Feb. 14, 1933. W. R. WALKER 1,897,453

LOW RESISTANCE FLUID FLOW SWITCH

Filed March 3, 1931

Fig. 1

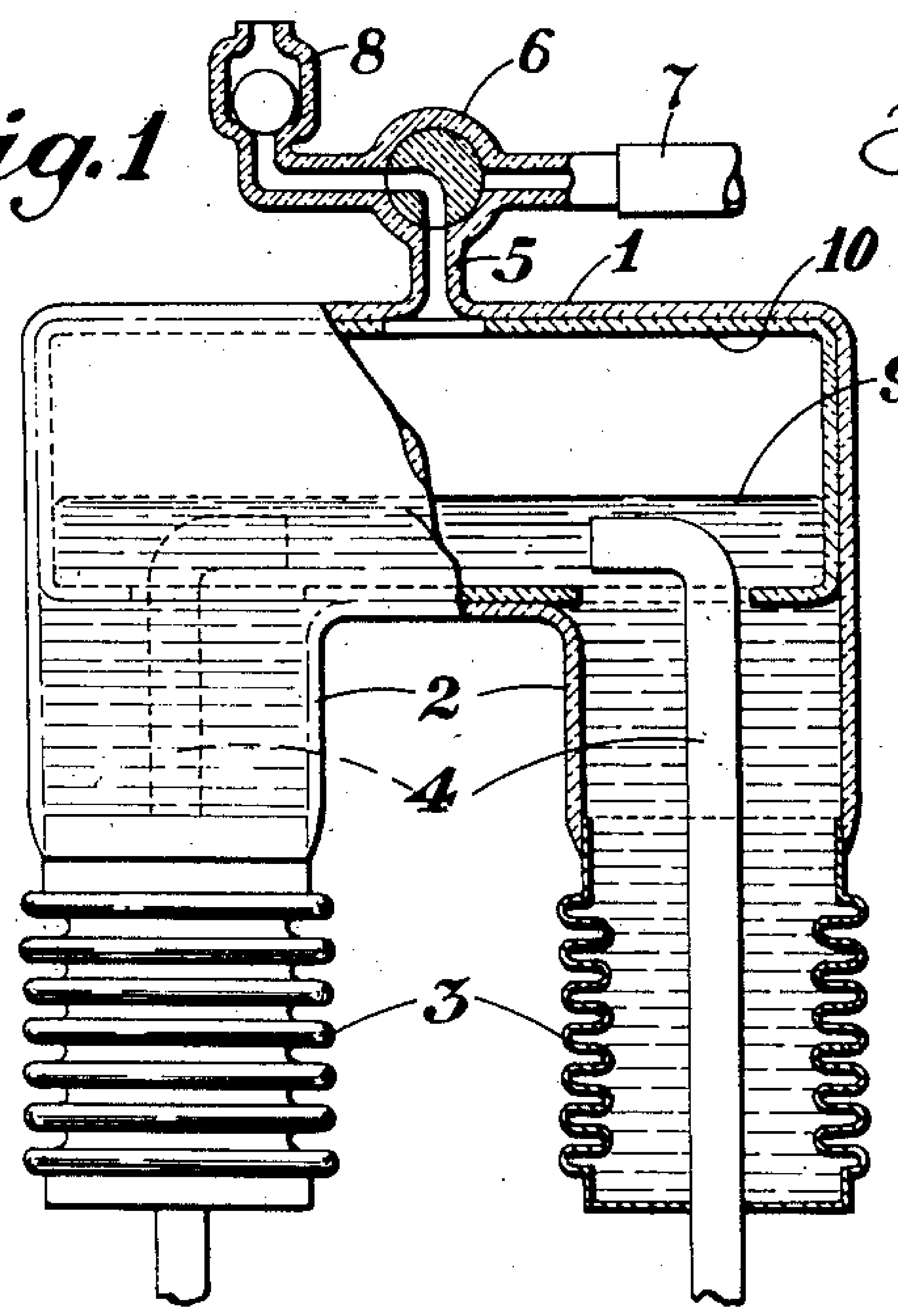
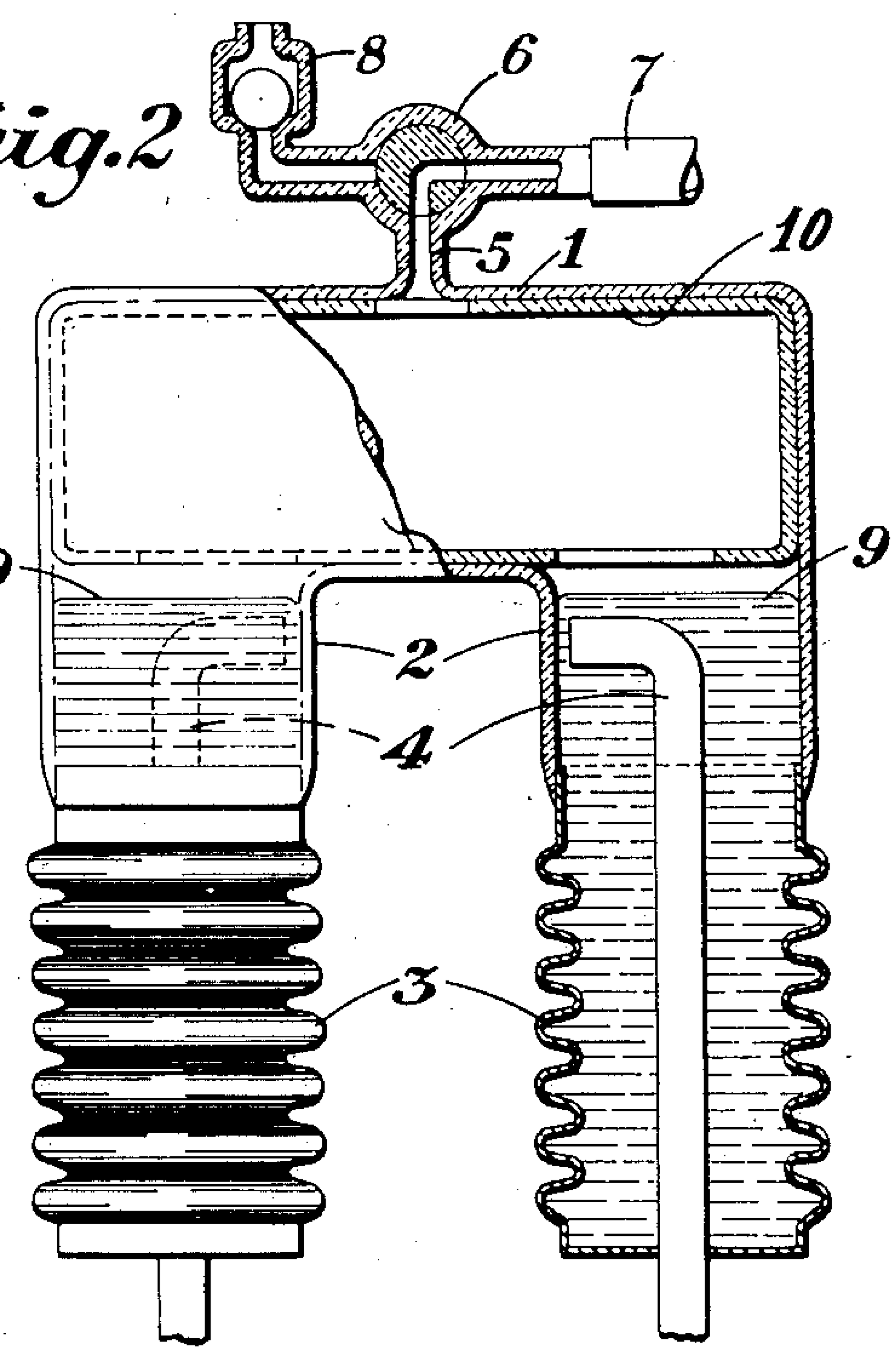


