Nov. 6, 1962 C. D. FLANAGAN 3,062,937

ELECTRICAL SWITCHES

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Fig. 1.

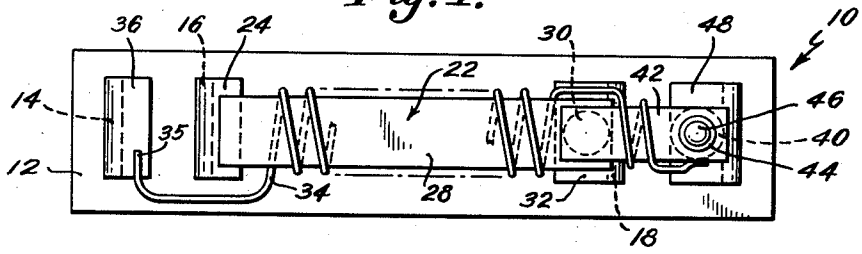


Fig. 2.

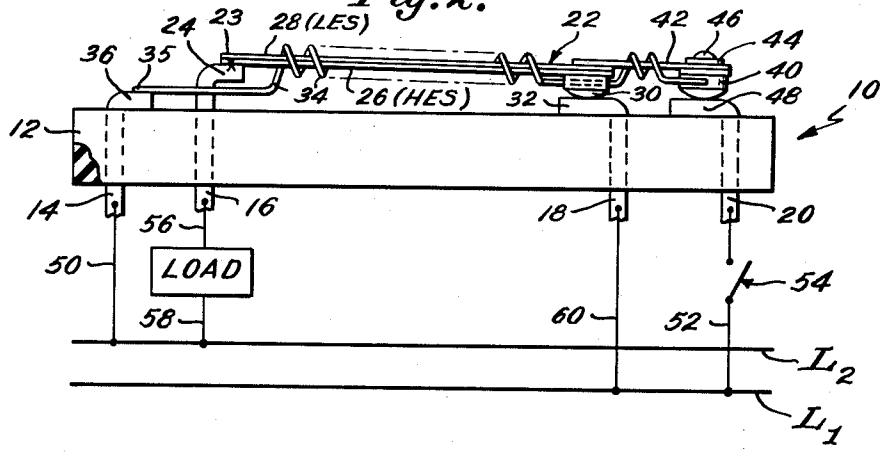


Fig. 3.

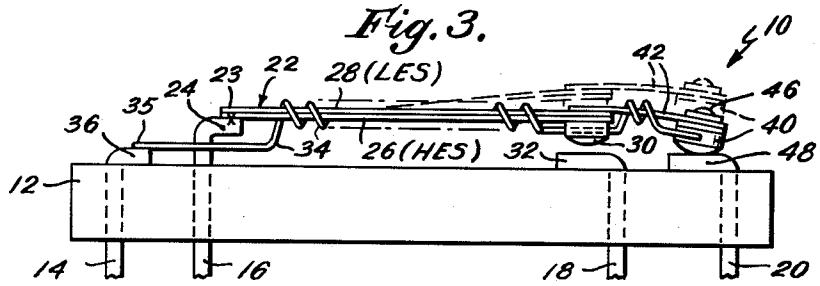
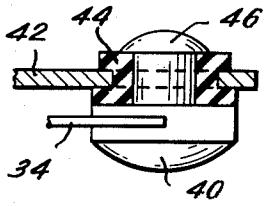


Fig. 4.



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ELECTRICAL SWITCHES

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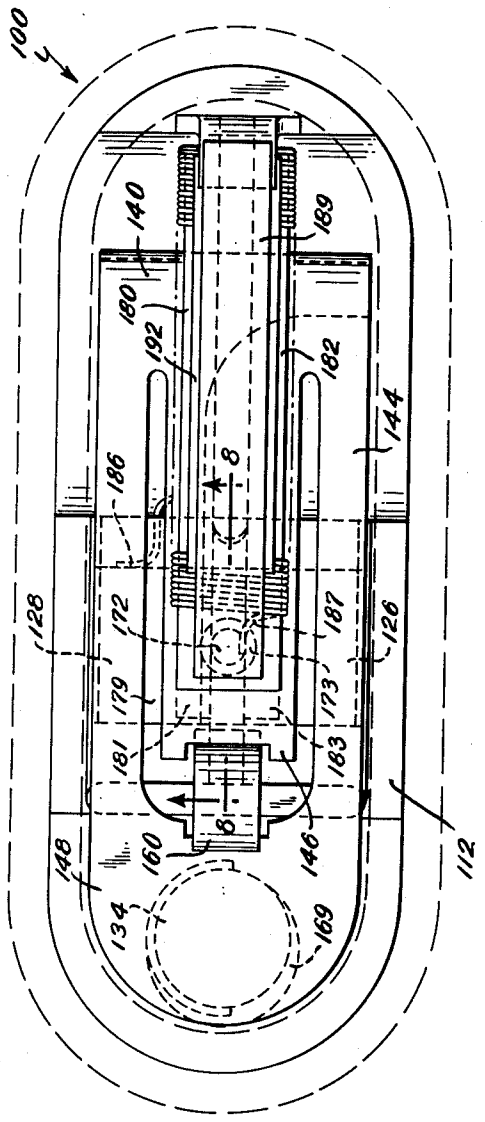

Fig. 5.

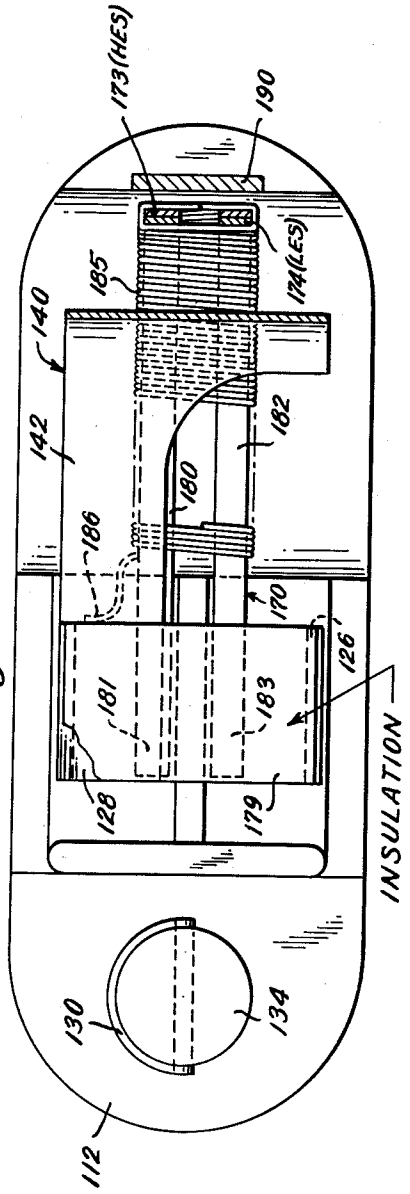

Fig. 6.

