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2,793,268

THERMAL RELAY WITH SHORTING STRIP

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2 Sheets-Sheet 1

Fig 1

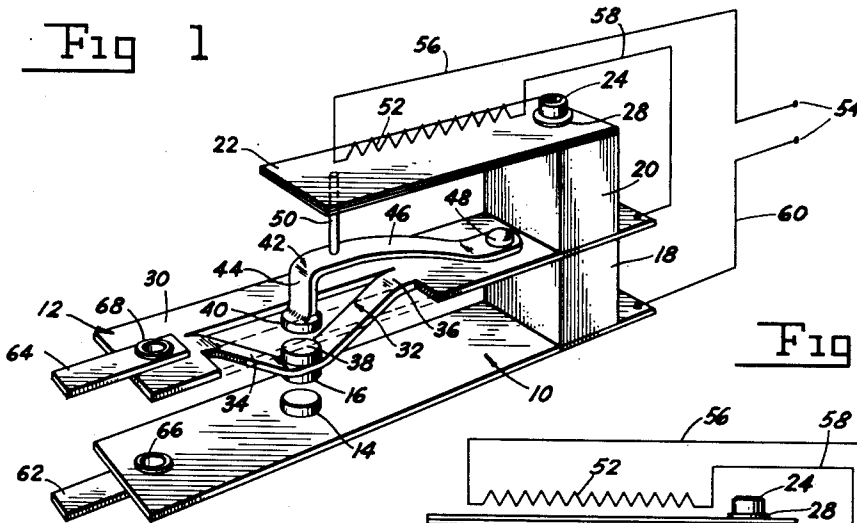


Fig 2

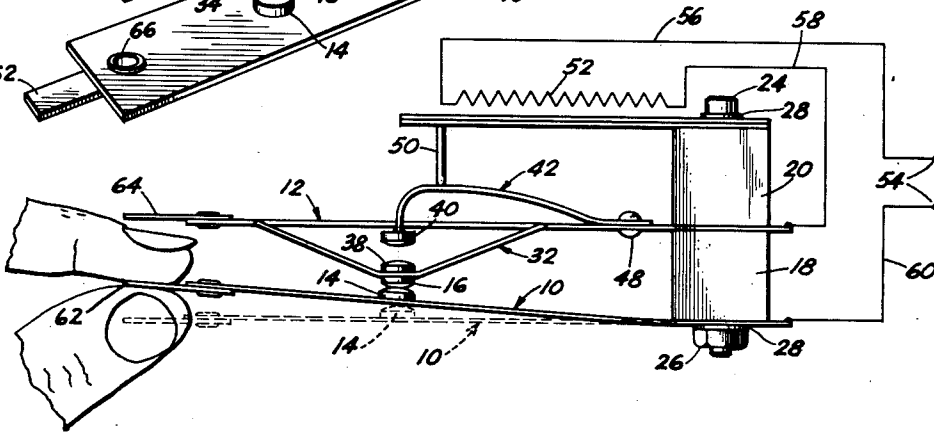
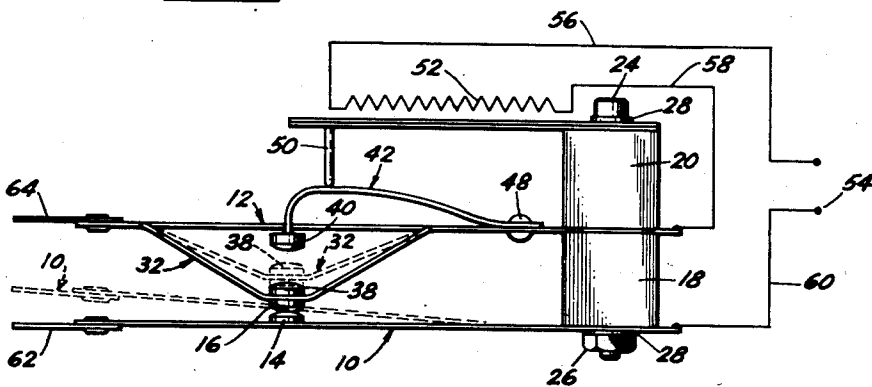


