# United States Patent [19]

**Kasahara**

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[54] **AUTOMATICALLY RESETTING RELAY**


[75] Inventor: **Yasuo Kasahara**, Tokyo, Japan

[73] Assignee: **Kabushiki-Kaisha Nakatani**, Tokyo, Japan; a part interest



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[52] **U.S. Cl.** .....**337/90,** 335/31, 335/145

[51] **Int. Cl.**.....**H01h 61/01**

[58] **Field of Search** .....335/145, 31; 337/90, 337/366, 344, 54



[56] **References Cited**

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*Primary Examiner*—Harold Broome

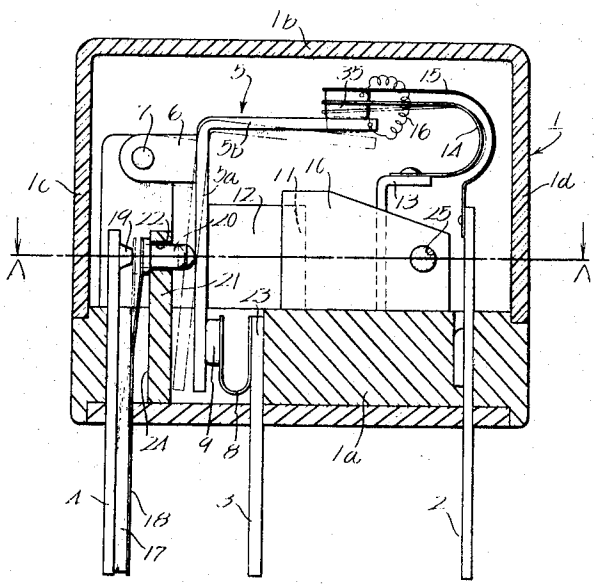
*Attorney*—William D. Hall et al.



[57] **ABSTRACT**

A permanent magnet is secured within an insulating casing, and on opposite sides thereof, first and second terminals are mounted in the bottom plate of the casing. An L-shaped body of magnetic and electrically conductive material is pivotally mounted within the casing with its one limb being adapted to be attracted by the magnet and having a contact for circuit-opening and-closing purpose interposed in the path to the second terminal. Bimetal is connected between the other limb of the body and the first terminal. When current flow across the first and second terminals exceeds a given value, a distortion of the bimetal due to Joule heat and a reduction in the magnetic permeability of the body due to Joule heat effect in combination a movement of the body away from the magnet, whereby the contact is opened. The body is automatically reset, i.e., attracted by the magnet upon recovery of the bimetal from distortion and increase of the permeability of the body.


