July 7, 1942. W. J. LEVERIDGE 2,288,811

SWITCHING DEVICE

Filed May 13, 1941

FIG. 1

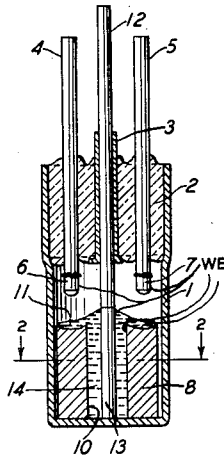


FIG. 3

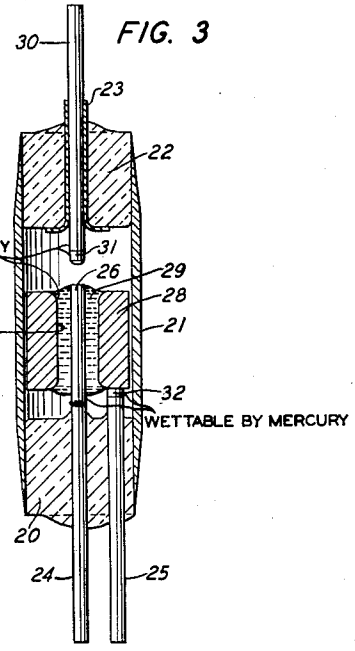


FIG. 2

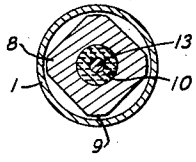


FIG. 4

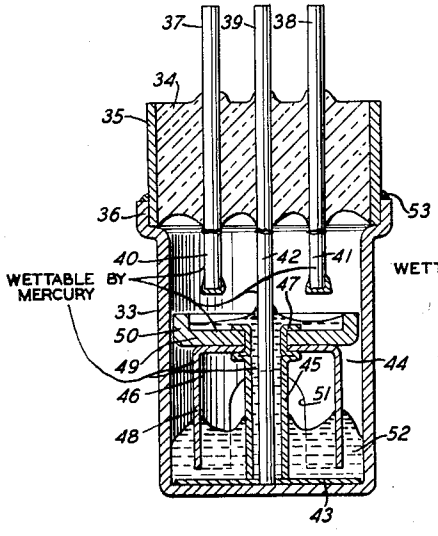
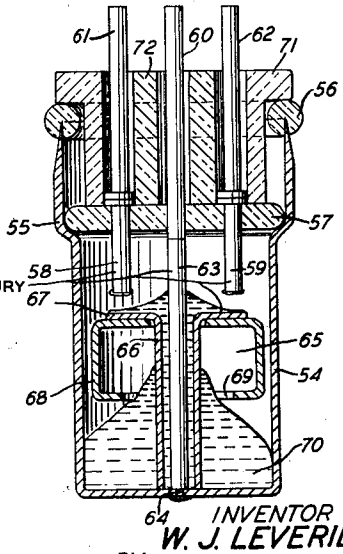


FIG. 5



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UNITED STATES PATENT OFFICE

2,288,811

SWITCHING DEVICE

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Application May 13, 1941, Serial No. 393,163

10 Claims. (Cl. 200—112)

This invention relates to electrical switching devices and relays and more particularly to those in which a conducting liquid such as mercury is used as the contact-making medium.

The object of the invention is to simplify switching devices of this character whereby connections through the devices may be made by moving a very small body of mercury.

It is well recognized that mercury has certain distinct advantages over solid elements as a contact-making medium for electrical circuits. For instance a body of mercury presents a fresh surface for each successive contact closure and it it not subject to the pitting or corroding effects that gradually reduce the usefulness of solid contact elements. With these advantages in view, several forms of mercury switches have been devised in the past which generally fall into one or the other of two classes. In one of these classes the container is tilted or otherwise moved to cause the body of mercury within it to shift its position thus opening or closing the desired connections. In the other class an armature or other movable element is forced into a pool of mercury, the free surface of the mercury being displaced into engagement with circuit making contacts. In either case it is necessary to move all or a considerable part of the mercury mass into a position in which it physically engages or disengages the desired contact or contacts.

In accordance with the present invention, an armature is movable within a container but is not required to displace a large body of mercury but to lift only a small amount of mercury to effect the interconnection of contacts. The invention has been illustrated by several embodiments but in each case the armature is so arranged that it is provided with a small reservoir of mercury of sufficient volume to provide all the mercury that is required for contact establishment or a small pool or reservoir of mercury which may by capillary action be fed from a large pool in which the armature rests. Since the amount of mercury carried by the armature in any case is small and the armature itself is of light weight, the amount of energy required to move the armature to its contact closing position is very slight.