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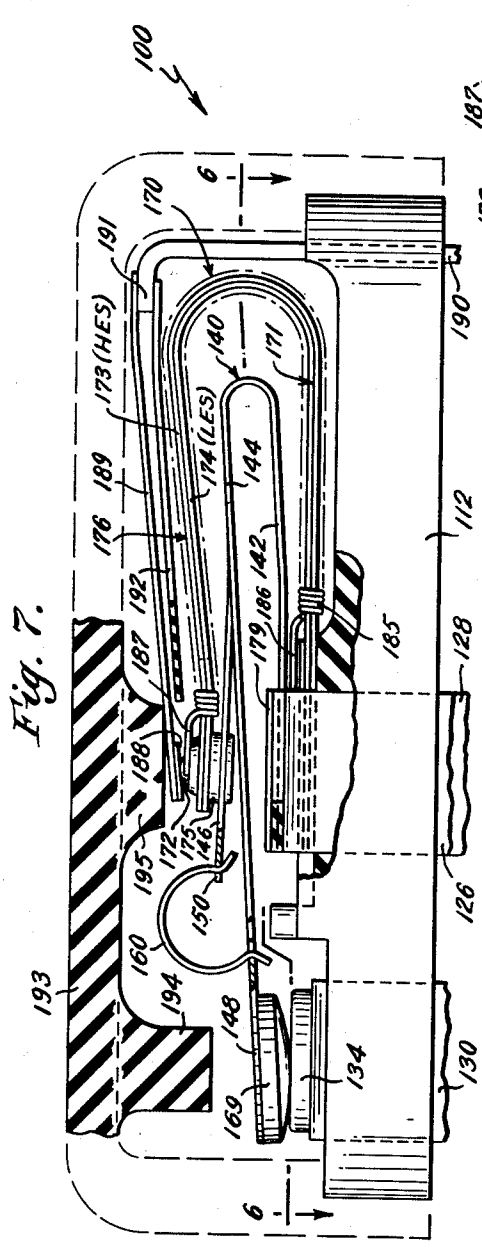

Fig. 7.

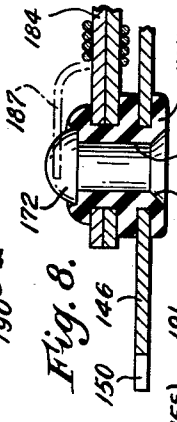

Fig. 8.

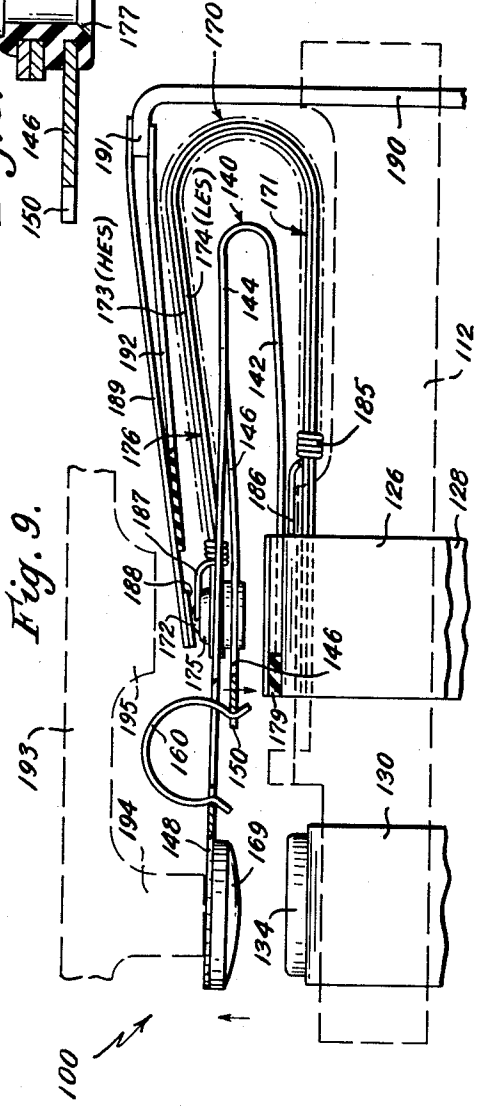

Fig. 9.

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Fig. 10.

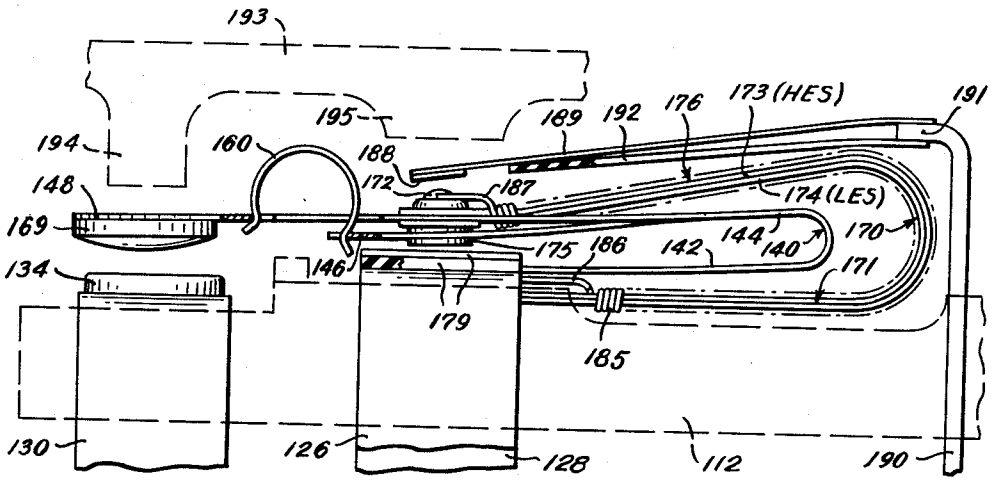

Fig. 11.

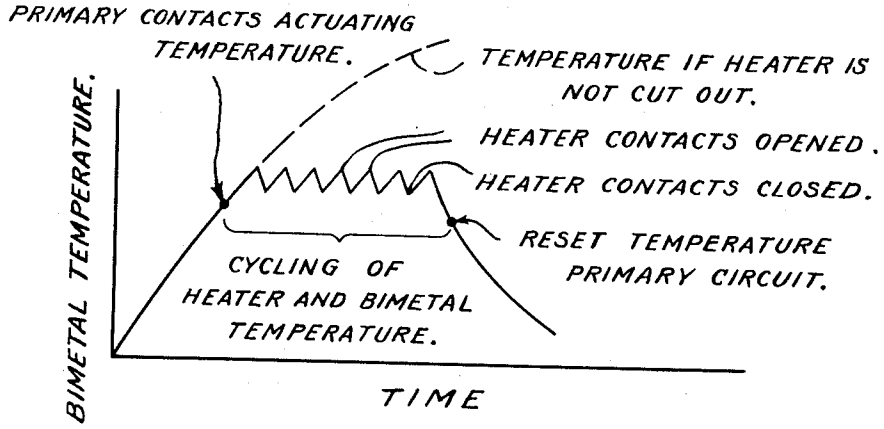

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Fig. 12.

