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Jost

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[54] **RELAY**

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[52] **U.S. Cl.** **337/25,** 337/140

[51] **Int. Cl.** **H01h 61/013**

[58] **Field of Search** 317/25, 27, 18, 140

[56] **References Cited**

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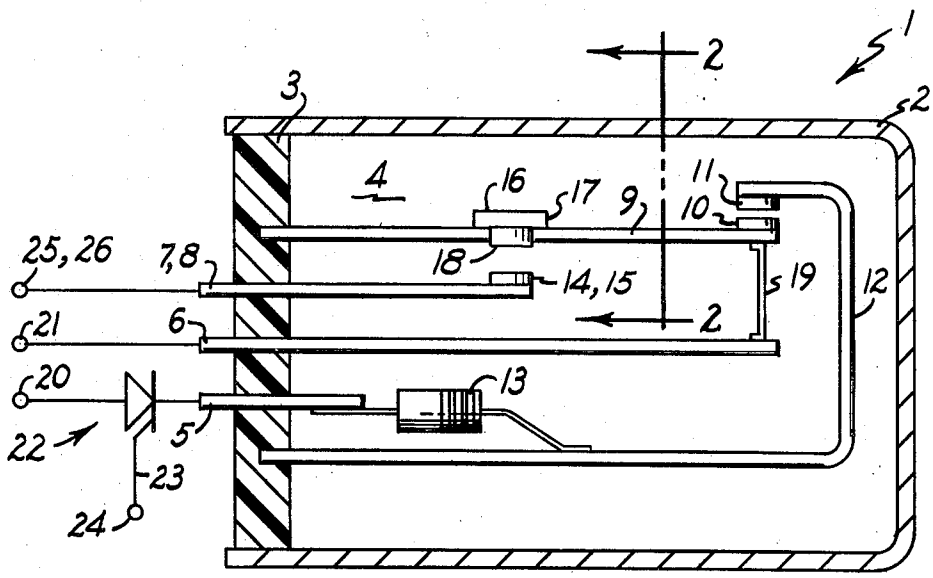
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[57] **ABSTRACT**

The disclosure relates to a relay having a gas tight enclosure filled with a noble gas. A spring member carrying a first contact is normally biased to engage the first contact with a second contact within the enclosure. A wire of a selected nickel-titanium alloy is connected to the spring member and is arranged in series with the noted contacts to form a control circuit. When this control circuit is energized, as through an SCR, current directed through the alloy wire heats the wire causing the wire to abruptly shorten in length to separate the noted contacts but to permit a glow discharge to occur across the contacts for maintaining the wire in heated condition with less current being directed through the wire. The spring member carries a bridging contact arm for closing a relay output circuit when the spring member is moved by shortening of the alloy wire. When the glow discharge is terminated, as by shutting off the SCR, the alloy wire cools and is stretched as the spring member moves in response to its bias to reopen the relay output circuit and reengage the noted control contacts.

6 Claims, 2 Drawing Figures



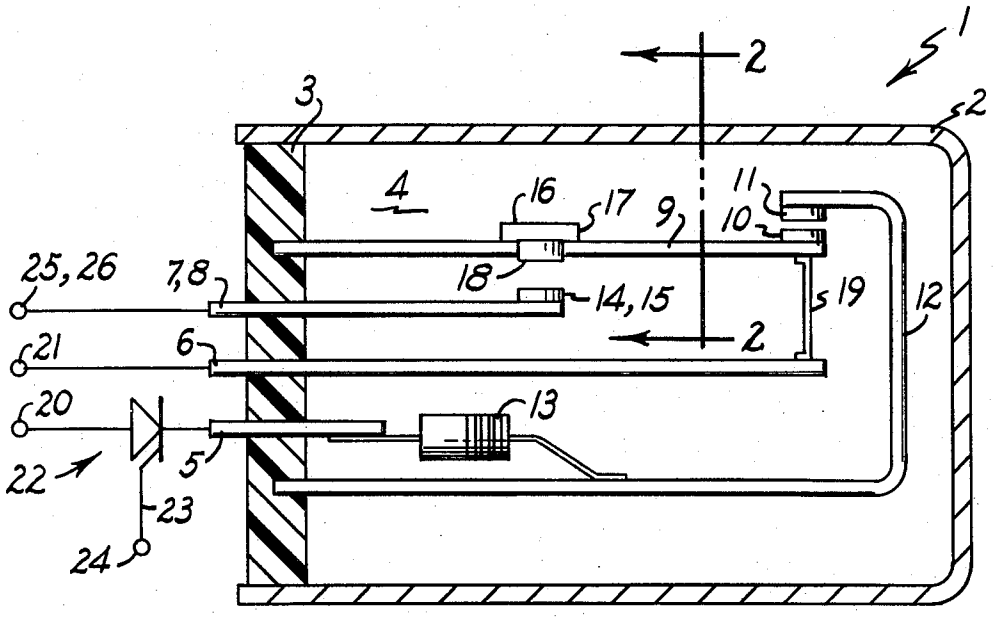

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Fig. 1.

