July 13, 1965 M. E. ANDERSON ETAL 3,194,074

THERMALLY-OPERATED CONTROL MEANS

Filed Nov. 16, 1961

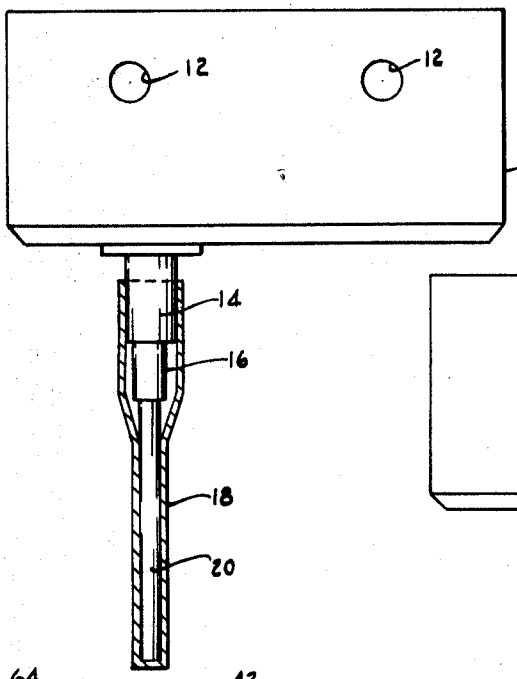


FIG_1

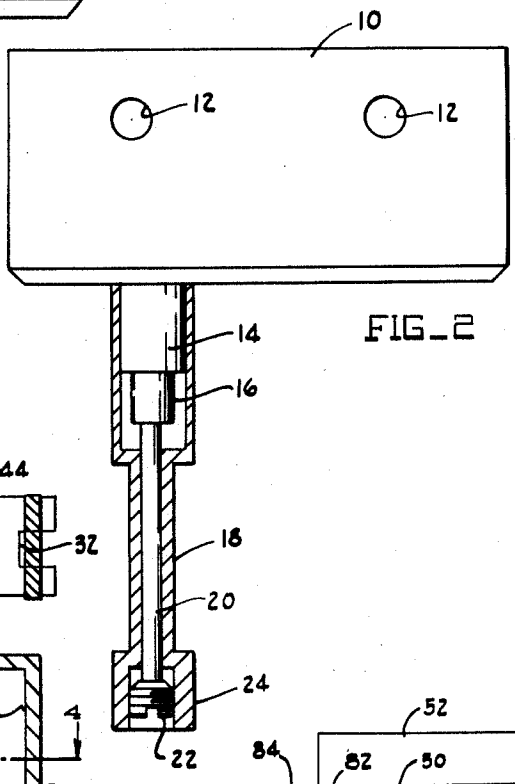


FIG_2

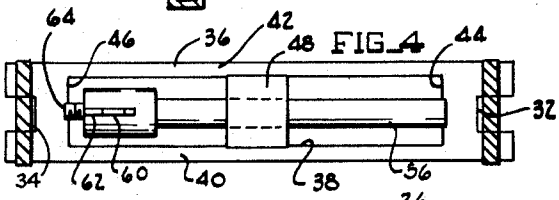


FIG_4

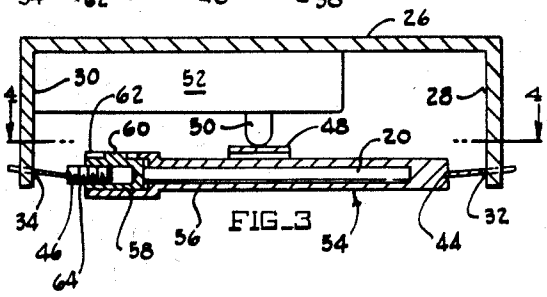


FIG_3

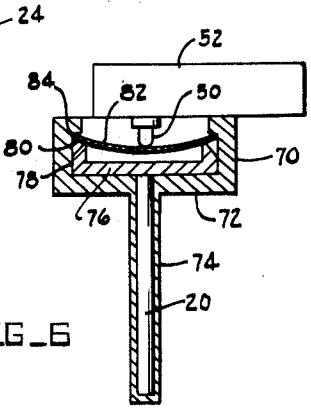


FIG_6

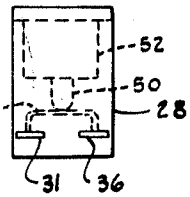


FIG_5

INVENTOR.
MAYNARD E. ANDERSON
JOHN CHAPA
BY MELVIN W. POLKINGHORN
Andrew K. Jones
their ATTORNEY

United States Patent Office 3,194,074 Patented July 13, 1965

3,194,074

THERMALLY-OPERATED CONTROL MEANS

Maynard E. Anderson and John Chapa, Birmingham, and Melvin W. Polkinghorn, Livonia, Mich., assignors to American Radiator & Standard Sanitary Corporation, New York, N.Y., a corporation of Delaware

