United States Patent [19]

Bell

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[54] **ELECTRO-THERMAL RELAY ACTUATOR**

[75] Inventor: **Lon E. Bell,** Altadena, Calif.

[73] Assignee: **Technar Incorporated,** Arcadia, Calif.

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[52] **U.S. Cl.** **337/107,** 337/57, 338/314, 337/94

[51] **Int. Cl.** **H01h 61/02**

[58] **Field of Search** 337/52, 53, 57, 82, 89, 337/85, 94, 102, 103, 107, 377, 365; 200/DIG. 28; 338/307, 308, 314; 219/511

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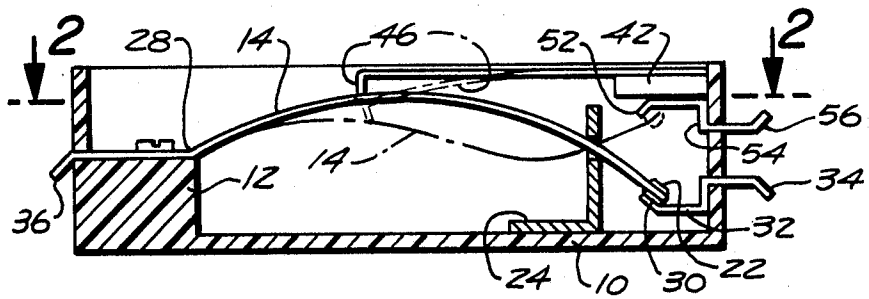
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Attorney, Agent, or Firm—Christie, Parker & Hale

[57] **ABSTRACT**

A relay in which the actuator is a bimetallic strip to which is applied a thin coating of electrical insulation material. Over the layer of insulation material is applied a layer of electrically resistive material which heats up in response to an electric current. A movable contact in the form of a flat spring is supported between two spaced pivot points that are more closely spaced than the length of the spring. The bimetal is linked to the spring such that bending of the bimetal with heating causes the movable contact spring to snap over center between the pivots.

