

April 27, 1943.

C. E. POLLARD
ELECTRIC SWITCH

Filed June 15, 1940

2,317,695

2 Sheets-Sheet 1

FIG. 1

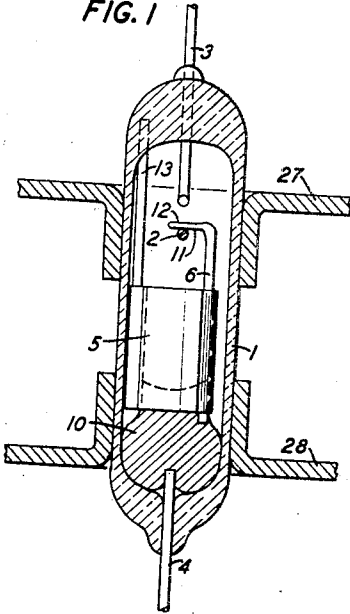


FIG. 2

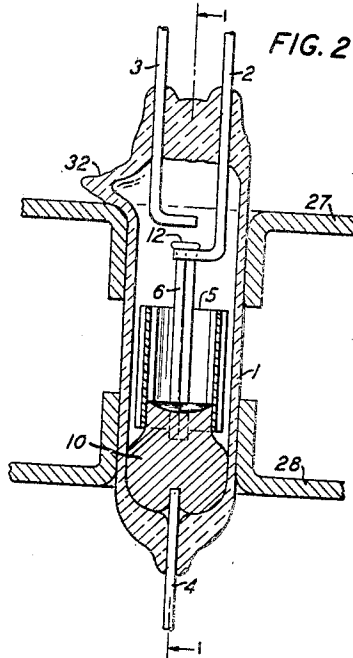


FIG. 3

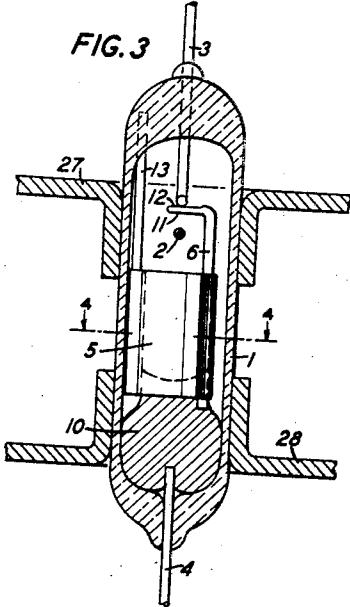
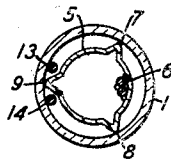


