

Nov. 17, 1942.

H. C. HARRISON

2,302,546

ELECTRIC SWITCH

Filed June 15, 1940

3 Sheets-Sheet 1

FIG. 1

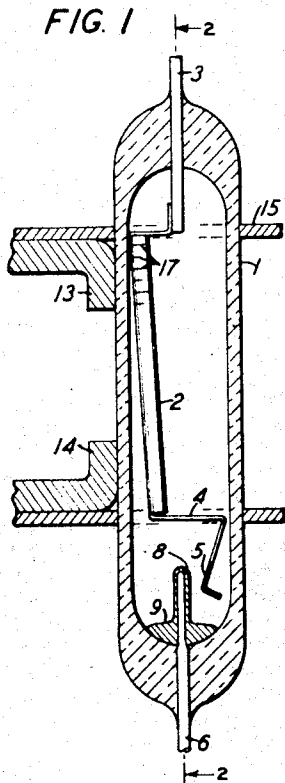


FIG. 2

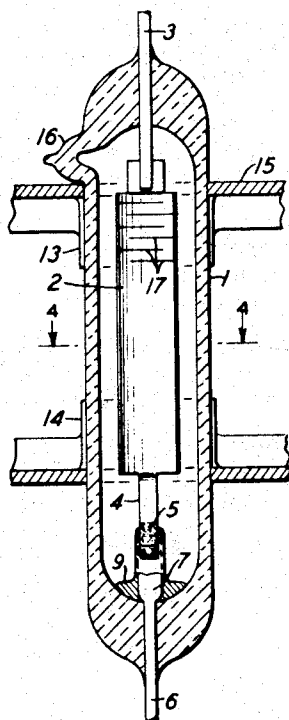


FIG. 5

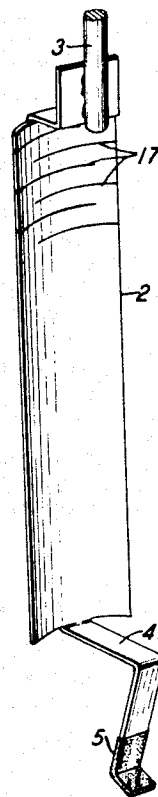


FIG. 3

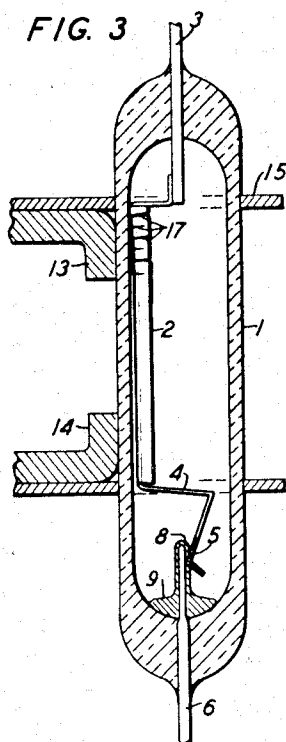


FIG. 4

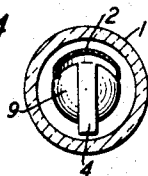
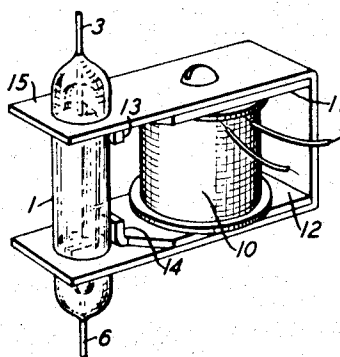


