Oct. 21, 1941. C. E. POLLARD 2,259,661

ELECTRICAL SWITCH

Filed June 15, 1940

FIG. 1

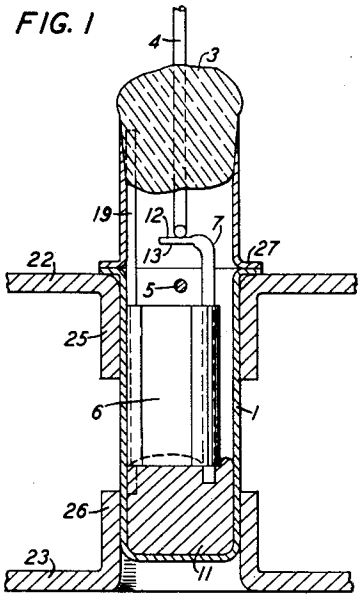


FIG. 2

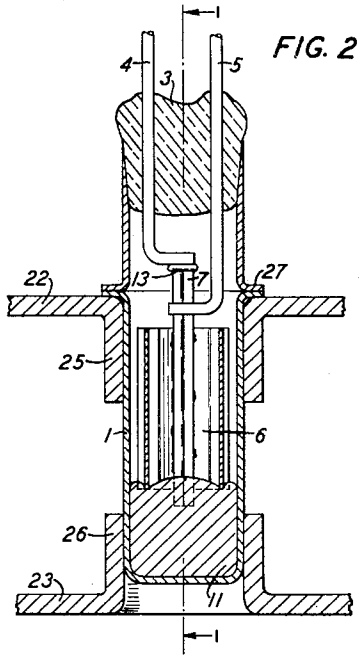


FIG. 3

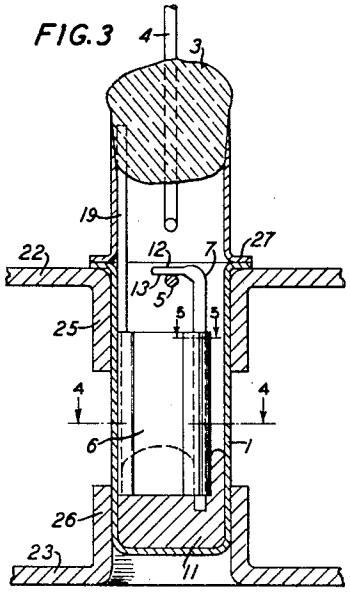


FIG. 4

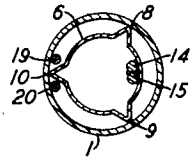


FIG. 5

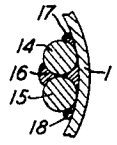
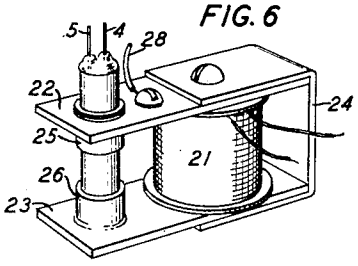


FIG. 6



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UNITED STATES PATENT OFFICE

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ELECTRICAL SWITCH

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Application June 15, 1940, Serial No. 340,662

4 Claims. (Cl. 200—112)

This invention relates to electrical 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 either all or a considerable part of the mercury mass into a position where it physically engages or disengages the desired circuit contact.

In accordance with the present invention advantages are achieved over these prior devices by means of a switch in which the movable and stationary contacts are of solid material, in which the movable contact comprises a pair of parallel wires extending vertically into a pool of mercury in the bottom of the housing envelope, these wires being attached to a hollow cylindrical armature which floats normally on the surface of the pool. The parallel wires lie close together to form a capillary duct which attracts a small portion of the mercury up out of the pool. The mercury thus attracted by the capillary forces runs up and forms a film over the surfaces of the movable contact and also the surfaces of the stationary contacts which are engaged by the movable contact in response to the movement of the armature in the field of a coil disposed externally of the envelope.

A feature of the invention is a switch of the kind above described in which the armature normally floats on the mercury pool at a level to hold the movable contact, secured to said armature, in engagement with one of the stationary contacts; in which the armature, when pulled downwardly by the magnetic field, shifts the movable contact from engagement with the one stationary contact and into engagement with the other stationary contact, shortens the length of the capillary duct between the surface of the pool and the contact-engagement surfaces, and sets up surface tension forces in the body of mercury; and in which these forces of surface tension act to restore the armature and movable contact to normal when the magnetic force is removed.

