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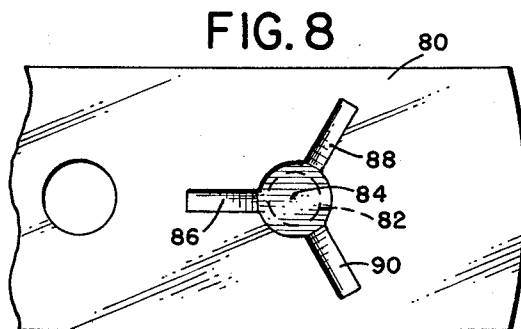
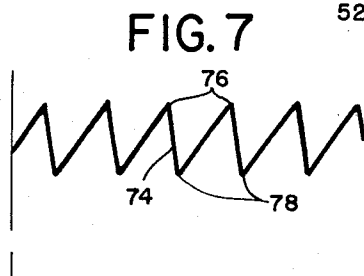
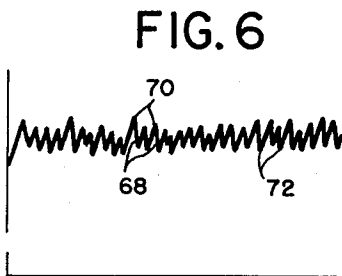
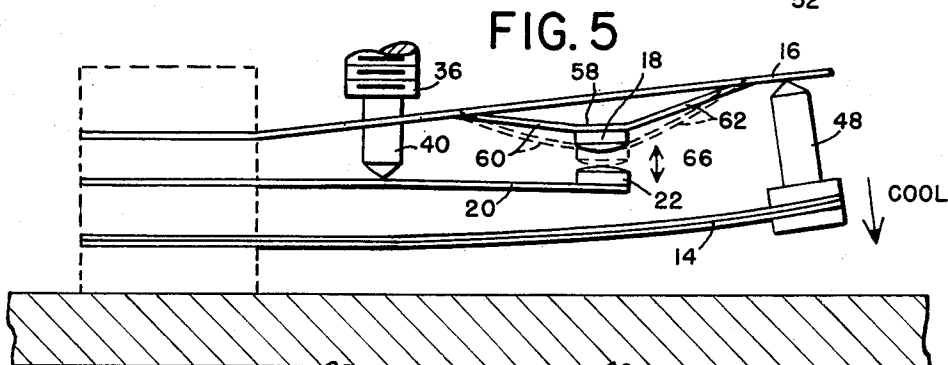
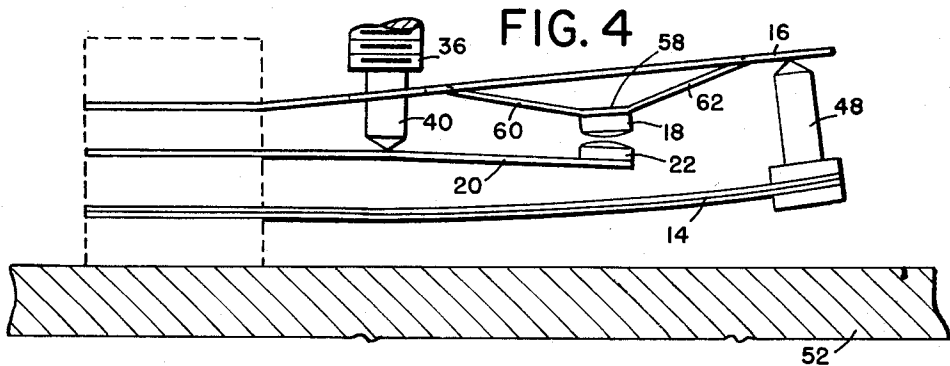
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THERMAL SWITCH WITH CYCLING DELAY

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2 Sheets-Sheet 2



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2,716,174

THERMAL SWITCH WITH CYCLING DELAY

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10 Claims. (Cl. 200—138)

The present invention relates to thermally responsive switches and particularly to such switches having improved means for delaying the cycling of the contacts.

Many thermal switches in the prior art suffer from the disadvantage of rapid cycling. For example, where the thermally responsive portion of the switch responds relatively rapidly to changes in temperature controlled by the current through the switch, the thermally responsive member may open the contact to break the circuit and then almost immediately permit such contacts to re-engage as the thermally responsive member quickly reflects the new temperature conditions. In such a case, the contacts will engage and disengage at relatively short time intervals. These rapid changes in the switch condition are undesirable in certain types of appliances which have to meet standards such as those of the National Electrical Manufacturers' Association prescribing the maximum number of permitted cycles per unit of time. In other cases, the sensitivity may be so great that there is a substantial chattering of the contacts which effectively prevents a clean engagement and disengagement of the contacts and thus causes unnecessary heating and wear of the contacts themselves.

