July 29, 1941. P. S. BEAR 2,251,011

SWITCH

Filed Sept. 28, 1934 3 Sheets-Sheet 1

Fig. 1

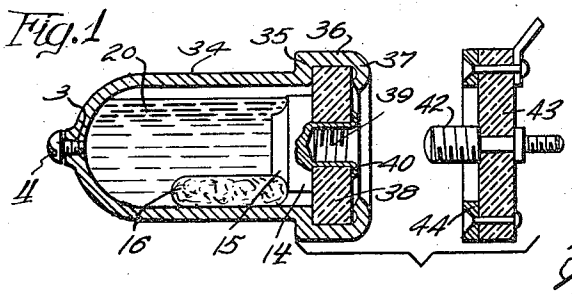
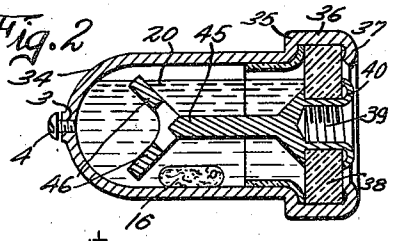


Fig. 2



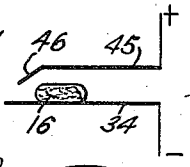
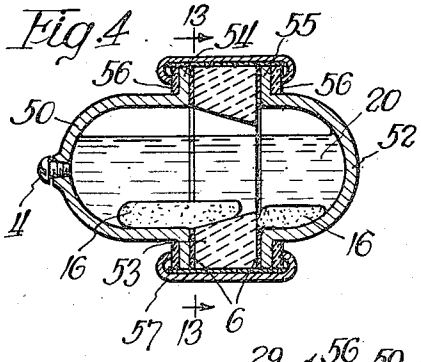


Fig. 3

Fig. 4



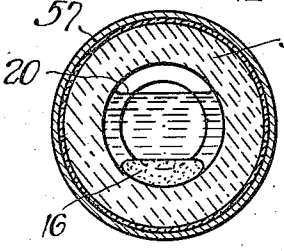
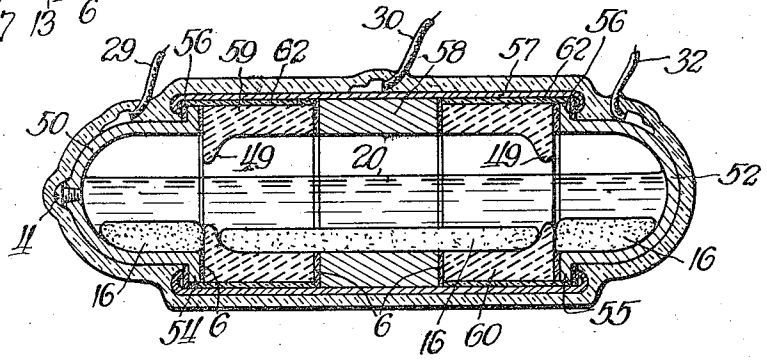


Fig. 5

Fig. 6



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Fig. 7

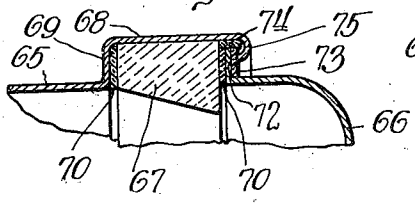


Fig. 8

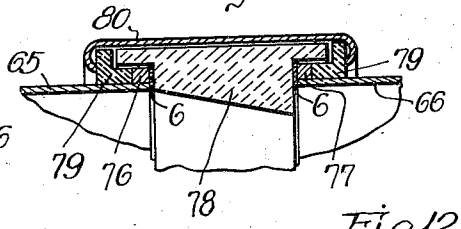


Fig. 12

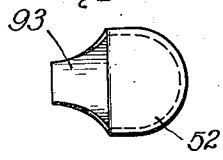


Fig. 9

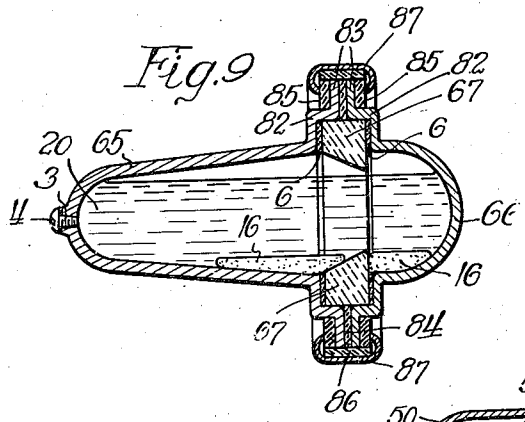


Fig. 11

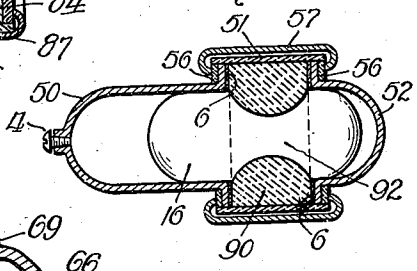
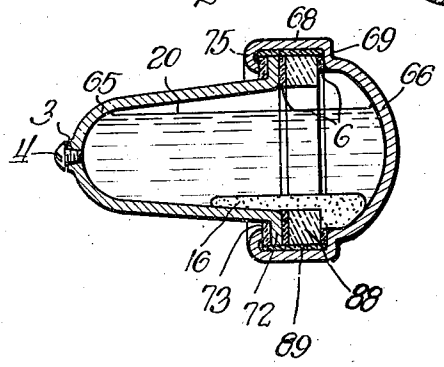


Fig. 10



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SWITCH

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Fig. 13.

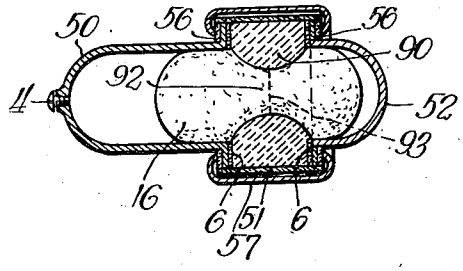


Fig. 14

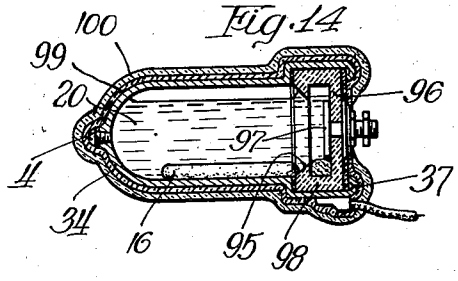


Fig. 15.

