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FLUID SWITCH

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Fig. 1.

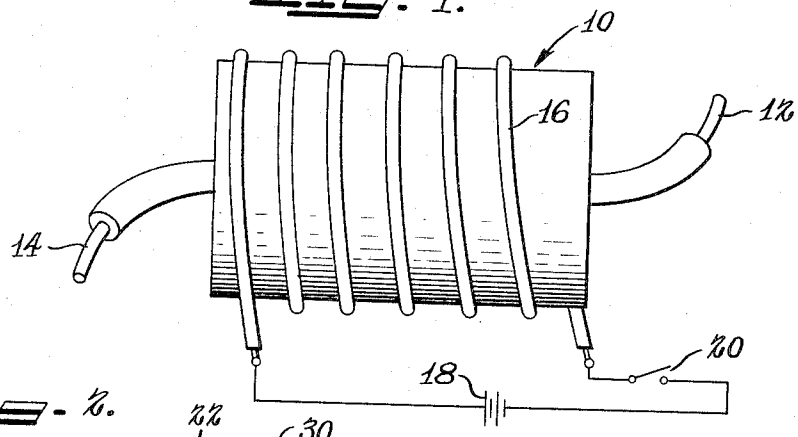


Fig. 2.

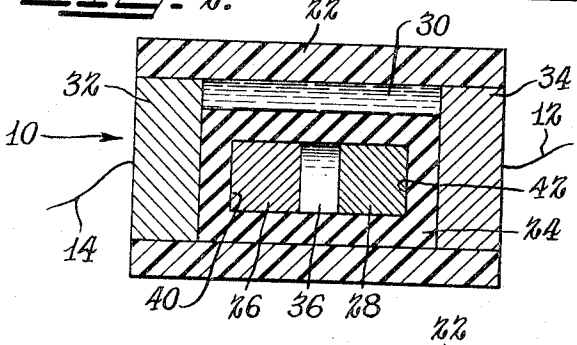
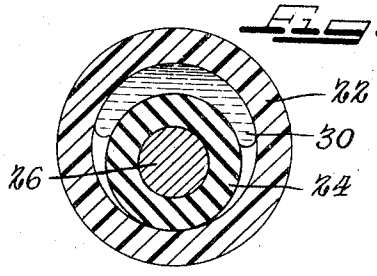


Fig. 3.



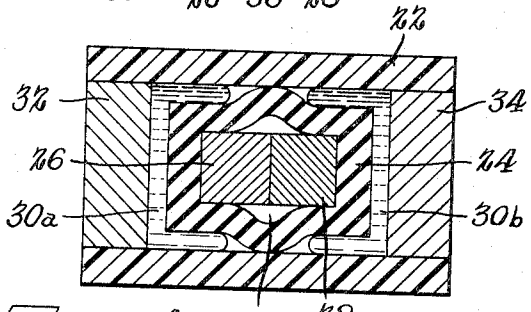


Fig. 4

Fig. 5.

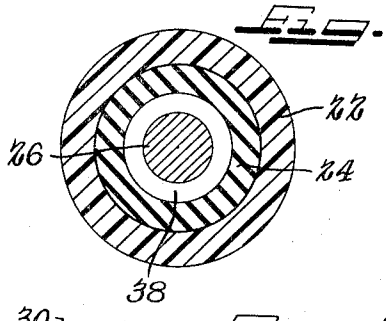


Fig. 14.

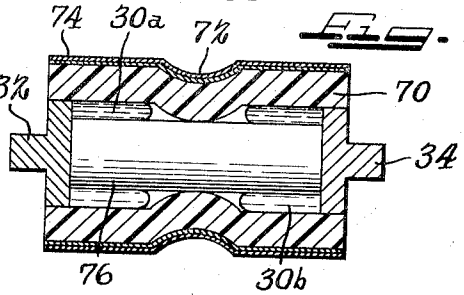
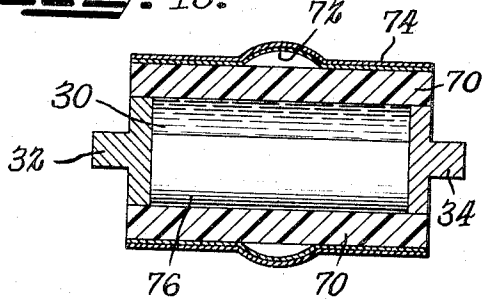


Fig. 13.



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Fig. 6.

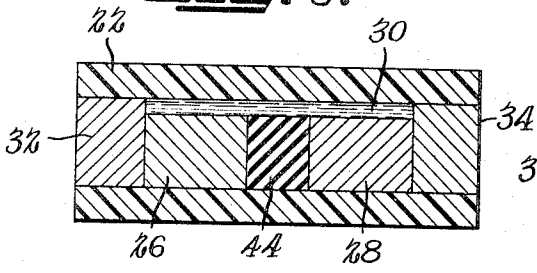


Fig. 7.

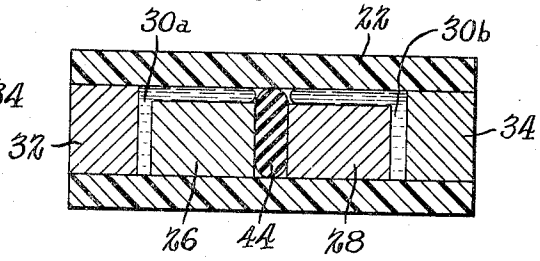


Fig. 8.

