Feb. 14, 1933. R. D. MAILEY 1,897,485

MAGNETICALLY OPERATED LOW RESISTANCE FLUID FLOW SWITCH

Filed March 21, 1931

Fig. 1

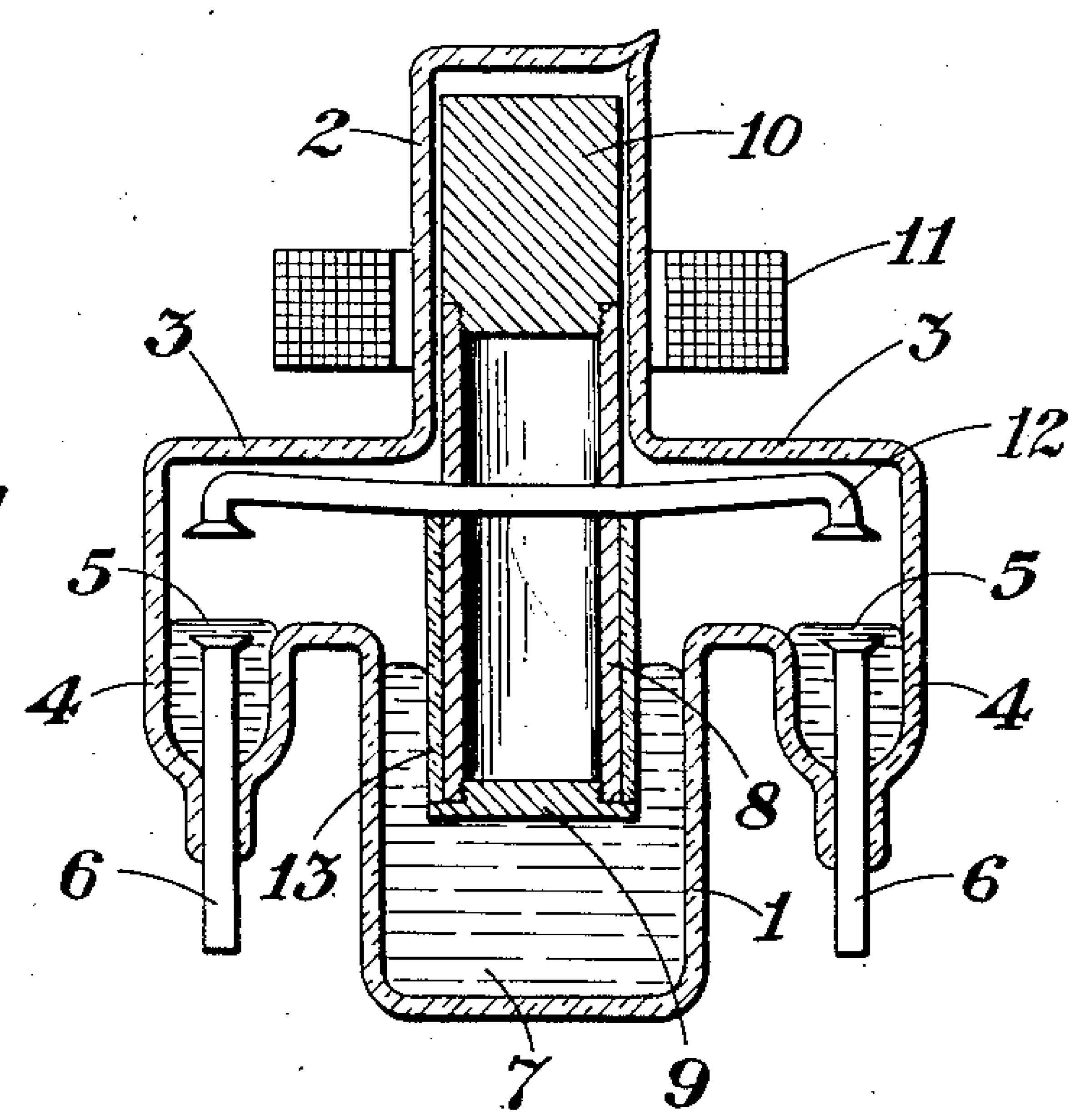
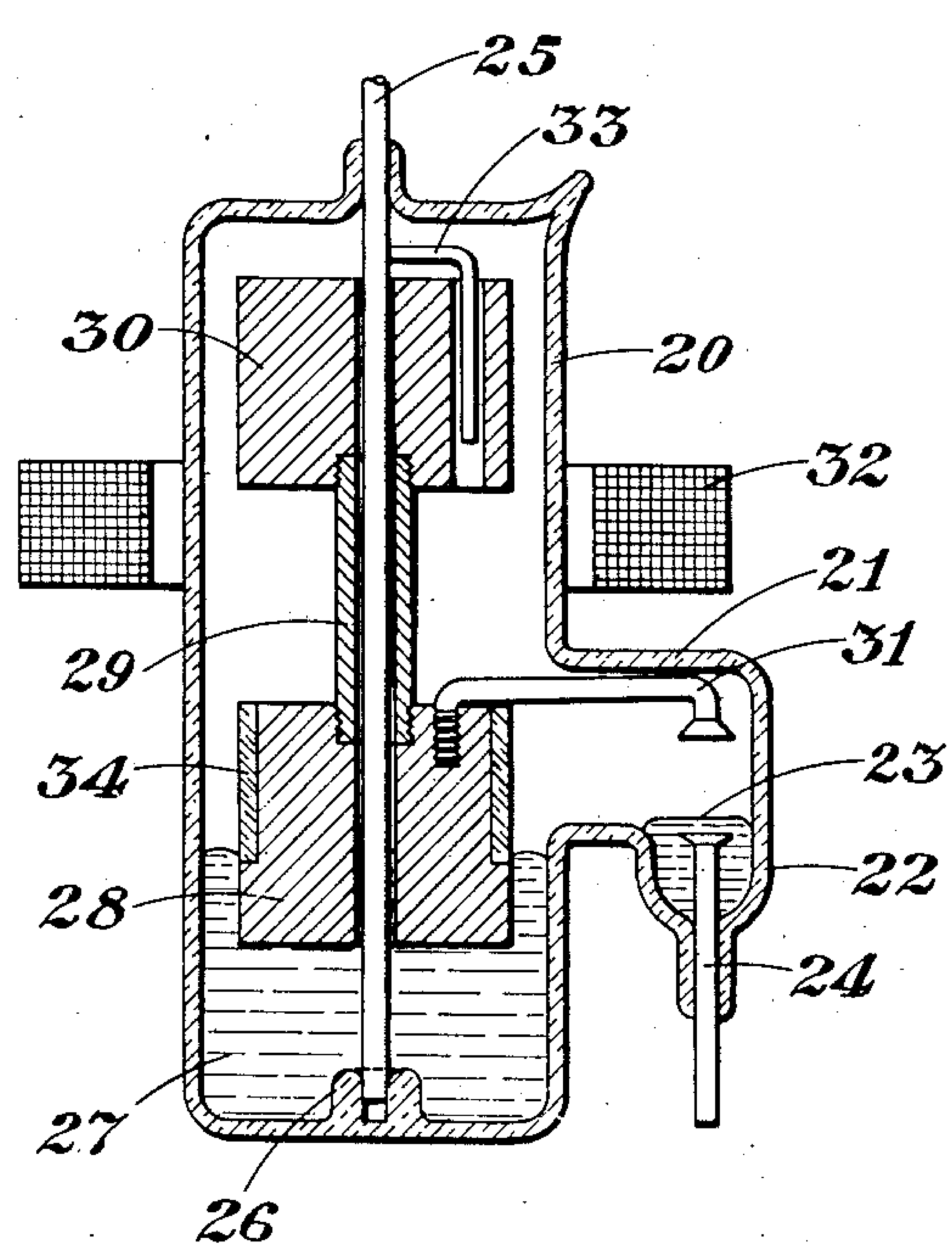


Fig. 2



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MAGNETICALLY OPERATED LOW RESISTANCE FLUID FLOW SWITCH

Application filed March 21, 1931. Serial No. 524,377.

