Dec. 20, 1949 C. H. LARSON 2,491,986

ELECTROMAGNETIC MERCURY SWITCH RELAY

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Fig. 1

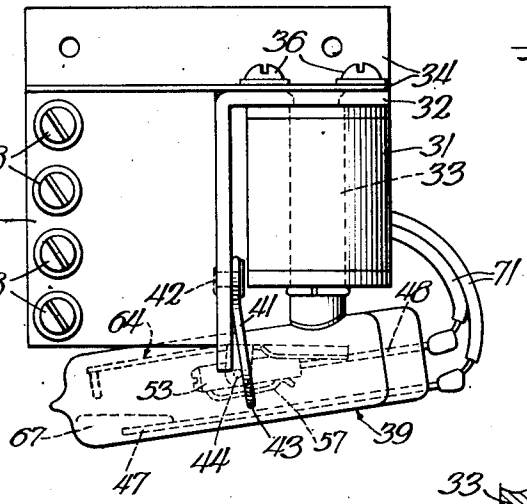


Fig. 2

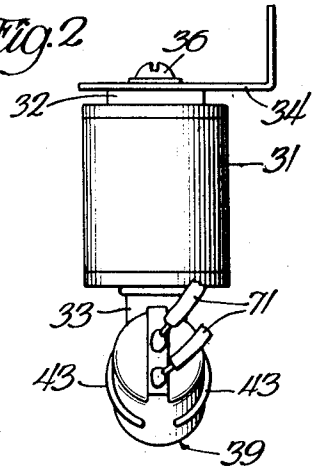


Fig. 3

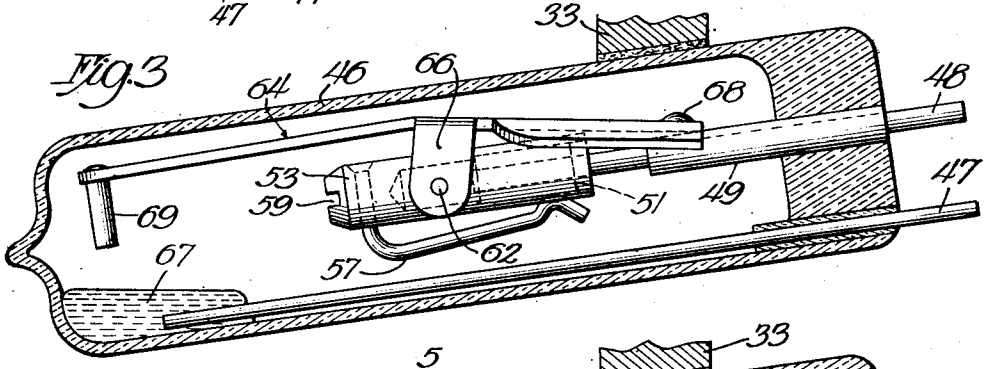


Fig. 4

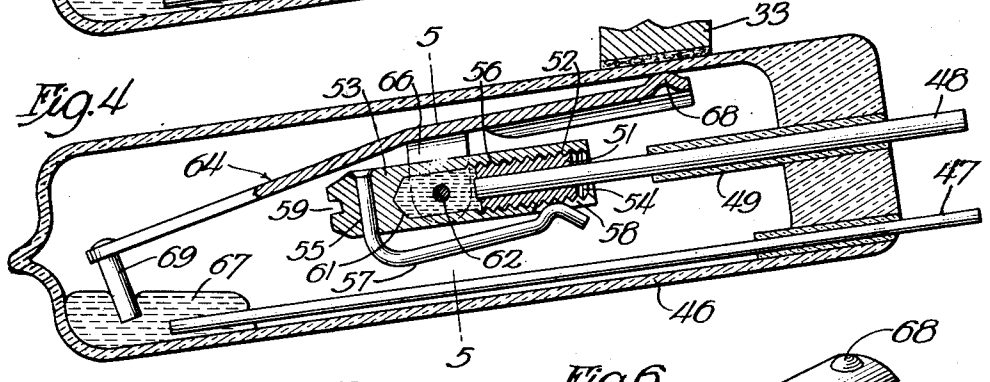


Fig. 5

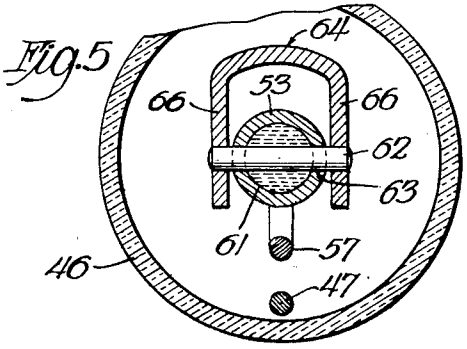
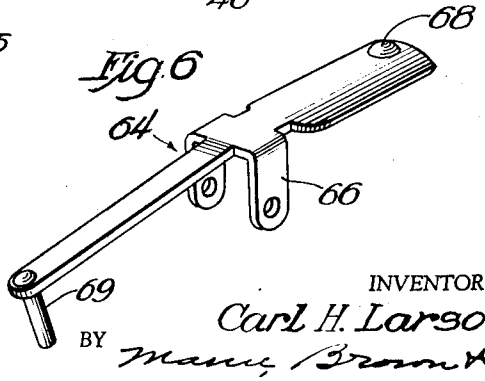


Fig. 6



INVENTOR.
Carl H. Larson
BY Mann, Brumbaugh & Co
ATTYS

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ELECTROMAGNETIC MERCURY SWITCH RELAY

