

[54] **VACUUM SWITCH**

[76] Inventor: **Julius C. Westmoreland**, 6607
Avenida de La Pescas, La Jolla,
Calif. 92037

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[51] Int. Cl. **H01h 9/02**

[58] Field of Search **200/144 B, 168 G**

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Primary Examiner—Robert S. Macon

Attorney—Ronald W. Reagin and Ralph M. Braunstein

[57]

ABSTRACT

A sealed electrical switch is disclosed which includes a first conductive element and a second conductive element. The second conductive element is positioned with its first end in abutting relationship with the first end of the first conductive element, with the abutting surfaces of the conductive elements forming the contacts of the switch. Electrical terminals are connected to the other ends of the conductive elements, and an elastomer coating surrounds all of the switch except the electrical terminals.

9 Claims, 5 Drawing Figures

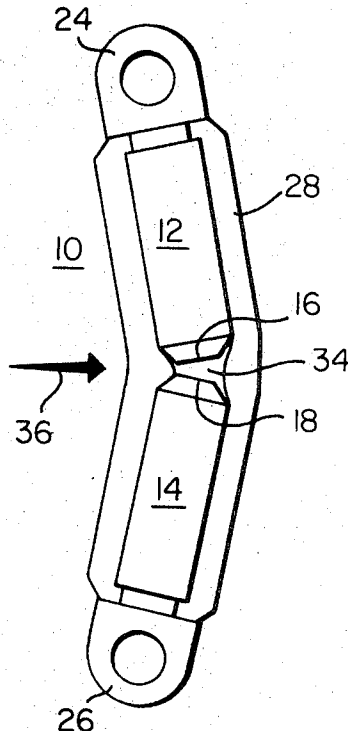


Fig. 1

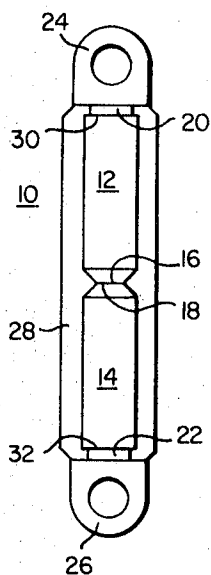


Fig. 2

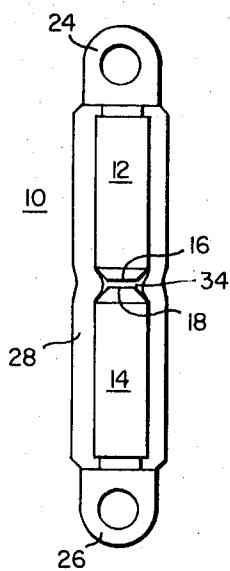


Fig. 3

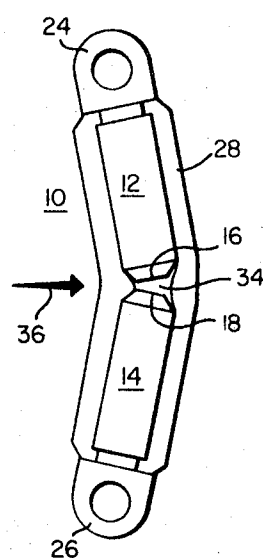


Fig. 4

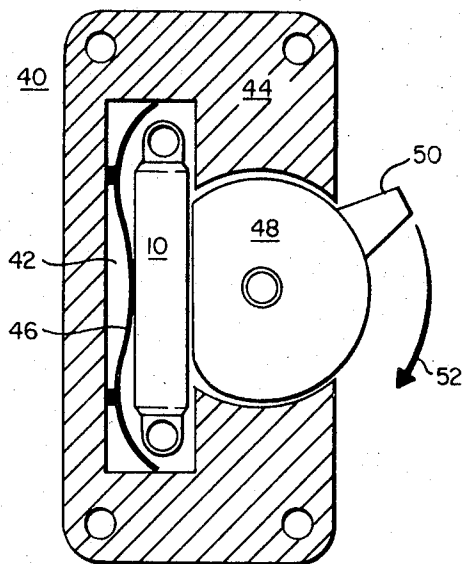
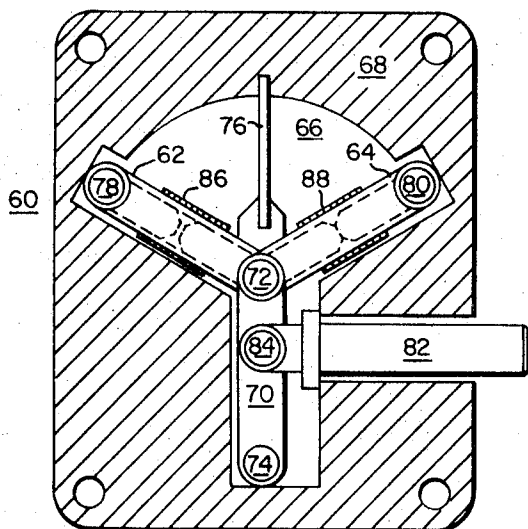


