Feb. 18, 1941. H. T. OLSON 2,232,626

ELECTRIC SWITCH

Filed Oct. 7, 1937 2 Sheets-Sheet 1

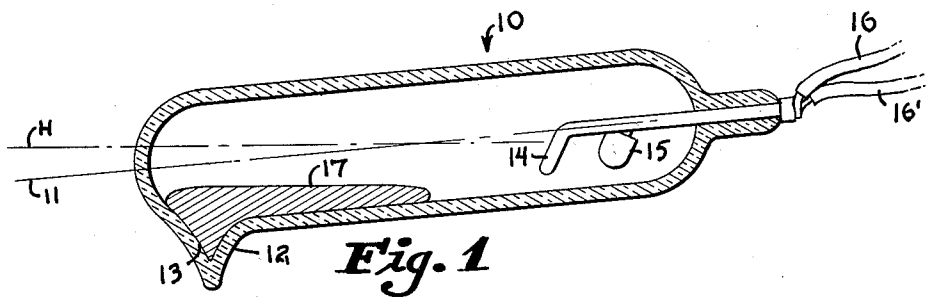

Fig. 1

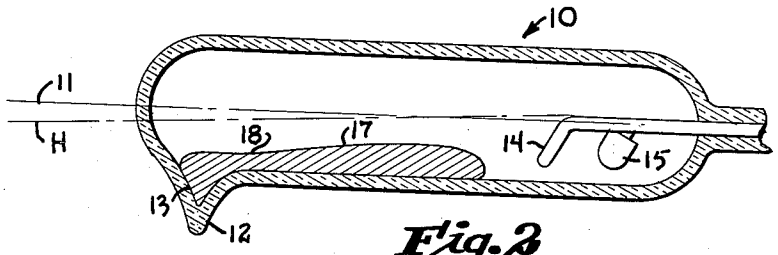

Fig. 2

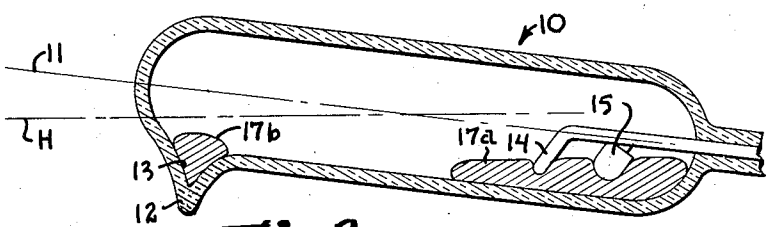

Fig. 3

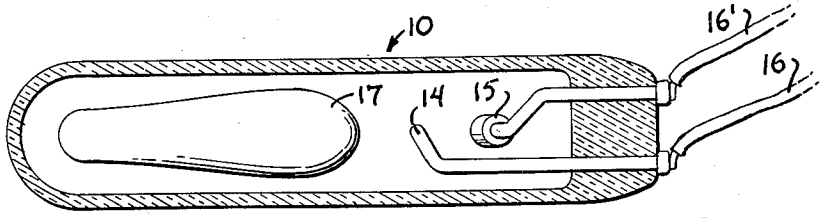

Fig. 4

Inventor

Harold T. Olson

By George H Fisher

Attorney

Feb. 18, 1941. H. T. OLSON 2,232,626

ELECTRIC SWITCH

Filed Oct. 7, 1937 2 Sheets-Sheet 2

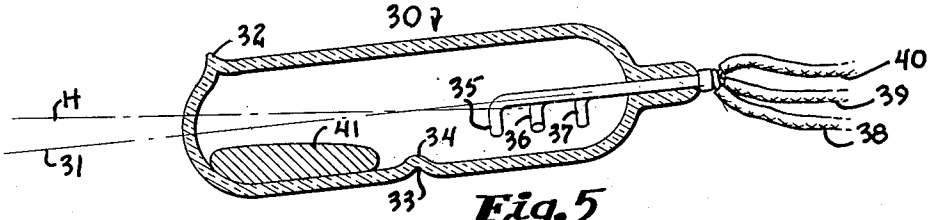

Fig. 5

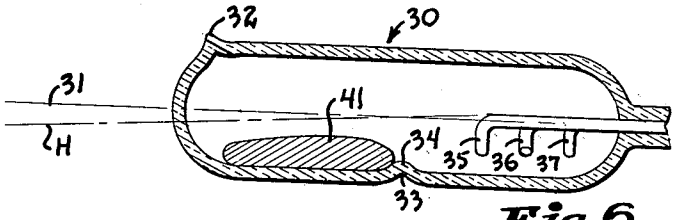

Fig. 6

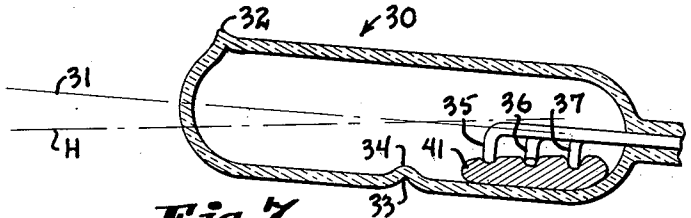

Fig. 7

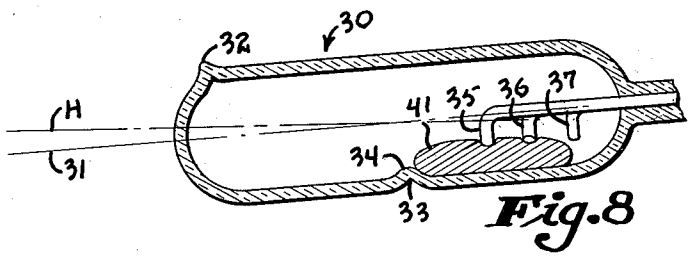

Fig. 8

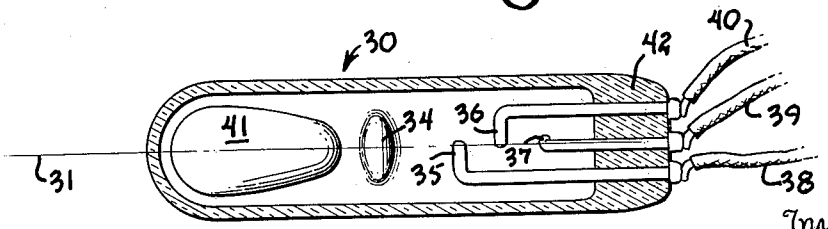

Fig. 9

Inventor

Harold T. Olson

By George H. Fisher

Attorney

Patented Feb. 18, 1941 2,232,626

UNITED STATES PATENT OFFICE

2,232,626

ELECTRIC SWITCH

Harold T. Olson, Minneapolis, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

Application October 7, 1937, Serial No. 167,754

12 Claims. (Cl. 200—152)

The present invention relates to liquid flow switches, and more particularly to mercury switches.

Mercury switches of the most common type consist of a straight tubular glass envelope, in one end of which a pair of electrodes are located. A globule of mercury lies within the envelope and completes the electrical circuit by bridging the electrodes when the envelope is tipped so that the electrode end is the lower. When the device by which the switch is actuated tips it past its horizontal position rather rapidly, this construction works out well for the reason that the mercury then moves into or out of engagement with the electrodes rather rapidly. The speed with which the mercury moves within the envelope of such a switch depends on how rapidly the switch is tipped since the force of gravity attempts to keep the mercury in the lowest portion of the envelope and rapid movement of the envelope past its horizontal position results in rapid movement of the mercury from one end of the envelope to the other.

When an electrical circuit is made or broken between two conductors, there is a tendency for an arc to form between the conductors at the time they are close to each other. Arcing in a mercury switch shortens its life due to the intense heat of the arc which is destructive to the electrodes and envelopes. Particles removed from the electrodes and envelope by arcing also contaminate the mercury rendering it sluggish and eventually the mercury may become so contaminated and viscous that the usefulness of the switch is brought to an end. It is therefore desirable to pass through this period of proximity of the conductors as quickly as possible.

An object of this invention is to provide a mercury switch in which the circuit is both made and broken with a snap action to obviate the above objections.

Another object of the invention is to indent the material forming the envelope or container of a mercury switch either from the outside or from the inside and thereby provide an obstacle to the normal flow of the mercury that will cause the mercury to engage or disengage the electrodes with a snap action.

Another object of this invention is to provide a mercury switch in which the circuit is completed with a snap action by reason of a depression in the envelope surface that engages the mercury in open circuit position until there is a gradient along the envelope floor toward the electrodes.

Another object of the invention is to provide a mercury switch in which a raised portion in the floor of the envelope causes the mercury to move from either end of the envelope to the other with a snap action.

