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Sorimachi

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[54] **CURRENT LIMITER**

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[52] **U.S. Cl.** **337/343,** 337/53, 337/91, 337/348, 337/367

[51] **Int. Cl.** **H01h 37/74**

[58] **Field of Search** 337/52, 53, 89, 91, 342, 337/343, 365, 367, 348

[56] **References Cited**

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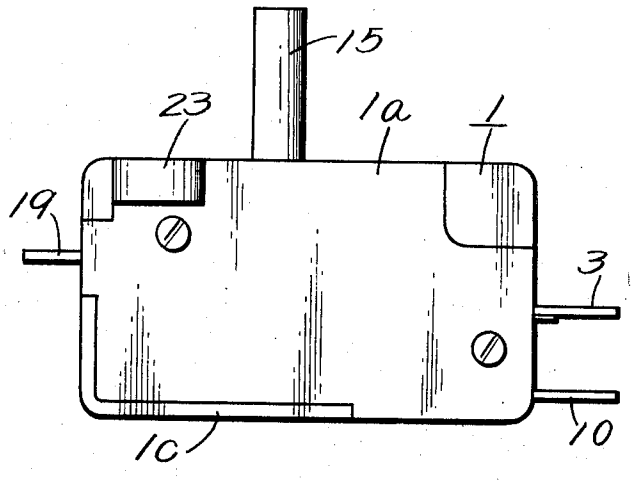
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Primary Examiner—J. D. Miller
Assistant Examiner—Fred E. Bell
Attorney, Agent, or Firm—Elliott I. Pollock

[57] **ABSTRACT**

A current limiter is provided comprising a casing housing a first and a second terminal, the first terminal being electrically connected with a thin blade-shaped bimetal. The bimetal is energized with a bias force acting lengthwise thereof so that it assumes a pair of stable positions in which its plane lies on opposite sides of a critical line. In one stable position, a contact attached to the bimetal is held in abutment against the second terminal. When the current flow through the bimetal across the first and second terminals exceeds a given value, Joule heat from the bimetal causes it to deform, inducing its snap action movement to the other stable position located on the opposite side of the critical line.

