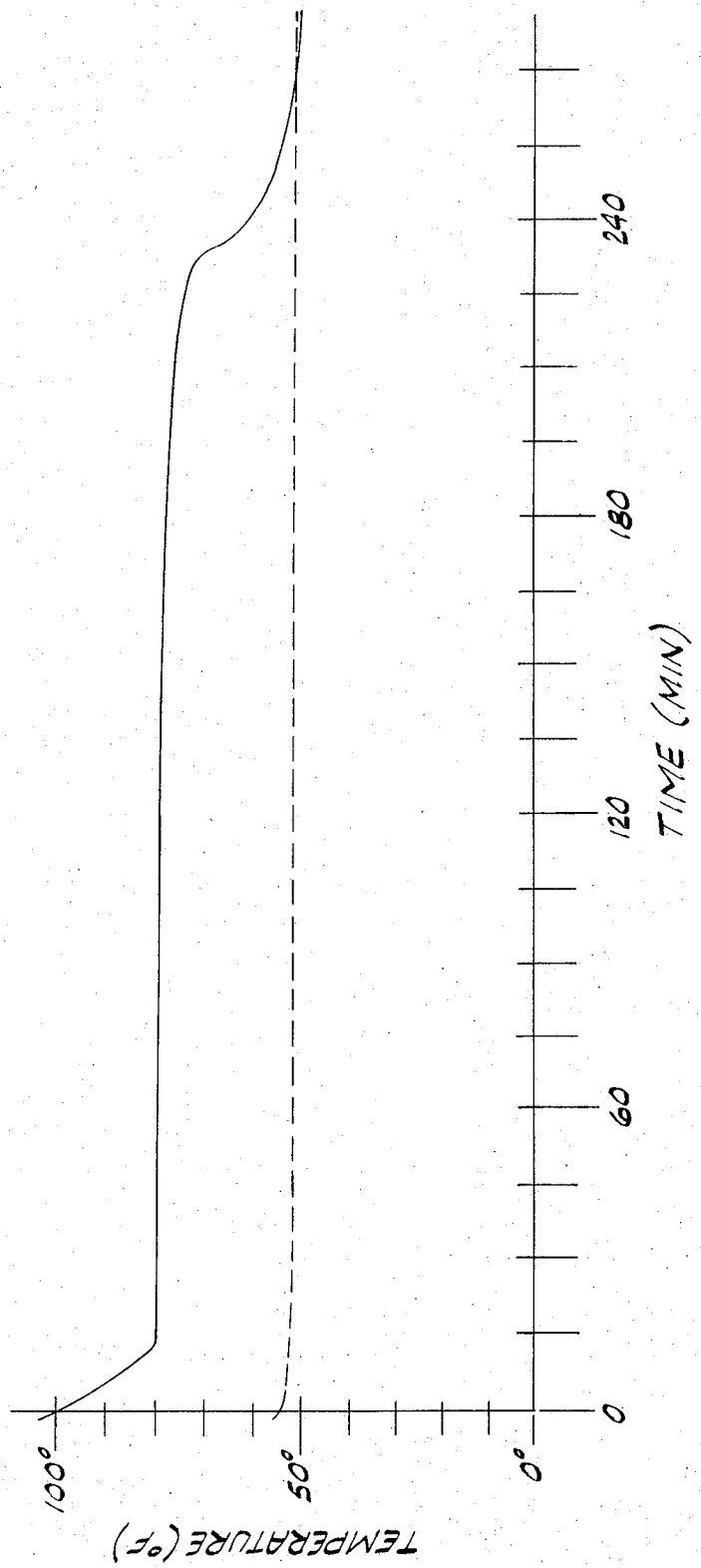


FIG. 2

TIME DELAY RELAY

BACKGROUND OF THE INVENTION

This invention relates to time delay relays and more particularly to thermal time delay relays.

As the use of such relays in many types of control systems has increased, there has been a growing need for thermal time delay relays which would provide longer time delays. In order to increase the delay periods of these relays the thermal mass thereof has been increased and/or the operating temperature has been elevated. However, it is impractical to increase the size and operating temperatures sufficiently to achieve extended time delays of, for example, several hours, particularly where the available mounting space and application requirements limit such increases in size and operating temperature.

SUMMARY OF THE INVENTION

Among the several objects of this invention may be noted the provision of time delay relays which have extended periods of delay and yet are compact in size and do not require excessive operating temperatures and the provision of such thermal time delay relays which are economical in construction and reliable in operation. Other objects and features will be in part apparent and in part pointed out hereinafter.