Fig. 5



JULIUS C. WESTMORELAND

INVENTOR

BY *Paul W. King*

ATTORNEY

VACUUM SWITCH

This invention relates to electrical switches, and more particularly to a novel sealed electrical switch and a method for making the same in which the switch can be manufactured at an extremely low cost.

As used in this specification, the terms "sealed switch" and "vacuum switch" are used essentially interchangeably, and are used to mean an electrical switch in which the contacts are maintained in at least a partial vacuum and are sealed from the ambient environment in which the switch is used. Conventionally, the contacts are supported within a suitable hermetically sealed container and the electrical leads to the contact are brought out through the container. Such switches are required to be used in hazardous areas where a spark between contacts might set off an explosion or the like. However, vacuum switches also have many advantages over conventional switches in areas other than explosion hazard areas. For example, less arcing occurs between the contacts when there is no gaseous medium to support an arc when the contacts are broken while they are carrying current. Since the resultant pitting and erosion from such arcing is one of the major causes of contact wear and switch failure, vacuum switches typically exhibit a much longer life than conventional switches. Also, it is known that in a vacuum switch it is not necessary to separate the contacts by as great a distance to enable the switch to hold off a given voltage, since the absence of the gaseous medium between the contacts makes it less likely that arcing will occur at a time when the contacts are open.

However, to date the relatively high price of vacuum switches has limited their application to either explosion hazard areas, where such switches are absolutely required, or to extremely high specification systems where the added cost of the vacuum switch can be justified. This added cost is usually caused by the requirement that the switch have relatively expensive glass or ceramic to metal seals in order to allow the electrical leads to be brought out in a suitably insulated manner while still maintaining the necessary hermetic seal of the container.

It is accordingly an object of the present invention to provide an improved vacuum switch.

It is another object of the present invention to provide an improved vacuum switch which is simple and inexpensive to manufacture.

It is yet another object of the present invention to provide an improved method of making a vacuum switch.

Briefly stated, and in accordance with the presently preferred embodiment of the invention, a vacuum switch is provided which includes a first electrically conductive element and a second electrically conductive element. Each of these conductive elements has a first end and a second end, with the first end of each forming the contact surfaces of the switch. The first ends of the two conductive elements are complementary surfaces, and are preferably planar. These conductive elements are positioned with their first ends in abutting relationship so that the two contact surfaces normally mate with each other in intimate relation. Suitable electrical terminals are connected to the second ends of the conductive elements. An elastomer coating is provided which surrounds all of the switch except the terminals, whereby a low resistance electri-

cally conductive path normally exists between the contact surfaces of the two electrically conductive elements, and thus between the two terminals of the switch. However, if the switch is laterally deflected or elongated, a gap develops between the contact surfaces to form an open circuit between the electrical terminals. The elastomer coating allows the switch to elongate or to deform to enable this gap to develop, but prevents any gaseous medium from getting between the contacts, and thus a self-contained and self-generated vacuum is developed between the contacts.

In accordance with another feature of the present invention, the vacuum switch is manufactured by forming the two conductive elements mentioned above from a single elongated body of electrically conductive material. An electrical terminal is provided on each end thereof. The elongated body is then coated with an elastomer coating entirely along its length and over its shoulders, but leaving the terminals exposed for electrical connection. After the coating is applied, the elongated body is broken, for example by placing the switch under tension to break the elongated body into the two electrically conductive elements mentioned above. If desired, a notch may be provided in the side of the elongated body prior to the coating operation to assist this breaking step and to assure that the break occurs at a desired location. By this method, the vacuum switch is formed in an extremely inexpensive manner while at the same time assuring that a good vacuum is achieved between the contact surface when the switch is actuated.