A further object of this invention is to provide a mercury switch in which a raised portion formed by an indentation in the switch envelope is provided in the floor of the envelope whereby the mercury completes two electrical circuits almost simultaneously with a snap action, holds the mercury in a position completing the second electrical circuit after the first is broken and finally breaks the second circuit with a snap action.

Other objects will be apparent when reference is had to the specification and to the drawings, in which:

Figure 1 is a vertical sectional view taken longitudinally of the switch embodying my invention and shown in open circuit position;

Figure 2 is a vertical sectional view with a part broken away, also shown in open circuit position but tipped somewhat away from the position shown in Figure 1;

Figure 3 is a vertical sectional view of the switch shown in closed circuit position;

Figure 4 is a horizontal sectional view of the switch and being shown in a position corresponding to Figure 2;

Figure 5 is a vertical sectional view of a second embodiment of the invention having electrodes for two circuits and shown in open circuit position;

Figure 6 is a vertical sectional view of the switch shown in Figure 5, still in open circuit position but tipped so that the electrode end of the envelope is slightly lower than the other end;

Figure 7 is a vertical sectional view showing the same switch in closed circuit position;

Figure 8 is a vertical sectional view showing the switch of Figure 5 in the position in which one of the circuits is closed and the other is open; and

Figure 9 is a horizontal sectional view of the switch and shown in a position corresponding to Figure 5.

One embodiment of the invention is shown in Figures 1 through 4 and in these figures like reference characters refer to like parts. In this embodiment of the invention, the switch is sup-

ported by a mechanism that tips it one way or the other about its horizontal position but as that mechanism comprises no part of the invention it is not shown. The switch is generally designated at 10 and comprises a glass switch envelope or container cylindrical in form, the longitudinal axis of which is represented by the line 11. The envelope is hermetically sealed, the process of sealing the envelope resulting in a sealing-off tip 12 which forms an indentation or depression 13 within the envelope. As will be noted from the drawings, the sealing-off tip 12 is located on the lower side of the switch envelope. In the other end of the envelope 10 are sealed a pair of electrodes 14 and 15. For a purpose to be hereinafter set forth, electrode 15 is made of a metal that will amalgamate slightly. Flexible lead wires 16 and 16' are suitably secured to the outer ends of electrodes 14 and 15. Mercury 17 serves to complete the electrical circuit between electrodes 14 and 15 when moved to that end of the envelope.

The operation of the switch in its illustrative embodiment will now be described by referring to Figures 1 through 4. In Figure 1, the switch is in open circuit position due to the electrode end of the envelope being higher than the end in which the sealing-off tip 12 forming the depression 13 is located. The axis 11 of the tube is shown tipped counter-clockwise somewhat from the line H representing the horizontal. The mercury 17 is in one body with a part lying in depression 13. In order to close the electrical circuit, it is necessary to tip the envelope 10 clockwise so that the mercury will flow to the electrode end of the switch. As the envelope is tipped clockwise from the position shown in Figure 1, it will reach the position shown in Figures 2 and 4 in which the axis 11 of the envelope 10 is shown rotated very slightly in a clockwise direction from the line H representing the horizontal. The mercury is still in one piece but the main body of it has moved down the tube somewhat. Although the force of gravity is here tending to move the mercury into engagement with electrodes 14 and 15, the mercury is restrained from so moving by its surface tension. Part of the mercury lies in depression 13 and is held there partly by its weight, partly by a vacuum being formed beneath it and partly by its adhesion to the envelope wall forming the depression. The tendency of this small portion of the mercury to remain in the depression is strong enough so that the surface tension of the mercury tending to move toward the other end of the envelope is not great enough to dislodge it. As the envelope is tipped clockwise from the position shown in Figures 2 and 4, the force tending to move the main body of mercury into engagement with the electrodes becomes greater and eventually a point will be reached where the surface tension tending to hold the mercury in one piece is overcome and the mercury separates into two parts, one part 17*a* flowing down the envelope to make contact with electrodes 14 and 15, and the other part 17*b* remaining lodged in depression 13, as shown in Figure 3.

It should be pointed out that the parts of the switch are so proportioned that at the instant the mercury separates into two pieces, the mercury is still a substantial distance away from the electrodes. At this instant also the tube is tipped to a position in which there is a substantial gradient toward the electrodes. Thus, when the mercury is released, it will immediately commence to gain speed and will be moving quite rapidly at the time it engages the electrodes. It is apparent, therefore, that the action of this switch is such that no matter how slowly the envelope is actuated, it is impossible for the mercury to move slowly into engagement with the electrodes and, therefore, arcing is reduced to a minimum.

