

June 30, 1942.

H. C. HARRISON

2,288,452

ELECTRIC SWITCH

Filed June 15, 1940

2 Sheets-Sheet 1

FIG. 1

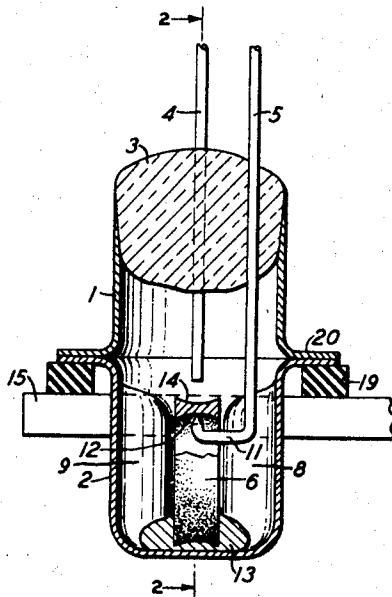


FIG. 2

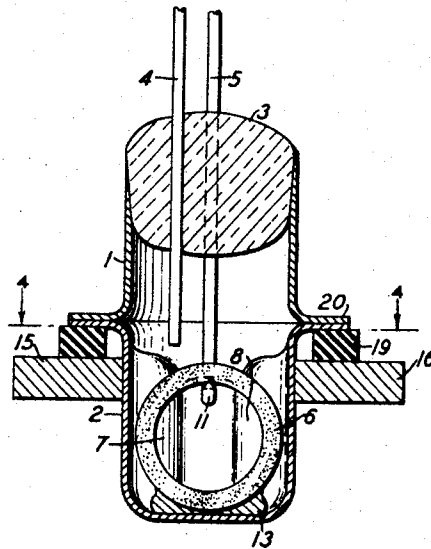


FIG. 3

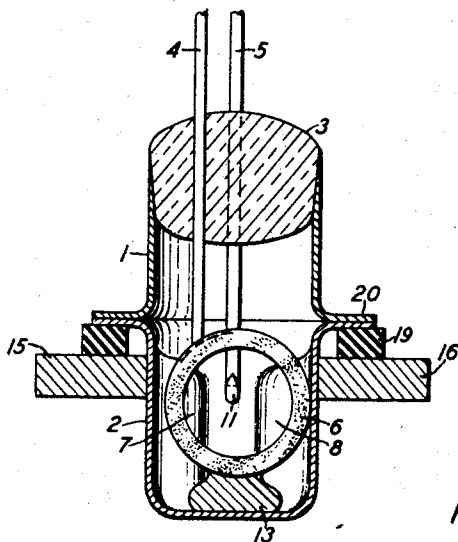


FIG. 4

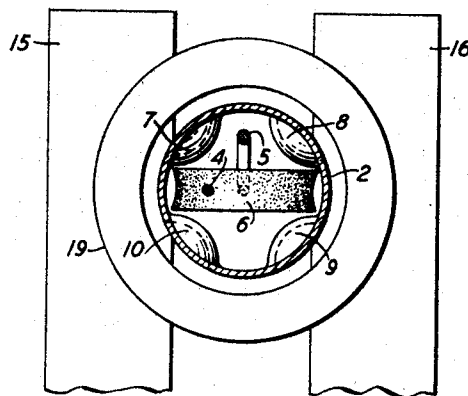
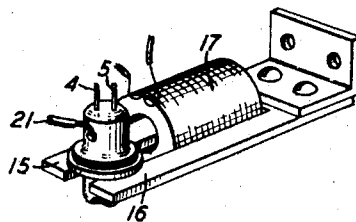