For a complete understanding of the invention, and an appreciation of its other objects and advantages, please refer to the following detailed description of the attached drawings, in which:

FIG. 1 shows a cross-section view of a vacuum switch in accordance with the present invention;

FIG. 2 shows a cross-sectional view of the vacuum switch of FIG. 1 and illustrates how the contacts of the switch are opened when the switch is elongated;

FIG. 3 shows a cross-sectional view of the vacuum switch of FIG. 1 and illustrates how the contacts of the switch are opened when the switch is deflected laterally;

FIG. 4 is a cross-sectional view of a switch assembly employing the vacuum switch of FIG. 1; and

FIG. 5 is a cross-sectional view of a second switch assembly employing two of the vacuum switches of FIG. 1.

FIG. 1 shows a cross-sectional view of a vacuum switch 10 in accordance with the present invention. As shown therein, the switch 10 is formed from a first conductive element 12 and a second conductive element 14. Each of the conductive elements 12 and 14 contains a first end 16 and 18 respectively and a second end 20 and 22 respectively. The conductive elements 12 and 14 are positioned as shown in FIG. 1 with their first ends 16 and 18 in abutting relationship. When the switch is in its closed position, as is shown in FIG. 1, these first ends 16 and 18, which form the contact surfaces of the switch 10, are mated against each other in intimate contact to provide an extremely low resistance electrically conductive path between the two conductive elements 12 and 14. Electrical terminals 24 and 26 are directly connected to the second ends 20 and 22 respectively of the conductive elements 12 and 14. Thus, when the switch 10 is in the condition shown in FIG. 1,

essentially a short circuit exists between the electrical terminals 24 and 26.

The switch 10 is completed by an elastomer coating 28 which completely surrounds all of the switch 10 except the electrical terminals 24 and 26. The elastomer coating 28 surrounds all of the side portions of the conductive elements 12 and 14 and extends around the shoulder portion 30 of conductive element 12 and the shoulder portion 32 of conductive element 14 in order to prevent these elements from sliding out of the elastomer coating.

As shown in FIG. 1, the conductive elements 12 and 14 are each substantially cylindrical elements along their length, but each has a tapered or frusto-conical portion at its first end adjacent the contact surfaces 16 and 18. These tapered sections thus define a notch around the center of the conductive portion of the switch when it is in the condition shown in FIG. 1. The reason for this notch is explained in connection with the description below of the manufacturing process by which the vacuum switch is made.

FIG. 2 is a cross-sectional view similar to FIG. 1, but shows how an open circuit is developed between the contact surfaces 16 and 18 of the vacuum switch 10 whenever the switch 10 is elongated, such as by applying tension between the terminals 24 and 26. When this occurs, the elastomer coating 28 stretches slightly and allows the conductive elements 12 and 14 to separate from each other, thereby causing a gap 34 to develop between the contact surfaces 16 and 18. Since this gap 34 is hermetically sealed from the outside atmosphere by the elastomer coating 28, if sufficient care is taken in the manufacturing process of switch 10 to assure that no gasses are present within the elastomer coating 28 or the conductive elements 12 and 14, the gap 34 is essentially a self-contained and self-generated vacuum, and thus switch 10 is a vacuum switch, with all the inherent advantages thereof.

FIG. 3 is again a cross-sectional view similar to FIG. 1, but illustrates what happens when a force, indicated by the arrow 36 is applied laterally against the center of switch 10 to cause switch 10 to deflect laterally. As is shown in FIG. 3, a gap 34 again develops between contact surface 16 and 18 to effect an open circuit between terminals 24 and 26. Again, as in the case of FIG. 2, there are no gasses present in the gap 34 and it is thus essentially a vacuum.

At this point it is appropriate to discuss the process by which the vacuum switch 10 just described is manufactured. In accordance with one of the features of the present invention, the two conductive elements 12 and 14 are initially formed as a single unit. This unit is a cylinder of electrically conductive material which is relatively brittle and has a low tensile to shear strength ratio. In practice, it has been found that this element can readily be formed from a suitable zinc alloy having these physical characteristics but it can also be formed from any other suitable material having the above mentioned physical properties, such as cast magnesium, cast aluminum, a high leaded tin bronze, a nickel-silver alloy, brass or beryllium copper.

