

July 20, 1965

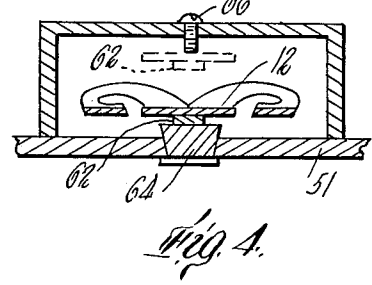
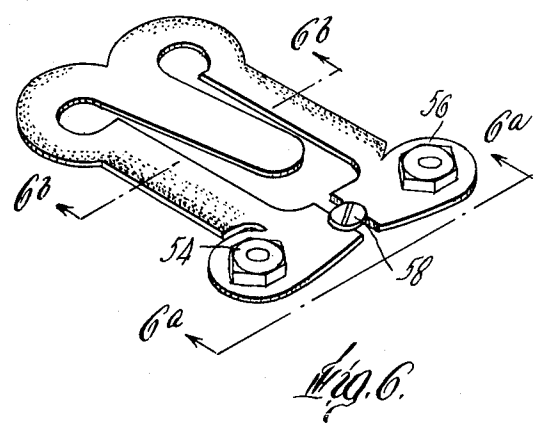
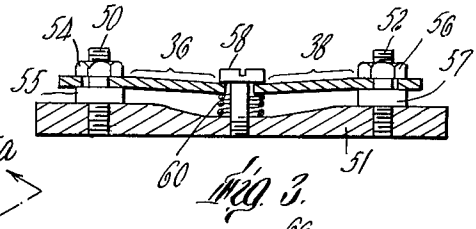
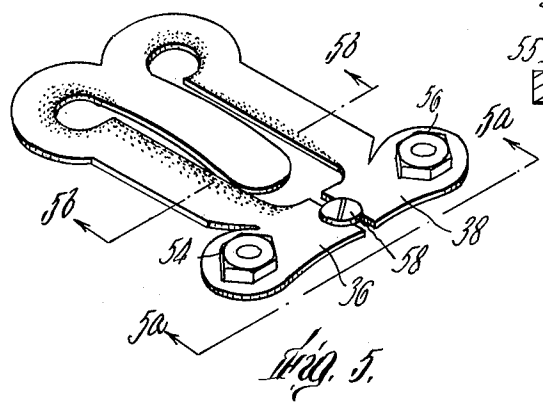
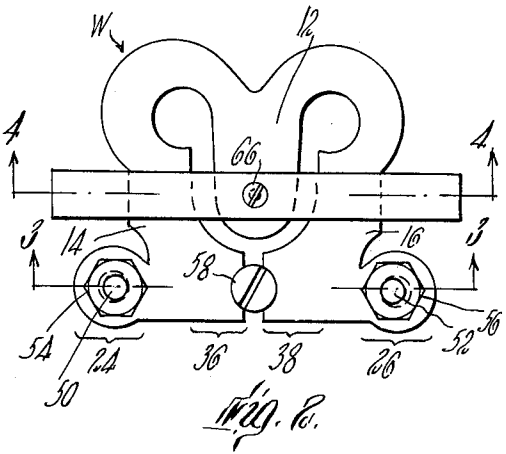
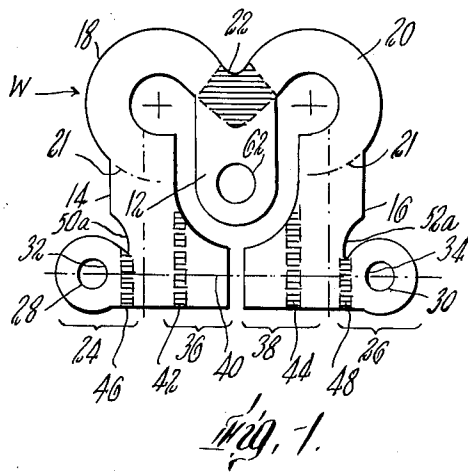
L. W. BURCH ETAL