18 Claims, 7 Drawing Figures



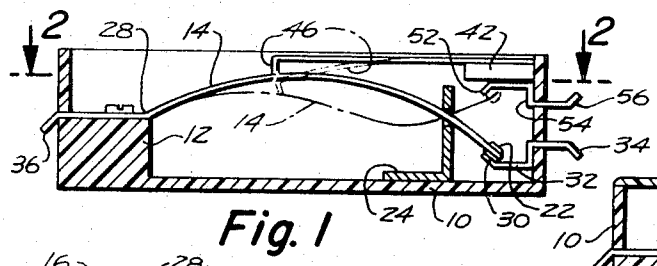


Fig. 1

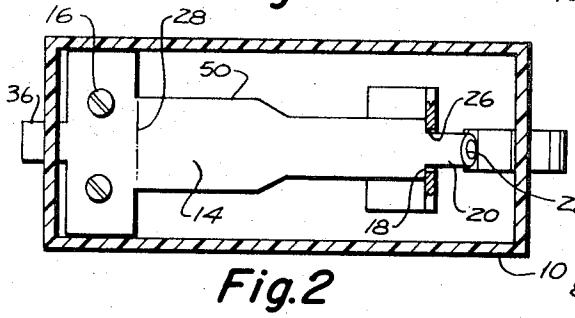


Fig. 2

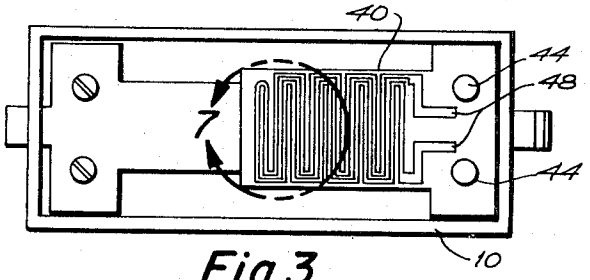


Fig. 3

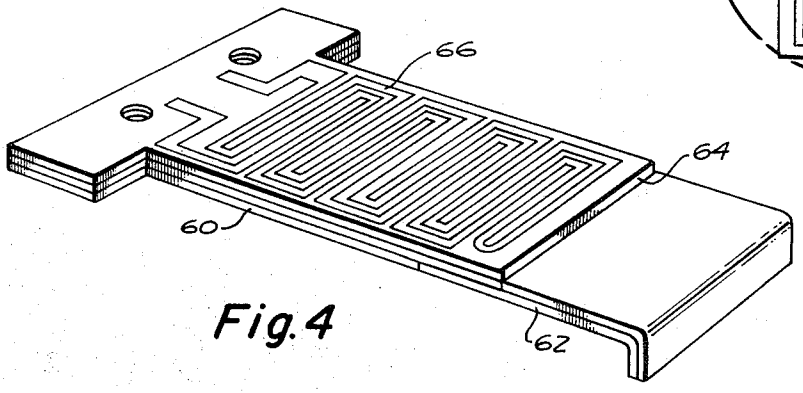


Fig. 4

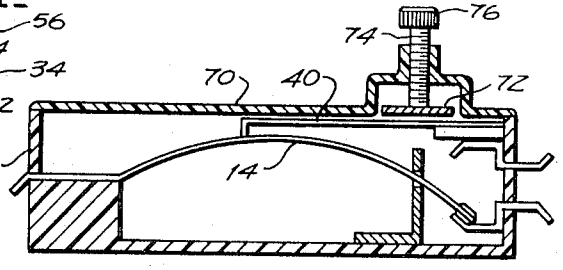


Fig. 5

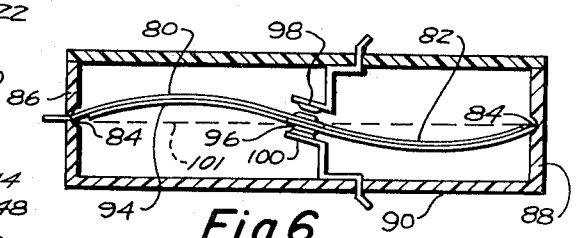


Fig. 6

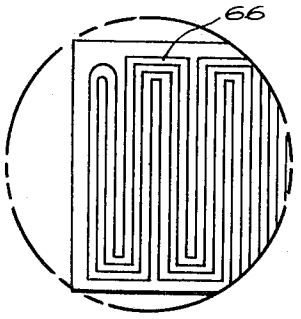


Fig. 7

ELECTRO-THERMAL RELAY ACTUATOR

FIELD OF THE INVENTION

This invention relates to electrical relays, and more particularly to a thermo-electric actuator for operating a relay.

BACKGROUND OF THE INVENTION

Conventional relays are magnetically actuated, that is, an electrical current applied to a relay coil magnetically attracts an armature to which are linked the moving contacts of the relay switch. Relays are used in increasing numbers and many diverse applications, such as in automobiles and home appliances where cost is a major factor. Because they require a coil winding of fine copper wire, the cost of relays is relatively expensive. Moreover the high inductance of the coil presents electrical problems, such as induced high-voltage spikes and stray magnetic fields which must be shielded.

The present invention provides an improved relay in which the actuator is thermo-electrically controlled rather than electromagnetically controlled. The relay is substantially less expensive to manufacture and avoids the electrical problems inherent in the conventional electromagnetically actuated relay.

Thermo-electric actuated switch devices are well known in which the heating and cooling of a bimetallic strip operates a switch, for example. The use of an electrical heating element to control the temperature of the bimetal strip has also heretofore been proposed. Generally the heater has been in the form of a heating unit which is separate from the bimetal strip. The thermal lag is rather substantial, providing a relatively slow response time to the control of current through the heater. While it has been proposed to mount a heater directly on the bimetal element, such known arrangements have required special forming of the bimetal strip to mount the heating element and have not provided uniform heat distribution over the entire surface of the bimetallic strip.

SUMMARY OF THE PRESENT INVENTION

The present invention provides an improved thermo-electrical actuator for operating a switch to provide a relay. In brief, the invention provides an actuator mechanism which comprises a bimetallic strip having a thin coating of electrical insulation on one surface of the strip, the insulation being overlayed with a thin coating of electrically resistive material. The bimetal strip engages a flat spring anchored in bowed condition between two spaced pivots. Movement of the bimetal strip causes the flat spring to snap over center to open and close a pair of switching contacts.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the invention reference should be made to the accompanying drawings, wherein:

FIG. **1** is a cross-sectional view of a relay utilizing a thermal actuator according to the present invention;

FIG. **2** is a sectional view taken substantially along the line **2—2** of FIG. **1**;

FIG. **3** is a top view of the relay of FIG. **1**;

FIG. **4** is an enlarged perspective view of a modified thermal actuator designed for the relay of FIG. **1**;

FIG. **5** is a further modification to the relay of FIG. **1** having a controlled response time; and

FIG. **6** is an alternative embodiment of a relay using a thermal actuator.