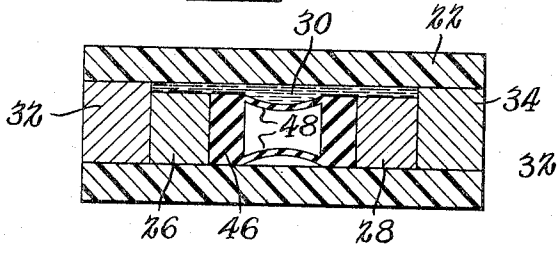


Fig. 9.

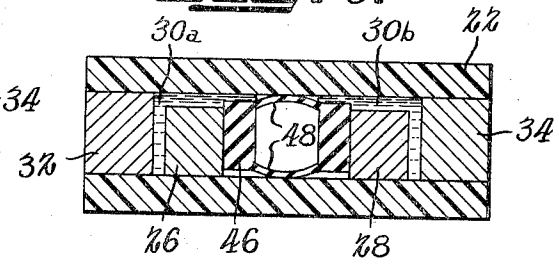


Fig. 10.

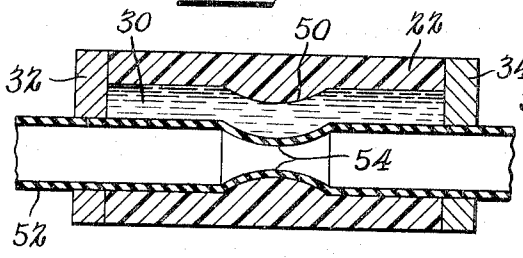


Fig. 11.

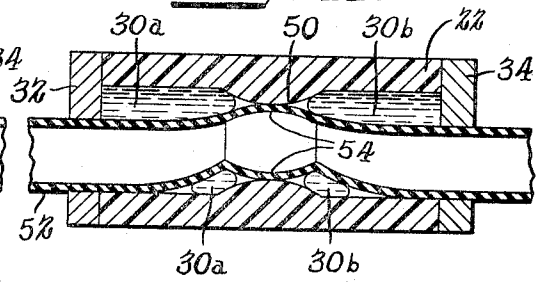
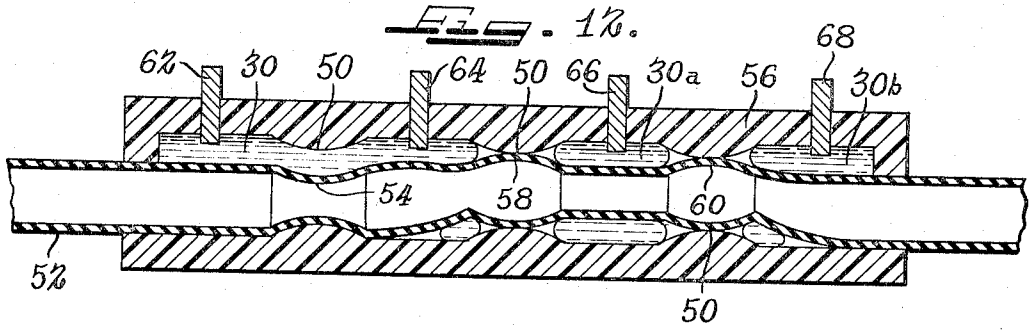


Fig. 12.



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Fig. 15.

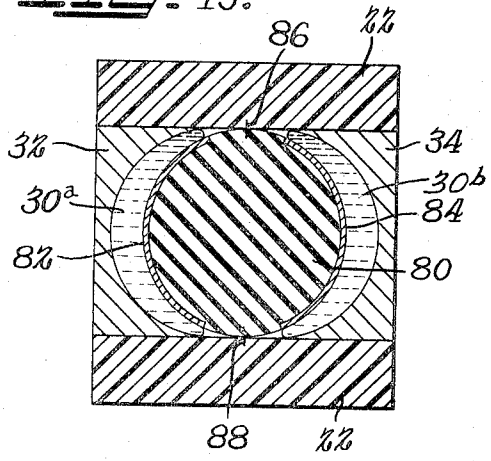


Fig. 16.

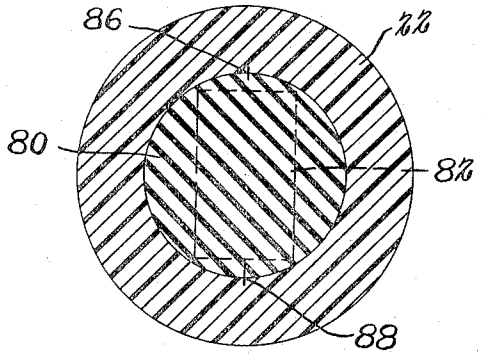


Fig. 17.

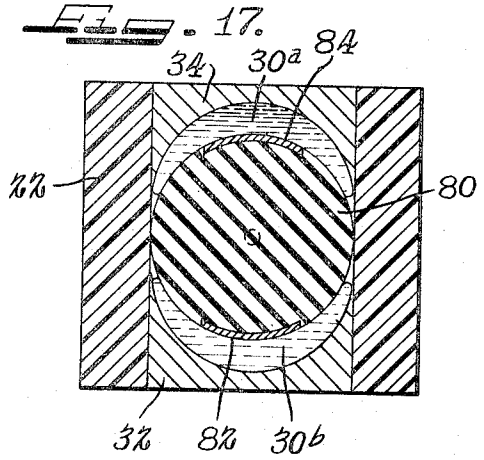


Fig. 18.