9 Claims, 9 Drawing Figures



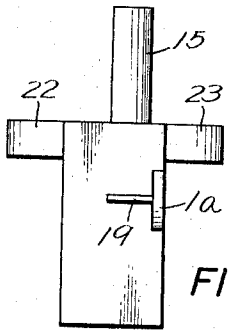


FIG_3

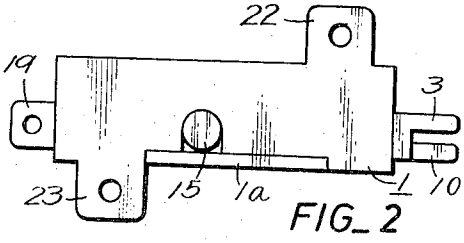


FIG_2

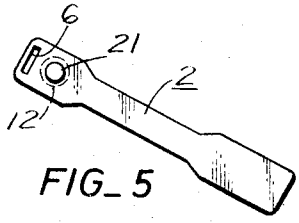


FIG_5

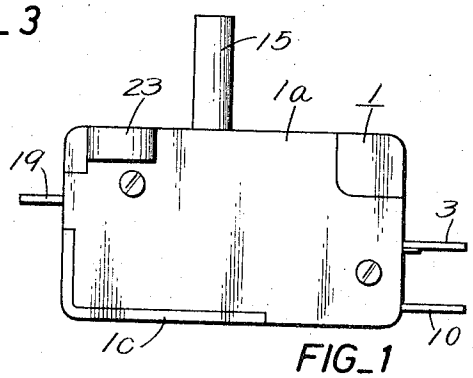


FIG_1

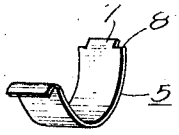


FIG_6

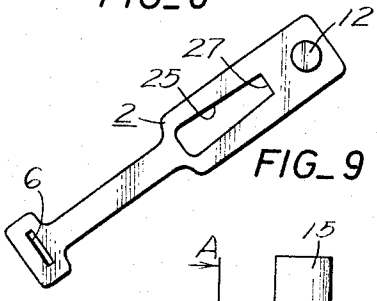


FIG_9

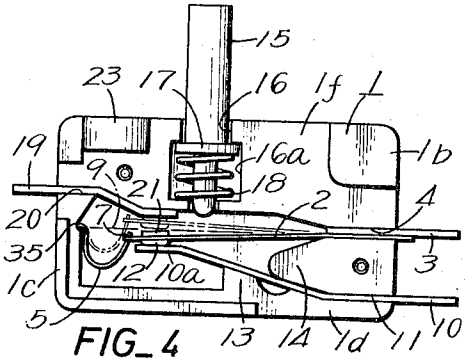


FIG_4

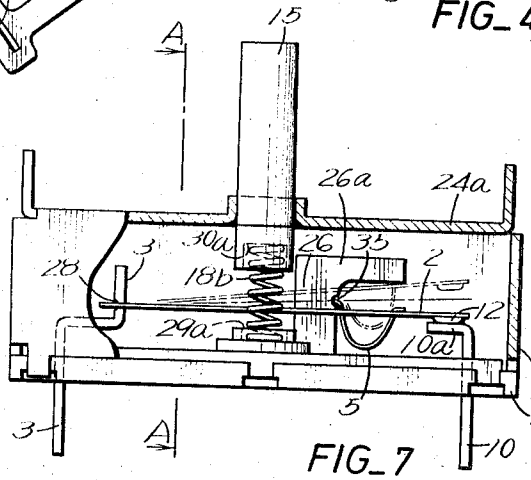


FIG_7

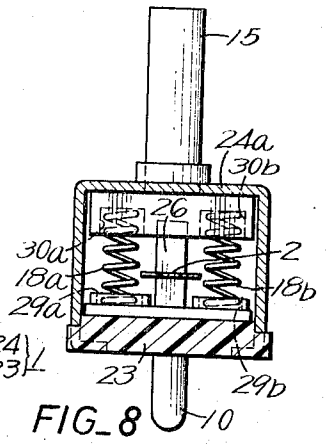


FIG_8

CURRENT LIMITER

BACKGROUND OF THE INVENTION

The invention relates to a current limiter adapted to interrupt a circuit in response to an overcurrent.

Current limiters of the kind described heretofore used a cantilever beam comprising a bimetal secured at one end. The only available deformation of the bimetal was that caused by Joule heat alone and such deformation has been utilized to drive a separate movable member. This required the use of a relatively thick bimetal, which prevented the use of a thin bimetal having sufficient resistance to allow its operation at a small current level of say 1 to 5 amperes.

Therefore, it is an object of the invention to provide a current limiter incorporating a bimetal which allows its operation at a relatively low current level.

It is another object of the invention to provide a current limiter which permits a compact construction and an easy assembly while using a reduced number of components.

SUMMARY OF THE INVENTION

In accordance with the invention, there is provided a current limiter comprising a casing housing a first and a second terminal as well as a blade-shaped bimetal. The bimetal is electrically connected with the first terminal at its one end and is energized with a bias force acting lengthwise thereof. The bias force causes the bimetal to assume either of a pair of stable positions in which its plane lies on opposite sides of a critical line. In one stable position, the bimetal is held in abutment, with a contact attached thereto, against the second terminal. When the current flow through the bimetal across the first and second terminals exceeds a given value, the bimetal is caused to deform from its position adjacent to the second terminal toward the other stable position, and as the deformation goes through a critical point, the bias force applied thereto is effective to cause it to move into the other stable position by a snap action, thereby interrupting the circuit connection between the first and second terminals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front view of one embodiment of the current limiter according to the invention,

FIG. 2 is a top view of FIG. 1,

FIG. 3 is a left-hand elevational view of FIG. 1,

FIG. 4 is a similar view of FIG. 1 with the front cover removed,

FIG. 5 is a plan view of a bimetal,

FIG. 6 is a perspective view of an arcuate spring,

FIG. 7 is a longitudinal section of another embodiment of the current limiter according to the invention,

FIG. 8 is a cross section taken along the line A—A shown in FIG. 7, and

FIG. 9 is a plan view of another bimetal.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Initially referring to FIGS. 1 to 4, there is shown a casing 1 moulded from synthetic resin and having a front cover 1a detachably mounted thereon as illustrated in FIG. 4. A thin blade-shaped bimetal 2 extends horizontally across the central area of the interior of the casing 1, and is fixedly mounted in the right-hand sidewall 1*b* of the casing 1 to be electrically connected with a first terminal 3. In the example shown, this end of the bimetal 2 is lap welded with one end of a plate-shaped terminal 3, with the weld zone being fitted in a slit 4 formed extending through the sidewall 1*b* to permit the other end of the terminal to project externally.

