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LOW RESISTANCE FLUID FLOW SWITCH

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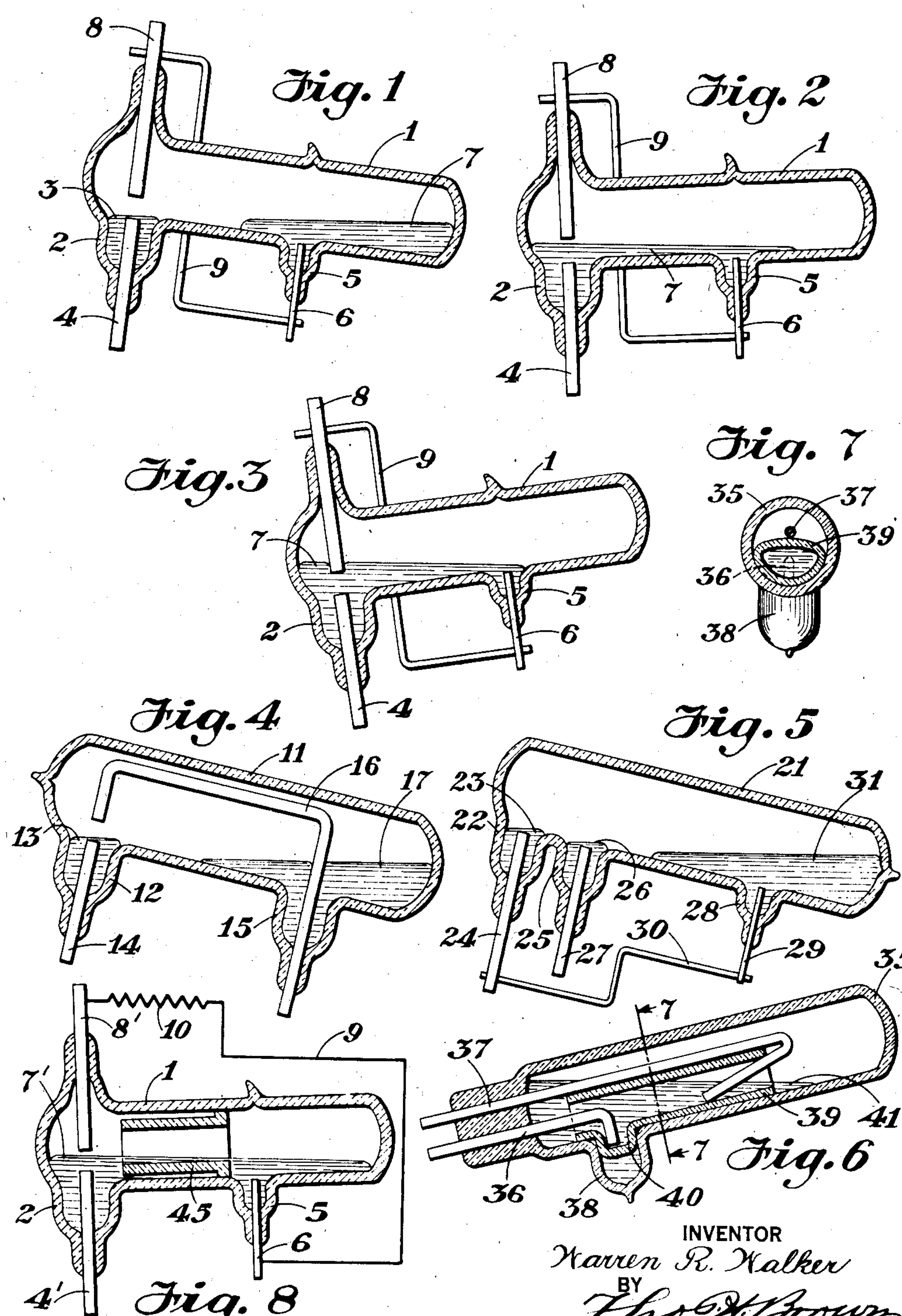

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UNITED STATES PATENT OFFICE

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LOW RESISTANCE FLUID FLOW SWITCH

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The present invention relates to fluid flow switches, and particularly to fluid flow 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 the 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 which will have a high current capacity. Another object of the invention is to provide a switch having a low internal resistance. A further object of my invention is to provide a switch of extremely simple construction having the aforesaid characteristics. Still another object of my invention is to provide a novel method of operating a fluid flow switch. Other objects and advantages of my 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; one the current which they can safely interrupt, and the other the current which they can continuously carry without undue heating due to the 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 to a sufficient length 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 as great as 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 inleads should be as short as possible, especially since the effective conducting area of the fluid connector 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 corresponding loss in rupturing capacity, with the result that there has been heretofore a more or less definite limit to the capacity of commercially practical fluid flow switches.