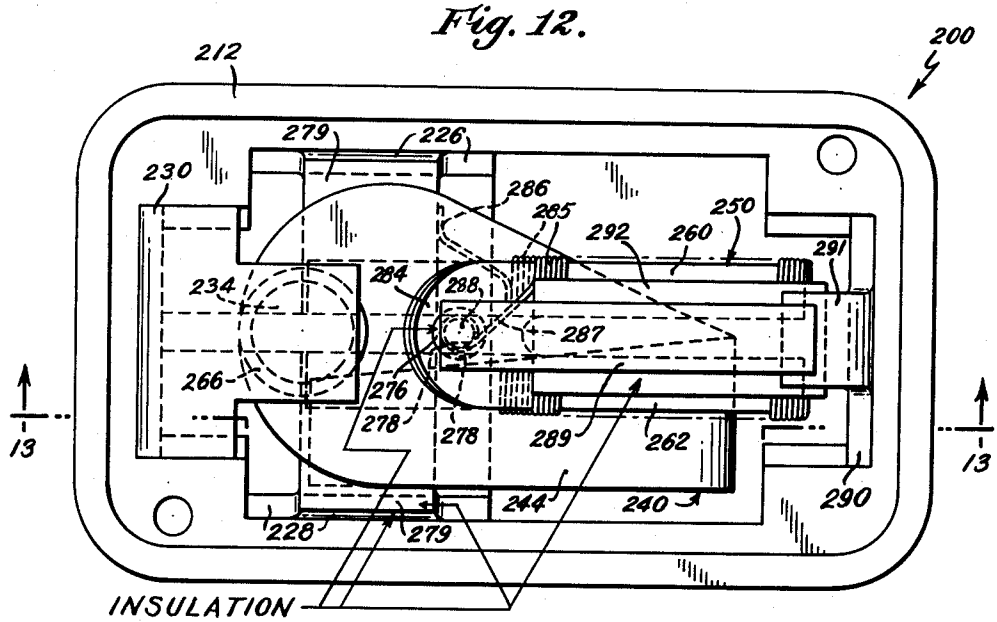

Fig. 13.

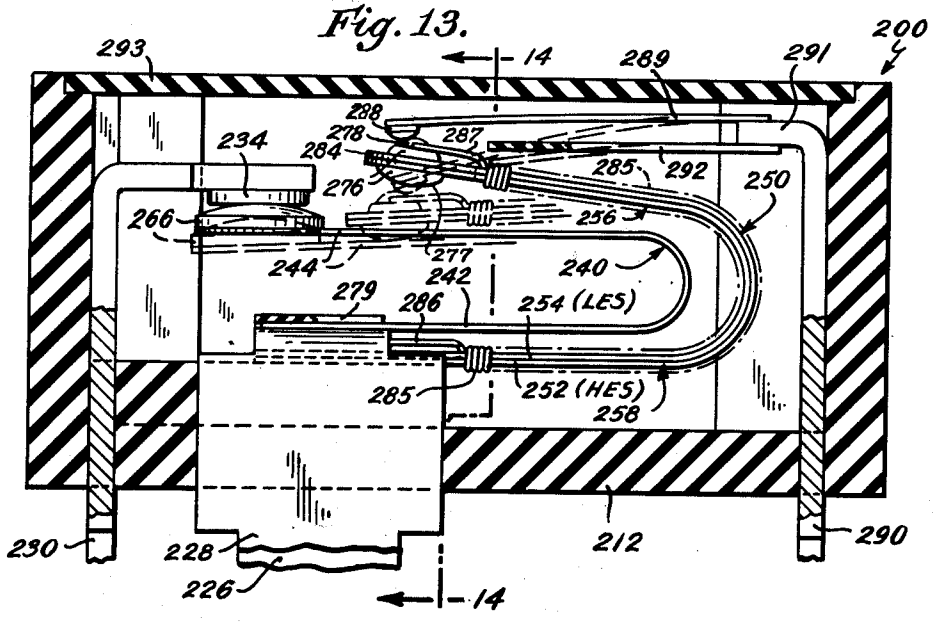

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Fig. 14.

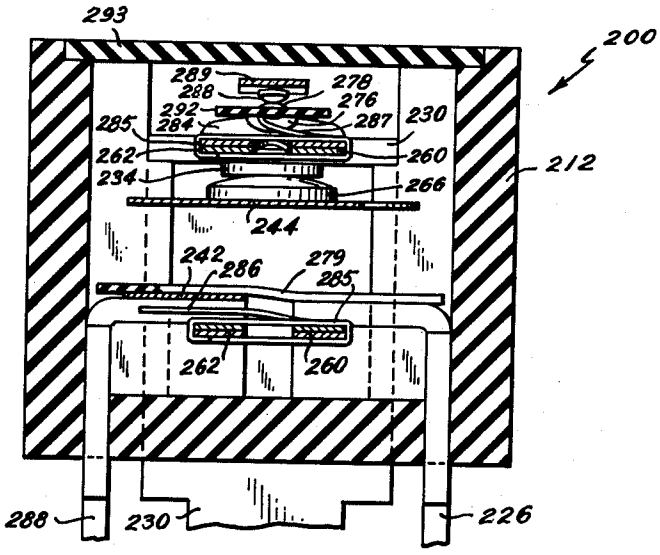
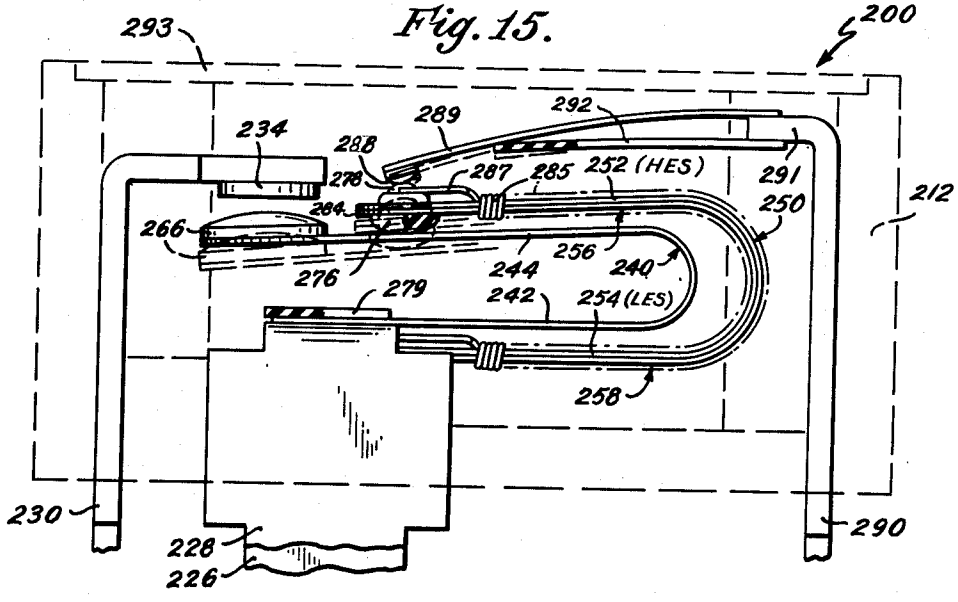