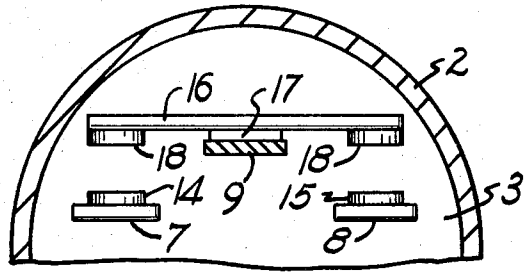

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Fig. 2.

RELAY

This invention relates to a relay using a wire of a nickel-titanium alloy commonly known as Nitinol for providing a switching action in a gas filled device, the switching action being latched by heat provided by a glow discharge within the device.

In many instances where a relay is used to perform work in response to a relatively small energy input, it would be desirable to operate the relay from a conventional power source in response to a small control signal while latching the relay in energized condition with relatively less power. This is particularly desirable in the case of high gain relays where the initial energy input is relatively high with respect to the device rating to assure prompt relay response.

In accordance with the present invention, these desirable results are achieved in a high gain relay wherein a small electrical input provides a large electrical output in a device of relatively inexpensive construction. Briefly described, the relay of this invention utilizes a wire of a selected nickel-titanium metal alloy which is adapted to be deformed from an original length to a relatively greater length while the wire material displays a relatively low modulus of elasticity below a transition temperature and which is adapted to abruptly return to its original, shorter length and to display a relatively greater modulus of elasticity when the wire material is heated above the noted transition temperature. This alloy wire is employed within a gas tight enclosure which is filled at subatmospheric pressure with a noble gas and which is provided with a pair of switching terminals and with a pair of control terminals extending into the enclosure. The wire is secured to a spring member which carries a first control contact and which is normally biased to engage the first contact with a second control contact. The wire is also arranged in series with these control contacts and with a resistor across the control terminals of the device. When this control circuit is energized from a conventional 110 volt line, as through an SCR which has been rendered conductive in response to small control signal, current directed through the noted alloy wire promptly heats the wire material to its transition temperature so that the wire abruptly shortens in length to move the spring member against its bias to separate the noted control contacs but to permit a glow discharge to occur between the contacts. In this way, the glow discharge maintains the wire heated to its transition temperature with lesser current being directed through the alloy wire. The spring member carries a bridging contact arm, preferably electrically isolated from the spring member, and this bridging contact arm is connected across the switching terminals of the relay as the wire is shortened in length, thereby to close the output circuit of the relay. When the control circuit is subsequently deenergized as by turning off the SCR, the glow discharge is terminated, the wire is permitted to cool below its transition temperature, and the wire is deformed to its longer length by the bias of the spring member as the spring member moves to reengage the control contacts and to move the bridging contact arm to open the output circuit of the relay.

It is an object of this invention to provide a novel and improved relay; to provide such a relay displaying high gain which is operable from conventional power sources; to provide such a relay which is latched in energized position by a glow discharge in a gas filled device; and to provide such a relay which is of inexpensive construction.

Other objects, advantages and details of the relay of this invention appear in the following detailed description of a preferred embodiment of the invention, the detailed description referring to the drawings in which:

FIG. **1** is a section view along the principal axis of the relay of this invention; and

FIG. **2** is a partial section view along line **2—2** of FIG. **1**.

Referring now to the drawing, there is shown a high gain electrical relay **1** which includes an enclosure member **2** of glass or the like having a header **3** of a phenolic resin or the like sealing an open end of the enclosure in any conventional manner to form a device housing. The enclosure is filled as at **4** with a noble gas such as argon at subatmospheric pressure. A pair of control terminals **5** and **6** are extended through the header in sealing relation to the header and a pair of switching or output terminals **7** and **8** extend through the header in similar manner. See FIG. **2**.

In accordance with this invention, a spring leaf member **9** of phosphor bronze or the like is cantilever mounted on the header to support a first control contact **10** at the distal end of the sring member for mating engagement with a second, stationary control contact **11** mounted on a stationary contact support arm **12** which is also cantilever mounted on the header. A resistor **13**, preferably of from about 2K to 5K ohms is electrically connected between the control terminal **5** and the contact support arm **12** as shown. Each of the output terminals **7** and **8** also carries a contact **14** and **15** at its distal end and a bridging contact arm **16**, preferably secured to the spring member **9** in any conventional manner while being electrically isolated from the spring member by an insulator plate **17** as shown in FIG. **2**, carries contacts **18** for mating engagement with the output terminal contacts **14** and **15** for closing an output or switching circuit of the relay across the output terminals **7** and **8**.