The foregoing and other features of this invention will be discussed more fully in the following detailed specification.

In the drawing 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 of Fig. 3;

Fig. 5 is an enlarged cross-sectional view taken along the line 5—5 of Fig. 3; and

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

While the invention is not limited to a switch of any given size or proportions, it may be noted that this switch or 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 drawing are greatly enlarged to facilitate a clearer understanding of the construction.

Referring now particularly to the drawing, the relay there illustrated comprises an electromagnetic structure for supplying the operating force and a separate operating unit for opening and closing the circuit-making contacts. The operating unit includes a metallic tube or container 1 formed by welding together two eyelets. These eyelets are made of any suitable non-magnetic metal to prevent interference with the magnetic circuit. The upper end of the tube thus formed is closed with a mass 3 of sealing and insulating material, such as glass. This construction provides a gas-tight chamber into which any suitable gas may be introduced prior to the sealing operation for the purpose of improving the operating

characteristics of the relay and for prolonging its useful life.

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

The two stationary contacts 4 and 5 are sealed into the insulating mass 3 and project into the interior of the tube where their ends are bent at right angles to form the contact-making surfaces with which the movable contact of the switch engages.

The movable element comprises an electromagnetic armature 6 and a movable contact 7. The armature 6, which has the general shape of a hollow cylinder, open at both ends, is formed from a thin sheet of magnetic metal. In shaping the armature 6 a plurality of corrugations or ridges 8, 9 and 10 are provided to space and locate the armature in its centralized position within the housing tube 1. The diameters of the tube 1 and armature 6 are so chosen that the armature may move freely up and down within the tube, the corrugations 8, 9 and 10 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 7, which cooperates with the stationary contacts 4 and 5, is welded or otherwise secured to the inner surface of the cylindrical armature 6.

This movable element, comprising the armature 6 and the contact 7, floats on the surface of a pool of mercury 11, which rests in the bottom of the tube 1. The amount of mercury in the pool 11 and the dimensions of the various elements of the relay are such that the forces of the mercury acting on the armature 6 urge the movable contacts 7 against the stationary contacts 4 with sufficient pressure to maintain a good electrical contact.

The movable contact 7, 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 12 and 13. When the contact thus formed is secured to the inner surface of the armature 6, the lower end of the contact projects into the mercury pool 11, 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 12 and 13. These capillary channels are illustrated more clearly in the enlarged section of Fig. 5. This figure shows the two sections 14 and 15 of the contact 7 and also the mercury columns 16, 17 and 18 that run up the capillary ducts from the pool to the upper end of the terminal.

The stationary contacts 4 and 5 are also bent at right angles to present contact-making surfaces for cooperation with the movable contact 7. These stationary contacts also serve as stops to limit the armature 6 in its movement between the normal and operated positions. The armature 6 is restrained from any rotary movement within the tube by means of guide wires 19 and 20. These guide wires are embedded in the seal 3 and may also be welded to the inner surface of the housing tube. They are spaced sufficiently to admit the corrugation 10 on the armature 6. As the armature moves up and down within the tube corrugation 10 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 magnetic operating structure for the relay, shown in Fig. 6, comprises a winding 21 and pole members 22 and 23. The winding 21 is wound on a core, which is not visible in the drawing, and the pole members 22 and 23 are secured to the core by screws or bolts as illustrated in the figure. A non-magnetic member 24 is also included in the assembly to hold the parts in place. The ends of the pole members 22 and 23 are punched and drawn to form cylindrical pole-pieces 25 and 26, respectively. These cylindrical pole-pieces extend toward each other and form the air-gap, across which the flux passes when the coil 21 is energized. Furthermore, these cylindrical pole-pieces serve as a receptacle and holder for the switch unit. When the switch unit is inserted in the receptacle thus formed by the pole-pieces, the peripheral shoulder 27, formed at the juncture of the upper and lower eyelets, engages the surface of the pole member 22 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 6 lies above the center of the air-gap when the relay is in its normal position. This relation is clearly illustrated in Figs. 1 and 2.