Fig. 15.



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United States Patent Office

3,062,937

Patented Nov. 6, 1962

3,062,937

ELECTRICAL SWITCHES

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Filed Feb. 5, 1960, Ser. No. 6,950
11 Claims. (Cl. 200—122)

The instant invention relates to electrical switches, and more particularly, to thermal time delay relays.

In devices of this kind, one of the principal difficulties encountered is the provision of a thermal time delay relay which has a relatively short reset time and at the same time, provides a very high initial heat input to afford accurate timing.

It is accordingly one object of the instant invention to provide a thermal time delay relay which has a relatively short reset time.

It is another object of the instant invention to provide a thermal time delay relay which utilizes a heater means and which is provided with a very high initial heat input which affords accurate timing characteristics.

It is yet another object of the instant invention to provide a thermal time delay relay which affords both accurate timing and a relatively short reset time.

It is yet another object of the instant invention to provide a thermal time delay relay which utilizes an electrically conductive bimetal element and heater means therefor and wherein the bimetal element is protected from overheating and burnout.

It is yet another object of the instant invention to provide a thermal time delay relay which utilizes a thermally responsive element and a heater, and wherein the thermally responsive element is maintained at a temperature just slightly above its reset temperature to afford a relatively short resetting time.

It is yet another object of the instant invention to provide a thermal time delay relay which affords a quick circuit breaking and making (or resetting) operation.

Other objects will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the elements and combinations of elements, features of construction, and arrangements of parts which will be exemplified in the structures hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated:

FIG. 1 is a top plan view of a relay according to one embodiment of the instant invention;

FIG. 2 is a side elevational view of the switch shown in FIG. 1, in combination with a schematic wiring diagram;

FIG. 3 is a view similar to FIG. 2, indicating relative movement between parts;

FIG. 4 is an enlarged sectional view of a detail of construction of the switch shown in FIGS. 1 and 2;

FIG. 5 is a top plan view of an electrical switch according to another embodiment of the instant invention;

FIG. 6 is a sectional view of the electrical switch shown in FIG. 5 taken on line 6—6 of FIG. 7;

FIG. 7 is an elevational view of the switch shown in FIGS. 5 and 6, with portions thereof broken away, and shown in phantom lines;

FIG. 8 is a sectional view of a portion of the switch taken on line 8—8 of FIG. 5;

FIG. 9 is a sectional elevational view similar to FIG. 7, indicating relative movement between parts;

FIG. 10 is a view similar to FIG. 9, indicating further relative movement between parts;

FIG. 11 is a diagram illustrating the relationship between the bimetal temperature and time, as effected by the heater;

FIG. 12 is a top plan view of an electrical switch according to another embodiment of the instant invention;

FIG. 13 is a sectional view taken on line 13—13 of FIG. 12;

FIG. 14 is a sectional view taken on line 14—14 of FIG. 13; and

FIG. 15 is a side elevational view similar to FIG. 13, illustrating relative movement between parts.

Similar reference characters indicate corresponding parts throughout the several views of the drawings.

Dimensions of certain of the parts as shown in the drawings have been modified for the purposes of clarity of illustration.

It is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring now to the drawings, there is illustrated in FIGS. 1–4 a relay according to a first embodiment of the instant invention generally referred to by numeral 10. Relay 10 includes a base 12 which may be formed of one of the conventional electrically insulating plastics. Base 12 has mounted therein a plurality of electrically conducting terminals 14, 16, 18 and 20, as best seen in FIGS. 2 and 3. Thermal relay 10 includes an electrically conducting, creep-type thermostatic element indicated generally at 22. Thermally responsive member 22 is electrically connected to and cantilever mounted on an upper bent-over portion 24 of terminal 16 such as by welding or the like. Creep-acting thermal element 22 may be formed of a conventional thermostatic material such as bimetal, formed of two layers 26 and 28 having unequal coefficients of thermal expansion, with layer 26 having the higher coefficient of expansion. Layers 26 and 28, which are respectively the high and low expansion layers, are respectively represented in the drawing by HES and LES. Thermally responsive element 22 is provided, adjacent its free end, with an electrical contact 30 electrically connected thereto, as shown. Contact 30 is adapted to mate with a stationary electrical contact 32 provided by terminal 18.

Thermal time delay relay 10 is further provided with a heating element 34. Heater means 34 may be formed of a conventional electrical resistance wire and be provided with an electrically insulating coating. Heater means 34 is electrically connected at one end 35 to a bent-over portion 36 of terminal 14, and is wound or wrapped about thermally responsive member 22 substantially throughout its entire length. Heating element 34 is thus maintained in thermal juxtaposition with the thermally responsive element 22 throughout substantially the entire length thereof. The other end of heater means 34 is electrically connected to an electrical contact 40. Contact 40 is mounted in electrically insulated relation to and at one end of a spring element 42 for a purpose later to be described.

Referring now to FIG. 4, electrical contact 40 is mounted on spring member 42 in electrical insulated relation therewith by means of an electrically insulating bushing 44. Bushing 44 is disposed about shank portion 46 of the electrical contact member 40, as best seen in this figure. Bushing 44 may be formed of an electrically insulating material such as, for example, mylar or Teflon (the latter being a registered trademark to E. I. du Pont de

Nemours & Co. for a plastic consisting of a tetrafluoroethylene polymer). Spring member 42 is cantilever mounted on thermally responsive element 22, as shown. Contact 40 (which is carried by spring member 42) is adapted to mate with stationary contact 48 which is provided by electrically conducting terminal 20.

