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CONDITION RESPONSIVE SWITCH WITH WELD BREAKING MEANS

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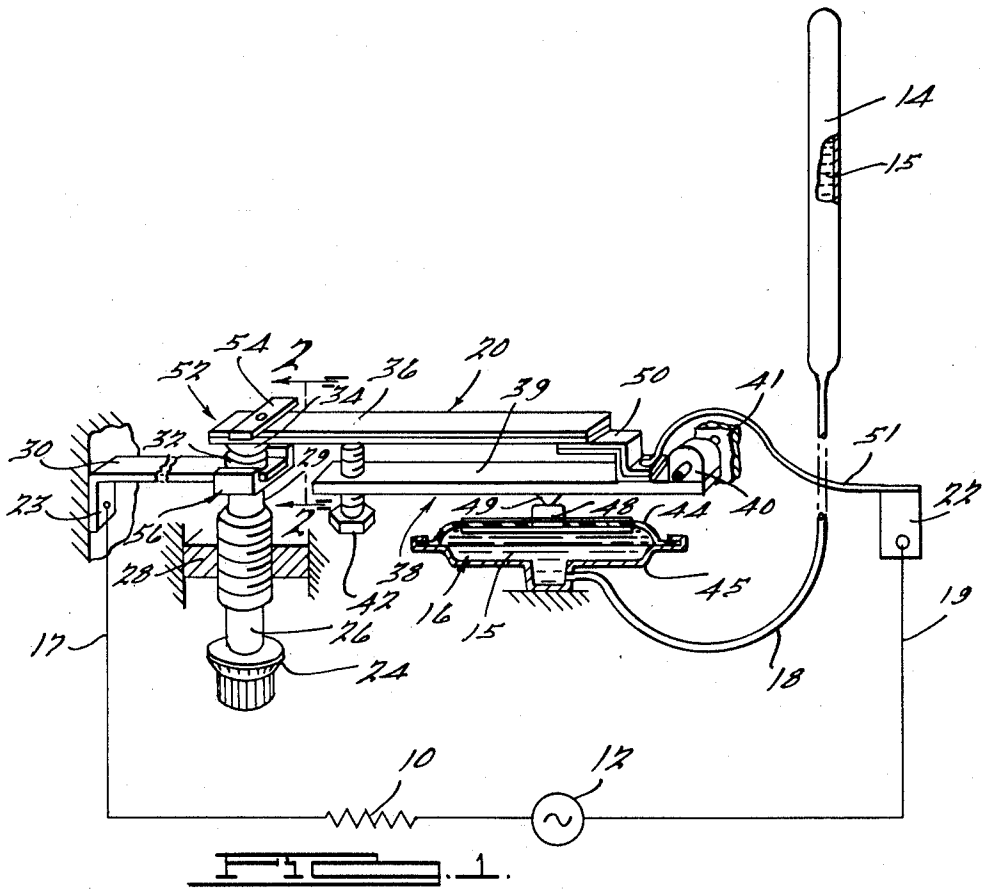


Fig. 1.

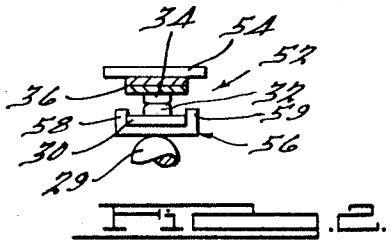


Fig. 2.

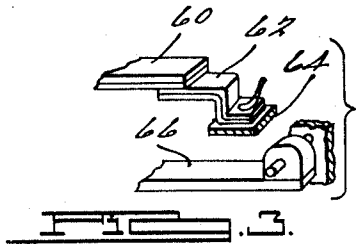


Fig. 3.

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CONDITION RESPONSIVE SWITCH WITH WELD BREAKING MEANS

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This invention relates to a temperature controlling system and more particularly to a hydraulic responder assembly for controlling the energization of an electro-responsive device.