For a clearer understanding of the invention, reference may be had to the following detailed description taken in connection with the accompanying drawing in which:

Fig. 1 is a side view partly in cross section of a switching device constructed in accordance with the present invention;

Fig. 2 is a sectional view taken along section line 2—2 of Fig. 1;

Fig. 3 is a side view partly in cross section of another embodiment of the invention;

Fig. 4 is a side view partly in cross section of a further embodiment of the invention; and

Fig. 5 is a side view partly in cross section of a still further embodiment of the invention.

While the invention is not limited to a switch of any given size or proportion it may be noted that switches in accordance with the invention are particularly useful in electrical circuits where relatively small currents are involved, such, for example, as currents of the order generally used in telephone or telegraph systems. For these purposes the switch unit may be made quite small and it should be understood that the figures of the drawing have been made to an enlarged scale to facilitate a clearer understanding of the construction. All of the switch units disclosed are designed for use in connection with a magnetic circuit which may be of any desired type, for example, of the type disclosed in application Serial No. 340,662, of C. E. Pollard, filed June 15, 1940, or of the type disclosed in my application Serial No. 398,538, filed June 18, 1941.

Referring first to Figs. 1 and 2 the switch unit comprises a stainless steel or other suitable non-magnetic container 1 sealed at its upper or open end by a glass bead 2. Sealed axially through the bead 2 is a thin-walled sleeve 3 of an alloy which readily seals to the glasss and also sealed through the bead 2 are two lead wires 4 and 5 also of an alloy which readily seals to the glass. Welded to the inner end of these wires are contact portions 6 and 7 which are of a metal wettable by mercury, such as nickel. A soft iron armature 8 is positioned within the container and is of substantially octagonal cross section as best disclosed in Fig. 2, four of the eight faces thereof being narrow as indicated by the numeral 9 to decrease the frictional contact area between the armature and the inner wall of the container 1. The armature is provided with an axial hole 10 therethrough and the upper surface of the armature is provided with a circular depression 11, the wall of the hole 10 and the surface of the depression being coated nickel or other material wettable by mercury. The other surfaces of the armature and the inner surface of the container are not so wettable. A rod formed of an upper lead wire section 12 and a lower contact

section 13 of a metal wettable by mercury are welded together end to end and inserted through the sleeve 3 and the hole in the armature 8 and then welded to the sleeve 3. The hole 10 in the armature 8 is filled with a body of mercury 14.

In assembling the switch unit, the armature 8 is first inserted into the container 1 and the bead 2 with the lead wires 4 and 5 and sleeve 3 sealed therein is placed in the upper end of the container and sealed thereto. The container is then evacuated, a measured amount of mercury is placed therein, the container is filled with an atmosphere of hydrogen, and the guide rod is then inserted through the tube 3 and welded thereto. With the rod in the position disclosed, the mercury is forced up through the hole in the armature and overflows into the depression 11 in the upper surface of the armature, and due to the fact that the wall of the hole 10 and the surface of the depression 11 and the surface of the lower portion 13 of the rod are wettable by the mercury, the mercury will adhere thereto as indicated and any portion of the mercury which may have entered between the outer surfaces of the armature and the walls of the container will not adhere thereto but be drawn by surface tension into the hole 10 or reservoir within the armature.

When the armature 8 is raised within the container by the attraction of a magnetic field applied to the unit, it will lift the reservoir of mercury with it and will engage the mercury which fills the depression 11 in its upper surface with the lower wettable contact ends of the lead wires 4 and 5 thereby interconnecting them through the mercury. When the armature is released, it will drop into the bottom of the container carrying the mercury with it, thus breaking the connection between the lead wires 4 and 5 but due to the fact that the lower or contact ends 6 and 7 of the lead wires are wetted by the mercury, small films of mercury will be retained on these ends so that on all operations subsequent to the first, the elevation of the armature will result in a mercury to mercury contact between the lead wires 4 and 5.

The modified form of switch unit disclosed in Fig. 3 is quite similar to that of Fig. 1. In this switch unit, the container 21 of stainless steel or other suitable non-magnetic material is tubular and is sealed at its ends by glass beads 20 and 22. The bead 22 has a thin-walled sleeve 23 of an alloy which readily seals to glass sealed axially therethrough and the bead 20 has two lead wires 24 and 25 sealed therethrough, the lead wire 25 terminating just above the inner end of the seal 20 and serving as a support for the armature 28 and the axially disposed lead wire 24 having an extension 26 of metal wettable by mercury such as nickel welded thereto. The armature 28 is similar in cross section to the armature 8 of Fig. 1 and has an axial hole 27 therethrough serving as a reservoir for the mercury 29. A third lead wire 30 extends through the sleeve 23 with its upper end slightly above and out of engagement with the upper end of lead wire 24 and is welded to the sleeve 23.