Various proposals have been made in the past for delaying the engagement and disengagement of the contacts in such a thermal switch. Some of these prior proposals have produced auxiliary changes in the position of one of the contacts in response to passage or interruption of current through the contacts.

With these problems and constructions of the prior art in view, it is one object of the present invention to provide an improved thermal switch of a type having means for delaying the cycling in response to changes in the current controlled by the switch.

Another object is the provision of a thermal switch having one of its contacts displaced from the corresponding contact arm and connected to such arm by a plurality of current-conducting struts which change the relative displacement of the contact and arm in response to passage of interruption of current through the struts and contact.

A further object is the provision of such a switch in which the displaced or offset contact support, the contact arm, and the current-conducting struts connecting the contact support and arm are all formed economically and conveniently from a single piece of material.

Still another object is the provision of such a thermal switch in which the relative arrangement of the current-conducting supporting struts for the displaced or offset contact is such as to amplify the expansion and contraction of the struts and thus cause corresponding but greater relative displacements of the contact support in a direction perpendicular to the contact arm.

Other objects and advantages of the invention will be apparent from the following specification in which certain preferred embodiments have been described. In the drawings which accompany this description, and in which like reference numbers indicate like parts,

Figure 1 is a plan view of a preferred form of thermal switch according to the invention.

Fig. 2 is a side elevation of the thermal switch of Fig. 1, with certain portions broken away to the section line 2—2 of Fig. 1, showing the parts at the instant of engagement of the contacts.

Fig. 3 is a schematic view similar to Fig. 2 showing the position of the parts shortly after the contacts have engaged as in Fig. 2.

Fig. 4 is a view similar to Fig. 2 and Fig. 3 but showing the switch parts in the position wherein the contacts have just barely been opened by the thermally responsive member.

Fig. 5 is a view similar to Fig. 4 showing the action of the thermal switch shortly after the contacts have opened as in Fig. 4.

Fig. 6 is a chart showing typical operation of a prior art switch similar to that of Figs. 1 through 5 except for the omission of the displaced contact and inclined contact supporting struts.

Fig. 7 is a typical chart of operation of the switch of Figs. 1 through 5, and

Fig. 8 is a plan view of a thermal switch contact arm embodying another form of the present invention.

As shown in Figs. 1 through 5, the preferred embodiment of the present invention is incorporated in a switch indicated generally at 10. This switch has a supporting post 12 on which the various switch parts are mounted. At one end of the post 12 is located a thermally responsive member 14, which in this case is in the form of a bimetallic strip projecting laterally from the post. In appropriate cases other thermally responsive actuating means may be used in place of the bimetal to actuate the switch in known manner.

Also mounted on the post is a first contact arm 16 carrying a first contact 18 in the manner described below, as well as a second contact arm 20 with its corresponding second contact 22. Contacts 18 and 22 are thus adapted to engage and disengage each other to control the passage of current through the switch and thus control in known manner the temperature of some object or space to which the bimetal 14 is responsive. The current reaches the switch contact arms through terminals 17 and 19 respectively.

The supporting post 12, in this case, has a shoulder 24 at one end against which the various switch elements may be stacked in assembled relation. Suitable insulating spacers 26 are provided to isolate the contact arms electrically from the rest of the assembly. Above the first contact arm and suitably insulated therefrom is an outwardly projecting rigid frame member 28 having its outer end return-bent as shown at 30 to provide a parallel frame portion 32 above the frame 28. The extreme end of the frame portion 32 is bent upwardly to provide a stop 34. At least one of the horizontal frame portions 28 and 32 is internally threaded to receive the threaded portion 36 of a manual adjusting shaft 38. Shaft 38 carries an insulating button 40 at its lower end which projects through an opening 42 in the upper or first contact arm 16 in order to engage the lower or second contact arm 20. This lower arm 20 is spring-biased upwardly against the insulating button 40, so that the position of the second contact 22 may be established in advance by rotation of the manual adjustment shaft 38 and consequent vertical movement of the insulating portion 40 to the desired position. Shaft 38 carries a collar 44 with a projection 46 adapted to engage the stop 34 of the frame member and thus limit the relative rotation of the shaft to the desired range.