I have now discovered that this limitation can be overcome by means of a novel construction of my invention, which operates in a unique manner to provide a relatively short fluid path of low resistance during the time that the circuit is closed, and a relatively long fluid path at the moment that the circuit is opened. This new result is obtained by providing the switch with inleads which are so arranged that as the fluid flow takes place a circuit is first closed therebetween through a relatively long fluid path, while upon further flow of said fluid a parallel circuit is closed therebetween through a relatively short fluid path, these circuits being opened in the reverse order when the circuit through the switch is to be interrupted. With this novel construction it is obvious that the fluid path which is opened to interrupt the current may be made as long as desired, despite the fact that the other path, utilized to conduct the current when the switch is in the closed position, is extremely short. Thus I have succeeded in combining the desirable characteristics of a switch having a short fluid path and those of a switch having a long fluid path in a single switch of unique construction. My new construction is, moreover, extremely simple, requiring only a suitable extension of an inlead, or the provision of an auxiliary inlead, and hence my new switch is not only relatively inexpensive but also extremely reliable in service. My new construction also has the added advantage that it permits the circuit to be ruptured between two fluid pools, which has long been recognized as the most desirable mode of rupture.

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

Fig. 1 is a sectional view of a fluid flow switch in which the circuit is made and broken to a mercury pool about an auxiliary inlead, said switch being shown in the open circuit position,

Fig. 2 is a similar view of the switch of Fig. 1, showing the switch in an intermediate position,

Fig. 3 is a similar view of the switch of Fig. 1, showing the switch in the fully closed circuit position,

Fig. 4 is a sectional view of a modification of the switch of Fig. 1, in which a main inlead also performs the function of the auxiliary inlead, the switch being shown in a closed circuit position,

Fig. 5 is a similar view of another modification of the switch of Fig. 1,

Fig. 6 is a sectional view of a preferred embodiment of my invention,

Fig. 7 is a sectional view of the switch of Fig. 6, taken on the line 7—7, and

Fig. 8 shows another modification of the switch of Fig. 1, in which a resistance is included in the lead between the auxiliary inlead and the main inlead.

In this drawing, with particular reference to the switch shown in Figs. 1–3, the closed tubular body 1, which is preferably made of a suitable arc resisting vitreous material, such as a boro-silicate glass, although other vitreous materials may be used when desired, has a cup 2 formed in the bottom thereof adjacent to one end which retains a mercury pool 3. An inlead 4 of sufficient diameter to carry the rated current without undue heating, and which may be conveniently made of tungsten when the body 1 consists of a boro-silicate glass, is sealed into said cup 2. Said inlead 4 preferably extends upwardly as far as is consistent with its remaining below the surface of the mercury pool 3. Another cup 5 is formed in the bottom of the tubular body 1 at some distance from the cup 2, into which is sealed an inlead 6 of tungsten or other suitable metal. Since this inlead is not called upon to carry the rated current, except for short intervals, it need not be of as large diameter as the inlead 4. A pool of mercury 7 is enclosed within the tubular body 1, said mercury being present in sufficient quantity to make simultaneous contact, when the switch is in the position shown in Fig. 3, with said inlead 6 and with an inlead 8, similar in nature to the inlead 4, which is sealed through the top of the tubular body 1 at a point directly opposite said inlead 4 and which terminates at a point which is just above the surface of the mercury pool 7 at the moment of its merger with the mercury pool 3. Said inlead 8 is permanently connected with the inlead 6 by means of a suitable conductor 9. The switch body 1 is preferably filled with an arc suppressing atmosphere, such as hydrogen, ammonia or the like, at a suitable pressure.