The present invention relates to fluid flow switches, and especially to magnetically operated switches which are adapted for use in circuits carrying relatively large currents.

The invention consists in a fluid flow switch of novel construction, and in a novel method of operating the same as hereinafter set forth and claimed.

A particular object of the invention is to provide a fluid flow switch having a relatively large current capacity. Another object of the invention is to provide a switch having a low internal resistance. Still another object of the invention is to provide a magnetically operated switch of simple construction having the aforesaid characteristics. Another object of the invention is to provide a fluid flow switch of the magnetic type which will withstand severe jolting. A further object of the invention is to provide a novel method of operating such a fluid flow switch. Other objects and advantages of the invention will appear from the following detailed specification, or from an inspection of the accompanying drawing.

The current rating of electrical switches is determined, as is well known, by two factors; the current which they can safely interrupt, and the current which they can continuously carry without undue heating due to the internal resistance thereof. In switches of the fluid flow type the emphasis has been on the first of these factors, hence in this type of switch the metallic inleads have invariably been spaced a considerable distance apart, in order to permit the arc of rupture to be drawn out sufficiently to extinguish it. This construction obviously necessitates the use of a relatively long fluid path to complete the circuit through the switch when it is in a closed circuit position. A long fluid path is, however, highly undesirable from the standpoint of the second factor mentioned above, due to the fact that any of the fluids which are ordinarily used have a relatively high specific resistance. For example, mercury, the fluid almost universally used, has a specific resistance which is approximately twenty times that of tungsten, and sixty times that of copper. Hence from the standpoint of minimum internal resistance, and thus of minimum heating, it is obvious that the fluid path between the inleads should be as short as possible, especially since the effective conducting area of the fluid path is limited by practical considerations, such as maximum dimensions for the switch, weight, cost, and the like. It would thus appear that additional current carrying capacity could be obtained in a practical switch only by a sacrifice of the rupturing capacity, with the result that there has been heretofore a more or less definite limit to the capacity of commercially practical switches.

I have now discovered, however, that a fluid flow switch of the so-called magnetic type, in which the circuit is opened or closed by displacement of the fluid conductor through magnetic movement of a float, may be so constructed that the length of the path which the current must traverse through the fluid is materially reduced after the circuit through the switch has been closed, and again increased before the circuit through the switch is interrupted between fluid pools in the usual manner. This new result, which permits extremely large currents to be continuously carried in a switch without any impairment or limitation of the current rupturing capacity, is obtained in a very simple manner. According to a preferred form of my invention a metallic bridging member is carried by the aforesaid float, whereby said bridging member is caused to enter the fluid and reduce the length of the fluid path which must be traversed by the current after the circuit through the switch has been closed by fluid flow. Thus the internal resistance of the switch is very materially reduced, so that large currents can be continuously carried thereby without undue heating. My new bridging member moreover also performs another function in a preferred embodiment of my invention. This type of switch is, as is well known, peculiarly subject to damage by jolts and shocks due to the relatively massive parts which are freely movable therein. As a result of the serious breakage losses which have thus been suffered, especially during shipment, when the cushioning effect of the fluid could not be relied upon to prevent rapid movement of these parts, this type of switch has never gone into extensive use, despite the manifest advantages thereof. I have now discovered that the resilience of my new bridging member may be relied upon to absorb any shocks or jolts which would otherwise destroy the vitreous member. As a result, my new switch not only has a current capacity which is far beyond that of any switch heretofore proposed of commensurate size, but it also is exceptionally resistant to damage by rough handling, so that it may be shipped without danger of breakage.

For the purpose of illustrating my invention I have shown two embodiments thereof in the accompanying drawing, in which

Fig. 1 is a sectional view of a fluid flow switch of the magnetic type, shown in an open circuit position, and

Fig. 2 is a sectional view of a modification of the switch of Fig. 1.

