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MERCURY SWITCH

Filed June 1, 1961

FIG. 1.

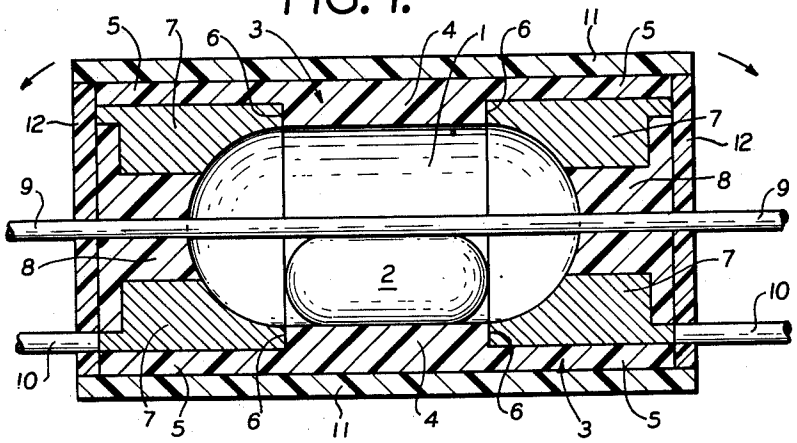
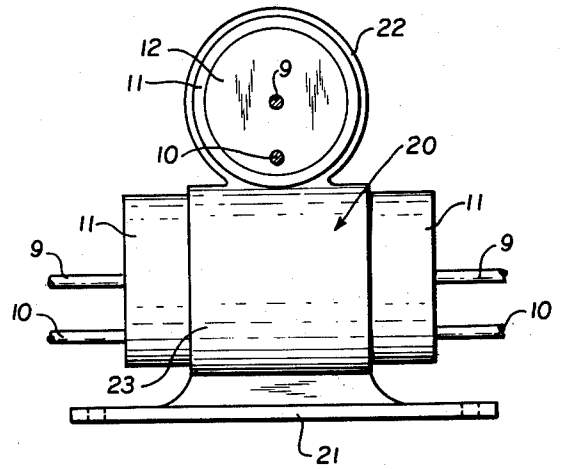


FIG. 2.



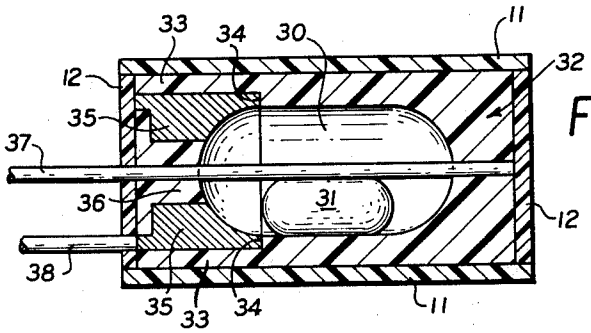


FIG. 3.

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MERCURY SWITCH

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This invention relates to tilt-sensitive switches.

The general object of the invention is to provide a novel and extremely rugged tilt-sensitive switch, the tendency of which to arc is greatly reduced even at high altitudes, and the sensitivity of which to tilt may be made, if desired, such that the switch will make contact if it is tilted however slightly from a particular position with respect to verticality and horizontality. In short, the invention contemplates a tilt-sensitive switch, as described above, which may be adapted for detecting any vertical and horizontal change of position from the slightest to one that is quite considerable. Within the purview of the invention the switch may be modified to serve as an extremely delicate gravity-sensing device or to function like any other toggle switch, but however modified with respect to sensitivity, providing novel features of ruggedness and greatly reduced tendency to arc.

A particular object of the invention is to provide a tilt-sensitive or toggle switch in which contact is made and broken in response to the force of gravity acting upon a globule of mercury and in which not only is the material of the electrodes inert chemically with respect to mercury, but the insulating parts of the switch, instead of being made of glass, in usual manner, are of a tough plastic similarly inert to mercury. Thus a significant feature of the switch is that it may be used in many applications in which the common glass-shelled mercury switch would be subject to fracture, as, for example, in locations wherein severe shock and vibration are to be expected. Another feature of the present switch is that, being encased in a tough plastic instead of glass, shock absorbing characteristics of mounting means may be substantially disregarded and the means therefore simplified.