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Fig. 7

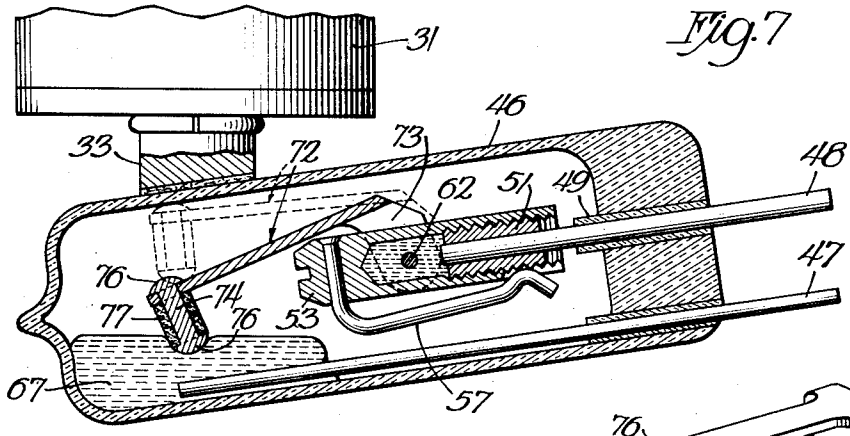


Fig. 8

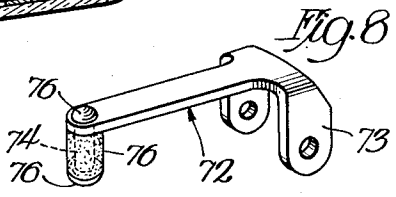


Fig. 9

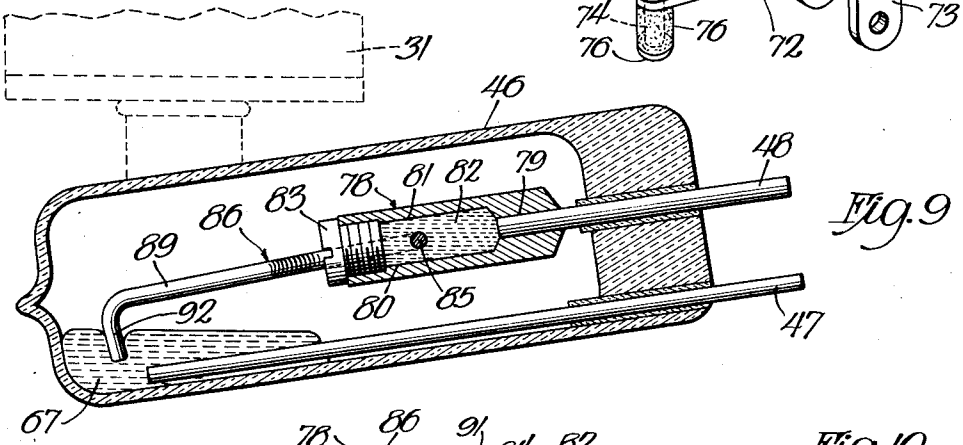


Fig. 10

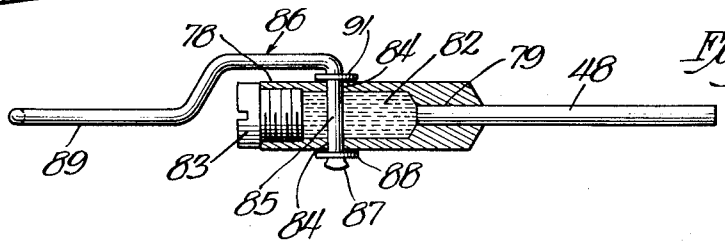
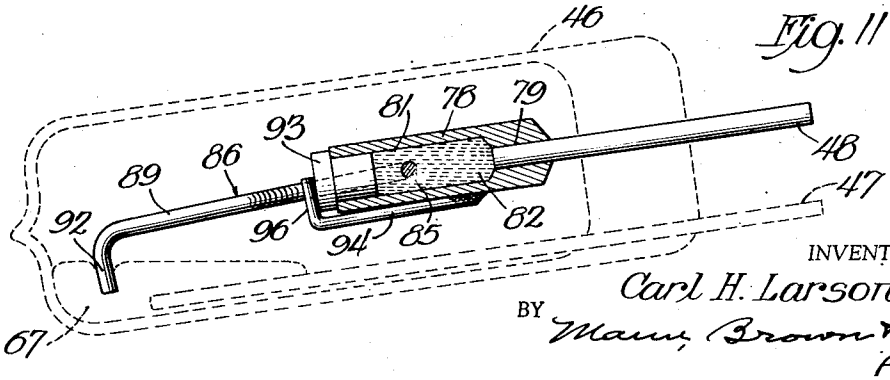


Fig. 11



INVENTOR.
Carl H. Larson
BY Mann, Brown & Ol
ATTYS.

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ELECTROMAGNETIC MERCURY SWITCH RELAY

