

Jan. 1, 1963

L. MARTON
MERCURY SWITCH

3,071,673

Filed March 16, 1959

2 Sheets-Sheet 1

Fig. 1.

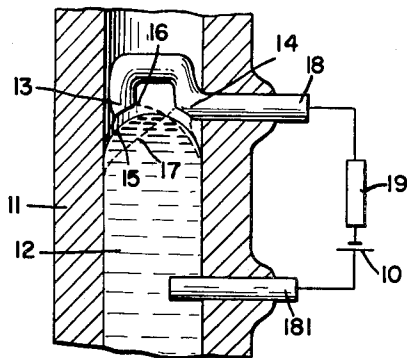


Fig. 2.

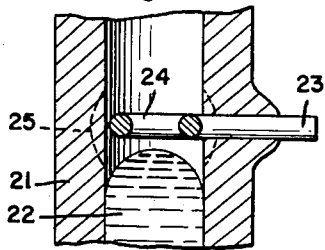
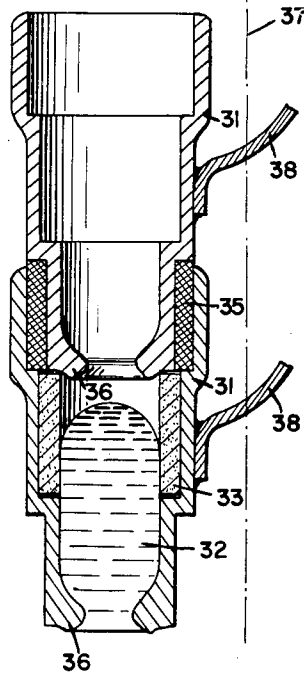


Fig. 3.



INVENTOR

Louis Marton

BY

Townsend and Townsend
Attorneys

Jan. 1, 1963

L. MARTON
MERCURY SWITCH

3,071,673

Filed March 16, 1959

2 Sheets-Sheet 2

Fig. 4

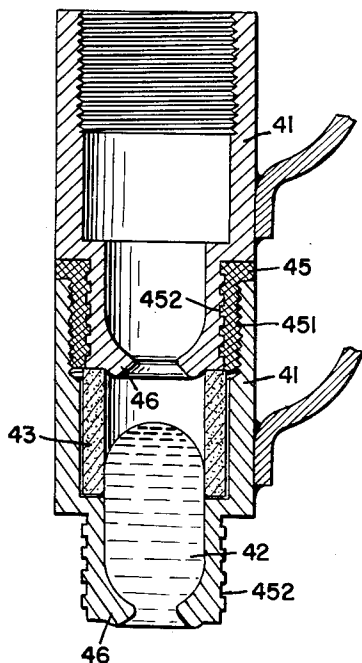


Fig. 6.

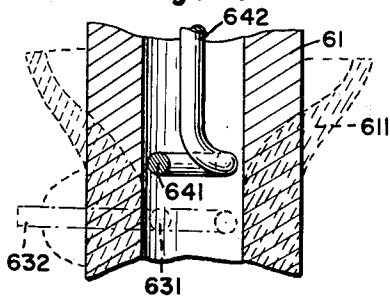


Fig. 5.

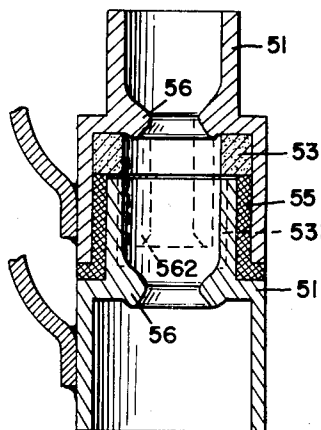
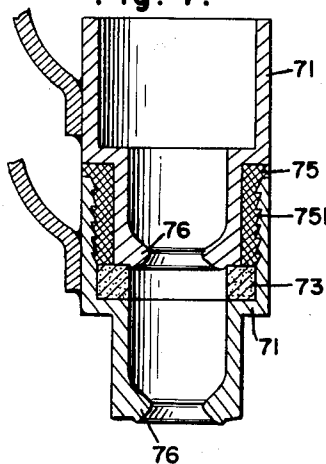


Fig. 7.



