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THERMALLY ACTUATED BISTABLE SWITCH

Filed April 28, 1967

2 Sheets-Sheet 1

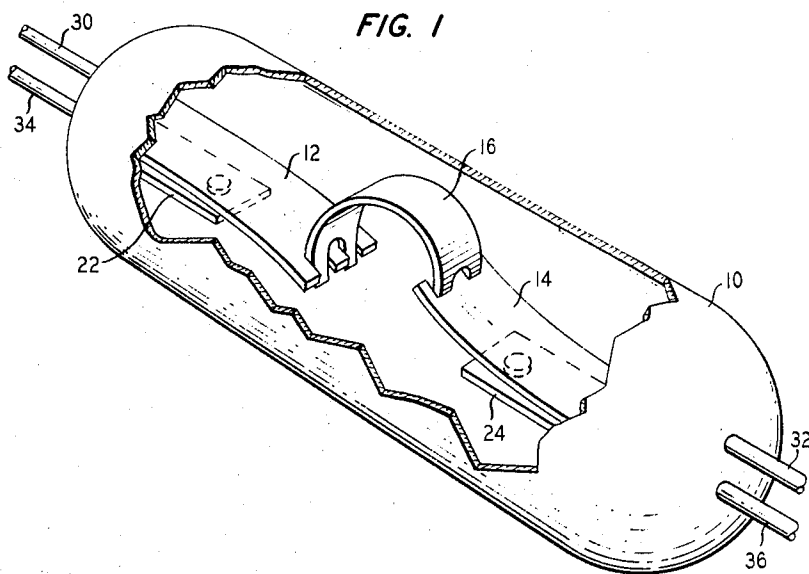
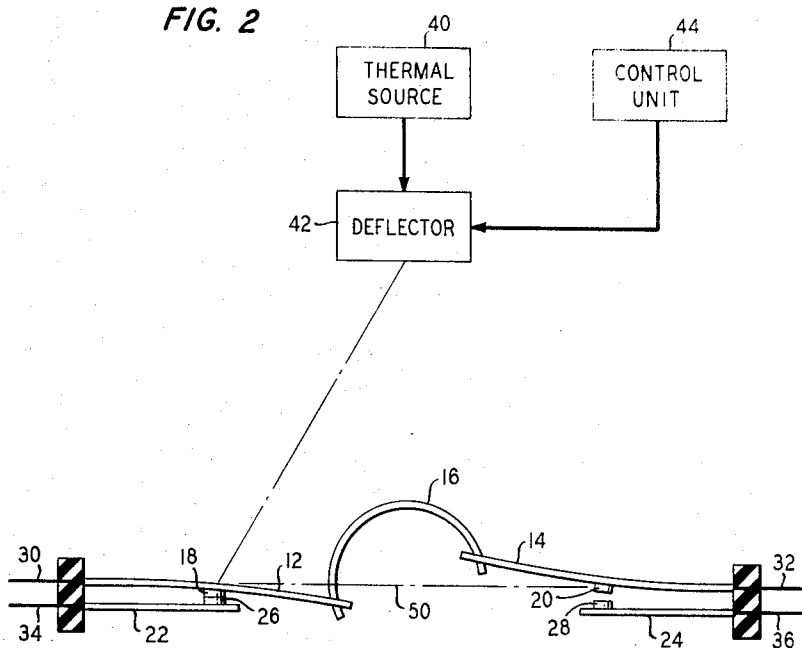