Referring now to FIG. 2, it can be seen that thermal relay 10 provides two electrically conducting paths, one leading from terminal 14 to heater means 34 to contact 40, to contact 48 and to terminal 20 and the other leading from terminal 16, through thermally responsive element 22 to contact 30, to contact 32 and to terminal 18. Spring member 42 biases contact 40 into engagement with contact 48. Spring member 42 is so biased that contacts 40 and 48 will remain in engagement for a predetermined period of time and predetermined movement of thermally responsive member 22 in response to a predetermined increase in temperature thereof to separate contacts 30 and 32.

Referring now to FIG. 2, the thermal relay 10 is schematically illustrated in an exemplary circuit. In the exemplary circuit of FIG. 2, terminal 14 is electrically connected to L_2, one side of a power source, by conductor 50. Terminal 20 is electrically connected by conductor 52 to L_1, the other side of the power source, through a conventional line switch generally referred to by numeral 54. Terminal 16 is electrically connected by conductor 56 to a load L which is electrically connected by conductor 58 to L_2. Terminal 18 is electrically connected to L_1, the other side of the power source, by conductor 60.

In operation, when line switch 54 is closed and contacts 30, 32 and 40, 48 are closed, two electrically conductive paths are established; one leading from L_2, through conductor 50, terminal 14, heater means 34, contact 40, contact 48, terminal 20, conductor 52, line switch 54, to L_1; and another path leading from L_2, through conductor 58, load L, conductor 56, terminal 16, thermally responsive member 22, contact 30, contact 32, terminal 18, electrical conductor 60 to L_1.

The operation of thermal relay 10 is substantially as follows. When the circuits as described above are energized, the thermally responsive element 22 will be heated both by the load current traversing it and by the heat generated by heater means 34 which is in thermal juxtaposition therewith. Thermally responsive element 22, when heated to a predetermined amount by excessive load current, will flex and move upwardly from the position shown in FIG. 2 to the solid and dashed-line positions, as shown in FIG. 3, to separate contacts 30 and 32 and thereby de-energize the load circuit. Initially, when contacts 30 and 32 are separated, as shown in full lines in FIG. 3, contacts 40 and 48 will still be maintained in engagement by spring member 42. In this condition, thermally responsive element 22 will continue to be heated by heating element 34 (the circuit for which is still energized) and will continue to move upwardly in response thereto. As thermally responsive element 22 continues to move upwardly, spring member 42 and contact 40 will also be moved upward, as seen in FIG. 3, until contacts 40 and 48 open and thereby de-energize the heater circuit. After contacts 40 and 48 are open, thermally responsive element 22 will cool and move downwardly, as seen in FIGS. 2 and 3, and will permit contacts 40 and 48 to again close under the bias of spring member 42 before contacts 30 and 32 are closed. Reclosing of contacts 40 and 48 re-energizes the heater circuit and causes further heating and upward movement of thermally responsive element 22 to again open contacts 40 and 48. From the above, it can thus be seen that once having opened load circuit contacts 30 and 32, thermally responsive element 22 will maintain these contacts open and will hunt between a position in which both contacts 30, 32 and heater circuit contacts 40, 48 are open and a position in which contacts 30, 32 are open and heater circuit contacts 40, 48 are closed. This cyclic action will continue as long as line switch 54 is closed. Contacts 40, 48 in cycling between the contacts open and closed position while load circuit contacts 30, 32 are open, are effective to maintain thermally responsive means 22 at a lower temperature which is slightly above the reset temperature of the device (that is that temperature at which thermally responsive means 22 will effect the closing of load circuit contacts 30, 32 to re-energize the load circuit). Contacts 40, 48, spring member 42 and heater 34, by co-operating with the thermally responsive means 22, as described above, to maintain the latter at the aforementioned lower temperature, advantageously afford a quick reset of the device. Further, the bias of spring member 42 is such that contacts 40 and 48 will open in response to predetermined movement of thermal element 22 to de-energize the heater circuit so as to prevent overheating and burnout of both the heater element and the thermally responsive means 22.

Referring now to the graph of FIG. 11 which illustrates the operation of the device, it can be seen that thermal time delay relay 10 provides a very high initial heat input to afford accurate timing and also maintains the thermally responsive element at a temperature which is just slightly above its reset temperature. Thus, it can be seen that the creep-acting thermally responsive element 22 will move in response to predetermined temperature and current conditions to open the contacts quickly while operating on the linear portion of the exponential heating curve, i.e. at the point labeled, "Primary Contacts Actuating Temperature," shown on the curve in FIG. 11. After having opened the contacts 30, 32, the thermally responsive element 22 will continue to be cyclically heated by heating element 34, as shown in the graph (i.e. contacts 40 and 48 will hunt between open and closed position while contacts 30, 32 are open, as described above) until line switch 54 is opened. When line switch 54 is opened, thermally responsive element 22 will quickly cool to its reset temperature, i.e. the point on the graph of FIG. 11 labeled, "Reset Temperature Primary Circuit." The dashed-line portion of the curve indicates what the rise in temperature of the thermally responsive element would be after opening contacts 30 and 32, without the provision of spring member 42 and contacts 40 and 48 for cyclically de-energizing the heater.

Thus it can be seen that relay 10 provides a device which affords a short reset time, relatively quick opening of contacts and a device wherein the bimetal thermostatic element and heater are protected from overheating and burnout.

It should be understood that while contacts 30 and 32 have been illustrated as being normally closed in the circuit as shown in FIG. 2, the relay may be used in other circuits wherein contacts 30 and 32 would be normally open. Further, it should be understood that thermally responsive element 22 need not be current conducting but could also be only thermally responsive to effect opening and closing of contacts. Further, it should be noted that while a creep-acting thermally responsive element 22 has been shown, the thermally responsive element may also be snap-acting.

It should also be noted that although the point in temperature at which the heater contacts reclose has been illustrated in FIG. 11 to be at a temperature above both the primary contacts actuating and reset temperature, this point of temperature can also be below the primary contacts actuating temperature and above the reset temperature within the purview and practice of the instant invention.

Referring now to FIGS. 5–10 of the drawings, there is illustrated a relay, according to another embodiment of the instant invention, generally referred to by numeral 100. Relay 100, as illustrated in FIGS. 5–10, embodies certain features of construction which are similar to or may be substantially identical to corresponding features

of the thermal relay disclosed and claimed in a copending application, Serial No. 830,319, filed July 29, 1959, assigned to the assignee of the instant application. Reference may be had to this copending application for specific details of construction common to the thermal relays disclosed therein and in the instant invention, as noted hereinafter.

