

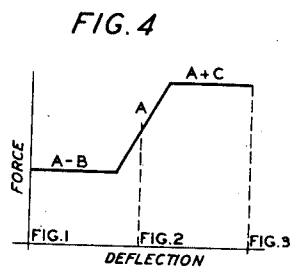
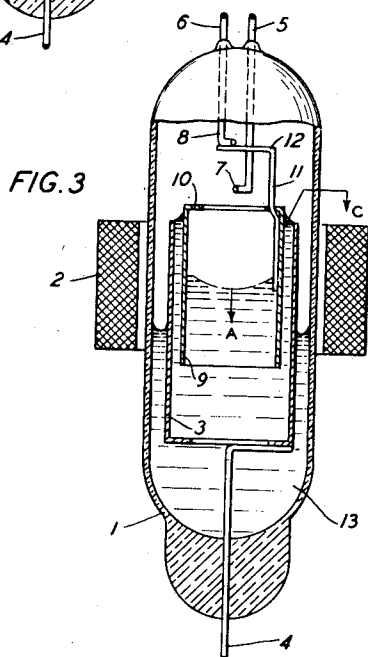
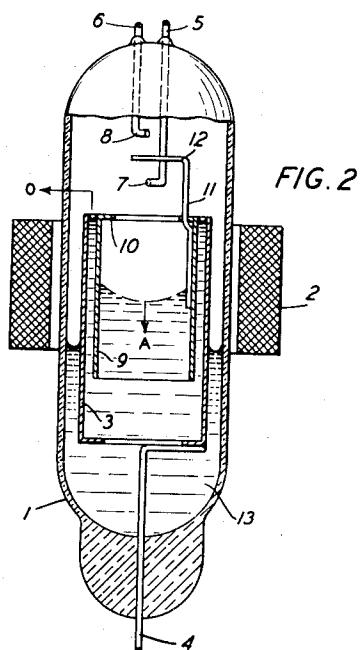
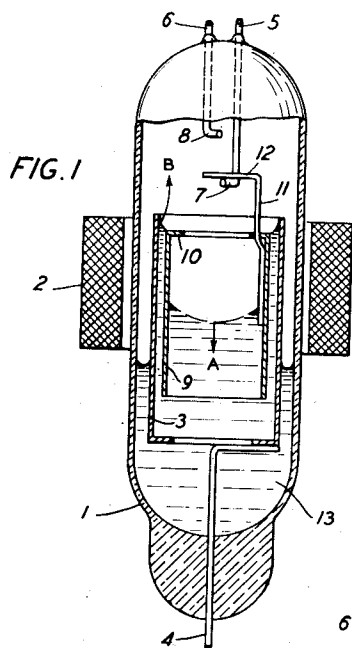
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SWITCHING DEVICE

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SWITCHING DEVICE

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3 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 enable devices of this type to operate in two definite steps.

It is well recognized that mercury has 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 several forms of mercury switches have been devised in the past. These 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 connection. 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 circuit contact or contacts.

In accordance with my prior application, Serial No. 340,662 filed June 15, 1940, certain advantages were achieved over these prior devices by means of a switch in which the movable and stationary contacts are of solid material and in which the movable contact comprises a pair of parallel wires extending vertically into a pool of mercury in the bottom of an envelope, these wires being attached to the inner surface of a hollow cylindrical armature which floats with its lower end partially submerged in the pool of mercury. This movable contact is operable by the armature between two stationary contacts depending through the top of the envelope and with the armature in its unattracted position engages the end of one of these contacts to make a back contact closure therewith. In the fully attracted position of the armature, the movable contact carried thereby engages the other stationary contact and in the half attracted position of the armature the movable contact is out of engagement with both stationary contacts.

In accordance with the present invention, the armature cylinder is surrounded by a second stationary cylinder or guide sleeve having its lower end held immersed in the pool of mercury by a

terminal lead which is sealed through the lower end of the envelope. Both ends of the guide sleeve are open so that mercury from the pool enters into it and into the cylindrical armature and fills the entire space between its inner wall and the outer wall of the armature. In the normal unattracted position of the armature, its upper edge is slightly below the upper edge of the stationary cylinder or guide sleeve and the surface tension of the surface of the mercury extending between the upper edges of the two cylinders tends to move the armature cylinder upwardly but, since the surface tension of the mercury within the cylindrical armature is stronger and tends to move the armature downwardly, the movable contact carried by the armature is held firmly against the back contact.