FIG. 2



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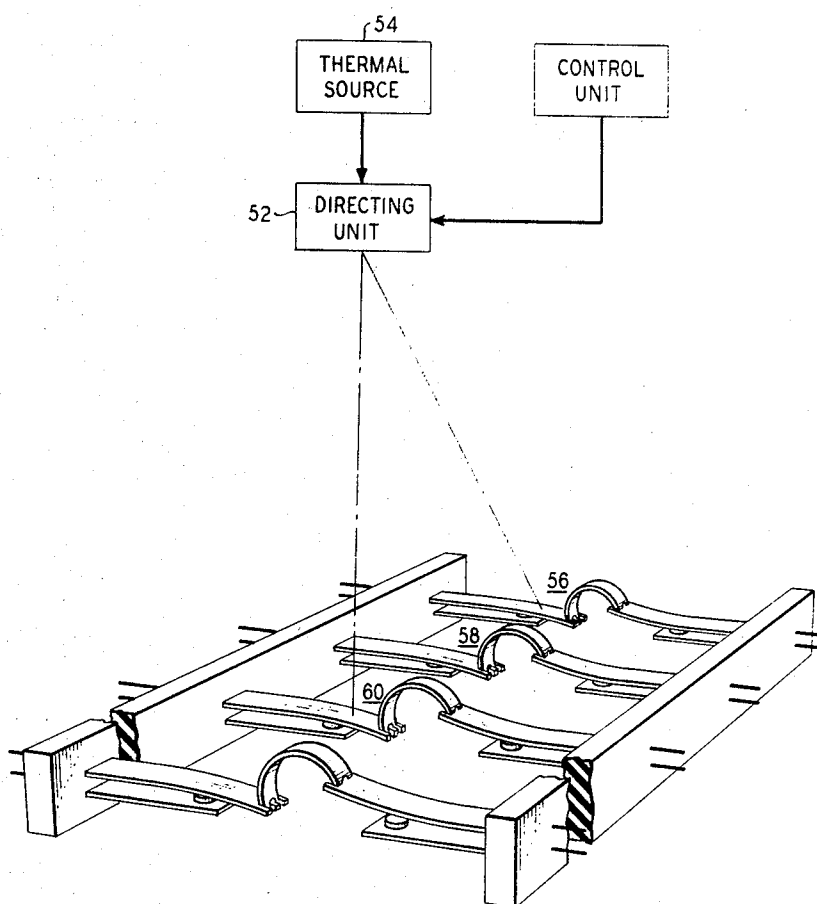
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FIG. 3



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THERMALLY ACTUATED BISTABLE SWITCH
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6 Claims

ABSTRACT OF THE DISCLOSURE

This disclosure is directed to a thermally actuated snap-action bistable switching device that comprises two bimetallic actuating members connected together by a compressed C-shaped spring element. Switching and consequent latching of the device from one to the other of its two stable positions is accomplished by selectively deflecting the radiant energy output beam of a laser to alternately impinge upon the actuating members.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to switching devices and more particularly to such devices of the thermally actuated snap-action type.

Description of the prior art

Various known switching devices as heretofore constructed are adapted to be controlled in response to prescribed temperature variations. A typical such device includes a bimetallic member connected at its free end to a spring element. In this type of device, actuation of the member in response to a temperature change in a specified direction causes contacts associated with the member to open (or close). Switching in the opposite direction is then accomplished either by subjecting the member to a temperature change in the opposite direction or by some appropriate nonthermal means such as electromagnetic or manual actuation.

SUMMARY OF THE INVENTION

An object of the present invention is an improved switching device.

A more particular object of this invention is an improved snap-action switch which is thermally actuated.

More specifically, an object of the present invention is a bistable snap-action thermally actuated device which is responsive to temperature changes in the same direction, applied at different times, to effect successive switching between its two stable conditions.

Another object of this invention is a remotely-controlled switching device characterized by long life, low cost and a high degree of contact reliability.

Briefly, these and other objects of the present invention are realized in a specific illustrative switching embodiment thereof that comprises two bimetallic actuating members. These members are mounted in cantilever configurations at opposite ends of an enclosure, with the adjacent free ends of the members being joined together by an arcuate compressed spring element. In addition, an electrical contact is affixed to each cantilever member, and mating contacts are attached to the free ends of two contact strips which are respectively mounted below and parallel to the cantilever members.

The construction of the switch is such that each bimetallic actuating member has only two stable positions, either deflected upward, with its associated contact pair in an open or "break" position, or deflected downward, with its associated contact pair in a closed

or "make" position. The actuating members are further constrained by the spring element to always occupy opposite stable positions. Consequently, when the spring is in a stable condition, there is always one open pair of contacts and one closed pair.

Switching is accomplished by heating the bimetallic actuating member whose associated contact pair is in the closed position. As the heated member distorts, its contact pair opens and the arcuate spring is rotated into an unstable over-center position. From this position the spring moves towards its second stable state and forces the other cantilever member down with a snap action, thereby closing and latching the previously open pair of contacts. As the energized actuating member cools, it redistorts, thereby increasing the contact pressure of the closed contacts. The switch maintains the stable position just attained until it is switched again by heating the actuating member associated with the newly closed pair of contacts.

Advantageously the switch is actuated in the manner described by selectively directing thereat a thermal signal derived from a remote radiant energy source such as a laser. In an arrangement in which a plurality of such switches are configured in a desired array, the laser beam may be focused and deflected to actuate any single selected switch or any selected group of switches to effect closure or opening of any selected contact independent of the remainder.

It is a feature of the present invention that a bistable switching device include two mounted temperature responsive members having adjacent free ends connected together by an arcuate compressed spring element which maintains the free ends in opposed stable positions.