In the switch of Fig. 4 a similar closed tubular body 11 has a cup 12 formed in the bottom thereof adjacent to one end, in which is retained a mercury pool 13. An inlead 14 is sealed into said cup 12, terminating just below the surface of the pool 13, this construction all being identical with that of the switch previously described. A second cup 15 is formed in the bottom of the tubular body 11 at some distance from the cup 12, an inlead 16 of large current capacity being sealed into said cup 15. Said inlead 16 continues upwardly through said cup 15 to a point near the top of the tubular body 11, thence longitudinally through said body to a point above the inlead 14, at which point it turns downwardly toward said inlead 14, terminating at a point a short distance above said inlead. A mercury pool 17 sufficient in quantity to simultaneously connect with the inlead 16 at the cup 15 and at its downturned end at one position of the switch is enclosed within the tubular body 11. A suitable arc suppressing atmosphere, such as hydrogen, is also preferably sealed within said tubular body.

With reference to the modification shown in Fig. 5, the closed tubular body 21 has a cup 22 in the bottom thereof adjacent to one end, in which is retained a mercury pool 23. An inlead 24 of large current capacity is sealed into said cup 22, terminating just below the surface of the pool 23. A second cup 25 is formed in the bottom of said tubular body 21 as close as is practicable to the cup 22, a pool of mercury 26 being retained therein. An inlead 27 of large current capacity is likewise sealed into said cup 25, said inlead terminating just beneath the surface of the pool 26. A third cup 28 is formed in the bottom of the tubular body 21 at some distance from the cup 25, into which is sealed an inlead 29, which need not be of as large current carrying capacity as the inleads 24 and 27. A suitable conductor 30 permanently connects the inleads 24 and 29. A sufficient quantity of mercury 31 is enclosed within the tubular body 21 to make contact simultaneously with the mercury pools 23, 26 and the inlead 29 at one position of the switch, and a suitable arc suppressing atmosphere, preferably hydrogen, is sealed within said switch.

A switch having a preferred construction is illustrated in Figs. 6 and 7. In this switch the closed tubular body 35 has the two inleads 36 and 37 sealed into one end thereof through a common pinch seal. A cup 38 is formed in the bottom of said body 35 as near as is practicable to the aforesaid seal. A refractory lining 39 of suitable vitreous material, such as fused silica, porcelain, or the like extends longitudinally within the tubular body 35, said lining 39 having a cup 40 formed therein near one end which extends into the cup 38. Said lining is preferably of such a shape, as shown in Fig. 7, that it can be inserted within the tubular body 35 in a completely formed condition, the lower portion thereof conforming to the curvature of said body 35, while the upper portion thereof is somewhat flattened, so that the maximum diameter of said lining 39 at the cup 40 is less than the internal diameter of the tubular body 35. Said lining 39 is held in its proper position within the tubular body 35 by the inlead 36 which extends into the end of said lining which is adjacent to the seal, and then turns downwardly, terminating in the cup 40. The inlead 37, which extends longitudinally through the tubular body 35 above said lining 39 and then turns back and downwardly within the opposite end of said lining, terminating near the bottom thereof at some distance from the cup 40, likewise assists in retaining the lining 39 in the desired position. A quantity of mercury 41 which is sufficient to make contact simultaneously with the inlead 37 at a point near the seal and with the end of said inlead is enclosed within said tubular body 35. An arc suppressing atmosphere, such as hydrogen, ammonia, or the like at a suitable pressure is preferably sealed within said tubular body 35.

The switch of Fig. 8 is in most respects similar to that of Figs. 1–3. A resistance 10 is connected in series with the conductor 9 of this switch, however, between the inleads 6 and 8′. A refractory lining 45 of porcelain, lavite, fused silica or the like extends longitudinally within the tubular body 1 from a point near the cup 2 to a point near the cup 5. When this lining has a suitable coefficient of expansion it is fused directly to the body 1, as shown. Other refractory materials may be used, however, in which case the lining 45 may be cemented to the body 1, or the space therebetween may be packed with asbestos, spun glass or the like, or any other suitable method of mounting may be used. A somewhat larger quantity of mercury 7′ is used and the inleads 4′ and 8′ are somewhat longer and shorter respectively in order to maintain the same relative position to the mercury levels as in the switch of Fig. 1.