Another object of the invention is to provide a switch as described above in which arcing is greatly reduced even at high altitudes, a feature which is accomplished by causing the globule of mercury to remain permanently in contact with one electrode, by so shaping the other electrode or electrodes, as the modification may require, whereby only a smooth concave surface is available for contact by the convex surface of the globule of mercury and by sealing the switch with air therein at normal atmospheric pressure. Thus the present switch renders arcing between the mercury and one electrode always impossible and avoids the usual arc-favoring point contact in the electrode or electrodes with which the globule of mercury makes and breaks contact; and, since air within the switch is equivalent to normal atmosphere, arcing and corona are not promoted at high altitudes.

A further object of the invention is to produce such a tilt-sensitive switch adapted to make contact when tilted from a particular position however slightly in either of two opposite directions, and which, rigidly mounted in association with a like switch at right angles thereto, with both switches normally having like relationships to verticality and horizontality, forms part of a device for detecting a tilt, however slight, in any direction whatever, and for signaling such tilt by completing a circuit.

A further object is to provide a tilt-sensitive switch, the insulating parts of which are of plastic and in which a globule of mercury is contained, the electrodes are accessible thereto, and contact is made and broken within a smooth-walled chamber of intermediate cylindrical shape with concave and preferably hemispherical ends; and in

which one electrode is a bar extending axially through the chamber and being in permanent contact with the globule of mercury, and another electrode is an annular part of one of the concave ends of the chamber surrounding but out of electrical engagement with the first-named electrode. Where the switch is modified for use as a detector of tilt in either of two opposite directions, another electrode, as last described above, is also present at the other end of the chamber; and, plainly, the only position in which contact is broken is that in which the chamber is horizontally disposed and the globule of mercury is resting upon the lower part of the intermediate cylindrical portion of the chamber. In connection with this object the invention contemplates a tilt-sensitive switch that is externally a cylinder coaxial with the chamber described above and with the electrodes accessible for the connection of leads either at one or both ends of the cylinder. Further, the cylindrically shaped switch is preferably encased in a plastic protective tube, slightly longer than the switch itself, with the switch sealed within the tube by plugs of potting compound. An epoxy resin is highly suitable for the tube and the compound. The ease with which the cylindrical unit may be mounted is obvious.

These and other objects, features, and advantages of the invention will be more fully understood from the following description and from the drawing, in which

FIG. 1 is an axial section of one form of the invention, this embodiment being a double-throw switch which is in off position only when its axis is horizontally disposed, as shown, and in which contact is made in response to the slightest longitudinal tilt in either of two opposite directions;

FIG. 2 is an elevational view of a structure comprising, as a unit, a frame rigidly supporting two of the switches of FIG. 1, one above the other, and with their axes horizontally disposed and at right angles to each other; and

FIG. 3 is an axial section of another form of the invention, this embodiment being a single throw switch in which contact is made only in response to a tilt in a single longitudinal direction, i.e., to the left in the figure.

By preference, and not in limitation of the invention, and to facilitate high speed production, embodiments of the present tilt-sensitive switch shown and described herein are of cylindrical external shape and all fabricated parts are of circular cross-section; and electrical connections are to be made either at one or both ends of the switch.

FIG. 1 shows, in axial cross-section, a double throw switch built according to the invention and with its axis horizontally disposed. This figure, being a longitudinal section taken on the axis of a cylinder and various fabricated parts of circular cross-section, clearly shows the far half of the coaxial switch chamber **1**, which is seen to be about twice as long as its diameter, intermediately cylindrical intermediate wall of chamber **1**, is, as shown, The globule of mercury **2**, not in section, is seen to be resting on the lowest disposed portion of the cylindrical wall of the chamber. The switch chamber **1**, which is a particularly novel feature of the invention, is smoothly walled by several specially fabricated parts. The cylindrical intermediate wall of the chamber is provided by the approximate middle third of a hollow cylindrical shell **3** (arrow) of plastic chemically inert to mercury, such as polytetrafluoroethylene ("Teflon"). The thickness of the midportion **4** of the wall of shell **3**, which is also the cylindrical intermediate wall of chamber **1**, is, as shown, greater than the end portions **5** of the wall of the shell; and at either end of midportion **4**, within the shell, there is provided an annular shoulder **6**. Securely fitted into each end portion **5** of the shell, and abutting a shoulder **6**, is an annular electrode **7** of a metal chemically inert with respect to mercury, such as tungsten. Each elec-