Filed Nov. 16, 1961, Ser. No. 152,723
8 Claims. (Cl. 73—363)

This invention relates to thermally-operated control devices, as for example electric switches and fluid valves. The invention, among its features, includes the use of a recently developed crystalline material comprised of manganese, chromium and antimony, said material having the unusual property of having little or no dimensional change in a low temperature range, but undergoing a substantial dimensional change per unit temperature change in a higher transition temperature range. The sharp nature of the dimensional change makes the material particularly advantageous as an operator for various thermally actuated control devices, particularly control devices which are required to have snap action in response to small temperature change.

One object of the present invention is to provide improved control devices which utilize the advantageous characteristics of the aforementioned manganese-chromium-antimony compound.

Another object of the invention is to provide a thermally actuated control device which is operated by a relatively small temperature change.

A further object of the invention is to provide a thermally operated control device which can easily be manufactured to operate at precise temperatures and which will retain its manufactured operating characteristics after prolonged service.

Other objects of this invention will appear from the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIGURE 1 is a view of one embodiment of the invention with parts thereof shown in section;

FIG. 2 is a view partly in section of a second embodiment of the invention;

FIG. 3 is a sectional view through a third embodiment of the invention;

FIG. 4 is a sectional view taken on line 4—4 in FIG. 3;

FIG. 5 is a right end elevational view of the FIG. 3 embodiment; and

FIG. 6 is a sectional view through another embodiment of the invention.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Referring to FIG. 1, there is shown a thermally-operated electrical switch comprising a conventional snap action switch housing having mounting holes **12**, a tubular cylindrical guide structure **14**, and a switch-operating plunger **16** slidably disposed within the guide structure. The switch housing **10** may have any suitable form of snap action switch blade therein, as for example a blade constructed as shown in U.S. Patent 2,669,618. Preferably the switch is made so that only a relatively small movement of plunger **16**, as for example .0005 inch, is required to actuate the switch.

For plunger actuation purposes there is provided a thermally responsive power means comprising a fixed tubular sleeve element **18** and a slidable cylindrical rod element **20**. Element **18** may be constructed of any suitable material which undergoes negligible dimensional change per unit temperature change, while element **20** is preferably formed of a crystalline material having the formula $Mn_{2-x}Cr_xSb_{1-y}In_y$, where $0.025 \leqq x \leqq 0.20$ and

$$0 \leqq y \leqq 0.05$$

According to an article entitled "Evidence for an Anti-ferromagnetic-Ferrimagnetic Transition in Cr-Modified Mn_2Sb" appearing at pages 509 through 511 in Physical Review Letters, volume 4, Number 10, issued May 15, 1960, the indium in the compound acts principally to retard the precipitation of Mn_2Sb and does not otherwise affect the characteristics of the compound. It is therefore contemplated that the compound can be employed without the indium. The manganese-chromium-antimony material is advantageous in that in certain temperature ranges it experiences a relatively large dimensional change per unit temperature change. The temperature range in which the large dimensional change occurs may be varied by varying the chromium concentration within the limits above specified.

One crystalline material within the above specified composition range experiences a relatively small linear dimensional change of approximately .001 percent per degree until the temperature reaches a transition value of approximately 100° C., whereupon the material then undergoes a linear dimensional change of approximately .2 percent during the next five degree temperature rise. By varying the chromium concentration in the compound the transition point can be lowered from the 100° C. value. It can be seen that the material has negligible linear expansion per unit temperature change below its transition temperature but has substantial linear expansion of about .04 percent per degree in its transition temperature range so that it can be advantageously used as the material for element **20**. In an actual construction wherein plunger **16** requires a movement of .0005 inch for actuation of the switch blade, element **20** may have a length of approximately one inch, in which case the switch is actuated by a temperature change of one or two degrees.