In the use and operation of the switch of Figs. 1–3, assuming the switch to be in an open circuit position such as shown in Fig. 1, upon tilting the switch body 1 in a counterclockwise direction the mercury pool 7 flows toward the cup 2, eventually merging with the mercury pool 3 therein. A circuit is thereby closed from the inlead 8 through the conductor 9, inlead 6 and mercury 7 to the inlead 4, as shown in Fig. 2. Due to the small area and great length of the mercury path at this time the resistance heating of the switch is too great to permit the continuous carrying of large currents through this path. This difficulty is eliminated, however, by further tilting of the switch body in a counter-clockwise direction. This tilting causes the level of the mercury 7 to rise until it makes contact with the inlead 8, as shown in Fig. 3. A circuit is thereby established directly from the inlead 8 through the mercury 7 to the inlead 4. Since the mercury 7 is still in contact with the inlead 6 at the time this new circuit is established there can obviously be no arc at the making of the contact between the mercury pool 7 and the inlead 8, since said pool is at substantially the same potential as said inlead. Due to the extremely large area and short length of the new fluid path the internal resistance of the switch is obviously very markedly reduced, to say a few percent of the initial value, hence very large currents may be continuously carried thereby without undue heating. For example, it has been found possible to carry currents of 50–100 amperes in switches of my novel construction having such dimensions that their current carrying capacity, if operated according to the prior art, would not be more than 25 amperes. Further tilting of the switch body 1 will not make any appreciable change in the operation of the switch, since the opening of the circuit to the inlead 6 will only negligibly increase the internal resistance of the switch, this increase being offset in some cases by an accompanying reduction of the resistance through the mercury 7 to the inlead 8. Hence it is not essential that the tilting be stopped at any particular point, such as shown in Fig. 3.

Upon reverse movement of the switch of Figs. 1–3, assuming that the switch body 1 has been tilted so far beyond the position shown in Fig. 3 as to open the circuit to inlead 6, it is obvious that the flow of the mercury 7 to again merge with the pool retained in the cup 5 will not cause any arc of make, due to the absence of any appreciable potential between the mercury 7 and said pool. Further movement of the switch body 1 in a clockwise direction soon causes the level of the mercury 7 to fall away from the inlead 8, thereby opening the direct circuit between the inleads 4 and 8. Since a circuit is still closed, however, from the inlead 4 to said inlead 8 through the mercury 7, inlead 6 and conductor 9, as shown in Fig. 2, it is obvious that said mercury 7 and said inlead 8 are maintained at substantially the same potential so that there can be no arc of rupture therebetween. Further movement of the switch body 1 back to the position shown in Fig. 1 causes the mercury 7 to flow away from the cup 2, and to eventually separate from the mercury pool 3 retained therein, the arc of rupture occurring between said pool 3 and the body of mercury 7, this arc being quickly quenched, however, by the hydrogen atmosphere. Since this arc occurs at an appreciable distance from the inlead 8 there is no danger of it striking thereto. From the foregoing description it will be readily apparent that my new switch thus combines in a single switch for the first time the advantage of high current carrying possessed by a switch having a short low resistance fluid path with the advantage of high current rupturing capacity possessed by switches in which the circuit is ruptured between relatively remote fluid pools.

The switch of Fig. 4 operates in a similar manner. As this switch is tilted in a counter-clockwise direction from the open circuit position in which it is shown the mercury pool 17 flows toward the cup 12, eventually merging with the mercury pool 13 therein. A circuit is thereby closed from the inlead 14 through the mercury 17 to the inlead 16 at a point adjacent to the cup 15. Since this circuit includes a relatively long fluid path it is not adapted to continuously carry a large current. By further tilting of the switch body 11, however, the level of the mercury 17 is caused to rise, with respect to the inner end of the inlead 16, until it comes into contact therewith. The fluid path between said inleads 14 and 16 is thereby greatly decreased, so that the internal resistance of the switch is materially reduced. Where the inlead 16 consists of tungsten, due to the ease with which it is sealed to the borosilicate glasses, the internal resistance of the switch may be still further reduced, if desired, by making the portion of said inlead which extends within the switch envelope of a better electrical conductor, such as copper, the latter being preferably plated with nickel, chromium or the like in order to prevent contamination of the mercury by amalgamation. Upon movement of the switch body 11 in the reverse direction the mercury 17 first falls away from the end of the inlead 16, but since the circuit is still closed to said inlead 16, albeit through a longer mercury path, there obviously can be no arc of rupture between said mercury 17 and the end of said inlead. Upon further movement of the switch body 11 in a clockwise direction the mercury pool 17 will separate from the mercury pool 13, opening the circuit through the switch, an arc thereupon occurring between said pools which is immediately quenched by the hydrogen atmosphere. Experience has proven that there is no danger of this arc striking to any part of the inlead 16. It will thus be seen that this switch embodies the advantages of the switch of Figs. 1–3 in a switch having but two inleads.

