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Hickling

[11] **3,849,756**

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[54] **NITINOL ACTIVATED SWITCH USABLE AS A SLOW ACTING RELAY**

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[52] **U.S. Cl.** **337/382,** 337/140
[51] **Int. Cl.** **H01h 37/50**
[58] **Field of Search**..................... 337/382, 393, 140

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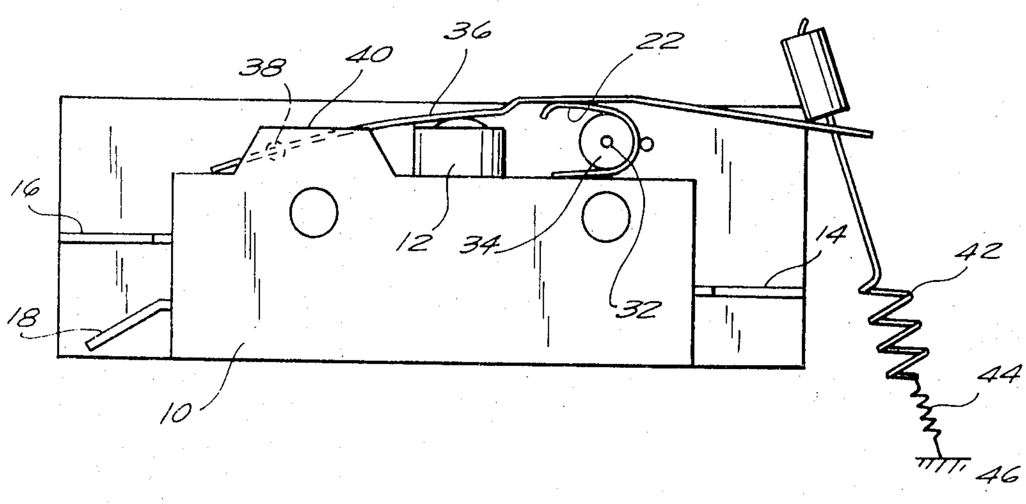
Primary Examiner—Harold Broome

[57] **ABSTRACT**

Apparatus usable as a slow acting relay is provided for changing the state of a switch in response to the presence of a given amount of thermal energy such as is produced by a selected magnitude of current flowing in a conductor. The switch which is used in conjunction with this apparatus is of the type which employs a pair of relatively movable contacts normally biased to retain the switch in a first state. A depressible actuating member for relatively moving the contacts against the bias to place the switch in a second state is operably connected to a thermally activated deformation element. The deformation element is in thermal communication with the conductor and will deform to depress the actuating member, thus changing the state of the switch, when the thermal energy generated by the conductor exceeds a given level. A second embodiment is additionally responsive to the heat generated by an external heat source. A second thermally activated deformation element is employed therein which is in thermal communication with the external heat source and operably connected to the actuating member to change the state of the switch when the heat from the external heat source exceeds a given level.