The embodiment of the invention shown in Figures 1 through 4 obtains a snap action break by forming the electrode that is first to be disengaged by the mercury of a metal that will amalgamate slightly. As the mercury 17*b* moves away from electrode 15, it adheres to the electrode until the main body of mercury is away from the electrode and only a small arm of mercury bridges the gap between the main body of mercury and the electrode. On further movement of the mercury away from the electrode, contact will be broken suddenly and there will be little time for an arc to form. Since the mercury adheres to the electrode until there is a gradient toward the other end of the tube, once released it moves rapidly away from the electrodes.

It should be noted that while the seal-off tip of the glass envelope is conveniently used to provide a depression in the lower surface of the envelope, the depression may also be formed in any other suitable manner as by indenting the envelope from the inside, as would be done if the envelope were made of metal.

Another embodiment of the invention is shown in Figures 5 through 9 wherein like reference characters represent like parts. Figure 5 shows a mercury tube 30 substantially cylindrical in shape and having an axis represented by the line 31. The tube is made of glass and is hermetically sealed in the conventional manner at 32. In the lower side of the tube and approximately at the center of its length, the tube wall is indented inwardly as at 33. Indenting the tube from the outside forms a raised portion 34 upon the inside of the tube. In one end of the tube, electrodes 35, 36 and 37 extend inwardly and have their ends bent downwardly in such a manner that their extremities lie substantially in a line parallel to the axis 31 and slightly above the bottom of the tube. These electrodes are suitably sealed in the envelope as shown at 42 in Figure 9. The outer extremities of the electrodes have attached to them flexible lead wires 38, 39 and 40.

Figure 9 shows the mercury in the position in which it is also illustrated in Figure 5. The shape of the raised portion 34 as viewed from above is here illustrated as is also the position of the electrodes. A globule of mercury 41 lies within the switch envelope and flows from one end of the tube to the other, depending upon which end is the lower. In traveling from one end of the tube to the other, the mercury must pass over the raised portion 34.

The sequence of operation of the switch is shown in Figures 5 through 8, in which line H represents the horizontal in each case. In Figure 5, the electrode end of the switch is raised considerably above line H and the mercury 41 is in the opposite end of the switch envelope so that the switch is in open circuit position. As the electrode end of the switch is lowered to a point only slightly below line H, the globule of mercury moves up to the raised portion 34, as shown in Figure 6. The tube has not yet been tipped sufficiently, however, to cause the mercury to flow over the raised portion 34. Mercury possesses a very high degree of cohesion and although the level of the globule of mercury 41

is above the top of the raised portion 34, the portion of the mercury below a horizontal line through the top of 34 holds it in this position.

Lowering the electrode end of the switch envelope still further will eventually overcome the tendency of the mercury to remain held by the raised portion 34 and the mercury 41 will move as a unit over raised portion 34, flow quickly down the bottom of the envelope and engage the electrodes 35, 36 and 37 almost simultaneously. This position of the envelope and mercury is shown in Figure 7. If now the electrode end of the switch is elevated to a position slightly above line H, the mercury, although tending to flow toward the other end of the envelope, will again be engaged by the raised portion 34 as shown in Figure 8. The amount of mercury and the relative position of electrode 37 and raised portion 34 is such that while the mercury 41 is still in engagement with electrodes 35 and 36 it has disengaged electrode 37. Thus, there is a range of positions of the envelope from a position in which the electrode end is very slightly above line H to the position in which mercury 41 will flow over the raised portion 34 in which the electrical circuit controlled by electrode 37 is open but in which the circuit controlled by electrodes 35 and 36 remains closed. If the electrode end of the envelope is raised beyond the position shown in Figure 8, the position of the elements of the switch again returns to the open circuit position shown in Figure 5.

While the raised portion 34 has been described as formed by indentation 33 on the outside of the envelope, it could also be provided by other means as for instance by an insert placed within the tube or by making the tube wall of increased thickness at that point.

By omitting electrode 37 it is apparent that a switch controlling a single circuit and in which contact is both made and broken with a snap action would be provided.