In order to control the engagement and disengagement of the contacts 18 and 22 in response to the temperature conditions of the bimetal 14, this bimetallic member car-

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ries an insulating projection 48 at its outer end adapted to engage the outer end of the first or upper contact arm 16. In the present case, the outer end of bimetal 14 is adapted to move upwardly in response to increases in temperature of the bimetal and thus to lift the upper contact arm and its contact 18 away from the lower contact 22 and interrupt the circuit when the temperature of bimetal 14 is increased to a certain predetermined point. This temperature of operation can, of course, be adjusted by changes in the initial position of contact 22 under the control of adjustment shaft 38.

To hold the various switch parts in their assembled and stacked relation on supporting sleeve 12, the upper end of this sleeve is riveted over, as shown at 50, above the frame member 28. The switch assembly may then be secured to a device 52, the temperature of which is to be controlled, by means of a bolt 54 passing axially through the supporting sleeve 12 of the switch assembly and screwed into a threaded opening 56 in the member 52. Member 52 may, for example, be the soleplate of a flatiron, a heated cooking plate, or some other device, the temperature of which is to be controlled by the current passing through the switch contacts 18 and 22 in known manner.

According to the present invention, a new and improved arrangement is provided for supporting the first contact 18 on the first contact arm 16. According to this portion of the invention, the contact 18 is carried by a contact support 58 which is offset or displaced as shown in Fig. 2 from the plane of contact arm 16 toward the second contact 22. This displaced contact support 58 is connected to the first contact arm 16 by a plurality of struts 60 and 62. In the preferred embodiment of Figs. 1 through 5, there are two of these struts 60 and 62 spaced substantially 180° apart as measured in the plane of the contact arm 16 or the plane of the contact support 58. As shown in Fig. 2, these supporting struts 60 and 62 are also inclined at a small angle with respect to the plane of the first contact arm 60. This inclination of the struts 60 and 62 is designed to increase the effectiveness of the cycling delay according to the present invention for reasons described below.

As shown in Fig. 1, the supporting struts 60 and 62 are also relatively narrow, so that their total cross section is small. The exact cross section can be determined readily in any given case and will depend primarily on the size of the current to be carried by contacts 18 and 22 as well as on the nature of the material from which the struts 60 and 62 are made. According to the invention, the total cross section of these struts must be so small or limited, with respect to the current to be carried by the contacts, that the passage of such current through the struts 60 and 62 will heat the struts sufficiently to cause substantial expansion thereof. Similarly, when the current is interrupted, the struts 60 and 62 must cool sufficiently to cause substantial contraction of the struts to their original position.

Since the struts 60 and 62 constitute the sole connection between the contact support 58 and the remainder of contact arm 16, it will be understood that the current passing through the contact arm to contact 18 must be carried entirely by struts 60 and 62 and will thus achieve the desired heating effect if the cross section of these struts is properly chosen.

Because of the inclination of struts 60 and 62 in this preferred form of the invention, and because the struts extend in opposed directions from the contact support 58, the actual expansion and contraction of struts 60 and 62 from the heating and cooling effect due to passage and interruption of current will result in increased or amplified relative displacement of contact 18 in a direction normal or perpendicular to the plane of upper contact arm 16. For a given length of strut the amplification varies inversely with the angle of inclination of the strut; that is, small angles give higher vertical motions than large angles do. This amplified relative displacement will thus en-

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hance the effectiveness of the cycling delay according to the invention.

The operation of the cycling delay mechanism described above may be understood by study and comparison of Figs. 2 to 5, inclusive. Fig. 2 shows the parts at that point in their operating cycle where the contact 18 has just engaged contact 22. Prior to the engagement of the contacts, the circuit has, of course, been open, and the member 52, as well as the bimetal 14, has been cooling. This cooling of the bimetal 14 has resulted in movement of the insulating button 48 down toward the plate 52 and has thus permitted downward movement of the upper contact arm until the point of Fig. 2 was reached at which the contacts 18 and 22 have barely engaged each other.