10 Claims, 10 Drawing Figures



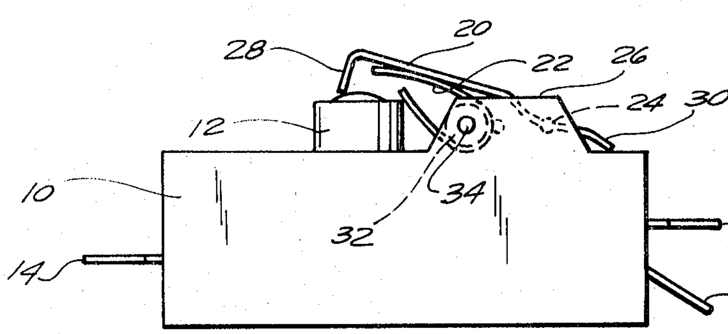


FIG. 1

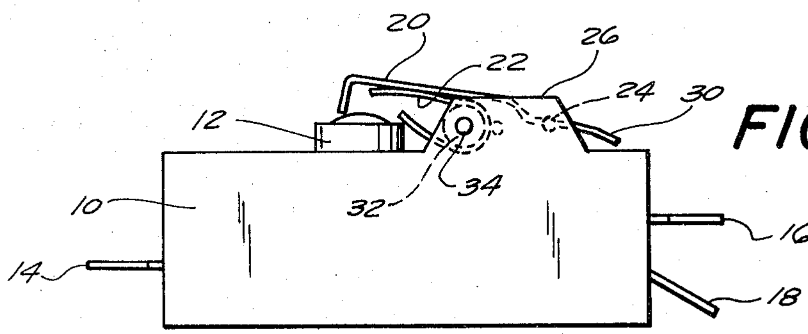


FIG. 2

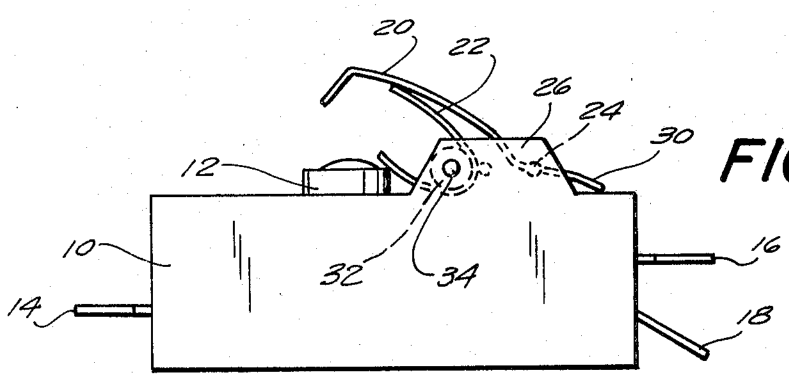


FIG. 3

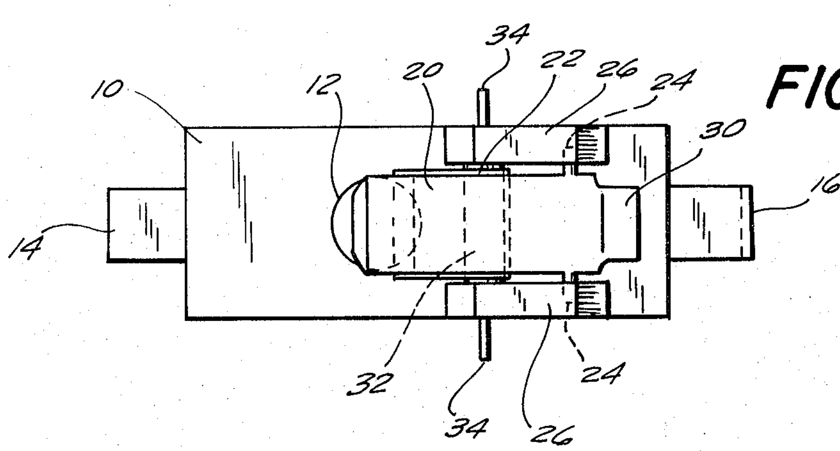


FIG. 4