It is a further feature of this invention that a thermal source be associated with the device to direct signals in alternation at the two temperature responsive members to cause the device to switch between its two stable states.

It is another feature of the present invention that a plurality of such switching devices be arranged in an array responsive to a thermal source adapted to simultaneously switch any prescribed number of the devices in either direction.

BRIEF DESCRIPTION OF THE DRAWING

A complete understanding of the present invention and of the above and other objects, features and advantages thereof may be gained from a consideration of the following detailed description of a specific illustrative embodiment thereof presented hereinbelow in connection with the accompanying drawing, in which:

FIG. 1 is a pictorial depiction of a specific exemplary switching device made in accordance with the principles of the present invention;

FIG. 2 is a schematic showing of the device of FIG. 1 combined with an illustrative thermal source for controlling the device; and

FIG. 3 schematically illustrates a plurality of the FIG. 1 devices arranged in an array which is controlled by an associated thermal source.

DETAILED DESCRIPTION

The illustrative switching device shown in FIG. 1 comprises a housing or envelope 10 made of a material which is transparent to radiation that is to be directed therethrough to actuate the various contained components. (The housing may be replaced by any other suitable supporting structure.) Two conventional bimetallic members 12 and 14 are fixedly mounted in cantilever configurations at opposite ends of the housing 10. Interposed between the spaced-apart free ends of the members 12 and 14 is a compressed arcuate spring element 16. In practice, the

spring element 16 is lightly stressed relative to the endurance limit of the material thereof, thereby contributing to the long life of the depicted switching device. Illustratively the element 16 is a thin, flat so-called C-shaped spring having bifurcated ends that resiliently engage cut-out channel portions of the members 12 and 14. The junction interfaces between the element 16 and the members 12 and 14 are essentially line contacts; hence heat conduction therebetween is minimized.

Mechanically fixed to and electrically continuous with the bimetallic members 12 and 14 are two contacts 18 and 20, respectively (see FIG. 2). Positioned below the members 12 and 14 shown in FIG. 1 are two respectively associated contact strip supports 22 and 24, each of which carries a fixed electrical contact. (These last-mentioned contacts are designated 26 and 28, respectively, and are shown in FIG. 2.) Advantageously the contact strip supports 22 and 24 are made of the same bimetallic material as the members 12 and 14, thereby to minimize ambient temperature-change effects. Additionally, it is advantageous to plate or otherwise treat the members 12 and 14 and the strips 22 and 24 to reduce the electrical resistance thereof.

The bimetallic members 12 and 14 of FIG. 1 are respectively connected to leads 30 and 32, and the contact strip supports 22 and 24 are connected to leads 34 and 36, respectively. To minimize the cooling-time characteristic and the electrical resistance of these leads, it is advantageous to make them of copper.

It is apparent that the configuration depicted in FIG. 1 is in effect that of a single pole-double throw switch. Various other illustrative switch configurations embodying the principles of the present invention are of course possible. These other configurations include single pole-single throw, multiple pole-single throw and multiple pole-double throw arrangements.

FIG. 2 shows the illustrative herein-considered switching device latched in one of its stable positions. (The reference numerals specified above in connection with FIG. 1 have also been employed in FIG. 2 to identify corresponding components.) In the depicted position, the contacts 18 and 26 are resiliently maintained together in secure electrical contact in response to a downward force applied to the bimetallic member 12 by the compressed spring 16. On the other hand, the contacts 20 and 28 are at the same time maintained apart by an upward force applied to the member 14 by the spring 16. The depicted position is one of stable equilibrium.

Actuation of the device shown in FIG. 2 is accomplished by directing the output of a thermal source 40 (advantageously a laser) onto the bimetallic member 12. In practice this is done by passing the output of the source 40 through a deflector 42 which is controlled by a unit 44 to direct the radiant energy output of the source 40 onto either the member 12 or the member 14.

As indicated in FIG. 2 the radiant energy output of the source 40 is directed at the member 12 which, as a result, heats up. In response to this heating, the right-hand end of the member 12 bends upward toward reference center line 50. As the member 12 distorts in this way, the contacts 18 and 26 are moved apart and the spring 16 is rotated to an unstable over-center position in which the right-hand end of the member 12 moves slightly above the center line 50. Continued upward movement of the member 12 above the center line 50 causes the spring 16 to rotate in a clockwise direction with a snap action, thereby to exert a sudden downward force on the member 14. As a consequence thereof, the contacts 20 and 28 are snapped together into juxtaposed engagement. Since the initial electrical connection between the contacts 20 and 28 is made while the actuating bimetallic member 12 is still warm, the pressure between these contacts increases as the member 12 subsequently cools and redistorts following extinguishment of the incident radiation.