This invention is an improvement upon a temperature controlling system of the type comprising a hydraulic sensing element containing a thermally expansible fluid which communicates through suitable conduit means with extensible hydraulic responsive means such as a bellows or diaphragm. The hydraulic sensing element may be adapted to be mounted in heat transfer relationship with a heated object or environment such as a container on a stove or an oven. As the heated environment varies in temperature, expansion or contraction of the thermally expansible fluid causes the hydraulic responsive means to correspondingly expand or contract. The system further comprises a cantilevered spring contact arm operatively associated with the hydraulic responsive means and having a fixed end portion and a freely movable end portion carrying one of a pair of contacts which are adapted to be moved between opened and closed positions as the hydraulic responsive means expands and contracts.

In systems of this type, when such contacts become welded during operation, the hydraulic responsive means may fail to open the contacts since the spring contact arm has a substantial flexibility which permits the arm to deflect in a compound curve under the welded-contact condition as the responsive means expands.

The present invention includes hydraulic responsive means and a contact-carrying spring arm which are operatively associated by means of a rigid element which imposes a positive force adjacent such welded-contacts sufficient to cause contact separation as the responsive means expands.

With the foregoing as well as other considerations in view, which are disclosed below, principal objects of the present invention are to provide an improved temperature controlling system having hydraulic responsive means and contact-carrying means associated therewith in a manner to facilitate separation of contacts which have become welded during the controlling operation; and to provide such separation by moving pusher means including a rigid element against a polymetallic contact-carrying blade to multiply the deflection of a hydraulic responder and apply a positive force at a point near to but spaced from the contacts on the contact-carrying blade; to control the opening and closing of such contacts by providing magnetic circuit means in combination with the contacts; and to further control the opening and closing of such contacts by mounting one of the contacts on such a polymetallic blade which is operatively associated with electrical circuit means for heating and deflecting the polymetallic blade to separate the contacts a predetermined distance.

With the above, as well as other and in certain cases more detailed objects in view, preferred but illustrative embodiments of the invention are shown in the accompanying drawing, throughout the several views of which like reference characters are used to designate corresponding parts and in which:

FIGURE 1 is a diagrammatic view of a temperature control system embodying the invention;

FIGURE 2 is a view in vertical section, taken along the line 2—2 of FIGURE 1; and

FIGURE 3 is a fragmentary view, of a modification of the embodiment of FIGURE 1.

Referring now to the drawing, FIGS. 1 and 2 illustrate one embodiment of the invention arranged to control an electrical load 10 included in circuit with a suitable power source 12. The load 10, for example, may be an indicator, such as a buzzer, light or the like, and/or a power controller such as a relay which controls the energization of an electrical heating unit or a solenoid valve controlling the supply of gas to a burner unit, both in response to variations in the temperature sensed by the senser portion of the control system. Furthermore, the load 10 can be an electrical heating unit per se.

The senser portion of the control system may, for example, be an elongated hydraulic temperature sensing element 14 which is adapted to be mounted in heat transfer relationship with a heated object or environment such as a container on a stove or an oven. As the temperature of the object or environment increases a suitable thermally expansible fluid 15 contained in the tube 14 expands in direct relation to the increased environmental temperature, causing an extensible hydraulic responsive actuating means, for example, a diaphragm 16 connected to the sensor 14 by a suitable fluid conduit 18, to expand to actuate a relay means 20 associated with the diaphragm 16.

The diaphragm 16 comprises a flexible disc 44 which is spring-biased inwardly toward a housing 45 and is adapted to be moved outwardly of the housing 45 by the thermally expansible fluid 15.

The diaphragm 16 is operatively associated with the relay means 20 through pusher means 38 wherein a contact 48 secured on the outer surface of the disc 44 which engages a point contact, for example, a knife-edge pivot 49 on the underside of a rigid arm portion 39 of the pusher means 38 having one end 40 pivotally carried on suitable support means 41 and an opposite free end which carries a threaded calibration screw 42.

The screw 42 is located adjacent the underside of the freely movable end of an elongated cantilevered spring arm, representatively illustrated as being a flexible polymetallic blade 36, having its opposite end anchored on the rigid arm portion 39 by means of an S-shaped polymetallic element 50 which has a freely movable end connected to the opposite end of the blade portion 36 and an end fixedly secured to the arm portion 39. The S-shaped element 50 compensates for variances in ambient temperature conditions by deflecting to counteract any deflections in the blade portion 36 caused by such variances. For example, the polymetallic blade portion 36 may be constructed so that an ambient temperature increase will cause its freely movable end to deflect upwardly. In the illustrated embodiment, such deflection will be counteracted by downward deflection of the upper and middle legs of the illustrated S-shaped polymetallic element 50.