FIG. 5

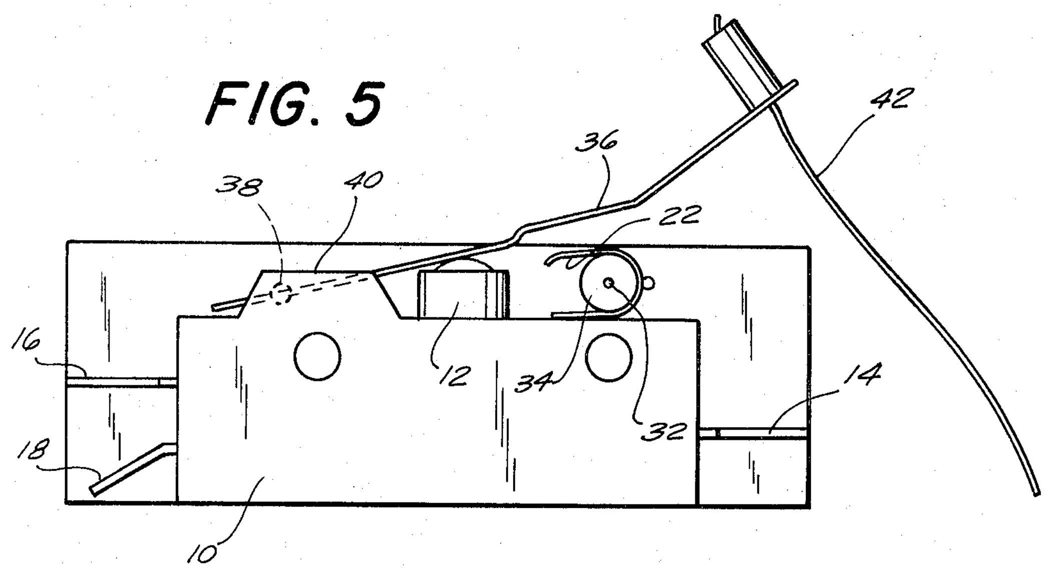


FIG. 6

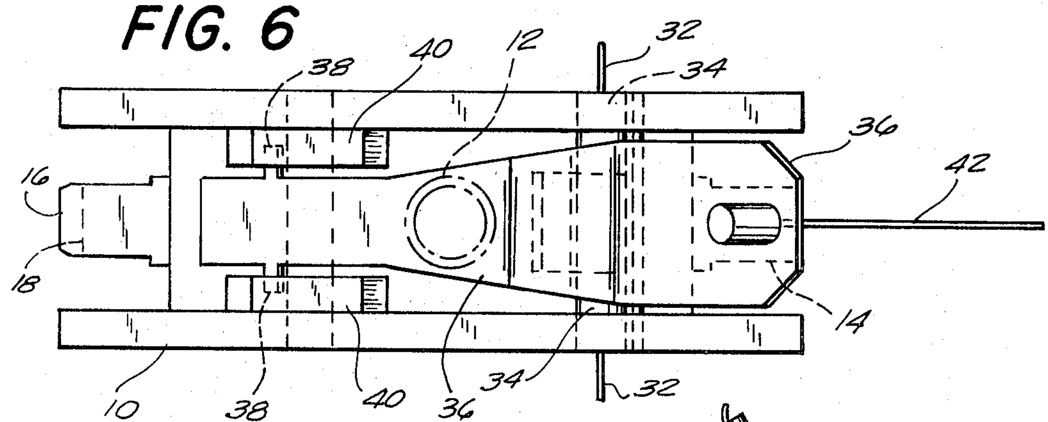


FIG. 7

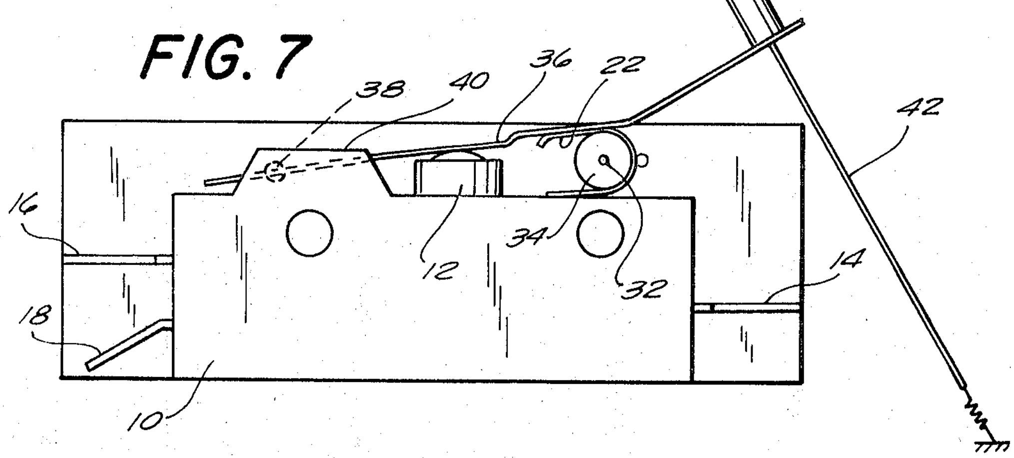


FIG. 8

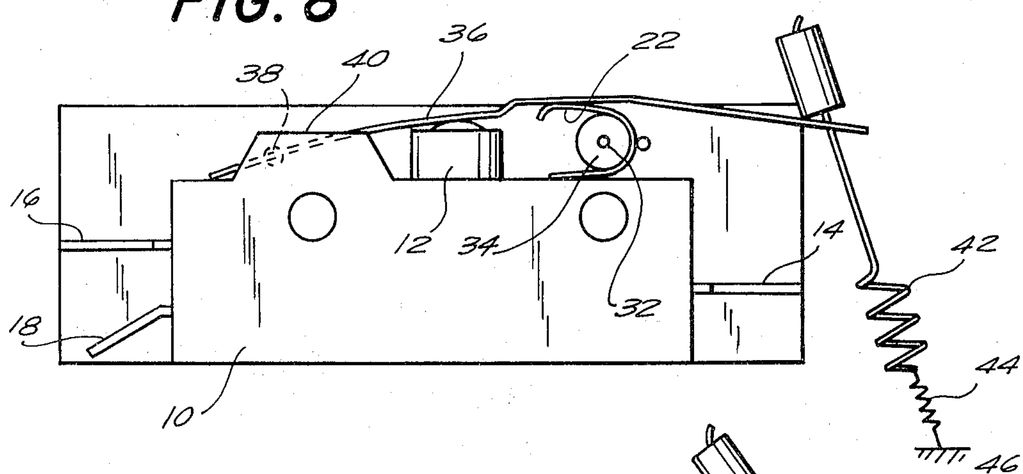
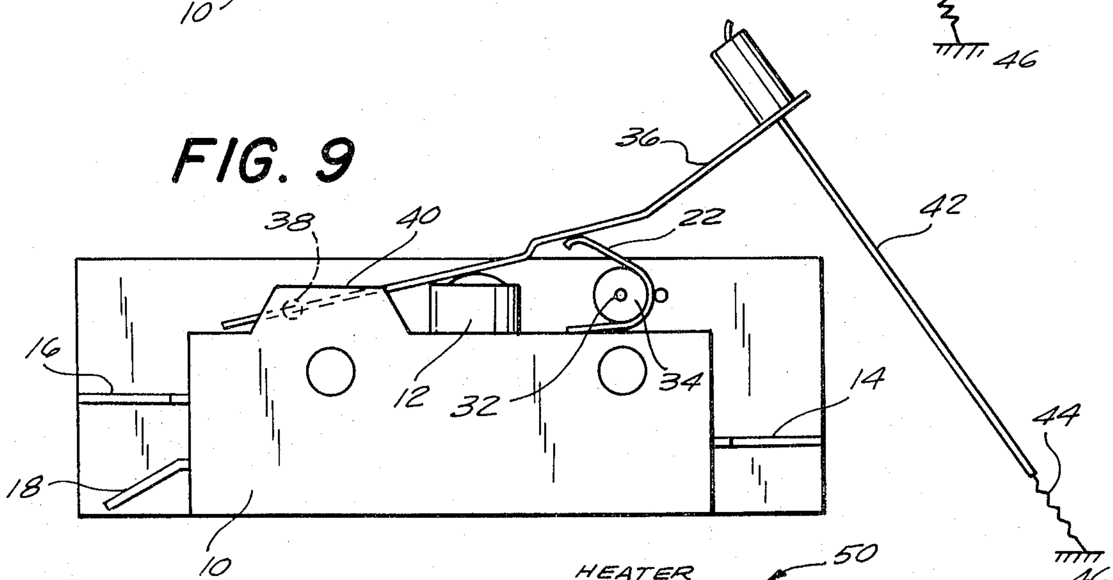