DETAILED DESCRIPTION

Referring to FIGS. **1–3** in detail, the numeral **10** indicates generally the housing or case for the relay, which is preferably molded of a plastic material that provides both a good thermal and electrical insulation. The case is molded with a shelf **12** at one end to which is secured a flat spring **14.** The spring **14** is preferably secured in position on the shelf **12** by a pair of screws **16.** The flat spring **14** extends in cantilever fashion from the shelf **12** longitudinally of the housing **10.** As best seen in FIG. **2,** the flat spring **14** is provided with a step reduction in width adjacent one end, as indicated at **18.** The reduced width portion **20** terminates in an electrical contact **22.** The step **18** engages a pivot member **24** which is secured to and projects up from the bottom of the housing **10.** The pivot has an opening **26** through which the reduced width portion **20** of the flat spring **14** projects. The flat spring is bent upwardly slightly at the edge of the shelf **12,** as indicated at **28,** so that the flat spring bows upwardly between the shelf **12** and the pivot **24.** In this condition, the moving contact **22** on the end of the flat spring **14** engages a fixed contact **30** mounted on the bottom of the case **10** by an electrically conductive contact support member **32** which is electrically connected to the outside of the case by a terminal **34.** The flat spring **14** is also formed with a terminal portion **36** which extends outside the housing or case **10** at the shelf **12.** Thus the contacts **22** and **30** provide a normally closed current path between the terminals **34** and **36.**

An actuator is provided for operating the switch and to open the normally closed contacts. The actuator comprises a bimetallic strip **40** which is supported on a shelf **42** at the opposite end of the housing from the shelf **12.** The bimetallic strip is secured to the shelf **42** by means of a pair of screws **44.** The bimetallic strip **40** is substantially flat and extends in cantilever fashion above the flat spring **14.** The free end of the bimetallic strip **40** is bent downwardly, as indicated at **46,** in position to press against the top of the flat spring **14** at a point which is nearer to the shelf **12** than to the pivot member **24.**

Electrical heating of the bimetal element **40** is provided by coating the top surface of the bimetallic element with a very thin layer of a high-temperature plastic material, such as a polymide insulation capable of withstanding temperatures up to 600°F. A thin sheet or foil of nichrome material is then bonded or cemented to the insulating coating. The nichrome layer is then formed into a serpentine-shaped current conductive path by an etching process, such as is well known in the printed circuit art. The current path provided by the nichrome material terminates in a pair of terminals **48** which can be connected across a suitable power source such as a battery (not shown). By passing a current through the nichrome material, heat is applied uniformly over the entire surface of the bimetallic element causing it to deflect so as to move the end **46** downwardly against the flat spring **14.**

By making the spring constant of the flat spring **14** higher adjacent the shelf **12,** as by increasing the width of the spring **14** over a portion of its length, indicated

at **50,** the downward movement of the flat spring under the urging of the bimetallic element when heated, causes the flat spring to snap into an S-shaped configuration, as shown by the dotted line in FIG. **1.** As a result, the moving contact **22** snaps upwardly from the position shown in FIG. **1** against a normally open electrical contact **52.** The contact **52** is securely mounted within the case **10** by a conductive support member **54** having a terminal **56** extending outside of the case.

On disconnecting the electrical heater from the power source, the bimetallic strip, as it cools, returns to its original position, as shown in FIG. **1.** The cantilever mounting of the flat spring **14** causes the spring to return to its initial shape in which it snaps from the S-shape shown by the dotted line back to its initial bowed shape, thereby returning the moving contact **22** from the normally open contact **52** to the normally closed contact **30.**

The arrangement as thus far described is relatively fast acting because there is almost instantaneous thermal transfer from the heater to the bimetallic element over substantially the full area of the bimatallic element. The relay switching mechanism provides a snap action, giving longer contact life. The particular design insures that the contact force remains high until the moment that switching occurs, thereby further reducing contact wear and burning due to arcing.

Referring to the embodiment of FIG. **4,** the bimetallic element may be constructed in two sections, **60** and **62.** In section **62,** the metallic materials forming the two layers of the bimetallic strip are reversed so as to provide deflection in the opposite direction on heating. A coating of insulation **64** is applied over the section **60** only and the heating element layer **66** is coextensive with the insulating layer **64.** Thus all bending takes place in the section **60** in response to thermal heating by the resistive element **66.** The bimetal section **62** acts to compensate for changes in ambient temperature which acts on both the sections **60** and **62.** By this arrangement, the response time of the relay to the application of a current to the heating element **66** is not affected by changes in ambient temperature conditions.