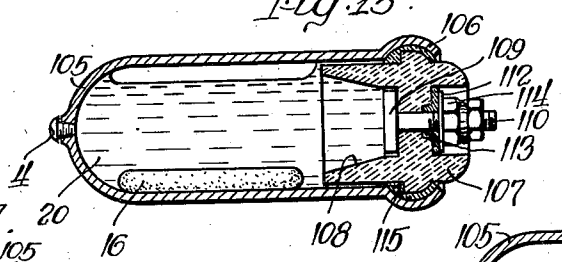


Fig. 17.

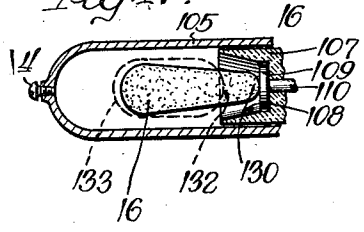
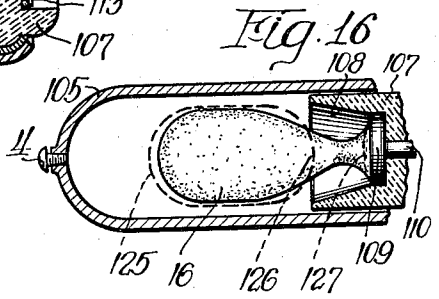


Fig. 16



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Patented July 29, 1941

2,251,011

UNITED STATES PATENT OFFICE

2,251,011

SWITCH

Paul S. Bear, Dowagiac, Mich., assignor, by mesne assignments, to Bucklen-Bear Laboratories, Inc., Elkhart, Ind., a corporation of Indiana

Application September 28, 1934, Serial No. 745,842

41 Claims. (Cl. 200—152)

My invention relates to gravity operated switches of the enclosed type. A typical switch of this type is the mercury switch.

The chief object of the present invention is to increase the capacity of switches of this type.

Other and subsidiary objects will be apparent from the following specification and claims.

A serious drawback of switches of this type is the fact that the current carrying and interrupting ability is relatively low and hence their field is greatly limited.

I have determined that the thing which causes failure in switches of known construction is, in general, breakage of the seal of the envelope. Commercial switches heretofore constructed employ glass envelopes. Glass is, first of all, a poor conductor of heat. Next, its rate of expansion, as compared to metals, is low. It is difficult to make a bond between glass and metal and the seal deteriorates under high temperatures. I have developed a construction which does not depend upon a fused seal, and thereby have freed my switch of the limitations of structure and mode of operation imposed by a fused seal. At the same time I have provided for equalizing temperatures, and for efficient heat dissipation. I have found thereupon that the capacity of my switch or interrupter may be based or rated solely upon the amount of heat which the device can dissipate under working conditions, and not upon the special problem of maintaining a fused seal.

In the concept of means to increase the capacity of a switch of this type I have started with literally turning the switch inside out. Where the prior art used an envelope of glass with metal inserted, I make an envelope of metal with only so much insulation inserted as is necessary to interruption of the circuit, or electrical segregation of adjacent conducting parts.

The prior art had attempted to confine a gas (usually hydrogen) in the glass envelope. This was difficult from a mechanical standpoint. Also, any leakage of air into the envelope caused explosion. I fill the envelope substantially full of liquid, leaving preferably a suitable vapor or gas bubble for taking up expansion and contraction due to temperature changes. So far as I am aware, the filling of a glass envelope switch with liquid was never before practiced.

I am aware that it has been proposed to employ a liquid fill in switches of the gravity type, but in such devices as have been proposed no adequate envelope has been provided from the standpoint either of tightness or heat dissipating ability.

It is one of the novel features of my invention to provide a metallic envelope which can be sealed liquid tight and which at the same time will have great mechanical strength, and suitable electrical characteristics, and the ability to dissipate heat readily and in relatively great quantities without developing any points of high temperature, i. e., hot spots.

The ability to hold liquid under high pressure allows the use of a suitable liquid fill and facilitates heat equalization and heat dissipation.

A further feature of novelty resides in the specific liquid fill, i. e., triethanolamine or equivalent liquid, which has the ability to maintain the metals with which it is in contact clean and bright, and to assist in suppressing arcs and distributing and dissipating heat.

In the construction of the metal envelope various forms of joints may be employed. A highly advantageous form involves a pair of hollow electrodes held against an intervening insulating ring by flanges engaged by a sleeve or ring beaded into effective holding engagement, or wherein one of the flanges is beaded over the other.

The form of the switch may be varied, not only to provide narrow angle and wide angle switches but also to provide endwise tilting or angularly rocking switches with single or multiple circuits for multiple or successive interruption.

A further feature of my invention resides in the method of preparing and filling the switch. According to the preferred procedure the envelope is assembled and closed except for a filling opening or vent hole; the mercury and a charge of the filling liquid are then introduced. The whole unit is then heated to bring the material to the boiling point, expelling air from the part which is unfilled. Thereupon the envelope is closed by a sealing screw that closes the vent or opening. Preferably, about one third or less of the volume is thus occupied by vapor of the filling liquid. This condition of a gas or vapor bubble normally at less than atmospheric pressure allows for expansion of the liquid without danger to the envelope. The envelope is unusually strong and may easily resist pressures of two to three hundred pounds per square inch. I find it to be a fact that pressure of the fluid medium surrounding the arc assists in putting out the arc if that is not otherwise readily accomplished.

I have further devised a form of switch in which the magnetic forces of current flow tend to throw the contacts into better conducting relation upon initial contact and to retain them in contact until a positive force is developed tending to throw

them apart, whereupon a more positive action is secured in both operations.

A further feature of novelty resides in the manner of making a beaded joint between the parts of a switch of this class.

Numerous other features of novelty will be apparent from the following detailed specification and claims.

Now, in order to acquaint those skilled in the art with the manner of constructing and operating a device embodying my invention I shall describe, in conjunction with the accompanying drawings, at least one specific form in which my invention may be practiced. Throughout the drawings the same or similar reference numerals indicate the same or similar parts.