From the above it is seen that a new and novel snap action mercury switch is obtained wherein the circuit controlled by the switch is made and broken with a snap action. In one modification the breaking of the circuit with a snap action is caused by the same means which causes snap action making of the circuit, while in the other modification the circuit may be broken with a snap action by a separate means. In addition, provision is made for sequentially breaking a plurality of circuits.

Although for purposes of illustration two modifications of this invention have been described, other forms thereof may become apparent to those skilled in the art upon reference to this specification and therefore this invention is to be limited only by the scope of the appended claims and prior art.

I claim as my invention:

1. In an electrical switching mechanism, in combination, a tiltable container, electrodes extending into the container, a body of fluid conducting medium having relatively high surface tension characteristics movable in the container upon tilting thereof to bridge the electrodes for making and breaking an electric circuit, and a depression in the bottom of the container formed solely by the seal-off tip and being of such a depth that it continuously retains a portion of said fluid acting in conjunction with the surface tension of the fluid for holding the fluid in one end of the container until the container is tilted to a position in which there is a sufficient gradient toward the other end of the container to overcome the surface tension of the fluid whereupon a portion of the fluid is released and moves rapidly to the other end of the container.

2. In an electrical switch mechanism, in combination, an elongated tiltable container having first and second ends, electrodes in the first end of the container, a body of fluid conducting medium having relatively high surface tension characteristics movable from one end of the container to the other upon tilting thereof to bridge and unbridge the electrodes for making and breaking an electric circuit, and a depression in the bottom of the second end of the container formed solely by the seal-off tip and being of such a depth that it continuously retains a portion of the fluid acting in conjunction with the surface tension of the fluid for holding the fluid in the second end of the container until the container is tilted to a position in which there is a sufficient gradient toward the first end of the container to overcome the surface tension of the fluid whereupon a portion of the fluid is released and moves rapidly to the first end of the container to bridge rapidly the electrodes for completing the circuit with a snap action.

3. In an electrical switching mechanism, in combination, a movable container, electrodes extending into said container, a fluid conducting medium movable in said container to bridge said electrodes, and a depression in the lower side of said container comprising the seal-off tip thereof to control the movement of said fluid conducting medium said depression being of such a depth as to continuously retain a portion of the fluid conducting medium.

4. In an electrical switching mechanism, in combination, an elongated tiltable container, a plurality of electrodes extending into one end of the container for controlling a plurality of circuits, a body of fluid conducting medium having relatively high surface tension characteristics movable in the container to bridge and unbridge the electrodes as the container is tilted in first and second directions respectively, and an indentation in the lower surface of the container wall and separated from the outermost electrode by a distance greater than the normal length of the body of conducting fluid acting in conjunction with the surface tension of the fluid as the container is tilted in the second direction to allow the fluid to unbridge certain of the electrodes for opening at least one circuit but holding the fluid in contact with the remaining electrodes until the container is tilted to a position in which there is a substantial gradient away from the electrode end of the container whereupon the fluid moves away from the electrode end of the container to unbridge the remaining electrodes.

5. In an electrical switch mechanism, in combination, an elongated tiltable container having first and second ends, electrodes in the first end of the container, a body of fluid conducting medium having relatively high surface tension characteristics movable from one end of the container to the other upon tilting thereof to bridge and unbridge the electrodes for making and breaking an electric circuit, and a depression in the bottom of the second end of the container formed solely by the seal-off tip and being of such a depth that it continuously retains a portion of said fluid acting in conjunction with the surface tension of the fluid for holding the fluid in the second end of

the container until the container is tilted to a position in which there is a sufficient gradient toward the first end of the container to overcome the surface tension of the fluid whereupon a portion of the fluid is released and moves rapidly to the first end of the container to bridge rapidly the electrodes for completing the circuit with a snap action, one of the electrodes being of a material which amalgamates with the fluid to hold the body of fluid in engagement therewith in the first end of the container until the container is tilted to a position in which there is a substantial gradient toward the second end of the container whereupon the fluid moves rapidly to the second end of the container to unbridge rapidly the electrodes for breaking the circuit with a snap action.

6. In an electrical switching mechanism, in combination, an elongated tiltable container, a plurality of electrodes extending into one end of the container for controlling a plurality of circuits, a body of mercury movable in the container to bridge and unbridge the electrodes as the container is tilted, and means acting in conjunction with the surface tension of the mercury to cause the mercury to bridge all the electrodes substantially simultaneously to complete all the circuits regardless of how slowly the container is tilted from circuit open to circuit closed positions and to cause the mercury to unbridge the electrodes sequentially to break the circuits sequentially as the container is tilted slowly from circuit closed to circuit open positions.