As previously noted, tubular element **18** may be formed of any material having a relatively low dimensional change per unit temperature change since element **20** has sufficient expansion properties in its transition temperature range to provide a satisfactory net movement. Thus, operation of the control device of this invention depends primarily on the characteristics of element **20**, which operation is distinct from the usual operation of prior art devices which depended on the differential expansion characteristics of two telescoped elements, each having a relatively small thermal expansion characteristic.

In order for the FIG. 1 device to properly operate with snap action, element **18** must be adjusted on tubular guide **14** so that the high expansion period for element **20** occurs when plunger **16** is being actuated. Calibration may be accomplished by maintaining element **20** at the actuation temperature, mechanically forcing sleeve **18** onto tubular guide structure **14** as a press fit, and halting the press fit movement when plunger **16** is actuated. With this arrangement the plunger **16** will thereafter always be actuated during the period when element **20** is undergoing its sharp increase in linear dimension.

Referring now to the FIG. 2 construction, tubular element **18** thereof enjoys a non-adjustable press fit on tubular guide structure **14**, and screw **22** is threaded into the enlargement **24** of element **18**. Calibration of the device may be accomplished by holding element **20** at the

desired actuation temperature and turning screw 22 until plunger 16 is operated. After calibration the FIG. 2 device operates in the same manner as the FIG. 1 device.

The embodiment of the invention shown in FIGS. 3, 4 and 5 comprises a rigid frame 26 having two arms 28 and 30. The portions of the arms adjacent their free ends are notched, as at 31, to form fulcrum areas for the oppositely facing edges 32 and 34 of the resilient blade 36. As best shown in FIG. 4, blade 36 is provided with an elongated cut away area 38 which defines two longitudinally extending blade arms 40 and 42 and two facing blade edges 44 and 46. Elongated arm portions 40 and 42 are interconnected by a raised bridge portion 48 which, as shown in FIG. 3, engages the plunger 50 of a conventional snap action switch housing 52. The raised nature of bridge 48 provides a free space between blade edges 44 and 46 for reception of the thermally responsive power means generally designated by numeral 54. The illustrated power means comprises a sleeve-like support element 56 and a rod-like thermal expansion element 20 preferably formed of the chromium-manganese-antimony material previously specified.

The right end of element 20 abuts against the right end wall of element 56, and the left end of element 20 abuts against a slidable plug 58 which is retained against rotary motion by means of a key-like extension 60 operating in a slot 62 which is formed in the enlarged end portion of element 56. Plug 58 is of hollow construction and threadedly accommodates a screw 64, the left end of which is notched to have fulcrum engagement with the aforementioned edge 46 of blade 36. Members 58 and 64 together function as a slack take-up device for ensuring that the opposite extremities of power means 54 will operatively engage the blade edges 44 and 46 and will cause a deflection of blade 36 when element 20 is undergoing its period of high expansion.

Blade 36 is preferably formed with a slight downward bow as shown, and is installed so that its edges 32 and 34 are spaced slightly away from the adjacent surface areas of arms 28 and 30. As a result, any tendency of power means 54 to expand will cause the blade to move toward a flattened condition, with consequent upward movement of bridge 48.

In its FIG. 3 position power means 54 is in a low temperature contracted condition wherein blade 36 is bowed downwardly and plunger 50 is extended from the switch housing 52. Raising of the ambient temperature through its transition temperature range causes element 20 to undergo a substantial linear expansion, whereupon blade 36 moves toward a flattened condition with the central bridge portion 48 of the blade moving upwardly to thus actuate plunger 50.

The FIG. 3 construction is advantageous in that a relatively small linear dimensional change of element 20 results in a relatively large flexing of blade 36; thus a switch 52 having a relatively long plunger operating stroke can be employed. Such long stroke switches are less expensive than the switches required in the FIG. 1 and FIG. 2 constructions wherein small plunger motions are relied on to actuate the switch blades.

Because the dimensional change per unit temperature change for element 20 has a relatively great effect on plunger 50 any undesired tolerance variations in the axial dimension of the thermally responsive power means 54 or blade 36 will have a magnified error-producing tendency. However, adjustment structure 64 may be turned to properly calibrate the construction in spite of such manufacturing tolerance variations.