Fig 3



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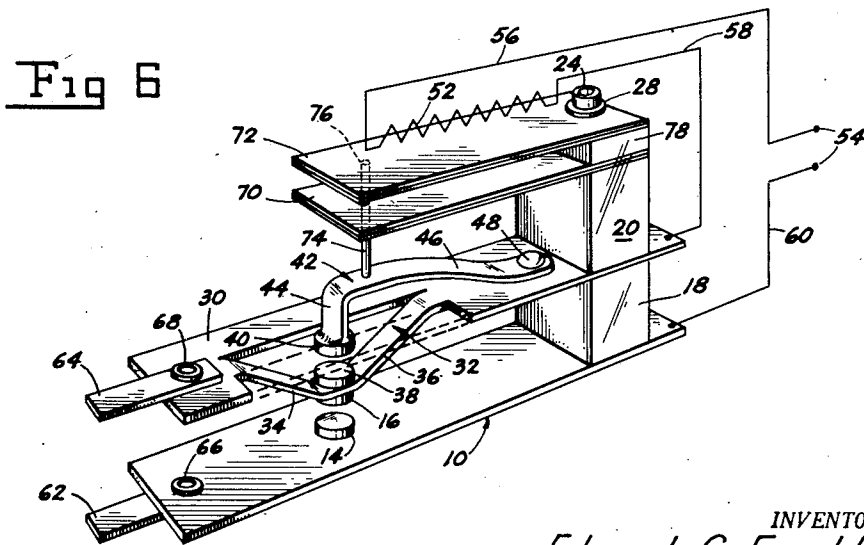
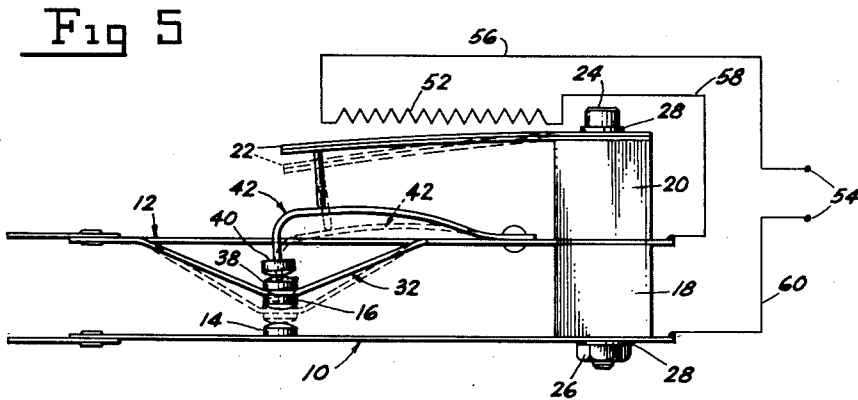
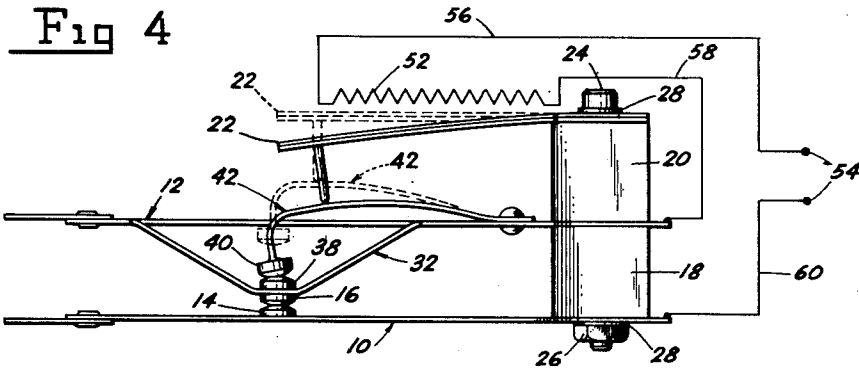
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THERMAL RELAY WITH SHORTING STRIP

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9 Claims. (Cl. 200—122)

This invention relates in general to thermal relay switches and pertains more particularly to a switch especially suited for the thermoelectric control of appliances and the like.

