United States Patent

Wolf

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[54] REED SWITCH ANG MAGNETIC OVER-CENTER DEVICE THEREFOR

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[52] **U.S. Cl.** **335/207**

[51] **Int. Cl.** **H01h 5/02**

[58] **Field of Search** ..... 335/205–207, 153, 335/234; 200/67 F

[56] **References Cited**

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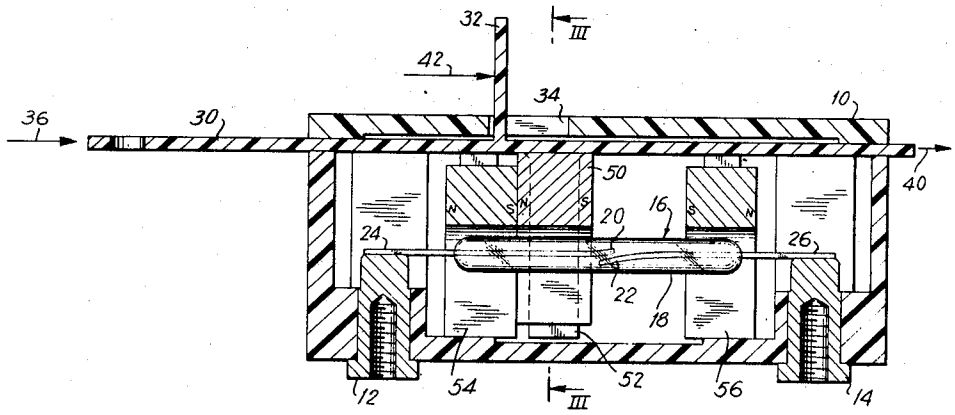
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[57] **ABSTRACT**

A reed switch which is magnetically actuated is provided with a magnetic arrangement which affords an over-center feel or force gradient or curve. The arrangement includes oppositely polarized and spaced magnets between which is located a further magnet which directly operates the reed switch or which is connected to another magnet which operates the switch.