FIG. 9



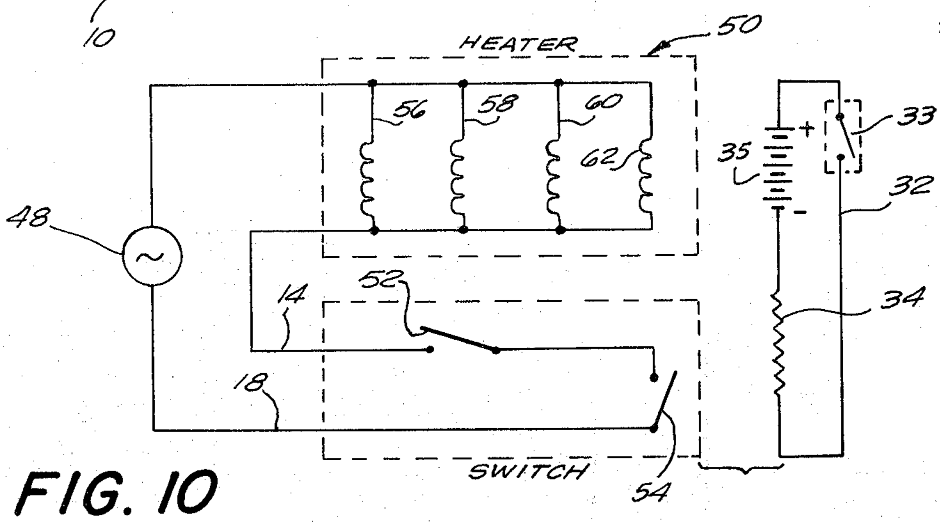


FIG. 10

NITINOL ACTIVATED SWITCH USABLE AS A SLOW ACTING RELAY

The present invention relates to temperature sensitive apparatus for changing the state of the switch in response to the presence of a given level of thermal energy and more particularly to apparatus for changing the state of a switch having a relatively long response time such that it may be utilized as a slow acting relay.

Devices which open or close a circuit in response to the occurrence of an external event, such as the presence of a selected magnitude of current flowing in a wire, have been known in the art and take many forms. Some of these devices are of the purely electrical type such as those using semiconductor switching devices. The response of such devices is substantially instantaneous with the occurrence of the proper biasing potential. Others of the electromechanical type, such as those which utilize a conventional electrical relay coil, also respond extremely quickly to current flow through the coil and for most purposes are considered to respond instantaneously, However, for some applications it is desirable, if not necessary, to have a device which will open or close an electrical circuit at a given time subsequent to the occurrence of the flow of current in a conductor which exceeds a selected magnitude. These devices are known as slow acting relays. Although many attempts have been made to produce a relatively simple, inexpensive, and reliable slow acting relay, these attempts have failed for a variety of different reasons, mostly pertaining to the size or complexity of the devices.

The apparatus of the present invention, which is usable as a slow acting relay and for a variety of other applications which will appear to one skilled in the art as the apparatus is described, utilizes the time lag inherent in the production of thermal energy by an electrically conducting material as a current flows through the conductor. This time lag is normally in the order of seconds or tens of seconds and can easily be controlled through the proper selection of resistivity of the conductor. Preferably, a resistor is utilized to produce the thermal energy because resistors of various sizes and compositions are inexpensive and readily available. Further, it is easy to determine the amount of thermal energy a given resistor will generate when a current of a given magnitude passes through it as well as the time necessary to develop the given amount of thermal energy. In this way the response time of the apparatus of the present invention can easily be determined.

The thermal energy generated by a resistor because of the current flowing therethrough is utilized in the present invention to cause the deformation of a temperature sensitive element. This deformation is then used to condition a switch in order to change the state of the switch to either open or close an electrical circuit.

Switches of the type which are utilized in conjunction with the apparatus of the present invention normally comprise a pair of relatively movable contacts which are biased by a spring to retain the switch in a first state and a depressible actuating member for moving the contacts against the bias of the spring to place the switch in a second state. Such a switch, for example, might be connected to control an external electrical mechanism, such as an electrical heater having a plurality of heating coils. The conductor of the apparatus of the present invention might be connected to a conventional thermostat which is responsive to room temperature. The thermostat, in turn is connected to a constant voltage source, whose output magnitude is sufficient to generate enough thermal energy in the resistor to deform the temperature sensitive element. If, for example, the thermostat senses that the room temperature is too low, the source is connected to the conductor thus charging the state of the switch to turn on the heater. On the other hand, if the room is too hot, the voltage source is not connected to the conductor and the heater remains off. The great advantage of the use of the present invention in such a system is that room temperature is kept more constant due to the slow response time of the system. Thus, temperature transients such as those which occur from air currents caused by drafts etc. which may be of a temporary nature, are not immediately over-reacted to, as they are in a conventional quick response system. The slow response of the system acts as a damper to insure reaction only when a true temperature has occurred in the room. After the room has returned to the desired temperature, the thermostat disconnects the voltage source from the conductor, thermal energy is no longer generated by the resistor and the deformation element softens. The biasing spring in the switch will then move the switch back to the original state thus turning the heater off again.

Further, with certain types of mechanisms it may be important to control the mechanism in accordance with the occurrence of two different and independent types of events. Moreover, it may be desirable to have the apparatus responsive to the occurrence of the individual events at different response times. For instance, in the previous example, the mechanism was regulated in accordance with room termperature. However, sometimes a heating element (which is normally physically remote from the thermostat) may be aerodynamically obstructed by, for example, drapes or clothing dropping on the heater orifice. In this case, the room temperature may be too low because of insufficient air circulation due to the obstruction. Thus the heater is kept on eventually causing a fire. It is therefore desirable to have a device which is slow acting with respect to room temperature, for the reasons described above, and yet which has a fast acting response in the event that overheating of the mechanism itself is occuring because of an obstruction.

The second embodiment of the present invention is designed to be responsive to the occurrence of two independent events and with different response times to the occurrence of the events respectively. In the second embodiment, in addition to the first deformation element which is in thermal communication with the conductor, a second deformation element is placed in thermal communication with an external heat source, such as the heater itself. If the heater begins to overheat the second deformation element deforms to activate the switch in order to open the circuit, thus turning off the heater. Thus, overheating which occurs independently at room temperature is immediately controlled regardless of the room temperature. Further, since the response of the second deformation element does not depend upon the thermal energy generated by a resistor, but directly senses the overheating, the response is immediate such that fire is prevented.