In general, relay **100** includes a base member **112** formed of a conventional electrically insulating plastic, electrically conductive terminals **126**, **128** and **130** mounted on base **112**, electrically conducting snap-acting switch means **140** and a thermally responsive member **170**, each of which may be substantially identical to their respective counterparts in the relay disclosed and claimed in the aforementioned copending application. As is more fully described in the aforementioned copending application, switch means **140** comprises a U-shaped member formed of an electrically conducting material, having a lower leg **142** and an upper leg **144**. Lower leg **142** is mounted on and electrically connected to terminal **128**, as by welding. The upper leg provides two integrally connected, contact-carrying arms **146** and **148**. Arm **148** has mounted at its free end an electrical contact **169** adapted for engagement with a contact **134** provided by electrically conducting terminal **130**, as best seen in FIGS. 7 and 9. Switch means **140** also includes a thin C-shaped overcenter toggle spring **160** which is connected to arms **146** and **148**, as shown, and is effective to maintain arm **148** in one of two positions of stability corresponding to a contacts-open and contacts-closed position.

Thermally responsive member **170** may be formed of a conventional thermostatic material, such as a bimetal, formed of two layers **173** and **174** having unequal coefficients of thermal expansion, with outer layer **173** having the higher coefficient of thermal expansion. Layers **173** and **174**, which are respectively the high and low expansion layers, are respectively represented on the drawings by HES and LES. As best seen in FIGS. 7, 9 and 10, thermally responsive element **170** is substantially U-shaped in elevation and includes a lower arm **171** and an upper arm **176**. Thermally responsive element **170** is also U-shaped, as seen in plan, and includes two legs **180** and **182**. One end, **181**, of leg **180** is electrically connected to and mounted on terminal **128** and leg **182** is electrically connected, at one end **183**, to and mounted on terminal **126**. The other ends of legs **180** and **182** meet at an intermediate or bight portion **184**. Bight portion **184** is interconnected with arm **146** of switch member **140** by means of an electrically insulating bushing **175**. As best seen in FIG. 8, bight portion **184** of thermally responsive means **170** is secured to and maintained in electrically insulated relation with arm **146** of switch member **140** by means of an electrically insulating bushing **175**. Electrically insulating bushing **175** is provided with an aperture **175***a* and a countersunk portion **177**. Contact rivet **172** is disposed in aperture **175***a* and is maintained in electrically insulated relation with both the thermally responsive member **170** and switch **140**, as clearly shown in FIG. 8.

Relay **100**, unlike the relay disclosed in the aforementioned copending application is not provided with a shunting contact arrangement and is provided with a heater arrangement in accordance with the instant invention. Thus, a layer of electrical insulation **179** is provided between the upper surfaces of terminals **126** and **128** and switch member **140**, as clearly shown in FIGS. 6 and 9. Thermal relay **100** is further provided with a heating element **185** which corresponds in function to heating element **34** of thermal relay **10** described above. Heating element **185** may be formed of a conventional electrical resistance wire and be provided with an electrically insulated coating. Electrical heating means **185** is electrically connected at one end, **186**, to electrical terminal **128**, as best seen in FIGS. 5 and 6. Heater **185** is wound or wrapped about thermally responsive element **170** substantially throughout its length, as shown, and is in close thermal juxtaposition therewith. It should be noted that the electrically insulating coating on the heater **135** and also on heater **34** is such as will provide the desired electrical insulation but will be insufficient to have any significant effect upon the heat conductivity or the heat flow between the heating element and the respective thermally responsive element. As best seen in FIGS. 7 and 9, the other end **187** of heater **185** is electrically connected to contact **172**.

Contact **172** is adapted to mate with contact **188** which is carried by a spring member **189**, as best seen in FIGS. 7 and 9. Spring member **189** corresponds in function to spring member **42** of thermal relay **10** described above. Thermal relay **100** further includes a fourth electrically conducting terminal **190** mounted in base **112** in any convenient, known manner. Terminal **190** includes, at its upper portion, a bent-over portion **191** to which spring member **189** is electrically connected and mounted on, as shown. Cantilever mounted on the underside of bent-over portion **191** is an electrically insulating strip **192**, which, as best seen in FIGS. 7 and 9, is intermediate contact-carrying spring member **189** and the U-shaped thermally responsive member **170** and heater **185** is carried thereby.

Thermal relay **100** may be electrically employed in a circuit similar to that described above for relay **10**. Relay **100** provides a plurality of electrically conducting paths: one leading from terminal **130**, contact **134**, contact **169**, contact-carrying arm **148** to leg **142**, to terminal **128**; another path leading from terminal **128**, leg **180** of thermally responsive element **170** to the bight portion **184** thereof, to leg **182** and to terminal **126**; and a third electrically conducting path leading from terminal **128**, heater means **185** to contact **172**, contact **188**, spring arm **189** and terminal **190**. Thermal relay **100** may further be provided with a cover member **193** which is provided with a plurality of downwardly extending projections **194** and **195**, the nature and purpose of which is fully described in the above-referenced copending application.

In operation, contacts **169** and **134** may be normally open or normally closed. Referring now to FIG. 7 wherein contacts **169** and **134** are closed, the circuit including contacts **169** and **134** would ordinarily be the primary or load circuit. As the thermally responsive element **170** heats up due to its internal resistance and the current flowing therethrough and to the heat provided by heating element **185**, upper arm **176** of thermally responsive element **170** will move downwardly and will move arm **146** of switch means **140** (which is connected therewith for movement by insulating bushing **175**) downwardly therewith (as viewed in FIGS. 7 and 9) and cause contact-carrying arm **148** to snap from its position of stability wherein contacts **169** and **134** are closed, to the opposite position of stability wherein contacts **169** and **134** are open (as shown in solid lines in FIG. 9). While the thermal relay is in the positions shown in FIGS. 7 and 9 (i.e. respectively wherein contacts **169** and **134** are closed and open) contacts **172** and **188** are still closed and the heater circuit for energizing heater **185** remains energized. As thermally responsive element **170** continues to heat due to the heat provided by heater element **185**, upper arm **176** of thermal element **170** will continue to move downwardly. Spring arm **189**, as spring arm **42** of thermal relay **10**, is biased in a downward direction and will urge contact **188** to remain in engagement with contact **172** as arm **176** moves downwardly, as viewed in FIGS. 7 and 9. Continued downward movement of thermally responsive member **170** will effect separation of contacts **172** and **188** (as shown in FIG. 10) and thus de-energization of the heating circuit. After contacts **172** and **188** are open, thermally responsive element **170** will cool and

move upwardly (as seen in FIGS. 7, 9 and 10) until contacts 172 and 188 again close. Reclosing of these contacts again energizes the heater circuit and causes further heating of the thermally responsive element which again causes the arm 176 to move downwardly to repeat the above-described cyclic operation. It should be noted that, once contacts 172 and 188 are open and arm 176 begins to cool and move upwardly, contacts 172 and 188 will mate before arm 176 has moved upwardly a sufficient distance to cause the overcenter spring 160 to snap arm 148 and close contacts 169 and 134. Thus it can be seen from the above that once contacts 134 and 169 have been opened with the snap action as described above, thermally responsive element 170 will maintain contacts 169 and 134 open and will hunt between the position in which the heater circuit contacts are open and a position in which they are closed. This cyclic action will continue as long as the heater circuit is energized. Thus heater circuit contacts 172 and 188, in cycling between the contacts open and closed position while contacts 169 and 134 are open, are effective to maintain the thermally responsive element 170 at a lower temperature which is slightly above the reset temperature of the device in a manner such as that described above for thermal relay 10 and shown in the graph of FIG. 11.