7. In an electric switch, in combination, an elongated tiltable container having first and second ends, a plurality of electrodes in the first end of the container for controlling a plurality of circuits, a body of fluid conducting medium movable in the container to bridge and unbridge the electrodes when the container is tilted, and means within the container for holding the fluid conducting medium in the second end of the container until there is a substantial gradient toward the first end of the container whereupon the fluid moves rapidly to the first end of the container to bridge all the electrodes for completing all the circuits and for holding the fluid in a position in which certain of the electrodes are bridged and certain of the electrodes are unbridged for breaking certain of the circuits when the container is tilted away from the position in which all the electrodes are bridged to a position in which there is a slight gradient toward the second end of the container.

8. In an electrical switching mechanism, in combination, an elongated tiltable container having first and second ends, a plurality of electrodes extending into the first end of the container for controlling a plurality of circuits, a body of fluid conducting medium having relatively high surface tension characteristics movable in the container to bridge and unbridge the electrodes as the container is tilted in first and second directions respectively, and an obstruction in the bottom of the container between the above mentioned electrodes and the second end of the container of such a height as to act in conjunction with the surface tension of the fluid as the container is tilted in the second direction to allow the fluid to unbridge certain of the electrodes for opening at least one circuit but holding the fluid in contact with the remaining electrodes until the container is tilted to a position in which there is a substantial gradient away from the electrode end of the container whereupon the fluid moves away from the electrode end of the container to unbridge the remaining electrodes and open the remaining circuits.

9. In an electrical switching mechanism, in combination, an elongated tiltable container having first and second ends, a plurality of electrodes extending into the first end of the container for controlling a plurality of circuits, a body of fluid conducting medium having relatively high surface tension characteristics movable in the container to bridge and unbridge the electrodes as the container is tilted in first and second directions respectively, and an obstruction in the bottom of the container between the above mentioned electrodes and the second end of the container of such a height as to act in conjunction with the surface tension of the fluid for holding the fluid in one end of the container until the container is tilted in the first direction to a position in which there is a substantial gradient toward the electrode end of the container whereupon the fluid moves rapidly to the electrode end of the container to bridge rapidly all of the electrodes, said obstruction also acting in conjunction with the surface tension of the fluid as the container is tilted in the second direction to allow the fluid to unbridge certain of the electrodes but holding the fluid in contact with the remaining electrodes until the container is tilted in the second direction to a position in which there is a substantial gradient away from the electrode end of the container whereupon the fluid moves rapidly away from the electrode end of the container to unbridge rapidly the remaining electrodes and open the remaining circuits.

10. In an electrical switching mechanism, in combination, an elongated tiltable container having first and second ends, at least three electrodes for controlling at least two circuits extending into the first end of the container, a body of mercury movable in the container to bridge and unbridge the electrodes as the container is tilted in first and second directions respectively, and an obstruction in the bottom of the container between the above mentioned electrodes and the second end of the container of such a height as to allow the mercury to unbridge certain of the electrodes for opening at least one circuit as the container is tilted in the second direction but holding the mercury in contact with the remaining electrodes until the container is tilted to a position in which there is a substantial gradient away from the first end of the container whereupon the mercury will move away from the first end of the container to unbridge the remaining electrodes and open the remaining circuits.

11. In an electrical switching mechanism, in combination, an elongated tiltable container having first and second ends, at least three electrodes for controlling at least two circuits extending into the first end of the container, a body of mercury movable in the container to bridge and unbridge the electrodes as the container is tilted in first and second directions respectively, and an obstruction in the bottom of the container between the above mentioned electrodes and the second end of the container of such a height as to hold the mercury in the second end of the container until the container is tilted to a position in which there is a substantial gradient toward the first end of the container whereupon the mercury moves rapidly to the first end of the container to bridge rapidly all the electrodes, said obstruction also acting on the mercury to allow the mercury

to unbridge certain of the electrodes for opening at least one circuit as the container is tilted in the second direction but holding the mercury in contact with the remaining electrodes until the container is tilted to a position in which there is a substantial gradient away from the first end of the container whereupon the mercury will move away from the first end of the container to unbridge the remaining electrodes and open the remaining circuits.

12. A mercury switch comprising an envelope, mercury, electrodes, and a well in said envelope, a part of said well constituting a sealing off tip.

HAROLD T. OLSON.