trode 7 is securely plugged by an insert 8, preferably composed of the same plastic as that of shell 1. The inner ends of each electrode 7 and its insert 8 are together turned or otherwise formed to provide a smooth concave (here, hemispherical) end wall for the chamber 1, as shown. Another electrode 9, preferably a round bar of the same material as that of electrodes 7, extends not only completely and coaxially through chamber 1, in permanent contact with the globule of mercury 2 without respect to the horizontality of the axis of the switch, but also through the entire switch structure; and electrode 9 is rigidly cemented to the plugs or inserts 8 through which it passes, and is accessible outside each end of the switch for the purpose of connecting a lead. Suitably secured to the periphery of the outer end of each annular electrode 7 is a lead 10.

The structure so far described is a complete double-throw tilt-sensitive mercury switch, but it is desired that the structure be provided with a protective plastic housing. For this reason the structure is encased within an open-ended plastic shell 11, preferably of epoxy resin, slightly longer than the structure; and the latter is sealed within the shell 11 at each end thereof perferably by a plug 12 of epoxy resin potting compound. Accordingly the finished product is rugged and compact, and capable of withstanding considerable shock, as well as being moisture-proof.

From the foregoing several novel features will be apparent. The most important, perhaps, is the avoidance of any use of glass, and the substitution therefor in the insulating portions of the switch of a tough plastic inert, like glass to mercury. The globule of mercury is always in contact with one electrode, i.e. the axial electrode 9, without respect to the disposition of the switch. When the globule of mercury contracts either one of the annular electrodes 7 as a result of tilting the switch so that its axis is no longer horizontal, and subsequently rolls out of contact with an electrode 7 when the axis of the switch resumes horizontality, the smooth concave surface of the electrode 7 and the smooth rotund surface of the globule of mercury greatly minimizes the tendency to arc. Arcing in mercury tilt switches is, of course, promoted by the presence of pointed electrodes, which, in the present switch, are avoided. The chemical inertness of the plastic portions of the wall of the switching chamber and of the electrodes with respect to mercury precludes the introduction into the chamber of extraneous matter. Also, since, because of the greatly reduced tendency of the switch to arc, it is not necessary to evacuate air from the chamber 1 during assembly; and, as the air is sealed within the chamber at normal atmospheric pressure, use of the switch at high altitude will not promote arcing or corona.

The double-throw switch shown in FIG. 1 is exemplary of the most sensitive device that can be built according to the invention for detecting and signaling tilt in eiher of two directions, as indicated by the arrows to the left and right at the top of the figure. The switch of FIG. 1 is in the "off" position only when its axis is horizontally disposed, as in the drawing. In this position the globule of mercury naturally centers itself upon the lowest part of the intermediate cylindrical mid portion 4 of the wall of shell 3, which, of course, is non-conductive. However, as always, the globule is in contact with the axial electrode 9. Any tilt of the switch in the direction of either arrow in the drawing will cause the globule to roll, without detaching itself from electrode 9, to one or the other end of chamber 1 and into contact with one of the electrodes 7, thus completing the circuit. In theory the switch could be completely rotated on its axis with the latter maintained horizontal, or shifted gently in a horizontal direction, without causing the globule of mercury to roll toward either end of chamber 1; but plainly any tilting movement will instantly close the switch. Therefore, two double-throw switches, constructed as described above and as shown in FIG. 1, rigidly connected together with their axes disposed at right angles to each other and both axes normally horizontal, would provide an extremely sensitive means for detecting and signaling tilt in any angular direction.

The last described means are shown in the embodiment illustrated in FIG. 2, which is an elevation view of a unitary frame 20 (arrow), which may be of plastic, having a base 21, whereby it may be conveniently mounted on, say, a normally horizontal surface, and two sleeves 22 and 23, rigidly connected together and to the base, with sleeve 22 above sleeve 23, and with the axes of the sleeves at right angles to each other and parallel to the base. Securely held within each sleeve is a double-throw switch as illustrated in FIG. 1. Necessarily the axes of the two switches are at right angles to each other and parallel to each other and to the base 21. The entire structure shown in FIG. 2 is a rigid unit, and if the base 21 is mounted on a normally horizontal surface, incidental tilt in any angular direction of which is desired to be detected and signaled, any such tilt will effect closing one or both of the switches depending upon the direction of tilt.