A notch is formed around the center of the cylinder from which the conductive elements 12 and 14 are eventually formed. This notch may be either machined into the material or, if the cylinder is formed by a process such as die-casting or molding, it may be formed simultaneously with the conductive cylinder in the

mold. The electrical terminals 24 and 26 are next attached to the ends 20 and 22 respectively.

It is important that the conductive cylinder be formed with as little gaseous material as possible within the conductive material. For many conductive materials, such as those mentioned above, it is sufficient if the material is machined or die-cast in a conventional manner. For other materials which have a propensity to contain gas within their structure or to be porous materials, it may be necessary to do the casting in a vacuum to assure that no gasses are trapped within the material to be freed at the time the conductive cylinder is broken into two pieces, as is described below. If the conductive cylinder is formed from a particularly porous material, such as if it is sintered from a powdered metal, this forming in a vacuum may be quite important.

The switch 10 as thus processed is then coated with a coating of elastomer material 28 around all the portions shown in FIG. 1, including over the shoulders 30 and 32. The elastomer material may be any synthetic or natural material which is capable of a hermetic seal and which has resilience or memory sufficient to return to its residual shape after major or minor distortion. Preferably, the elastomer material 28 is silicone, but it may also be any material exhibiting suitable elastomer characteristics, such as natural rubber, butyl, fluorosilicone, polyurethane, polyacrylate, nitrile or chloroprene.

The final step in the manufacturing process is to break the central conductive core into the two conductive elements 12 and 14. This may be easily effected by subjecting the coated switch 10 to a tensile pull sufficient to separate the elements 12 and 14 at the notch while only slightly stretching the surrounding elastomer material 28. The contact surfaces 16 and 18 are thus produced within a self-contained vacuum. If the material is sufficiently brittle and exhibits a sufficiently low tensile to shear strength ratio as mentioned above, the elements 12 and 14 will separate along a substantially planar break surface, thereby forming substantially planar contact surfaces 16 and 18 which will mate in intimate contact to provide good electrical conduction between the terminals 24 and 26. In any event, even if the break occurs as other than a planar break, the contact surfaces 16 and 18 are inherently complementary and mate along their entire surface to provide good electrical contact.

Alternatively, the break may be effected by applying a lateral force to the switch 10 adjacent to the notch, much like a match stick might be broken. Again, this form of breaking results in complementary contact surfaces 16 and 18 within a self-contained vacuum.

FIG. 4 shows a cross-sectional view of a switch assembly 40 which incorporates the vacuum switch 10 described in FIGS. 1 and 3 above. As is shown in FIG. 4, the switch 10 is positioned in a cavity 42 within a housing 44. A leaf spring 46 is positioned behind the switch 10 and a cam element 48 is positioned in front of the switch 10. An actuating lever 50 is provided on cam 48, and if lever 50 is rotated clockwise as shown by arrow 52, cam 48 rotates in a clockwise manner to cause a section of cam 48 which has a larger radius to move against switch 10, causing it to deflect laterally back into cavity 42 against leaf spring 46. When this occurs, an open circuit is created within switch 10 as is shown in FIG. 3 above, and this open circuit remains until the lever 52 is rotated back to the shown position

of FIG. 4. At this time, leaf spring 46 deflects switch 10 back into a straight position to cause a short circuit between its terminals, as is shown in FIG. 1 above.

FIG. 5 shows a cross-sectional view of a second switch assembly 60 which incorporates two vacuum switches 62 and 64, each of which is the like vacuum switch 10 of FIGS. 1 through 3. The vacuum switches 62 and 64 are positioned within a cavity 66 in a housing 68. One terminal of each of the switches 62 and 64 is pivotally connected to an electrically conductive lever 70, such as being mounted on a pin 72 which is secured to lever 70. The bottom end of lever 70 is pivotally mounted on a pin 74 which forms the common terminal of switch assembly 60. A leaf spring 76 is connected between the top end of lever 70 and the housing 68 to hold the lever 70 in the position shown in FIG. 5 whenever switch assembly 60 is not actuated.

As shown in FIG. 5, the other terminal of switch 62 is connected to a pin 78, and the spacing between pin 78 and pin 72 is such that, when the assembly is in the position shown in FIG. 5, sufficient tension exists along switch 62 to cause its elastomer coating to stretch a sufficient amount to create an open circuit between its contact surfaces. This is shown in the hidden lines within switch 62. Thus, pin 78 serves as a normally open contact relative to the common terminal at pin 74.