Fig. 3 illustrates the condition of the parts just shortly after this instant of engagement. In Fig. 3, the dotted lines show the position of the upper contact arm at the instant of "make," i. e., the same position illustrated in Fig. 2. The heavy line position of Fig. 3 then shows the effect of the initial passage of current through the supporting struts 60 and 62 to contact 18. This passage of current has caused expansion of struts 60 and 62 longitudinally, this longitudinal expansion has resulted in amplified relative displacement of the first contact 18 in a direction perpendicular to the plane of the contact arm. Since, however, lower contact arm 20 is relatively stiff, the increased offset or perpendicular displacement of contact 18 from its contact arm 16 is unable to depress the lower contact 22 any farther. Instead, this relative displacement increases the contact pressure and causes the upper contact arm 16, which is made of thinner stock than the lower contact arm 20, to flex upwardly a distance indicated by the arrow 64 which is just sufficient to accommodate the increased displacement of contact 18 due to expansion of struts 60 and 62 by the current flow.

While the contacts are in engagement, the heating circuit for the device 52 will be in operation and will thus heat both plate 52 and the bimetal 14. The heating of the bimetal 14 will cause it to move upwardly in the direction shown by the arrow in Fig. 3 so that the insulating button 48 will ultimately engage the upwardly displaced upper contact arm 16 and reopen the circuit. It will be obvious, however, that the relative displacement of the upper contact due to the heating of struts 60 and 62 by the current will make it necessary for the bimetal 14 to move upwardly a greater distance than would be necessary if contact arm 18 were rigidly connected to its contact arm without the supporting struts 60 and 62 of the present invention. In other words, it will take a longer heating period before the bimetal will move sufficiently to reopen the circuit. Thus the period of cycling between the engagement of the contacts in Fig. 2 and the subsequent disengagement thereof will be greater than would be the case without the present invention.

Fig. 4 illustrates the position of the parts when the heating cycle has progressed far enough so that the bimetal 14 and its insulating button 48 have just reengaged the upper contact arm and have lifted the arm so that the contacts 18 and 22 are just barely open. As illustrated in Fig. 4, the struts 60 and 62 have not yet cooled, so that contact 18 still remains in its position of greatest relative displacement or offset downwardly from the plane of the first contact arm.

Fig. 5 illustrates the condition of the parts very shortly after the contacts have opened as in Fig. 4. Here the struts 60 and 62 have cooled and contracted due to the interruption of the current through them and have thus decreased the downward displacement or offset of the contact 18 with respect to its contact arm 16. The dotted lines in Fig. 5 illustrate the position corresponding to Fig. 4 when the contacts have barely opened, while the heavy lines in Fig. 5 illustrate the position of the contact just after the position of Fig. 4, when the struts have cooled. Incidentally, this cooling effect takes place

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relatively rapidly so that there is no perceptible time interval between the positions of Fig. 4 and Fig. 5.

As shown in Fig. 5, the decrease in displacement of contact 18 due to interruption of the current lifts the contact a distance shown by arrow 66 to increase the gap between the contacts. Thus the interruption of current through the contacts is more positive and effective and there is no tendency for chattering or hunting of the contacts. This interruption of the current will, of course, terminate the heating effect on device 52 and bimetal 14 so that the bimetal 14 will shortly begin to cool and move downwardly as shown by the arrow in Fig. 5. Obviously this downward movement will have to extend over a great enough distance to make up for the increased gap illustrated at 66 due to contraction of the struts as the contacts were disengaged. In other words, the re-engagement of contacts 18 and 22 will be substantially delayed, as compared to re-engagement of contacts in a similar switch in which the expanding and contracting struts of the present invention are not included. Ultimately, then, the operating position of Fig. 5 will be followed by a restoration of the parts to the position of Fig. 2 in which contact 18 will again barely engage contact 22 and will then repeat the above described cycle.

To illustrate the advantages of the construction shown in Figs. 1 to 5, Fig. 6 is a typical graph showing operation of a switch of the same type as that shown in Figs. 1 to 5 but in which the contact on the upper arm is either rigidly mounted on the arm or the cross section of the supporting struts is so great that there is no substantial heating and cooling effect and thus no substantial expansion and contraction of the parts. Here the curve 68 shows the temperature of a controlled device 52 plotted against time and it will be apparent that these cycles occur relatively rapidly and that the peaks 70 and valleys 72 of the chart are far from regular. In contrast, the curve of Fig. 7 illustrates the operation of the device shown in Figs. 1 to 5 in which the cycling delay mechanism described is reflected in a wider spacing of the cycles in the curve 74, while at the same time the peaks 76 and depressions 78 of the curve are far more uniform.

