United States Patent

Lindermeyer

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[54] LIQUID ARMATURE SWITCH

[72] Inventor: **Michael Edward Lindenmeyer,** North Aurora, Ill.

[73] Assignee: **Bell Telephone Laboratories, Incorporated,** Murray Hill, N.J.

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[52] **U.S. Cl.**.....**335/49,** 200/182

[51] **Int. Cl.**.....**H01h 29/02**

[58] **Field of Search**.....335/47, 48, 49, 50, 55, 56, 335/57, 58; 200/182, 194

[56] **References Cited**

UNITED STATES PATENTS

2,844,688 7/1958 Pfann 335/56

Primary Examiner—Harold Broome

Attorney—R. J. Guenther and R. B. Ardis

[57] **ABSTRACT**

A liquid armature switch having two control electrodes mounted between two signal electrodes in a chamber is disclosed wherein the control electrodes are in constant contact with the armature and are positioned to restrain any movement of the armature which is not the result of the application of an electromagnetic switching force to the armature.

4 Claims, 4 Drawing Figures

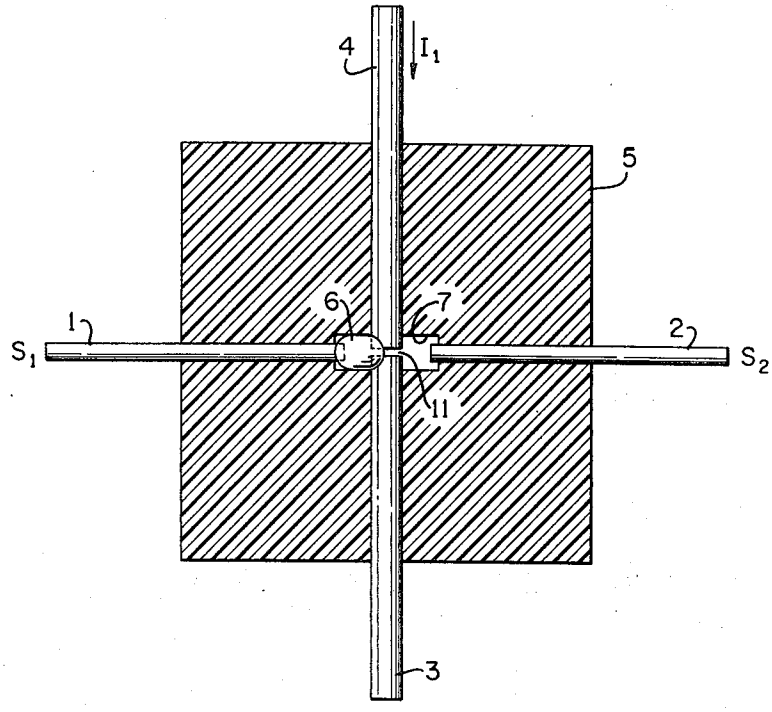


FIG. 1

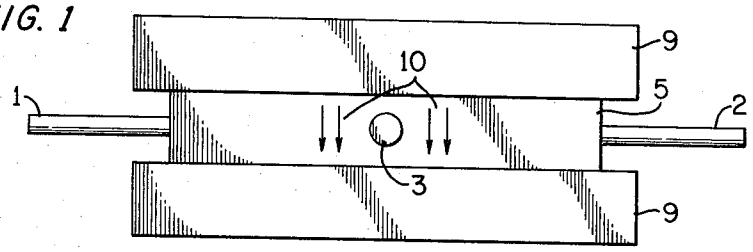


FIG. 2

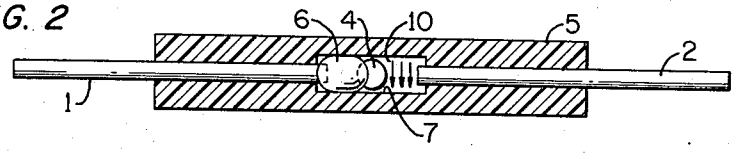


FIG. 3

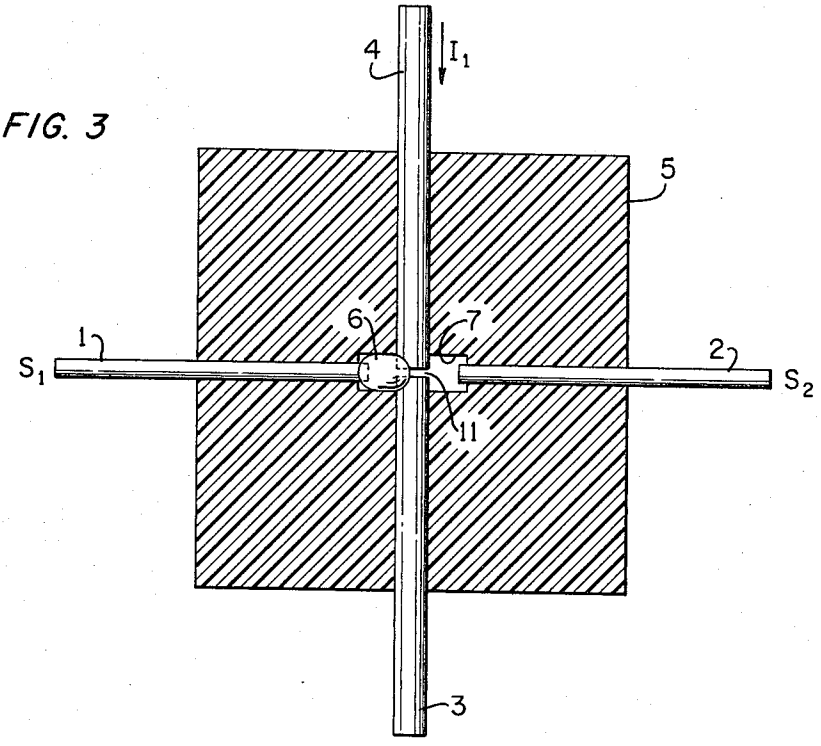
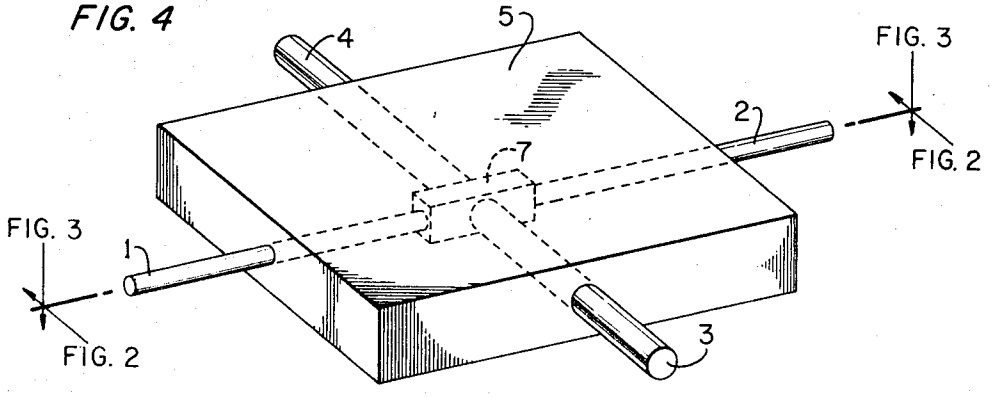


FIG. 4



LIQUID ARMATURE SWITCH

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to switching devices and, more particularly, to electrical switches in which the switching operation is dependent upon the interaction of a magnetic field with a current flowing through a nonmagnetic liquid switching member.

2. Description of the Prior Art

Several years ago W. G. Pfann, U.S. Pat. No. 2,844,688, issued July 22, 1958, disclosed a type of switch in which a mercury globule or other suitable nonmagnetic liquid conductor, henceforth referred to as an armature, is positioned in a magnetic field. This armature is moved from one switch state to another by a force resulting from the interaction of the magnetic field with a switching current flowing through the armature. For a two-state switch of the Pfann type, two pairs of electrodes are required to conduct the switching currents to the armature. The electrodes of a first of these pairs are in contact with the armature when it is in a first of the two switch states. These electrodes, along with the armature, provide a path for the switching current which interacts with the magnetic field to produce the force that moves the armature to a second switch state. Conversely, when the switch is in the second switch state, the second pair of electrodes and the armature provide a path for the switching current which is needed to produce the force that returns the armature to the first state.

In the Pfann switch the armature is restrained from inadvertent movement from the desired switch state, resulting from the influence of gravitational or other forces, by selectively positioning the switch with respect to the gravity field or by selectively forming the housing of the switch to increase armature stability. While the Pfann switch is effective in many applications, it is not useful in those applications where it is impossible or impractical to achieve switch stability in the above manner.