The freely movable end of the polymetallic blade portion 36 carries a movable contact 34 which normally engages a fixed contact 32 carried on the free end of a cantilevered spring arm 30 which is pre-tensioned into operative engagement with means for adjusting the position of the fixed contact 32 with respect to the movable contact 34 comprising an adjusting screw 26 threadably connected in a fixed support 28 and having a rounded end 29 contacting the underside of the free end of spring arm 30 and an opposite end connected to a manually rotatable control knob 24.

The relay means 20 is included in an electrical circuit comprising the load 10 and the power source 12 by means including current-carrying conductors 17 and 19 which

are connected, respectively, to terminals 23, 22 on the relay means 20. In this embodiment the terminal 23 is representatively illustrated as being an anchored leg portion of the cantilevered spring arm 30 and the terminal 22 is electrically connected to the S-shaped ambient compensating element 50 by means of a suitable current-carrying conductor 51. Thus, when the contacts 32, 34 are closed, current will pass through an electrical circuit defined by the conductors 19, 51, the blade 36, contacts 32, 34, spring arm 30 and the conductor 17.

Energization of the load 10 is adjustably controlled by means of the control knob 24 which may be marked in degrees of temperature or in well-known cooking terms such as "simmer," "boil" or "fry." Rotation of the knob 24 moves the contact 32 relative to and into engagement with the movable contact 34 to move the freely movable end of the blade portion 36 upwardly a predetermined distance corresponding to a given temperature setting on the control knob 24. The rigid arm 39 will concurrently swing upwardly about its pivoted end 40 and be spaced from the diaphragm 16. The contacts 32, 34 of the relay means 20 will thereby initially be closed allowing current to flow through the relay means 20 and the load 10.

When the temperature of the environment increases a predetermined amount, the expansible fluid 15 in the hydraulic sensing element 14 expands and causes the flexible disc 44 to move outwardly from the housing 45 to move the contact 48 carried thereon against the knife-edge 49 on the rigid arm 39 to swing it upwardly, along with the blade portion 36 which acts as a rigid arm, about the pivoted end 40 of the arm 39. The free end of the rigid arm 39 moves through a greater arc than does the portion of the arm 39 which contacts the diaphragm 16 and causes the screw 42 to exert a positive force against the underside of the polymetallic blade 36 at a point near to but spaced from the contact 34 carried thereon. This arrangement effectively multiplies the displacement of the diaphragm 16 to maintain a desired predetermined contact spacing between contacts 32, 34 when they attain their opened position. Eventually the environmental temperature reaches a point, related to the temperature setting on the control knob 24, at which the diaphragm 16 will expand sufficiently to open the contacts 32, 34 and thereby deenergize the load 10. The contacts 32, 34 remain open until the temperature sensed by the temperature sensing element 14 is reduced sufficiently to cause the flexible disc 44 to move inwardly toward the housing 45 and thereby reverse the above described action.

A further embodiment of the invention illustrated in FIGURE 3 includes a polymetallic contact-carrying blade 60 which is the counterpart of blade 36 of the first embodiment. In this embodiment the blade 60 connects through an S-shaped polymetallic ambient compensating element 62 to a fixed support 64 spaced from a pivoted rigid arm portion 66 which is the counterpart of the arm portion 39 in the first embodiment. The remainder of the details of this embodiment are identical to those found in the first embodiment. The blade 60 will act as the blade 36 of the first embodiment except that when it moves the movable contact away from the fixed contact portion of the relay means it will act as a flexible arm rather than as a rigid arm since such movement will deflect the blade 60 about the fixed support 64 rather than rotate it about a pivot point as was the case in the first embodiment.