It is therefore the prime object of the present invention to provide apparatus for changing the state of a switch in response to the current flow in a conductor which has a relatively long response time and which does not utilize a conventional electrical relay coil or a semiconductor switching device.

It is another object of the present invention to provide apparatus for changing the state of a switch in which the response time can be controlled in accordance with the results desired.

It is another object of the present invention to provide temperature sensitive apparatus for changing the state of a switch controlling a heating mechanism connected thereto, which, when used in conjunction with a conventional thermostat can provide a slow acting response to temperature changes in order to regulate room temperature in a relatively stable manner.

It is a further object of the present invention to provide apparatus for changing the state of a switch controlling a mechanism connected thereto which is sensitive to two independent events occurring independently or jointly.

It is an additinal object of the present invention to provide apparatus for changing the state of a switch controlling a mechanism connected thereto which has inexpensively and easily produced parts which are reliably mounted for long life and which can be readily replaced in the event that repair of the apparatus is necessary.

In accordance with the present invention, apparatus for changing the state in response to the occurrence of certain external events is provided. The apparatus comprises a conductor having means operably connected therewith for controlling the current flowing therethrough. A resistor is electrically connected to the conductor and generates thermal energy in accordance with the current flowing in the conductor. A thermally activated deformation element is in thermal communication with the resistor and operably connected to the actuating member of the switch. The element deforms to actuate the actuating member to change the state of the switch when the thermal energy generated by the resistor exceeds a given level. A manual override member is additionally provided which is operably connected to the actuating member so that the actuating member can be actuated manually. The manual override member is a lever which is pivotally mounted on the switch housing to be movable between a first position wherein the actuating member is actuated by the lever and a second position wherein the lever is operably disconnected from the actuating member. The deformation member has a portion which is operably connected to the actuating member and another portion which is operably connected to the lever. In the element's undeformed state, these two portions are relatively close together. When the current flowing in the conductor generates sufficient thermal energy to deform the deformation element, these portions are relatively moved apart. This relative movement pivots the lever to the second position wherein it provides a structural abutment such that the change in configuration of the deformation member causes the actuating member to be actuated. When the deformation element is in the undeformed state, the lever can be moved to the first position wherein it actuates the actuating member. This movement of the lever toward the first position also serves to reset the deformation element into the undeformed configuration. Thus, the actuating member can be actuated by the deformation element or the manual movement of the lever to the first position.

In a second embodiment, the apparatus is sensitive to the occurrence of two independent events such as the thermal energy generated by current flowing in a conductor and the heat produced by an external heat source. This embodiment comprises resilient means operably connected to the switch actuation member. The resilient means is movable between a first position wherein the actuation member is deactivated, a second position wherein the actuating member is acutated, and a third position wherein the actuating member is again deactivated. Means are provided operably connected to the conductor for controlling the current flowing therethrough. A resistor connected to the conductor generates thermal energy in accordance with the current flowing in the conductor. A first thermally activated deformation element is provided in thermal communication with the resistor and operably connected to the resilient means such that the deformation of the first element, cause when the thermal energy generated by the resistor exceeds a given level, moves the resilient means to the first position. A second thermally activated deformation element is in thermal communication with the external heat source and operably connected to the resilient member such that the deformation of the second element, caused when the heat from the external source exceeds a given level, moves the resilient means to the third position. Means for biasing the resilient means to move from the first towards the second position is provided. The biasing means exerts a biasing force on the resilient member which is less than the force on the resilient member caused by the deformation of the first element and therefore does not counteract the deformation of the first element.

The resilient member of the second embodiment also comprises a lever which is pivotally mounted to the housing on which the switch is mounted. The lever is movable between a first, second and third position. In the first position the lever does not exert sufficient force on the actuating member to actuate the switch. In the second position the lever is held under sufficient tension by the biasing means, which acts through the second deformation element to actuate the actuating member. This is the normal operating position of the switch. When the resistor, which is in thermal communication with the first deformation element, generates sufficient thermal energy to deform the first deformation element, the element expands in order to move the lever to the first position. The biasing means exerts less force on the lever than the deformation of the first deformation element such that the force exerted by the biasing means is overcome and the lever moves to the first position thus changing the state of the switch. The deformation of the second deformation element, caused by an excess of heat produced by an external heat source, will move the lever to the third position. In this position the lever abuts against the first deformation element causing it to bend sufficiently to relieve the force on the actuating member thus changing the state of the switch. Therefore, the state of the switch is changed from its normal state to the second state when either of the deformation elements is deformed. This provides a temperature sensitive apparatus which will control external mechanism attached thereto in order to either switch it on or off when either of two independent events occurs, for example, a change in room temperature or overheating of the apparatus.