FIG. 6



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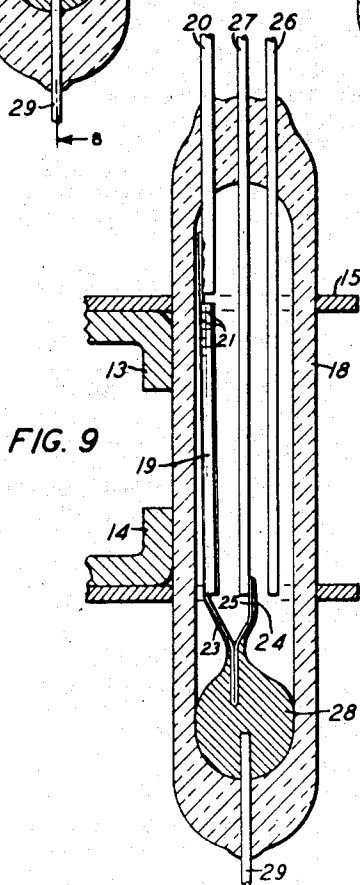
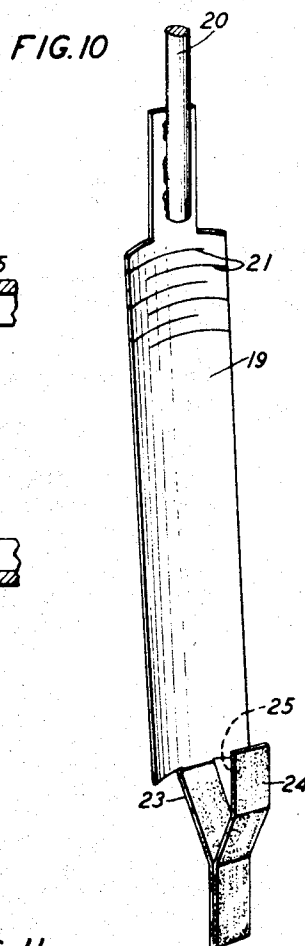
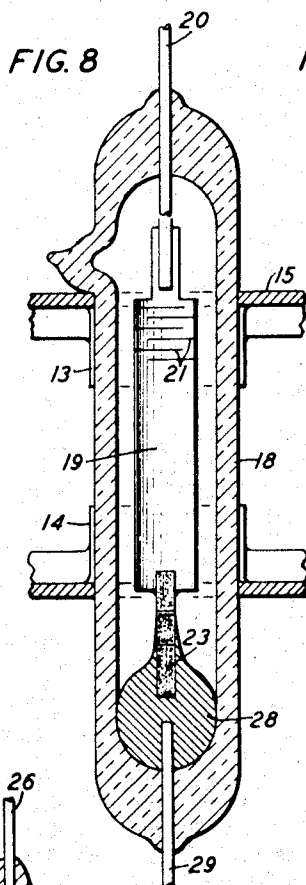
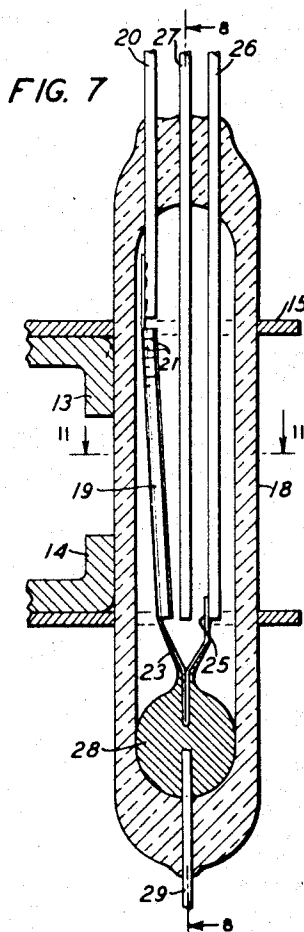
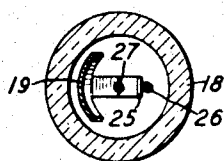