3,196,233

W BLADE THERMOSTAT WITH FREE-ENDED MOMENT ARM

Filed Aug. 28, 1962

2 Sheets-Sheet 1



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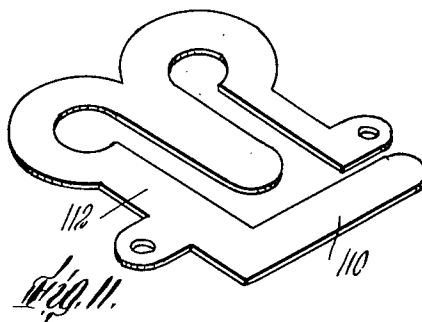
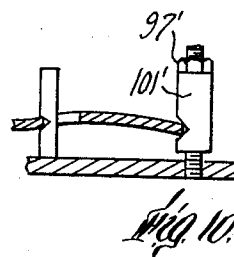
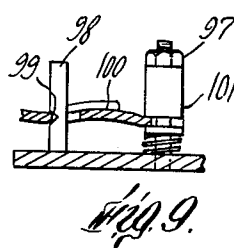
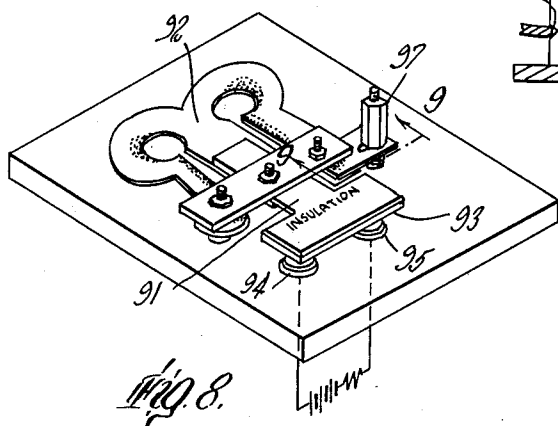
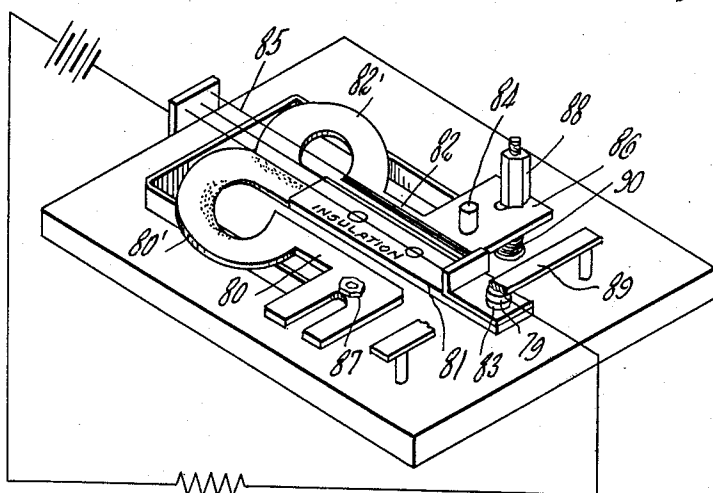
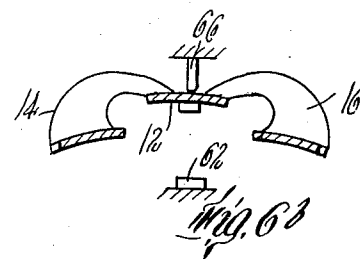
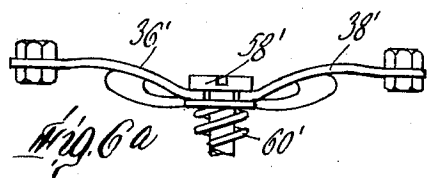
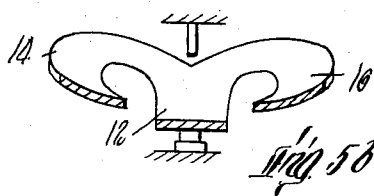
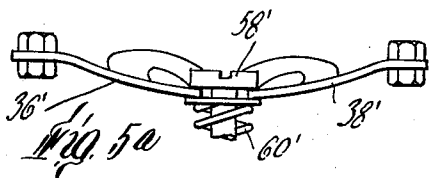
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W BLADE THERMOSTAT WITH FREE-ENDED MOMENT ARM

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W BLADE THERMOSTAT WITH FREE-ENDED MOMENT ARM

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11 Claims. (Cl. 200-113)

Our invention relates to switching devices and in particular to a thermostatic metal element having high and low heat-expansive sides which makes and breaks circuits by snap action.

The principal object of this invention is to provide an improved thermostat which is easily adjustable over a wide range of temperatures, has a low temperature differential of actuation, and is a construction which by simple adjustments and changes in size and materials can be widely applied to thermostatic switch needs.