The resistor utilized in both embodiments is connected to the conductor to generate thermal energy in accordance with the current flow in the conductor caused by an external source. The first deformation element is in thermal communication with the resistor. The size and composition of the resistor are selected in accordance with the desired response time of the device. The lower the resistance of the resistor, the faster the thermal energy is generated when the voltage is at a given level, thus the quicker the response time of the device. Of course, care must be taken in the selection of the resistor to insure that it will not burn out. On the other hand, the resistor chosen must be capable of generating enough thermal energy to trigger the deformation element when the current exceeds the given level.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to apparatus for changing the state of a switch as defined in the appended claims and as described in this specification, taken together with the accompanying drawings in which like numerals refer to like parts and wherein:

FIG. 1 is a side elevational view of a first preferred embodiment of the present invention showing the switch in the first state;

FIG. 2 is a view similar to that shown in FIG. 1 wherein the actuating member is actuated by means of the manual override;

FIG. 3 is a view similar to that shown in FIG. 1 but wherein the actuating member is actuated by means of the deformation of the deformation element;

FIG. 4 is a top elevational view of the embodiment shown in FIG. 1;

FIG. 5 is a side elevational view of a second preferred embodiment of the invention showing the resilient means in the first position and wherein the biasing means has not been attached to the second deformation element;

FIG. 6 is a top elevational view of the embodiment illustrated in FIG. 5;

FIG. 7 is a view similar to that illustrated in FIG. 5 showing the resilient means in the second position such that the actuating member of the switch is actuated;

FIG. 8 is a view similar to that of FIG. 5 but wherein the second deformation element has been deformed to place the resilient means in the third position;

Fig. 9 is a view similar to that shown in FIG. 5 but wherein the first deformation element is deformed to place the resilient means in the first position; and

FIG. 10 is a circuit diagram showing how the second embodiment of the present invention can be connected to be used in conjunction with an external electric heater.

The switch preferred for use in conjunction with both embodiments of the invention described herein forms no part of the present invention and therefore its internal mechanism has not been illustrated in the drawings. However, such a switch functions by means of a pair of relatively movably contacts normally biased by a spring to retain the switch in a first state and an actuating member for relatively moving the contacts against the bias of the spring to place the switch in the second state. In the first preferred embodiment, as seen in FIGS. 1 through 4, the switch is normally supported by a housing or base **10** from which the switch actuating member **12** extends. The actuating member **12** is movable between a normal position, as shown in FIG. **1**, wherein the movable contacts are normally biased to retain the switch in the first state and a depressed position as shown in FIGS. **2** and **3** wherein the contacts have been moved against the spring bias to place the switch in the second state. The contacts of the switch are electrically connected to terminals **14**, **16** and **18** such that current flowing into the switch through terminal **14** will flow from the switch to terminal **16** when the switch is in one state and from the switch to terminal **18** when the switch is in the other state. Therefore, the switch can be utilized as a double throw switch when both terminals **16** and **18** are connected to external mechanisms. Alternately, when either terminal **16** or **18** is not connected to an external mechanism, the switch can be utilized as an on-off switch such that when the actuating member places the switch in a one state the external mechanism is switched on and when the actuating member causes the switch to be in the second state the external mechanism is turned off.

The position of actuating member **12** is controlled by the action of the manual override lever **20** and the deformation element **22**. The manual override lever **20** is pivotally mounted on housing **10** by means of a pair of colinear prongs **24** which extend into apertures provided for this purpose in the side portions **26** of the housing **10**. Side portions **26** extend vertically from the surface of housing **10**. The manual override lever **20** has a bent portion **28** which operably connects lever **20** to the actuating member **12**. Lever **20** also has a tail portion **30** which extends rearward from the pivot point of the lever in order to limit the moveent of manual override lever **20**.

Manual override lever **20** is movable between a first position wherein portion **28** depresses actuating member **12** to change the state of the switch and a second position wherein rear portion **30** rests against housing **10** and wherein portion **28** is operably disconnected from actuating member **12**. Manual override lever **20** is moved towards the first position by means of an external force which is exerted on the lever by the operator of the apparatus such that the switch can be manually operated when desired.

Deformation element **22** is also provided in operable connection with actuating member **12**. Preferably, deformation element **22** is made of a temperature sensitive material which will normally retain a first configuration without any appreciable change over a significant range of temperatures, but which when a particular temperature has been reached, will tend to change its configuration quite radically and exert an appreciable amount of force in doing so. One substance having this characteristic is a nickel titanium intermetallic compound known as nitinol. It is disclosed in U.S. Pat. No. 3,174,851 of Mar. 23, 1965, entitled "Nickel Based Alloys," U.S. Pat. No. 3,351,463 of Nov. 7, 1967 entitled "High Strength Nickel Based Alloys," and U.S. Pat. No. 3,403,238 of Sept. 24, 1968 entitled "Conversion of Heat Energy to Mechanical Energy," all of these patents being assigned to the United States of America as represented by the Secretary of the Navy. This material has a "memory." If it is given a first shape or configuration and subjected to appropriate treatment, and thereafter its shape or configuration is changed, it will retain the change shape or configuration until such time as it is subjected to a predetermined temperature level. When it is subjected to that temperature level, it tends quite strongly to return to its original shape or configuration. In this case, the original shape or configuration of the nitinol element 22 may be flat. The shape has then been changed to a U-shape wherein the portion which contacts the actuating member 12 and the portion which contacts the manual override lever 20 have been moved relatively close together, as shown in FIGS. 1 and 2.

The deformable element 22 is in thermal communication with a resistor 32 which is also mounted between the two vertically extending side panels 26 on housing 10. Resistor 32 forms part of an external circuit and has a constant voltage source (not shown) as part thereof. It is connected into the circuit by means of conductor 34 which is electrically connected to resistor 32.

Whether or not current flows through conductor 34 and therefore resistor 32 is controlled by a conventional thermostat (not shown). When this current flows the thermal energy produced by resistor 32 due to the current flow therein reaches a given level. When this given level is reached, the deformation element 22 will rapidly deform thus tending to move the portion operably connected to actuating member 12 and the portion operably connected to manual override lever 20 relatively away from each other. This movement will cause manual override lever 20 to move to a position wherein portion 28 no longer engages actuating member 12 and portion 30 abuts housing 10. This portion is shown in FIG. 3. Since manual override lever 20 can move no further because of portion 30, it acts as an abutment and the deformation of the deformation member 22 towards its original flat configuration causes actuating member 12 to be depressed in order to change the state of the switch.