Conversely, pin 64 has its other terminal connected to a pin 80 which is spaced from pin 72 a sufficient distance that the elastomer coating of switch 64 is in its relaxed state, whereby its contact surfaces mate intimately to provide a short circuit between its terminals. Again, this is shown in the hidden lines in FIG. 5. Accordingly, pin 80 is a normally closed contact relative to the common terminal at pin 74.

As is shown in FIG. 5, a push button actuator 82 is provided which is pivotally connected to a pin 84 in the center of lever 70. In operation, whenever push button 82 is depressed, lever 70 pivots counter-clockwise on pin 74, deflects leaf spring 76 and causes pin 72 to move closer to pin 78 and further from pin 80. At this time, switch 62 is shortened and the contact surfaces therein are closed, thereby creating an electrical connection between the common terminal at pin 74 and the normally open contact at pin 78. Simultaneously switch 64 is elongated and its contact surfaces are opened, thereby creating an open circuit between the common terminal at pin 74 and the normally closed contact at pin 80. This condition remains until the force is removed from push button 82, at which time leaf spring 76 returns lever 70 to its shown position and once again pin 78 is an open contact and pin 80 is a closed contact relative to the common terminal at pin 74.

FIG. 5 also shows anti-buckling sleeves 86 and 88 positioned around the elastomer coatings on switches 62 and 64. These sleeves 86 and 88 prevent switches 62 and 64 from laterally deflecting when push button 82 is actuated and assures that the switches are opened and closed only by elongation and shortening of the switches 62 and 64.

While the invention is thus disclosed and several specific embodiments described in detail, it is not intended that the invention be limited to these shown embodiments. Instead, many modifications will occur to those skilled in the art which lie within the spirit and scope of the invention. For example, in many applications it

will not be necessary to provide a notch all the way around the center of the conductive cylinder before it is coated with its elastomer coating. For some materials and applications it will be sufficient to provide a notch in only one side to assure a sufficiently clean break. For other materials or other breaking methods, it may not be necessary to provide a notch at all. It is thus intended that the invention be limited in scope only by the appended claims.

What is claimed is:

1. A sealed switch, comprising:

a first conductive element having a first end and a second end, said first end of said first conductive element forming a first contact surface and said second end of said first conductive element including a shoulder portion,

a second conductive element having a first end and a second end, said first end of said second conductive element forming a second contact surface and said second end of said second conductive element including a shoulder portion, said second contact surface being complementary to said first contact surface,

said second conductive element being positioned with its first end in abutting relationship with the first end of said first conductive element, whereby said second contact surface mates with said first contact surface,

first terminal means connected to the second end of said first conductive element,

second terminal means connected to the second end of said second conductive element, and

an elastomer coating surrounding and being in intimate contact with all of said first and second conductive elements except said first and second terminal means and said first and second contact surfaces, said elastomer coating extending over said shoulder portions of said first and second conductive elements, whereby a low resistance electrically conductive path normally exists between said first and second terminal means and an open circuit between said first and second terminal means is formed by a resultant vacuum gap between said first and second contact surfaces whenever said vacuum switch is elongated or is laterally deflected.

2. The sealed switch of claim 1 in which said first and second surfaces are each substantially planar.

3. The sealed switch of claim 3 in which the area of said contact surfaces is less than the cross-sectional area of said conductive elements between said contact surfaces and said shoulder portions.

4. The sealed switch of claim 4 in which said elastomer material is selected from the group consisting of silicone, rubber, butyl, fluoro silicone, polyurethane, polyacrylate, nitrile and chloropene.

5. A process for making a sealed switch which comprises the steps of:

forming an elongated body of electrical conductive material having a terminal at each end thereof, coating said body with an elastomer coating but leaving at least a portion of said terminals uncoated, and

breaking said elongated body within said elastomer coating into first and second conductive elements, whereby the adjacent surfaces of said conductive elements, after breaking, form first and second contact surfaces, respectively, which are comple-

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mentary and which are hermetically sealed by said elastomer coating.

6. The process of claim 5 which further includes the step of forming a notch in the side of said elongated body prior to the step of coating said body with an elastomer material.

7. The process of claim 6 in which said notch is

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formed entirely around the circumference of said body.

8. The process of claim 7 in which said notch is machined into said body after said body is formed.

9. The process of claim 6 in which said body is molded from a conductive material and said notch is molded into said body at the time said body is formed.

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