12 Claims, 7 Drawing Figures



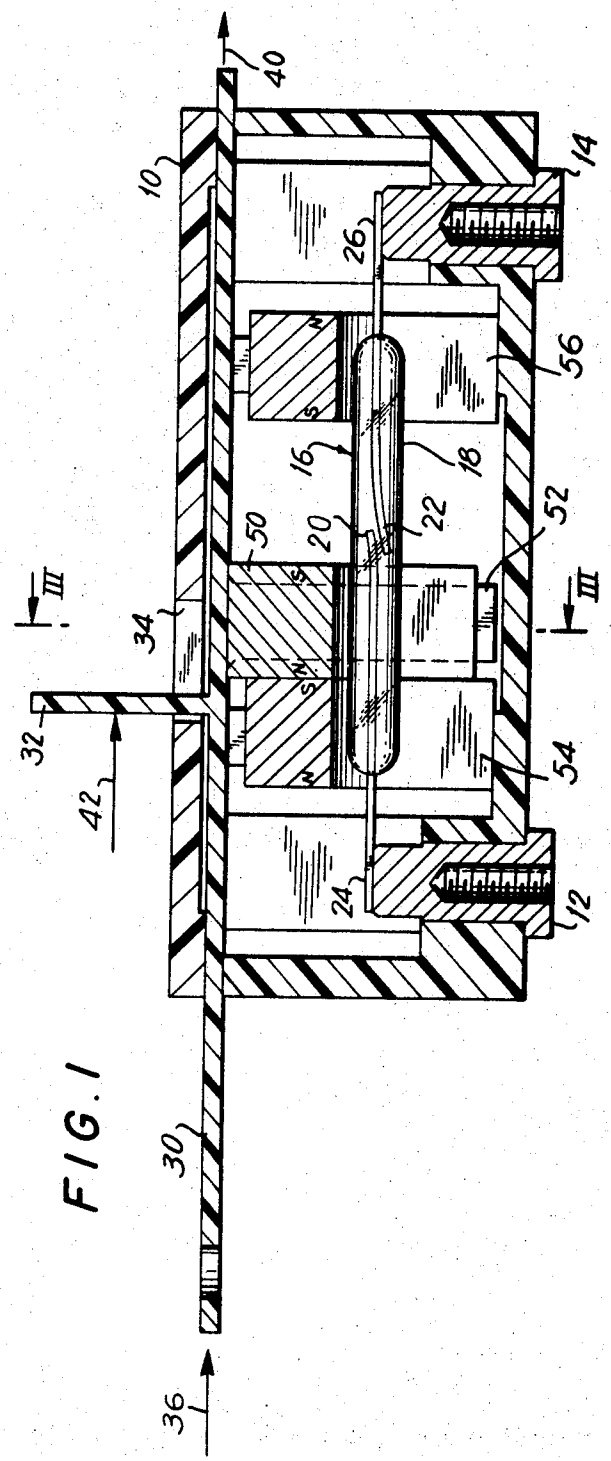


FIG. 1

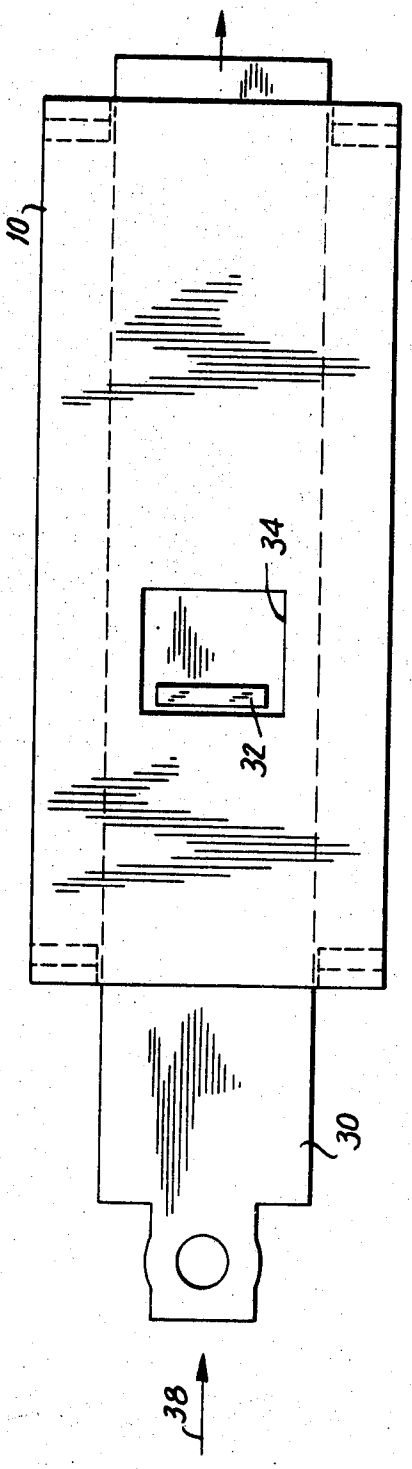


FIG. 2

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FIG. 3

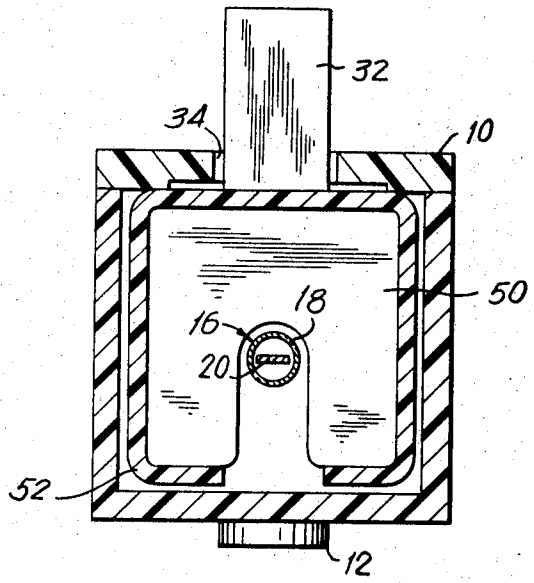


FIG. 4

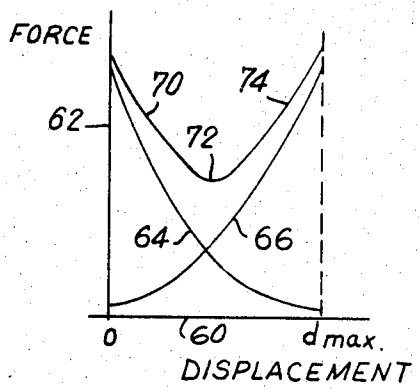


FIG. 5

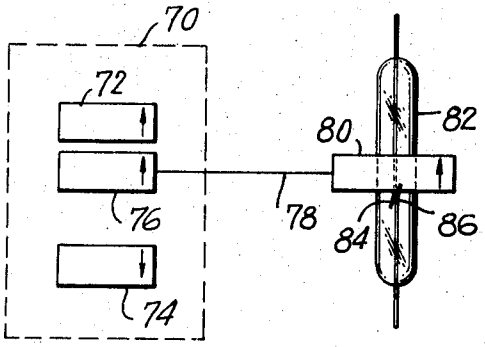


FIG. 7

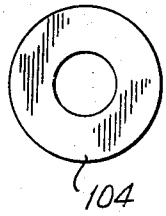
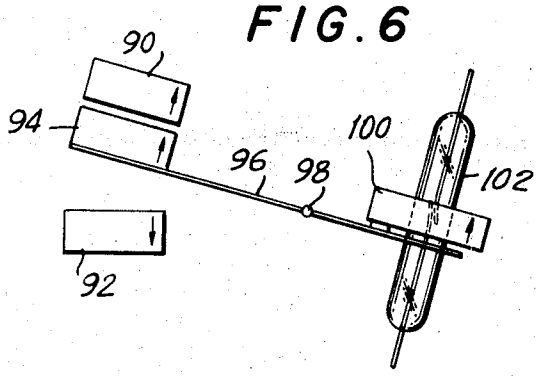


FIG. 6



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REED SWITCH ANG MAGNETIC OVER-CENTER DEVICE THEREFOR

FIELD OF INVENTION

The invention relates to devices which provide over-center force gradients or curves and more particularly to switches which employ such devices.

BACKGROUND

Permanent-magnet actuated reed switches usually consist of contacts which are housed within an envelope such as glass and which are operated by a permanent magnet which is displaced along the envelope until a critical position is reached for the operation of the contacts.

These reed switches have been widely used as keyboard, pushbutton and limit switches. Thus, for example, in data processing apparatus employing typewriters for data input or output, these switches have been used in conjunction with typewriter keys in such a manner as to be operated, when a particular key is struck, to generate an electrical signal for any one of a number of purposes such as, for example, the encoding of characters into electronic signals.

One advantageous characteristic to be incorporated into a reed switch, or as a matter of fact into other kinds of switches and mechanisms, is an over-center feel or force gradient. This characteristic relates to the travel of a member which in the case of a reed switch is the permanent magnet that operates the contacts. It is the characteristic according to which, after the member has reached a critical position, there is a tendency to retard its further movement in the same direction and, preferably, a tendency to return the member to its original position.

To achieve this over-center feel or force gradient by mechanical structures will frequently involve increased costs especially for obtaining sharply defined operating and release points for switch contacts. Moreover, mechanical structures usually involve the use of like forces in opposite directions and this may result in switch dither. Still further, mechanical force control means giving over center force curves are subject to wear or fatigue and, thus, have relatively limited lives.

SUMMARY OF INVENTION

It is an object of the invention to provide an over-center device which is especially suitable for use in connection with reed switches and the like and which is adapted for manufacture at relatively low cost.

