United States Patent

Beavitt

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[54] REED SWITCHES

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[52] **U.S. Cl.**.....**335/154**
[51] **Int. Cl.**.....**H01h 1/66,** H01h 51/28
[58] **Field of Search**.....335/151, 152, 154, 83

[56] **References Cited**

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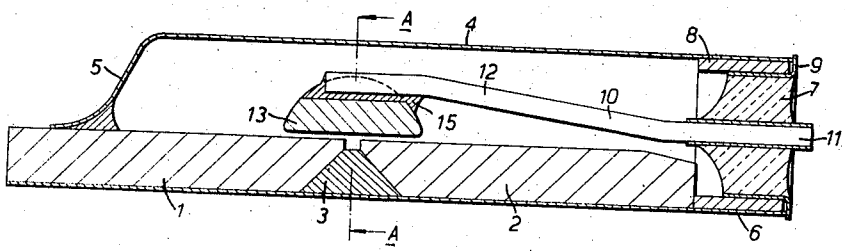
[57] **ABSTRACT**

A reed switch comprises a pair of longitudinally spaced members of magnetizable material which constitute an electrical contact of said switch, a magnetizable armature which is movable into and out of bridging contact with said members, and a cantilever, preferably of non-magnetic material on which the armature is mounted, the cantilever being mounted so as to be electrically independent of said members and forming a second electrical contact of said switch.