The switch of Fig. 5 also operates in a manner similar to that of Figs. 1–3. As the switch body 21 is tilted in a counter-clockwise direction from the open circuit position in which it is shown the mercury 31 moves toward the cup 25, and eventually merges with the mercury pool 26 therein. A circuit is thereupon closed from inlead 27 through a relatively long path in the mercury 31 to the inlead 29, thence through the conductor 30 to the inlead 24. This circuit, being similar in fluid length to that through switches of the prior art, is obviously not adapted to continuously carry large currents. Hence provision is made for the mercury 17 to move further, upon further tilting of the switch body 1, until it merges with the mercury pool 23. A circuit is thereupon completed from the inlead 27 through a relatively short mercury path to the inlead 24. Upon movement of the switch body 21 in the reverse direction the mercury 31 flows away from the cup 22, eventually separating from the mercury pool therein, opening this short mercury path, inlead 29 and conductor 30 there are still connected through the longer mercury path, inlead 29 and conductor 30 there can be no arc of rupture. Further tilting of the switch body 21 in a clockwise direction, however, causes the mercury 31 to separate from the mercury pool 26, whereupon the circuit through the switch is interrupted, an arc occurring between the mercury 31 and the mercury pool 26, this arc being rapidly extinguished in a well known manner by the arc suppressing atmosphere. This switch thus operates in a manner analogous to the switch shown in Fig. 1. At the same time it has certain features of construction which render it especially desirable for some uses.

With the construction illustrated in Figs. 6 and 7, as the switch body 35 is tilted in a clockwise direction from the closed circuit position illustrated in Fig. 6 the level of the mercury 41 falls until said mercury is no longer in contact with the inlead 37 at a point adjacent to the seal. The short fluid path between the inleads 36 and 37 is thereby opened. No arc ensues however, due to the fact that a circuit is still closed between said inleads through a relatively long path in the mercury 41 to the tip of the inlead 37. Further tilting of the switch in the same direction results in the separation of the mercury body 41 from a pool thereof which is retained within the cup 40, whereby the circuit through the switch is interrupted, a relatively long arc of rupture being permitted between the aforesaid pool and the moving mercury body 41, this arc being rapidly suppressed by the hydrogen atmosphere. The refractory lining 39 effectively shields the switch body 35 from this arc, and likewise prevents any possible striking of the arc of rupture to an intermediate point on the inlead 37. When the sealed envelope of the switch is thus protected by a refractory lining it is obvious that not only may very large currents be safely ruptured, but the envelope itself can be constructed, where desired, of a cheaper glass, such as lead or lime glass.

As shown in Fig. 8 the conductor 9 by which the inleads 6 and 8 of the switch of Fig. 1 are connected may have an appreciable resistance 10 connected therein. This resistance, which may result from forming the conductor 9 of resistance material, such as nichrome, of suitable current carrying capacity, may be of a value which is commensurate with the impedance of the load which the switch controls, in which case the current that the switch must handle during the intermediate stage illustrated is materially reduced. More important, however, the current which the switch must interrupt is also reduced to say a half of the normal value. In operation, assuming the switch to be in a closed circuit position, upon tilting the switch in a clockwise direction the mercury 7′ flows away from the inlead 8′, opening the short fluid path thereto from the inlead 4′. The current is thereupon forced to traverse the longer path through the mercury 7′ to the inlead 6, thence through the conductor 9 and resistance 10 to said inlead 8′, the current being thereby greatly reduced. Despite the fact that a considerable potential difference is created between said inlead 8′ and the mercury 7′ as a result of the voltage drop through the resistance 10 it is found that there is no arc of rupture as the mercury 7′ falls away from said inlead 8′. Further tilting of said switch causes the circuit to be interrupted between the mercury pool 3 and the mercury 7′, with a resulting arc therebetween. The intensity of this arc is much reduced, however, due to the smaller current which is interrupted. The tubular body 1 is effectively shielded from this arc, however, by the refractory lining 45. Upon closing the circuit through the switch the circuit is first closed in an obvious manner through the resistance 10, and then directly from the inlead 4′ to the inlead 8′ through the desired short mercury path. Thus my new construction in addition to materially increasing the current carrying capacity of mercury switches, lends itself to increasing the rupturing capacity thereof. A switch of this construction is thus especially adapted, both by reason of the reduced arc of rupture and of the refractory lining, to control extremely large currents of the order of hundreds of amperes. Or, where desired, this construction may be utilized to permit the control of relatively large currents in a switch whose envelope is made of one of the less expensive soft glasses, such as lead glass, lime glass, etc.