FIG. 4



INVENTOR
C. E. POLLARD
BY *W. McKenney*
ATTORNEY

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FIG. 5

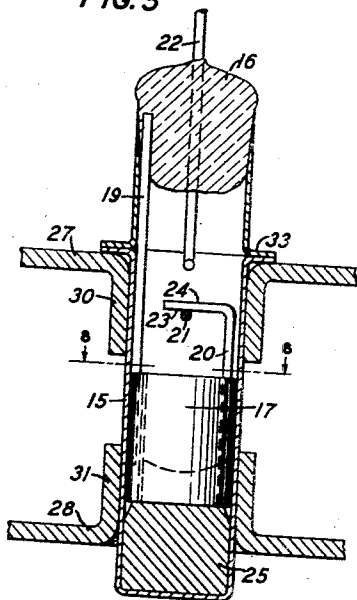


FIG. 6

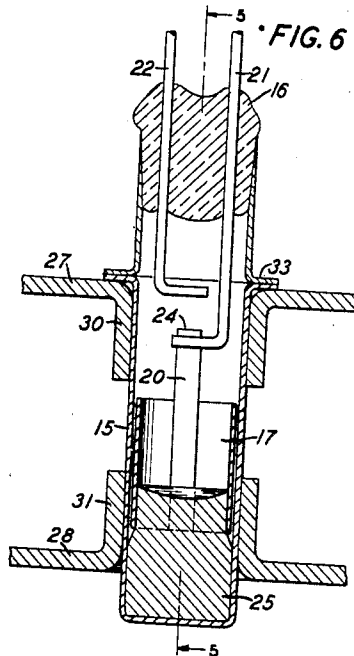


FIG. 7

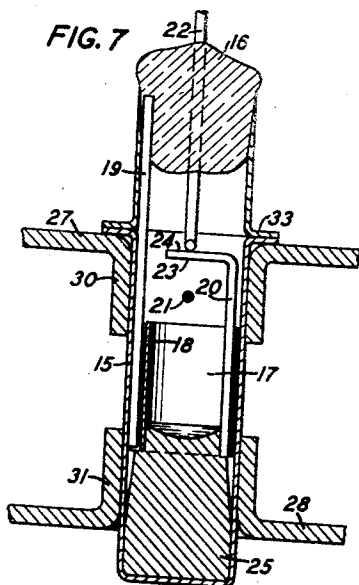


FIG. 8

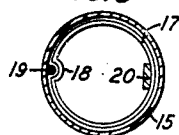
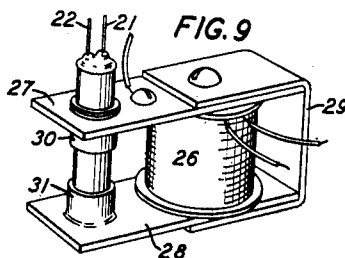


FIG. 9



INVENTOR
C. E. POLLARD
BY *W. P. Moteney*
ATTORNEY

UNITED STATES PATENT OFFICE

2,317,695

ELECTRIC SWITCH

Charles E. Pollard, Hohokus, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application June 15, 1940, Serial No. 340,663

6 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. In either case it is necessary to move all or a considerable part of the mercury mass into a position where it physically engages or disengages the desired contact.

In accordance with the present invention the benefits following from the use of mercury as a contact-closing medium are retained, and at the same time other advantages are obtained over these prior switching devices, by means of a switch in which a small amount of mercury is transferred by capillarity from a common pool or reservoir to maintain a film or coating over the surfaces of the contacts, and in which the force of surface tension in the mercury pool serves to hold the armature in its normal contact-making position and also to draw the armature back from its operated position to its normal position when the operating force is removed.

More specifically the objects and advantages of the present invention are realized in a switch including a sealed tubular envelope containing a pool of mercury in the bottom thereof and a hollow cylindrical armature arranged to move up and down in the envelope for the purpose of engaging movable and stationary contacts. The movable element is secured to the armature in a vertical position with one end extending down into the mercury pool and the other end bent at

right angles to form a contact portion, which, in the normal or lower position of the armature, engages the overturned end of a stationary contact. This engagement limits the downward movement of the armature. Mercury from the pool creeps up the movable contact by capillary action and maintains a liquid film over the contact-making surfaces. The mercury in the pool also adheres to the inner surface of the armature and is drawn up somewhat to distort the shape of the pool when the armature is in its normal or lowermost position. This distortion increases the surface tension forces which pull down on the armature to hold the movable contact firmly in engagement with said stationary contact. When the armature is moved upward to its operated position by magnetic attraction, the movable contact engages a second stationary contact, and the mercury pool is pulled or stretched still farther, increasing thereby the forces of surface tension. When the armature is again released from the magnetic attraction, the surface tension in the distorted pool pulls the armature and movable contact quickly back to the normal position.

These and other features of the invention will be described more fully in the following detailed specification.

In the accompanying drawings:

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 of Fig. 3;

Figs. 5 and 6 are side views, partly in section, showing a modified form of the relay;

Fig. 7 is similar to Fig. 5, except that the relay is shown in its operated position;

Fig. 8 is a cross-sectional view taken along the line 8—8 of Fig. 5; and

Fig. 9 is a perspective view of the relay including the magnetic structure and operating unit.

While the invention is not limited to any particular size or proportions for the relay switch it may be noted that this relay is especially 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 dimensions of the relay may be relatively small, and it should be understood that the figures shown in the drawings are greatly enlarged in

order to facilitate a clearer understanding of the construction.

Referring to the drawings, the operating unit illustrated in Figs. 1 to 4 comprises a housing vessel or container in the form of tube 1 of glass or other suitable material having stationary contacts 2 and 3 sealed in the upper end thereof. These contacts project into the interior of the tube where they are turned at right angles to present the contact-making surfaces with which the movable contact cooperates, as will be described later. At the time the glass tube 1 is sealed any suitable gas may be introduced into the enclosure for the purpose of improving the operating characteristics of the relay and for prolonging its useful life. A terminal 4 is also sealed in the lower end of the tube and serves as a common feed terminal for the circuits closed through the contacts 2 and 3.