In the drawings:

Figure 1 illustrates one form of our switch and its mounting; this view is a vertical longitudinal section;

Figure 2 is a view similar to Figure 1, showing a modification embodying the principle of electromagnetic boosting to insure establishment of connection between the contacts;

Figure 3 is a diagram explaining the mode of operation of the device shown in Figure 2;

Figure 4 is a longitudinal vertical section through a modified form of wide angle switch;

Figure 5 is a cross-sectional view taken on line 10—10 of Figure 4;

Figure 6 is a longitudinal vertical section of a multiple form of switch;

Figure 7 is a longitudinal vertical section through a modified form of wide angle switch in which one of the metal sections is beaded over the other;

Figure 8 is a similar view of a different method of joining the two metal sections together by a beaded band;

Figure 9 is a similar view of a further modification showing the use of a beaded band or ring for clamping the flanges together on the two metal sections;

Figure 10 is a similar vertical section through a modified form of switch in which the shorter section is flanged and beaded over the edge of the longer section;

Figure 11 is a horizontal longitudinal section of a modified form of switch;

Figure 12 is a top plan view of a form of cup such as may be used in the switch of Figure 13;

Figure 13 is a detailed sectional view through a switch structure employing the electrode shown in Figure 12;

Figure 14 is a sectional view through a modified form of switch structure;

Figure 15 is a sectional view through a modified wide-angle type of mercury switch;

Figure 16 is a sectional view of a switch of the type shown in Figure 15 at the instant prior to breaking of contact between the two electrodes; and

Figure 17 is a view similar to Figure 16 but showing the snap action when a non-wetting type of electrode is employed.

It is to be observed throughout the present disclosure that the switches which I have shown embody enclosures for the mercury contactor, or like element, constructed mainly of metal, the metal being preferably iron or some other metal or alloy which does not amalgamate with mercury where that is used. The metal which constitutes the enclosures serves also as an electrode, or such part of it as is in contact with the mercury or other contactor serves as an electrode, and I wish it to be understood throughout that while my invention is chiefly in switches of this character, there are certain features of my invention which are applicable to switches of the generally known type, that is, embodied in envelopes made of a non-conductor, with the electrodes constituting merely inserts or inleads to secure the necessary electrical conductivity.

By the aforesaid use of metal for the electrodes and simultaneously for constructing the container, two notable advantages are achieved; first, that greater conductivity electrically is secured, and second, heat conductivity is enhanced. Furthermore, the mounting of a device employing a metal envelope in spring clips or the like is facilitated.

Preferably, but not necessarily, the entire device is dipped and coated with cellulose acetate, as indicated in certain of the figures. This same dipping and coating may be applied to each of the forms of switches herein illustrated. This is to be understood, although omitted from some of the drawings for the sake of clearness.

The switch shown in Figure 1 is a narrow angle switch and the parts are shown in the position where the circuit is closed. If the switch be tilted slightly in a counterclockwise direction, as viewed in Figure 1, the mercury contactor will recede promptly and break circuit with the electrode portion. The switch chamber is filled to substantially two-thirds of its capacity with a liquid which serves an important function. The liquid which I employ is one of the ethanolamines. The preferred liquid is triethanolamine. I employ the material as it is found in the open market, and I find the same to be satisfactory. I am advised that the commercial variety comprises approximately 70% triethanolamine, about 20% diethanolamine and about 8% monoethanolamine. The specific gravity is approximately 1.11 to 1.12 at 20° C.

This commercial grade of triethanolamine is a viscous hygroscopic liquid with a slight ammoniacal odor and slightly alkaline in its reaction. This alkalinity is approximately ⅛ that of ammonia. Due to its basic reaction it readily absorbs such acid gases as carbon dioxide, chlorine, sulphur dioxide, hydrochloric acid, etc. The triethanolamine combines freely with fatty acids to form soaps which are substantially neutral. The boiling point is approximately 277° C. at 150 mm. In the present instance, the liquid serves the important function of an arc extinguishing medium to assist in current interruption. Also, the liquid conducts heat from the point of generation and diffuses it throughout the entire body of the switch and allows dissipation thereof at the surface of the switch, particularly because of the relatively high conductivity of the major part of the envelope. Thus, because of the internal distribution of heat and the ready dissipation thereof to the surrounding atmosphere, switches of this type are capable of handling heavier current and withstanding a higher rate of interruption than switches of known type.

The vapor space above the liquid 20 is at less than atmospheric pressure for normal room temperatures, although this is not essential. It is, however, a suitable way of evacuating gases which might otherwise lead to corrosion of the electrodes or of the mercury. The expansion space or the vapor chamber above the liquid may be varied as desired, and is provided for the purpose of accommodating expansion and contraction of the liquid due to variations in tempera-

ture. The heavy viscous liquid filler does not leak from the switch as readily as gas from gas filled switches, and a little leakage merely results in enlarging of the expansion space.

The action of the triethanolamine upon the metal surfaces is highly beneficial. Impurities are removed or neutralized, and the metal is left in clean condition, greatly improving its contact with the mercury and keeping the mercury and other metal surfaces clean throughout the life of the device. While I have shown the switch submerged in a bath 23 heated by a burner 24, obviously, other methods of applying the necessary heat may be employed. Also, it is not necessary that the outside of the switch be subjected to the cleaning action of triethanolamine.

In fact, each of the switches herein disclosed is adapted to employ a filling of triethanolamine or equivalent liquid, such as glycerin. The liquid must be of such character that it will have no catalytic action tending to produce a reaction between the metal electrode and the mercury.

Figure 1 discloses a switch of the narrow angle type embodying certain features of the present invention. The main hollow electrode 34 has a shoulder at 35 and an extension 36 of greater diameter, the margin of which is beaded over as indicated at 37. Between the shoulder 35 and bead 37 a disc 38 of insulation is gripped. This disc may be made of porcelain, in which event suitable elastic gaskets may be placed between the porcelain and the metal parts, but preferably it is constructed of a more or less fibrous material, such as bakelized cotton fabric or bakelized fiber board, or any other suitable insulation which is relatively tough and unaffected by the liquid fill. The shorter electrode 14 has a hollow stem 39, the edge of which is beaded over as shown at 40 to hold the head 14 firmly against the inside surface of the insulator 38 and to seal off the opening through said insulator. The inside of the hollow stud 39 may be threaded to provide a suitable mounting as by means of the external threaded stud 42 which is mounted upon a supporting plate 43 and has a cooperating ring contact 44 for engaging the bead 37 and making contact therewith. Thus the switch may readily be mounted upon a support which makes electrical connection with the electrodes. Obviously, if desired, the portion 36 may be provided with Edison threads for mounting the switch of this character in the Edison type socket.

Figure 2 shows a modification of the device shown in Figure 1, in that the inner electrode has an elongated stem 45 terminating in a cone or divergent portion which approaches the walls of the electrode 34. The mercury contactor 16 is adapted to be wedged between the converging portions of the electrode produced by the cone 46, and as soon as the mercury contactor bridges the gap, so that current is conducted, the magnetic field is confined in the loop formed by the electrodes 45, 16 and 34, and forces the movable portion 16 outwardly, that is, to the left, thereby increasing the area of contact and producing cumulatively an increase in the contacting area between the mercury contactor 16 and the associated electrical conductors 46 and 34. This is illustrated in diagram in Figure 3, where the mercury contactor 16 is shown as guided horizontally on top of the electrode 34. It will be seen that an electrical loop is formed by the three contacts, and the tendency of the magnetic field is to shove the mercury 16 more firmly into engagement with the portion 46, thereby improving the contact, instead of, as in all devices of the prior art with which I am familiar, the magnetic repulsion tending to drive the mercury away from making contact as soon as the initial contact was instituted. That is to say, heretofore there has been no recognition of the principle of magnetic repulsion of the mercury when it starts to make contact. I have observed that in the usual switch the approach of the mercury to the contact, particularly in a narrow angle switch, is accompanied by a period of oscillation in which an arc appears to be formed with great rapidity. This condition is known as "frying." The force of gravity is not great enough to force the mercury firmly into engagement and hold it there, and the repulsive magnetic effect established by the initial contact is great enough to throw the mercury again out of contact.