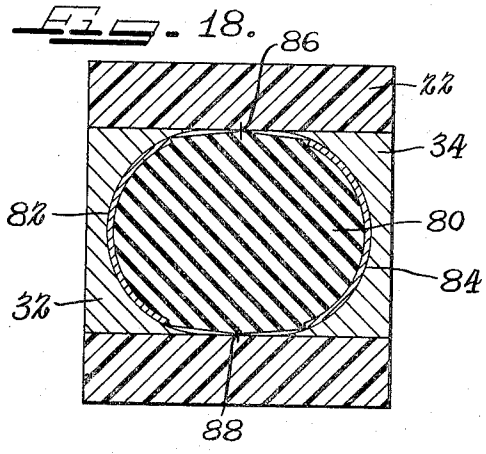


Fig. 19.

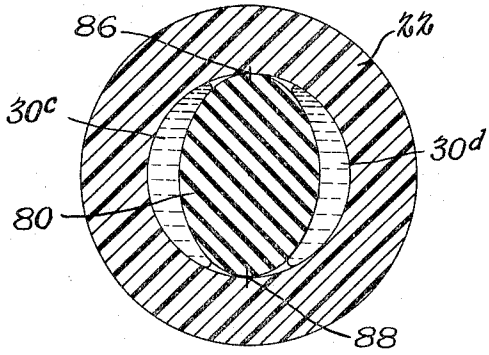
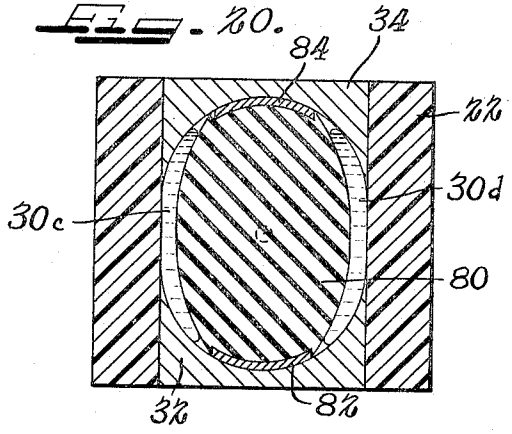


Fig. 20.



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United States Patent Office

3,341,676

Patented Sept. 12, 1967

3,341,676

FLUID SWITCH

Phillip L. Schwarz, Chicago, Ill., assignor to
Beltone Electronics Corporation

Filed Dec. 29, 1965, Ser. No. 517,342
11 Claims. (Cl. 200—152)

ABSTRACT OF THE DISCLOSURE

A fluid switch comprising a sealed, hollow container partially filled with an electrically conductive, non-wetting fluid. Spaced apart electrical terminals extend into the hollow interior of the container. An elastically deformable barrier constructed from an electrically insulating material is supported within the hollow container. Switch actuating means are employed for deforming the barrier to constrict a fluid passageway which normally provides a circuit path through the fluid between the terminals. Upon deformation of the barrier, the fluid is separated at the constriction into spaced apart physical segments, thereby opening the circuit path between the terminals.

This invention relates generally to an improved switch construction of opening and closing electrical circuits, and more particularly to a novel fluid switch construction characterized by the provision of a fluid enclosing container having an internal insulating barrier capable of being deformed sufficiently to cause the fluid to be physically separated into two or more segments to provide an electrical switching function.

Patent No. 3,177,327, which was granted on April 6, 1965 to Erwin M. Weiss discloses a fluid switch construction having a sealed, deformable container partially filled with an electrically conductive non-wetting fluid. One of the more important advantages of this prior fluid switch construction is its freedom from contact bounce or oscillation even at high switching rates. It is a general object of the present invention to provide such a no contact bounce type of fluid switch construction having an internal deformable insulating barrier for selectively separating the electrically conductive non-wetting fluid into spaced-apart segments to provide the desired switching action wherein said switching action is based upon the physical laws governing a three phase system, i.e., a relatively non-conducting fluid phase, a conducting fluid phase and a non-conducting solid phase.

It is a more specific object of this invention to provide a novel fluid switch having an internal deformable insulating barrier and an electrically conductive non-wetting fluid, and further defining and aperture through which said fluid is positioned to provide an electrical switch closing function, and in which said insulating barrier may selectively be deformed to alter said aperture so as to separate said fluid to provide an electrical switch opening function.

The novel features which are characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following description taken in conjunction with the accompanying drawings in which:

FIGURE 1 shows one illustrative embodiment of a fluid switch constructed in accordance with the invention and adapted to be magnetically actuated to provide switch opening and closing functions;

FIGURES 2, 3, 4 and 5 are cross-sectional views of one preferred embodiment of fluid switch constructed in accordance with the invention in which FIGURES 2 and 3 show the switch in its closed condition and FIGURES 4 and 5 show the manner in which the open circuit switching function is effected in response to the energization of the switch;

FIGURES 6 and 7 are cross-sectional views of another illustrative embodiment of the invention which includes a solid, deformable insulator between movable magnetic elements to provide the switching function in response to magnetic energization;

FIGURES 8 and 9 are cross-sectional views of still another embodiment of the invention which includes the provision of a hollow deformable, snap acting insulator between a pair of movable magnetic members, with FIGURE 8 showing the fluid switch in its unactuated closed circuit condition and FIGURE 9 showing the fluid switch in its actuated open circuit condition;