4 Claims, 6 Drawing Figures



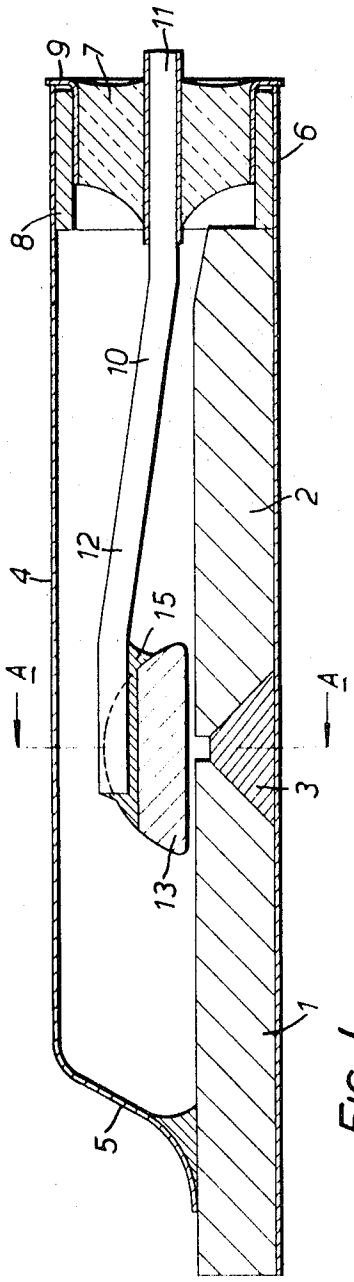


FIG. 1

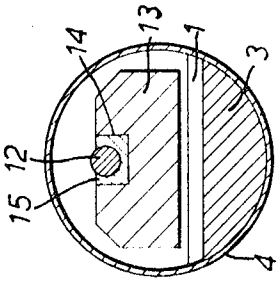


FIG 2

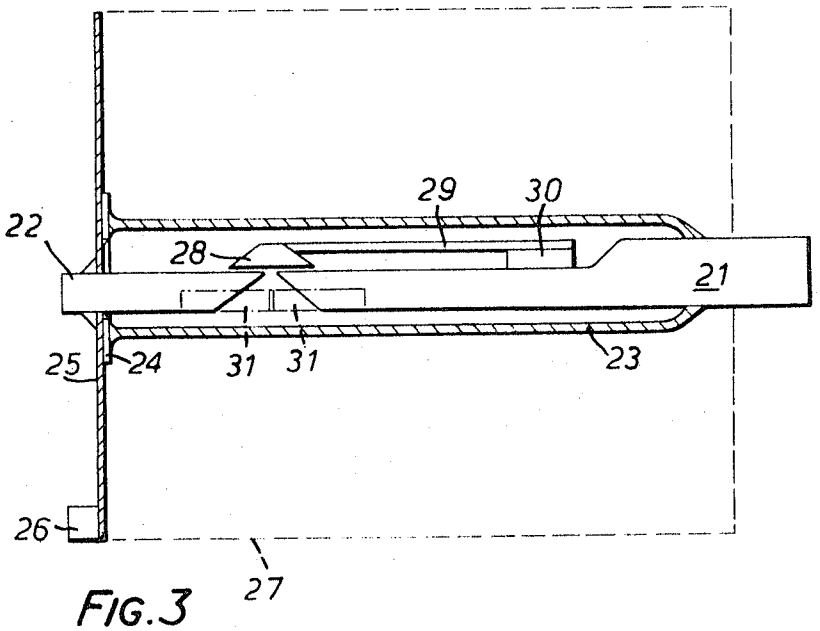


FIG. 3

FIG. 4

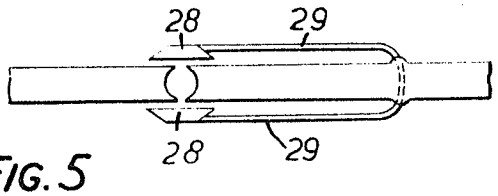


FIG. 5

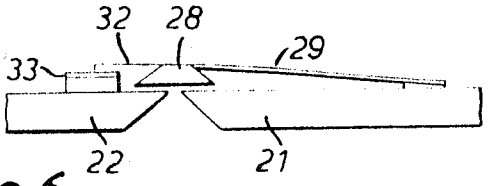


FIG. 6

REED SWITCHES

This invention relates to electrical switches and relates more specifically to so-called reed switches.

According to one feature of the present invention a reed switch comprises a pair of spaced members of magnetizable material, said members constituting an electrical contact of said switch, a magnetizable armature which is movable into and out of bridging contact with said members, a cantilever on which the armature is mounted, said cantilever being mounted so as to be electrically independent of said members and forming a second electrical contact of said switch.

According to another feature of the present invention a reed switch comprises a pair of longitudinally spaced members of magnetizable material, each of which is provided with a longitudinal flat contact surface at the inner end thereof, said members constituting an electrical contact of said switch, a magnetizable armature having a corresponding longitudinal flat contact surface, the contact surface of the armature being movable into and out of bridging contact with contact surfaces of said members, a cantilever on which the armature is mounted, said cantilever being mounted so as to be electrically independent of said members and forming a second electrical contact of said switch.

According to yet a further feature of the present invention a reed switch comprises a pair of longitudinally spaced members of magnetizable material each of which is provided with a longitudinal flat contact surface at the inner end thereof, said members constituting electrical contacts of said switch, a magnetizable armature having a corresponding longitudinal flat contact surface, the contact surface of the armature being movable into and out of bridging contact with the contact surfaces of said members, a cantilever on which the armature is mounted, said cantilever being mounted on one of said members.

By way of example, embodiments of the invention will be further described with reference to the accompanying drawings in which:

FIG. 1 shows a cross-sectional side view of one form of reed switch according to the present invention,

FIG. 2 shows a cross-sectional view on the lines A—A of FIG. 1,

FIG. 3 shows a side view of a further form of reed switch according to the invention,

FIG. 4 shows a series of three detailed views of the contact making members of the switch of FIG. 3 when carrying out a sequence of movements for making and breaking an electrical circuit,

FIG. 5 shows a modification of the contact making members of the switch of FIG. 3, and

FIG. 6 shows a further alternative modification of the contact making members of the switch of FIG. 3.