Specifically, the invention comprehends the provision of a thermally expandable bridge comprised of a pair of inclined struts, the apex of which carries one of two cooperable contacts. Associated with the thermally expandable bridge is a shorting strip which is actuated by a bimetallic element to divert some of the flow of current from the bridge directly to the contact mounted thereon. In this way the bridge is permitted to contact once the shorting strip has been urged into engagement therewith and the contraction is instrumental in withdrawing the one contact away from the other.

One important object of the invention is to provide a thermal relay that will require only lightweight parts in its construction, including the utilization of an exceptionally lightweight bimetal as the heat responsive element which is used to control a pair of contacts capable of carrying a fairly heavy current. Not only does the employment of lightweight parts result in an exceedingly compact relay which requires little space, but the relay is rendered very sensitive in its operation, requiring only a small change in temperature for its proper functioning. Also the relay envisioned by the instant invention is quite inexpensive to fabricate, due in part to the thin gauge stock requirements above referred to and also due to the over-all simplicity of construction.

Another object of the invention is to provide a relay that is especially suited for electrically heated appliances such as toasters, coffeemakers and the like, where a heating cycle is manually initiated and automatically terminated upon a desired elevated temperature being reached. Further, in this connection it is an aim of the invention to provide a relay that lends itself readily to ambient temperature compensation.

A further object is to provide a relay of the foregoing variety possessing good positive "make" and "break" characteristics.

Other objects will be in part obvious, and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application which will be indicated in the appended claims.

In the drawings:

Figure 1 is a perspective view, partly diagrammatic, of the relay which the invention contemplates, the parts thereof being shown in a pre-operational position;

Fig. 2 is a side elevational view with the parts in one operating position;

Fig. 3 is a view corresponding to Fig. 2 with the parts in a different operative position;

Fig. 4 is an elevational view illustrating a still further different operating position;

Fig. 5 represents still another operating position, and

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Fig. 6 is an elevational view showing a somewhat modified arrangement which provides for ambient temperature correction.

Referring in detail to the drawings, the thermal relay selected for the purpose of exemplifying the present invention includes a pair of switch arms 10 and 12, each arm carrying a contact 14 and 16 respectively. The arms 10 and 12 are retained in vertically spaced relationship with each other by means of insulating blocks 18 and 20, the latter serving to maintain a superimposed bimetallic element 22 in operating position above the vertically arrayed switch arms. To assure retention of the switch arms 10, 12 and the bimetal 22 in their fixed spaced relationship at one end, it is suggested that threaded means comprising a bolt 24 extending through the aforementioned parts with a nut secured to its lower end be employed, and to insulate the threaded means from the bimetal 22 and the switch arms it is planned that insulating washers 28 be used, these washers being under the head of the bolt 24 and above the nut 26. Of course, if desired, the parts could be maintained in their stacked condition by a tubular rivet, as is quite customary in the manufacture of thermostatic switches.

The switch arm 10 is of rather conventional structure but the switch arm 12 is considerably different inasmuch as it includes a relatively flat or blade portion 30 which has been stamped or cut to provide a thermally expandable bridge designated in its entirety by its reference numeral 32. It will be observed that the bridge includes a pair of inclined struts 34 and 36, these struts being of limited cross-section with respect to the amount of current intended to pass therethrough. By having the cross-section of the struts limited, it will be appreciated that the flow of sufficient current through them will cause their expansion due to the electrically generated heat, and inasmuch as their opposite ends are anchored to the flat portion 30, the contact 16 carried at the apex of the struts 34 and 36 will move substantially perpendicular relative to the contact 14.

While the current entering the switch arm 12 normally courses through the bridge 32, nonetheless, it is within the contemplation of the invention to divert at times at least a portion of this current so that it will not pass through the struts 34 and 36 but will instead be conducted directly to the contact 16. With this in mind, a contact 38 is mounted on the upper side of the apex formed by the inclination of the struts 34 and 36. The contact 38 is disposed so as to be engaged by another contact 40 mounted on the free end of a generally L-shaped shorting strip 42. From the drawings it will be discerned that the shorting strip is composed of a relatively short leg 44 and a comparatively long leg 46, the distal end of the long leg being anchored directly to the switch arm 12, as by a rivet 48. Whenever the shorting strip 42 is moved so as to cause the contact 40 to meet its cooperable contact 38, then it will be manifest that the current that has been flowing through the bridge 32 will have at least a portion thereof diverted so that it instead passes through the shorting strip 42. The purpose of so doing is to shunt sufficient current so that the heating effect thereof is no longer responsible for maintaining the struts 34 and 36 in an expanded condition. Once having diverted the current as above explained, then the struts are permitted to cool with a concomitant contraction which results in the withdrawal of the contact 16 from its cooperable contact 14.