FIG. 5



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FIG. 6

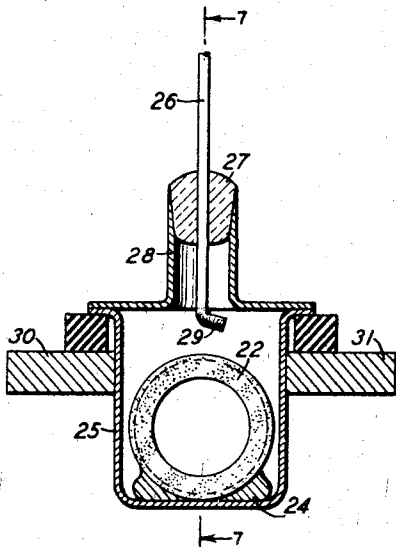


FIG. 7

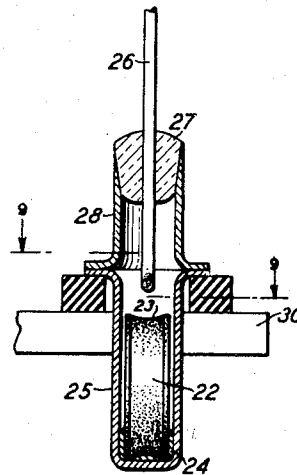


FIG. 8

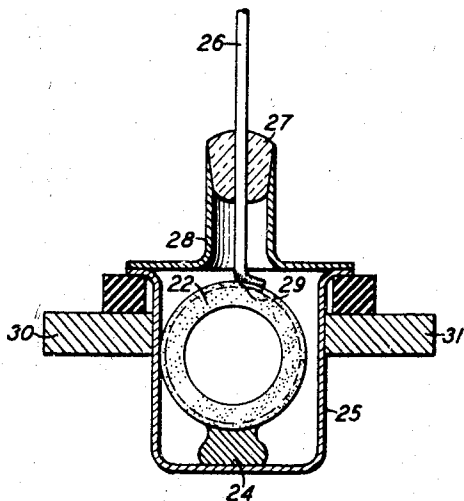
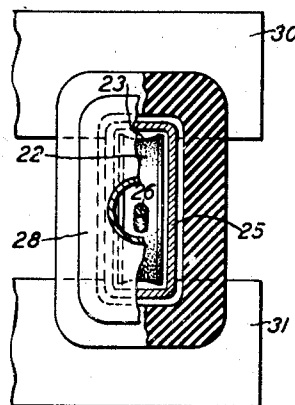


FIG. 9



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2,288,452

ELECTRIC SWITCH

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Application June 15, 1940, Serial No. 340,654

7 Claims. (Cl. 200-112)

This invention relates to electromagnetic relays and switches.

The objects of the invention are to attain a greater degree of simplicity both in the structure and in the principle of operation of these devices, to realize a higher efficiency as a result of these simplifications, to improve the circuit-making contacts, and in other respects to improve relays and switches for circuit controlling purposes.

It is well recognized that mercury has certain advantages over solid contacts for opening and closing electric circuits. Being a fluid, it presents a fresh surface for each contact closure and does not become corroded and pitted as a result of successive circuit interruptions. On the other hand, solid contacts have advantages too. They can be made of materials that are lighter than mercury and can be moved at higher speeds. Also it is possible to apply the forces of the magnetic field more directly to solid contact-operating elements than to a mass of mercury for effecting the desired circuit closures and openings.

Accordingly the foregoing objects of the present invention are achieved by an improved switch or relay which realizes not only the advantages of mercury as a contact-making medium but also the characteristic advantages of solid contact elements.

To this end a feature of the present invention is a switch comprising a closed housing tube having a small quantity of mercury therein for the purpose of maintaining a liquid coating over the contact-making surfaces, fixed solid circuit contacts mounted within the tube, and a movable magnetic armature of improved design for engaging and disengaging said fixed contacts. More specifically the armature consists of an annulus resting on edge in a guide channel, which, in one alternative construction, is formed by re-entrant portions shaped in the lower end of the housing tube. When the armature is in its lower or normal position in the channel, the inner surface of the annulus engages the contact-making end of one of the fixed contacts. Also the lower part of the armature, when in its normal position, rests in mercury, which forms a small pool in the bottom of the guide channel. A second fixed contact extends down in the tube to a point of proximity with the outer surface or periphery of the annulus. When, therefore, the magnetic field is produced, the armature is drawn up in its guide slot, disengaging its inner surface from the first contact and moving its outer surface into engagement with the second contact.

According to another feature of the invention

the inner and outer surfaces of the armature are concaved, increasing thereby the forces of capillarity, which cause some of the mercury in the pool to creep up these concave channels to maintain a liquid covering over the armature surfaces that make and break the electrical contacts with the stationary elements. Moreover, the contact-making surfaces of the stationary contacts are constantly wet with some of the mercury that is transferred thereto from the armature. A further advantage of the external groove in the armature is that the armature tends to come to rest at the end of its operative movement with the engaged stationary contact in the bottom of the groove where the depth of the mercury coating is greatest, thus giving a good electrical contact.

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 of Fig. 2;

Fig. 5 is a perspective view of a relay assembly showing a magnetic structure suitable for operating the relay unit;

Figs. 6 to 9, inclusive, are similar views of an alternative form of the relay, Figs. 6 and 7 showing the relay in its normal position, Fig. 8 showing the relay when operated, and Fig. 9 being a cross-sectional view taken on the line 9-9 of Fig. 7.

While the invention is not limited to a switch or relay having any particular size or proportions, 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 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 4, the relay here illustrated comprises an operating unit including a housing vessel or container in the form of a metal tube. This tube is formed by welding together the rims of two

eyelets 1 and 2 of some suitable metal. The lower eyelet is preferably of non-magnetic material, but the upper one may be made of magnetic material, such as stainless steel, if desirable. The open end of the upper eyelet 1 is sealed with a mass 3 of insulating material, such as glass, and the interior of the tube may be evacuated and filled with any suitable gas.