Fig. 2



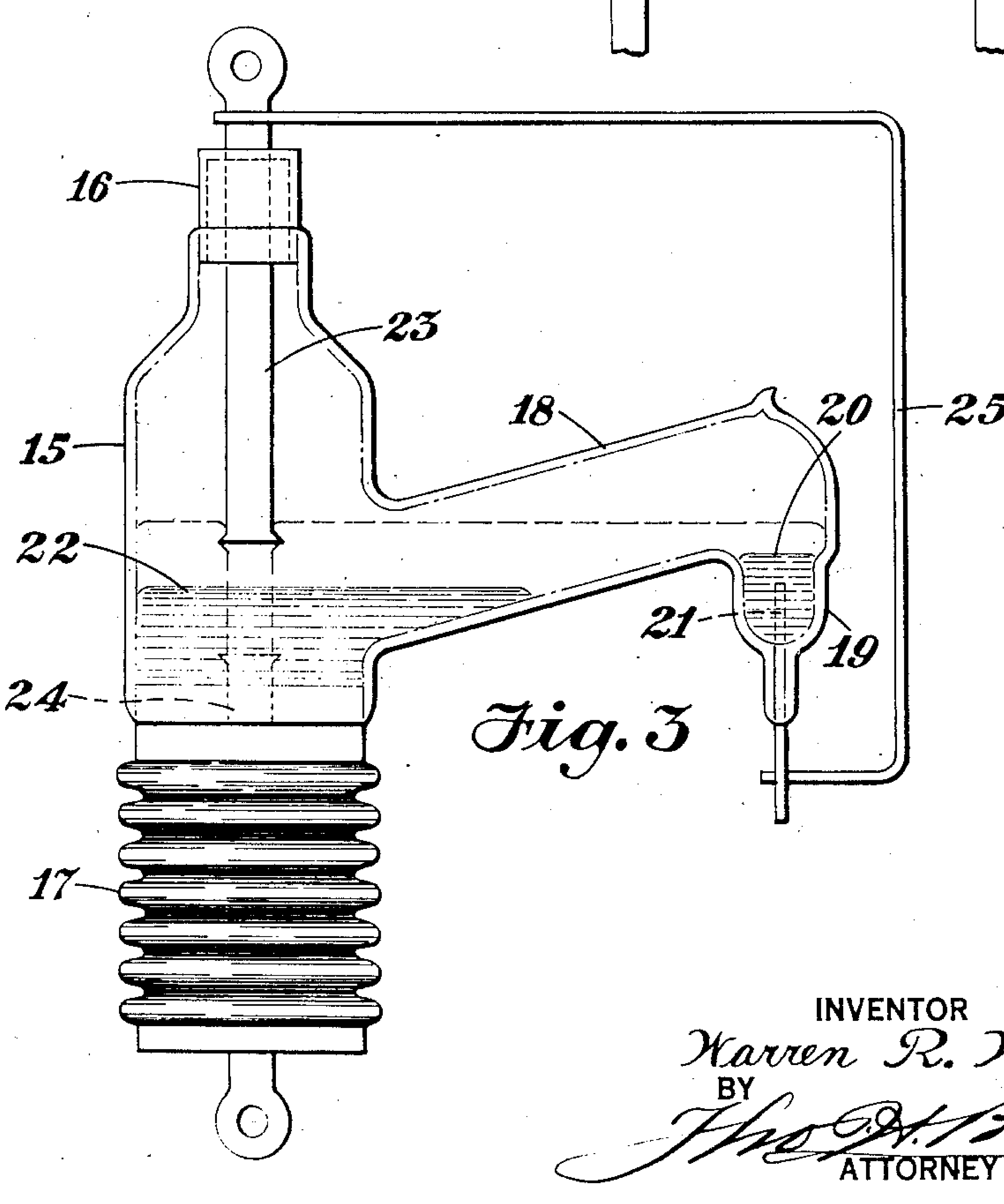


Fig. 3

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LOW RESISTANCE FLUID FLOW SWITCH

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The present invention relates to fluid flow switches, and especially to 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 fluid flow switches, as hereinafter set forth and claimed.