In this drawing, with special reference to Fig. 1, there is shown a fluid flow switch having a sealed envelope comprising a tubular chamber 1, the vertical tubular extension 2 thereof, and two chambers 3 which open into opposite sides of said tubular chamber 1 near the top thereof. Said envolope may be made of any suitable vitreous material, such as lead or lime glass, but where large currents are to be interrupted I prefer to use one of the more refractory vitreous materials, such as a borosilicate glass or fused silica. A cup 4 is formed in each of the chambers 3 at the outer end thereof, in each of which there is retained a mercury pool 5. An inlead 6, which is preferably made of tungsten when the switch envelope is made of a borosilicate glass, is sealed into each of the aforesaid cups 4, each inlead extending upwardly to a point just below the surface of one of said mercury pools 5. The tubular chamber 1 contains a mercury pool 7, on which floats a plunger comprising a tubular body 8 tightly closed at the bottom by a suitable cap 9 and at the top by the magnetic core 10, said plunger extending into and being freely movable axially within the upward extension 2 of the aforesaid chamber 1. A coil 11 which is positioned about the aforesaid extension 2 serves to depress said plunger into the mercury 7 at will, raising the level of said mercury until it merges with the pools 5. A bridging conductor 12 which is carried by the tubular body 8 extends into each of the chambers 3 to a point directly above the inleads 6, the ends thereof being preferably turned downwardly toward said inleads. Said bridging conductor is normally out of contact with the mercury pools 5, but is moved into contact therewith after said pools have been merged with the mercury pool 7, further movement of the magnetically operated plunger causing the bridging conductor to make contact with each of the inleads 6, the ends of said bridging conductor and of said inleads preferably being flanged to ensure registry thereof despite any slight rotational movement of the magnetic plunger. Said bridging conductor 12 is also preferably curved upwardly toward each end, so that excessive upward movement of the magnetic plunger will be arrested by these upwardly curved portions of said bridging conductor moving into contact with the vitreous walls of the chamber 3, thus not only transferring the impact to the portion of the envelope which is best capable of resisting it, but also utilizing the resilience of the bridging conductor 12 to reduce the severity thereof. In some cases the bridging conductor 12 is flattened out in order to increase this resilience. The lower end of the tubular body 8 is preferably enclosed in a vitreous sheath comprising a tube 13 which is slipped thereon and which is conveniently held in a fixed position against the bridging conductor 12 by the cap 9. The bridging conductor 12 is ordinarily formed of tungsten, but in cases where a very low resistance is desired it is made of a better conductor, such as copper which has been plated or coated with nickel or chromium to prevent contamination of the mercury. When the coil 11 is to be energized by direct current the tubular body 8 and the cap 9 are preferably made either of a metal which will not contaminate mercury, such as a chrome-iron alloy, or of any other suitable metal plated with chromium or the like to prevent contamination of the mercury. When the coil 11 is to be energized by a pulsating or alternating current, however, these parts are preferably formed of porcelain, or an equivalent structure is formed of a suitable vitreous material such as glass, fusedsilica or the like, the vitreous tube 13 then being omitted. The iron core 11 is also preferably laminated to prevent undue heating thereof, it being convenient to extend the tubular body 8 upwardly in this case to aid in confining the laminations. A suitable arc suppressing gas, such as hydrogen, is sealed within the envelope of the switch.