Thermal relay 100, in addition to the advantages described above, also affords substantially all of the advantages afforded by thermal relay 10 described above.

Referring now to FIGS. 12–14, there is illustrated a further embodiment of a thermal relay of the instant invention generally referred to by numeral 200. Thermal relay 200 embodies certain features which are similar to or may be substantially identical to corresponding features of the thermal relay disclosed and claimed in a copending application, Serial No. 830,221, filed July 29, 1959, assigned to the assignee of the instant application. Reference may be had to this copending application for specific details of construction of features in common to the thermal relays disclosed therein and in the instant invention, as noted hereinafter.

In general, relay 200 comprises a casing member 212, terminals 226, 228 and 230 mounted therein, an electrically conducting switch member generally referred to as numeral 240 and a thermally responsive element 250, each of which are similar and may be substantially identical to their respective counterparts in the last-named copending application.

Electrically conducting switch means 240 comprises a U-shaped member (seen in elevation in FIG. 13) and includes a lower leg 242 and upper leg 244. Lower leg 242 is mounted on and electrically connected at one end to terminal 228 and upper leg 244 mounts at its free end and on its upper surface, a contact 266 for engagement with an electrical contact 234 which is carried by terminal 230, as shown. Upper leg 244 of switch member 240 is spring biased to a position in which contacts 234 and 266 are normally closed. Thermally responsive element 250 is U-shaped in elevation, as best seen in FIG. 13, and includes upper and lower portions generally indicated by numerals 256 and 258. Thermally responsive element 250 may be formed of a conventional bimetal or trimetal or other thermally responsive material. Element 250 is illustrated as being formed of bimetal having a high expansion layer 252 (HES) and a low expansion layer 254 (LES). Element 250 is also substantially U-shaped, as seen in plan view in FIG. 12, and includes legs 260 and 262. Legs 260 and 262 are respectively electrically connected to terminals 226 and 228, as best seen in FIG. 14. Thermally responsive member 250 is provided with an abutment member 276 formed of an electrically insulating material. Electrically insulating abutment member 276 provides a lower surface 277 adapted to engage the upper surface of upper leg 244 of switch means 240. Electrically insulating abutment 276 also mounts an electrical contact 278 and maintains the latter in electrically insulated relation to thermally responsive member 250 and to switch means 240, for a purpose to be described below.

Thermal relay 200 includes a layer of electrical insulation which extends transversely across the upper portions of terminals 226 and 228, and thereby electrically insulates these terminals from the upper portion 244 of switch means 240.

Thermal relay 200 further includes an electrical heating means 285 which corresponds to and may be substantially the same as electrical heating means 135 of thermal relay 100 or electrical heating means 34 of thermal relay 10, as described above. One end 286 of electrical heater 285 is electrically connected to electrical terminal 226, as best seen in FIG. 12. The main portion of the heater member 285 is wound about thermally responsive member 250 and is in close thermal juxtaposition therewith in a manner such as that described above for thermal relays 100 and 10. The opposite end 287 of heater 285 is electrically connected to electrical contact 278 which corresponds in function to electrical contact 172 of thermal relay 100. Thermal relay 200 further includes a fourth electrically conducting terminal 290 which is mounted in base 212 in any known, convenient manner. Terminal 290 includes a bent-over portion 291, as best seen in FIGS. 12 and 13. Cantilever mounted and electrically connected to the upper surface of bent-over portion 291 is an electrically conducting spring member 289 which carries and mounts, at its free end, an electrical contact 288 which is adapted for engagement with electrical contact 278. Spring member 289 biases electrical contact 288 in a direction for engagement with electrical contact 278 in the manner described above for spring member 189 of the thermal relay 100. Cantilever mounted on the lower surface of bent-over portion 291 is an electrically insulating strip member 292, as best seen in FIG. 13. Thermal relay 200 may be provided with a cover member 293, as shown.

Thermal relay 200 is adapted for connection in circuits similar to those described above for thermal relays 10 and 100. The operation of thermal relay 200 is similar to that described above for thermal relays 10 and 100.

Thermal relay 200 provides a plurality of electrical circuits as follows: one leading from terminal 230, contact 234, contact 266, switch member 240 to terminal 228; another path leading from terminal 228, leg 262 of thermally responsive member 250, bight portion 254 thereof, leg 260 to terminal 226; and a third path leading from terminal 226, to heating means 285, contact 278, contact 288, electrically conducting spring member 289, bent-over portion 291 and to terminal 290.

Ordinarily, normally closed contacts 234 and 266 will be in the primary circuit and as the thermally responsive element 250 is heated to a predetermined amount by the heat generated by the current traversing the element and by the heat derived from the heater means 285, upper leg 256 will move downwardly, as seen in FIG. 13, until abutting surface 277 engages the upper surface of upper leg 244 of switch means 240. During the downward movement, spring member 289 will urge contact 288 downwardly and will follow the downward movement of contact 278 and thereby maintain these contacts in engagement with each other. As the thermally responsive element continues to heat in the manner described above, leg 256 will continue to move downwardly and will move leg 244 downwardly and thereby separate contacts 266 and 234. This latter position is shown in full lines in FIG. 15. When contacts 266 and 234 are initially opened, contacts 278 and 288 are still maintained in engagement by spring member 289 and heating means 285 will remain energized and continue to heat thermally responsive member 250. Upon further heating, leg 256 of thermally responsive element 250 will continue to move downwardly until the contacts 278, 288 are separated, thereby deenergizing the heater circuit. When

the heater circuit is de-energized, thermally responsive element 250 will cool rapidly and begin to move upwardly until contacts 278 and 288 are again closed and the heating circuit is re-energized. Re-energization of the heating circuit will cause further heating of thermally responsive element 250 and leg 256 will again move downwardly. It should be noted that when the heating circuit is open and arm 256, upon cooling, moves upwardly, contacts 278 and 288 will close before arm 256 has moved upwardly a sufficient distance to close contacts 266 and 234. Thus, arm 256 will operate in a manner similar to thermally responsive element 22 of thermal relay 10 and thermally responsive element 170 of thermal relay 100 in that arm 256 will hunt between a position in which heater circuit contacts 278 and 288 are open and a position in which they are closed while the contacts 234 and 266 are open.