The bimetallic member 22 is designed to actuate the shorting strip 42, and with this end in view, there is carried at the free end of the bimetallic member a downwardly projecting stud 50, preferably of insulating material. Also, the bimetallic member 22 in actual use is placed so as to receive heat from an electrically heated

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element 52, shown only schematically in the drawings. In some situations, as in timers, the bimetal 22 may be in direct proximity with the element 52. However, in the case of an automatic coffeemaker, the bimetallic element would be heated by contact or proximity with the pot itself so the water temperature will be measured. When used with a waffle iron, then the bimetal would be in juxtaposition with the waffle grid. As shown, the element 52 is in circuit with a source of electrical power designated by the numeral 54, there being a conductor 56 leading from one side of the source 54 to the heating element 52, another conductor 58 leading from the opposite end of the heating element to the switch arm 12 and a third conductor 60 leading from the other side of the source 54 to the switch arm 10. Thus it will be seen that the heating element 52 is in series with both of the switch arms 10 and 12 and will be energized whenever the contacts 14 and 16 are closed.

Since the invention will find appreciable utility when installed in an electrical appliance such as a toaster, coffeemaker, waffle iron or the like, it is intended that each of the switch arms 10 and 12 be equipped with projecting finger lugs 62 and 64 of insulating material. These finger lugs may be secured to the switch arms in any suitable manner as by means of rivets 66 and 68, and permit ready manual closing of the contacts 14 and 16.

As will become more apparent during the course of the ensuing description of the operation of the relay device, the switch arm 12 should be relatively rigid. By use of the term "rigid" it is not meant that the switch arm must be absolutely rigid, for it can possess some resiliency. All that is necessary is that the switch arm 12 be less resilient than the bimetallic member 22 so that when the bridge 32 contracts as it is intended to do so when it is shorted by the strip 42, then such contraction will result in an upward deflective movement of the bimetal 22. If this were not the situation and the switch arm 12 were more resilient than the bimetal 22, then the bimetal would exert sufficient resistive or counterforce so that the contraction of the struts 34 and 36 would only pull the flat portion 39 of the switch arm 12 downwardly with no separation of the contact 16 from the contact 14. Further, at this time it might be well to explain that the shorting strip 42 can be of very lightweight material requiring little force from the bimetal 22 for its downward deflection. In this connection the strip 42 is bent so that it will have a normal upward bias which is overcome by the bimetal 22 when the bimetal is heated sufficiently. Here again, like the bimetal 22, the strip 42 should be more flexible than the arm 12 so as to permit the contacts 14 and 16 to open upon contraction of the struts 34 and 36, an end easily achieved.

Having set forth the mechanical and electrical relationship of the parts, it is now felt that a brief explanation of the operation of the relay device is desirable in order to afford a complete understanding of the invention. Referring first to the position of the parts pictured in Fig. 1, it will be observed that the contacts 14 and 16 are spaced from each other as are the contacts 38 and 40. When the contacts 14 and 16 are separated, as in the above alluded to figure, no flow of current can take place through the heating element 52. However, in the arrangement selected for illustrating the invention, the lower switch arm 10 is capable of being manually deflected upwardly due to its inherent resiliency, and to facilitate such deflection the finger lug 62 has been provided. When the lug 62 is grasped by a person's fingers, as illustrated in Fig. 2, the ensuing upward movement of the switch arm 10 brings the contact 14 carried thereby into engagement with the contact 16 mounted at the apex of the bridge 32. For the purpose of facile comparison, the position of the switch arm 10 pictured in Fig. 1 has been superimposed on Fig. 2, appearing in the latter figure in dotted outline. This action results in a flow of current through the con-