FIGURES 10 and 11 are cross-sectional views of still another illustrative embodiment of the invention which utilizes a hollow elastic tubular insulator extending through the switch housing to permit the switching action to be effected in response to a pressure differential within the hollow tubular insulator, with FIGURE 10 showing the fluid switch in its unactuated closing circuit condition and FIGURE 11 showing the fluid switch in its actuated open circuit condition;

FIGURE 12 is a cross-sectional view of the modification of the fluid switch shown in FIGURES 10 and 11 wherein the hollow tubular elastic insulator extending through the switch is provided with a plurality of actuatable portions to permit different selected switching actions in response to different pressure conditions within the tubular insulator;

FIGURES 13 and 14 are cross-sectional views of still another embodiment of the invention which utilizes a bimetal case to provide switching functions in response to temperature variations; and

FIGURES 15 through 20 are cross-sectional views of still another illustrative embodiment of the invention which utilizes a spherical deformable insulator between a pair of magnetic members in which FIGURES 15, 16 and 17 are different views of the switch in the unactuated closed circuit condition and FIGURES 18, 19, and 20 are different views of the switch in the actuated open circuit condition.

Referring now to the drawing, and more particularly to FIGURE 1 thereof, there is shown one illustrative embodiment of the invention wherein the switching function is effected by causing a magnetic field to be applied to the switch. The novel fluid switch of the illustrated invention is encased within a housing **10**, the internal details of which are further described with respect to the various remaining figures of the drawing. Advantageously, a first conductor **12** extends into one end of the switch housing **10**, and a second conductor **14** extends through the other end of the housing **10**, such that when the switch is in its unactuated condition, as described hereinbelow, a circuit path is completed between the conductors **12** and **14**. As some embodiments of the fluid switch are adapted to be actuated electromagnetically, the switch may have a coil of wire **16** positioned therearound and in circuit with a power source or battery **18** and a power switch **20**. Those skilled in the art will appreciate that when the power switch **20** is closed, current flows from the battery **18** through the coil of wire **16** to cause a magnetic field to be generated through the fluid switch housing **10**. In the operation of the present invention when the fluid switch is not energized, the conductors **12** and **14** normally are electrically connected to each other. Actuation of the fluid switch is initiated when the magnetic field is generated and is completed when the circuit path between the conductors **12** and **14** is broken providing the open circuit

switch function. Those skilled in the art will recognize that in this and other embodiments which require magnetic actuation, the magnetic field could be obtained by the use of a permanent magnet.

The manner in which the electrical switching function is effected by the embodiment of FIGURES 2 through 5 now will be described. As there shown, the switch housing **10** is comprised of a cylindrical enclosure **22** formed of a suitable electrical insulating material. The cylinder **22** is hollow and has its ends enclosed by the metallic electrodes **32** and **34**, respectively, so as to define a cylindrical opening therewithin. As illustrated in FIGURE 2, the electrode **32** is connected to the conductor **14** while electrode **34** is connected to the conductor **12** so as to permit the fluid switch to be connected into an electrical circuit, as desired.

In accordance with a feature of this invention, a pair of magnetic members **26** and **28** are positioned within an envelope **24** of deformable, visco-elastic material within the hollow interior of the housing **10**. The diameter of the envelope **24** is less than the diameter of the hollow opening within the switch housing **10** so as to permit the remaining space to be at least partially filled with an electrically conductive fluid **30**, such as mercury or the like. Advantageously, the deformable, visco-elastic envelope **24** may be formed of a chemically inert material such as silicone rubber. Each of the magnetic members **26** and **28** is secured to the deformable envelope **24** by a suitable adhesive, such as at the walls **40** and **42**. When the fluid switch is in its non-actuated condition, such as is illustrated in FIGURES 2 and 3 of the drawing, the magnetic members **26** and **28** are spaced from each other by an air gap **36**. In this condition, there is a complete electrical circuit path between the electrodes **32** and **34** by means of the electrically conductive fluid **30**. Thus, when the fluid switch of the present invention is in its unactuated condition, the switch provides a circuit closing function between the conductors **12** and **14**.

When a switching operation is desired, the coil **16** around the switch housing **10** is electrically energized to cause a magnetic field to be generated. This results in the movement of the magnetic members **26** and **28** towards each other so as to come into close proximity or abutment, as illustrated in FIGURES 4 and 5 of the drawing. Because the deformable envelope **24** is secured to the magnetic members **26** and **28**, its portions which are secured to the magnetic members are moved with the latter so as to cause the walls of the deformable envelope **24** to be spaced from the electrodes **32** and **34**. This movement of the deformable envelope **24** will cause its central portion to buckle outwardly in a radial fashion so as to provide an annular air space **38** between the magnetic members and the inner peripheral walls of the envelope **24**.

It will be appreciated by those skilled in the art that the outward buckling of the central portion of the deformable envelope **24** places the envelope into close proximity or contact with the inner peripheral walls of the cylinder **22** and serves to separate the electrically conductive fluid **30** into two spaced-apart segments designated **30***a* and **30***b* respectively. The movement of the deformable envelope **24** inwardly and away from the end electrodes **32** and **34** provides space for the electrically conductive fluid segments when the fluid has been separated into two separate and spaced-apart portions. It further will be appreciated by those skilled in the art that the separation of electrically conductive fluid into the two segments **30***a* and **30***b* serves to break the electrical circuit which had existed between the electrodes **32** and **34** so as to provide a switch opening function for the conductors **12** and **14**.