**5 Claims, 2 Drawing Figures**



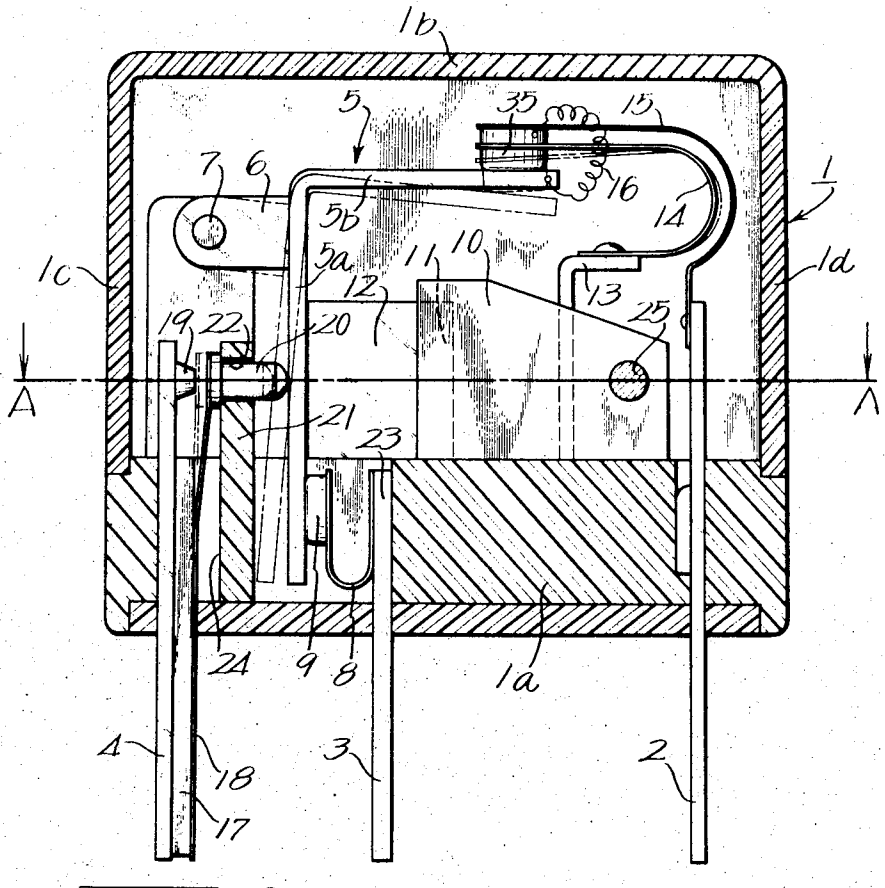

1b
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Fig. 1

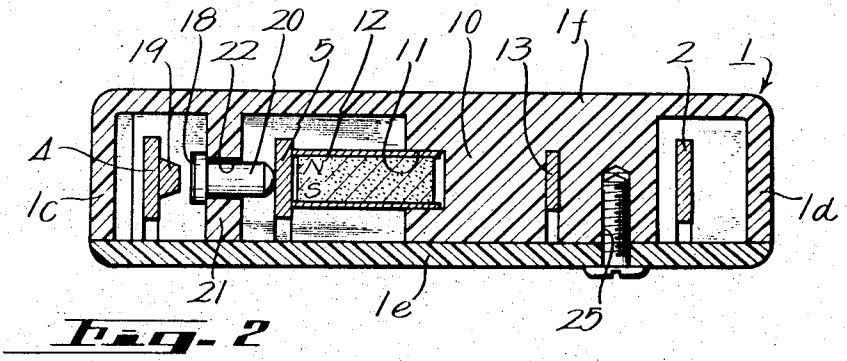
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Fig. 2

# AUTOMATICALLY RESETTING RELAY

## BACKGROUND OF THE INVENTION

The invention relates to an automatically resetting relay which operates to interrupt a circuit automatically upon load current flow in excess of a given magnitude and to be reset automatically after a given time period.

Automatically resetting relays are known of the type including a bimetal connected in a current path and adapted to be mechanically disengaged from its mating member for circuit interruption when the amount of deformation it undergoes under the influence of Joule heat exceeds a given value, the bimetal subsequently being deformed in the opposite direction to restore the mechanical engagement. Such a relay may be used in a substation, for example, where it provides circuit interruption function and operates an alarm unit upon occurrence of an overload condition, and subsequently restores the circuit which it interrupted. The relay is adapted to repeat such process, whereby it is ensured that by removal of part of the whole load, the restored condition once achieved can be maintained. The relay can also be utilized to generate a signal which is interrupted with a fixed time interval.

However, because of the nature of operation, i.e., mechanical engagement and disengagement, the prior art relay of the type described is slow in operation and of poor reliability, involving chattering resulting from mechanical abrasion, and hence does not lend itself for use for a prolonged period.