According to my invention, I utilize the magnetic effect to stabilize and increase the contact, no matter how small the contacting area and how small the force tending to hold the two parts together initially.

The magnetic force appears to be effective in two ways. First, assuming that the current flow is unidirectional, the tendency of a loop carrying current always to assume circular form, that is, for the parts thereof to be forced away from each other from a common center, thrusts the mercury 16 into the gap. Where the current is alternating, each wave of current has the same effect on the mercury, but also there is the repulsive effect due to induction between the portion 46 and the adjacent surface of the shell 34. This induction effect I conceive to be slight, but it is in the right direction.

The gaskets such as indicated at 6 may in the various figures be made of cork, or synthetic rubbers, or other similar materials.

Figures 4 and 5 illustrate a different form of the device. In this case a conical tapered ring 53 is interposed between the flanges 54 and 55 of the electrodes 50, 52, suitable sealing gaskets or washers 6—6 being interposed. Insulating rings 56—56 of fiber or the like lie against the outside faces of the flanges 54, 55 and an annular sheet metal ring 57 is beaded at each end against the washers 56—56 to produce a tight closure. The conical ring 53 provides a sharp shoulder which performs the severing function for dividing the mercury into two parts 16—16 as shown in Figure 12 for open circuit position but which allows the flow of mercury over the top of the same for establishing closed circuit condition through a mercury-to-mercury contact. The liquid fill 20 is employed, and it will be observed that it is instantly available to keep the flange or annular shoulder cooled and to dissipate the heat which is evolved by the arc formed upon making or breaking of the circuit.

In Figure 6 I have shown a multiple narrow angle switch. This figure shows a switch in which closure of the circuit between the central and one of the outer leads is secured by tilting the switch one way or the other, respectively, or by endwise bumping of the switch, whereby the relatively large mass or inertia of the large central body of mercury produces rapid making and breaking of the circuit across the dams 49. In this construction the end electrodes or cups 50, 52 are connected to the leads 29 and 32, whereas the lead 30 is connected to a central electrode 58 and this central electrode is separated from the end electrodes by the ceramic insulator

rings 59 and 60 having the annular shoulders 49—49 disposed adjacent to the end electrodes. The body of mercury 16 is divided into three parts, namely, a central part which is in contact with the central electrode 58, and end parts which are retained by the flanges 49—49 in the respective cups. The assembly is held in alignment by a metal sleeve 57 which is beaded over the flanges 54, 55 of the cups 50, 52 with suitable insulating gaskets 56 interposed to provide the necessary insulation. Cylindrical insulating sleeves 62—62 cover the edges of the flanges 54, 55 and gaskets 6—6 are interposed between the ends of the ceramic insulators and the adjacent metal parts. The central electrode 58 is conductively associated with the clamping sleeve 57 to which the lead 30 is connected, or the lead 30 may extend through the clamping sleeve 57 into engagement with the ring electrode 59.

In the preferred operation of the switch shown in Figure 6 a sudden oscillatory or axial motion of the switch, either to the right or to the left, will cause a make and break between the central electrode and the corresponding one of the end electrodes.

The external surface of the switch shown in Figure 6 is covered by a coating of cellulose acetate or the like. This is optional with each of the switches herein disclosed, and this coating may be formed over an inner coating of a phenol condensation product, as will be described in detail hereinafter.

In Figure 7 I have shown an improved method of coupling the two metal parts of the switch together. The drawn sheet metal cups 65 and 66 overlap, with only sufficient insulation between them to maintain the parts electrically independent, and the ceramic ring 67 is enclosed within the enlarged cylindrical part 68 which forms an extension of the main body of the cup 65. Between the cylindrical portion 68 and the main body part of the electrode 65 I provide the shoulder 69, which annular shoulder is deep enough to receive the ceramic ring 67. Preferably, a yielding gasket 70 is interposed to accommodate the ceramic ring to the metal shoulder. The cup 66 is provided with a flange 72 which rests against the opposite end of the ring 67 with a suitable gasket 70 of yielding material interposed. The flange 72 is insulated from the cup 65 by an insulating ring 73 lying flat against the flange 72, and a cylindrical ring 74 which lies between the edge of the flange 72 and the enlarged cylindrical portion 68. The rim of the enlarged cylindrical portion 68 is beaded over the flange 72 with the insulating washer 73, of fiber or the like, interposed. The switch is provided with the proper charge of mercury to provide the traveling contactor and is provided with the usual liquid fill heretofore described. It will be observed, in this connection, that the beading force tends to compress the ring 67. The joint may be made as will be referred to in Figure 9, where the bearing force comes upon the flanges and interposed insulating washer only, and not upon the ceramic ring. The switch may be constructed as a wide angle switch, which is the form shown in Figure 7, or it may be constructed as a narrow angle switch, in which event the ring 67 is made cylindrical and the cup 66 is provided with an electrode to secure the break between the electrode and the mercury contactor within the confines of the ceramic ring.

In Figure 8 I have shown a modified form of joint between the cups 65 and 66. In this case a ring 76 is welded to the rim of the cup 65 and likewise a similar ring 77 is welded to the rim of the cup 66. These rings are preferably rectangular in cross-section. The ends of the cups with the rings welded thereto seat in annular recesses or sockets in the ends of the ceramic ring 78 with suitable gaskets 6—6 of vellumoid, cork, or other suitable composition, interposed. Flanged rings 79 of fiber or fiber impregnated with a condensation product, have their axially extending parts resting against the rings 76 and 77 and their radially extending parts available to be engaged by the ends of the sheet metal band 80 which is beaded over at each end to engage the rings 79, 79 and to force the ends of the cups 65 and 66 tightly against the gaskets 6—6 to hold the cups firmly and in fluid tight relation against the ends of the ceramic ring 78. The ceramic ring 78 is shown as adapted for wide angle construction, but obviously its form may be varied.