Due to the elasticity of the deformable envelope **24**, the removal of magnetic field from the switch will cause the two magnetic members **26** and **28** to return to their original position, as illustrated in FIGURES 2 and 3. This, in turn, permits the electrically conductive fluid **30** to extend continuously from one electrode of the switch

to the other. As such, the switch is again in the closed circuit condition until such time as the coil **16** is again electrically energized to provide another circuit switch opening function.

Another illustrative embodiment of the invention is shown in FIGURES 6 and 7 of the drawing. Like the embodiment of FIGURES 2 through 5, the embodiment of FIGURES 6 and 7 is adapted to be actuated magnetically to provide the electrical circuit opening and closing functions. However, in order to simplify the drawing and to facilitate the explanation of its construction and operation, this embodiment has been illustrated without showing the energizing coil or circuit conductors. However, where elements are similar to those previously shown and described, the same reference numerals have been utilized.

In the illustrative embodiment of FIGURES 6 and 7, the fluid switch is provided with a cylindrical housing **22** of electrical insulating material and a pair of metallic electrodes **32** and **34** respectively positioned at opposite ends of the cylinder **22** so as to define a hollow opening therewithin. Positioned within the hollow opening are a pair of movable magnetic elements **26** and **28** which are separated from each other by a deformable elastic insulator **44**. The magnetic elements **26** and **28** with their intermediate deformable insulator **44** do not completely fill the hollow opening within the cylinder **22** and the remainder of the space is at least partially filled by the electrically conductive fluid **30**, which may be mercury or the like, as explained hereinabove.

In the unactuated condition of this embodiment of the invention, the magnetic members **26** and **28** are held apart by the deformable insulator **44**, as illustrated in FIGURE 6 of the drawing. In this condition, the electrically and conductive fluid **30** extends continuously from the electrode **32** to the electrode **34**. This places the fluid switch in its closed circuit condition such that the conductors connected to these electrodes would be electrically connected to each other by means of the conductive fluid **30**. When the fluid switch is actuated, as by the provision of a magnetic field generated in the manners described heretofore, the magnetic elements **26** and **28** are urged towards each other against the resiliency of the deformable insulator **44**. Dependent upon the characteristics of the deformable insulator **44** and the strength of the magnetic field, the magnetic elements **26** and **28** will be moved towards each other to reduce the length of the deformable insulator **44** and, at the same time, to increase its diameter. When the upper and lower surfaces of the deformable insulator **44** come into close proximity or contact with the internal peripheral surface of the cylinder **22**, the electrically conductive fluid **30** will be separated into two separate segments respectively designated as **30***a* and **30***b* in FIGURE 7 of the drawing.

The movement of the magnetic elements **26** and **28** inwardly against the deformable insulator **44** provides a space between the magnetic elements and their respective electrodes to permit the electrically conductive fluid to be positioned therewithin. At this time, the closed circuit path between the electrodes **32** and **34** will be broken and the switch in its actuated condition will provide an open circuit function. When the energization of the coil is terminated to eliminate the magnetic field, the self-restoring resilient force of the deformable insulator **44** will cause the magnetic elements **26** and **28** to be moved back into their initial position as illustrated in FIGURE 6 of the drawing. As a result, the conductive fluid **30** will once more define a continuous electrical path between the electrodes **32** and **34** to again place the switch in the closed circuit condition.

A modification of the embodiment of FIGURES 6 and 7 is illustrated in FIGURES 8 and 9 of the drawing. This embodiment of the invention is similar to the previous embodiment in that it comprises a cylindrical insulating member **22** having the end electrodes **32** and **34** for de-

fining a hollow space therewithin. The hollow space is filled with a pair of spaced-apart magnetic elements **26** and **28** having a deformable insulator **46** therebetween, and the conductive fluid **30**. The deformable insulator **46** of this embodiment is similar to the deformable insulator **44** of the FIGURE 6 embodiment in that it serves normally to maintain the magnetic elements in their spaced-apart condition, but is compressed when the magnetic elements are moved together by the application of a magnetic field to separate the conductive fluid into two separate segments.

In accordance with the feature of this embodiment of the invention, the deformable insulator **46** is formed with a hollow center and a pair of arcuate upper and lower walls **48** which are thinner than the main side walls of the insulator. As shown in FIGURE 8 of the drawing, the thin upper and lower wall **48** of the deformable insulator **46** are curved inwardly towards each other so as to define a concave outer peripheral surface. At this time, the fluid switch is in its unactuated condition, with the magnetic elements **26** and **28** being spaced a maximum distance apart so that there is a continuous electrical circuit path between the electrodes **32** and **34** by means of the uninterrupted conductive fluid **30** which extends between the electrodes.

When the magnetic field is applied to the fluid switch to cause the magnetic elements **26** and **28** to be moved towards each other against the resiliency of the deformable insulator **46**, the pressure on the latter causes the relatively thin upper and lower walls **48** to be forced outwardly with a snap action to thereby provide a generally convex outer configuration. This is illustrated in FIGURE 9 of the drawing which shows the thin upper and lower walls **48** of the deformable insulator **46** in close contact or abutment with the internal peripheral surface of the cylinder **22** to thereby separate the electrically conductive fluid into two separate segments, **30***a* and **30***b* respectively.