Another object of the invention is to provide an improved reed switch construction employing the aforesaid over-center device.

As will be explained in greater detail hereinafter, the above and other objects and advantages of the invention are achieved by the use of a principle relating to the use and interaction of three magnets. Two of these magnets are oppositely polarized with respect to each other and the third is displaceable therebetween. This third magnet travels under the application of an external force from the magnet to which it is attracted towards the magnet by which it is repelled. In so doing, the third magnet passes a critical point at which the force required to keep it in motion in the same direction reaches a minimum whereafter the force required begins to increase. This characteristic is in effect a magnetic cushion or spring which controls the restore force on the third magnet which may directly or indirectly control an associated switch.

Other features of the invention will be found in the following detailed description of some embodiments thereof as illustrated in the accompanying drawing.

BRIEF DESCRIPTION OF DRAWING

FIG. 1 is a longitudinal cross-sectional view through a switch assembly provided in accordance with the invention and inclusive of a reed switch and a magnetic over-center device in operative association therewith;

FIG. 2 is a front view of the switch assembly illustrated in FIG. 1;

FIG. 3 is a cross-sectional view of the switch assembly taken along line III—III in FIG. 1;

FIG. 4 is a force curve provided by magnets incorporated in the switch assembly of FIGS. 1–3;

FIG. 5 diagrammatically illustrates another embodiment of the invention;

FIG. 6 diagrammatically illustrates still another embodiment of the invention; and

FIG. 7 illustrates a variation of magnet form which may be employed in the aforegoing embodiments

DETAILED DESCRIPTION

FIGS. 1–3 illustrate a switch assembly provided in accordance with one embodiment of the invention. In these figures it is seen that the switch assembly comprises a housing or casing 10 which can be fabricated of a suitable plastic or of a non-magnetic metal or the like, this casing being provided with two contact posts 12 and 14 which are threaded elements that are press-fit into position.

The switch assembly moreover comprises a reed switch 16 consisting of a glass envelope 18, contacts 20 and 22 and leads 24 and 26 connected to the contacts. These leads are soldered or welded, or otherwise connected in electrically conductive fashion to the posts 12 and 14. The contacts 20 and 22 are so constructed and arranged in conventional manner as to be influenced by a magnetic field either to make contact or to lose contact with one another.

The illustrated switch assembly is provided with a slider or actuator 30 which is displaceable relative to the housing 10. This actuator may include a tongue 32 bent at right angles to the main body of the actuator 30 and extending through a window 34 provided in the casing 10. As indicated by arrows 36 and 38, the actuator 30 may be displaced by a pushing force applied at the left end thereof. However, as suitable alternatives, a pulling force may be applied as indicated by arrow 40 or a force may be applied against tongue 32 as indicated by arrow 42.

The contacts 20 and 22 are operated by a moveable or displaceable permanent magnet 50 which may, for example, be U-shaped or channel-shaped as appears in FIG. 3. This magnet is connected with the actuator 30 by means of arms 52 which are connected to or integral with the actuator and which are so arranged and constructed as to embrace the magnet 50 and hold the same rigidly with respect to the actuator.

At opposite ends of the reed switch 16 are positioned two further permanent magnets or magnetic elements 54 and 56. These are connected to the casing 10 so as to be immobile relative thereto. Magnets 54 and 56 can be separate as illustrated or can be part of the same magnetic structure.

Magnets 54 and 56 are oppositely polarized as indicated by the legend in FIG. 1. Magnet 50 is polarized in such a manner as to be normally attracted to magnet 54 and normally repelled by magnet 56. Movement of the magnet 50 from magnet 54 towards magnet 56 will bring the magnet 50 to a critical position whereat the contacts 20 and 22 are operated to make contact with one another and when magnet 50 is withdrawn to its original position adjacent magnet 54, contacts 20 and 22 are opened.