In Figure 9 I have shown the cups 65 and 66 as provided each with an annular offset shoulder 82—82 terminating in parallel flanges 83—83. These offset shoulders 82—82 form an annular recess in which the ceramic ring 67 is seated. A suitable gasket 6 may be employed between the adjacent shoulders and the ceramic ring to take up inaccuracies in manufacturing dimensions. The two flanges 83—83 bear upon the opposite sides of an insulating ring 84 which separates the flanges electrically. Insulating rings of fiber 85—85 bear against the outer surfaces of the flanges 83—83 and a cylindrical ring of insulation 86 covers the peripheral edges of the flanges 83—83. A sheet metal ring 87 enclosed the cylindrical ring 86 and is beaded over at its ends against the washers 85—85 holding the flanges 83—83 firmly against the interposed washer of insulation 84 and completing the enclosure.

The cup 65 is shown as tapered in diameter from the outer end where the filling screw is located towards the opposite end where the ceramic ring 67 is located. This permits the use of a smaller amount of mercury to perform the necessary interrupting operation for a given angular movement.

A modified form of construction is shown in Figure 10, in which the cup 66 is provided with a cylindrically enlarged portion 68 and a shoulder 69, just as the cup 65 was provided with these parts in the embodiment of Figure 7. The ceramic ring 88 in this case is rectangular in cross section and is held between the flange 72 and shoulder 69 with a suitable gasket such as 6 interposed to take up variations in dimensions. A cylindrical insulating ring 89 embraces the ceramic ring 88 and covers the peripheral edge of the flange 72. The rim of the enlargement 68 is beaded over against an insulating washer 73 to complete the enclosure. The switch shown in Figure 10 is a wide angle switch. It will be observed that the cup 65 is relatively sharply tapered from the smaller dimension at the end where the filling screw 4 appears to the wider part at the flange 72. The ceramic ring 88 has a relatively sharp shoulder, although this is rectangular in section. As the switch is tilted in a counterclockwise direction from the position shown in Figure 10, the mercury contactor 16 will be divided by the ceramic ring 88 and a part thereof retained in the cup 66 and the other part will run to the opposite end of the cup 65, producing the desired break. It will be obvious that the ring 88, or, in fact, any form of ceramic ring, does not necessarily have to be cone-shaped or

provided with a flange, but it should have an annular shoulder, preferably relatively sharp, to divide the mercury into two parts, particularly for wide angle operation.

Figure 11 shows a form of switch in which the assembly of electrodes and ceramic is substantially the same as that shown in Figure 4. The ceramic 90 has a cylindrical external surface, but the internal surface is formed to provide a slot 92 with parallel vertical defining walls and curved top and bottom walls. The side walls of the slot are convex to form a constriction which retards the flow of mercury through the opening or slot 92 until sufficient head is secured by tilting that the mercury flows from the cup 50 into the cup 52 with a snap action. This restriction is narrow enough to prevent free flowing of the mercury. The cups 50 and 52 are flanged and held against interposed gaskets 6 by a beaded clamping ring 57, the ring 57 being insulated from the flanges by interposed rings of insulation 56—56, at the ends of a cylindrical sleeve 51. In operation, the constricted slot 92 tends to retard the travel of mercury from the cup 50 therethrough until a sufficient head or hydrostatic pressure is secured by tilting of the cup 50 above the cup 52 that the retarding effect of the constriction is overcome, and the mercury breaks the surface tension of the bottom part of the advancing meniscus and rushes through the slot with a snap action. Thus the mercury flows along the bottom surface first and provides a clean contact. Any impurities floating on top are retarded and do not interfere.

Where the cups are held together in the manner shown in Figure 13, the margins or edges of either or both cups which lie in line with the slot may be provided with extended lips, as shown at 93 in Figure 12. The cup 52 in this case has an integral extension which is allowed to project into the space between the bulging walls which define the slot. Either one or both of the cups 50, 52 may thus be provided with the extension or lip. In that case, the floor or inside bottom wall of the slot is recessed accordingly to receive the lip in the slot. In operation, the same retarding and subsequent snap action as was described in connection with Figure 11 is secured, but to a greater degree, and by narrowing restriction 92 with the lip 93 extending into the restriction.

The embodiment disclosed in Figure 13 corresponds to Figure 12, except that the electrode or cup 52 has been modified as shown in Figure 13, having the lip 93 disposed in a recessed portion of the spacer 90, and extending substantially to the center of the restricted passageway 92. The remaining details of the construction are the same as noted in connection with Figure 11.

In Figure 14 I have provided a mercury-break type of switch having the electrode 34 spun over the end of an annularly recessed ceramic spacer 96, which has an inwardly protruding lip 95 formed by the internal annular groove adjacent the portion 98 of the spacer 96. The other electrode 97 preferably comprises a cold header, such as is used in bolt and screw work. The cup 34, together with the end portion of the spacer 96, is first covered with a coating 99 of Bakelite for strengthening the switch envelope, over which is applied a coating 100 of cellulose acetate for decorative and flexible purposes. It is to be understood that this double coating is applicable to any of the switch structures disclosed herein.

The embodiments of Figure 15 correspond insofar as operation of the switch is concerned, but vary in structural details. In Figure 15 I have provided a switch of the wide-angle type having the metal envelope or shell, which may be formed of an aluminum alloy, if desired, and which has the mercury contactor 16 therein and the liquid filler 20, which may be glycerin in the present embodiment. The cup 105 has its end 106 spun over a shoulder formed on the porcelain spacing member 107 to secure the member 107 to the end thereof. The porcelain member 107 has an outwardly flared central opening 108 which terminates in a relatively thin edge adjacent the inner periphery of the envelope 105. The electrode 109, preferably formed of nickel to provide a mercury to mercury contact after initial operation, is of relatively large surface area, being preferably a cold header such as is used in bolt or screw work, and having its shank portion 110 extending outwardly through a recessed portion of the member 107. A compression washer 112 is forced against a resilient yielding gasket member 113 by the compression nut 114 to seal the surface of the shank 110 so that no leakage occurs therepast. Suitable gasket means 115 seal the envelope adjacent the spun-over end 106.

By virtue of the sloping or venturi-shaped surface 108, the switch has a positive make and break snap action, since per unit of angular tilt the forward rate of movement of the left hand end of the mercury 16 is substantially constant, while the corresponding rate of movement of the right hand end is greatly increased, due to the diminishing perimeter of the surface over which this end is traveling, as this surface is converging toward the electrode. Due to this construction, therefore, a snap action is provided since adjacent the electrode the whipping action produced upon the mercury by reason of its cohesion with the main body of mercury after the breaking point is reached results in its quick separation from the electrode and rapid receding movement down the spillway upon breaking of contact. The same action, except reversed, occurs upon making of the contact. This is due to the fact that a small movement of the larger volume of mercury results in a large movement of the smaller volume of mercury. The diverging surface 108 therefore acts as a spillway for producing this snap action, it being understood that the quantity of mercury in a switch of this type is such that the leading edge thereof will not engage the curved end of cup 105 before contact is broken. The electrode 109, being preferably formed of nickel, is wetted by the mercury, and thus after initial operation of the switch there is produced a mercury to mercury make and break.