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Fig. 12

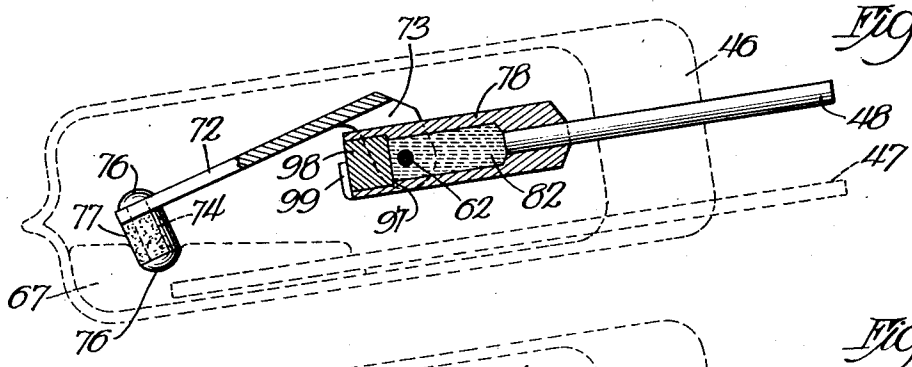


Fig. 13

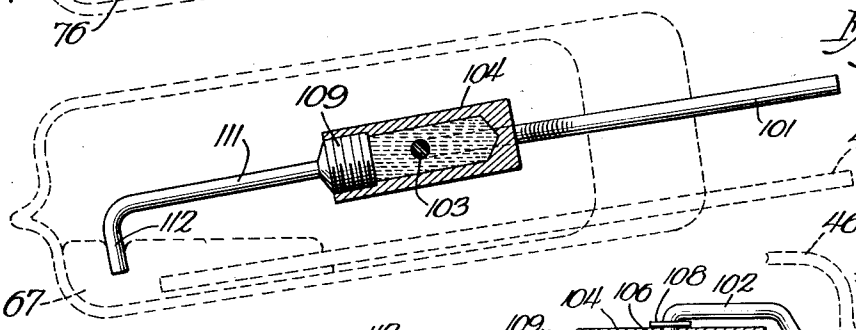


Fig. 14

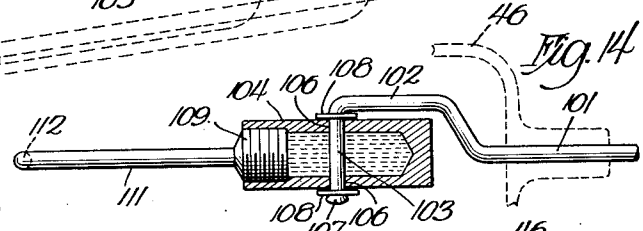


Fig. 17

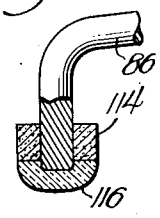


Fig. 18

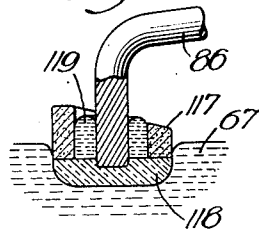


Fig. 15

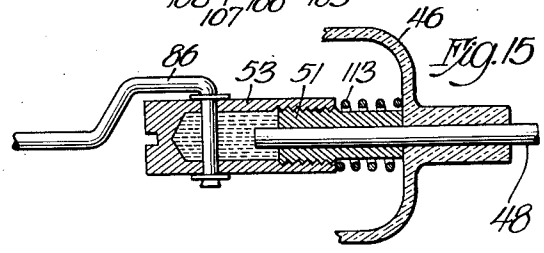
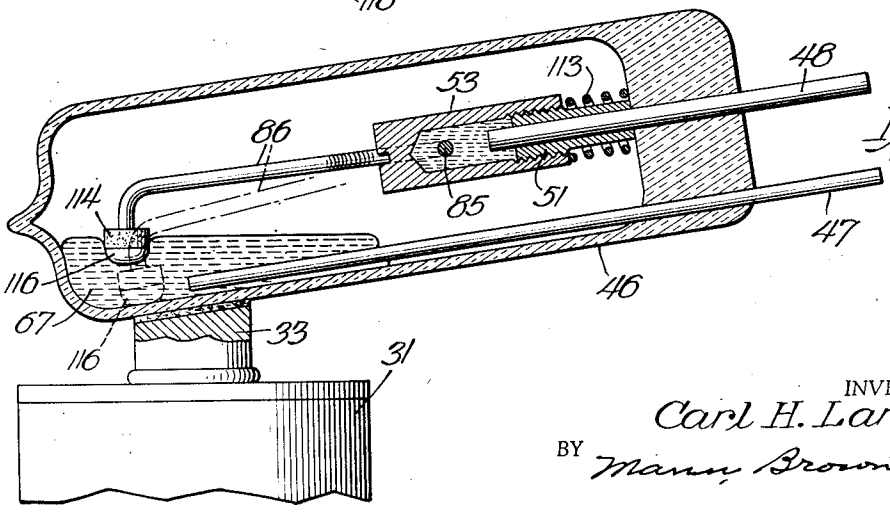


Fig. 16



INVENTOR.
Carl H. Larson
BY Mann, Brown & Dorf
ATTYS.