Another embodiment of the present invention is illustrated in Fig. 8 in which a modified upper contact arm 80 is shown. This contact arm carries its contact 82 on a contact support 84 carried by three struts 86, 88, and 90. Just as in the previous case, the struts 86, 88, and 90 and the central contact support 84 may be permanently deformed downwardly from the same original piece of stock constituting the contact arm 80. Here, also, the total cross section of struts 86, 88, and 90 must be limited with respect to the current to be carried by contact 82 so that passage of such current will heat the struts sufficiently to cause the desired expansion of the struts and relative perpendicular displacement of the contact 82 with respect to contact arm 80. The struts 86, 88, and 90 are spaced substantially equally around the contact support portion 84, and this substantially equal spacing of the struts in opposed directions insures the desired perpendicular displacement of the contact 82 in response to passage and interruption of current. Operation of the embodiment shown in Fig. 8 will be essentially the same as that of the device illustrated in Figs. 1 through 5 and need not be repeated.

As pointed out above, the actual total cross section of the supporting struts for the contact must, in any case, be sufficiently small to insure substantial heating, and the struts must be long enough to provide substantial expansion of the struts by the particular current passing through the contacts. While the specific dimensions will thus depend on the current-carrying characteristics of the material and on the size of the current to be passed, the following example illustrates one set of operating conditions and switch dimensions which will achieve the desired results.

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Example 1

In a switch constructed in the form shown in Figs. 1 through 5, the current to be passed through the switch contacts in a particular flatiron was 10 amps. In this case the upper contact arm was made of nichrome #5, a commercially available alloy containing 80% Ni and 20% Cr. Here the struts 60 and 62 have a length of substantially $\frac{3}{8}$ inch each and a width of 0.050 inch, the thickness of the struts being substantially .008 inch. The initial downward displacement of the contact support 58 from the plane of the contact arm 16 is .050 inch.

With these dimensions and currents, the relative change in vertical displacement of the contact 18 with respect to the plane of contact arm 16, resulting from interruption of current or reestablishment of current is of the order of 4 to 6 mils.

In general, some of the benefits of the present invention, such as increased contact pressure on the make, and cleaner make and break of the circuit, can be achieved even where the expansion and contraction of the supporting struts are relatively small. Preferably, however, the cross section of the struts is so related to the current to be carried that the relative change in displacement of the contact in a direction perpendicular to the plane of the contacts is of the order of at least 2 to 4 mils when used on 60 cycle A. C. 115 volts. Higher A. C. voltages would require a still greater motion to insure positive extinguishing of the arc. These minimum requirements apply to both the construction shown in Figs. 1 to 5, and that shown in Fig. 8, as well as to alternate or equivalent forms of construction.

In this connection it will be noted that the invention is not necessarily limited to the use of two or three supporting struts for the contact. There must be at least two such struts extending in opposed directions according to the invention in order that the expansion and contraction of the inclined struts may be translated into the desired perpendicular displacement. A greater number than three, however, can be used, provided the total cross section of all the struts is still sufficiently limited to achieve the heating and cooling effects and expansion and contraction which will cause the necessary vertical displacements when used in conjunction with a reasonable angle of inclination of the struts.

Since minor variations and changes in the exact details of construction will be apparent to persons skilled in this field, it is intended that this invention shall cover all such changes and modifications as fall within the spirit and scope of the attached claims.

Now, therefore, we claim:

1. A thermal switch comprising first and second contact arms having first and second contacts respectively adapted to engage and disengage each other, thermally responsive means engaging and moving one arm with respect to the other and thereby engaging and disengaging said contacts in response to predetermined temperature changes, the first arm having a contact support on which the first contact is mounted, said support being offset from the plane of the first arm toward said second arm and contact, and at least two current-conducting struts constituting the sole connection of the contact support to the first contact arm, the total cross section of said struts being limited with respect to the current passing through the contacts and thereby causing substantial expansion and contraction of the struts by heating and cooling in response to the changes in current carried by the struts on engagement and disengagement of the contacts, the expansion of the struts due to current increase when the contacts engage tending to increase the offset of the first contact toward the second thus increasing the contact pressure and delaying subsequent disengagement of the contacts, and the contraction of the struts due to current decrease when the contacts disengage tending to move the first contact away from the second thus increas-

ing the gap between the contacts and delaying subsequent reengagement of the contacts.

2. A thermal switch according to claim 1 having only two current conducting struts, said struts extending from the contact support outwardly substantially 180° apart as measured in the plane of the support, and said struts being inclined from the contact support to the contact arm and thereby amplifying the expansion and contraction of the struts and causing corresponding but greater relative displacements of the contact support in a direction normal to the contact arm and support.