Those skilled in the art will appreciate that the particular construction of this embodiment causes the fluid switch to go from a closed circuit to an open circuit condition with an instantaneous snap action such as is desirable in many applications. In the manner discussed above, the removal of the magnetic field from the fluid switch permits the deformable insulator to return to its initial condition with a snap action and once again to place the fluid switch in its closed circuit condition as shown in FIGURE 8 of the drawing.

The novel principles of the invention are equally applicable to a pressure responsive fluid switch wherein the circuit opening and closing functions may be effected in response to pressure changes in lieu of the application of a magnetic field to the switch. One illustrative embodiment of a pressure actuated fluid switch is illustrated in FIGURES 10 and 11 of the drawing. Advantageously, this embodiment of the switch comprises a cylinder **22** formed of suitable electrical insulating material which is closed at its ends by a pair of electrodes **32** and **34**. A tubular elastic insulator **52** is positioned through suitable apertures in the electrodes **32** and **34** so as to extend completely through the interior of the fluid switch housing. Advantageously, a convex rib or bead **50** may be provided on the internal peripheral surface of the insulated cylinder **22** at a position adjacent to a concave constriction **54** in the elastic insulated tube **52**.

As shown in FIGURE 10, the fluid switch is in its closed circuit condition with the electrically conductive fluid **30** extending in an uninterrupted fashion between the electrodes **32** and **34**. When the pressure of the fluid within the elastic tube **52** exceeds a predetermined amount, the constricted portion **54** will be caused to expand radially so as to place the outer peripheral surface of the elastic tube into close proximity or contact with the internal convex rib **50** of the insulated cylinder **22**. This causes the conductive fluid to be separated into two spaced-apart segments **30***a* and **30***b* to place the switch in the open circuit condition, as illustrated in FIGURE 11.

It will be appreciated by those skilled in the art that when the fluid pressure within the elastic tube **52** is reduced below the predetermined value, the constricted portion **54** will return to its initial concave condition, as illustrated in FIGURE 10, to again switch back to a closed circuit condition. In this manner, the fluid switch in this embodiment of the present invention provides a switching function in response to the fluid pressure within the elastic tube **52**. In the illustrative embodiment of FIGURES 10 and 11, the elastic tube **52** is shown to be open at both ends to permit the flow of fluid therethrough. As such, the fluid switch could be used to monitor the pressure in flowing fluids without disturbing the flow, and to provide a signal when a predetermined pressure level is reached or is no longer present. Manifestly, if desired, the elastic tube **52** need not be open at both ends but can be open at one end only if the switch is used to monitor static fluid pressure.

A further modification of the embodiment shown in FIGURES 10 and 11 is illustrated in FIGURE 12 of the drawing. As there shown, the fluid switch comprises a closed hollow cylinder **56** formed of suitable rigid, electrical insulating material. An elastic tube **52** extends through the end walls and the interior of the cylinder **56**. Advantageously, the elastic tube is made hollow to permit the flow of fluids therethrough. In accordance with a feature of this invention, the plurality of constrictions capable of radial expansion is provided at spaced points along the elastic tube **52** within the cylinder **56**. Further, a plurality of electrodes are inserted through the tubular wall of the cylinder **56** so as to be in contact with the electrically conductive fluid **30** within the internal hollow portion of the cylinder **56**. Preferably, the electrodes are spaced along the cylinder **56** such that a pair of electrodes straddle each constriction of elastic tube **52**.

Thus, the electrodes **62** and **64** are positioned on opposite sides of the elastic tube portion **54**, the electrodes **64** and **66** are positioned on opposite sides of the elastic tube portion **58**, and the electrodes **66** and **68** are positioned on opposite sides of the elastic tube portion **60**. Those skilled in the art will appreciate that the principles of the present invention are not limited to the specific embodiment illustrated in FIGURE 12 but that the number of electrodes and constricted portions may be multiplied as desired in accordance with the specific use to which the invention is put. Also, it will be seen in FIGURE 12 that an arcuate rib or bead **50** may be provided on the internal peripheral surface of the cylinder **56** adjacent each of the constricted portions of the elastic tube **52** and between each pair of adjacent electrodes. The remaining space between the elastic tube **52** and the internal peripheral walls of the cylinder **56** is at least partially filled with a suitable electrically conductive fluid **30**, which, as explained heretofore, may be mercury or the like.

In the operation of this embodiment of the invention, each of the constricted portions of elastic tube **52** may be formed to expand radially at a selected fluid pressure into close proximity or abutting contact with its associated rib **50** of the cylinder. As illustrated in FIGURE 12, the fluid pressure within the elastic tube **52** has attained a value sufficient to radially expand the portions **58** and **60**, while it is not yet high enough to cause the constricted portion **54** to be radially expanded. As such, the conductive fluid between electrodes **64** and **66** has been separated into two spaced-apart segments **30** and **30***a*, and in addition the radial expansion of the tube portion **60** into close proximity or abutting contact with the arcuate rib **50** of cylinder **56** has separated the electrically conductive fluid between electrodes **66** and **68** into two spaced-apart segments **30***a* and **30***b*, respectively.

It will be appreciated that under the conditions shown

in FIGURE 12, a complete electrical circuit path exists between electrodes **62** and **64**, but that the electrical circuit is open between electrodes **66** and **68**. Accordingly, the embodiment of FIGURE 12 represents a plurality of fluid pressure actuated switching devices capable of operation at different fluid pressure levels, and further capable of providing electrical output signals to indicate when these levels have been attained. The electrical output of this embodiment can be made digital in accordance with known practices familiar with those skilled in the electrical arts.