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Fig. 19

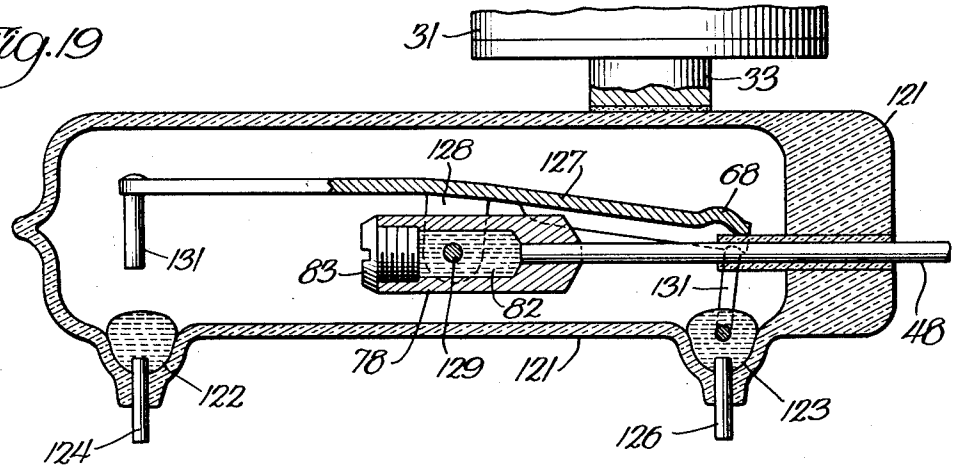


Fig. 20

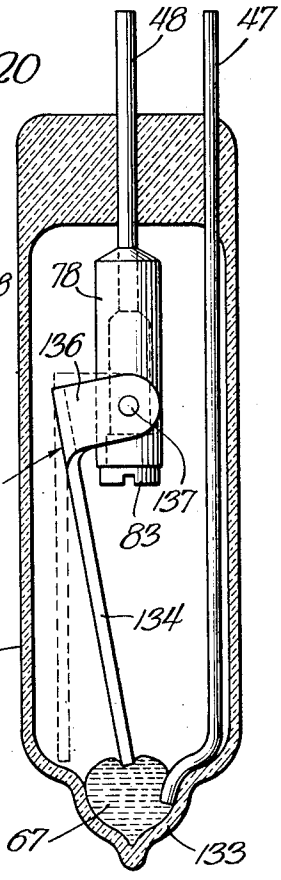
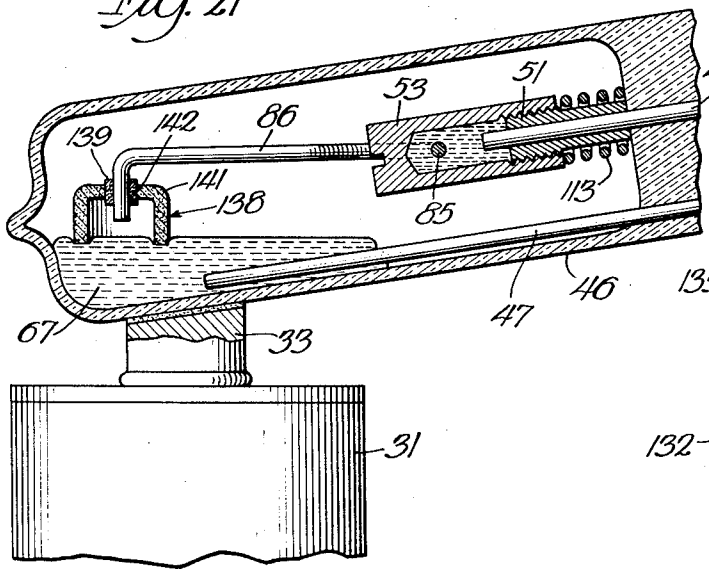


Fig. 21



INVENTOR.
Carl H. Larson
BY Mann, Brown & Cof
ATTYS.

Patented Dec. 20, 1949 2,491,986

UNITED STATES PATENT OFFICE

2,491,986

ELECTROMAGNETIC MERCURY SWITCH RELAY

Carl H. Larson, Elkhart, Ind., assignor to The Adlake Company, a corporation of Illinois

Continuation of application Serial No. 432,297, filed February 25, 1942. This application September 20, 1947, Serial No. 775,220

20 Claims. (Cl. 200—112)

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This invention relates to mercury switches and more particularly to mercury switch relays of the non-tilting type.

Among the objects of this invention is the provision of a simple and compact switch structure which may be easily constructed, is sensitive to minute actuating currents, has greatly improved current carrying capacity as well as greater durability and long life, exhibits substantially uniform current carrying characteristics over extended periods of operation, which may be fabricated to incorporate various desired operating characteristics, and which is well adapted for rapid actuation with a minimum of inertia or electrical or mechanical resistance.

Broadly, the switch is of the type having pivoted metallic contact means and comprises a sealed envelope, containig a mercury fill ordinarily confined to a small pool at one end of the envelope by sloping the switch. A heel electrode extends into the envelope into contact with this mercury pool or, if desired, the envelope may be formed of a conductive material, such as non-magnetic stainless steel, or other non-magnetic conductive materials having suitable resistance to amalgamation with mercury, in which instance the envelope forms the heel electrode.

Immovably disposed within the envelope is a container supporting a quantity of mercury in spaced relation to the mercury fill. A toe electrode extends into the envelope and may, if desired, support the container, but in any event, is in electrical contact with the mercury within the container. A magnetically responsive contact arm is pivotally mounted within the envelope and positioned to move into and out of engagement with the mercury fill. This arm is preferably, although not necessarily, pivoted on the container and in either instance, is in electrical contact with the mercury therein in such manner that the mercury within the container constitutes a current path between the contact arm and the toe electrode. In the preferred form, the mercury within the container may be considered as short circuiting or shunting a metal to metal pivot connection between the arm and the electrode and forms a fluid conducting medium interconnecting these parts.