FIG. 11



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FIG. 12

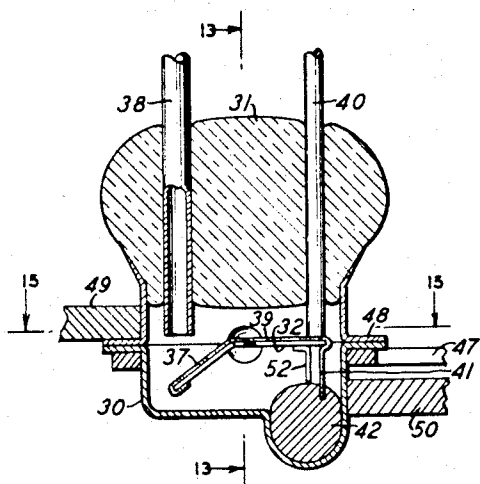


FIG. 13

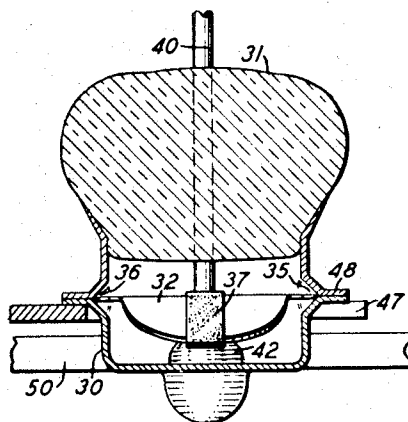


FIG. 14

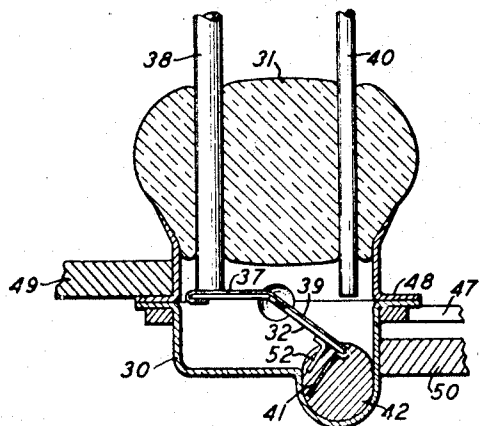


FIG. 15

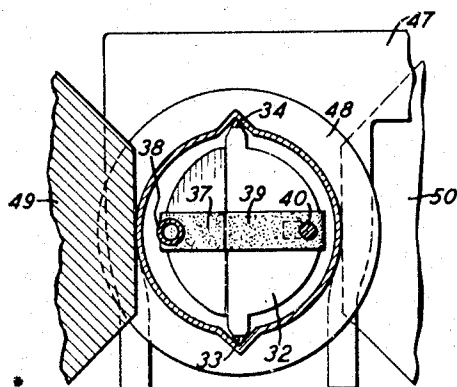


FIG. 16

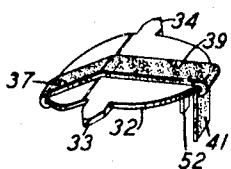
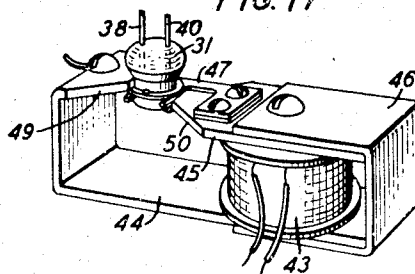


FIG. 17



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2,302,546

ELECTRIC SWITCH

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Application June 15, 1940, Serial No. 340,652

15 Claims. (Cl. 200—112)

This invention relates to electric switches and relays and particularly to those in which a conducting liquid, such as mercury, is used as the contact-making element.

The objects of the invention are to increase the efficiency and reliability of switches using liquid contacts; to increase the speed of operation; to simplify the construction; and in other respects to improve these devices.

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 is not subject to the pitting and corroding effects that gradually reduce the usefulness of solid contact elements. With these advantages in view numerous varieties of mercury switches have been devised in the past. These generally fall in one or the other of two classes. In one of these the container is tilted or otherwise moved to cause the body of mercury within 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 mercury pool, the free surface of the mercury being displaced into engagement with circuit-making contacts. To release such a switch a spring may be provided to withdraw the armature when the operating force is removed, or the force of flotation of the mercury may be used to restore the armature. In these prior switches, however, it is necessary to move either all or a substantial portion of the mercury mass from one part of the switch to another; therefore, they are relatively slow in operating, and their efficiency is low in comparison with other types of relays and switches, particularly those having solid contacts.

In accordance with the present invention the disadvantages of these prior devices are overcome, while all the advantages of a liquid contact medium are retained, by means of a switch in which the movable switching element is of solid material, such as iron, in which all of the operating force is available for moving the switching element, and in which a supply of mercury is always maintained at the points of contact without requiring the expenditure of any part of the operating energy of the switch for this purpose.

More specifically a feature of the invention is a switch comprising a closed envelope which contains a movable magnetic armature carrying a movable switching contact of some solid conducting material, preferably one to which mer-

cury adheres readily. The envelope or container also includes one or more stationary solid contacts of like material which the movable contact engages and disengages in response to the movement of the armature in the magnetic field set up by a coil disposed on the exterior of the envelope. Also the envelope contains a small pool or reservoir of mercury for maintaining a film or coating of mercury over the engaging surfaces of the moving and stationary contacts. To this end advantage is taken of the force of capillary attraction by arranging one of the solid contacts so that a portion of it, or a part extending from it, is constantly immersed in the pool, where it serves as transfer means to attract some of the mercury up out of the pool to the surfaces of contact engagement, which are positioned considerably above the surface of the pool. Some of the mercury thus attracted to the contact surfaces is transferred by physical engagement to the mating contact surfaces. In this way the advantages of a mercury contact are obtained for all circuit closures and openings without using any of the switch operating energy for moving the mercury mass.