For years we have designed and produced snap-action switches employing a three-legged W-shaped resilient element stamped from sheet metal, as described in U.S. Patent No. 2,777,032. The two outer flat legs of the blade are joined to the middle leg at the same end, each by a flat semi-circular loop. When mounted, the outer legs are compressed towards each other in the plane of the sheet, causing the surfaces of these outer legs and of the loops to curve to one concave-convex position or the other from which they can be snapped to the reverse curve position by an actuating force. The middle leg carries an electrical contact. Its root is integral with the two loops and snaps over-center to make and break a circuit.

This W blade has many well-known advantages. Its contact pressures are very high even at the instant before breaking, it snaps strongly, and the separation of contacts is large, all being features which prevent arcing. The blade has such a strong snap action that the middle leg can carry a pair of bridging contacts or connection wires so that no current is required through the blade. The blade can be stamped from sheet metal at high speeds. It can be mounted using ordinary commercial tolerances by means of fixed supports, but nevertheless it is capable of high precision action. When its ends are rigidly mounted, it is not subject to vibrations, particularly when the center leg is short. It has no rolling springs or other such members which are subject to wear so that it has an extremely long life over which it retains constant characteristics.

As soon as the W blade was conceived, we realized that most of its advantages would be of value in a thermostat when the blade is made of bimetallic material and the blade actuates itself when it reaches a predetermined high temperature and returns when it gets cool. But we were prevented from so employing the W blade because all configurations we attempted had an intolerably high temperature differential, above 25° F. While we were able to employ the W blade as a circuit breaker, this was only because in such a device it is acceptable to have a large temperature differential, and a narrow range of adjustment.

The importance of a low temperature differential throughout the range of the thermostat is readily illustrated by an oven thermostat. The oven temperature should not be allowed to go below a selected control temperature without the thermostat energizing the heating element, nor should the temperature be raised much above the control temperature, e.g. 5° F., before the thermostat should de-energize the heating element.

The importance of wide-range temperature adjustment for a thermostat is obvious, because the greater the range, the more universal is a thermostat's application. The art

has long been striving without success for a simple thermostat having an adjustable range of 100° F. and a differential below 5° F.

Therefore, a further object of the invention is to adapt the W blade for use as a thermostat to achieve the many advantages inherent in that construction, and in particular to produce a W blade thermostat having a range of adjustment of 100° F. and wider and a temperature differential over this range of 5° F. and lower.

Another object is to provide a thermostat construction having rigid mountings with no rolling springs or knife edges so that the blade is not subject to wear or vibration and is simple and inexpensive to assemble.

These and many additional objects and features are achieved by the invention now to be described.

We have discovered that a moment arm extending transversely to the longitudinal axis of one of the outer legs of the W blade at a point spaced towards the mounting from the juncture between one of the loops and its leg and preferably in substantial transverse alignment with the mounting of the free end of the leg enables extremely simple, wide range and accurate adjustment of the particular level of temperature at which the middle leg snaps (temperature) level, between the open and closed states, a differential as low as 2° F.

At first it appeared that these features together with adequate snap pressure could be obtained only by the use of special mountings for the outer legs, such as V-cut posts to permit the legs to be twisted for adjustment while still being pressed laterally together and restrained from facewise escape. Such mountings not only would substantially increase the cost of manufacture, but would be subject to vibration and wear. But we further discovered that rigid mountings could be employed if we did not mount the main body of the leg directly, but instead employed a transverse mounting projection which could bend at its connection to the main body of the leg in the direction about the longitudinal axis of the leg. With this arrangement a very strong snap action can still be obtained and the moment arm adjustment for temperature can proceed as above.