In order to illustrate in detail the snap-action of the switch during making and breaking of the contact, I have shown, in Figure 16, a switch of the type illustrated in Figure 15, which is being tilted toward contact-breaking position. It is obvious that any of the switches described heretofore having an inclined or angled spillway will operate in the same manner. The mercury 16 is shown in its attenuated position, that is, the larger portion of the mercury is disposed in the electrode cup 105, and is being moved toward the rounded end of the cup by the tilting movement of the switch. The portion of the mercury lying in the opening formed in the spacer 107 and engaging the electrode 109 is being stretched away from the electrode, and is under tension. This results in what might be termed "necking" of the mercury between the electrode and the open end of the spacer 107.

As the switch is tilted a little further toward open position, the larger volume of mercury, due to gravitational pull, moves into a corresponding lower position indicated in dotted lines at **125**. This increment of movement results in stretching the attenuated neck of mercury in the spillway past its limit of cohesion, and the mercury parts or separates in the spillway, breaking contact, the two contiguous portions snapping into receded positions as shown at **126** and **127**. The entire volume of mercury, except that small portion which adheres to the surface of electrode **109**, thereafter moves downward into the end of the cup **105**. It is to be noted that the quantity of mercury in the switch is such that at no time will the mercury approach the rounded end of the tube before the snap breaking action occurs.

In Figure 17 I show a switch in action, similar to the showing in Figure 16, except that the electrode **109** is, in this embodiment, of such material that the mercury will not wet the surface thereof. An iron or steel electrode might be employed for this purpose. In the operation of this switch, the snap action is brought about by reason of the difference in linear movement of the forward and trailing portions of the mercury upon equal increments of volumetric displacement. Thus, while the forward edge of the mercury, upon tilting of the switch, moves only a small distance in the envelope, the rearwardly extending tongue **130**, which lays upon the sloping spillway surface **108**, and is of tapering depth up toward the electrode **109**, moves a relatively large distance downwardly along the surface **108**. For example, at the instant of breaking contact, as shown in this figure, for the next unit of angular tilt of the switch the tongue **130** will flow down the spillway, its trailing edge assuming the position shown at **132**, while the forward edge of the mercury body moves only into the dotted line position **133**. It is therefore apparent that an accelerated snap action is produced.

Obviously, the ceramic may be made of various shapes, as required. The cups need not be circular cylinders, but may be made of any desired shape. For example, they may be provided with a substantially flat bottom wall or floor, particularly for such forms of the switch as are shown in Figure 11, where heavy currents are to be handled. The flat bottom type of construction may be used in any of the forms herein shown for heavy current work.

The ceramic may be so shaped as to hold the cups with their axes at an angle to each other to secure a hill and valley effect, or to control the travel of the mercury in any desired manner.

I have heretofore referred to the fact that the metal electrode cups are preferably of iron, or some other metal or alloy which does not amalgamate with mercury. I contemplate particularly the use of stainless steel, or known alloys of iron such as nickel-copper-iron or nickel-chromium-iron, or others which are characterized by freedom from corrosion and which do not easily fuse or roughen under the action of making or breaking current. In addition, I have found that various types of aluminum alloy are applicable for this purpose and are advantageous because of lightness, high current carrying capacity and low cost.

The insides of the cups are preferably sand-blasted or brushed to give them clean but rough surfaces.

While I contemplate the use of triethanolamine as the preferred liquid filling in connection with such metal electrodes, I do not wish to be limited to that particular liquid, as I may use glycol, glycerol, ethylene glycol, various polyhydroxy alcohols and the like, particularly because of high boiling points and their basic character. Also glycerine, especially when used with aluminum alloy cups, has been found to produce a switch having the desirable characteristics and relatively economical to manufacture.

The metallic cups herein referred to are preferably of drawn sheet metal, although this is optional, as they may be die-cast metallic cups or the like.

It will be seen from the above explanation that switches of my invention, may comprise substantially complete metallic envelopes, using only so much insulation or ceramic as is necessary to insulate the electrodes from each other and to divide the mercury. The liquid fill which I employ assists in distributing and equalizing the heat and permits substantially the entire shell, which is of metal, to act as a heat radiator, with the result that the switch runs cold even under very high loads. I have run tests demonstrating the great effectiveness of the construction herein disclosed in keeping down the temperature and particularly avoiding hot spots at any point in the device.

The filling liquid, namely, triethanolamine, polyhydroxy alcohols, or the like, is relatively viscous and tends to damp out any sharp oscillatory motion or vibration of the mercury contactor. This is desirable on both wide angle switch construction and on narrow angle switch construction.

I do not intend to be limited to the details shown and described except as they are recited as essential features in the appended claims.

I claim:

1. In a mercury switch of the enclosed type having a mercury contactor and insulated electrodes, a filling of an ethanolamine.

2. In a mercury switch comprising a closed envelope having electrodes and a body of mercury, a filling of triethanolamine.

3. A switch of the class described, comprising a ring of insulation, a concave hollow electrode sealed at its rim to one side of said ring, a convex electrode sealed at its rim to the other side of the ring, and a body of mercury for connecting and disconnecting said electrodes, said convex electrode extending axially toward the concave electrode to provide a break between the mercury and said convex electrode at a point spaced longitudinally from the joint between said convex electrode and said ring, said hollow electrode providing free runway room for the body of mercury to travel as a unit after it breaks connection between the electrodes.

4. A switch of the class described having a chamber comprising two electrodes and a ring between them, said ring providing an effective constriction between two mercury holding parts of the chamber to provide a mercury to mercury break over said ring, and a filling of ethanolamine in said chamber wetting said mercury, said electrodes and said ring.

5. A mercury switch of the gravity class having an enclosure, contacts, and a mercury contactor, and a body of arc extinguishing liquid in said enclosure maintained at sub-atmospheric pressure under normal room temperature.

6. In a switch of the class described, a hollow cup-shaped metallic electrode, a ceramic spacing ring secured to said electrode and having an

outwardly diverging spillway surface terminating within said electrode, a second electrode carried within said ring and closing the other end of said surface, said second electrode being adapted to be wet by mercury, and a mercury contactor in said switch having accelerated movement along said surface into and out of contact with said second electrode upon tilting of said switch, said surface producing attenuation of said mercury adjacent said second electrode prior to breaking of contact between said electrodes whereby upon breaking of contact the contiguous portions of mercury engaging said surface at the point of said break snap into receded positions.