FIG. 4 is a chart of the forces resulting from magnets 54 and 56. In FIG. 4, numeral 60 indicates the abscissa of the chart which is measured in units of displacement of magnet 50 away from the magnet 54. The ordinate 62 of the chart is measured in units of force corresponding to the displacement.

Curve 64 illustrates the forces relative to magnet 54 alone and in the absence of magnet 56. From curve 64, it is seen that a large initial force is required to displace the magnet 50 away from magnet 54 when magnet 50 is in close juxtaposition to magnet 54, this force steadily decreasing as magnet 50 moves away from magnet 54.

Curve **66** is the curve of forces with respect to magnet **56** alone and in the absence of magnet **54**. It is seen from curve **56** that as magnet **50** approaches magnet **56**, the force required to continue the motion of magnet **50** towards magnet **56** increases, this being due to the fact that normally magnet **56** repels magnet **50**.

Curve **70** is the curve of forces in the presence of both magnets **54** and **56**, curve **70** being the resultant between curves **64** and **66**. Thus, at the outset when magnet **50** is moved away from magnet **54**, the force required is great. This force, however, decreases as the magnet **50** moves further away from magnet **54** until a minimum is reached at critical point **72**. Thereafter, the force required to continue motion of magnet **50** increases due to the fact that magnet **50** is then approaching repellent magnet **56**.

The critical point **72** is the point of minimum force requirements and the uphill portion of the curve indicated at **74** thereafter operates as a magnetic cushion or spring in accordance with the principles of the invention.

Stated otherwise, a principle employed by the invention relies upon the use and interaction of three magnets or three magnetic forces to achieve a specific force curve or gradient which may preferably be employed for switch actuation. The actuated force required is high at the start or rest position, low in the mid-travel area and high again at the maximum displacement end. This results from the fact that initially there is a strong attraction and a very weak repulsion of the travelling magnet, whereas at the mid-position both forces are relatively low and in the end section there is a strong repulsion coupled with a very weak attractive force. Thus, it is seen that by proper arrangement of the magnets there is achieved an over-center force curve or gradient relative to the magnet **50** which travels between stationary and permanent magnets **54** and **56**.

This simple over-center device, which is a long life device, is used in conjunction with a magnetic reed switch actuator such that the magnetic actuation caused by switch **50** occurs in the relatively low force area. Thus, for example, a typist actuating such a switch by operating a typewriter key, which in turn displaces actuator **30**, causes the actuating magnet **50** to "fall through" the low force area. Thus, by particular use of the reed switch hysterisis (i.e., differential between operate and drop-out magnetomotive force requirements) coupled with the action of magnets **54** and **56**, switch dither is avoided due to the fact that the magnetic force required to make the switch is higher than the magnetic force required to break the switch.

The magnetic spring disclosed may be employed to control the restore force on a separate switch actuator magnet as will be discussed hereinafter, or the magnetic switch actuator may be directly involved as illustrated in FIGS. **1–3**.

Referring next to FIG. **5**, it is seen that other arrangements are possible. Thus, for example, in FIG. **5** appears a housing **70** within which are stationary and permanent magnets **72** and **74** with a displaceable magnet **76** therebetween. Magnet **76** is normally attracted to magnet **72** and normally repelled by magnet **74** so that a curve is established in the manner described hereinabove. Magnet **76** is coupled by a mechanical link **78** to an actuator magnet **80** associated with reed switch **82** having contacts **84** and **86** operated by magnet **80**.

In the embodiment of the invention illustrated in FIG. **5**, the same over-center curve or gradient is employed as is employed in the embodiment of FIGS. **1–3**.

FIG. **6** illustrates still another embodiment of the invention employing magnets **90** and **92** which are both stationary and permanent magnets, there being a displaceable magnet **94** therebetween polarized so as to be attracted towards magnet **90** and repelled by magnet **92**. Magnet **94** is mounted on link **96** which is pivoted at axis **98**, the link **96** being adapted for displacing actuator magnet **100** associated with reed switch **102**. Once again the over-center curve or force gradient is employed so that displacement of magnet **84** passes through a critical zone of minimum force requirement whereafter a magnetic spring or cushion resists movement of this magnet.