A more detailed description follows in connection with the drawings wherein:

FIG. 1 is a plan view of a preferred blade of the invention;

FIG. 2 is a plan view of a thermostat incorporating the blade of FIG. 1;

FIGS. 3 and 4 are vertical sections taken on lines 3-3 and 4-4 of FIG. 2, respectively;

FIG. 5 is a perspective view of a blade similar to that of FIG. 1 in the cold position;

FIGS. 5a and 5b are vertical sections of the blade of FIG. 5 taken on lines 5a-5a and 5b-5b, respectively;

FIG. 6 is a perspective view similar to FIG. 5 of the blade in the hot position;

FIGS. 6a and 6b are vertical sections taken on lines 6a-6a and 6b-6b of FIG. 6, respectively;

FIG. 7 is a perspective view of a thermostat in which the middle leg carries connection wires and no current flows through the blade;

FIG. 8 is a perspective view of a thermostat in which the middle leg carries a pair of bridging contacts;

FIG. 9 is a vertical section view taken on line 9-9 of FIG. 8 of the V post support and showing an adjustment means which employs a spring;

FIG. 10 is a view similar to FIG. 9 which employs another embodiment of an adjustment means; and

FIG. 11 is a perspective view of another thermostatic W blade.

Referring to FIG. 1, the blade W comprises a sheet of bimetallic material formed into a middle leg 12 and

two outer legs 14, 16 connected to the same end of the middle leg by integral, generally semi-circular loops 18, 20, the line of juncture of each loop and its leg being indicated by numeral 21. The shaded area 22 designates the root portion by which the middle leg is joined to the loops.

A transverse mounting projection 24, 26 extends transversely outwardly from the free end of each of the legs and is provided with a hole 28, 30 to receive a mounting post. The inner edge 32, 34 of each of these holes serves as a compression edge by which the two outer legs can be pressed together, and the upper and lower margins surrounding these holes provide surfaces by which the projections can be engaged and confined against face-wise movement.

A transverse lever 36, 38 extends inwardly from the free end of each of the legs along a transverse axis 40 which corresponds to the axis of projections 24, 26. Each lever is joined to its leg by a root section 42, 44 which is of substantial extent. Each mounting projection is joined to its leg by a root section 46, 48, delimited by a cut 50a, 52a, so that projection root 46, 48 is substantially less extensive than the root 42, 44 of the corresponding lever; hence the mounting projection is more flexibly joined to the main body of the leg than the lever.

Referring to FIGS. 2 and 3, the bimetallic blade W is simply incorporated into a thermostat, low-heat-expansive side down, by two rigid mounting posts 50, 52 which extend from a base 51 through holes 28 and 30 of the blade and engage its compression edges 32 and 34, pressing the legs 14 and 16 together generally in the plane of the unstressed blade. Mounting nuts 54 and 56 engage the upper face margins of the mounting projections 24 and 26 and hold them rigidly against bosses 55, 57.

Referring to FIG. 3, the two levers 36, 38 are engaged by a single adjustable member comprising a screw 58 threaded into the base whose head engages the upper surfaces of the levers and a compression spring 60 engaging the lower surfaces.

Referring to FIGS. 2 and 4, the middle leg 12 carries a contact 62 which engages, when cold, a stationary electrical contact 64 carried by base 51. When the blade is in the warmer state, the middle leg 12 snaps up, breaking from contact 64 and engaging upper contact or stop 66.

The mounting posts 50, 52 can be electrically conductive and serve as one pole for the circuit, contact 64 can serve as the other pole and the blade being conductive can carry current when contact 62 engages contact 64.

As an example of the details of construction, the blade may be conveniently sized to fit within a circle of one-inch diameter. For this size preferably the blade is made of high activity bimetal of about .010 inch thickness. The centers of the loops can be spaced about $\frac{7}{32}$ " apart, the outer loop radii can be .250 inch and the inner radii .100 inch. Each lever can have a length somewhat greater than the width of a loop. The separation of the mounting holes can be $\frac{3}{4}$ inch, and when mounted as shown in FIG. 2 these are resiliently drawn together about .025 inch to compress the blade. This particular blade can serve, for example, as a thermostat for refrigerators, hot air heaters and stack control. When current is carried through the body of the blade, 10 amperes can be carried and when connector wires like FIG. 7 or a bridge like FIG. 8 are carried by the middle leg, no current through the blade, then 20 amperes can be carried through the contacts without destructive arcing.

By means of adjustment of the levers 36, 38 downwardly by the threaded member 58, we found the cold control temperature (temperature at which the middle leg snaps down) could be very accurately raised. By adjustment of screw 58 upwardly, with spring 60 pressing upwardly on the levers, we found the cold control temperature could also be accurately lowered. The

range of temperature thus achieved can be very extensive, exceeding 100° F., the specific limits of course being dependent upon the type of bimetal chosen, the size and compression of the element, and the particular form selected. Reproducible temperature differentials have been obtained with certain constructions as low as 2° F.