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

The stationary contact members of the relay consist of contact wires 4 and 5, both of which are fixed in the seal 3 and project down into the interior of the tube. The upper ends of these wires serve as terminals for the switch. The lower end of the contact wire 5 is formed in the shape of a hook, as illustrated in Fig. 1, and the tip ends of both contact wires 4 and 5 serve as the contact-making surfaces.

The armature and movable contact of the relay consists of a magnetic annulus 6 which rests in a vertical position in the guide channel formed by shaping the lower eyelet 2 with reentrant portions 7, 8, 9 and 10. When the armature 6 is in its normal position, it is supported by the hook 11 on the end of contact 5, which engages the inner surface 12 of the armature. A pool of mercury 13 resting in the bottom of the container serves to restore and hold the armature 6 in its normal position and also to maintain a liquid film or covering over the contact-making surfaces. To this end both the inner and outer annular surfaces 12 and 14 of the armature are concaved to form channels. The force of capillarity causes the mercury to move around the annulus in both of these channels, thus maintaining a film over the surfaces which engage the contacts 4 and 5. The adhesion of the mercury pool 13 to the armature 6 and the capillary action may be augmented by coating the armature with suitable materials, such as platinum, nickel or copper, and by maintaining the coated surfaces free from oxidation and corrosion. This may be accomplished, as above mentioned, by introducing inert gases into the sealed container.

The magnetic operating structure of the relay, which is illustrated in Fig. 5, comprises pole members 15 and 16 and an operating coil 17 for producing the magnetic field. The ends of the pole members 15 and 16 are notched, as illustrated in Fig. 4 to receive and hold the tube of the relay unit. A washer 19 of insulation is interposed between the pole members 15 and 16 and the shoulder 20, formed by the welded rims of the eyelets 1 and 2, to locate the armature 6 with respect to the air-gap formed by members 15 and 16.

When it is desired to operate the relay, a circuit is closed for the energizing coil 17. The magnetic flux produced in the air-gap between the pole members 15 and 16 attracts the armature 6 from the normal position shown in Fig. 1 to the operated position shown in Fig. 3. The armature in its initial upward movement disengages the contact 5 and opens the normally closed circuit path through the relay. This circuit path may be traced from conductor 21 (Fig. 5) to the metal tube, which serves as one terminal of the relay, through the mercury pool 13, armature 6 to the contact 5. As the armature 6 approaches its operated position, the mercury-

covered surface 14 engages the end of the contact 4, and a second circuit path is established which may be traced from conductor 21 to the metal tube, through the mercury pool 13 and armature 6 to the contact 4. It will be noted that the contact 4 is located to one side of the center of the tube; consequently the armature 6 first engages the end of the contact 4 and then rotates through a small arc until it finally comes to rest against the side of the tube. The result of this action is that a new contact surface is presented to the stationary contact 4 each time the armature is operated. The mercury mass 13 clings to the armature 6 as the latter moves from its normal to its operated position. This displaces the mercury and sets up therein forces of surface tension which tend to draw the armature back to its normal position. When, therefore, the coil 17 is deenergized and the magnetic field is removed, the force of gravity aided by the force of the mercury causes the armature to restore quickly to the normal position, opening the circuit to the contact 4 and restoring the normal circuit path to the contact 5.

An advantage of the concave surfaces 12 and 14 is that they cause the armature to come to rest at the end of each movement with the end of the stationary contact engaging the center of the concave channel where the capillary film of mercury is deepest. Since these surfaces 12 and 14 are constantly covered with a coating of mercury, the repeated engagement of the armature with the contacts 4 and 5 causes some of the mercury to be transferred from the armature to the contact-making surfaces of these contacts. Thus each circuit closure is made by the merging of two liquid surfaces, which 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. This method of closing and opening all circuit paths through liquid-covered surfaces protects the solid contact members 4 and 5 and the armature 6 from deterioration by sparking. Moreover, the armature is further protected against excessive deterioration at any one point by the rotating effect obtained by the eccentrically placed stationary contact 4.

The relay shown in Figs. 6 to 9 is similar to the one above described in that it has a ring-shaped armature 22 provided with a concaved surface 23 for attracting the mercury from the pool 24 to cover the contact-making surfaces of the armature. In this relay, however, the armature 22 normally rests on the bottom of the lower housing member 25, and the internal walls of the housing member serve as a guide to the armature 25 in its movement up and down within said member. The single stationary contact 26 is fixed in the seal 27 which closes the upper housing member 28, and the lower end of this contact is overturned to present a substantial contact-making surface 29 for engagement by the armature 22.