The FIG. 6 embodiment comprises a support structure having a cylindrical side wall 70, a radial wall 72, and a tubular sleeve-like wall 74. Disposed within the support structure is a rod element 20 preferably formed of the aforementioned manganese-chromium-antimony material. The upper end of element 20 engages the bottom wall portion 76 of a cup-shaped thrust element 78. The knife edge portion 80 of the thrust element engages a curved disc 82

on an annular line of contact disposed inwardly of the annular fulcrum line of contact 84 for the curved disc. Disc 82 is preferably not imperforate; instead it is preferably formed with radial notches extending inwardly from its periphery so that it may better mechanically expand or breathe when it is axially actuated by rod 20. In operation, thermal expansion of element 20 causes thrust element 78 to push disc 82 upwardly from its deeply bowed condition toward but not necessarily to a flat condition (not shown).

The central portion of disc 82 engages the operating plunger 50 of a conventional snap switch 52 so that a given movement of rod 20 produces a magnified movement of plunger 50. In this way a relatively small length of material 20 may be used to actuate the conventional snap switch which requires approximately .005 inch of plunger stroke for actuation. FIG. 6 is semi-schematic in character, and it is contemplated that suitable adjustment devices (not shown) may be incorporated in commercial forms of the device to insure that element 20 will undergo its period of highest expansion when disc 82 is being operated.

The drawings show the invention as incorporated in thermally operated electric switches. It is contemplated, however, that the invention in certain of its aspects can be incorporated in other thermally operated control devices such as fluid valves and electrical potentiometer devices, this being particularly the case with respect to the use of the chromium-manganese-antimony material as a thermally responsive power means. It will be understood that variations in construction and arrangement may be resorted to as come within the scope of the appended claims.

We claim:

1. In combination, a thermally responsive power means, including a support structure having a negligible coefficient of thermal expansion, and a thermal element carried by said support structure; said thermal element being formed of a material comprising the compound

$$Mn_{2-x}Cr_xSb_{1-y}In_y$$

where $0.025 \leqq x \leqq 0.20$ and $0 \leqq y \leqq 0.05$.

2. In combination, a thermally responsive power means, including a support structure having a negligible coefficient of thermal expansion, and a thermal element carried by said support structure; said thermal element being formed of a material comprising the compound $Mn_{2-x}Cr_xSb_{1-y}$, where $0.025 \leqq x \leqq 0.20$ and $0 \leqq y \leqq 0.05$.

3. The combination of claim 2 wherein the thermal element comprises an elongated rod formed of the aforementioned material, and the support structure comprises a sleeve-like support structure surrounding said rod in intimate thermal engagement therewith along a substantial portion of the rod length.

4. In combination, a thermally responsive power means, comprising an elongated support structure having a negligible dimensional change per unit temperature change, and an elongated rod carried thereby; said rod being formed of a material which in a low temperature range has a dimensional change per unit temperature change on the order of .001 percent per degree and which in a higher temperature range experiences a dimensional change on the order of .04 percent per degree.

5. In combination, an elongated flexible blade having two facing edges arranged so that a longitudinal force acting thereagainst is effective to flex the blade in a direction generally normal to its length; and thermally responsive power means having its opposite ends operatively engaged with respective ones of the blade facing edges so that change in the overall length of the power means provides the aforementioned longitudinal force; said power means comprising a sleeve having a negligible dimensional change per unit temperature change, and an elongated thermal expansion rod carried therewithin.

6. The combination of claim 5 wherein the rod comprises an element formed of a material comprising the

compound $Mn_{2-x}Cr_xSb_{1-y}$, where $0.025 \leqq x \leqq 0.20$ and $0 \leqq y \leqq 0.05$.

7. The combination of claim 5 wherein the power means is adjustable in length independently of temperature to take up potential slack between the power means and the facing edges of the blade.

8. In combination, a curved disc; support means engaging the peripheral edge of said disc to locate same for axial movement of its central area; and thermally responsive power means for operating said curved disc, including a thrust element having an operating line of contact with the disc located radially inwardly from its peripheral edge, a substantially non-expansible tube rigid with the support means and disposed on the line of action of the thrust element, and a thermal expansion rod disposed within the tube in pressure relation with the thrust element; said expansion rod being formed of a material comprising the compound $Mn_{2-x}Cr_xSb_{1-y}$, where $0.025 \leqq x \leqq 0.20$ and $0 \leqq y \leqq 0.05$.

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ISAAC LISANN, *Primary Examiner.*

B. A. GILHEANY, P. K. SCHAEFER, *Examiners.*