The reason for these results is not wholly clear, but we know the results are better than we ever expected, and we know that a number of features are important.

The first feature is the location of the moment arm for applying the torque. By applying the torque about the longitudinal axis of one of the legs spaced from the loop, an unambiguous, gradual tendency to decrease or increase the convexity of the low-heat-expansive side of the blade can be produced. The proper torque is applied by one or two moment arms (e.g., lever 36 or 38) which is preferably perpendicular to the longitudinal axis (37 or 39) of the blade and transversely aligned with the mounting (e.g., 50, 52), although two forces producing a perfect couple about the leg axis can satisfactorily be employed at other locations on the leg in some instances.

In operation, a leg, its loop, and the root of the middle leg have their low expanding sides convex in the cold state. Then application of force by a threaded member, spring or the like to the moment arm in the direction to increase the convexity increases the force necessary to over-center the middle leg. Since all of this force must be supplied by the curling tendency of the bimetallic blade as it is heated a very accurate adjustment is obtained to increase the temperature at which the middle leg snaps. Force applied to the moment arm in the opposite direction lowers the temperature at which the middle leg snaps in a similar manner. Thus the temperature of actuation can be adjusted both higher and lower from the neutral temperature at which the blade would tend to snap if no moment were applied.

Because we have found the temperature differential is directly related to the degree the two outer legs are pressed together, it is of critical importance to achieve the necessary low differential that the torque be applied at a location spaced from the loop and its juncture with its leg. A force on or near a loop grossly inhibits the loop from over-centering, thus causing the loss of snap action unless the outer legs are pressed much more tightly together, but such pressing would create an intolerable temperature differential. Furthermore, such a force cannot produce an adjustment on both sides of the neutral position of the blade so the range of adjustment would be grossly inadequate. Finally, such a force would tend to bend the longitudinal axis of the loop and leg, counteracting the desired effect upon the curvature of the blade.

The second feature is the flexible mounting of the outer legs, preferably employing the flexible mounting projections 24 or 26 whose ends are rigidly mounted. If a flexible mounting were not employed, the resistance to twist of the outer leg would decrease the snapping tendency of the middle leg, necessitating higher compression of the outer legs together which would impose a higher temperature differential.

Without the particularly preferred rigid mounting of the flexible projections 24, 26 (rather than employing the V-cut post type of flexible mounting (FIG. 9)) the W blade thermostat has much better reliability and life, is less expensive to manufacture and is more rugged, and hence has a greatly increased usefulness. The shape of the projections can vary, but are characterized by being cut away from the body of the leg enabling the latter to twist about its longitudinal axis clear to its end.

The third feature is that the outer legs need not be adjustable towards each other because the temperature adjustment is independent of the degree by which the legs are forced together. The position of the legs is a constant which is selected to cup the loops to the minimum necessary to make them so unstable at center that the middle leg will reverse its position with a clean snap at

the neutral or natural temperature level (level at which the middle leg snaps when no torque in either direction is being applied by the moment arm from the cold state).

The fourth feature, which is particularly preferred when a very small temperature differential is required is that the adjustment device acts on the moment arm to improve the temperature differential. When the blade snaps from cold to warm, the moment arm tends to turn about its compression edge to align its surface with that of the corresponding leg and loop. This tendency to turn causes a change in the force being applied to the moment arm by the adjustment device, always in the sense of helping to pretravel the blade back to the cold position. By having the adjustment device engage both sides of the lever firmly, this pretraveling effect is maximized.

For a more extensive explanation, referring to FIGS. 5, 5a, 5b, the W blade is shown in the cold condition, low-expansive-convex side down. In this instance the screw head 58' has been screwed down to force the levers 36', 38' down beyond the neutral level, to raise the temperature of actuation. A washer 61 is pressed upwardly against the edge margins of the levers by spring 60', tending to keep these margins horizontal. When the blade is heated to the point where the high-expansive side produces a reversing force, the root of the middle leg is caused to over-center and snaps to hot position (FIG. 6) in which the upper side of the root is, and the loops and legs are, or tend to be, convex. Since each outer leg is free to twist about its mounting, it tends to conform to the convex curvature and raise the inside edge of each outer leg relative to its outer mounted edge. This tends to force the levers 36', 38' upwardly, which causes the screw head 58' to apply an even greater downward force against the levers. This additional force is made greater because the spring and washer tend to prevent the margin of the lever from twisting as it tends to do. Thereby, the blade is in effect preloaded towards the cold state. This additional force is never completely relieved until the blade snaps reversely, so the combination lever and adjustment device have the effect of decreasing the amount of energy required to be transferred to reverse the blade.