With the relay in its normal position, as illustrated in Figs. 1 and 2, the movable contact 7 engages the stationary contact 4, and the electrical circuit established thereby may be traced from the terminal conductor 28, pole member 22, metallic housing tube 1, mercury pool 11, armature 6, movable contact 7 and thence to the stationary contact 4. When it is desired to open this normally-established circuit and to close a circuit between the terminal conductor 28 and the other stationary contact 5, a circuit is closed in any well-known manner for energizing the coil 21. The flux set up in the magnetic circuit by the energized coil 21 traverses the air-gap, and the magnetic armature 6 is drawn downwardly in an effort to reduce the reluctance of the air-gap. This downward movement of the armature carries the movable contact 7 out of engagement with contact 4 and into engagement with contact 5 to close the desired circuit. The downward movement of the armature also distorts the mercury pool 11, forcing a substantial amount of the mercury up on the inside of the hollow armature, as seen in Fig. 3, and setting up therein forces of surface tension which oppose the magnetic field and endeavor to return the armature to its normal position.

As above explained the contact-making surfaces 12 and 13 of the movable contact 7 are constantly wet with mercury, which is transferred thereto along the capillary ducts resulting from the special configuration of the stationary contact. This deposit of mercury on the engagement surfaces of the movable contact is also transferred by physical engagement and deposited on the stationary contacts 4 and 5, thus providing mercury surfaces for the closing and opening of the circuits controlled by the relay. It will also be noted that the transfer of the mercury to the contact surfaces is facilitated by the substantial reduction in the length of the capillary ducts when the armature is attracted

to its operated position. Also this action may be augmented by coating the contacts with certain materials, such as platinum, nickel, and copper, and by including inert gases in the container to maintain these coated elements free from corrosion.

When the circuit of the energizing coil 21 is opened, the magnetic field is removed, and the armature 6 is restored to its normal position by the forces set up in the distorted mercury pool.

It will, of course, be understood that the invention is not limited to the particular structure used to illustrate it in the present disclosure. If desirable, the housing tube may be made in various shapes and sizes and of other materials, such as glass; the armature may vary in its shape and proportions and in the method by which it is formed; the shape 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 closed envelope having a pool of mercury in the bottom thereof, an armature resting on said pool, a movable contact comprising two parallel sections of conductor secured to said armature, one end of said contact being immersed in said pool and the other end constituting the contact-making surface, a stationary contact mounted in said envelope for engagement by the contact-making surface of said movable contact, the conductor sections of said movable contact lying close together to form a capillary channel for attracting mercury from said pool to said contact-making surface, and electromagnetic means for moving said armature.

2. The combination in an electric switch of an envelope having a pool of mercury therein, an armature resting on said pool, a movable contact comprising two parallel sections of wire secured to said armature with the lower end of said contact projecting into said pool and the upper end constituting the contact-making surface, a stationary contact mounted in said envelope for engagement by the contact-making surface of said movable contact, the wire sections of said movable contact lying adjacent each other to form a channel for guiding the mercury attracted from said pool by capillary action to said contact-making surface, and electromagnatic means for moving said armature to displace the mercury in said pool and to effect engagement between the movable and stationary contacts, the forces of surface tension in the displaced mercury pool serving to restore said armature to its normal position.

3. The combination in an electric switch of a closed vertical tube having a pool of mercury in the bottom thereof, a hollow cylindrical armature resting on said pool, a movable contact comprising two parallel conductors secured to said armature in a vertical position with the lower end of said contact projecting into said pool and the upper end shaped to present contact-making surfaces, two stationary contacts secured in said tube for engagement by the contact-making surfaces of said movable contact, the conductor sections of said movable contact arranged to form a channel for guiding the mercury attracted from said pool by capillary action to said contact-making surfaces, and electromagnetic means for moving said armature to displace the mercury in said pool and to advance the movable contact out of engagement with one of said stationary contacts and into engagement with the other, the forces set up in the displaced mercury serving to restore said armature to its normal position when said electromagnetic means becomes ineffective.

4. In an electric switch, a closed vertical tube having a pool of mercury in the bottom thereof, a vertical cylindrical armature resting on the surface of said pool, a movable circuit contact comprising two parallel conductor sections secured to said armature in a vertical position with the lower end of said contact projecting below the surface of said pool and the upper end formed to present contact-making surfaces, a stationary contact normally engaged by said movable contact, a second stationary contact, the conductor sections of said movable contact arranged adjacent each other to form a capillary tract for guiding mercury from said pool to cover said contact-making surfaces, and electromagnetic means for pulling said armature down to displace the mercury in said pool, to shorten the length of said capillary tract, and to advance said movable contact out of engagement with the first-mentioned stationary contact and into engagement with said second stationary contact, the forces of surface tension in the displaced mercury serving to restore said armature to its normal position.

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