The switch unit is assembled by first inserting the armature 28 into the container and then sealing the beads 20 and 22 with the lead wires and sleeve sealed therethrough to the ends of the container. The container is then evacuated, a measured amount of mercury is placed therein, the container is then filled with an atmosphere of hydrogen and the lead wire 30 is finally inserted through the sleeve 23 and welded thereto. Due to the surface tension of the mercury and its adhesion to the wall of the hole 27 in the armature, the mercury will be drawn up into the hole in the armature as indicated in the drawing.

When the armature is raised within the container, the normal connection from the lead wire 25 through the armature 21 and the mercury to the lead wire 24 will be broken and the mercury within the armature reservoir will be carried by the armature into bridging engagement between the ends of the lead wires 24 and 30. The switch unit, therefore, functions as a simple contact transfer. To insure a mercury to mercury contact after the initial operation of the unit, the contact end 31 of lead wire 30 and the contact end 32 of the lead wire 25 may be made of a metal wettable by mercury such as nickel and welded to the ends of such wires.

The modified form of switch unit disclosed in Fig. 4 comprises a container 33 of stainless steel or other suitable non-magnetic material, the upper or open end of which is closed by a closure comprising a glass bead 34 sealed to a ring 35. The ring 35 has such an outside diameter that it may be seated on the inner shoulder of the flanged portion 36 of the container 33. Extending through the glass bead 34 are three lead wires 37, 38 and 39 which terminate just below the inner surface of the bead 34. Spot welded to the inner ends of the wires 37 and 38 are contact portions 40 and 41 made of a metal easily wettable by mercury, as for example nickel, and welded to the inner end of the axially disposed wire 39 is a portion 42 of nickel which extends to the bottom of the container 33 and is seated in a central hole in the stainless steel disc 43 positioned in the bottom of the container. The portion 42 is thus axially positioned within the container and serves as a guide rod for the armature assembly 44.

The armature assembly comprises a central nickel tube 45 having an inner diameter slightly greater than the diameter of the rod 42 and having an inner flanged portion 46 and an upper flanged portion 47, a depending cup-shaped member 48 also of nickel and a permalloy armature disc 49. The base portion of the member 48 and the armature disc 49 are assembled on the upper end of the tube 45 after the inner flange 46 is formed on the tube and then held in place thereon by spinning the outer flange 47 down upon the upper surface of the armature disc. The outer edge of the armature disc 49 is upturned at 50 and the upper surface of the armature is preferably coated with a material easily wettable by mercury, for example, coated with nickel. The depending wall of the member 48 is cut away at diametrically opposite portions thereof as indicated at 51 and the lower edge of the member is normally partly submerged in a pool of mercury 52 located in the bottom of the container 33.

Due to the capillary action between the outer surface of the guide rod 42 and the inner surface of the tube 45 some of the mercury is conducted upwardly to fill the space between the tube and guide rod and to form an auxiliary pool upon the upper surface of the armature disc 49.

In assembling the switch unit, the lead wires 37, 38 and 39 are sealed into the glass bead 34 and the bead 34 is sealed within the ring 35 to form the closure assembly. The disc 43 is then inserted into the bottom of the container 33, the required amount of mercury is then placed

in the container, and the armature assembly **34** is then placed within the container resting in the mercury. The enclosure assembly is then placed in position with the guide rod extension **42** of the lead wire **39** extending through the tubular portion **45** of the armature assembly into the central hole of the disc **43** and the lower edge of the ring **35** of the closure assembly seated in the shoulder of the flanged portion **46** of the container. The assembled switch unit is then evacuated and refilled with hydrogen after which the closure assembly is sealed to the flange of the container by plastic material placed at the junction point **53**.

In the operation of this switching unit when the armature is raised within the container by an external magnetic field, it will lift the small pool of mercury carried upon its upper surface into engagement with the contact ends **40** and **41** of the lead wires **37** and **38** thus interconnecting such lead wires or connecting both of such lead wires to the central lead wire **39**. When the armature is released, it will be drawn towards the bottom of the container **33** by the surface tension of the mercury pool **52** acting upon the outer surface of the tubular portion **45** and upon the surfaces of the skirt portion of the member **48** of the armature assembly thereby disconnecting the lead wires **37**, **38** and **39** from each other. Small films of mercury will be retained on the contact ends **40** and **41** of the lead wires **37** and **38** so that after the first operation of the switch unit, the lead wires will be interconnected through a mercury to mercury contact upon each subsequent operation of the unit.