The sensed temperatures at which the contacts 32, 34 open and close may be "spread" by a permanent magnet circuit means 52 comprising a generally rectangular armature 54 which is fixed to the upper side of the free end of the polymetallic blade 36 in a direction generally transverse to the longitudinal axis of that blade. The circuit 52 further comprises a permanent magnet 56 which is held on the free end of the contact-carrying spring arm 30 by suitable fastening means the upper end of which defines the contact 32 which is located between the pole pieces or outer sides 58, 59 of the permanent magnet 56.

The contacts 32, 34 preferably are arranged to prevent the armature 54 from physically engaging the pole pieces 58, 60 of the magnet when the contacts are closed. The flux density of the magnet 56 is sufficient, however, to initially resist movement of the movable contact 34 away from the fixed contact 32. When the contact separating force reaches a predetermined level sufficient to overcome the attractive force of the magnet 56 the movable contact 34 will snap away from the fixed contact 32. Likewise, when the armature 54 becomes sufficiently proximate to the permanent magnet on closing of the contacts 32, 34, they will snap into reenagegement. The sensed temperature at which the contacts 32, 34 open will thereby differ from the sensed temperature at which they will close because the magnet 56 holds the contacts together on opening, increasing the opening temperature. Likewise, the magnet 56 prematurely pulls the contacts together on closing to thereby decrease the closing temperature. The difference between the opening and closing sensed temperature is the "spread."

In certain control operations it is desirable to partially, fully, or overcompensate for the above described temperature spread caused by the magnet 56. In the illustrated arrangement, this is accomplished by arranging for the bimetallic element to be selectively heated under the control of its own contacts. For example, the representatively illustrated bimetallic portions of the blade 36 may be proportioned such that current passing therethrough during periods in which the contacts 32, 34 are closed will cause self-heating and a consequent deflection of the freely movable end of blade 36 which will fully compensate for the attraction between the magnet 56 and armature 54. Thus, as the environmental temperature sensed by the sensing element 14 approaches a predetermined point, the force exerted near to but spaced from the contacts 32, 34 will be sufficient to open the contacts at an opening temperature corresponding to the sensed temperature. Similarly, the polymetallic blade may be sized to undercompensate for the magnetic effect or overcompensate for the magnetic effect causing the snap action between the contacts. In the latter case, the unit will pulse, even independently of any change of the sensed temperature.

It has been found that the force exerted by the diaphragm 16 will quickly and freely push the contacts 32, 34 to open position. Absent any welding between the contacts, the polymetallic blade 36 will act as a rigid bar during the opening of the contacts. Movement of the diaphragm 16 will, therefore, freely move the polymetallic blade 36 upwardly to space the contacts 32, 34 in an opened position. The mutual attraction of the armature 54 and magnet 56 and the compensating effect of the self-heated polymetallic blade 36 will, in part, determine what diaphragm movement is required to obtain such contact separation.

In the event the contacts 32, 34 are welded the polymetallic contact-carrying blade 36 (or blade 60 of FIG. 3) will act as a long flexible spring arm during the opening of the contacts. The expansion of the diaphragm 16 will cause the rigid arm portion 39 to pivot and push the screw 42 against the underside of the polymetallic blade 36 at a point near to but spaced from the contacts 32, 34. The force of the screw 42 on the blade 36 causes it to flex or bow about the point at which the screw 42 contacts blade 36. The polymetallic blade 36 is, however, sufficiently rigid between the point of engagement between the screw 42 and the blade 36 and the welded contacts 32, 34, due to the short length, so that a substantial force is exerted on the welded contacts 32, 34. This force tends to rotate the contact 34 in a counterclockwise sense (FIG. 1) relative to the contact 32 so that the applied force is concentrated at the right-hand edge of the weld (and progressively advances leftwardly as the weld progressively fractures) rather than being distributed over the complete weld.

While it will be apparent that the embodiments of the invention herein disclosed are well calculated to fulfill the objects of the invention, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the spirit and scope of the invention.