In the embodiment shown in FIG. **5,** a modification of the thermally-actuated relay is shown in which the case **10** is provided with a cover **70** in which is mounted an adjustably positioned heat sink **72.** The heat sink is in the form of a mass of metal secured to the end of a screw **74** which threadedly passes through the top **70** and is rotated by a knurled head **76.** By screwing the heat sink in and out to vary the distance between the heat sink and the heating element on the surface of the bimetallic strip **40,** the rate of heating of the bimetallic strip can be varied so as to change the time response of the relay.

An alternative relay design is shown in FIG. **6,** in which the bimetal strip is in the form of two sections **80** and **82** that bend in opposite directions in response to a given temperature change. Opposite ends of the strip formed by the two sections **80** and **82** engage slots **84** in opposite ends **86** and **88** of an enclosing housing or case **90.** A resistive heating layer **94** is bonded to the surface of the section **80** in the same manner as described above. A moving contact **96** is provided intermediate the sections **80** and **82** which moves between two fixed contacts **98** and **100** positioned inside the case **90.** The bimetallic strip is formed into an S-shape, as shown, by compressing the ends together, with the moving contact **96** pressing against the fixed contact **98.** The natural spring effect of the compressed S-shaped strip holds the strip in position. It should be noted that, although the ends of the strip are shown as pivoting in notches **84,** either or both ends may be anchored to the housing in cantilever fashion, as indicated at **28** in FIG. **1.**

The S-shaped spring formed by the bimetallic strip is unstable and, in the absence of the restraint of fixed contacts **98** and **100,** tends to snap outwardly into a U-shape. Assuming equal but opposite bending of each half the strip, the center of the S-shaped strip is at a point of unstable equilibrium when located on centerline **101.** On either side of this position the straightening action of the S-shaped spring urges the contact **96** either upwardly or downwardly. If the fixed contacts **98** and **100** are spaced on either side of the equilibrium point, the device has two stable positions. However, if as shown in FIG. **6,** contact **100** is positioned at or slightly above the centerline **101,** the only stable position is against the contact **98.** If the strip section **80** is then heated by the heater **94,** causing the left half of the strip to bend more, the equilibrium point of the center of the strip is shifted upwardly sufficiently that the contact **96** snaps downwardly against the contact **100.** When the heater cools, the strip returns to its initial condition because the equilibrium point moves down to the centerline **101,** and the contact **96** snaps back to the contact **98.**

To provide a bistable device having the logic characteristics of a latch, the arrangement of FIG. **6** is provided with a heater on both sections **80** and **82** of the bimetal strip. The contacts **98** and **100** are equally spaced on either side of the centerline **101,** i.e., the equilibrium point under ambient conditions is half way between the fixed contacts. Applying heat to one section of the strip will shift the contact **96** in one direction to its other stable position. Applying heat to the other section of the strip will restore the contact to its initial stable condition.

While the heater has been specifically described as formed by etching a layer of nichrome material, the resistive layer can be formed by other well known means, such as by vapor depositing a metallic film on the insulating layer or by using a resistive paint, such as a carbon dag coating. Either of these alternative arrangements provides a heating element which is highly flexible so as not to interfere with the normal bending of the bimetallic material with change in temperature.

While the thermo-electrical actuator has been specifically described as providing an actuation of a switch mechanism to provide a relay, the actuator itself may be useful in other applications heretofore reserved for solenoids and other electro-megnetic devices. The actuator is the complete analog to a coil/magnetic movement.

The relay is particularly useful where the speed of response is not a critical factor. Response times of the order of 1 or 2 seconds for the relay are readily provided. Where such response times can be tolerated, the device provides an extremely low cost non-inductive, non-magnetic relay mechanism.

What is claimed is:

1. An actuator mechanism comprising a bimetal strip, the bimetal strip including two contiguous sections having opposite bending action with change in

temperature, a thin coating of electrical insulation bonded to a portion of the surface of the strip, a thin electrically resistive heater layer bonded to the surface of the coating and being positioned on only one of said sections of the bimetal strip, the insulation coating being sufficiently thin to provide good thermal conductivity between the resistive layer and the bimetal, means for connecting a source of electrical current across the resistive layer, and means supporting the strip at one end in cantilever fashion, the other end of the strip being movable with bending of said one section by the resistive layer.