The modified form of switch unit disclosed in Fig. 5 comprises a container **54** of stainless steel or other suitable non-magnetic material having an upper flanged portion **55** and to the upper edge of which is sealed a glass rim **56**. Seated on the inside shoulder of the flanged portion **55** is a disc **57** of suitable insulating material, such as Lavite, through which extend two flanged contact members **58** and **59**, preferably of a metal wettable by mercury such as nickel, and a centrally disposed lead wire **60**. Welded to the outer or flanged ends of the contact members are two lead wires **61** and **62**. The lead wires **60**, **61** and **62** are all of a material which may be readily sealed to glass. Spot welded to the inner end of the lead wire **60** is a guide rod **63** of stainless steel, preferably nickel plated, the lower end of which extends through an axial hole **64** in the bottom of the container and is welded therein. The rod **63** serves as a guide for the armature assembly **65**.

The armature assembly comprises a central tubular portion **66** having an inside diameter slightly larger than the diameter of the guide rod and an upper flange **67**. Preferably it is made of nickel and thus wettable by mercury. Welded or otherwise secured to the under-side of the flange **67** is a hollow cylindrical iron armature **68**, the upper end wall of which is secured to the flange **67**, the cylindrical wall of which is disposed for free sliding movement with respect to the inner surface of the container **54** and the lower end wall of which is provided with a large opening **69** to permit mercury from the pool **70** deposited in the bottom of the container to enter into the armature. Some of the mercury from the pool **70** is drawn upwardly between the inner surface of the tubular portion **66** of the armature assembly and the guide rod **63** to form a shallow pool upon the upper surface of the flange **67** as illustrated.

In assembling this switch unit, the required amount of mercury is first placed in the bottom of the container and the armature assembly **65** is then inserted into the container resting in the mercury pool **70**. The supporting disc **57** with the lead wires **60**, **61** and **62** with their guide rods and contact extensions assembled therein, is then inserted to rest on the shoulder on the flange portion **55** of the container and the ends of the guide rod **63** where it extends through the hole in the bottom of the container are welded thereto. The glass rim **56** is then fused to the upper edge of the container **54** and the glass tube **71** is then inserted between the rim **56** and the lead wires **61** and **62** and the glass tube **72** is placed around the lead wire **60**. The switch unit is then evacuated, fillled with hydrogen and finally sealed by fusing the glass tube **71** to the rim **56** and fusing the glass tube **72**, the fused glass thereby flowing around the wires **60**, **61** and **62** and sealing them to the glass thereby completely sealing the unit. The unit functions in the manner described in connection with the unit disclosed in Fig. 4.

It will, of course, be understood that the invention is not limited to the particular structures used to illustrate it in the present disclosure. If desirable the container might be made in various shapes and sizes and of other material such as glass. The armature may vary in shape and proportion, the shape and location of the contacts may also be varied and the switch unit may be adapted for use in various types of magnetic circuits.

What is claimed is:

1. A mercury switch comprising a container, an armature movable within said container having an axial hole therethrough, the wall of said hole being of a material wettable by mercury, a column of mercury held within said hole, and terminals interconnectable by said mercury upon the movement of said armature within said container.

2. A mercury switch comprising a container, a guide rod axially positioned in said container, an armature movable within said container and having an axial hole therein through which said guide rod extends, the wall of said hole being of a material wettable by mercury, a column of mercury held by surface tension within said hole between the wall thereof and said guide rod, and terminals interconnectable by said mercury upon the movement of said armature within said container.

3. A mercury switch comprising a container, a guide rod axially positioned in said container, an armature movable within said container and having an axial hole therein through which said guide rod extends and having a depression in the upper surface thereof, the wall of said hole and said depressed surface being of a material wettable by mercury, a column of mercury held by surface tension within said hole between the wall thereof and said guide rod and forming a shallow pool in the depression in the upper surface of said armature, and terminals interconnectable through the mercury of said pool upon the movement of said armature within said container.

4. A mercury switch comprising a metal container, a glass bead for sealing the open end of said container, a metal tube sealed axially through said bead, a lead wire extending through said tube welded thereto and having a contact

portion wettable by mercury, an armature movable within said container and having an axial hole therein, the wall of said hole being of a material wettable by mercury, a column of mercury held within said hole, and other lead wires having contact portions wettable by mercury and connectable with each other and with said first lead wire by said mercury upon the movement of said armature within said container.