The described switching device maintains the stable

position just attained (opposite to the one shown in FIGS. 1 and 2) until it is switched again by heating the actuating member 14 associated with the newly closed pair of contacts 20 and 28. Such heating is accomplished by controlling the deflector 42 to direct the output of the source 40 at the member 14. The ensuing operation of the depicted device in returning to the stable position shown in FIGS. 1 and 2 is the exact counterclockwise equivalent of the operation described above.

The principles of the present invention also encompass arrangements in which a plurality of switching devices arranged in a network array are simultaneously actuated. A simple such array is represented in FIG. 3. Any desired number of the devices in the illustrative array can be switched by controlling a unit 52 to direct the output of a thermal source 54 to selected ones of the depicted devices. Focusing, deflecting and control units adequate to perform this function are well known in the laser art. For illustrative purposes the output of the unit 52 is shown in FIG. 3 as being directed at the left-hand actuating members of the switching devices 56 and 60. As a result of the depicted energization, the spring elements of the devices 56 and 60 are rotated clockwise, in a mode of operation identical to that described above, whereby the respective left-hand contacts associated with the devices 56 and 60 are moved apart and the respective right-hand contact pairs associated therewith are subsequently snapped together.

It is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. In accordance with these principles numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention. For example, the spring element described herein can easily be adapted to provide electrically insulating contacts with the bimetallic members which it engages, thereby to achieve electrical isolation between the opposed contact pairs.

What is claimed is:

1. In combination

a first bimetallic temperature-responsive member having first and second ends,

a second bimetallic temperature-responsive member having first and second ends,

wherein each of said members includes at least one contact mounted thereon,

means for mounting the first ends of said first and second members thereby to maintain the second ends thereof free in an adjacent spaced-apart relationship,

an arcuate compressed spring means resiliently engaging the free ends of both of said members and exerting respectively opposed forces thereon for maintaining said combination in one of two stable positions, and

contact means positioned adjacent to each of said members and having at least one contact mounted thereon in alignment with the contact(s) mounted on the associated adjacent member for establishing an electrical connection between selected ones of said aligned contacts when said combination is in either one of its stable positions.

2. A combination as in claim 1 further including means for alternately directing thermal signals at said members.

3. A combination as in claim 2 wherein said directing means comprises a deflector responsive to an associated control unit for directing the output of a high-energy radiant beam source at said members in alternation.

4. In combination in a snap-action switch,

thermal energization means,

first and second bimetallic actuating members responsive to the output of said thermal energization means being applied thereto,

an arcuate compressed spring resiliently engaging the ends of both of said first and second bimetallic actuating members and exerting respectively opposed forces thereon,

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and electrical contact means having first and second conditions and including contacts mounted on said members and other contacts contiguous to said members for engagement with said mounted contacts, said first condition resulting from applying the output of said thermal energization means to said first bimetallic actuating member and said second condition resulting from applying the output of said thermal energization means to said second bimetallic actuating member, each of said resulting conditions of said electrical contact means persisting in the absence of thermal energization until the other of said conditions results from again applying the output of said thermal energization means to the proper one of said bimetallic actuating members, whereby each of said conditions of said electrical contact means is established with a snap-like action after the persistence of the other of said conditions of said contact means terminates.

5. A combination as in claim 4, wherein said thermal energization means comprises a high-energy radiant beam source and beam deflecting means for directing the output of said source to impinge on a selected one of said bimetallic actuating members.

6. In combination
thermal energization means,
a plurality of snap-action switches each comprising first and second bimetallic actuating members responsive to the output of said thermal energization means being applied thereto,
an arcuate compressed spring resiliently engaging the ends of both of said first and second bimetallic actuating members and exerting respectively opposed forces thereon,
and electrical contact means having first and second conditions and including contacts

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mounted on said members and other contacts contiguous to said members for engagement with said mounted contacts,

said first condition resulting from applying the output of said thermal energization means to said first bimetallic actuating member and said second condition resulting from applying the output of said thermal energization means to said second bimetallic actuating member, each of said resulting conditions of said electrical contact means persisting in the absence of thermal energization until the other of said conditions results from again applying the output of said thermal energization means to the proper one of said bimetallic actuating members,

and wherein said thermal energization means comprises a radiant energy source and beam deflecting and focusing means for directing the output of said radiant energy source to simultaneously cause either of said conditions of said electrical contact means for each of a selected plurality of said snap-action switches.

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