The inventor has proposed a circuit protector which provides a circuit interrupting function by disposing a permanent magnet and a body of magnetic and electrically conductive material for relative movement with each other so that they are normally attracted magnetically and biased away from each other with a force of less magnitude than the magnetic attraction, but move relative to one another when the current flow through the body exceeds a given value to operate a contact or contacts, such protector being the subject matter disclosed and claimed in U.S. Pat. No. 3,453,566 issued July 1, 1969. By connecting a bimetal in the current path of such a circuit protector, there is obtained a relay which functions in the same manner as the prior art automatically resetting relay described above. Since mechanical engagement is not relied upon in this construction, i.e. the magnetic attraction maintains the magnet and the body in a predetermined relationship, the speed of operation is improved over the mechanical disengagement type of relay and the construction for engagement is greatly simplified, together with additional advantages of avoiding abrasion and improved reliability to enable its use over a prolonged period. Its operation depends not only on the deformation of the bimetal, but also on the variation of its magnetic permeability caused by Joule heat occurring in the body, thereby rendering the time required for circuit interruption or resetting accurate.

It is an object of the invention to provide an automatically resetting relay which operates in a stable manner for a prolonged period.

It is another object of the invention to provide an automatically resetting relay which is rapid in operation and has an accurate operational period.



It is a further object of the invention to provide an automatically resetting relay which is compact and simple in construction.

## SUMMARY OF THE INVENTION

In accordance with the invention, a permanent magnet is secured substantially centrally within a casing, and a body of magnetic and electrically conductive material is disposed for attraction by the magnet. The body is biased in a direction away from the magnet by a force of less magnitude than the force of magnetic attraction. The opposite ends of the body are electrically connected with first and second terminals, respectively, mounted in the casing, and intermediate these terminals and the ends of the body are connected an opening and closing contact and a bimetal. When a current in excess of a given value flows across the first and second terminals, Joule heat causes the bimetal to deform, thereby urging the body away from the magnet. Simultaneously, the Joule heat effects a reduction in the magnetic permeability of the body. Both of these coact to move the body away from the magnet, thereby opening the contact and interrupting the circuit. Subsequent to this circuit interruption, the bimetal returns to its original position, and the permeability of the body increases, whereby the body is again attracted by the magnet and the contact is closed.

The above arrangement does not rely on the mechanical engagement and disengagement of the contact, but depends on the fact that the body is attracted by or detached from the magnet, so that the construction is simplified and its operation gains both speed and stability with increased useful life.

The above and other objects, features and advantages of the invention will become apparent from the following detailed description thereof with reference to the drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal section of an embodiment of the automatically resetting relay constructed in accordance with the invention, and

FIG. 2 is a section taken along the line A-A shown in FIG. 1.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, the relay includes a casing **1** moulded from synthetic resin and having a bottom plate **1***a*, top plate **1***b*, left-hand side plate **1***c*, right-hand side plate **1***d*, front plate **1***e*, and rear plate **1***f*. The top, left- and right-hand side, and rear plates **1***b*, **1***c*, **1***d* and **1***f* are formed as an integral structure, to which the bottom plate **1***a* is a sliding fit and secured thereto as by adhesive. The front plate **1***e* is releasably fixed to this structure by threaded bolts (not shown).

Adjacent the right-hand side plate **1***d*, the bottom plate **1***a* is formed with an aperture in which a first terminal member **2** is fitted and secured in place by suitable locking means, the terminal member **2** having its opposite ends extending internally and externally of the casing **1**. The bottom plate **1***a* has fixedly mounted therein a second terminal member **3** and an alarm terminal member **4** at positions intermediate the side

plates and adjacent the left-hand side place 1*c*, respectively. An L-shaped, plate-like body 5 of magnetic and electrically conductive material is pivotally mounted within the casing 1 at a pivot 7 which is secured to the rear plate 1*f*. The material for the body 5 must be magnetically permeable and electrically conductive such that the magnetic permeability thereof varies with temperature changes, and may, for example, comprise magnetic compensating steel which is used in a pole piece of a permanent magnet. One limb 5*a* of the L-shaped body 5 extends in a direction transverse to the top and bottom plates 1*b* and 1*a* and has its end disposed in opposing relationship to the second terminal member 3, while the other limb 5*b* extends adjacent the top plate 1*b* in a direction transverse to the side plates 1*c* and 1*d*. Adjacent the bend, the limb 5*a* has an integral arm 6 extending therefrom toward the left-hand side plate 1*e*, which arm is pivotally connected at 7 to the casing 1.