SUMMARY OF THE INVENTION

Applicant's invention is a liquid armature switch that, regardless of its position, maintains its switch state in the absence of a switching current. The stability problems of the prior art switches are overcome by mounting two control electrodes in applicant's switch between two signal electrodes within a chamber in a housing in such a relationship that a liquid armature, in contact with one of the signal electrodes, can only come into contact with the other signal electrode by passing between the control electrodes under the influence of a force derived from the interaction of a magnetic field with a switching current passing through the armature and the control electrodes. As a result of this type of construction, the switch is stable in any physical mounting position. Furthermore, the positioning of the control electrodes and the volume of the liquid armature are such that contact between the control electrodes and the armature is always maintained. Since the armature and the control electrodes are in constant contact, only two control electrodes are needed to change the state of the switch from either of its stable states to the other. In summary, applicant's invention increases the stability of liquid armature switches and eliminates the need for more than one pair of control electrodes in such switches.

It is an object of this invention to provide a switch with improved armature position stability.

It is another object of this invention to utilize a single pair of control electrodes to control the state of a liquid armature switch.

It is another object of this invention to provide a switch in which the position of the armature is stabilized in its last switched state by the control electrodes of the switch.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation view of applicant's switch positioned within a magnetic field source;

FIG. 2 is a sectional view of applicant's switch in the direction shown in FIG. 4;

FIG. 3 is a sectional view of applicant's switch in the direction shown in FIG. 4; and

FIG. 4 is a perspective view of the illustrative embodiment of applicant's invention.

DESCRIPTION OF THE INVENTION

As shown in the illustrative embodiment of applicant's switches in FIG. 1, the switch housing 5 is mounted between two elements 9 that produce a magnetic field which passes through the housing 5 as indicated by the vectors 10. A perspective view of the switch housing 5 is shown in FIG. 4. The housing 5 may be made of glass or other suitable material as described in the Pfann patent. The electrodes 3 and 4 (FIG. 4) constitute the control electrodes of the switch and electrodes 1 and 2 constitute the signal electrodes of the switch.

The operation of the switch can be readily explained using the sectional view of the switch in FIG. 3 which shows the switch in what will be referred to as its first state. The armature 6 (FIG. 3) is a liquid conductor globule of the types described in the Pfann patent. The relative volumes of the globule forming the armature 6 and the chamber 7, and the positioning of the electrodes 3 and 4 are selected such that the armature 6 is always in contact with a signal electrode and both control electrodes 3 and 4 when no switching current is applied to the switch. For instance, in the first state of the switch, the armature is in contact with the signal electrode 1 and the control electrodes 3 and 4. Additionally, it is apparent that the armature 6 will be in constant contact with the control electrodes 3 and 4 whether resting on either side of these electrodes or passing through the gap 11 between them during a transition of the switch state. Since the armature 6 is always in contact with the control electrodes 3 and 4, it is possible to use the single pair of control electrodes 3 and 4 and the armature 6 as the conduction path for the switching current that controls the state of the switch.

In changing the state of the switch from its first state to its second state, a switching current I_1 (FIG. 3) is generated that flows through the control electrode 4, the armature 6 and the control electrode 3. This switching current I_1 interacts with the magnetic field 10 shown in FIG. 2. This interaction results in a force being applied to the armature 6 (FIG. 3) that moves the armature 6 through the gap 11 between the control electrodes 3 and 4. The switching current I_1 is main-

tained until the armature has moved through the gap 11 and come into contact with the electrode 2. At this point, the state of the switch has been changed from its first to a second state.

If, at some later time, the switch is to be returned to its original state, a current is established through the armature 6 and the control electrodes 3 and 4 in the direction opposite to that of the current I_1. Again, in this case, the current interacts with the magnetic field 10 to produce a force on the armature 6 that moves the armature through the gap 11 and into contact with the signal electrode 1, putting the switch back in its original state.