The switch shown in Fig. 2 has a sealed vitreous envelope in the form of a tubular chamber 20 with a side chamber 21 opening into the side thereof at some distance from the bottom. A cup 22 is formed in the outer end of said side chamber 21 in which a pool of mercury 23 is retained. An inlead 24 which is sealed through the bottom of said cup extends nearly to the surface of said mercury pool. An inlead 25 which is sealed through the upper end of the chamber 20 extends axially within said chamber into the boss 26 on the bottom thereof. Said inleads are of tungsten, or of chromium plated copper, or the like. The chamber 20 contains a large pool 27 of mercury, on which floats a cylindrical electrically conducting body 28. Said conducting body, which may be conveniently formed of chromium plated copper, has a central opening therein through which passes the inlead 25, said body being freely slidable thereon. A tube 29 which surrounds the inlead 25 and which is threaded into the floating body 28 supports at its upper end the magnetic core 30 which likewise has a central opening therein for the inlead 25. A bridging conductor 31 extends from the floating body 28, with which it makes a good electrical contact, into the side chamber 21 to a point above the inlead 24, at which point it turns downwardly a short distance. A coil 32 which extends about the chamber 20 at a point somewhat below the normal level of the iron core 30 serves, when energized, to attract said core and thereby depress the floating body 28 sufficiently to cause the mercury pools 23 and 27 to merge and the end of the bridging conductor 31 to move into contact with the inlead 24. The ends of said inlead and of said bridging member are preferably flanged to ensure an appreciable area of registry, despite any slight rotation of the floating body 28 which may be permitted by movement of the bridging conductor 31 between the walls of the side chamber 21. Where desired, however, an additional guide member 33 which is conveniently supported by the inlead 25 is used, said guide member entering a suitable hole in the core 30, whereby all of the floating parts are maintained in a fixed rotational position. In order to prevent the arc of rupture striking to the floating body 28 that portion of the side wall thereof which extends above the mercury 27 is preferably enclosed in a suitable vitreous sheath. As shown, this is conveniently done by placing a glass tube 34 about said body, said tube resting on a shoulder on said body and being locked in position by the bridging conductor 31. The bridging conductor 31 is also utilized to absorb the shocks caused by abnormal movements of the movable parts of the switch, as in the switch shown in Fig. 1, the end portion of this conductor being the first to engage the envelope wall upon upward movement. When the coil 32 is to be operated on alternating current, it is obvious that the magnetic core 30 should be laminated to reduce eddy current loss, and that the tube 29 should have a slit therein for the same reason. In some cases it is desirable to mold the core 30 of magnetizable particles intermixed with any binder which may be easily degassed, instead of using the more conventional laminated structure. A suitable arc suppressing atmosphere, such as hydrogen, is sealed within the switch envelope.

In the use and operation of the switch of Fig. 1, the switch being in the open circuit position as shown, upon passage of an electric current through the coil 11 the core 10 is drawn downwardly causing a displacement of the mercury 7. The level of the mercury pool 7 thereupon rises, causing said pool to merge with the mercury pools 5. A circuit is thereupon closed between the inleads 6 through a relatively long path in the mercury. Further movement of the core 10 then causes the bridging conductor 12 to make contact at each end with the rising mercury, after which still further movement of said core causes the bridging conductor to come into direct contact with the inleads 6, greatly reducing the resistance of the circuit between said inleads. It will be noted that the proper sequence of these operations is ensured, due to the fact that the mercury must be displaced sufficiently to close the circuit before the bridging conductor 12 can be depressed enough to make contact with said mercury. Upon deenergization of the coil 11 the magnetic core is allowed to rise, whereupon the level of the mercury 7 starts to fall. The bridging conductor 12 soon rises above the level of the mercury, but no arc of rupture occurs since a circuit is still closed between the inleads 6 through the mercury. As said bridging conductor reaches a point well above said mercury the latter reaches the level at which the mercury 7 again separates from the pools 5, with an ensuing arc of rupture, which usually occurs at one or the other of said pools, as the circuit through the switch is interrupted, this arc of rupture being rapidly suppressed by the hydrogen atmosphere. The bridging conductor being well above the level of the mercury at this time, there is no danger of the arc striking thereto, while the vitreous tubing 13 prevents the arc from striking to the tube 8. It is obvious that the separation between the pools 5 and the pool 7 at the moment of rupture may be made as long as desired in a switch of my novel construction, without in any way increasing the length of the fluid path traversed by the current when my switch is fully closed. Hence this switch is especially adapted to operate with extremely large currents, of the order of 100 amperes or more. Moreover, with a switch constructed as shown and described, any sudden movement of the plunger in an upward direction will be arrested by the bridging conductor making contact with the walls of the chambers 3. Due to the resilience of this bridging conductor, which need not be very great to be effective, the impact on the envelope is reduced, and at the same time is directed to a part of said envelope which can best withstand the impact. Similarly, any sudden movement of the plunger in the opposite direction will be arrested by contact of the flanged ends of said bridging conductor 12 with the inleads 6, said bridging conductor again tending to reduce the shock by virtue of its resilience. In some cases where it is desired to direct this reduced shock to the envelope rather than to said inlead I omit the flanged ends on said bridging conductor 12, and double the ends of said conductor back under the main portion thereof, said ends extending inwardly far enough to make contact with the lower walls of the chambers 3 between the cups 4 and the main chamber 1 when the plunger is moved downwardly. With this construction said bridging conductor has an even greater effective length, and therefore greater resiliency, when it is absorbing downward shocks than it has when it is absorbing upward shocks, and in addition causes the shock to be directed to a preferred position of the envelope. Since the bridging conductor 12 still very closely approaches the inleads 6 at the moment its movement is arrested by contact with the lower wall of the chamber 3, it is obvious that the fluid path traversed by the current in the fully closed position of the switch is extremely short, and that the switch has, therefore, an extremely low internal resistance, despite this modification. As a result of this absorption and redirection of shocks my new switch, with either of these constructions, is singularly immune to damage by rough handling, such as is ordinarily experienced in transit.