The inner end of the second terminal member 3 has welded thereto one limb of a U-shaped conductive spring 8, the other limb of which carries a contact 9 which is resiliently urged by the spring 8 against the free end of the limb 5a. Intermediate the body 5 and the first terminal member 2, integrally formed with and projecting inwardly from the inner surface of the rear plate 1f is a magnet holder 10, which has a slot 11 formed in its surface opposite to the limb 5*a* of the body 5 for fitting engagement with and fixedly mounting a permanent magnet 12. The magnet 12 serves to attract the limb 5*a* of the body 5, and the body 5 is biased in a direction away from the magnet 12 by the resilient force of the U-shaped spring 8 which force is less in magnitude than the force of such magnetic attraction.

At the end adjacent the first terminal member 2, the holder 10 has mounted thereon a support 13 extending toward the top plate 1*b*, the support 13 having secured thereto one end of a bimetal 14, the other end of which carries a contact 35 which contacts the end of the limb 5*b* of the body 5 from above, that is, from the side thereof nearer the top plate 1*b*. This free end of the bimetal 14 is electrically connected with one end of a heater 15, the other end of which is connected with the first terminal member 2. The bimetal 14 and the body 5 are interconnected by a flexible lead wire 16.

A spring contact 18 is secured to an insulating plate 17 located on the side of the alarm terminal member 4 adjacent the second terminal 3. A contact 19 is secured to the alarm terminal member 4 at a position within the casing 1 which is opposite to the spring contact 18. At its free end, the spring contact 18 carries a pusher 20 formed of an insulating material and located closely adjacent the limb 5*a* of the body 5. A post 21 is integrally secured to and extends upwardly from the bottom plate 1*a*, and is formed with a guide hole 22 therein at its top to allow passage therethrough of the pusher 20 for the purpose of guiding it.

The U-shaped spring 8 is located within a recess 23 formed in the bottom plate 1*a*, which engages the holder 10 in abutting relationship. To permit a large span for the movable part of the spring contact 18, the bottom plate 1a is formed with another recess 24 here also. The holder 10 is formed with a horizontally extending threaded hole 25, into which is placed and clamped a threaded bolt (shown in FIG. 2) to secure the front plate 1*e*. While not shown in the drawings, the front plate 1*e* is formed with a small opening for receiving one end of the pivot 7.

With the above arrangement, the current path of a circuit to be monitored (not shown) is connected across the first and second terminal members 2 and 3. When the current flow exceeds a given value, the resulting amount of deformation which the bimetal 14 undergoes due to Joul heat becomes sufficient to cause the body 5 to move angularly clockwise as viewed in FIG. 1 to the position indicated in phantom line, while the temperature rise of the body 5 effects a reduction in the magnetic permeability thereof with consequent reduction in the amount of attractive force acting between the body 5 and the magnet 12. As a result of the angular movement of the body 5, it rapidly moves away from the contact 9 to interrupt the current flow across the terminal members 2 and 3. At the same time, the pusher 20 is pushed by the body 5 to move the spring contact 18 into contact with the contact 19, whereby an alarm unit which may be connected across the alarm terminal member 4 and the spring contact 18 can be operated.

Subsequent to the interruption of current flow across the first and second terminal members 2 and 3, temperature decrease causes the bimetal 14 to restore its original shape and also causes an increase in the magnetic permeability of the body 5 to enhance the attractive force between the body 5 and the magnet 12, whereby the body 5 returns to its original position where it is attracted and held by the magnet 12 to restore the connection across the terminal members 2 and 3 and to disconnect the terminal member 4 from the spring contact 18. If the current flow across the terminal members 2 and 3 still exceeds the given value, there again occurs the deformation of the bimetal 14 and the variation of the magnetic permeability of the body 5 to repeat the above process.