The movable element of the operating unit comprises an electromagnetic armature 5 and a movable contact 6. The armature 5, which has the general shape of a hollow cylinder open at both ends, is formed from a thin sheet of magnetic material. In shaping the armature 5 a plurality of corrugations or ridges 7, 8 and 9 are provided to space and locate the armature in a centralized position within the housing tube 1. The diameters of the tube 1 and armature 5 are so chosen that the armature may move freely up and down within the tube, the corrugations 7, 8 and 9 acting as guiding and bearing elements during the armature movement and also serving to hold the armature in proper position when at rest. The movable contact 6, which cooperates with the stationary contacts 2 and 3, is welded or otherwise secured to the inner surface of the armature 5.

A pool of mercury 10 resting in the bottom of the tube 1 serves not only as a conducting medium but also to supply the forces for holding the armature in its normal position and for restoring it to its normal position after use. The amount of mercury and the proportions of the different parts are such that the mercury fills a substantial portion of the hollow armature 5 when the armature is in its normal position, as seen in Figs. 1 and 2. Since in actual practice the internal diameter of the armature 5 is relatively small, there is a considerable force of capillarity acting on the mercury in the pool 10. This force and the tendency of the mercury to adhere to the inner surfaces of the armature distort or stretch the mercury pool 10 from its normal configuration, setting up forces of surface tension therein which exert a downward pull on the armature 5. This downward force on the armature holds the movable contact 6 firmly against the contacting surface of the stationary contact 2 in the normal position of the relay. The forces of capillarity and adhesion may be accentuated by coating the inner surface of the armature 5 with certain materials, such as platinum, nickel or copper, and by maintaining the coated surfaces free from corrosion. This may be accomplished, as above noted, by introducing inert gases into the sealed container.

The movable contact 6, it will be noted, is formed by doubling a length of wire, bending the looped end of the contact at right angles and flattening the same to provide the necessary area for the contact surfaces 11 and 12. When the contact thus formed is secured to the inner surface of the armature 5, the lower end projects into the mercury pool 10, and the channels

formed between the two parallel wire sections and between each section and the adjacent surface of the armature serve as capillary ducts for attracting some of the mercury from the pool to the upper end of the movable contact where it spreads and deposits in a film over the contact-making surfaces 11 and 12. These capillary channels are illustrated more clearly in Fig. 4.

The specific construction of the movable contact 6, whereby mercury is transferred by capillarity from the pool to the contact-making surfaces, is the subject-matter of the patent to C. E. Pollard, No. 2,259,661 of October 21, 1941.

The stationary contacts 2 and 3 are also bent at right angles to present contact-making surfaces for cooperation with the movable contact 6. These stationary contacts also serve as stops to limit the armature 5 in its movement between the normal and operated positions. The armature is restrained from any rotary movement within the tube 1 by means of guide wires 13 and 14. These guide wires are embedded in the upper end of the housing tube 1, and they are spaced sufficiently to admit the corrugation 9 on the armature 5. As the armature moves up and down within the tube the corrugation 9 bears freely against these guide wires and prevents any excess rotation of the armature, thus maintaining the proper relation between the movable and stationary contacts.

The alternative switch shown in Figs. 5 to 8, inclusive, is similar in its general construction and operation to the one above described. There are, however, specific differences which will now be explained. The housing tube 15, for example, is made of some suitable non-magnetic metal instead of glass. It is formed by welding together two metal eyelets and by sealing the open end of the resulting tube with a mass 16 of any suitable material, such as glass. During the sealing operation the air within may be extracted and any suitable gas introduced.

The process by which the container is formed and evacuated and charged with gas is the subject of a copending application by H. C. Harrison and J. B. Little, Serial No. 340,655, filed June 15, 1940.

The magnetic cylindrical armature 17 has a substantially smooth external surface. In order that the armature may move freely up and down within the tube the diameter of the armature is made somewhat less than that of the tube. However, the relatively close fit of the armature within the tube serves to maintain the armature in its proper centralized position. The armature 17 is prevented from rotation within the tube by means of a vertical channel 18 in the external wall of the armature which cooperates with the guide wire 19 embedded in the seal 16.