The operation of the switch of Fig. 2 is similar to that of Fig. 1. In this switch, when a current is passed through the coil 32 the magnetic core 30 is drawn down, forcing the floating body 28 into the mercury 27. The level of the latter thereupon rises until said pool 27 merges with the pool 23. Current thereupon flows from the inlead 25 through a relatively long path in the mercury 27 to the inlead 24. Upon further depression of the floating body 28 the end of the bridging conductor 31 is moved downwardly into said mercury and into contact with the inlead 24. Since the latter contact is always made below the surface of the mercury it is evident that a good electrical connection is always established. Practically all of the current thereupon flows through the path of extremely low resistance thus established from the inlead 25 through a short path of large area in the mercury 27 to the floating body 28, and thence through the conductor 31 to the inlead 24. This circuit, due to its low resistance, is especially adapted to continuously carry very large currents. Upon deenergization of the coil 32 the floating body 28 is buoyed up by the mercury 27, carrying the bridging conductor 31 away from the inlead 24, and causing it to move above the level of the mercury 27 which is, of course, simultaneously falling. No arc of rupture occurs at this time, however, due to the fact that a circuit is still closed between the inleads 24 and 25 through a relatively long fluid path. As the mercury level continues to fall the pool 27 again separates from the pool 23, disrupting the circuit through the switch. An arc of rupture thereupon occurs between said pools, this arc, however, being quickly suppressed by the hydrogen atmosphere. Since the bridging conductor has been raised well above the mercury surface before the circuit is opened there is no likelihood of this arc of rupture striking thereto. The floating body 28 is also amply protected from this arc by the vitreous tubing 34. It will be obvious, moreover, that the bridging conductor 31 functions in the same manner as the bridging conductor 12 of the switch of Fig. 1 in reducing and directing any impacts of the movable parts of the switch on the envelope thereof due to rough handling.

While I have described my invention by reference to specific embodiments thereof it is to be understood that it is not limited thereto, but that various omissions, substitutions and changes, within the scope of the appended claims, may be made therein without departing from the spirit of my invention.

I claim as my invention:

1. A fluid flow switch comprising a sealed envelope, inleads sealed into said envelope, a conducting fluid in said envelope, the normal level of said fluid being insufficient to connect said inleads, a body floating on said fluid, a bridging conductor carried by said floating body, and means to depress said body into said fluid at will to connect said inleads by way of a long fluid path and then to move said bridging conductor to diminish the length of said path.