INVENTOR

Louis Marton

BY

Townsend and Townsend
Attorneys

1

3,071,673 MERCURY SWITCH

Louis Marton, 2704 College Ave., Berkeley, Calif.
Filed Mar. 16, 1959, Ser. No. 799,500
7 Claims. (Cl. 200—152)

The invention embraces a mercury switch comprising a column of mercury moving axially within a capillary tube of relatively small diameter, one immersed contact reaching into the mercury and, appropriately spaced from said contact, at least one metal switching contact located in the tube along the switching path of the mercury. The known mercury switch types of similar construction possess only a relatively small loadability. They make exclusive use of single metal wire contacts within a narrow capillary tube (approx. under a bore of $\frac{5}{16}$ " where the accommodation of mercury to mercury contacts is hardly feasible unless loadability is greatly reduced), and their single operational pattern does not permit instantaneous switching at slow rate of speed of mercury displacement. It is customary to remove the sensitive exit seal of the contact wire from the vicinity of the arc by elbow-shaped design of the contact wire, and to reduce the detrimental effects of arcing by the provision of a thicker arc-resistant sleeve around the lower end of the contact wire. This alone, however, is unable to improve the making capacity considerably. When such a single contact is employed above a certain load value, the slow approach of the rising mercury column unavoidably brings about the creation of an arc which, in turn, may be sustained and could lead to the failure of the tube. Owing to this, the load must be kept below a certain value so that the application of an auxiliary relay is usually unavoidable for amplification.

It is the purpose of this invention to introduce a simple mercury switch with reduced dimensions, combined with increased shock resistance, a switch permitting direct and instantaneous switching of considerably higher loads without an auxiliary relay.

An essential feature of the invention is represented by its arrangement employing at least one switching contact consisting of at least two, electrically and mechanically rigidly interconnected metal contact elements accommodated at the same height on opposite sides within the tube, arranged symmetrically with respect to the nearly hemispherical mercury surface subjected to the influence of surface tension. In the absence of the second metallic contact element of the double contact unit, the flashover between the mercury and only metal contact element, occurring at the commencement of the switching process, would develop into an arc provided the limits for arc creation are exceeded. However, if the capillary tube is provided with the double contact feature proposed by the invention, a flashover to one contact element of the double contact unit creates a pressure gradient which is no longer symmetrical with respect to the longitudinal axis of the tube. This pressure rise in turn throws the mercury surface instantaneously against the opposite element of the double contact unit, thus bridging and immediately quenching the arc burning at the other contact element. (This phenomenon will be briefly referred to as "Double Contact Effect" in the following.) The arrangement of the metal contact elements suggested by the invention, provides for smooth and sufficiently large metallic surfaces to which, due to the influence of the passing of current, mercury will adhere vigorously until its level is sufficiently lowered to provoke instantaneous separation. The immediate vaporization of the last mercury path bridging the gap creates an instantaneous pressure rise which, combined with the contact separation just established, may even afford an arc-free interruption up to substantially increased outputs.

2

According to a further essential feature of the invention, the switching contact may comprise more elements (multiple contact) or, as the number of elements approaches infinity, it may assume the form of a metallic ring contact supported concentrically with the axis of the narrow tube, with its plane perpendicular to the axis. All kinds of similar contacts (double-, multiple-, or ring contacts) are simple and cheap to manufacture by bending or pressing from wire or sheet metal.

According to another essential feature of the invention, the mercury switch may comprise at least two tubular elements of conducting media, which are insulated from each other. At least one of these is provided with a tubular extension formed to serve as a double-, multiple-, or ring contact. In this manner the switch can be built up from a multiplicity of tubular contact elements in the appropriate number to suit switching requirements, each element operating in accordance with the advantageous double contact effect outlined in the foregoing.

Further essential features will become apparent on the basis of the following description. Various exemplary embodiments of the invention are illustrated in the accompanying drawings.

FIGS. 1, 2 and 6 show axial cross sections of switches employing envelopes of non-conducting material, and . . .

FIGS. 3, 5 and 7 are longitudinal cross sections of switches built up from tube elements of conducting material insulated from each other.

Referring to the drawings, in which like numerals identify similar parts throughout, it will be seen from FIG. 1 that a narrow capillary tube built up from an envelope 11 of non conducting material, say glass and a mercury column 12 moves axially inside said tube. The surface of the mercury, in accordance with the bore of the capillary tube, tends to form an approximate hemisphere 15 due to the influence of surface tension. At least two electrically and mechanically rigidly interconnected metal contact elements 13, 14 are accommodated with their rounded off flat surfaces towards the mercury at the same height on opposite sides in capillary tube, arranged symmetrically with respect to surface 15 of the mercury. The contact element 13, 14 provide a double contact unit connected to the current source 10 through terminal 18. Contact 18.1 reaching into the mercury 12 affords the second terminal of the switch in the form of an immersed contact.

The mode of operation of the mercury switch is the following . . .