In accordance with this invention, a metal actuator wire **19** is secured between the distal end of the leaf spring member **9** and the control terminal **6** or other member fixedly secured to the relay housing, the wire electrically connecting the control contacts **10** and **11**, the contact arm **12** and the resistor **13** in series across the control terminals **5** and **6** to form a control circuit. This actuator wire is formed of a selected nickel-titanium metal alloy having a composition by weight of from about 54 to 56 percent nickel and the balance titanium. As this metal alloy is well known, it is not further described herein and it will be understood that the alloy material is adapted to be deformed from an original length to a second greater length while the alloy displays a relatively low modulus of elasticity below a transition temperature and is adapted to abruptly return to its original length and to display a relatively much higher modulus of elasticity when the wire is heated above the noted transition temperature.

In the relay of this invention, the wire **19** is arranged as shown so that, when the control circuit of the relay is energized by connecting the relay control terminals **5** and **6** across a conventional 110 volt line as indicated by the terminals **20** and **21**, with an SCR **22** interposed in this control circuit and with the SCR gate electrode **23** arranged to receive a control signal from a source

24 such as an integrated circuit device or the like, the wire 19 is rapidly heated to its transition temperature. For example, where the resistor 13 provides 2,000 ohms, and where 110 volts is applied across the terminals 21 and 22, a current of about 50 milliamps flows in the relay control circuit through the alloy wire 19. Where this wire is approximately one inch long and has a diameter of about 0.0025 inches, the alloy wire has a resistance of about 10 ohms and uses about 30 milliwatts of power in heating the alloy wire to its transition temperature in about 0.3 seconds. This causes the wire 19 to abruptly shorten in length and to move the spring member 9 to separate the control contacts 10 and 11 while permitting glow discharge to occur across the control contacts 10 and 11. As this glow discharge occurs, the voltage drop across the gap between the contacts 10 and 11 is about 70 volts and the current in the control circuit is reduced to about 20 milliamps. This glow discharge releases sufficient heat to maintain the actuator wire 19 above its transition temperature. As will be understood, this movement of the spring member 9 moves the bridging contact arm to engage the bridging contacts 18 with the output terminal contacts 14 and 15 to close a relay output circuit. Then, when the SCR 22 is turned off by not receiving a gate signal, the voltage across the gap between the contacts 10 and 11 disappears, the wire 19 cools below its transition temperature and displays its relatively lower modulus of elasticity, and the wire is redeformed to its relatively greater length by the bias of the spring member 9 as the spring member reengages the control contacts 10 and 11 and disengages the bridging contact arm from the output contacts 14 and 15.

It should be understood that although a particular embodiment of the relay of this invention has been described by way of illustrating the invention, this invention includes all modifications and equivalents of the disclosed embodiment falling within the scope of the appended claims.

I claim:

1. A control device comprising gas-filled housing means, control means mounted on said housing means for movement between first and second control positions, first contact means mounted on said housing means, second contact means mounted for movement with said control means to engage said first contact means when said control means is in said first control position and to be spaced a selected distance from said first contact means within said gas-filled housing means for permitting a glow discharge between said contact means when said control means is in said second control position, means biasing said control means to said first control position, and a metal actuator element secured to said housing means and connected in series with said first and second contact means, said actuator element being formed of a selected metal alloy to be deformed from a first configuration to a second configuration in response to said bias as said control means is moved to said first control position while said alloy displays a relatively low modulus of elasticity below a transition temperature and to abruptly return to its original configuration and to display a relatively higher modulus of elasticity to move said control means to said second control position against said bias when said alloy is heated above said transition temperature by electrical current directed between said contact means and to retain said control means in said second control position while said alloy is maintained in heated condition above said transition temperature by said glow discharge.

2. A control device as set forth in claim 1 wherein said metal actuator element is formed of a selected nickel-titanium alloy having a composition, by weight, of from about 54 to 56 percent nickel and the balance titanium.

3. A control device as set forth in claim 1 having current limiting resistor means arranged in series relation to said metal actuator element.

4. A relay comprising a gas-tight housing, a noble gas filling said housing at subatmospheric pressure, a pair of control terminals mounted on said housing extending into said housing, in electrically insulated relation to each other, a stationary control contact mounted on one of said control terminals, a spring member mounted on said housing carrying a second control contact, said spring member normally biasing said second control contact into engagement with said stationary control contact and being movable for spacing said second control contact from said stationary control contact for permitting a glow discharge across said control contacts, a metal actuator wire of a selected nickel-titanium alloy secured between said spring member and said other control terminal forming a control circuit, said actuator wire being adapted to be deformed from an original length to a greater length in response to said spring member bias as said spring member bias engages said control contacts while said metal alloy displays a relatively low modulus of elasticity below a transition temperature and to abruptly return to said original length and to display a relatively greater modulus of elasticity when said metal alloy wire is heated above said transition temperature by electrical current directed through said control circuit for moving said second control contact against said spring member bias for spacing said control contacts to permit said glow discharge to retain said metal alloy in said heated condition, and output switch means movable between first and second control positions with said movement of said spring member.

5. A relay as set forth in claim 4 having current limiting resistor means interposed in series with said actuator wire in said control circuit.

6. A relay as set forth in claim 5 having semiconductor means connected to one of said control means for regulating current flow in said control circuit.

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