3. A thermal switch according to claim 1 having at least three current-conducting struts, said struts extending from the contact support outwardly and spaced substantially equiangularly around the support, and said struts being inclined from the contact support to the contact arm and thereby amplifying the expansion and contraction of the struts and causing corresponding but greater relative displacements of the contact support in a direction normal to the contact arm and support.

4. A thermal switch according to claim 1 in which said contact support, struts and first contact arm are integrally formed from a single piece of material, the support and struts being permanently deformed out of the plane of the remainder of the arm.

5. A thermal switch comprising first and second contact arms, first and second contacts on said arms adapted to engage and disengage each other, means resiliently biasing the first arm toward engagement with the second arm, means for manual adjustment of the position of the second arm, and a thermally responsive member having means engaging and moving the first arm away from engagement with the second arm in response to predetermined changes in temperature, the first arm having a contact support on which the first contact is mounted, said support being offset from the plane of the first arm toward said second arm and contact, and at least two current-conducting struts constituting the sole connection of the contact support to the first contact arm, said struts being inclined from the contact support outwardly in opposed directions to the first contact arm, the total cross section of said struts being limited with respect to the current passing through the contacts and thereby causing substantial expansion and contraction of the struts by heating and cooling in response to the changes in current carried by the struts on engagement and disengagement of the contacts, the expansion of the struts due to current increase when the contacts engage tending to increase the offset of the first contact toward the second thus increasing the contact pressure and delaying subsequent disengagement of the contacts, and the contraction of the struts due to current decrease when the contacts disengage tending to move the first contact away from the second thus increasing the gap between the contacts and delaying subsequent reengagement of the contacts.

6. A thermal switch according to claim 5 in which the second contact arm and contact are resiliently biased toward the first arm and in which the means for manual adjustment includes an adjustable stop limiting the resiliently biased movement of the second contact arm toward the first.

7. A contact arm subassembly for a thermal switch, said subassembly comprising a flexible metallic contact arm susceptible of deflection in opposite directions, a contact relatively displaced from the plane of the arm in a direction perpendicular to said plane, and at least two cur-

rent-conducting struts constituting the sole means electrically and mechanically connecting the contact arm and contact for movement of said contact in correspondence with the arm when the temperature of each strut has become stabilized, said struts extending outwardly from the contact in opposed directions and being inclined at an acute angle with respect to the plane of the contact arm to produce the displaced relation of the contact with respect to the plane of said arm, and the total cross section of the struts being relatively small with respect to the current passing through the contact and thereby causing substantial expansion and contraction of the struts by heating and cooling in response to passage and interruption of current through the switch to effect transverse movement of said contact relative to said contact arm during periods of temperature change produced by passage or interruption of current through said struts and contact.

8. A thermal switch comprising first and second contact arms having first and second contacts respectively adapted to engage and disengage each other, thermally responsive means engaging and moving one arm with respect to the other and thereby engaging and disengaging said contacts in response to predetermined temperature changes, and at least two current-conducting struts constituting the sole electrical and mechanical connection of the first contact with the first contact arm, the total cross section of said struts being limited with respect to the current passing through the contacts and thereby causing substantial expansion and contraction of the struts by heating and cooling in response to the changes in current carried by the struts on engagement and disengagement of the contacts, the expansion of the struts increasing the contact pressure and delaying subsequent disengagement of the contacts, and the contraction of the struts due to current decrease increasing the gap between the contacts and delaying subsequent re-engagement of the contacts.

9. A thermal switch according to claim 8 in which said struts are formed from a strip bent intermediate its ends to provide struts inclined at an angle only slightly less than 180° with respect to each other, thereby amplifying the expansion and contraction of the struts and causing corresponding but greater relative displacements of the bent portion in a direction normal to the contact arm.

10. A contact arm subassembly for a thermal switch, said subassembly comprising a flexible switch arm carrying one contact of the switch and capable of deflection to move the contact back and forth in a direction generally normal to the plane of the arm, a contact positioning portion offset from the plane of the arm, and at least two current-conducting struts constituting the sole means mechanically connecting said contact positioning portion to said switch arm, said struts being electrically connected to said one contact, and the cross section of said struts being limited with respect to the current passing through them and thereby causing substantial expansion and contraction of the struts and consequent relative displacement of said contact positioning portion away from and toward the plane of said switch arm by heating and cooling of the struts in response to passage and interruption of current through said contact.

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