7. In a switch, a metallic cup-shaped shell, a ring of insulation in the open end thereof, an electrode carried by said ring and extending into said ring, an annular surface on said electrode curved inwardly and axially of said shell, a body of mercury in said shell having a predetermined vertical height when said shell is in horizontal position, said curved surface conforming to the curvature of the meniscus of said mercury whereby upon tilting of said shell said mercury has initial surface contact with the adjacent portion of said curved surface.

8. A mercury switch comprising a pair of metallic cup-shaped electrodes and an intermediate insulating ring forming a switch envelope of substantially uniform internal diameter, opposed inwardly extending lateral projections on opposite sides of said ring defining with the floor of said envelope a Venturi passageway, and a body of mercury lying on the floor of said envelope for making and breaking contact between said electrodes, said mercury having accelerated snap movement through said passageway upon tilting of said envelope.

9. A mercury switch comprising a pair of metallic cup-shaped electrodes and an intermediate insulating ring forming a switch envelope of substantially uniform internal diameter, opposed inwardly extending lateral projections on opposite sides of said ring defining with the floor of said envelope a Venturi passageway, and a body of mercury lying on the floor of said envelope for making and breaking contact between said electrodes, said mercury having accelerated snap movement through said passageway upon tilting of said envelope, one of said electrodes having a lip portion lying flush with the floor of said envelope and extending substantially to the center of said passageway.

10. A mercury switch having a ferrous shell, an insert of insulation in one end of the shell, a ferrous electrode carried centrally of the insert, said shell and electrode being sealed to the insert, a body of mercury in the switch, and a liquid in the shell comprising an amine.

11. In a mercury switch having a fluid tight envelope and provided with ferrous electrodes, a body of mercury, and a liquid in said envelope in contact with the electrodes and the mercury, said liquid comprising an amine.

12. A mercury switch comprising a ferrous shell forming an electrode, a second electrode, an insulator sealed between the electrodes, a body of mercury in the shell for making and breaking contact between said electrodes, and a liquid in contact with the electrodes and the mercury, said liquid comprising an amine.

13. A closed contact making and breaking device comprising a closed envelope provided with ferrous electrodes and a mercury contact which is adapted to be severed to break circuit and to be joined to make circuit, and a liquid in the envelope in contact with the electrode and the mercury, said liquid comprising an amine.

14. The combination of claim 13 wherein the liquid comprises triethanolamine.

15. A mercury switch having a tubular metal shell comprising a main body portion closed at one end and having a portion of larger diameter at the other end, a circular insulator disposed in said open end and having an opening communicating with the main body portion and having an external shoulder facing endwise, said portion of larger diameter having its margin flanged radially inwardly over said shoulder, yielding gasket means between the insulator and the shell to form a fluid tight joint, an electrode carried by the insulator, and a body of mercury in the shell, said communicating opening being defined by a tapered portion flared outwardly toward the closed end of the shell and an enlarged circular recess forming a mercury retaining pocket defined by a sharp circular edge.

16. The combination of claim 15 wherein said electrode is supported axially of the insulator, and has a surface in contact with the mercury trapped in said enlarged recess.

17. A mercury switch comprising a closed end tubular metallic shell having an insert of insulation disposed in its open end, said insert having an external annular projection, a tapered recess being formed in said insert, said recess opening into the inside of the shell, an electrode disposed at the smaller end of said tapered recess and having a stem extending outside the insert, said shell having an enlargement embracing said projection and being sealed thereto, and a body of mercury in said shell.

18. The combination of claim 17 wherein said annular projection has annular shoulders facing in opposite directions, and resilient material being disposed against said shoulders and the ends of said enlargement to provide a tight seal, and resilient sealing means for said stem.

19. A mercury switch comprising a closed end tubular shell having an enlarged portion at the open end, an insert of insulation sealed in said enlarged portion, said enlarged portion having its margin beaded over the end of the insert, yielding gasket means forming a seal between the shell and the insert, and a central electrode carried by said insert and communicating at its inner end with the inside of the shell and a body of mercury in said shell.

20. For use in a mercury switch, an insulator and electrode assembly comprising the combination of a generally cylindrical body of refractory insulation having a longitudinal axis and having a bore comprising a tapered internal surface extending from one end and terminating at its most restricted portion in a sharp shoulder defined by a surface extending substantially radially, an electrode disc supported by said body in axial alignment with said bore and spaced from said surface, there being an internal peripheral groove between said surface and said disc for trapping a body of mercury in contact with said disc.

21. In a mercury switch, a metal shell comprising a first main cylindrical portion and a second portion of larger diameter joined to the first portion by a shoulder and having an inturned flange at its open end, a circular insulator disposed in said second portion of the shell and held against endwise displacement by said shoulder and said flange, an axially disposed electrode

having a stem extending outside of said insulator, and a body of mercury for making contact between the electrode and the shell.

22. The combination in a mercury switch of a metal shell having a first main tubular portion and a second portion of larger diameter than the first portion joined to the first portion by a shoulder, a circular insulator disposed in said second portion of the shell, said insulator having a tapered bore terminating in a sharp annular shoulder defined in part by an annular wall extending substantially radially, an electrode member closing the end of the insulator, there being a groove for retaining a body of mercury between said shoulder and said electrode and in contact with the electrode, said second part of the shell having at its open end an inwardly extending bead, and a washer of insulation disposed between said bead and said electrode, said bead holding the shell, insulator and electrode in fixed relation to seal the shell.

23. The combination in a mercury switch of a generally cylindrical insulator having a longitudinal axis having shoulders at its ends and having an internal tapered portion terminating in an acute angle inwardly facing edge, a first electrode comprising a tubular metallic shell terminating in a peripheral outwardly extending shoulder, a tubular metallic insulator receiving shell of larger diameter than said first shell for receiving said insulator, a second electrode bearing endwise against the other end of the insulator, said second shell being anchored to the first shell adjacent said peripheral shoulder and extending beyond said electrode and having an inwardly extending flange, a washer of insulation between said flange and said second electrode, and insulation between said insulator and both of said electrodes.

24. The combination of claim 23 with a gasket of insulation disposed between the second electrode and said body of insulation, there being a mercury retaining groove for retaining a body of mercury back of said acute angle edge and in contact with said electrode.

25. In a mercury switch, the combination of an envelope provided with iron electrodes, a body of mercury arranged to make and break a circuit between the electrodes, and a liquid in the envelope comprising a substantially anhydrous ethanolamine in contact with said electrodes and said body of mercury.

26. A heavy duty mercury switch comprising an iron shell closed at one end and open at the other, a plug of insulation closing the open end, a body of mercury in the shell, an electrode extending through said plug and adapted to be contacted by said body of mercury, the margins of the open end being beaded over the plug to hold the same firmly in said shell, and a substantially anhydrous ethanolamine in contact with the shell, the electrode and the mercury.