If current is now applied to the relay coil of a predetermined strength until the upper edge of the armature is flush with the upper edge of the guide sleeve, there is then no surface tension of the mercury between the upper edges of the sleeve and the armature tending to move the armature upwardly and the downward pull of the surface tension of the mercury within the armature then becomes fully effective to arrest the further upward movement of the armature in a position in which the contact carried thereby is out of engagement with both stationary contacts. If a stronger current is now applied to the relay coil, the armature moves to the upper limit of its travel to engage its contact with the front stationary contact. At this time, the upper edge of the armature will be above the upper edge of the guide sleeve, whereby the surface tension of the mercury extending between these edges exerts a downward pull on the armature which with the downward pull of the surface tension of the mercury within the armature, quickly restores the armature to its normal position when the relay coil is thereafter deenergized.

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:

Figs. 1 to 3, inclusive, are side views partly in cross section of a relay incorporating the features of the invention, Fig. 1 illustrating the relay in its normal position, Fig. 2 illustrating the relay in its partially operated position and Fig. 3 illustrating the relay in its fully operated position; and,

Fig. 4 is a curve illustrating the relationship between the deflection of the armature and the force required to operate the armature in mov-

ing it from its normal to its fully operated position.

While the invention is not limited to a switch of any given size or proportion, 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 generally used in telephone and telegraph systems. For these purposes the relay 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 its construction.

Referring now particularly to the drawing, the relay comprises a switch unit enclosed in a glass envelope 1 which is surrounded by an operating coil 2. It is to be understood, however, that the switch unit could be mounted in aligned holes in the pole-pieces of a magnetic circuit including an energizing coil, such a magnetic circuit being illustrated, for example, in my application hereinbefore referred to.

Positioned within the envelope is a cylindrical guide sleeve 3 entirely open at its upper end and partially closed at its lower end to add rigidity thereto and supported on and secured to the upper end of lead wire 4. Lead wire 4 is sealed through the bottom of the envelope 1. The guide sleeve 3 is made of a material such as nickel which is wettable by mercury. Sealed through the upper end wall of the envelope are two parallelly disposed lead wires 5 and 6 having their ends which depend into the envelope bent at right-angles toward each other to form two stationary contacts 7 and 8, the upper one 8 of which serves as a front contact and the lower one 7 of which serves as a back contact.

Movable within the guide sleeve 3 is a cylindrical tubular armature 9, the lower end of which is entirely open and the upper end of which is partially closed at 10 to add rigidity to the armature. The armature is made of magnetic material but its surfaces are such that they are readily wetted by mercury. Secured to the inner surface of the armature is a movable contact member 11 which may be formed by doubling a length of wire, bending the looped end at right-angles and flattening the same to provide the necessary contact area 12 for engagement with the contacts 7 and 8. A contact of this character is fully disclosed in my application hereinbefore referred to and has the property of conducting mercury along the capillary ducts formed therein to its upper contact end from which a small amount of mercury is transferred to the surfaces of the contacts with which it cooperates.

To complete the switch unit, a measured amount of mercury 13 is deposited in the bottom of the envelope. The envelope is then evacuated and refilled with a gas such as hydrogen to a required operating pressure. With the measured amount of mercury in the envelope, the mercury rises within the guide sleeve 3 and within the tubular armature 9 to the positions illustrated in Fig. 1 and the mercury is also attracted by the capillary action of the inner surface of the guide sleeve 3 and the outer surface of the armature 9 to fill the entire space between such surfaces. The surface of the mercury within the cylindrical armature assumes the shape disclosed in Fig. 1 whereby the tension of its surface exerts a downward pull on the armature which may be indicated as A. The mercury within the armature also engages the lower end of the contact 11 carried by the armature whereby mercury is car-

ried along the contact to its upper contact end 12 and, in the normal position of the relay, to the back contact 7 thereby establishing a mercury contact between the contacts 12 and 7 and thus between the lead wires 4 and 5. The armature 9 in its normal position is positioned with its upper edge slightly below the upper edge of the guide sleeve 3 whereby the surface tension of the mercury extending between the upper edges of the sleeve and armature exerts an upward pull on the armature which may be indicated by the letter B. Thus normally the downward pull on the armature exerted by the surface tension of the mercury against the buoyant force exerted by the mercury with respect to the armature, may be expressed as $A-B$.