The movable contact 20 is formed of a single strip of metal and is secured by welding or otherwise to the inner surface of the armature 17. The upper end of the movable contact 20 is bent at right angles to cooperate with the contact surfaces of the stationary contacts 21 and 22. The contact 20, the lower end of which is immersed at all times in the mercury pool 25, serves to attract some of the mercury up out of the pool to the contact-making surfaces 23 and 24. The distance from the surface of the pool to the surfaces 23 and 24 is small, and the capillary action of the mercury may be augmented by making the contact 20 of such metals as platinum, nickel or copper or by coating it with these metals.

One suitable magnetic operating structure for

these relays is shown in Fig. 9. It comprises a winding 26 and pole members 27 and 28. The winding 26 is wound about a core, which is not visible in the drawing, and the pole members 27 and 28 are secured to the core by screws or bolts as illustrated in the drawing. A non-magnetic member 29 is also included in the assembly for holding the parts in place. The ends of the pole members 27 and 28 are punched and drawn to form cylindrical pole-pieces 30 and 31. These cylindrical pole-pieces extend toward each other and form the air-gap, across which the magnetic flux passes when the coil 26 is energized. Furthermore, these pole-pieces serve as a receptacle and holder for the switch unit. When the switch unit shown in Figs. 1 to 4, inclusive, is inserted in the receptacle thus formed by the pole-pieces, the protuberance 32, formed by sealing the glass tube 1, engages the surface of the pole member 27 (seen more clearly in Fig. 2) and fixes the position of the switch unit with respect to the air-gap of the magnetic structure. This fixed position is such that the greater part of the armature 5 lies below the center of the air-gap when the relay is in its normal position. When one of the switch units shown in Figs. 5 to 8, inclusive, is inserted in the receptacle formed by the pole-pieces 30 and 31, the peripheral shoulder 33, formed by the juncture of the upper and lower eyelets, engages the surface of the pole member 27 and fixes the position of the unit in the structure.

When, as above explained, the relay is in its normal position, the mercury pool assisted by the action of gravity, holds the armature down against the lowermost stationary contact to complete a normally closed circuit through these contacts. In the relay shown in Figs. 1 to 4, for example, the mercury pool 10, pulling down on the armature 5, holds contact 6 in engagement with the stationary contact 2, and a circuit may be traced through the relay from terminal 4, mercury pool 10, contact 6, thence to the stationary contact 2. When it is desired to open this normally established circuit and to close a circuit between the terminal 4 and the other stationary contact 3, a circuit is closed in any well-known manner for energizing the coil 26. The flux set up in the magnetic circuit by the energized coil 26 traverses the air-gap, and the magnetic armature 5 is drawn upwardly in an effort to reduce the reluctance of the air-gap. This upward movement of the armature carries the movable contact 6 out of engagement with contact 2 and into the operated position (seen in Fig. 3) where it engages contact 3 to close the desired circuit. The upward movement of the armature further distorts the mercury pool 10, which continues to cling to the inner surfaces of the armature, thereby increasing the forces of surface tension which oppose the magnetic field and endeavor to return the armature to its normal position. When the circuit of the energizing coil 26 is opened, the magnetic field is removed, and the armature 5 is quickly restored to its normal position by the force of gravity and the downward pull exerted thereon by the distorted mercury pool 10.

The operation of the relay shown in Figs. 5 to 8 is the same as that already described.

In the relays described herein the mercury pool accomplishes a plurality of essential and useful purposes. By the simple action of capillarity some of the mercury is transferred out of the pool to the contact-making surfaces of the movable contact from whence it spreads to the con-

tact surfaces of the stationary contacts. Furthermore, the mercury pool serves to hold the armature and movable contact firmly in the normal position and restore them to the normal position when they are released from the attractive force of the magnetic field.

It will, of course, be understood that the invention is not limited to the particular structure shown in the present disclosure. If desirable, the housing tube may be made in various shapes and sizes; the armatures may vary in their shape and proportions and in the methods by which they are formed; the shapes and location of the stationary and movable contacts may also be varied; and numerous variations of the magnetic structure may be employed.