Other features and advantages of the invention will be described more fully in the following detailed specification.

In the drawings accompanying this specification:

Figs. 1 and 2 are side views, partly in section, of a switch or relay incorporating the features of the invention. These figures illustrate the relay in its normal position;

Fig. 3 is a view similar to Fig. 1 showing the relay in its operated position;

Fig. 4 is a cross-sectional view taken along the line 4—4 in Fig. 2;

Fig. 5 is an enlarged perspective view of the armature and movable contact; and

Fig. 6 is a perspective view of the relay including the magnetic structure and operating unit.

Figs. 7 to 11, inclusive, are similar views of an alternative form of the relay in which circuits are controlled both in the normal and operating positions.

Figs. 7 and 8 are side views, partly in section, showing the normal position of relay;

Fig. 9 is a side view in section showing the relay in its operated position;

Fig. 10 is an enlarged perspective view of the armature and the operating contact; and

Fig. 11 is a cross-sectional view taken along lines 11—11 of Fig. 7;

Figs. 12 to 17, inclusive, illustrate a third form of the relay.

Figs. 12 and 13 are side views, partly in section, illustrating the relay in its normal position;

Fig. 14 is a similar view showing the relay in its operated position;

Fig. 15 is an enlarged plan view showing the armature and movable contact;

Fig. 16 is a perspective view of the armature and movable contact; and

Fig. 17 is a perspective view of the relay assembly including the magnetic structure and the operating unit.

While the invention is not limited to a switch or relay of any given size or proportions, it may be noted that this relay is particularly useful in electrical systems where relatively small currents are involved, such, for example, as currents of the order commonly used in telephone and telegraph systems. For these purposes the relay may be made to small dimensions, and it should be understood that the figures shown in the drawings are much enlarged to facilitate a clearer understanding of the construction.

Referring now to the drawings and first to Figs. 1 to 6, the relay here illustrated comprises an operating unit including a housing vessel or container in the form of a glass tube 1 and an electromagnet armature 2. The armature 2 comprises a strip of relatively thin magnetic metal cylindrically shaped to conform to the interior surface of the tube 1. The armature 2 is welded or otherwise secured at its upper end to a terminal post 3, which is sealed into the upper end of the glass tube 1. The lower end of the armature 2 carries the movable contact 4, which is integrally formed with the armature and is shaped in any suitable manner to present a contact-making surface 5 for engagement with the stationary contact. The upper end of the armature 2 has a series of transverse cuts 17, forming a spring portion which enables a flexing movement of the armature when subjected to the magnetic field and which also restores the armature to its normal position.

The terminal 6 projects through the bottom of the tube 1 and extends for a considerable distance above the bottom surface of the tube chamber. The portion 7 of the terminal 6 within the tube chamber is flattened somewhat, as shown in Fig. 2, to increase the area thereof, and the uppermost section of this flattened portion constitutes the stationary contact-making surface 8 which is engaged and disengaged by the contact-making surface 5 of the movable contact 4.

A pool of mercury 9 rests in the bottom of the tube 1 and surrounds the stationary contact 7. This pool, however, is relatively shallow when compared with the projecting contact 7. The upper surface of the pool, therefore, lies substantially below the end of the movable contact 4, so that the movable contact is not immersed in the pool and is not interfered with thereby in its movement into and out of engagement with the contacting surface of the stationary contact. However, the flattened contact 7, projecting up through the mercury pool, serves as a transfer agency whereby the forces of capillary attraction cause some of the mercury to creep up out of the pool and cover the entire surface of the contact 7 with a thin film of the liquid. This coating or film of mercury, which is illustrated particularly in Figs. 1 and 3, covers at all times the contact-making area 8 of the stationary contact. Furthermore, the repeated engagement of the mov-

able contact with the stationary contact causes some of the mercury to be transferred to the contact-making area 5 of the movable contact where it deposits and maintains a similar film or coating of the liquid. Thus the two contact-making surfaces 5 and 8 are constantly coated with mercury.