The free end of the bimetal 2 is biased toward the fixed end thereof by a spring 5 which may comprise a semi-elliptic spring formed of a leaf spring. The semi-elliptic spring 5 engages, at its one end, a detent groove 35 formed in the left-hand side wall 1c opposite to that in which the one end of the bimetal 2 is secured and extending in a direction perpendicular to the sheet of drawing, and engages the free end of the bimetal 2 at its other end. Such engagement between the spring 5 and the bimetal 2 may be achieved, for example, between a crosswise elongate slot 6 adjacent the free end of the bimetal 2 (FIG. 5) and an integral tab 7 (FIG. 6) extending centrally from that end of the spring 5 which engages the bimetal 2. A shoulder 8 defined between the tab 7 and the body of the spring bears against the surface of the bimetal 2.

The semi-elliptic spring 5 energizes the bimetal 2 with a bias force which tends to compress it lengthwise, so that it will be seen that the free end of the bimetal 2 remains unstable when it lies on a line, referred to herein as "critical line," joining the point of abutment of the semi-elliptic spring 5 against the left-hand wall 1*e* and the point of anchorage of the bimetal 2, but that it assumes a stable position on either side of the critical line 9 as viewed normal to the plane of the bimetal. A second terminal 10 is arranged to bear against the free end of the bimetal 2 when the latter is in one of its stable positions. In the example shown, the second terminal 10 is located adjacent the bottom wall 1*d* of the casing 1, and a plate-shaped second terminal 10 is inserted through a slit 11 formed in the sidewall 1*b* adjacent the boundary with the bottom plate 1*d*, the second terminal being inserted from the exterior so as to extend it externally on the same side as the first terminal 3. Within the casing 1, the second terminal 10 is bent at an angle extending toward the free end of the bimetal 2 and has its free end 10*a* bent reversely to run substantially parallel to the bottom plate 1*d*. The free end of the bimetal 2 has a contact 12 secured to its side nearer the bottom plate 1*d*, and by virture of the bias imparted thereto by the spring 5, this contact is urged against the free end 10*a* of the second terminal 10. The terminal 10 is secured in position by being held between a ramp 13 formed on the bottom plate 1*d* and a projection 14 formed on the right sidewall 1*b*.

As soon as the joint between the bimetal 2 and the spring 5 moves even slightly to the side of the critical line 9 which is nearer the top wall 1*f* of the casing 1, the free end of the bimetal 2 is immediately urged toward the position adjacent the top wall 1*f* as shown in dotted line in FIG. 4, where it becomes stabilized, whereby the contact 12 is removed from the second terminal 10. To reset the bimetal from this position to the original position to reestablish the conduction between the first and second terminals 3, 10, a reset button 15 is provided. A through opening 16 is formed in the top wall 1*f* oppositely to the free end of the bimetal 2, and a rod-shaped reset button 15 is placed therethrough. The opening 16 has an enlarged portion 16*a* of increased diameter in-

termediate its ends, and the button **15** has an integral flange **17** which is received in the enlarged portion **16***a*. A coil spring **18** is disposed around the button **15** and abuts against the lower face of the flange as well as the end of the enlarged portion **16***a* to urge the button **15** upwardly or in a direction away from the casing **1**. When the button **15** is pushed inward against the resilience of the spring **18**, its inner end is urged against the bimetal **2** to cause it to be depressed below the critical line **9**.

To provide the convenience of actuating a warning circuit such as a warning lamp or buzzer when the bimetal **2** moves away from the second terminal **10**, a third terminal **19** is inserted into the casing **1** through a slit **20** formed in the sidewall **1***c* adjacent to its boundary with the top wall **1***f*, and has its free end positioned so as to be opposite to the free end of the bimetal **2** on the opposite side from the terminal **10**. As the bimetal **2** deflects toward the top wall **1***f* beyond the critical line **9**, a contact **21** carried by the free end of the bimetal **2** is urged into abutment against the third terminal **19**. A warning circuit may, for example, be connected across the terminals **3** and **19**. As will be noted in FIG. **2**, a pair of brackets **22** and **23** are provided to extend laterally from the casing **1** in order to permit its attachment to an equipment with which the current limiter is associated.