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ductor 60, the switch arm 10, the contacts 14 and 16, the bridge 32, the rest of the switch arm 12, the conductor 58, the heating element 52 and the conductor 56 back to the other side of the source of power 54. The flow of current through the bridge 32 by the meeting of the contacts 14 and 16 immediately causes sufficient longitudinal expansion of each of the struts 34 and 36 so that the apex thereof, together with the contact 16, is urged downwardly in the direction of the contact 14. By having the contacts 14 and 16 in the position of Fig. 1 only slightly spaced from each other, say on the order of 0.010 to 0.020", it can be recognized that release of the lower switch arm 10 from the position to which it has been moved in Fig. 2 will of course permit this lower switch arm to return to its normal position, but since the bridge 32 has expanded adequately, the contact 16 will remain in engagement with the contact 14.

To facilitate a comparison of what occurs after the switch arm 10 has been released by the operator, the position which the switch arm 10 assumed in Fig. 2 has been indicated in phantom outline in Fig. 3. Likewise the original length of the bridge before heating is shown in phantom outline in Fig. 3 which outline is the same as the solid outline condition shown in Fig. 2. However, the solid line position of the switch arm 10 in Fig. 3 is that occasioned by release of this switch arm and the solid line position of the bridge 32 is the expanded one. Accordingly, from Fig. 3 it will be discerned that the contacts 14 and 16 remain closed after manual upward pressure has been removed from the lower switch arm 10 and this switch arm has been permitted to return to its original position.

While the V-shaped bridge 32 heats and expands almost instantaneously from the position of Fig. 2 to that of Fig. 3, the heat transferred from the element 52 to the bimetallic member 22 occurs at a lower rate and the bimetal proceeds to deflect downwardly in accordance with the amount of heat received from the heating element 52. Attention therefore is now directed to Fig. 4 where the original position of the bimetal 22 is represented in dotted outline and the heated position thereof is indicated in solid outline. Thus by the free end of the bimetal 22 moving downwardly sufficiently, the stud 50 is instrumental in also moving the shorting strip 42 downwardly to such an extent that its contact 40 meets the upper contact 38 situated at the apex of the bridge 32. Establishment of electrical contact between the contacts 38 and 40 serves to by-pass a proportion of the current that has up to this point been flowing through the bridge 32. The degree of diversion, of course, depends on the cross-section of the shorting strip 42 and its length, and by having these dimensions appreciably larger than the dimensions of the bridge 32, it will be seen that considerable current can actually be diverted. Obviously, though, the degree of diverted current is only relative and the criterion that is imposed upon the design of the instant relay is that sufficient current be diverted so that the bridge 32 will quickly contract to such an extent as to result in the separation of the contact 16 from the contact 14. Stated somewhat differently, an optimum condition would be for all of the current to be shunted from the bridge 32, this giving the most rapid contraction and initial contact separation.

The action that transpires while the bridge 32 is contracting is best seen from an inspection of Fig. 5 where the phantom outline relationship of the bridge is the same as the solid line position of Fig. 4. However, from the dotted line position of Fig. 5 the bridge contracts so as to move its contact 16 upwardly, and it is the solid line relationship that shows the bridge 32 in its fully contracted state, which contracted state is the same as that pictured in Fig. 1. However, the bimetallic member 22 has not as yet cooled sufficiently to remove the downward pressure being applied to the shorting strip 42, and consequently the device has not returned entirely to the

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position illustrated in Fig. 1. After sufficient time has elapsed though, the bimetal 22 will move upwardly to its cooled position and the contact 40 will be permitted to withdraw from the contact 38 in preparation for the beginning of a new and subsequent cycle.

One nicety about the invention stems from the fact that when the V-shaped bridge 32 is in the process of expanding after the contacts 14 and 16 have been initially closed by moving the lower switch arm 10 upwardly, a firm, positive "make" of the contacts is effected, for the expansion of the bridge is in such a direction as to increase the contact pressure. By the same token, a positive "break" to the contacts is produced upon separation, since the bridge 32 quickly contracts once the contacts 40 and 38 have been brought together. Concurrently with the positive "break" of the contacts 14 and 16, there is produced a fortuitous momentary positive "make" of the contacts 40 and 38, which happening assures a quick shunting of the desired portion of current from the bridge 32 to a path via the strip 42 then in parallel therewith. A further point to be emphasized is that since the shorting strip 42 has to carry a current of less than 10 amperes, and the voltage across it is only a fraction of a volt, it can be made very light and flexible so that the bimetal 22 can move this strip with a minimum of force through the medium of the stud 50.