The magnetic operating structure of the relay, which is illustrated in Fig. 6, comprises a coil 10 wound on a core which is not visible in the drawings. Magnetic pole members 11 and 12 are secured to the core in any suitable manner, and the other ends of these members are turned at right angles to form the pole-pieces 13 and 14. These parts are held in position by a non-magnetic member 15, which extends beyond the pole-pieces 13 and 14 and serves as a receptacle for the housing tube 1. When the housing tube 1 is inserted in the holding receptacle, the protuberance 16 on the tube 1 engages the surface of the member 15 and locates the armature 2 in line with the air-gap formed by the pole-pieces 13 and 14.

When it is desired to operate the relay, a circuit is closed for energizing the coil 10. The magnetic flux produced by the pole-pieces 13 and 14 attracts the magnetic armature 2 from the position shown in Fig. 1 to the position shown in Fig. 3. As the armature 2 approaches its operated position the mercury-covered surface 5 engages the mercury-covered surface 8 to effect the initial closure of the circuit. Immediately thereafter the solid contact 7 resists the movement of the movable contact 4, and the spring portion of the armature 2 flexes to provide a firm engagement between the movable and stationary contacts. When the operating coil 10 is deenergized, the spring portion of the armature 2 returns the armature and movable contact to the normal position.

Thus each circuit closure is made by the merging of two liquid surfaces without the necessity of utilizing any appreciable amount of the operating force of the relay for moving the mercury. During the operated condition of the relay the liquid surfaces maintain a good electrical contact and prevent any momentary openings in the event the solid contact members are subjected to vibration. Also each circuit opening is effected by the disengagement of one mercury-coated surface from another. One of the advantages of this construction is that the solid contact elements 4 and 7 are protected from deterioration by sparking in that each circuit closure and opening is effected through the mercury film.

The relay shown in Figs. 7 to 11 is similar to the one above described in that it utilizes the capillary attraction principle for maintaining a coating of mercury on the contact-making surfaces. The sealed glass tube 18 is provided with an armature 19, which is welded or otherwise secured to the terminal post 20. As in the relay previously described, the armature 19 is provided with transverse cuts 21 forming a spring portion at the upper end thereof. The lower end of the armature, however, is formed with a narrow integral contact strip 23 which is doubled and shaped as seen in Fig. 10 to present a depending portion and a contact portion having two contact-making surfaces 24 and 25. These contact-making surfaces cooperate with the stationary contacts 26 and 27, both of which are sealed into the upper end of the tube 18. In the normal position of the armature 19 the surface 24 of the movable contact engages the stationary

contact 26 to establish a normally closed circuit through the relay. In the operated position of the armature the surface 25 of the movable contact engages the stationary contact 27 to close an alternate circuit through the relay.

The depending portion of the movable terminal 23 is constantly immersed in a pool of mercury 28 and serves to attract the mercury by capillarity up out of the pool to the contact-making surfaces 24 and 25. The mercury, which spreads itself in a film over the entire surfaces 24 and 25, is transferred by physical engagement to the contact-making surfaces on the lower ends of the stationary contacts 26 and 27.

The magnetic structure for the relay of Figs. 7 to 10 may also be the same as the one shown in Fig. 6. When the coil 10 is deenergized, the armature 19 assumes its normal position, and a closed path for the flow of current through the relay may be traced from the feed terminal 29, mercury pool 28, movable contact 23 and stationary contact 26. When the operating coil 10 is energized, the armature 19 is attracted from its normal position (Fig. 7) to its operated position (Fig. 9), and the circuit path through the relay is now transferred from the stationary contact 26 to the stationary contact 27.

The relay shown in Figs. 12 to 17, inclusive, includes a housing container 30, formed by welding together two eyelets of any suitable non-magnetic metal; or if desirable some material such as stainless steel may be used for the upper eyelet. The open end of the upper eyelet is sealed with a mass 31 of a non-conducting material, such as glass.

The armature 32 is provided with pivot points 33 and 34, which engage the notches 35 and 36 formed at the junction of the upper and lower eyelet members comprising the container 30. A contact strip, secured to the upper surface of the armature 32, provides one contact-making surface 37 for engagement with the stationary contact 38 in one position of the armature and a second contact-making surface 39 for engagement with the stationary contact 40 in the other position of the armature. The contact strip has a depending portion 41 which projects down into a pool of mercury 42 and acts to attract the mercury over the contact-making surfaces 37 and 39. The mercury 42 rests in a small spherically shaped cavity formed in the bottom of the container 30. The different parts of the armature 32 are so proportioned that the armature normally rests in the position shown in Fig. 12 to engage the stationary contact 40. The projecting arm 52 rests on the surface of the pool and counteracts any tendency the mercury may have to pull down on the immersed member 41 and shift the position of the armature.