In operation, a circuit to be protected is connected across the terminals **3** and **10**. While the current flow across these terminals is below a given value, the bimetal **2** remains on that side of the critical line **9** adjacent to the bottom wall **1***d* even though the bimetal is subject to Joule heat. However, when the current flow across the terminals **3** and **10** exceeds the given value, Joule heat produced in the bimetal **2** becomes sufficient to cause it deform in such a manner that it moves, by snap action, beyond the critical line **9** toward the top wall **1***f*, whereby the contact **12** moves away from the terminal **10** to interrupt the circuit across the terminals **3** and **10**. At the same time, the circuit across the terminals **3** and **19** is completed. Subsequently, the bimetal **2** can be restored to its stable position abutting against the terminal **10** by pushing the reset button **15** inward.

Thus it will be appreciated that in the current limiter of the invention, a deformation of the bimetal **2** is not used to drive another movable member, but the bimetal **2** is energized with a bias force by spring **5** to cause it to assume either of two stable positions into which it switches upon movement across the critical line **9** and the movement of the bimetal itself is directly used to interrupt its contact with the second terminal **10**, so that the bias force to the bimetal **2** may be low and a thin bimetal, for example, of a thickness on the order of 0.15 mm, may be used to increase its resistance, whereby the current limiter can be made to operate at a small current on the order of 1 to 5 amperes. The bias force afforded by the spring **5** urges the contact **12** on the bimetal **2** into abutment with the terminal **10**, thereby normally maintaining a good electrical contact therebetween. It will also be noted that the current limiter is constructed with a reduced number of components and in a simple configuration, and the assembly is greatly facilitated in that the terminals **3**, **10** and **19** can be fitted into the respective slits **4**, **11** and **20** from the front side when the front cover **1**a is removed and the semi-elliptic spring **5** is simply hooked between the bimetal **2** and the casing **1** without the need for set screws or the like, thus allowing the current limiter to be provided inexpensively and as a compact structure of reduced overall size.

While a compressive bias force is applied to the bimetal **2** in the above embodiment, a lengthening bias force may be applied to the bimetal **2** as well, as illustrated in FIGS. **7** to **9**. In this embodiment, the casing **1** comprises a base **23** of an insulating material which forms the bottom wall, and a metallic cover **24** which covers various components mounted on the base **23**. The first and second stationary terminals **3** and **10** are mounted on the opposite ends of the base **23** and extend therethrough. The blade-shaped bimetal **2** extends across these terminals within the casing **1** and has a slot **6** at its one end into which is inserted the inner end of the first stationary terminal **3**. The bimetal **2** has an opening **25** formed intermediate its ends, through which extends a column **26** formed integrally with the base **23** and serving as a fixture. In its surface facing the second terminal **10**, the column **26** is formed with a detent groove **35** which extends substantially parallel to the plane of the bimetal **2**. The semi-elliptic spring **5** engages the detent groove **35** at its one end and engages an edge **27** of the opening **25** in the second stationary terminal **10** at its other end, thereby applying a tension to the bimetal **2** which tends to lengthen it toward the second terminal **10**.

It will be understood that the stable positions of the bimetal **2** will be on the opposite sides of the point of engagement between the semi-elliptic spring **5** and the column **26**, that is, the detent groove **35**, and more specifically when the plane of the bimetal is located on the side nearer the base **23** and on the side nearer the top plate **24***a* of the cover **24**, respectively, with respect to this groove **35**. The inner end of the second stationary terminal **10** is bent as shown to provide the contact **10***a*, and the free end of the bimetal **2** is resiliently urged against the contact **10***a* with its contact **12** when the bimetal is located so that its plane lies on the side nearer the base **23** with respect to the detent groove **35**. The free end of the column **26** is formed so as to extend toward the second stationary terminal **10**, thereby providing a stop **26***a*. As the bimetal **2** deflects beyond the detent groove **35** toward the top plate **24***a*, it ceases its movement by abutting against the stop **26***a* and the contact **12** moves away from the second terminal **10**. To permit pivotal motion of the bimetal **2** between the abovementioned two positions, a detent recess **28** is formed in the surface of the first terminal **3** removed from the second terminal **10** and is engaged by the bimetal **2**, thus preventing its dislocation.

The reset button **15** extends through the top plate **24***a* from the exterior at a position adjacent the column **26** on the side nearer the first terminal **3** and has its inner end formed in the configuration of an inverted T with the head of the T extending crosswise of the base **23**. In an area opposing the reset button **15**, the bimetal **2** has a reduced width, and a pair of helical springs **18***a* and **18***b* are disposed between the inner end of the reset button **15** and the base **23** on opposite sides of the bimetal portion having a reduced width. The opposite ends of the springs **18***a* and **18***b* are received in recesses **29***a*, **29***b* formed in the base **23** and recesses **30***a*, **30***b* formed in the inner ends of the button **15**, respectively. Thus the reset button **15** is normally biased outwardly through the top plate **24***a*.