The magnets **80** and **100** of FIGS. **5** and **6** respectively may be in the form indicated in FIG. **3**; i.e., they may be U-shaped or channel-shaped. Alternatively, these two magnets, as well as the magnet **50** of FIGS. **1–3**, may take the toroidal form indicated in FIG. **7** at **104**. In this latter case, a very sharp field is provided at the axis of the magnet and of the reed switch. This affords an extremely sharp actuating point for the reed because of well defined flux changes as the magnet is displaced along the axis of the reed. The U-shaped magnet indicated in FIGS. **1–3**, however, provides for a somewhat more convenient assembly procedure inasmuch as the displaceable magnet need not be threaded over the reed switch for purposes of assembly.

From what has been described hereinabove, it will now be apparent that in accordance with the invention there is provided an apparatus comprising first and second oppositely polarized and spaced magnets with a magnetic means including a magnet being provided which is displaceable between these first and second magnets, the latter said magnet being adapted for being attracted to the first magnet and repelled by the second magnet as a result of which there is provided an over-center force gradient or curve between the first and second magnets with respect to the force required to displace the third said magnet. It will also be appreciated that in accordance with the invention, a utilization device is operatively associated with the aforesaid magnetic means to be controlled by the same.

In accordance with a preferred embodiment of the invention the utilization means includes a reed switch which in turn includes magnetically operated contacts. The third said magnet may be operatively associated with these contacts to operate the same. Alternatively, a further magnet may be mechanically connected to the displaceable magnet to be operated by the latter to make and break the contacts according to the displacement which results from movement of the displaceable magnet.

It will be noted that the third magnet which travels between the two stationary magnets has a critical position relative to the switch to cause the contacts to be operated, the stationary magnets being so constructed and arranged to provide a force curve reaching a minimum in correspondence with this critical position.

There will now be obvious to those skilled in the art many modifications and variations of the structures set forth above. These modifications and variations will not depart from the scope of the invention if defined by the following claims.

What is claimed is:

1. Apparatus comprising first and second oppositely polarized and spaced permanent magnets, magnet means including a permanent magnet displaceable between said first and second magnets and adapted for being attracted to said first magnet and repelled by said second magnet whereby there is provided an over-center force gradient between said first and second magnets with respect to the third said magnet, and utilization means operatively associated with said magnetic means to be controlled by the latter.

2. Apparatus as claimed in claim **1** wherein said utilization means includes a switch including magnetically operated contacts.

3. Apparatus as claimed in claim **2** wherein the third said magnet is operatively associated with and operates said contacts.

4. Apparatus as claimed in claim **3** wherein said utilization means includes a further permanent magnet operatively associated with and adapted for operating said contacts, and wherein said magnet means includes a mechanical link connection between said further and third magnet.

5. Apparatus as claimed in claim **3** wherein the third said magnet encircles said switch.

6. Apparatus as claimed in claim **3** wherein the third said magnet straddles said switch.

7. Apparatus as claimed in claim **4** comprising means supporting said link so that the third said magnet is rectilinearly displaceable.

8. Apparatus as claimed in claim 4 comprising means supporting said link so that the third said magnet is arcuately displaceable.

9. Apparatus as claimed in claim 2 comprising an actuator cooperatively coupled to the third said magnet for displacing the same.

10. Apparatus as claimed in claim 9 comprising a housing accommodating said switch and magnets, said actuator extending out of said housing.

11. Apparatus as claimed in claim 2 wherein the third said magnet has a critical position relative to the switch to cause said contacts to be operated and wherein the first and second magnets are so constructed and arranged to provide a force curve reaching a minimum in correspondence with said critical position.

12. Apparatus as claimed in claim 1 wherein said first and second magnets are separate from each other.

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