As soon as the slowly rising mercury column 12 approaches the vicinity of contact elements 13 and 14, the applied voltage brings about a flashover to one of the two metal contact elements, say element 14, where a small switching spark will occur. Were element 14 the only contact provided, an arc would be established and sustained. However, if a double contact unit is employed, only a brief mercury vapour generation will take place at element 14. This in turn creates a pressure responsible for pushing over the mercury surface from its original contour 15 to a new position like the one represented by contour line 16. This way the contact established between the mercury and contact element 13 bridges and instantaneously extinguishes the transitory spark created at contact element 14. Current is now passed by element 13 alone; the mercury is unable to separate from the latter because its adhesion to the metal surface is being enhanced by the influence of current passing through the contact area, and also because the surface tension tending to reestablish the original hemispherical surface is too small. These effects lend the switching process such a high efficiency that multiples of the loads normally attained with the single metal contacts, are easily handled with as much as a small switching spark.

As soon as the mercury starts to recede, the interruption of the circuit is accomplished instantaneously, no matter how slowly the mercury withdraws. The mercury is free to separate from one of the elements of the double contact unit 13, 14, so that the entire current is now passed by only one element. Due to the effect of the passing of current, mercury adheres persistently to the rounded flat metal surface of the contact element so that it has to withdraw about an extent equal to the radius of the bore of the capillary tube before the bridge of mercury between the mercury column and the contact element is severed. When the bridge is sufficiently drawn out, separation is instantaneous, accompanied by a brief spark (see FIG. 1, contour line 17). In this instant the droplets of the narrowing mercury bridge are evaporated so violently that no incandescent spot remains to serve as a base for the arc. As the surface of metals remains cold, the persistence of an arc is impossible even when handling D.C. currents amounting to multiples of the normal current range. As soon as the break is accomplished and the mercury assumes its original hemispherical form, contact separation will amount to an extent about equal to the radius of the bore. The recurrent voltage is no longer adequate to reestablish an arc.

The contact design illustrated in FIG. 1 represents a solution making use of a double contact unit with two elements, which is the minimum number of contact elements suitable for the realization of the principle put forward by the invention. The actual construction however, may employ a multiple contact assembly as well, consisting of several opposed contact pairs at the same height in the tube, interconnected with one another both electrically and mechanically. A ring-shaped contact can be made in this manner, employing any number of shaped contact elements. Increasing the number of elements to infinity, a ring-shaped contact would result with a smooth round surface.

The contact in FIG. 2, taking the form of a smooth ring, readily lends itself for application in glass switch envelopes. The mercury column 22 moves axially within a glass envelope 21 provided with a concentric ring contact 24 with its exit end serving as a terminal 23. Readily bent or pressed from wire, resp. sheet metal, contact 24 is supported with its plane perpendicular to the axis of the tube. In some cases it might be feasible to employ a ring contact with increased diameter. If so, it is advisable to expand the tube in the vicinity of the ring contact by blowing (according to dashed line 25). This also promotes the ease of fusing the contact into the tube wall.

The exemplary embodiment of a switch assembly in FIG. 3 comprises a combination of a metal tube element 31, a synthetic sleeve 35 and a tubular refractory liner 33. With their diameters decreasing in three steps, the metal tube elements 31 are assembled with the insertion of synthetic sleeves 35 between them, providing electrical insulation as well as vacuumtightness. A liner is accommodated within the middle section of the tube element 31, made of a fireproof material, for instance quartz or ceramic. The narrower end section of tube elements 31 is provided with a concentric extension 36 shaped to serve as a multiple or plain ring contact. With the aid of tube elements of identical shape, it is possible to assemble a mercury switch featuring any desired number of subsequent switching contacts. In order to enhance the rigidity and vacuumtightness of the entire switch assembly, it is feasible to mould it in a plastic jacket using any known jacketing method (see contour 37).

The switch shown in FIG. 4 is composed of tube elements featuring only one shoulder. In order to enhance the safety of the connections between the successive tube elements, the inner, resp. outer peripheries 451, 452 of the end sections of the tube elements are provided with surface grooves or threading.

FIG. 5 also illustrates an assembled capillary tube made

of metal. Each of the single-shouldered tube elements 51 carries one contact 56 and also a fireproof liner 53. The synthetic sleeve 55 serves to interconnect the two elements.

It is often required that two successive contacts be operated, one directly after the other, by only a minute displacement of mercury. This mode of operation is easy to realize with the aid of the extended form 562 of the top contact 56. This affords a pair of contact elements with the smallest possible gap between them. The minimum contact spacing is determined solely by the insulation strength of the gap so that no more than a few hundredths of an inch are required up to several hundred volts. If a contact extension like 562 is used, it is recommended to provide the fireproof insert 53 in the form of an extended tubular liner 531.