27. A mercury switch of the enclosed type having a metallic shell, an electrode, and an insulator closing the space between the electrode and the shell, a body of mercury, and a liquid ethanolamine in the envelope, the free space in the envelope being occupied by a vapor of said liquid ethanolamine at a pressure below atmospheric.

28. In an enclosed mercury switch, the combination of a tubular cup-shaped shell, an apertured body of insulation abutting the open end of the shell, an electrode member carried on and closing the aperture in said body, said electrode member having a head provided with an annular concave face for engaging the meniscus of a body of mercury, and a body of mercury for making contact with said concave face at its forward convex meniscus surface.

29. In a switch comprising a metallic sealed envelope having a pair of contacts sealed therein, fluid means for effecting contact between said contacts, and an alkaline liquid fill in the interior of said envelope and acting to increase the mobility of said contact means.

30. A mercury switch having a tubular metal shell comprising a main body portion closed at one end and a portion of larger diameter at the other end terminating in a beaded edge portion which extends radially inwardly to provide a retaining flange, a shoulder portion joining said main body portion and said portion of larger diameter, an insulator fitting within said portion of larger diameter and held endwise in one direction by said shoulder portion of the shell and in the other direction by said retaining flange, sealing means between said insulator and said retaining flange, an electrode mounted in said insulator and a body of mercury in said shell which connects the main body portion of the shell and the electrode across a portion of the insulator when the switch is tilted in one direction.

31. The combination of claim 30 wherein the insulator has an internal peripheral groove for retaining a part of said body of mercury in contact with the electrode when the switch is in open circuit position.

32. In a mercury switch a cup-shaped metallic shell, a ceramic insert sealed in the open end of said shell, said insert having an outwardly projecting annular flange, an electrode disposed in said insert and having an outwardly projecting stud, sealing means about said stud, and means engaging said stud and sealing means for compressing said sealing means about said stud, said last-named means being disposed within said annular flange.

33. In a mercury switch, a switch envelope having a ceramic insert in one end thereof, means for sealing said insert in position within said envelope, an axially extending funnel-shaped recess in said insert, an electrode disposed in the small end of said recess, a stud supporting said electrode in said recess, means engaging about said stud and compressible into sealing engagement therewith, and a terminal conductor secured to the end of said stud externally of said sealing means.

34. A mercury switch of the class described comprising a cup-shaped metallic electrode, an insulating insert secured in the open end of said electrode, a second electrode carried by said insert within the open end of said first electrode, an annular groove in said insert forming a mercury retaining pocket, a body of mercury in said pocket contacting with said second electrode, an inclined raceway formed in said insert and extending from the inner surface of said cup-shaped electrode to said annular groove, and a second body of mercury in said first electrode movable through said raceway upon tilting of the switch from a horizontal position into and out of contact with said first body of mercury and constituting the entire current conducting medium between said electrodes.

35. In a switch of the class described, a cup-shaped metallic shell, a ceramic insert in the open end thereof, cushioning means between said insert and said shell, said insert having an out-

wardly flared axial recess opening into said shell and having imperforate side walls, an annular groove at the inner end of said recess, an electrode disposed in the center of the back wall of said recess and spaced from the annular radial surface of said groove, a stable body of mercury in said groove engaging said electrode and standing above the defining edge of said surface, a second body of mercury in said shell having free running movement through said recess to make and break contact with said first body of mercury above said defining edge, said mercury only partially filling the small end of said recess in normal closed position of said switch, and means at the open end of said shell for locking said ceramic in position therein.

36. A mercury switch comprising a cup-shaped metallic envelope having an enlarged open end, an axially recessed ceramic bushing, means for cushioning said bushing with respect to the inner surface of said enlarged end, means integral with said envelope at said end for supporting said bushing in said end and an electrode in said recess supported by said bushing independently of said envelope and sealing means, and a body of mercury adapted to move through said recess to effect contact between said envelope and electrode upon tilting of said switch from horizontal position.

37. A switch for relatively high currents comprising a cup-shaped metallic envelope having an enlarged open end, a ceramic bushing fitting in said end and having an axially extending flared recess opening toward the closed end of said envelope, means for resiliently sealing said bushing in said end of said envelope, an electrode at the smaller end of said recess and supported entirely by said bushing, independent means sealing said electrode with respect to said bushing, and a body of mercury adapted to move through said recess to effect contact between said envelope and electrode upon tilting of said switch from horizontal position.

38. The combination, in a mercury switch having a cup-shaped metallic shell electrode provided with an enlarged open end, of a ceramic insert in said end having an inwardly extending axial bore opening into the interior of said shell, an electrode disposed in said bore and having a shank extending axially outwardly of said insert, said insert being sealed in said open end of said shell and the defining edge of said shell being forced radially inwardly to lock said insert in position, an annular ceramic flange formed about the projecting portion of said shank and having an axial recess defining a chamber about the outer end of said shank, and means in said chamber for holding said shank in position including means effecting electrical connection to said shank adjacent said chamber.

39. An electrode-supporting insert for a metallic envelope type mercury switch having a cup-shaped metal shell electrode provided with an enlarged open end, comprising a ceramic member disposed in said end and having an inwardly directed axial bore opening into said shell, an electrode supported within said bore and having a shank projecting axially outwardly of said member, a ceramic flange portion surrounding the projecting portion of said shank and forming at its outer end an axial recess providing a radial chamber about the outer end of said shank, and means disposed within said recess for sealing said shank, said shank having an electrical conductor connected to said outer end.

40. In a switch having a conducting fluid for completing the circuit, a metallic casing which serves as one of the electrodes of said switch and having an enlarged open end, an electrode having a portion thereof extending into said open end, a ceramic insert in said open end inwardly of said electrode providing a stop for determining the point to which said electrode may extend into the casing, means forming an insulating seal between said electrode and said casing, means of resilient insulating material between said casing and insert and between said insert and electrode, and means comprising a spun-over end on said casing for placing said means of resilient material under a suitable deforming stress and for holding said electrode in position relative to said insert.

41. In a switch, a metallic cup-shaped shell having an enlarged open end, a radial shoulder internally of said shell, a ceramic ring seated axially against said shoulder and having a bore therethrough, an electrode having a peripheral portion in axial abutment with the insert, means of resilient insulating material forming a seal between said shell and said insert, gasket means between said electrode and said shell, a spun-over end on said shell placing said means of resilient insulating material and said portion of said electrode in compression between said shoulder and said end, and a body of conducting fluid in said shell for completing a circuit between said electrode and said shell through said bore in said insert.

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