A circuit path is closed through this relay only when the armature 22 is in its operated position. When the operating coil, such as the coil 17 shown in Fig. 5, is energized, the armature 22 is drawn upward by the magnetic field set up between the pole members 30 and 31. As the armature 22 strikes the inclined surface 29 it rotates slightly and comes to rest in engagement with the wall of the housing member 25, as seen in Fig. 8.

The circuit path is now closed from the metallic housing through the mercury and armature 22 to the stationary contact 26. When the magnetic field is removed, the armature is restored quickly to its normal position by the action of gravity assisted by the forces of capillarity stored in the distorted mercury mass 24.

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 armature is also subject to variation; the shapes, number and location of the stationary contacts may also be varied; and numerous alternative forms of the magnetic structure may be employed. For example, the ring armature may have flat surfaces, it may have grooved surfaces, it may be formed of several rings of wire welded together to provide grooves or channels to increase the attraction for the mercury, or it may be replaced by a disc having grooves therein. Also, the pole-pieces of the magnetic structure may have straight instead of notched edges, the switch units being held in place by any other suitable means.

It may be noted, however, that the feature of arranging terminal conductors in parallel relation and adjacent each other to form capillary ducts for attracting the mercury is claimed in the patent to C. E. Pollard, No. 2,259,661 of October 21, 1941.

It should also be understood that the amount of mercury in the pool may be varied. In some cases it may be desirable to use only enough mercury to maintain a film over the contact-making surfaces, the force of gravity being relied on for releasing the armature to its normal position when the magnetic force is removed.

What is claimed is:

1. The combination in an electric switch of a housing envelope, a fixed solid contact mounted in said envelope and projecting into the interior thereof, a magnetic armature in the form of an annulus resting in said housing envelope in cooperative relation with said fixed contact, electromagnetic means for attracting said armature into engagement with said fixed contact, and a reservoir of mercury for wetting the contact-engaging surfaces of said armature and fixed contact.

2. The combination in an electric switch of a closed housing tube having two fixed contacts mounted therein and extending into the interior thereof, a magnetic armature in the form of an annulus normally in contact-engaging relation with one of said fixed contacts, electromagnetic means for moving said armature out of its normal engagement with said contact and into contact-making engagement with the second of said contacts, and a pool of mercury in said housing tube for maintaining a liquid film over the contact-engaging surfaces of said armature and of said fixed contacts.

3. The combination in an electric switch of a housing having two fixed contacts therein, a magnetic armature in the form of an annulus, said armature normally resting with its internal surface engaging one of said fixed contacts, elec-

tromagnetic means for moving said armature to disengage the same from said contact and for advancing its external surface into engagement with the other of said fixed contacts, and a reservoir of mercury in said tube responsive to the forces of capillarity for maintaining a coating of the liquid on the contact-engaging surfaces of said armature.

4. The combination in an electric switch of a housing tube, a contact therein, a pool of mercury in said tube, a movable armature of magnetic material in the form of an annulus normally resting in engagement with said pool of mercury, the external periphery of said armature being concaved for enhancing the forces of capillarity to attract some of the mercury from said pool to the upper surfaces of said armature, and electromagnetic means for moving said armature to bring the mercury-coated surface thereof into engagement with said contact.

5. The combination in an electric switch of a closed housing having a small pool of mercury at the bottom thereof, two fixed contacts in said housing, an armature of magnetic material in the form of an annulus normally resting with its lower edge in engagement with said pool and with its internal surface in contact-making engagement with one of said fixed contacts, the internal and external surfaces of said armature being concaved to enhance the forces of capillarity for attracting the mercury from said pool to the upper internal and external surfaces of said armature, and electromagnetic means for moving said armature to break its normal engagement with one of said contacts and to advance the external concaved surface thereof into engagement with the second one of said stationary contacts.

6. The combination in an electric switch of a metal housing tube having the sides pinched in to form an internal guide channel, a combined armature and electrical contact member of magnetic material resting in said guide channel, a pool of mercury in said tube engaging said armature member, said armature member having irregular surfaces for enhancing the forces of capillarity to attract some of the mercury from said pool to the upper surfaces of said armature member, a stationary contact mounted within said housing tube, and electromagnetic means for moving said armature member to bring the mercury-coated contact surface thereof into engagement with said stationary contact.

7. In an electric switch, a closed housing formed of sheet material which is shaped to provide an interior guide channel within said housing, a movable armature of magnetic material resting in said guide channel, a fixed contact in said housing, electromagnetic means for moving said armature in said guide channel to engage said fixed contact, and a pool of mercury in the bottom of said guide channel, said armature having a concave surface for enhancing the forces of capillarity to draw mercury from said pool to the contact-engaging surfaces of said armature.

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