If the levers had been adjusted by the screw head 58' so that spring 60' pushes upwardly beyond the neutral position and tends to lessen the convexity of the low differential side of the root 22, less thermal energy is required to cause the middle leg 12 to snap up than that required at neutral. But when the middle leg snaps the levers 36, 38 tend to press upwardly away from the spring so that the external torque is diminished or removed, and the blade is in effect again preloaded towards the reverse condition. So again the temperature differential is decreased. Accordingly, over the entire wide range of temperatures a low-temperature differential is preserved.

Numerous other embodiments can produce results that are adequate for some purposes.

Referring to the thermostat of FIG. 7, one outer leg 80 is rigidly mounted at 87 and the second outer leg 82 is held under compression by a V-cut post 84 which enables twisting of the leg while restraining the faces of the leg from escape. The lever 86 extends laterally outwardly in transverse alignment with post 84. A threaded post 88 on the upper surface and a compression spring 90 apply torque to the lever.

In this embodiment the middle leg supports a non-conductive plate 81 which in turn mounts an electrical contact 83 which engages an upper fixed contact (not shown) when the blade is hot. Three flexible wires 85 are connected to this contact and extend rearwardly to a fixed support. The fixed bridge 89 shown partly broken away mounts the upper contact which can be positioned at a sufficiently low level as to engage the middle arm when loop 82' reverses its curvature but before loop 80' does so, a desirable provision when the end of leg 80 is rigidly mounted, to avoid requiring a large temperature differential. This construction can employ very heavy

bimetallic material which produces correspondingly large actuating forces.

The embodiment of FIG. 8 differs from FIG. 7 in that the insulative plate 91 mounted on the end of the middle leg 92 is T shaped, on the bar of which is mounted a conductive plate 93 which in the lower position engages fixed contacts 94 and 95 to make a circuit, again without current flowing through the blade.

Referring to FIG. 9 the V-cut post 98 is shown applying forces to compressive edge 99 of the leg in the direction of the other leg, the V-shaped slot restraining only the smallest part of the face margins of the leg.

FIG. 10 of another embodiment employs a V-cut block 101' for positioning the lever in space, ensuring that adjustment of the screw 97' to any position carries the lever therewith and restrains the edge margin of the lever.

The blade shown in FIG. 11 has a lever 110 extending the width of the blade providing for extremely accurate adjustment of the torque applied to its leg 112.

For some purposes adequate operation of the W blade thermostat is obtained by pressing upon one side only of a moment arm. In some instances in the cold state, one loop though not the root of the middle leg or the other loop may have its low-expansive side concave. The device may be employed as an accurate electric current sensing devices rather than a thermostat.

These and various other modifications of the specific details of the embodiments are within the spirit and scope of the invention.

What is claimed is:

1. A heat-sensitive, over-center switching element formed of a sheet of resilient metal having high and low heat-expansive sides, the element having a middle leg adapted to carry an electrical contact for making and breaking a circuit and first and second outer legs each having one end portion connected to the same end of the middle leg, each by an integral loop, the opposite end portions of said outer legs being free from each other and each having a mounting part means adapted to receive an inward external force to resiliently press the outer legs towards each other generally in the plane of the sheet to curve the surfaces of said loops and outer legs, the element including at least one free-ended moment arm lying substantially in the plane of the element, said moment arm being integral with and extending transversely from a longitudinal edge of said first outer leg at a location spaced from the juncture of said first outer leg with its loop, said moment arm positioned to receive a force in a direction at an angle to the plane of the element to cooperate with an opposite reaction force acting on said first outer leg to produce a torque essentially about the longitudinal axis of said first outer leg whereby the temperature of actuation of said switching element, when employed in a thermostat, can be adjusted while maintaining a low temperature differential.

2. The switching element of claim 1 wherein said free-ended moment arm extends from said opposite end portion of said first outer leg in substantially transverse alignment with the mounting means part thereof.