Still another illustrative embodiment of the present invention which provides fluid switching action in response to temperature changes is shown in FIGURES 13 and 14 of the drawing. As there illustrated, the fluid switch comprises an elastic insulator **70** which, together with the end electrodes **32** and **34** form a hollow housing. Within the interior of the hollow housing, there is placed a solid insulator member **76** and an electrically conductive fluid **30**. A case **74** formed of a suitable bimetal assembly is positioned around the outer surface of the elastic insulator **70**. Advantageously, the bimetal case **74** is provided with a convex arcuate portion which, during the non-actuated condition of the fluid switch, is radially bowed out so as to be spaced from the elastic insulator **70**.

The switch in its non-actuated condition is shown in FIGURE 13 of the drawing. At this time, the elastic insulator **70** is not depressed by the bimetal case **74** and the electrically conductive fluid **30** extends in an uninterrupted fashion between the electrodes **32** and **34** so as to complete a circuit path therebetween. Thus, the fluid switch shown in FIGURE 13 is in the closed circuit condition.

When the temperature reaches the level that causes the arcuate portion **72** in the bimetal case to snap inwardly, the fluid switch changes from a closed circuit to an open circuit condition. This is illustrated in FIGURE 14 of the drawing. As there shown, the inward flexing of the arcuate portion **72** of the bimetal case **74** in response to temperature change causes the elastic insulator **70** to be flexed inwardly so as to abut the solid insulator **76** within the switch housing. This causes the electrically conductive fluid therewithin to be separated into two spaced apart segments **30***a* and **30***b* which results in opening the electrical circuit path between electrodes **32** and **34**. It will be appreciated that when the temperature returns to its initial value, the arcuate portion **72** of the bimetal case **74** will snap back to the position shown in FIGURE 13 of the drawing so as to close the electrical circuit path between electrodes **32** and **34**.

It also will be appreciated that the electrodes **32** and **34** need not be located at opposite ends of the switch housing as illustrated in FIGURES 13 and 14 of the drawing. If desired, connection to one of the electrodes could be made through the solid insulator member **76** or elastic insulator **70** to permit both electrical leads to be positioned through the same end of the fluid switch housing and to permit the bimetal case **74** to completely enclose the elastic insulator **70**. This would provide for protection of the fluid switch as well as allowing it to be immersed in the environment whose temperature will actuate the switch to its open and closed circuit conditions.

Still another embodiment of the present invention which takes advantage of the novel principles disclosed herein is shown in FIGURES 15 through 20 of drawing. In this embodiment, the deformable insulator for separating the conductive fluid into two separate and spaced-apart segments in response to the switch actuation has a generally spherical form. As shown particularly in FIGURES 15, 16 and 17, the fluid switch comprises a housing formed of cylinder **22** of rigid, electrical insulating material having open ends enclosed by the electrodes **32** and **34** so as to define a hollow opening therein. The spherical elastic or deformable insulator **80** within this opening is affixed at the points **86** and **88** to the internal peripheral surface of cylinder **22**. Advantageously, the radii of the spherical deformable insulator **80** is substantially the same as the internal radii of electrodes **32** and **34**.

In the unactuated condition of the switch, as illustrated in FIGURES 15, 16 and 17, the deformable insulator **80** is spaced from the electrodes **32** and **34** so as to define a space therebetween for the electrically conductive fluid **30**, such as mercury or the like. In addition, each side of the spherical deformable insulator **80**, opposite the respective electrodes **32** and **34**, has a sheet of magnetic material bonded thereto. Thus, as shown in the drawing, the sheet of magnetic material **82** is bonded to one side of the spherical insulator **80** opposite the electrode **32** while the sheet of magnetic material **84** is bonded to the side of the spherical insulator **80** opposite the electrode **34**. Each electrode is formed of magnetic material so as to be attracted to its associated sheet of magnetic material when a magnetic field is applied to the switch.

In the unactuated condition of the switch, as illustrated in FIGURES 15, 16 and 17, the electrically conductive fluid **30** is separated by the spherical insulator into spaced-apart segments **30***a* and **30***b*. Because of the separation, there is no circuit path between electrodes **32** and **34** and the fluid switch is in its open circuit condition. When a magnetic field is applied to the fluid switch, such as by an energized coil or the like, the attraction between each electrode and its associated sheet of magnetic material will cause the deformable insulator **80** to become distended, in a direction perpendicular to a plane containing the fixed points, **86** and **88**, that same plane being parallel to the plane of FIGURE 19 until the sheets of magnetic material are placed into close proximity or abutting contact with their associated electrodes. This is illustrated in FIGURES 18, 19 and 20 of the drawing and it can be seen that the result of this action is to cause the electrically conductive fluid **30** to be separated into two spaced-apart segments **30***c* and **30***d*, each of these segments completing a circuit path between electrodes **32** and **34** so as to place the switch in the closed circuit condition.

While a number of embodiments of the present invention has been shown and described in the present application to illustrate its novel principles fully, those skilled in the art will appreciate that the present fluid switch generally is characterized by an internal, deformable, insulating barrier and an electrically conductive fluid which is adapted to be positioned in an aperture to provide an electrical switching function when the size of the aperture is varied pursuant to a selected switch controlling force. As described in detail herein, it is a feature of the present invention that the aperture size be varied by selectively deforming the insulating barrier so as to separate the conductive fluid into two separate, spaced-apart segments when a switch opening function is desired, and to permit the conductive fluid to provide to a single, uninterrupted circuit path between the switch electrodes when a switch closing function is desired.