In operation, an electrical circuit to be protected is connected across the first and second terminals **3, 10** with the bimetal **2** being in its normal position abutting against the second terminal **10.** When the current flow across the terminals **3** and **10** exceeds a rating of the associated circuit element, Joule heat produced by the current flow through the bimetal **2** causes a sufficient deformation of the bimetal **2** to cause it to assume the position shown in dotted lines in FIG. **7,** whereby the contact **12** moves away from the second terminal **10** to interrupt the current flow across the terminals **3** and **10.** It will be appreciated that the semi-elliptic spring **5** functions to cause the bimetal **2** to pivotally move rapidly, by snap action, into the other position in which its plane is located nearer the top plate **24***a* with respect to the detent groove **35.** To restore the bimetal from this interruption position, the reset button **15** may be depressed against the resilience of the springs **18***a* and **18***b*, whereby the bimetal **2** can be urged toward the base **23** and returned to its original position. The effects described in connection with the first embodiment can similarly be achieved with the second embodiment. By comparison, the bias force from the spring **5** functions to flex the plane of bimetal **2** in the first embodiment to increase the sensitivity, while in the second embodiment, securing one end of the bimetal **2** will cause a reduced sensitivity. This is avoided by the first embodiment while permitting to secure one end of the bimetal for ease of assembly.

A current limiter can be constructed in accordance with the first and second embodiments which satisfies the performance requirements for an overcurrent protector as provided in U.L. Standard 492 of the United States. Specifically, this demands a circuit interruption within two minutes below 175 percent of a rating for a contact pressure of 20 grams, 2.0 ampere rating and at an ambient temperature of 25°C ± 3°C. A current limiter constructed in accordance with the invention provided a circuit interruption within 10 to 20 seconds, and the required operation was maintained up to an ambient temperature of 70°C.

It will be noted that the spring used to energize the bimetal **2** with the required bias force is not limited to a semi-elliptic spring, but other springs may be used as well, and that the bimetal **2** may be secured at its end adjacent to the first terminal **3** in the second embodiment.

Having described the invention, what is claimed is:

1. A current limiter comprising a first and a second terminal mounted in a casing, a thin blade-shaped bimetal electrically connected with the first terminal within the casing and incapable of providing a contact pressure by itself, bias means for energizing the bimetal with a bias force acting lengthwise thereof to cause it to assume either of two stable positions in which the plane of the bimetal is respectively located on opposite sides of a critical line, said bias means serving to provide a contact pressure, a contact mounted on the surface of the bimetal and adapted to be urged against the second terminal in one of the stable positions and to move away from the second terminal in the other stable position, said bimetal when located in said other stable position being incapable of returning to said one stable position by itself, and reset means for selectively returning the bimetal from said other stable position to said one stable position.

2. A current limiter according to claim **1** in which one end of the blade-shaped bimetal is secured to the first terminal, said bias means supplying a bias force which acts from the other end of the blade-shaped bimetal toward the secured end thereof.

3. A current limiter according to claim **2** in which the bias means comprises a semi-elliptic spring of plate-like configuration engaging the casing at its one end and engaging the free end of the bimetal at its other end, said critical line being defined by a line extending from the point of engagement of the spring with the casing and to the secured end of the bimetal.

4. A current limiter according to claim **1** in which the bimetal is hooked onto the first terminal, the bias means being operative to exert a bias force upon the bimetal which maintains the hooked engagement.

5. A current limiter according to claim **4** in which one end of the bimetal is formed with a slot through which the first terminal extends, the bimetal being formed with an opening through which extends a column integral with the casing, said bias means comprising a semi-elliptic spring extending resiliently between the column and an edge of the opening located nearer the contact on the bimetal.

6. A current limiter according to claim **1** wherein said reset means comprises a manually operable reset button extending through the casing wall and adapted to be advanced to and retracted from the bimetal, and second bias means for normally urging the reset button away from the bimetal, whereby the reset button can be depressed against the resilience of the second bias means to urge the bimetal toward a position of contact with the second terminal.

7. A current limiter according to claim **1,** further including a third terminal mounted in the casing for abutment with the contact on the bimetal as it moves away from the second terminal.

8. A current limiter according to claim **1,** further including a stop which is engaged by the bimetal moving away from the second terminal.

9. The current limiter of claim **1** wherein the bimetal has a thickness of substantially 0.15 mm.

* * * * *