What is claimed is:

1. In a control device the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto, flexible elongated element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, pusher means including an elongated lever arm disposed between said actuating means and said flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

2. The combination of claim 1 wherein said lever arm comprises a pivotally mounted rigid arm.

3. In a control device the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto, flexible elongated element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, pusher means including an elongated lever arm disposed between said actuating means and said flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said arm having contact means thereon for contacting said flexible element at a point near to but spaced from said freely movable end and said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

4. In a control device the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto, flexible elongated element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, manually adjustable means operatively connected to said first contact means for moving said freely movable end of said flexible element means to select environmental conditions which operate to control the relative position of said first and second electrical contact means, pusher means including an elongated lever arm interposed between said actuating means and said flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

5. The combination of claim 4 wherein said lever arm comprises a pivotally mounted rigid arm.

6. In a control device the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto, flexible elongated element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, snap-acting means operatively connected to said first and second electrical contact means for varying the sensed condition at which said contact means will open and close, and pusher means including an elongated lever arm interposed between said actuating means and said flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means to reduce the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

7. The combination of claim 6 wherein said lever arm comprises a pivotally mounted rigid arm.

8. In a device for controlling the energization of an electrical circuit from a source of electrical energy the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto for controlling the electrical circuit, flexible elongated polymetallic element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, means for selectively heating said flexible element means under the control of said first and second electrical contact means to vary the sensed conditions at which said first and second electrical contacts will open and close, pusher means including an elongated lever arm interposed between said actuating means and said flexible element means, and means for

fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

9. The combination of claim 8 wherein said lever arm comprises a pivotally mounted rigid arm.

10. In a control device the combination comprising; a base member, condition sensing means for sensing conditions of an enviroment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto, flexible elongated element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, snap-acting means operatively connected to said first and second electrical contact means for varying the sensed conditions at which said contact means will open and close, manually adjustable means operatively connected to said first contact means for moving said freely movable end of said flexible element means to select the environmental conditions which operate to control the relative position of said first and second electrical contact means, pusher means including an elongated lever arm interposed between said actuating means and said flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

11. In a device for controlling the energization of an electrical circuit from a source of electrical energy the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto for controlling the electrical circuit, flexible elongated polymetallic element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, manually adjustable means operatively connected to said first contact means for moving said freely movable end of said flexible element means to select the environmental conditions which operate to control the relative position of said first and second electrical contact means, means for selectively heating said flexible element means under the control of said first and second electrical contact means to vary the sensed conditions at which said first and second electrical contact means will open and close, pusher means including an elongated lever arm interposed between said actuating means and said flexible element means, and means for

fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of the contact means to break said weld.

12. In a device for controlling the energization of an electrical circuit from a source of electrical energy the combination comprising; a base member, condition sensing means for sensing conditions of an environment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto for controlling the electrical circuit, flexible elongated polymetallic element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, snap-acting means operatively connected to said first and second electrical contact means for varying the sensed conditions at which said contact means will open and close, means for selectively heating said flexible element means under the control of said first and second electrical contact means to vary the sensed conditions at which said first and second electrical contact means will open and close, pusher means including an elongated lever arm interposed between said actuating means and flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

13. In a device for controlling the energization of an electrical circuit from a source of electrical energy the combination comprising; a base member, condition sensing means for sensing conditions of an enviroment, first electrical contact means supported by said base member and second electrical contact means matable with said first contact means and actuated for movement relative thereto for controlling the electrical circuit, flexible elongated polymetallic element means having a first end and a freely movable end for supporting and actuating said second electrical contact means, responsive means operatively connected to said condition sensing means including actuating means operating to actuate said second electrical contact means for controlling the relative position of said contacts in response to predetermined conditions sensed by said condition sensing means, snap-acting means operatively connected to said first and second electrical contact means for varying the sensed conditions at which said contact means will open and close, manually adjustable means operatively connected to said first contact means for moving said freely movable end of said flexible element means to select the environmental conditions which operate to control the relative position of said first and second electrical contact means, means for selectively heating said flexible element means under the control of said first and second electrical contact means to vary the sensed conditions at which said first and second electrical contact means open and close, pusher means including an

elongated lever arm interposed between said actuating means and said flexible element means, and means for fixedly supporting said first end of said flexible element means relative to a portion of said pusher means, said pusher means creating a first moment arm about said flexible element means support and said actuating means creating a second moment arm about said flexible element means support, said first moment arm being substantially greater than said second moment arm and operative in response to welding of said contact means for reducing the effective stiffness of a portion of said flexible element means thereby permitting the rocking motion of said contact means to break said weld.

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