The stationary contact 38 is illustrated as a tube and may be used for the purpose of evacuating the interior of the relay container 30. If desirable, however, the contact 38 may be a solid member similar to contact 40, and the tube may be evacuated by other means.

A suitable magnetic operating structure for the relay shown in Figs. 12 to 16 is illustrated in Fig. 17. It includes an operating coil 43 wound on a core to which the magnetic members 44 and 45 are secured, the non-magnetic member 46 being provided as a part of the assembly to hold the different parts in place. A non-magnetic plate 47 is shaped to receive and hold the container 30 in position. When the relay unit is assembled in the magnetic structure, the shoulder 48 formed

by welding together the upper and lower metal eyelets of the container 30 rests on the holding plate 47 and fixes the position of the armature 32 with respect to the pole-pieces 49 and 50.

Normally a circuit path may be traced from the container 30 through the mercury pool 42 through the transfer member 41 of the armature to the stationary contact 40. When the coil 43 is energized, the flux produced across the pole-pieces 49 and 50 moves the armature about its pivot to the position shown in Fig. 14. The circuit path through the relay now extends from the container 30, pool 42, armature 32 to the stationary contact 38.

Each of the relays described herein is constructed to take full advantage of the forces of capillarity to maintain a coating or film of mercury on the contact-making surface of the movable and stationary contacts. The capillary action may be enhanced by making the translating member of certain materials, such as platinum, nickel and copper, or by coating it with these materials, and by including inert gases in the container to prevent corrosion of the contact surfaces. Thus it is possible to obtain the benefits of liquid contacts without utilizing any of the operating force of the relay. This feature is particularly important where small operating currents are involved, such as those encountered in telephone and telegraph systems.

It will, of course, be understood that the invention is not limited to the particular structures shown in the present disclosure. If desirable the housing tubes may be made in various shapes and sizes; the armatures may vary in their shapes and proportions; the shapes and location of the stationary and movable contacts may also be varied; and numerous variations of the magnetic structure may be employed. Furthermore, the chamber within the housing tube or container may be supplied with any suitable gas for preserving the contacts and for improving the operation of the relay.

What is claimed is:

1. The combination in an electric switch of a reservoir containing a pool of conducting liquid, and an element having a contact-making surface and a part extending downward into said pool for the purpose of attracting by capillary action some of the liquid from said pool to said contact-making surface.

2. The combination in an electric switch of a pool of mercury, and an electric contact having a contact-making surface and an extension leading down into said pool for the purpose of attracting by capillary action some of the mercury from the pool and onto said contact-making surface.

3. The combination in an electric switch of a container having a pool of mercury therein and a contact having an engagement surface for the making and breaking of an electric circuit and having a part extending downward into said pool for the purpose of attracting by capillarity some of the mercury out of said pool and for maintaining a film thereof over said engagement surface.

4. In an electric switch, a housing having a pool of mercury therein, an armature mounted in said housing, a movable contact actuated by said armature, a stationary contact projecting into said pool and serving as a transfer means to attract the mercury by capillary action out of said pool and onto the contact-making surface of said stationary contact, and means for mov-

ing said armature to effect engagement and disengagement between said movable contact and the contact-making surface of said stationary contact.

5 In an electric switch, a closed housing tube having a pool of mercury in the bottom thereof, a magnetic armature mounted in said tube for movement under the influence of a magnetic field, a movable contact secured to said armature, a stationary contact extending into said pool of mercury and having a contact-making surface disposed above the level of said mercury in said pool, said stationary contact serving to attract the mercury from the pool to cover said contact-making surface, and an energizing coil for operating said armature.

6 The combination in an electric switch of a closed tube having a pool of mercury therein, a resilient magnetic armature mounted in said tube, a movable contact secured to said armature, a stationary contact secured in said tube and projecting upwardly through said pool of mercury, said stationary contact having a contact-engaging surface disposed above the level of the mercury in said pool, said stationary contact serving to attract by capillarity mercury from the pool to maintain a deposit thereof over said contact-engaging surface, and an energizing coil for moving said armature to advance said movable contact into engagement with the mercury-covered contact-engaging surface of said contact.