Thus it can be seen that heater 285 is effective to maintain thermally responsive element 250 at a reduced temperature which is just slightly above its reset temperature and will afford substantially all of the advantages as described above for thermal relays 10 and 100 and will operate in the manner shown in the graph of FIG. 11.

It should be understood that while heater elements 34, 185 and 285 have been disclosed as being provided with a coating of electrical insulation, that any other suitable convenient insulating means may be provided intermediate the heater element and the thermally responsive element.

It can thus be seen from the above that the instant invention provides thermal time delay relays which are efficient and provide accurate timing and a very high initial heat input whereby operation of the thermally responsive element occurs on the linear portion of an exponental heating curve and additionally affords the advantageous result of a quick or short reset time by the maintenance of the thermally responsive element at a temperature which is just slightly above its reset temperature.

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

As many 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, and it is also intended that the appended claims shall cover all such equivalent variations as come within the true spirit and scope of the invention.

I claim:

1. A switching device comprising a pair of normally closed contacts, thermally responsive means, means mounting one of said contacts for movement away from the other of said normally closed contacts in response to initial movement of said thermally responsive means in one direction, at one predetermined temperature thereof, a heating circuit for said thermally responsive means including electrical heating means, and a pair of normally closed contacts, one of which contacts is mounted for movement out of engagement with the other contact of said last-named pair of contacts in response to movement of said thermally responsive mean beyond said initial movement in said one direction, said last-named contacts being operative to cyclically interrupt the flow of current to said heating means in response to movement of said thermally responsive means so as to maintain said thermally responsive means at a temperature within a predetermined range which is slightly higher than the reset temperature of the device.

2. The device as set forth in claim 1 and wherein said second-named pair of contacts are normally closed and said one contact thereof is electrically insulated from and mounted on said thermally responsive means, and spring means urging the other contact of said second-named pair of contacts into engagement with said one contact thereof.

3. A switching device comprising four terminals, thermally responsive means, a first pair of contacts, one of said contacts being electrically connected to and carried by a first one of said terminals, electrically conducting means mounting the other of said contacts for movement into and out of engagement with said one of said contacts in response to movement of said thermally responsive means, said electrically conducting means being electrically connected to a second one of said terminals, a second pair of contacts, means electrically connecting one contact of said second pair of contacts to a third one of said terminals, the other contact of said second pair of contacts being associated with said thermally responsive means for movement into and out of engagement with said one of said second pair of contacts in response to movement of said thermally responsive means, electrical heater means associated with said thermally responsive means in heat-transfer relation thereto and being electrically connected at one portion thereof to a fourth one of said terminals, and at another portion thereof to said other of said second pair of contacts, said thermally responsive means being mounted for movement in response to heating by said heater means to open and close said first pair of contacts at predetermined temperature conditions and to selectively energize and de-energize said heater means by respectively closing and opening said second pair of contacts to maintain the temperature of said thermally responsive means within a predetermined range.

4. The device as recited in claim 3 and wherein said other contact of said second pair of contacts is carried by said thermally responsive means and said means electrically connecting said one of said second pair of contacts to said third terminal comprises an electrically conducting spring member constantly urging said one contact into engagement with the other of said second pair of contacts.

5. A switching device comprising thermally responsive means, a first pair of contacts, means mounting one of said contacts for movement into and out of engagement with the other of said contacts in response to movement of said thermally responsive means, electrical heating means for said thermally responsive means, a pair of normally closed contacts associated with said heater means, spring means urging one of said normally closed contacts into engagement with the other contact thereof, means mounting said last-named other contact for movement out of engagement with said one of said normally closed contacts to interrupt the flow of current to said heater means in response to movement of said thermally responsive means at predetermined temperature conditions thereof, only after said one of said first pair of contacts has moved to a contacts-open position.

6. The device as set forth in claim 5 and wherein said first pair of contacts are normally closed and said one contact thereof moves out of engagement with the other contact thereof in response to movement of said thermally responsive means at a predetermined temperature condition, which is different from the predetermined temperature condition of said thermally responsive means at which said second-named normally closed contacts are separated.

7. The device as set forth in claim 6 and wherein said second-named predetermined temperature condition is slightly above the reset temperature of the device for said first pair of contacts.

8. An electrical switching device comprising a first pair of electrical contacts; one of said contacts being movable into and out of engagement with the other of said contacts; thermally responsive means operatively associated with said movable contact for movement of the latter into and out of engagement with the other of said contacts in response to movement of said thermally

responsive means at predetermined temperature conditions; electrical heater means disposed in thermally conductive juxtaposition to said thermally responsive means; said device including a second pair of contacts for said electrical heater means; spring means mounting one of said second pair of contacts and urging the latter for movement into engagement with the other contact of said second pair of contacts; said thermally responsive means being connected with one of said second pair of contacts for actuating said second pair of contacts to interrupt current flow in said heater means in response to predetermined movement of said thermally responsive means; said spring means being operatively associated and co-operating with said thermally responsive means to cyclically energize and de-energize said electrical heater means to maintain said thermally responsive means at a temperature within a predetermined range which is slightly higher than the reset temperature of the device.

9. The switching device as set forth in claim 8 and wherein said first and second named pairs of contacts are normally closed, and said spring means is effective to maintain said second named pair of contacts in a contacts-closed position after said thermally responsive means has moved a limited predetermined amount in a first direction to open said normally closed first pair of contacts and said second pair of contacts being opened upon further predetermined movement of said thermally responsive means in said first direction.

10. The switching device as set forth in claim 9 and wherein said spring member is carried by and cantilever mounted on said thermally responsive means and said one contact carried by said spring means is operatively connected in electrically insulated relation with said thermally responsive means.

11. An electrical switch comprising a first pair of normally closed electrical contacts; one of said contacts being movable into and out of engagement with the other of said contacts; thermally responsive means being operatively connected with one of said movable contacts to move the latter out of engagement with the other of said first pair of contacts in response to a first predetermined movement of said thermally responsive means in a first direction; electrical heater means disposed in thermally conductive juxtaposition to said thermally responsive means; said switch including a second pair of normally closed contacts for said heater means; spring means mounting one of said second pair of contacts and urging the latter for movement into engagement with the other contact of said second pair of contacts; said thermally responsive means being operatively connected with one of said second pair of contacts for separating said second pair of contacts in response to movement of said thermally responsive means in said first direction beyond said first predetermined movement; said spring means being effective to maintain said second named pair of contacts in a contacts-closed position after said first pair of normally closed contacts are opened and before said thermally responsive means moves beyond said first predetermined movement.

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