If now the coil 2 is energized to such an extent as to produce just sufficient lines of force to raise the armature until its upper edge is flush with the upper edge of the guide sleeve 3, as illustrated in Fig. 2, the surface tension B becomes zero so that the downward pull A of the surface tension of the mercury within the armature now becomes fully effective to arrest the upward movement of the armature. In this position the movable contact 12 is out of engagement with both contacts 7 and 8 and the relay has completed the first step of its operation.

If thereafter the coil 2 is energized to a greater extent, the armature becomes raised a second step to the position disclosed in Fig. 3 in which position the contact 12 engages the front contact 8 through a film of mercury carried by the contact 12 and deposited on the surface of the contact 8 and therefore establishes a connection between the leads 4 and 6. The upper edge of the armature is now above the upper edge of the guide sleeve 3 and the surface tension of the mercury between the upper edges of the sleeve and armature exerts a downward pull on the armature which may be designated C. This force aids the downward pull of A exerted by the surface tension of the mercury within the armature cylinder so that the total force tending to restore the armature is now $A+C$. When thereafter the coil 2 becomes deenergized, this force becomes effective to quickly restore the armature.

Fig. 4 illustrates graphically the force tending to restore the armature at the different stages of its deflection, such force being normally $A-B$ as illustrated by the lower horizontal portion of the curve until the coil becomes partially energized, whereupon the curve slopes upwardly against the restoring influence of the force A and the switch assumes the position illustrated in Fig. 2 and upon further energization of the coil slopes further upwardly until it again becomes horizontal when the forces A and C become cumulative and the switch assumes the position illustrated in Fig. 3.

An experimental model of the switch when tested clearly demonstrated the two step action. When the operating coil was energized with current of 22.5 milliamperes, the contact 12 left the back contact 7 and assumed its midposition which it retained until the current in the coil was increased to 39 milliamperes whereupon the contact 12 left its midposition and engaged with the front contact 8. When thereafter the current was reduced to 30 milliamperes, the contact left the front contact 8 and returned to the midposition in which it remained until the current was further reduced to 11 milliamperes whereupon it returned to its back contact 7. This indicated that a current range between 22.5 and

30 milliamperes was attained in which the movable contact was retained in its mid or first step position.

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 envelope might be made in various shapes and sizes and of other materials, such for example as is illustrated in my application hereinbefore referred to; the armature may vary in its shape and proportions; the shape and location of the stationary and movable contacts may also be varied and numerous variations of the magnetic structure may be used.

What is claimed is:

1. In an electric switch, an envelope having a pool of mercury in the bottom thereof, a tubular armature movable within said envelope having its lower end immersed in said mercury, a contact member carried by said armature, other contact members for engagement by said first contact member, electromagnetic means for moving said armature and means operable to cause the surface tension of said mercury to render said armature operable in a first step upon a predetermined energization of said electromagnetic means and to render said armature operable in a second step upon an increased energization of said electromagnetic means.

2. In an electric switch, an envelope having a pool of mercury in the bottom thereof, a tubular armature movable within said envelope having its lower end immersed in said mercury, a contact member carried by said armature, other contact members for engagement by said first contact member, electromagnetic means for moving said armature and a stationary guide sleeve surrounding said armature with its lower

end immersed in said mercury and separated from said armature by a film of mercury, whereby the surface tension of the mercury within said armature and the surface tension of the mercury between the upper edges of said armature and said sleeve are effective to render said armature operable in a first step upon a predetermined energization of said electromagnetic means and to render said armature operable in a second step upon an increased energization of said electromagnetic means.

3. In an electric switch, an envelope having a pool of mercury in the bottom thereof, a tubular armature movable within said envelope having its lower end immersed in said mercury, a pair of contact members depending from the top of said envelope, a contact member carried by said armature and movable therewith and normally engaged with one of said other contact members, electromagnetic means for moving said armature and a stationary guide sleeve surrounding said armature with its lower end immersed in said mercury and separated from said armature by a film of mercury, whereby the surface tension of the mercury within said armature and the surface tension of the mercury between the upper edges of said armature and said sleeve are mutually effective to render said armature operable in a first step upon a predetermined energization of said electromagnetic means to cause said movable contact member to assume its midposition out of engagement with said other contact members, and to render said armature operable in a second step upon an increased energization of said electromagnetic means to engage said movable contact with the other of said contact members.

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