For example, the apparatus of the first embodiment of the present invention could be used as an on-off switch for an electric heater. For this application, the electrical input for the heater from an electrical source would be connected in series with terminals 14 and 16 with terminal 18 remaining unconnected. The internal mechanism of the switch is such that when actuating member 12 is in the normal position, as shown in FIG. 1, terminal 14 is electrically connected to terminal 16 forming a closed circuit to turn the heater on and when the actuating member 12 is in the depressed position, as shown in FIGS. 2 and 3, terminal 14 is operably disconnected from terminal 16 thus forming an open circuit which would turn the heater mechanism off. Conductor 32 could be connected in series, for instance, with a constant voltage source and a conventional thermostat such that the thermostat, which is responsive to changes in room temperature, regulates the current through resistor 32. If the thermostat sensed too high a temperature the voltage source would be connected to resistor 32 which would generate thermal energy above a predetermined level and deformation element 22 would deform depressing actuating member 12 to turn the device off. After the room cooled off the thermostat would disconnect the source from resistor 32; no more thermal energy would be generated and the deformation element would soften. The bias spring in the switch would then return actuating member 12 to the original (undepressed) position to turn the mechanism on again. A force could then be applied to manual override member 20 sufficient to move the deformation member 22 back to its undeformed position (shown in FIG. 1) thus resetting the switch. Further, in the event that the operator wishes to manually change the state of the switch in order to turn the heater off, he could simply, any time during the operation of the switch, exert sufficient force on manual override member 20 to depress actuating member 12 as shown in FIG. 2. Thus, the heater would be turned off regardless of the temperature sensed by the thermostat.

FIGS. 5 through 9 illustrate a second preferred embodiment of the present invention. In this configuration the apparatus for changing the state of the switch is responsive independently to the current flowing in a conductor and to heat generated by an external heat source. A resilient lever 36 is pivotally mounted to housing 10 by means of two colinearly protruding prongs 38 which extend into the vertically extending side portion 40 of housing 10. Resilient lever 36 is movable between a first position wherein actuating member 12 is in the normal position, as shown in FIG. 5, a second position wherein actuating member 12 is depressed, as shown in FIG. 7 and a third position wherein actuating member 12 is again in the normal position as shown in FIG. 8. In this embodiment the deformation member 22 is again in thermal communication with a resistor 32 which is connected to the circuit of the mechanism to be controlled by conductor 34. However, in the second embodiment deformation member 22 is located on the opposite side of actuating member 12 from the pivot point of resilient lever 36. Situated on the end of resilient member 36 opposite to the one pivotally mounted to the housing is an operable connection between a second deformation element 42 and resilient lever 36. Second deformation element 42 is preferably made of nitinol, the same material that deformation element 22 is made of. However, deformation element 42 has an original configuration of a coiled wire as shown in FIG. 8 and a changed configuration of a straight wire as shown in FIG. 7. At the opposite end of deformation element 42 is a spring biasing means 44 which is operably connected between deformation element 42 and an anchoring structure 46. Spring biasing means 44 exerts a force on resilient lever 36 through second deformation element 42 which is less than the force exerted on resilient lever 36 by deformation element 22 when deformation element 22 deforms. Therefore, as shown in FIG. 9, when deformation element 22 deforms, resilient lever 36 is moved into the first position against the biasing of spring lever 44 and actuating member 12 is depressed from its normal position shown in FIG. 5, thus causing the switch to assume a desired one of its states.

Second deformation element 42 is in thermal communication with an external heat source (not shown). When the heat generated by the external heat source reaches a certain level, the deformation element 42 deforms into its original configuration which is a coil, as shown in FIG. 8. This deformation creates a downward force on resilient member 36 which causes resilient member 36 to bend about a fulcrum point provided by deformable element 22. The bending of this lever causes the portion of the lever which normally contacts actuating member 12 to move upward to eliminate the force exerted by it on actuating member 12 thus allowing actuating member 12 to rise to its normal position as shown in FIG. 5 and therefore change the state of the switch.

As an example, the apparatus of the second preferred embodiment can be connected into a circuit to control an electric heater as shown in the schematic diagram of FIG. **10.** In this diagram the switch is theoretically divided into two switches **52** and **54,** each of which represents one function of the apparatus of the second embodiment. Heater **50** has a plurality of parallel heating coils **56, 58, 60, 62.** The switch is connected in series between heater **50** and an external power source **48** shown here as a conventional **120** volt alternating current power source.

Resistor **34** is connected to a constant voltage source, such as battery **35** through a conventional thermostat **33.** The switch is turned on by moving the resilient lever **36** from the first position as shown in FIG. **5** to the second position as shown in FIG. **7** and attaching biasing spring **44** to structural member **46** to keep it in that position. Actuating member **12** is thus depressed by the force exerted on it by resilient lever **36** and terminal **14** is electrically connected to terminal **18** thus permitting current to flow from source **48** to heater **50.** At this point both switch functions **52** and **54** are in the closed position and the circuit is operating.