2. A mercury switch comprising a sealed envelope, inleads sealed into said envelope, mercury in said envelope, the normal level of said mercury being insufficient to connect said inleads, a body floating on said mercury, a resilient bridging conductor carried by said floating body, and means to depress said body into said fluid at will to connect said inleads by way of a long fluid path and then to move said bridging conductor to diminish the length of said path, a free end of said bridging conductor serving to limit the movement of said floating body.

3. A fluid flow switch comprising a sealed envelope having a main chamber and a chamber extending laterally therefrom, an inlead sealed into said lateral chamber and another inlead sealed into another part of said envelope, a conducting fluid in said main chamber, the normal level of said fluid being insufficient to connect said inleads, a body floating on said fluid, a resilient bridging conductor carried by said floating body and extending into said lateral chamber, and means to depress said body into said fluid at will to connect said inleads by way of a long fluid path and then to move said bridging conductor to diminish the length of said path, the end of said bridging conductor which

extends into said lateral chamber serving to limit the movement of said floating body.

4. A mercury switch comprising a sealed envelope having a main chamber and a chamber extending laterally therefrom, mercury in said main chamber, an inlead sealed into said lateral chamber and another inlead sealed into another part of said envelope, a body floating on the mercury in the main chamber, a bridging conductor carried by said floating body and extending into said lateral chamber, and means to depress said body into said mercury at will to connect said inleads by way of a long fluid path and then to move said bridging conductor into contact with the inlead in said lateral chamber to diminish the length of said path.

5. A mercury switch comprising a sealed envelope having a main chamber and two chambers extending laterally therefrom, mercury in said main chamber, a mercury pool in each of said lateral chambers, an inlead sealed into each of said pools, a body floating on the mercury in said main chamber, a bridging conductor carried by said floating body and extending into each of said lateral chambers, and means to depress said body into said mercury at will to cause the mercury in said main chamber to merge with said mercury pools, and then to move said bridging conductor below the surface of the mercury in said lateral chambers.

6. A mercury switch comprising a sealed envelope having a main chamber and two chambers extending laterally therefrom, mercury in said main chamber, a mercury pool in each of said lateral chambers, an inlead sealed into each of said pools, a body floating on the mercury in said main chamber, a resilient bridging conductor carried by said floating body and extending into each of said lateral chambers, and means to depress said body into said mercury at will to cause the mercury in said main chamber to merge with said mercury pools, and then to move said bridging conductor below the surface of the mercury in said lateral chambers, the ends of said bridging conductor serving to limit the movement of said floating body.

7. A mercury switch comprising a sealed envelope having a main chamber and a chamber extending laterally therefrom, mercury in said main chamber, a mercury pool in said lateral chamber, an inlead sealed into said main chamber, an inlead sealed into said mercury pool, a body floating on the mercury in said main chamber and extending about the first mentioned inlead, said body being electrically conducting, a bridging conductor carried by said floating body and extending into said lateral chamber, and means to depress said floating body into said mercury at will to cause the mercury in said main chamber to merge with said pool and then to move said bridging conductor below the surface of said mercury in juxtaposition to the inlead sealed into the lateral chamber.

8. A mercury switch comprising a sealed envelope having a main chamber and a chamber extending laterally therefrom, mercury in said main chamber, a mercury pool in said lateral chamber, an inlead sealed into said main chamber, an inlead sealed into said mercury pool, an electrically conducting body slidable upon the first mentioned inlead and floating on the mercury in said main chamber, a resilient bridging conductor carried by said body and extending into said lateral chamber, and means to depress said body into said mercury at will to cause the mercury in said main chamber to merge with said pool and then to move said bridging conductor below the surface of said mercury in juxtaposition to the inlead sealed into the lateral chamber, the end of said bridging conductor serving to limit the movement of the floating body.

Signed at Hoboken, in the county of Hudson and State of New Jersey, this 20th day of March, A. D. 1931.

ROY D. MAILEY.