Briefly, a time delay relay of this invention comprises a set of electrical contacts movable between circuit-making and circuit-breaking positions and thermally responsive means for actuating said contacts to move them from one position to the other at a predetermined temperature. Thermal storage means are positioned in heat exchange relationship with the actuating means. The storage means is constituted by a body of material which will change from a first to a second physical state at a temperature intermediate that of the ambient of the relay and the predetermined temperature. A heatable means, such as an electrical resistance heater, is positioned in heat exchange relationship with the thermal storage means so as to effect a transfer of heat therebetween and cause the body of material to change states so that the transfer of heat between the heatable means and the thermally responsive means is delayed and the period of time required for the thermally responsive means to reach the predetermined temperature is extended.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a cross section of a time delay relay of the present invention showing alternate positions of the switch contacts; and

FIG. 2 graphically illustrates the time-temperature characteristics of a relay of this invention employed as a defrost initiation thermostat.

Corresponding reference characters indicate corresponding parts throughout the drawing.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawings, a thermal time delay relay of this invention is indicated generally at reference numeral **1**. This relay comprises a thermostatic switch **3** including a thermally responsive actuator **5**, a thermal storage device **7** and a heater **9** stacked within a compartment **11** of an insulated housing **13**. These components are held in respective contact with each other within the insulated compartment by an insulating cover **15** that has depending retainer lugs **15***a* to maintain the switch and storage device in coaxial alignment, and a spring terminal finger **17** that biases the entire stacked assembly against the inner surface of the cover.

Switch **3** has a switch arm **19**, one end of which is welded to the inner end of a terminal lug **21**. The free end of switch arm **19** has a pair of opposed contacts **23** movable between two fixed or stationary contacts **25,27** constituted by the inner ends of terminal lugs **29,31**. These three lugs are secured in an inverted cup-shaped case **33** of insulating material.

The intermediate portion of switch arm **19** is dimpled to provide a boss **35** aligned with one end of a transfer pin **37** axially slidable in a bore **39** of a generally cylindrical pin guide **41**. The other end of pin **37** rests on the central portion of thermal actuator **5** constituted by a snap-acting composite bimetallic disc, such as disclosed in U.S. Pat. No. 1,448,240. Because of the non-developable or dished shape of the thermally responsive disc **5**, it will snap from one curavture position to an opposite curvature position upon the temperature increasing to a predetermined level and will abruptly reverse its curvature when cooled below that level.

The undersurface of guide **41** is recessed to accommodate the flexing movement of disc **5** which peripherally rests on an annular ledge formed by a cup-shaped closure **43**, the upper end of which is swaged over and grips the lower edge of housing **33** to secure together the housing and pin guide. Closure **43** is formed of a thermally conductive material, such as aluminum or copper, to provide excellent heat transfer with and heat exchange between thermal storage device **7**.

Thermal storage device **7** comprises a capsule or cartridge of a thermally and electrically conductive material, such as aluminum or copper, partially filled with a body of material **45** which will change from one physical state to another at a temperature between ambient and the temperature at which the disc will snap to actuate the contacts. The body of material **45** contained in capsule **7** may be either a solid or a liquid at ambient temperatures of the relay. If a solid material is used, its fusion temperature is somewhat below that at which the disc snaps. If material **45** is a liquid at ambient temperatures, it will vaporize or boil at a temperature somewhat less than the actuation temperature of the switch. Exemplary of thermal storage materials that are solid at ambient temperatures but change to a liquid state or fuse at temperatures within typical operating ranges of thermal relays are many different waxes and paraffins, Rose's and Wood's metals and sulfur. These materials have melting points that range between about 80° and 250°F. Glycerol which melts at about **68**°F. but solidifies at lower temperatures is another useful thermal storage material. These materials have heats of fusion ranging from about 12–100 Btu/lb. Typical thermal storage materials that are liquid at ambient relay temperatures but boil at temperatures below maximum useful operating temperatures of thermal relays are methanol, ethanol and water with boiling points between about 150°F. and 212°F. and heats of vaporization between about 365–950 Btu/lb.

Heater **9** is a pill or disc of an electrical resistance material, preferably one formed from a steepsloped positive temperature coefficient (PTC) material such

as certain doped barium titanates. It is secured to the undersurface of thermal capsule 7 and supplied with electrical power by means of terminal finger 17 of a terminal lug 47 which extends outwardly through cover 15 and another terminal lug 49 the inner end of which has a similar spring finger 51 contacting the electrically and thermally conductive capsule 7.

Operation of relay 1 is as follows: Assuming that at ambient relay temperatures the switch contacts and disc 5 are in the solid line positions and electrical power is supplied to heater 9 via terminal fingers 17 and 51, the heater will generate heat with its resistance increasing with temperature until it reaches stabilization current and temperature conditions at a level that exceeds that at which disc 5 will snap into its broken line position and move contact arm 19 into its broken line position. However, as the thermal storage material is heated to the temperature at which it will change state, heat will continue to be absorbed by the heat storage device and contained thermal storage material without any substantial change in the temperature thereof until a sufficient quantity of heat is absorbed to effect a change of state of the material. This heat of fusion or vaporization may be many times the normal heat capacity of the material and thus the heat content of the material 45 is greatly increased as it undergoes a change in state without any substantial change in temperature. Therefore the thermal storage device or thermal capacitor 7 delays the transfer of heat between the heater 9 and the thermal actuator disc 5 until sufficient heat is absorbed by material 45 and thereafter it will increase in temperature with further heat input until the operating temperature of disc 5 is reached.