The reed switch shown in FIG. 1 of the drawings consists of two iron members 1 and 2 each of which is of segmental cross-section and which are separated by a brass insert 3. The adjacent ends of the members 1 and 2 are each angled, so that the gap between them is at a minimum at their top (flat) surfaces. The brass insert 3 is shaped so as to fill the gap thus formed. The two members 1 and 2 are housed in a metal tube 4, typically of copper-nickel alloy, one end 5 of which is compressed and soft soldered to the left-hand iron member 1. The tube 4 is thus closed at the end 5, and the member 1 forms one electrical contact for the reed switch. The other end 6 of the tube 4 is closed by means of a glass-to-metal seal 7 which is located in a stainless steel aligning ring 8, the purpose of which will hereinafter be explained, the aligning ring 8 being positioned in the end 6 of the tube 4. The outer part 9 of the glass-to-metal seal 7 is then soldered around its periphery to the tube 4.

In the center of the glass-to-metal seal 7 is fixedly secured a tungsten cantilever wire 10 which is arranged to pass right through the seal, one end 11 of the cantilever 10 forming a second electrical contact of the reed switch and the other end 12 forming the cantilever proper. The cantilever 10 carries at

the extreme end of the part 12 a magnetizable armature 13, typically of iron and conveniently stamped out of the iron strip from which the iron members 1 and 2 are formed, the armature 13 being provided with a slot 14 in which the cantilever 10 is located and which allows the armature 13 to be correctly aligned before it is fixed in position by silver bearing soft solder 15.

The cantilever wire 10 is bent so that in its normal position, the armature 13 is spaced away from and over the gap between the two iron members 1 and 2 so that when a longitudinal magnetic field (not shown) is brought into the vicinity of the iron members 1 and 2, they become polarized and cause the armature 13 to be attracted towards them, so that the armature 13 makes bridging contact with the two members 1 and 2. Since the two iron members 1 and 2 are in contact with the metal tube 4 they are electrically connected, and the effect of the magnetic field is to cause an electrical connection to be made between the two members 1 and 2 and the armature 13 and thus between the iron member 1, an end of which extends from one end 5 of the tube 4 and between the cantilever wire 10, an end 11 of which extends from the other end 6 of the tube 4. Thus the electrical circuit is from the iron member 1, armature 13 and cantilever wire 10 while the magnetic circuit is between the iron member 1, the armature 13 and the iron member 2.

To make it easier to correctly align the armature 13 and to set the required gap when the switch has been assembled, it is arranged that the aligning ring 8 is soldered to the iron member 2 before assembly in the tube 4, and the glass-to-metal seal 7 together with the cantilever 10 is then located in the aligning ring 7. The armature 13 is then correctly positioned and soldered on the cantilever 10 and the assembly is inserted into the tube 4 and the tube sealed.

The reed switch thus provided is very robust, reasonably cheap and capable of handling high currents e.g. 5 amp at 240 volts. a.c.

In FIG. 3 of the drawings there is shown an alternative construction of reed switch which comprises a right contact member 21 and a left contact member 22 both of which are made from flattened wire material. The contact members are supported in line with one another, the right contact member 21 being sealed by means of a glass-to-metal seal at one end of a glass envelope 23 formed from glass tubing of a round cross-sectional shape. A left-hand end of the glass envelope 23 is joined by means of a further glass-to-metal seal to an end plate 24 which is soldered to an end plate cover 25. The end plate cover 25 is formed of a high permeability material and it also supports by means of a soldered connection the left contact member 22. The soldering of the contact member 22 to the cover is effected during assembly of the switch after sealing-on the end plate 24, lining up the members 21 and 22 in a magnetic field and introducing a suitable gaseous atmopshere. In operation of the switch, the end plate cover 25 forms part of the magnetic circuit thereof and enables the air return reluctance of the circuit to be reduced without adding to the overall length of the switch. The end plate cover 25 carries a tag 26 which forms one of the electrical connections to the switch. A second electrical connection is made to the switch by connecting a suitable lead to the external end of the right contact member 21.

An operating coil for effecting actuation of the reed switch may be placed on the end plate cover 25 and the outline of the coil might then occupy the area indicated by the dotted line 27.