7 In an electric switch, a housing member, a pool of mercury in said housing member, an armature, means for operating said armature without displacing the mercury in said pool, an electric contact having an engagement surface for opening and closing an electric circuit in response to the movement of said armature, and a member extending from said engagement surface into said pool for attracting by capillarity some of the mercury from said pool to cover said surface.

8 In an electric switch, a container having a pool of mercury therein, an armature formed from a thin strip of magnetic material and mounted within said container, said armature having a series of transverse cuts forming a spring portion for restoring the armature to its normal position, movable and stationary contacts having contact-making surfaces for engagement in response to the movement of said armature, one of said contacts serving to attract mercury out of said pool and onto said contact-making surfaces, and electromagnetic means for operating said armature.

9 The combination in an electric switch of a container having a pool of mercury therein, an armature mounted in said container, contacts having contact-making surfaces cooperating with each other to open and close a circuit in response to the movement of said armature, said surfaces disposed a substantial distance above the surface of said mercury pool, and means including one of said contacts serving to attract the mercury by capillary action out of said pool to cover said contact-making surfaces with a liquid film.

10 The combination in an electric switch of a container having a pool of mercury in the bottom thereof, an armature mounted in said container, a movable contact element carried by said armature, said contact element having contact-making surfaces, a stationary contact engaged in the normal position of said armature by one of the contact-making surfaces of said movable contact,

a second stationary contact engaged in the operated position of said armature by another of the contact-making surfaces of said movable contact, and a transfer member associated with said movable contact and constantly immersed in said mercury pool for attracting some of the mercury by capillarity to said contact-making surfaces.

11 The combination in an electric switch of a vertically mounted housing tube, a terminal sealed in the upper end of said tube, a terminal sealed in the lower end of said tube having a portion projecting into the interior of the tube and serving as a stationary contact, a pool of mercury resting in the lower end of said tube, said stationary contact projecting through said pool and having a contact-making surface which lies above the surface of the mercury in said pool, said stationary contact serving to attract some of the mercury from said pool to cover said contact-making surface, an armature formed of a thin sheet of magnetic material shaped to conform generally to the interior surface of said tube and secured at its upper end to the terminal sealed in the upper end of said tube, said armature having a resilient portion formed by transverse cuts therein, a movable contact secured to the lower end of said armature and disposed in operative relation to the contact-making surface of said stationary contact, and means to produce a magnetic force for attracting said armature to move said movable contact into circuit making engagement with the contact surface of said stationary contact, the resilient portion of said armature serving to disengage said movable and stationary contacts when the magnetic force is withdrawn.

12 The combination in an electric switch of a container having a pool of conducting liquid therein, contacts having contact-making surfaces which engage and disengage each other for the purpose of closing and opening an electric circuit, and means including one of said contacts for utilizing the forces of capillarity to draw some of the liquid from said pool and to maintain a film thereof over said contact-making surfaces for the purpose of improving the circuit closure made by the engagement of said surfaces.

13 The combination in an electric switch of a container having a pool of mercury therein, an armature mounted exterior of said pool and movable in its path of operation without engaging said pool, contacts having contact-making surfaces which engage and disengage each other in response to the movement of said armature to open and close an electric circuit, and means including one of said contacts for utilizing the forces of capillarity to draw some of the mercury from said pool and to maintain a film thereof over said contact-making surfaces.

14 The combination in an electric switch of a housing having a pool of mercury therein, an armature mounted in said housing and having normal and operated positions, means for moving said armature between its normal and operated positions without causing it to engage the mercury in said pool, contacts of a solid material having contact-making surfaces which engage and disengage each other in response to the movement of said armature to open and close an electric circuit, and means including one of said contacts for utilizing the forces of capillarity to draw some of the mercury from said pool to said contact-making surfaces for the purpose of protecting said solid contacts from deterioration due

to the engagement and disengagement of said surfaces.

15. The combination in an electric switch of a housing having a pool of mercury therein, an armature mounted in said housing, stationary and movable contacts having contact-making surfaces for closing and opening an electric circuit, means for moving said armature to effect

engagement and disengagement of said contact-making surfaces without immersing the armature or said movable contact in said pool, and means including one of said contacts for attracting by capillary action some of the mercury from said pool to maintain a film thereon over said contact-making surfaces.

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