A particular object of the invention is to provide a fluid flow switch having a relatively high 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 novel method of operating 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 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 as great as that of tungsten, which is one of the metals commonly used for the inleads of fluid flow switches, 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 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 that this limitation can be overcome by means of a novel construction of my invention, which operates in a unique manner to give a minimum fluid path without necessitating any corresponding reduction of the path of the arc of rupture. According to my new invention the circuit is opened or closed in the usual manner by means of fluid flow, and in addition one or more of the electrodes is moved to reduce the fluid path after the circuit is closed, and to increase said path again before the circuit is opened, a single operating means causing these operations to take place in the desired sequence. According to another feature of my invention the fluid flow first closes the circuit through a long fluid path and then upon further movement closes the circuit through a short fluid path of low resistance, these circuits being opened in the reverse order, so that the rupturing capacity of the switch is unimpaired. My new construction also permits this result to be attained in a switch in which the break occurs between fluid pools.

To attain the maximum reduction in the internal resistance of these switches it is necessary to utilize a good electrical conductor for the inleads. In the past the metal used for these inleads has invariably been one which would not amalgamate with, and thereby deleteriously affect, the mercury. Nickel, tungsten, chrome-iron and nickel-steel may be mentioned as examples of the metals used for this purpose heretofore. Unfortunately each of these metals has a relatively high specific resistance, while copper, which is extremely desirable from the standpoint of low resistance, so rapidly contaminates the mercury that it has been impossible to use it. I have now discovered, however, that copper may be used in these switches by the simple expedient of plating it with a metal, such as nickel or chromium, which does not readily amalgamate with the mercury. Such inleads are especially desirable in switches of my novel construction, where there is never any danger of an arc striking thereto.

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

Fig. 1 is an elevational view, in part section, of a mercury switch having electrodes which are movable to reduce the distance therebetween during the interval that the circuit through said switch is closed, said switch being shown in a closed circuit position,

Fig. 2 is a similar view of the switch of Fig. 1 with the circuit therethrough open, and

Fig. 3 is an elevational view of a modification of the switch of Figs. 1 and 2, which operates in a preferred manner, shown in an open circuit position.

In the drawing, with particular reference to Figs. 1 and 2, there is shown a mercury switch having a horizontal tubular body 1 of glass, fused silica or other suitable material. Depending from each end of the aforesaid body are the tubular extensions or chambers 2 of the same material. A sylphon bellows 3 hermetically closes the lower end of each of said extensions. Said bellows is made of any flexible metal which will not readily amalgamate with mercury, such as iron, nickel, or the like; or, if desired, it can be made of a metal such as copper, and plated on the inside with chromium, nickel, or other metal which does not readily amalgamate with mercury. Due to the thinness of the metal it can be fused to the lower end of the vitreous chambers 2 in a well known manner regardless of variations in the coefficients of expansion. Where the fusing temperature of the vitreous material used for the chambers 2 is so high that destruction of the metal would result a graded seal may obviously be used between it and the metal. An inlead 4 which passes through the closed end of each of said sylphon bellows 3 is welded or otherwise hermetically sealed thereto. Each of said inleads extends upwardly to a point slightly above the lower wall of the tubular body 1 when said bellows is compressed, the ends of said inleads preferably extending horizontally toward each other as far as is consistent with the retraction of said inleads into the chambers 2. These inleads may be made of any metal which will not contaminate the mercury, such as tungsten or nickel, but I prefer to use copper which has been plated or otherwise coated with chromium, nickel or other metal which will not appreciably contaminate the mercury, due to the relatively low specific resistance thereof. A tubulation 5 extends from the top of the tubular body 1 to a suitable valve 6, said valve being adapted to connect said body 1 either through the tube 7 to a source of an arc suppressing gas such as hydrogen, under pressure, or to the atmosphere through the pressure relief valve 8. A quantity of mercury 9 which is sufficient to completely cover the inleads 4 when the sylphon bellows 3 is compressed is enclosed within the tubular body 1 and its appendages. Where desired a lining 10 of refractory material such as fused silica, porcelain, or the like is placed within the tubular body 1 to shield said body from the arcs of rupture, said lining preferably having suitable openings therein for movement of the electrodes 4 therethrough, and for the passage of gas to or from the tubulation 5. A suitable packing is also provided when desired, between the lining 10 and the bottom of the tubular body 1 to prevent mercury flow therebetween.