It will be appreciated that the relay according to the invention relies, not on mechanical engagement and disengagement, but on the attraction of the magnetically operable body 5 by the magnet 12, with the consequence that the required holding and release mechanism is greatly simplified to assure a stable operation over a prolonged period of time. In addition, the utilization of the deformation of the bimetal 14 in combination with the variation in the magnetic permeability of the body 5 assures sufficiently strong attraction of the body 5 in its normal condition to render the relay insusceptible to the influence of extraneous mechanical vibrations, and still assures a rapid interrupting operation. The relay exhibits an exact period of repetitive operation when a current flow of constant magnitude is applied across the terminal members 2 and 3.

The space within the casing 1 is most effectively utilized by forming the body 5 in the configuration of L so as to have its one limb 5*a* extending substantially parallel to the first terminal member 2 and its other limb 5*b* extending therebetween with the magnet 12 disposed in the area defined by the first terminal 2 and the body 5, and by locating the pivotal arm 6 of the body 5 outside this area or on the opposite side of the limb 5*a* to the terminal member 2, with the alarm terminal member 4

located within the area delineated by the arm **6** and the limb *5a*. In this manner, a compact structure is provided for the relay. In the art of wire communication, an alarm fuse is used which is fused, upon current flow in excess of a given value, to operate a contact that drives an alarm unit. The relay according to the invention can be constructed as compact as such an alarm fuse, and can operate an alarm unit in response to current flow in excess of the given value, and in addition subsequently restores the current path automatically to repeat the operation again if the current then is still in excess of the given value.

As a modification, the body **5** may be positioned close to the alarm contact **19** so that it directly contacts the latter upon angular movement of the pivotal arm **6**. The heater **15** for the bimetal may be omitted and the latter connected with the first terminal member **2**. Any bimetal may be used which deforms in shape in response to temperature change. For example, a bimetal of linear expansion type may be used. Furthermore, the spring contact **18** may be disconnected from the contact **19** upon angular movement of the body **5** rather than being brought into contact with the latter as described. Therefore, it should be understood that various changes and modifications are possible without departing from the scope of the invention defined by the appended claims.

Having described the invention, what is claimed is:

**1**. An automatically resetting relay comprising a casing of insulating material having a bottom plate which is separable from the remainder of the casing, a permanent magnet secured to the casing substantially centrally therein, first and second terminals secured to said bottom plate on opposite sides of said permanent magnet, said terminals extending through the casing from the interior to the exterior thereof, an L-shaped body of magnetic and electrically conductive material, said L-shaped body having one limb positioned for attraction by said permanent magnet and extending toward the top plate of the casing from a position adjacent said second terminal, said L-shaped body having its other limb bent to extend toward said first terminal in a direction substantially parallel to the top plate of the casing, a bimetal having one end mounted on said first terminal and having its other end contacting said other limb of the body, said bimetal being adapted to deform upon heating thereof so as to produce a displacement of the body operative to move said one limb away from said permanent magnet, and an opening and closing contact interposed between said second terminal and said body.

**2**. An automatically resetting relay according to claim **1**, in which said bimetal has its body contacting at one end thereof with the magnetic and conductive body and being held at the other end thereof by the casing, there being provided a heater for the bimetal, the heater having its one end connected with the magnetic and conductive body through a flexible lead wire and its other end connected with the first terminal member.

**3**. An automatically resetting relay according to claim **1**, further including a second opening and closing contact mounted on the bottom plate at the opposite side of the body from the second terminal member, said second terminal member being controlled by the angular movement of the body.

**4**. An automatically resetting relay according to claim **3**, in which said second contact comprises a third terminal member mounted on the bottom plate, a spring contact mounted on the bottom plate intermediate the third terminal member and said magnetic and conductive body, an insulative pusher mounted on the spring contact and arranged opposite to the magnetic and conductive body, and a contact mounted on the third terminal member in opposing relationship with the spring contact.

**5**. The relay of claim **1** wherein said body is formed of a material which undergoes a relatively large variation in magnetic permeability with temperature change.

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