While there has been shown and described a specific embodiment of the present invention it will, of course, be understood that various modifications and alternative constructions may be made without departing from the true spirit and scope of the invention. Therefore, it is intended by the appended claims to cover all such modifications and alternative constructions as fall within their true spirit and scope.

What is claimed as the invention is:

1. The improvement of a fluid switch construction comprising the combination of a sealed substantially non-deformable hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a barrier of deformable, electrically insulating

material positioned within said hollow container, said barrier defining at least one aperture through which said fluid is positioned, and selectively operable means for deforming said barrier to cause said aperture to be altered for separating said fluid into separate, spaced-apart segments to thereby open said closed electrical circuit path between the electrical terminals.

2. The improvement of a fluid switch construction in accordance with claim 1 wherein said barrier is formed of a visco-elastic material.

3. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a barrier of deformable, electrically insulating material supported within said hollow container, said barrier defining at least one aperture through which said fluid is positioned, and selectively operable means for deforming said barrier to cause said aperture to be altered for separating said fluid into separate, spaced-apart segments to thereby open said normally closed electrical circuit path between the electrical terminals, said selectively operable means comprising a pair of spaced-apart, magnetic elements respectively positioned on opposite sides of said barrier, and means for generating a magnetic field through the switch to cause said magnetic elements to be moved toward each other to deform said barrier.

4. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a barrier of deformable, electrically insulating material supported within said hollow container, said barrier defining at least one aperture through which said fluid is positioned, and selectively operable means for deforming said barrier to cause said aperture to be altered for separating said fluid into separate, spaced-apart segments to thereby open said closed electrical circuit path between the electrical terminals, said barrier comprising a closed, hollow envelope having a pair of spaced-apart magnetic elements positioned on opposite sides of said envelope and magnetic field generating means for creating a distorting force between said magnetic elements.

5. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a barrier of deformable, electrically insulating material supported within said hollow container, said barrier defining at least one aperture through which said fluid is positioned, said barrier comprising a closed, hollow-envelope having a pair of spaced-apart arcuate walls capable of expanding outwardly with a snap action when said barrier is deformed, and selectively operable means for deforming said barrier to cause said arcuate walls to expand outwardly with a snap action to alter said aperture for separating said fluid into separate, spaced-apart segments to thereby open said closed electrical circuit path between the electrical terminals.

6. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a barrier of deformable, electrically insulating material supported within said hollow container, said barrier defining at least one aperture through which said fluid is positioned, said barrier comprising a hollow tube extending through said switches and having a portion capable of radial expansion in response to the fluid pressure within the tube attaining a predetermined level, the radial expansion of said tube causing said portion to be placed into close proximity or abutment with the inner surface of the container to alter said aperture for separating said fluid into separate, spaced-apart segments to thereby open said closed electrical circuit path between the electrical terminals.

7. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a hollow tube of deformable, electrically insulating material extending through said hollow container, said tube and said container defining therebetween a plurality of apertures through which said fluid is positioned, said tube having a plurality of radially expandable portions capable of expanding into close proximity or abutment with said container at different levels of fluid pressure within said tube for separating said fluid into separate, spaced-apart segments, and a pair of electrical terminals associated with each radially expandable portion extending through said container into said fluid whereby the closed electrical circuit path between any pair of terminals is opened when its associated radially expandable portion is expanded by fluid pressure within the tube to separate the fluid thereat into separate, spaced-apart segments.

8. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals so as to provide a closed electrical circuit path between said terminals, a portion of said container comprising a barrier of deformable, electrically insulating material, said barrier defining at least one aperture through which said fluid is positioned, a casing of bimetal material around said barrier of deformable, electrically insulating material and operable means for deforming said barrier in response to temperature to cause said aperture to be altered for separating said fluid into separate, spaced-apart segments to thereby open said closed electrical circuit path between the electrical terminals.

9. The improvement of a fluid switch construction in accordance with claim 8 wherein said casing of bimetal material is formed with an outwardly extending arcuate portion to cause said deformable barrier to be deformed with a snap action in response to switch reaching the operating temperature of the bimetal.

10. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals, a spherical barrier of deformable, electrically insulating material supported within said hollow container, said spherical barrier defining at least one aperture within which said fluid is positioned, and selectively operable means for deforming said spherical barrier to cause said aperture to be altered for separating said fluid into separate, spaced-apart segments to thereby switch the

condition of the electrical circuit path between the electrical terminals.

11. The improvement of a fluid switch construction comprising the combination of a sealed hollow container, a plurality of electrical terminals spaced from each other and extending into said container, an electrically conductive non-wetting fluid partially filling the interior hollow portion of said container and in contact with said electrical terminals, a spherical barrier of deformable, electrically insulating material supported within said hollow container, said spherical barrier defining at least one aperture within which said fluid is positioned, and selectively operable means for deforming said spherical barrier to cause said aperture to be altered for separating said fluid into separate, spaced-apart segments to thereby switch the condition of the electrical circuit path between the electrical terminals, said selectively operable means comprising a pair of magnetic elements respectively secured to opposite sides of said spherical barrier for causing the latter to be deformed when the switch is within a magnetic field capable of causing said magnetic elements to be moved relative to each other.

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