While I have illustrated my invention by reference to several specific embodiments thereof it is to be understood that it is not limited thereto, but that various changes, omissions, or substitutions, within the scope of the appended claims, may be made either in the structures illustrated or the mode of operation thereof, 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, an electrically conducting fluid in said envelope whereby said inleads may be connected at will through a long fluid path, and means to connect said inleads by way of a shorter path in said fluid after said long fluid path is closed and to open said shorter path before said long fluid path is interrupted.

2. A mercury switch comprising a sealed envelope, mercury in said envelope, means to divide said mercury into two pools at will, inleads sealed into said envelope and making contact with each of said pools and means to reduce the length of the conducting mercury path to less than the distance between the portions of said inleads which are in contact with said mercury pools at the moment said pools are merged, said last mentioned means being effective only after said pools have merged and before they are separated.

3. A mercury switch comprising a sealed tubular envelope, mercury in said envelope, an open ended lining within said envelope, a mercury retaining cup in said lining at a point near one end of said envelope, two inleads sealed into the same end of said envelope, one of said inleads extending into said cup while the other inlead extends longitudinally above said lining and then turns downwardly within said lining.

4. A mercury switch comprising a sealed envelope, mercury in said envelope, inleads sealed into said envelope and making contact with said mercury only at remote points when the circuit through said switch is being opened or closed, one of said inleads being adapted to make an auxiliary contact with said mercury at a point close to a submerged part of the other inlead when said switch is in a closed circuit position.

5. A mercury switch comprising a sealed envelope, mercury in said envelope, a cup in said envelope near one end thereof, an inlead sealed into said cup, another inlead sealed into said envelope at a point remote from said cup and making contact with said mercury in both the open and the closed circuit position of said switch, the latter inlead extending upwardly to a point near the top of said envelope, thence longitudinally therein to a point above the first mentioned inlead, and thence downwardly to a point just above the level of the mercury retained in said cup.

6. A mercury switch comprising a sealed envelope, mercury in said envelope, means to divide said mercury into two pools at will, an inlead in contact with each of said pools, and a third inlead sealed into said envelope, said

third inlead extending to a point in proximity to one of said first mentioned inleads and being permanently connected to the other of said inleads, the relative position of said inleads being such that the gap between said adjacent inleads is bridged by said mercury after said pools have been merged and reestablished before said mercury is again divided.

7. A mercury switch comprising a sealed envelope, mercury in said envelope, means to divide said mercury into two pools at will, an inlead in contact with each of said pools, and a third inlead sealed into said envelope, said third inlead extending to a point in proximity to one of said first mentioned inleads and being permanently connected through a resistance to the other of said inleads, the relative position of said inleads being such that the gap between the inleads which are in proximity is bridged after said pools have been merged and reestablished before said mercury is again divided.

Signed at Hoboken in the county of Hudson and State of New Jersey this 2nd day of March A. D. 1931.

WARREN R. WALKER.

CERTIFICATE OF CORRECTION.

Patent No. 1,897,456. February 14, 1933.

WARREN R. WALKER.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, line 87, strike out the comma and words ", inlead 29 and conductor 30 there", and insert instead the period and words ". But since the inleads 24 and 27" and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 18th day of April, A. D. 1933.

M. J. Moore,

(Seal) Acting Commissioner of Patents.