5. A mercury switch comprising a metal container, a glass bead for sealing the open end of said container, a metal tube sealed axially through said bead, a plurality of lead wires sealed through said bead and having contact portions on their inner ends wettable by mercury, a guide rod extending through said tube and welded thereto, an armature movable within said container and having an axial hole therein through which said guide rod extends, the wall of said hole being of a material wettable by mercury, and a column of mercury held by surface tension within said hole between the wall thereof and said guide rod, said lead wires being interconnectable and connectable with said guide rod upon the movement of said armature within said container.

6. A mercury switch comprising a container, a guide rod axially positioned in said container, an armature assembly movable within said container comprising a central tubular portion surrounding said guide rod and having an inner surface wettable by mercury and a portion of magnetic material secured thereto, a pool of mercury in the bottom of said container and extending through the space between said guide rod and the inner surface of said tubular portion to form a shallow auxiliary pool upon the upper surface of said armature assembly, and terminals interconnectable by the mercury of said auxiliary pool upon the movement of said armature assembly within said container.

7. A mercury switch comprising a metal container, a glass bead for sealing the open end of said container, a guide rod sealed in said bead and extending axially to the bottom of said container, an armature assembly movable within said container comprising a central tubular portion surrounding said guide rod having a flange upon its upper end, said tubular portion being of a metal wettable by mercury and a portion of magnetic material secured to said flange, a pool of mercury in the bottom of said container and extending through the space between said guide rod and the inner surface of said tubular portion to form a shallow auxiliary pool upon the upper surface of said armature assembly, and lead wires having contact portions of a metal wettable by mercury sealed through said bead and connectable with each other and with said guide rod by the mercury of said auxiliary pool upon the movement of said armature assembly within said container.

8. A mercury switch comprising a metal container, a glass bead for sealing the open end of said container, a guide rod sealed in said bead and extending axially to the bottom of said container, an armature assembly movable within said container comprising a central tubular portion surrounding said guide rod and having a flange adjacent to its open end, an inverted cup-shaped portion having an opening in its base through which the upper end of said tubular portion extends, said tubular portion and said cup-shaped portion being of a material wettable by mercury and a disc of magnetic material having an upturned edge and having an opening in its base through which the upper end of said tubular portion extends, said cup-shaped portion and said disc being clamped to said tubular portion between said flange and a second flange spun over from the upper end of said tubular portion, a pool of mercury in the bottom of said container into which the tubular portion and the side wall of said cup-shaped portion extend, said mercury extending through the space between the guide rod and the inner surface of said tubular portion to form a shallow auxiliary pool upon the upper surface of said armature assembly, and other lead wires having contact portions of metal wettable by mercury sealed through said bead and connectable with each other and with said guide rod by the mercury of said auxiliary pool upon the movement of said armature assembly within said container.

9. A mercury switch comprising a metal container, a disc of insulating material supported in the upper end of said container, a guide rod extending axially through said disc to the bottom of said container, lead wires having contact portions of a metal wettable by mercury supported by said disc, a glass bead for sealing the open end of said container and for holding said disc in position, an armature assembly comprising a central tubular portion surrounding said guide rod having a flange upon its upper end and being of a material wettable by mercury and a portion of magnetic material secured to said flange, and a pool of mercury in the bottom of said container and extending through the space between said guide rod and said tubular portion to form a shallow pool upon the upper surface of said armature assembly, whereby said lead wires are connected together and with said guide rod by said auxiliary pool of mercury upon the movement of said armature assembly within said container.

10. A mercury switch comprising a metal container, a glass bead for sealing the upper end of said container, a guide rod extending axially through said bead to the bottom of said container, lead wires having contact portions of a metal wettable by mercury sealed through said bead, an armature assembly comprising a central tubular portion surrounding said guide rod having a flange upon its upper end and being of a material wettable by mercury and a hollow cylindrical armature portion of magnetic material secured by its upper base to the flange of said tubular portion and having openings in both of its bases through which said tubular portion extends, the opening through the lower base being sufficiently large to permit the penetration of mercury within said cylindrical armature portion, and a pool of mercury in the bottom of said container and extending through the space between said guide rod and said tubular portion to form a shallow auxiliary pool upon the upper surface of said armature assembly whereby said lead wires are connected together and with said guide rod by said auxiliary pool of mercury upon the movement of said armature assembly within said container.

WALTER J. LEVERIDGE.