As switch 3 may be connected into any conventional control circuit as a normally open or normally closed switch, the abrupt lifting of pin 37 as disc 5 snaps will open or close the circuit as desired. After this time delay in actuation of relay 1, the switch contacts thereof will remain in the broken line positions as long as electrical power continues to be supplied via terminal lugs 47,49 and disc 5 will be maintained at a temperature determined by the stabilization current and temperature of the PTC heater 9.

A similar time delay is achieved as material 45 is permitted to cool to an ambient temperature or one below that at which material 45 changes state to its original state and disc 5 abruptly returns to its solid line position and pin 37 moves down permitting the switch arm 19 to return to its solid line position. Thus relay 1 is effective as an extended time delay relay when permitted to cool from its operating temperature as well as being heated thereto. In both instances the heat absorbed or given off as material 5 changes from one to the other of its physical states delays the change in temperature of disc 5 and the actuation of the set of switch contacts.

A typical application for thermal relays of this invention is as a defrost initiation thermostat in a refrigerator-freezer. In such an application the ambient of the relay would be about 35°–55°F. or perhaps lower, but in any event well below the temperature at which the thermal storage material will change from a solid to a liquid, or a liquid to a gas. The heater 9 stabilizes at a temperature of over 100°F., for example, and the thermal actuator is maintained in its "hot" curvature position at this temperature. The time delay utilized would be that required to permit the temperature of the disc and thermal storage device to drop to a temperature of about 50°F. or less whereupon the disc will abruptly change its curvature from its "hot" to its "cold" position. FIG. 2 illustrates the extended time delay obtained with a relay 1 using a thermal storage device with 97.1 g. of wax (obtainable under the trade designation DW37 from Dura Commodities Corporation of Harrison, N.Y.) with a melting point of about 80°F., a specific heat of 0.465 Cal./g. 25°C. and a heat of fusion of 55.3 Cal./g. The solid line curve of FIG. 2 illustrates the relation of temperature to time of relay 1 after the power to the heater 9 is cut off and the relay cools in an environment of about 52°F., the refrigerator ambient, as illustrated by the dashed line curve. As indicated, the relay temperature decreases in about 15 minutes from about 100°F. to about 80°F. at which temperature the relay substantially remains for about 3½ hours during the transition or change of state of the wax from a liquid to a solid, after which the relay temperature will drop to the refrigerator ambient of about 52°F. in about 45 minutes. Thus the delay between the time of deenergization of heater 9 and the snapping of the disc as it actuates from its "hot" to its "cool" curvature is greatly extended by the heat given off, in this instance, during the change of state of the wax.

It will be understood that the extent of the delay is conveniently controlled by the type and amount of thermal storage material used, the shape and type of capsule or container utilized for device 7, the type of heater used, the amount of insulation employed and the operating temperatures and differential of the thermal actuator used. Thus one skilled in the art can conveniently provide relays with any preselected delay and operating range in accordance with the present invention.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A time delay relay comprising:

a set of electrical contacts movable between circuit-making and circuit-breaking positions;

thermally responsive means for actuating said contacts to move them from one to the other position at a predetermined temperature;

thermal storage means in heat exchange relationship with the thermally responsive actuating means, said storage means comprising a body of material which will change from a first to a second physical state at a temperature intermediate that of the ambient of the relay and the predetermined temperature; and

heatable means in heat exchange relationship with said thermal storage means adapted to effect a transfer of heat therebetween and cause said material to change states whereby the transfer of heat between said heatable means and the thermally responsive means is delayed and the period of time required for the thermally responsive means to reach the predetermined temperature is extended.

2. A relay as set forth in claim 1 wherein the heatable means is a heater for supplying heat to the thermal storage means.

3. A relay as set forth in claim 2 wherein the heater is a body of electrical resistance material having a positive temperature coefficient.

4. A relay as set forth in claim 1 wherein the storage means material is one that is a solid at ambient temperatures and a liquid at the predetermined temperature.

5. A relay as set forth in claim 1 wherein the storage means material is a liquid at ambient temperatures and a gas at the predetermined temperature.

6. A relay as set forth in claim 4 wherein the storage means material is a wax.

7. A relay as set forth in claim 4 wherein the material is glycerol.

8. A relay as set forth in claim 3 wherein the thermally responsive means is a dish-shaped bimetallic disc which abruptly changes its curvature as its temperature exceeds the predetermined temperature and will abruptly revert to its original curvature after the temperature thereof falls below the predetermined temperature.

9. A relay as set forth in claim 8 wherein the storage means material is one that is a solid at ambient temperatures and a liquid at the predetermined temperature.

10. A relay as set forth in claim 9 wherein the relay contacts, thermally responsive means and heater are all enclosed in a housing of thermal insulation material.

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