In the modification shown in Fig. 3 a vertical tubular chamber 15 of a suitable vitreous material, such as fused silica, a borosilicate glass or the like, is closed at its upper end by a thin cup 16 of any suitable metal, such as copper which has been nickel or chromium plated on the inside to prevent the formation of an amalgam, said cup being fused to said chamber in a well known manner. The lower end of said chamber is closed by the sylphon bellows 17, which likewise may be made of copper or the like, coated on the interior with nickel or chromium; or, if it is desired, said bellows may be made of iron. A side chamber 18, of the same material as the chamber 15, extends outwardly and preferably upwardly from the lower part of said chamber 15, a cup 19 being formed in the bottom thereof at the outer end. Said cup retains a mercury pool 20, which covers the inlead 21, which is of any suitable material, such as tungsten. The tubular chamber 15 is likewise filled with mercury 22 to a level, indicated by the dash line, which is above that of the pool 20 when said bellows 17 is compressed, the proportions of the various parts of the device being such that said mercury level is below that of the pool 20, as shown, when said bellows is expanded. A heavy inlead 23 which passes through the cup 16 and which is welded or otherwise hermetically sealed thereto, extends downwardly to a point which is below the level of the mercury 22 when in its upper position, but slightly above the level of the mercury pool 20. A second heavy inlead 24 passes through the sylphon bellows 17, being welded or otherwise hermetically sealed to the closed end thereof, said inlead extending upwardly as far as is consistent with its remaining below the surface of the mercury 22. In order to minimize the resistance of said inleads 23 and 24 they are preferably formed of copper and then plated or otherwise coated with chromium, nickel or other metal which resists amalgamation. The inlead 23 is connected by the wire 25 with the inlead 21, which may be of appreciable resistance, if so desired. A hydrogen atmosphere is preferably provided within this switch.

In the use and operation of the switch of Figs. 1 and 2, supposing the switch to be in a closed circuit position as shown in Fig. 1, in order to open the circuit therethrough the valve 6 is rotated in any suitable manner to disconnect the tubulation 5 from the relief valve 8, and then further rotated to connect said tubulation with the tube 7. Gas, preferably hydrogen, thereupon flows from the connected source of suitable pressure through the tube 9, valve 6 and tubulation 5 into the tubular body 1 of the switch. As the pressure in the switch rises the sylphon bellows expand, retracting the inleads 4 into the chambers 2. A moment later the mercury also recedes into the chambers 2, the circuit through the switch being interrupted as the mercury thus divides into two pools. It will thus be seen that the rupturing distance is determined solely by the spacing of the chambers 2. Furthermore, the relatively high gas pressure which is present at the time of rupture with this mode of operation materially increases the rate at which the arc is quenched. Hence this structure places no limitation on the currents which may be interrupted. In order to close the circuit again it is only necessary to again rotate the valve 6 to the position shown in Fig. 1 to disconnect the tubulation from the tube 7 and connect it with the pressure relief valve 8. The excess gas in the switch thereupon escapes through the tubulation 5, valve 6 and relief valve 8. As the pressure in the switch is thus decreased the sylphon bellows again contract due to their natural resilience. This contraction is also aided by the weight of the switch if said switch is supported by the inleads 4, this mode of support being especially desirable since it renders flexible electrical connections entirely unnecessary. A spring or other means to assist the contraction of the bellows may also be used if desired. As the bellows contracts the mercury therein is obviously forced into the tubular chamber 1, whereupon the two mercury pools again merge, closing the circuit through the switch. At this moment the inleads 4 are still some distance down in the chambers 2, hence the fluid path is relatively long and the internal resistance of the switch relatively high. Further contraction of the bellows 3, however, causes the mercury level to continue to rise, and likewise causes the inleads 4 to extend into the tubular chamber 1, thereby materially decreasing the length of the fluid path. Since the internal resistance of the switch is thus decreased it is obvious that the current carrying capacity for a given temperature rise is materially increased, despite the fact that the current rupturing capacity is unimpaired.