When switching current is not flowing through the armature 6 (FIG. 3), no electromagnetic force is exerted upon the armature 6. The armature 6 is, however, subjected to the normal forces of gravity. In order to prevent the effects of gravity or other undesired forces from inadvertently changing the state of the switch, the diameter of the control electrodes is selected sufficiently large to prevent any flow of the armature between the control electrodes and the walls of the chamber 7 and the gap 11 between the control electrodes 3 and 4 is selected to constrict the passageway through which the armature 6 must move to change the state of the switch. As a result, when the armature 6 comes to rest in contact with one of the signal electrodes, such as electrode 1, and switching current is removed, the armature 6 is maintained in this quiescent position by the restraining force exerted by the control electrodes 3 and 4 against the surface of the liquid globule comprising the armature 6. Since the stability of the armature 6, with respect to undesired forces, in either switch state is improved by narrowing the gap 11, the gap size is selected as small as practicable. One factor in determining the gap 11 is the acceptable transit time for the armature from one state to the other, where transit time is measured from the time switching is initiated with the armature in contact with one of the signal electrodes until the armature is in contact with the other signal electrode. For a given level of force available from the interaction of the magnetic field with the switching current, reducing the size of the gap 11 increases the armature transit time. If the transit time is greater than the desired value for the desired gap size, the magnetic field or switching current is increased to increase the force available for moving the armature which, in turn, decreases the transit time.

It should be noted that the switch will operate properly without creating a vacuum in the chamber 7 when the rectangular chamber cross section of the illustrative embodiment is used. Since the surface tension of the liquid globule armature 6 prevents the globule from filling the corners of the chamber 7, air can move past the armature as it is forced from state to state. It should be clear that other chamber configurations would also serve equally well without requiring evacuation. The chamber 7 can, of course, be evacuated, if desired.

To make use of the switch described above, either of the control electrodes may be selected to serve as the switched electrode for completing the circuit from either of the two signal electrodes. For example, if control electrode 3 (FIG. 3) is chosen to be the switched electrode, a signal S_1 (FIG. 3) appearing on signal electrode 1 also appears on electrode 3 when the switch is in the first state. The signal S_2 on electrode 2 appears on electrode 3 when the switch is in the second state. Thus, the signal appearing on electrode 3 is the same as that appearing on electrodes 1 and 2 depending on the state of the switch. Operation in this manner is commonly known as single pole, double throw operation.

In summary, the liquid armature switch disclosed above comprises two control electrodes 3 and 4 advantageously positioned between two signal electrodes 1 and 2 in such a manner that the control electrodes 3 and 4 are always in contact with the liquid armature and restrain movement of the liquid armature when the switch is in either quiescent state.

Clearly, applicant's invention is in no way limited to the particular configuration shown in the illustrative embodiment above. Many alternative configurations of the chamber 7 (FIG. 4), and of the placement of the control electrodes 3 and 4 and the signal electrodes 1 and 2 within the chamber 7, that are within the spirit and scope of the invention will become readily apparent to one skilled in the art upon reading this disclosure.

What is claimed is:

1. A switch comprising:
a switch housing containing a chamber;
means for generating a magnetic field within said chamber;
a pair of signal electrodes mounted within said chamber;
a nonmagnetic, liquid conductor globule located within said chamber in contact with one of said signal electrodes;
a pair of control electrodes mounted within said chamber between said signal electrodes in such manner as to maintain continuous contact with said globule irrespective of the position of said globule in said chamber; and
means for providing a potential difference between said control electrodes for generating a current through said globule to produce a force on said globule by the interaction of said current with said magnetic field for moving said globule into contact with said second signal electrode.

2. The combination of claim 1 wherein the electrodes of said pair of control electrodes are mounted on opposite sides of said chamber with a gap between said control electrodes sufficiently small to restrict movement of said globule except when said globule is moved by said force resulting from the interaction of said switching current with said magnetic field.

3. The combination of claim 2 wherein said electrodes of said pair of control electrodes are mounted midway between said signal electrodes.

4. A switch comprising;
a switch housing containing a chamber;
means for generating a magnetic field within said chamber;
a pair of signal electrodes mounted in said chamber;
a nonmagnetic, liquid globule armature of a selected size located within said chamber in contact with one of said signal electrodes;
a pair of control electrodes mounted in said chamber a selected distance apart opposite each other and between said signal electrodes;

where said pair of control electrodes is always in contact with said armature;

means for applying a difference in potential between said control electrodes for generating a switching current flow in a selected direction through said armature;

where the force on said armature resulting from the interaction of said switching current and said magnetic field moves said armature between said control electrodes to change the state of said switch by putting said armature in contact with the other of said signal electrodes; and

where the distance of separation of said control electrodes is selected to sufficiently constrict the passageway between said control electrodes, used by said armature in moving into contact with the other of said signal electrodes, to maintain the new state of said switch after said difference in potential is removed.

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