The device illustrated in FIG. 2 is therefore exemplary of the most sensitive device that can be built according to the invention for detecting and signaling tilt in any angular direction; and it is therefore a most reliable device for checking verticality. In FIG. 2 indexed parts of the switches are designated by the reference numerals of FIG. 1.

FIG. 3 is an axial section of another form of the invention, this embodiment being a single throw switch with its axis horizontally disposed. This figure, like FIG. 1, being a longitudinal section taken along the axis of a cylinder and various fabricated parts of circular cross-section, clearly shows the far half of the coaxial switch chamber 30, which is shaped exactly like chamber 1 but is of different wall construction. The globule of mercury 31, not in section, is seen to be resting on the lowest disposed portion of the cylindrical wall of chamber 30. It will be noted in the drawing that the left hand half of the switch of FIG. 3 is an exact copy of the left hand half of the double-throw switch of FIG. 1, but that no annular electrode equivalent to 7 or any plastic insert equivalent to 8 is provided at the right hand side of the single-throw switch. The cylindrical intermediate portion and the entire concave right hand end of chamber 30 is here formed by turning, say, or otherwise working from one end (here, the left hand end) of a plastic cylinder 32, preferably of polytetrafluoroethylene ("Teflon"). Also produced by working the cylinder 32 is, to the left, an end position 33 (equivalent to 5) and an annular shoulder 34 (equivalent to 6); and securely fitted into end portion 33 of cylinder 32, and abutting shoulder 34, is an annular electrode 35 (exactly like an electrode 7). Electrode 35 is securely plugged by an insert 36 (exactly like an insert 8). Another electrode 37, functionally equivalent to electrode 9, extends co-axially completely through the switch of FIG. 3, but does not continue, like electrode 9, through the right hand plug of the housing of the switch. However electrode 37 is accessible outside the single-throw switch to the left. Electrode 37 is always in contact with the globule of mercury 31 within chamber 30. Suitably secured to the periphery of the outer end of electrode 35 is a lead 38.

The single-throw switch of FIG. 3, like the double-throw switch of FIG. 1, is securely encased in an open-ended hollow plastic cylinder 11, which is slightly longer than the cylinder 32; and the entire switch structure is sealed within cylinder 11 at each end by a potting compound plug 12.

The features of ruggedness mentioned above with respect to the switch of FIG. 1 apply also to the switch of FIG. 3, as do the features of minimization of arcing. Plainly the single-throw switch of FIG. 3, while it could be used as a highly sensitive device for detecting and

signaling tilt in a single direction (for example, to the left, in FIG. 3), is also suitable for use where any glass encased mercury toggle switch might be used, as well as in many applications where in the likelihood of considerable shock and vibration would render the use of a glass-encased switch impracticable.

The single-throw tilt-sensitive switch of FIG. 3 literally can be tilted or rotated through 180° without making contact; therefore it can be turned through another half cycle without breaking contact. The switch is therefore of wide utility.

The amperage rating of a switch built according to the present invention is obviously a function of the size of parts.

I claim:

1. In a tilt-sensitive switch, an elongated plastic-walled chamber of circular cross-section, both ends thereof being sealed with at least one end sealed by a plug having a concave surface facing the chamber, the plug comprising an annular electrode surrounding a plastic insert; another electrode extending through the insert and coaxially through the chamber; and a globule of mercury within the chamber out of contact with the annular electrode unless the chamber is tilted toward that electrode, and invariably in contact with the other electrode.

2. A tilt-sensitive switch according to claim 1, wherein

both the plastic parts and the electrodes are chemically inert to mercury.

3. A tilt-sensitive switch according to claim 1, wherein the plastic parts are made of polytetrafluoroethylene.

4. A tilt-sensitive switch according to claim 1, wherein both electrodes are of tungsten.

5. A tilt-sensitive switch according to claim 1, wherein both electrodes are of nickel-iron alloy.

6. A tilt-sensitive switch according to claim 1, wherein air at one atmosphere is sealed within the chamber.

7. A tilt-sensitive switch according to claim 1, wherein the electrode extending through the chamber is of circular cross-section.

8. A tilt-sensitive switch according to claim 1, in combination with an epoxy resin housing enclosing the switch without rendering the electrodes externally inaccessible for the connection of leads.

9. A tilt-sensitive switch according to claim 1 in combination with a housing of electrically non-conductive material enclosing the switch without rendering the electrodes inaccessible for the connection of leads.

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