Within the glass envelope 23, the inner ends of the contact members 21 and 22 are shaped so that the gap between them is minimum on the upper edge of the gap as shown in FIG. 1. Above this gap there is an armature 28 which is carried on a cantilever spring 29 and a support 30 fixed to the right contact member 21. The armature 28 is made from pure iron material or a composite of magnetic and contact materials so that when it is moved by magnetic forces across the gap between the contact members 21 and 22, the armature 28 will provide an

efficient bridge without excessive electrical resistance at its contact areas. The cantilver spring **29** may be made of a high chromium stainless steel alloy or a high speed steel that will tend to resist creep at high temperatures. The support **30** may be made of the same material as the contact member **21** or optionally it might be a carbon resistor having silvered ends which are fixed appropriately to the contact member **21** and to the cantilever spring **29**.

Before describing the mode of operation of this reed switch, it is instructive first to consider the forces acting on a conventional reed switch in which all the current passing through the switch has to pass across contacts on the ends of two long cantilever springs.

With a conventional reed switch the sticking force between reed members is proportional to the area of magnetic contact (≃ cross-sectional area of the reed). Since the elastic restoring force is limited by the sticking force, a large magnetic contact area is essential for a direct weld breaking action. Welding is the principal feature limiting the power which a reed switch can handle. If a conventional reed switch is scaled up in size for use in power circuits the cantilevers become uncomfortably long and the switching time (proportional to $\sqrt{\text{effective mass}}$) increases.

The reed switch of FIG. **3** uses only twice the minimum mass required to complete the magnetic circuit and the restoring force is provided by a short, thin cantilever of negligible effective mass. In operation, the actuated armature (initially parallel to the contact members) moves towards the contact members and makes contact first with the contact members furthest from the cantilever. The initial current surge is conducted by the cantilever and can be limited by a resistance connected in series with the cantilever. The armature then makes contact with both contacts and the main current is carried. Upon removing the actuating magnetic field, the armature first breaks contact with the nearest member and a lever action breaks any welds between the armature and the further member. The break current and arc is limited by the cantilever circuit resistance.

A prototype switch of this action was successfully tested at 240 v AC and 5 A with a resistive load.

The actual contact making operation of the switch of the invention is shown in greater detail in FIG. **4**. This shows a series of sketches of the contact areas and in a make operation the sketches are followed from left to right. For a break operation the series is followed in the opposite direction. It will be seen from FIG. **4** that on the make operation the left-hand end of the armature **28** closes first with the contact member **22** due to a slight rocking of the armature **28** by the action of the cantilever spring **29**. This action partly arises from the use of a preferred method of assembly of the switch in which a spacer of uniform thickness is used to set the gap between armature and contact member before the cantilever spring is finally anchored to its support. The use of a short cantilever also promotes this rocking action and on the break operation the slight leverage promoted by this action helps to prevent welding of the switch contacts.

If desired, an auxiliary spark gap can be provided by joining two electrodes **31** (shown as dotted lines in FIG. **3**) between the contact members **21** and **22**. The electrodes **31** can be of an erosion resistant material and if the gap between them is made suitably narrow any sparking between the contact members will occur at this point in preference to occurring between the contact members and the armature **28**.

When compared with the conventional reed switch the switch of FIG. **3** has a number of advantages some of which are outlined in the following notes:

1. The total length of the switch of the invention can be comparatively short.

2. A faster switching time. By calculation this can be about twice as fast for a first contact and (as theoretically there should be no bounce) the switching time can be about 8 times faster for making a permanent connection.

3. A lever weld-breaking action. This motion has been depicted in FIG. **2** and is partly due to the use of a short cantilever spring as well as to use of the preferred method of assembly of the switch which has been described already.

4. The switch can incorporate a surge and arc limiting capability on make and break operations.

5. The cantilever spring does not have to be made of high permeability magnetic material, so that a creep resisting material can be used.