What is claimed is:

1. The combination in an electric switch of a housing tube, a stationary contact extending into said tube, an armature movable up and down within said tube, a movable contact secured to the armature and engaging said stationary contact in the normal position of the armature to define the lower limit of the armature movement, a mass of mercury resting in the lower part of said tube with its upper surface adhering to the lower end of said armature, the adhesion of the mercury to the armature serving to produce forces of surface tension therein which act to hold said movable contact firmly in engagement with said stationary contact, and means for moving said armature upward to further displace the mercury mass and to disengage said movable contact from said stationary contact, said forces of surface tension serving to increase the speed of restoration of said armature to its normal position.

2. The combination in an electric switch of a container, a stationary contact extending into said container, an armature movable up and down within said container, a movable contact secured to the armature and engaging said stationary contact in the normal position of the armature to prevent further downward movement thereof, a pool of mercury in the lower part of said container with its upper surface adhering to the surfaces of said armature and exerting a force thereon to hold said armature in its normal position with said movable contact in firm engagement with said stationary contact, and operating means for moving said armature upward, said mercury adhering to said armature in its upper position and serving to increase the speed of restoration of the armature to its normal position when the operating means becomes ineffective.

3. The combination in an electric switch of a closed housing vessel, a hollow cylindrical armature movable up and down within said vessel, a first stationary contact mounted within said vessel, a movable contact secured to said armature and normally engaging said stationary contact to limit the downward movement of said armature, a mass of mercury resting in the lower part of said vessel and extending up on the interior of said armature, said mercury adhering to the inner surfaces of said armature and exerting a force thereon to hold said armature in its lower position, and magnetic means for attracting said armature upward to disengage said movable and stationary contacts, said mercury continuing to adhere to the inner surfaces of said armature when moved to its upper position and serving to restore said armature when said magnetic means becomes ineffective.

4. The combination in an electric switch of a closed vertical tube, a hollow cylindrical arma-

ture having a diameter somewhat less than that of the tube, said armature being formed with a number of ridges spaced around its exterior for guiding its movement up and down within said tube, a stationary contact projecting into the interior of said tube, a movable contact secured to said armature and engaging the stationary contact in the normal position to prevent further downward movement of the armature, parallel guide rods secured within said tube, one of said ridges resting between said guide rods to prevent rotation of the armature within the tube, a pool of mercury in the bottom of said tube projecting up into the interior of the armature and adhering to the surfaces thereof to exert a force holding the armature in its downward or normal position, and electromagnetic means for drawing said armature up to disengage said terminals, the mercury continuing to adhere to said armature during its upward movement and serving to withdraw the same to its normal position when said electromagnetic means becomes ineffective.

5. The combination in a switch of a closed vertical housing tube, a hollow cylindrical armature movable up and down within said tube, a stationary contact projecting into said tube, a pool of mercury in the bottom of said tube extending up into said armature and adhering to the surfaces thereof to exert a downward pull on said armature, a movable contact secured to said armature with its lower end extending into the mercury pool and the other end engaging said stationary contact to limit the extent of the downward movement of the armature, said movable

contact serving to attract the mercury by capillarity up to the contact-engaging surfaces thereof, a second stationary contact projecting into said tube, and electromagnetic means for moving said armature in an upward direction to advance the movable contact out of engagement with the first-mentioned stationary contact and into engagement with said second stationary contact, the mercury continuing to adhere to the inner surfaces of said armature in its operated position and serving to withdraw the armature to its normal position when said electromagnetic means becomes ineffective.

6. The combination in an electric switch of a housing tube, a stationary contact extending into said tube, a hollow cylindrical armature movable up and down within said housing tube, a movable contact secured to said armature and having a contact-making surface for engagement with said stationary contact, a mass of mercury resting in the lower part of said tube and extending up into the interior of said cylindrical armature, said mercury adhering to the surfaces of said armature and exerting a force thereon to hold the armature in its lower position, and magnetic means for attracting said armature upward to cause the engagement of said movable and stationary contacts, the upward movement of said armature serving to distort the shape of the mercury mass and to set up therein forces of surface tension which act to withdraw the armature to its normal position when said magnetic means becomes ineffective.

CHARLES E. POLLARD.