Since it is envisaged that the invention will find utility in electrically heated appliances, it is frequently desirable, if not necessary, to provide some form of ambient temperature correction so that the residual heat from the preceding cycle will not adversely affect the temperature of the subsequent cycle. To this end the invention also has in view the employment of two bimetallic members, as in Fig. 6, these members being indicated by the numerals 70 and 72. The bimetallic member 70 carries at its free end a downwardly extending stud 74 and the other bimetallic member 72 carries a somewhat similar downwardly extending stud 76 which engages the upper surface of the bimetallic member 70, whereas the stud 74 engages the shorting strip 42. The two bimetallic members 70 and 72 are separated by an additional insulating block 78. Other than the differences noted, the remaining structure of Fig. 6 is identical with that of the earlier described single bimetallic member construction, and therefore bears identical reference numerals.

By way of comparison, in the structure pictured in Fig. 6, the bimetallic member 72 corresponds in function to the bimetallic member 22, receiving heat from the electric heating element 52. The bimetallic member 70, however, is purely for ambient temperature correction and is fairly well shielded from any heat that might be radiated or conducted from the heating element 52. Therefore, the bimetallic member 70 is arranged so that it will deflect upwardly when heated, while the bimetallic member 72 is designed to deflect downwardly just as the earlier referred to bimetallic member 22 does. Since both the members 70 and 72 are subjected to ambient temperature but only the upper member 72 is subjected to the heat from the heating element 52, it will be appreciated that the amount of downward deflection of the bimetallic member 72 attributed to the ambient temperature is neutralized or compensated for by the upward deflection of the bimetal 70.

It is not thought necessary to sufficiently describe fully the operation of the embellished device illustrated in Fig. 6, for it functions practically in an identical manner with the earlier described structure presented in Figs. 1-5. All that need be understood is that the bimetal 70 deflects upwardly due to ambient temperature, whereas the bimetal 72 deflects downwardly due to ambient temperature plus the temperature derived from the heating element 52 when it is energized. Other than the

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above mentioned difference, the operation, as already indicated, is the same as in the earlier described arrangement.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, 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.

It is also to be understood that the language used in the following claims is intended to cover all of the generic and specific features of the invention herein described and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

I claim:

1. A thermal relay comprising a pair of electrically conductive, inclined struts joined together at their adjacent ends and anchored at their opposite ends, said struts being capable of lengthwise expansion upon the passage of sufficient current therethrough, a pair of cooperable contacts, one of which contacts is carried by the adjacent ends of said struts, means providing electrical insulation between said struts and the other of said contacts, and means movable relative to said contacts for diverting at least some of the current flowing through said struts so that it will then flow directly to said contacts, whereby the struts will contract sufficiently to separate said contacts.

2. A thermal relay comprising a pair of electrically conductive, inclined struts connected at their adjacent ends and fixedly anchored at their opposite ends, said struts being capable of lengthwise expansion upon the passage of sufficient current therethrough, a pair of cooperable contacts, one of which contacts is carried by said struts at their connected ends, means providing electrical insulation between said struts and the other of said contacts, and a shorting strip movable relative to said contacts in parallel with said connected struts engageable with said connected ends thereof for by-passing at least a portion of the current that would otherwise flow through said struts and instead cause said portion of current to flow directly through said one contact, whereby the reduction of current flow through said struts will cause sufficient contraction thereof to separate said cooperable contacts.

3. A thermal relay comprising first and second switch arms having first and second contacts respectively adapted to engage and disengage each other, said first arm including a support member and a V-shaped bridge having its opposite ends connected to spaced portions of said support member and its apex supporting said first contact, said bridge having a cross-section limited with respect to the current passing through the contacts for causing substantial expansion and contraction of the bridge by heating and cooling in response to the changes in current carried by the bridge, means providing electrical insulation between said arms, means including a thermally responsive member for shunting said bridge at a predetermined temperature of said thermally responsive member so that at least a portion of the current flowing through said bridge will instead flow directly through said contacts, whereby the reduction of current flow via said bridge will cause sufficient contraction thereof to withdraw said first contact from the second contact.