6. The contact members can have a large cross-sectional area than that of the contact regions. In this way heat dissipation and terminal-to-terminal resistance of the switch is improved, and the switch becomes more sensitive to magnetic actuation since a lower flux density is required in the members.

FIGS. **5** and **6** show modifications of the reed switch of FIG. **3** that have been incorporated in switches according to the invention.

FIG. **5** is an embodiment in which two armatures **28** supported by cantilever spring **29** are used one on each side of the contact members **21** and **22**. The two armatures **28** can have a different gap or cantilever stiffness and different contact materials, with the faster acting armature being of erosion resistant material. In one switch constructed in the form of this embodiment switching time was reduced by a factor or about 1.4. If desired a fine tungsten wire can be mounted on the armature to make contact with the appropriate contact member before the armature does so and provide an additional period of surge and arc limitation time through the cantilever circuit in which an erosion resistant material was used. A different embodiment is shown in FIG. **6** in which surge limitation takes place through a tungsten wire **32** which contact first a resistor pad **33** of carbon material. The tungsten wire in this instance could be integral with the cantilever spring **29**.

There are two basic modes of operation of the reed switch of FIGS. **3** to **6** depending on whether the cantilever spring **29** is to be used in a current carrying capacity or not. The following list gives some of the requirements and advantages of each mode.

Mode 1. Cantilever spring is made from low resistivity material, and the member supporting the cantilever is used mainly as a magnetic contact.

a. The armature is assembled at an angle to the members so that it makes contact first with the furthest member. Good lever weld-breaking action is obtained.

b. Change of the surface profile of the members due to erosion is not important.

c. Tungsten would be an ideal cantilever spring material.

Mode 2. Cantilver spring can be made from resistive material, the armature is to make good electrical contact to both members.

a. The armature arrives at both members at approximately the same time.

b. On break, the cantilever spring circuit can provide an arc limiting capability.

c. High-temperature grade stainless steel would make an ideal cantilever spring material.

In either case, a spark gap as provided by the electrodes **31** made from sheet tungsten mounted on the reverse side of the members might be useful for inductive loads. A flattening or reduction in section of the cantilever spring near to the armature provides a hinge mounting for the armature without decreasing the cantilever spring stiffness significantly and is therefore useful in both cases.

What we claim is:

1. A reed switch comprising a pair of spaced members of magnetizable material, said members constituting an electrical contact of said switch, a magnetizable armature which is movable into and out of bridging contact with said members, a cantilever on which the armature is mounted, said cantilever being mounted so as to be electrically independent of said members and forming a second electrical contact of said switch.

2. A reed switch comprising a pair of longitudinally spaced members of magnetizable material, each of which is provided with a longitudinal flat contact surface at the inner end thereof, said members constituting an electrical contact of said switch, a magnetizable armature having a corresponding longitudinal contact surface, the contact surface of the armature being movable into and out of bridging contact with contact surfaces of said members, a cantilever on which the amrature is mounted, said cantilever being mounted so as to be electrically independent of said members and forming a second electrical contact of said switch.

3. A reed switch comprising a pair of longitudinally spaced members of magnetizable material, said members being of segmental cross-section and constituting an electrical contact of said switch, the adjacent ends of said members being angled away from the respective flat surfaces of said members so that the gap between the members is at a minimum at said surfaces, a magnetizable armature having a flat contact surface which is movable into and out of bridging contact with the flat surfaces of said members, a cantilever on which the armature is mounted, said cantilever being mounted so as to be electrically independent of said members and forming a second electrical contact of said switch.

4. A reed switch comprising a tubular housing, a pair of longitudinally spaced members of magnetizable material positioned in said housing one end of said housing being compressed and sealed around one of said members, said one member forming an electrical contact of said switch, a magnetizable armature which is movable into and out of bridging contact with said members, a cantilever on which the armature is mounted, said cantilever being mounted in a glass-to-metal seal located in the other end of said housing and forming a second electrical contact of said switch.

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