2. Apparatus of claim **1** including a heat sink adjustably positioned adjacent to but spaced from the resistive layer for absorbing heat generated by the resisitive layer.

3. Apparatus of claim **1** further comprising a pair of electrical contacts, and means actuated by movement of the bimetal strip for opening and closing said contacts to make and break an electrical current path.

4. An actuator mechanism comprising a bimetal strip, a thin coating of electrical insulation bonded to a portion of the surface of the strip, a thin electrically resistive heater layer bonded to the surface of the coating, the insulation coating being sufficiently thin to provide good thermal conductivity between the resistive layer and the bimetal, means for connecting a source of electrical current across the resistive layer, means supporting the strip at one end in cantilever fashion, the other end of the strip being movable with bending of the bimetal strip, a flat spring anchored on one end, a pivot engaging the spring at an intermediate position, the pivot being positioned to cause the flat spring to bow, means engaging the moving end of the bimetal with the flat spring at a point between the pivot and anchored end, the bimetal strip urging the flat spring past the center line between the anchor end and the pivot, a pair of electrical contacts, and means opening and closing the electrical contacts with rotation of the spring about said pivot.

5. The apparatus of claim **4** wherein the flat spring has a section adjacent the anchored end that has a higher spring constant than the remaining section adjacent the pivoted end.

6. An actuator mechanism comprising a bimetal strip, a thin coating of electrical insulation bonded to a portion of the surface of the strip, a thin electrically resistive heater layer bonded to the surface of the coating, the insulation coating being sufficiently thin to provide good thermal conductivity between the resistive layer and the bimetal, means for connecting a source of electrical current across the resistive layer, means constraining the ends of the bimetal strip to compress the strip into an S-shape in the center portion of the strip, the center of the compressed strip having an unstable equilibrium point corresponding to the maximum energy state of the compressed strip, the equilibrium point being shifted laterally by heating and cooling of the bimetal, and spaced limit means on either side of the center of the strip for restricting lateral movement of the center of the strip in either direction, the spacing being such that the equilibrium point shifts beyond the limits of the limit means with heating and cooling of the bimetal.

7. Apparatus of claim **6** wherein the limit means include a pair of fixed electrical contacts positioned on opposite sides of the strip, and a contact carried by the strip and movable with displacement of the center of the strip into contact with either of the fixed contacts.

8. Apparatus of claim **7** wherein both fixed contacts are positioned to limit movement of the center of the strip entirely to one side of the equilibrium point of the compressed strip at the ambient temperature.

9. Apparatus of claim **7** wherein the fixed contacts are positioned on either side of the equilibrium point of the compressed strip at the ambient temperature.

10. Apparatus of claim **9** including a second resistive heater layer, and means connecting a source of an electrical current, the first mentioned and second resistive layers being positioned respectively on the two loops of the S-shaped strip.

11. A switching device comprising a bimetallic strip, means constraining the ends of the strip to compress the center portion of the strip into an S-shape, the center of the compressed strip having an unstable equilibrium point corresponding to the maximum energy state of the compressed strip, the equilibrium point being shifted by heating and cooling of the bimetal strip, spaced limit means positioned on either side of the center of the strip for restricting lateral movement of the center of the strip, and means for heating the strip sufficiently to shift the equilibrium point outside the space between the spaced limit means.

12. Apparatus of claim **11** wherein the limit means include a pair of fixed electrical contacts positioned on opposite sides of the strip, and a contact carried by the strip and movable with displacement of the center of the strip into contact with either of the fixed contacts.

13. Apparatus of claim **12** wherein both fixed contacts are positioned to limit movement of the center of the strip entirely to one side of the equilibrium point of the compressed strip at the ambient temperature.

14. Apparatus of claim **12** wherein the fixed contacts are positioned on either side of the equilibrium point of the compressed strip at the ambient temperature.

15. Apparatus of claim **11** wherein the bimetal strip has two sections on either side of the center which bend in opposite directions with change in temperature.

16. Apparatus of claim **15** wherein the heater means heats only one of said sections of the strip.

17. Apparatus of claim **15** wherein the heater means includes means for separately heating each section of the bimetal strip.

18. Apparatus of claim **11** wherein the constraining means includes means for supporting at least one end of the strip in cantilever fashion.

* * * * *