A design using a glass envelope may be seen in FIG. 6, with a similar, closely-spaced pair of contacts. Contact 631 corresponds to contact 24 in FIG. 2. Contact 641 may be accommodated as close to it as required. It is advisable to provide contact 641 with an axial stem 642, bending this off a little higher in order to carry it through wall 61 resp. 611. This construction may prove helpful under heavier loads even when only the upper contact 641 has to be accommodated at the end of the tube.

An exemplary embodiment of the invention is displayed in FIG. 7 featuring a construction similar to the one in FIG. 5. The only deviation is that contact extension 76 is not in the middle but rather at the end of the narrower tube section.

Grooves featuring a sawtooth profile 751 are provided on the jointing surface of tube 71, in order to provide a safer grip for the synthetic insulating sleeve.

In order to prevent the tube wall against arcing damage, a refractory liner might be employed under the contact even in switches having envelopes of insulating material.

For the sake of simplicity, only plain ring contacts were shown in FIGS. 2 to 7. Nothing would prevent however, the employment of double or multiple contacts, or a combination of these, if such fulfill manufacturing or service requirements better.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A mercury switch comprising a capillary tube, a body of mercury within said tube, connector means to form electrical contact to said body of mercury, and electrode means mounted within said tube, said electrode means having at least two mercury engaging contact areas, each said area being spaced inwardly from the inner wall of said capillary tube, each said mercury engaging contact area having at least one face disposed at an angle substantially tangential to the adjacent surface of the body of mercury within said tube whereby the surface of the mercury is arranged to simultaneously engage all said mercury contact areas when the surface of the mercury is brought into immediate proximity of said contact areas to establish electrical contact between the electrode means and said connector means.

2. A switch according to claim 1 and wherein said electrode means comprises an annular member disposed at an angle substantially normal to the longitudinal axis of said tube formed by a conductive body having a round cross-sectional configuration.

3. A mercury switch according to claim 1 and wherein said electrode means comprises a conductive member having a first face adjacent one side of the tube and a second face adjacent the opposite side of the tube, said first and second faces each being disposed at an angle tangential to the upper surface of mercury within said tube.

4. In a mercury contact switch the combination of a capillary tube, a body of mercury within said tube, first electrical contact means in electrical contact with said body of mercury, and second electrical contact means

5

mounted within said tube at a position further away from the body of mercury within said tube than said first electrical contact means, said second electrical contact means comprising a plurality of electrically interconnected mercury contact areas disposed inwardly from the wall forming said capillary tube, a portion of said contact areas being disposed at an angle substantially tangential to the adjacent surface of said body of mercury.

5. The combination of claim 4 and wherein the contact areas of said contact means are bordered by curved edges.

6. In a mercury contact switch the combination of a capillary tube, a body of mercury within said tube, and first electrical contact means in electrical contact with said body of mercury, said first electrical contact means comprising a plurality of mercury contact areas disposed inwardly from the wall forming said capillary tube, a portion of said contact area being disposed at an angle substantially tangential to the adjacent surface of said pool of mercury having second electrical contact means mounted within said tube above said first electrical contact means, said second electrical contact means comprising a plurality of mercury contact areas disposed inwardly from the wall forming said capillary tube, said contact area of said second contact means being disposed at an angle substantially tangential to the adjacent surface of said pool of mercury, said contact areas of said first electrical contact means being electrically connected together

6

and said contact areas of said second electrical contact means be electrically interconnected together.

7. A mercury contact switch comprising a capillary tube, the mouth of said tube being formed of a larger diameter than the remainder of said tube, a second capillary tube mounted within the mouth of said first tube and having a neck portion having an outer diameter smaller than the mouth of said tube and an inside diameter substantially equal to the inside diameter of the body of said first tube, insulating means electrically insulating said first and second tubes from each other, electrical contact means connected to each tube and extending inwardly into the tube, each contact means being disposed on a plane substantially normal to the longitudinal axis of said tubes, a pool of mercury within said tube, each contact means having at least one face disposed in tangential relationship to the adjacent surface face of mercury within said tube.

References Cited in the file of this patent

UNITED STATES PATENTS

437,069	Wiesebrock	Sept. 23, 1890
1,658,620	Walker	Feb. 7, 1928
2,045,003	Staley	June 23, 1936
2,297,924	Trautman et al.	Oct. 6, 1942
2,851,618	Krawinkel	Sept. 9, 1958
2,959,650	Hajny	Nov. 8, 1960