3. A heat-sensitive, over-center switching element formed of a sheet of resilient metal having high and low heat-expansive sides, the element having a middle leg adapted to carry an electrical contact for making and breaking a circuit and first and second outer legs each having one end portion connected to the same end of the middle leg, each by an integral loop, the opposite end portions of said outer legs being free from each other and each having a mounting part means adapted to receive an inward external force to resiliently press the outer legs towards each other generally in the plane of the sheet to curve the surfaces of said loops and outer legs, the element including at least one free-ended moment arm joined to and extending transversely from a longitudinal edge of said first outer leg at a location spaced from the juncture of said first outer leg with its loop, said moment

arm positioned to receive a force in a direction at an angle to the plane of the element to cooperate with an opposite reaction force to produce a torque essentially about the longitudinal axis of said first outer leg, at least said mounting part means that is associated with said first outer leg having the free-ended moment arm being joined to the remainder of said first outer leg by a relatively narrow connecting part means, said connecting part means shaped and having sufficient stiffness to transmit transverse stress from said mounting part to said remainder means of said first outer leg for curving the surfaces of said loops while being sufficiently flexible to permit rotation of said remainder of said first outer leg about its longitudinal axis relative to said mounting part means, whereby the temperature of actuation of said switching element, when employed in a thermostat, can be adjusted while maintaining a low temperature differential.

4. The element of claim 3 wherein said free moment arm at the place where it joins its first outer leg is more extensive in the direction parallel to the longitudinal axis of said first outer leg than the corresponding dimension of the connecting part means which connects said mounting part means to the remainder of said first outer leg.

5. A thermostat device comprising a heat-sensitive, over-center switching element, said element formed of a sheet of resilient metal having high and low heat-expansive sides, the element having a middle leg carrying at least one electrical contact for making and breaking a circuit with a stationary contact and first and second outer legs each having one end portion connected to the same end of the middle leg, each by an integral loop, means pressing said outer legs towards each other generally in the plane of the sheet curving the surfaces of said loops and outer legs, at least one of said loops and the root of said middle leg having their low heat-expansive sides convex when in the cold state, the switching element including at least one free-ended moment arm joined to and extending transversely from a longitudinal edge of said first outer leg at a location spaced from the juncture of said first outer leg with its loop, said moment arm positioned to receive a force in a direction at an angle to the plane of the element, adjustable means for applying a force to said moment arm in said direction and a cooperating means producing an opposite reaction force acting on said first outer leg to produce a torque essentially about the longitudinal axis of said first outer leg, said first outer leg mounted in a manner to be free to turn about its longitudinal axis in response to said torque whereby the temperature of actuation of said device can be adjusted while maintaining a low temperature differential.

6. The thermostat of claim 5 wherein said mounting means, at least for the first outer leg to which said free-

ended moment arm is joined, includes a mounting part means joined by a connecting part to the remainder of said outer leg, said connecting part shaped and having sufficient stiffness to transmit transverse stress from said mounting part to said remainder means of said first outer leg for curving the surfaces of said loops while being sufficiently flexible to permit rotation of said remainder of said first outer leg about its longitudinal axis relative to said mounting part means, and said mounting means including means rigidly mounting said mounting part means in a manner applying pressing forces through said connecting part to said remainder of said first outer leg, to stress it towards the other of said outer legs generally in the plane of the sheet.

7. The thermostat of claim 5 wherein said moment arm is joined to the first outer longitudinal edge of said outer leg and extends transversely outwardly therefrom.

8. The thermostat of claim 7 wherein said middle leg extends lengthwise beyond said outer legs, a conductive bridge member is secured to the outer end of said middle leg, said bridge member including two contact portions, and two stationary contacts are provided, aligned to be engaged by said contact portions of said bridge member.

9. The thermostat of claim 5 wherein said adjustable means engages both sides of the free end portion of said moment arm and limits the freedom of said end portion to move with the outer leg to which it is joined when the middle leg over-centers.

10. The thermostat of claim 5 wherein each of said outer legs has one of said moment arms, and single adjustable means is positioned to exert forces upon the free end portions of both moment arms.

11. The thermostat of claim 5 wherein said adjustable means comprises a compression spring pressing against one side of said moment arm and a threaded nut pressing against the other, adapted to produce a moment about first outer leg, tending to make the low-expansive side of the corresponding loop convex when it is desired to raise the temperature of actuation and to produce a moment about said first outer leg tending to make that side of said loop concave when it is desired to lower the temperature of actuation.

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