Initially, no current is flowing through conductor **32** and thus resistor **34** because room temperature is low enough to keep thermostat **33** in the opened position. Should the temperature increase sufficiently to cause thermostat **33** to close, battery **35** will be connected to resistor **34,** resistor **34** will heat beyond a given level such that deformation member **22** will deform to move resilient member **36** to the first position. This movement will take place against the force exerted on resilient member **36** by bias spring **44.** This situation is shown in FIG. **9.** The deformation of element **22** will serve to open switch **54** thus turning off any current to heater **50** from source **48.** Once the room temperature reaches the desired level, thermostat **33** will open, resistor **34** cool and element **22** soften such that spring **44** will move element **22** back to the undeformed state. The activation member **12** is thus depressed to close the circuit and to reactivate the heater.

Should the heater elements themselves be aerodynamically obstructed in some way and thus produce a heat build up beyond a given level, this will be detected by the second deformation element **42** which is in thermal communication with the heater **50.** At this point the second deformation element **42** will suddenly change its configuration from the straight configuration shown in FIG. **7** to the coiled configuration shown in FIG. **8** thereby abruptly pulling the resilient lever **36** into the bent position thus releasing actuating member **12** to open the circuit. In FIG. **10** this would be shown by opening switch **52** which again would stop all current flow through heater **50** from source **48.** After the obstruction has been cleared, the switch can be reset by stretching deformation member **42** into its original straight configuration and therefore putting it back into the state as shown in FIG. **7.**

It can therefore be seen that the apparatus of the second preferred embodiment is both sensitive to the current passing through resistor **34** as well as the heat generated by heater **50.** Should an obstruction occur and thus the element generate more heat than a given preselected level, the heater circuit will be opened thus stopping any current to the heater until an operator has corrected the obstruction and reset the apparatus.

Two preferred embodiments of the present invention have been specifically disclosed herein for purposes of illustration It is apparent that many variations and modifications may be made upon the specific structures disclosed herein. It is intended to cover all of these variations and modifications which fall within the scope of this invention as defined by the appended claims.

I claim:

1. Apparatus for changing the state of a switch in accordance with the current in a conductor, said switch being of the type having a pair of relatively movable contacts normally biased to retain the switch in a first state and an actuating member for relatively moving the contacts against the bias to place the switch in a second state, said apparatus comprising a housing for said switch, a conductor, means operatively connected to said conductor for controlling the current flowing therethrough, said conductor generating thermal energy in accordance with the current flowing therethrough, a lever pivotally mounted on said housing, said lever being movable between a first position wherein said lever is operably connected to said actuating member to actuate said member and a second position wherein said lever is operably disconnected from said actuating member, and a thermally activated deformation element in thermal communication with said conductor and having a first portion operably connected to said actuating member and a second portion operably connected to said lever, said first and second portions being relatively close to one another when said element is in the undeformed state, said element deforming to move said first and second portions away from each other where the thermal energy generated by said conductor exceeds a given level such that said lever is moved to said second position and said actuating member is actuated.

2. Apparatus for changing the state of a switch in accordance with the current in a conductor and the heat produced by an external heat source, said switch being of the type having a pair of relatively movable contacts normally biased to retain said switch in a first state and an actuating member for relatively moving the contacts against the bias to place said switch in a second state said apparatus comprising resilient means operably connected to said actuation member, said resilient means being movable between a first position wherein said actuation member is deactuated and a second position wherein said actuation member is activated, a conductor, means operably connected to said conductor for controlling the current flowing therethrough, said conductor generating thermal energy in accordance with the current flowing therethrough, and a first thermally activated deformation element in thermal communication with said conductor and operably connected to said resilient means such that the deformation of said first element caused when the thermal energy generated by said conductor exceeds a given level moves said resilient means to said first position.

3. The apparatus according to claim **2** wherein said resilient means is additionally movable to a third position wherein said activation means is deactivated.

4. The apparatus according to claim **3** further comprising a second thermally activated deformation element, said element being in thermal communication with said heat source and being operably connected to said resilient member such that the deformation of said second element, caused when the heat from said source exceeds a given level, moves said resilient means to said third position.

5. The apparatus according to claim **2** further comprising means for biasing said resilient means to move from said first position towards said second position.

6. The apparatus according to claim **5** wherein said biasing means exerts a biasing force on said resilient member which is less than the force on said resilient member caused by the deformation of said first element.

7. The apparatus according to claim **3** wherein said resilient member is a lever.

8. The apparatus according to claim **7** wherein said lever is in operable communication with said first element when said lever is in said second and said third positions.

9. The apparatus according to claim **7** wherein said first element abuts against said lever causing it to bend sufficiently to deactivate said activation member when said lever is in said third position.

10. Apparatus for changing the state of a switch in accordance with the current in conductor and the heat produced by an external heat source, said switch being of the type having a pair of relatively movable contacts normally biased to retain said switch in a first state and an actuating member for relatively moving the contacts against the bias to place said switch in a second state, said apparatus comprising a housing for said switch, a lever pivotally mounted on said housing and operably connected to said actuating member, said lever being movable between a first position wherein said actuating member is deactuated, a second position wherein said actuating member is actuated and a third position wherein said actuating member is deactivated, a conductor, means operably connected to said conductor for controlling the current flowing therethrough, said conductor generating thermal energy in accordance with the current flowing therethrough, a first thermally activated deformation element in thermal communication with said conductor and operably connected to said lever, said element deforming to move said lever from said second to said first position when the thermal energy generated by said conductor exceeds a given level, a second thermally activated deformation element, said element operably connected to said lever and in thermal communication with said heat source, said second element deforming to move said lever from said second to said third position when the heat generated by said source exceeds a given level and biasing means for biasing said lever from said first position to said second position, said biasing means exerting a force on said lever which is less than the force exerted on said lever by the deformation of said first element.

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