4. A thermal relay comprising first and second switch arms having first and second contacts respectively adapted to engage and disengage each other, said first arm including a support member and a V-shaped bridge having its opposite ends connected to spaced portions of said support member and its apex supporting said first contact, said bridge having a cross-section limited with respect to the current passing through the contacts for causing substantial expansion and contraction of the bridge

by heating and cooling in response to the changes in current carried by the bridge, a resilient shorting strip having one end fixedly anchored to said support member and its other end engageable with the apex of said bridge, means providing electrical insulation between said arms, and a bimetallic member for actuating said shorting strip to urge said other end thereof into engagement with said bridge at a predetermined temperature of said bimetallic member, whereby said bridge will contract sufficiently to separate said contacts.

5. A thermal relay comprising first and second switch arms having first and second contacts respectively adapted to engage and disengage each other, said first arm including a relatively flat blade and a pair of inclined struts having their adjacent ends joined together and their opposite ends joined to said blade, said first contact being mounted on said struts at their adjacent ends and said struts having a cross-section limited with respect to the current passing through the contacts for causing substantial expansion and contraction of the struts by heating and cooling in response to the current carried thereby, means providing electrical insulation between said arms, an L-shaped resilient shorting strip having its longer leg fixedly anchored to said blade and its shorter leg engageable with the joined ends of said struts, a bimetallic member engageable with the longer leg of said shorting strip for urging the shorter leg into contact with the joined ends of said struts at a predetermined temperature of said bimetallic member, whereby said struts will contract sufficiently to separate said contacts, said bimetallic member being sufficiently resilient to flex from the contraction of said struts.

6. A thermal relay in accordance with claim 5 in which said second switch arm is resilient and including means for initially flexing said second switch arm in the direction of the first arm to close said contacts, expansion of said struts maintaining closure until said shorting strip has been actuated into engagement with said struts.

7. A thermal relay comprising first and second switch arms having first and second contacts respectively adapted to engage and disengage each other, said first arm including a support member and a V-shaped bridge having its opposite ends connected to spaced portions of said support member and its apex supporting said first contact, said bridge having a cross-section limited with respect to the current passing through the contacts and causing substantial expansion and contraction of the bridge by heating and cooling in response to the changes in current carried by the bridge, means providing electrical insulation between said arms, means for shunting said bridge so that at least a portion of the current flowing through said

bridge will instead flow directly through said contacts, a first thermally responsive member subjected to both ambient temperature and a source of heat being controlled for exerting a force upon said shunting means in a direction to shunt said bridge, and a second thermally responsive member subjected primarily to ambient temperature for exerting a compensating force upon said first thermally responsive member to lessen the force applied to said shunting means, the resulting net force applied to said shunting means being in substantial accordance with the force derived principally from said source of heat.

8. A thermal relay comprising first and second switch arms having first and second contacts respectively adapted to engage and disengage each other, said first arm including a relatively flat blade and a pair of inclined struts having their adjacent ends joined together and their opposite ends joined to said blade, said first contact being mounted on said struts at their adjacent ends and said struts having a cross-section limited with respect to the current passing through the contacts for causing substantial expansion and contraction of the struts by heating and cooling in response to the current carried thereby, means providing electrical insulation between said arms, an L-shaped resilient shorting strip having its longer leg fixedly anchored to said blade and its shorter leg engageable with the joined ends of said struts, a first bimetallic member subjected to both ambient temperature and a source of heat being controlled for exerting a force upon said shorting strip in a direction to shunt said struts, and a second bimetallic member subjected primarily to ambient temperature for exerting a compensating force upon said first bimetallic member to lessen the force applied to said shorting strip, the resulting net force applied to said shorting strip being in substantial accordance with the force derived principally from said source of heat.

9. A thermal relay in accordance with claim 8 in which said second switch arm is resilient and including means for initially flexing said second switch arm in the direction of the first arm to close said contacts, expansion of said struts maintaining closure until said shorting strip has been actuated into engagement with said struts.

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