In the use and operation of the modification of Fig. 3 a somewhat greater use of this principle is permitted. Assuming this switch to be in the open circuit position, as shown, upon the application of mechanical pressure tending to move the inlead 24 toward the inlead 23 the sylphon bellows 17 is collapsed, forcing the mercury 22 upwardly into the chamber 15 and the side chamber 18, the inlead 24 following beneath the surface of said mercury. First of all the mercury 22 merges with the pool of mercury 20, closing the circuit from the inlead 23 through wire 25 and inlead 21, thence through the mercury to the inlead 24. A further rise of the mercury 22 causes it to come into contact with the inlead 23, thereby establishing a relatively short fluid path from the inlead 23 to the inlead 24. Still further collapse of the bellows 17 causes the inlead 24 to move into contact with the inlead 23, as indicated by the dash lines in Fig. 3, the mercury 22 forming a perfect contact therebetween. As a result the internal resistance of the switch is negligible and its current carrying capacity with a given temperature rise is extremely large, of the order of hundreds of amperes. Upon release of the pressure applied between the inleads 23 and 24, assuming the switch to be supported by the inlead 23, the resilience of the bellows, or other resilient means, if necessary, plus the weight of the mercury 22 will again expand the sylphon bellows 17, with the result that the inlead 24 is first retracted from the inlead 23, after which the mercury recedes from the inlead 23. No arc occurs at this time, however, due to the fact that the circuit is still closed through the inlead 21. If the connecting wire 25 has an appreciable resistance it is obvious, of course, that the current which will have to be ruptured by the switch will be materially decreased at this time. As the mercury further recedes into the bellows 17 the mercury 22 will separate from the pool 20, completely opening the circuit, the arc of rupture being drawn out over a relatively long distance in the side chamber 18. Thus the rupturing capacity of my new switch is commensurate with its high current carrying capacity.

While I have shown the switch of Figs. 1 and 2 as being operated by change of gas pressure, and that of Fig. 3 as being mechanically operated it is obvious that either mode of operation could be used with either switch. It is further to be understood that these switches have been described in detail for purposes of illustration only, it being obvious that various changes, substitutions and omissions, 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 mercury switch comprising a sealed envelope, a sylphon bellows forming a cup sealed into the lower wall thereof, an inlead extending within said cup, a second inlead sealed into another part of said envelope, and mercury in said cup by which said inleads may be connected at will by flexing said bellows, said bellows being sufficiently flexible to permit further movement thereof to reduce the fluid path between said inleads.

2. A mercury switch comprising a sealed envelope, a sylphon bellows forming a cup sealed into the lower wall of said envelope, an inlead extending within said cup, a side chamber sealed to said envelope, an inlead in said side chamber, mercury in said envelope by which said inleads may be connected at will by flexing said bellows, a third inlead extending into said envelope and extending downwardly to a point which is just above the level of said mercury when it makes contact with the inlead in said side chamber, said bellows being sufficiently flexible to permit said mercury to be moved into contact with said third inlead at will, said third inlead being permanently connected to the inlead in said side chamber.

3. A mercury switch comprising a sealed envelope, a sylphon bellows forming a cup sealed into the lower wall thereof, an inlead sealed through the end of said bellows, a side chamber sealed to said envelope, an inlead sealed into a cup in said side chamber, mercury in said envelope by which said inleads may be connected at will by flexing said bellows, a third inlead extending downwardly above the first mentioned inlead to a point which is just above the level of said mercury when it makes contact with the inlead in said side chamber, said bellows being sufficiently flexible to permit further movement thereof to move the first mentioned inlead into contact with said third inlead and to raise said mercury above said point of contact, said third inlead being permanently connected to the inlead in said side chamber.

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

WARREN R. WALKER.