This structure effectively eliminates the difficulties oridinarily inherent in a switch involving a pivoted conductor, and, as the moving parts may be small and well balanced, the switch may be actuated by extremely small currents.

Other objects and advantages, in addition to those previously mentioned, will become apparent

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from the following description and from the drawings in which

Fig. 1 is a side view of a mercury switch relay;

Fig. 2 is an end view of the structure shown in Fig. 1;

Fig. 3 is a longitudinal partially cross sectioned view of the switch structure shown in Fig. 1;

Fig. 4 is a central longitudinal cross section of the switch structure shown in Fig. 3;

Fig. 5 is a transverse cross sectional view taken along the line 5—5 in Fig. 4;

Fig. 6 is a perspective view of the contact arm shown in Figs. 3 and 4;

Fig. 7 is a partial longitudinal cross sectional view of a modified form of switch;

Fig. 8 is a perspective view of the contact arm shown in Fig. 7;

Fig. 9 is a longitudinal partially cross sectioned view of another modification;

Fig. 10 is a horizontal cross section of the electrode and contact arm assembly shown in Fig. 9;

Fig. 11 is a vertical longitudinal cross section of the electrode and contact arm assembly of another modification;

Fig. 12 is a longitudinal cross sectional view of a further modification;

Fig. 13 is a longitudinal cross section of another modification of my switch;

Fig. 14 is a partial longitudinal cross section of electrode and contact arm assembly shown in Fig. 13;

Fig. 15 is a cross sectional view of another type of contact arm and electrode assembly;

Fig. 16 is a longitudinal cross sectional view of another modification of the switch;

Fig. 17 is a partially cross sectioned view of the end portion of the contact arm illustrated in Fig. 16;

Fig. 18 is a partially cross sectioned view of another form of contact arm;

Fig. 19 is a longitudinal cross sectional view of a modified form of the switch;

Fig. 20 is a longitudinal cross sectional view of another modification of the switch; and

Fig. 21 is a longitudinal cross sectional view of another modification of the switch.

Referring to the drawings, Fig. 1 illustrates broadly the preferred structure and assembly of the mercury switch relay and includes a coil 31 having an L-shaped iron circuit 32, one leg of which extends over the top of the coil 31 into contact with an iron core 33. The other leg of the iron circuit 32 extends downwardly parallel to the iron core 33 and is concave at its lower ex-

tremity to receive the switch. The coil 31 and the iron circuit 32 are joined to a supporting flange 34 by screws 36. If desired, a terminal panel 37 may also be attached to the flange 34 and may carry terminal posts 38.

The switch, generally designated 39, is supported against the core 33 and the iron circuit 32 by a clamp member 41 attached to the iron circuit 32 by a rivet 42 or other suitable fastening means. The clamp member 41 may have curved legs 43 extending around and firmly engaging the switch 39 to prevent displacement of the latter. It is preferable, although not essential, that either the core 33 or the leg of the iron circuit 32 be disposed directly over a central pivot point, generally designated 44, of the switch 39.

The switch structure 39 is illustrated more clearly in Fig. 3 and may comprise an envelope 46 of glass, through the base of which a heel electrode 47 extends, terminating adjacent the far end or top thereof. A toe electrode 48 is sealed through the central portion of the envelope base 46 above the heel electrode 47 and terminates approximately midway between the base and top of the envelope. These electrodes may be formed of a suitable metal such as tungsten, molybdenum, or iron, or alloys thereof, selected for its current carrying capacity, durability and non-amalgamating and non-wetting properties. It is also important that the electrodes 47 and 48 be of a material having substantially the same coefficient of thermal expansion as the glass employed in forming the envelope 46. If desired, an insulating sleeve 49 may extend inwardly around the toe electrode 48 and at least partially cover the rigid portion of the electrode within the switch, preventing accidental closing of the circuit through the electrodes by tipping of the switch.

A metal collar 51 having an axial bore is telescoped over the inner end of the toe electrode 48 and is firmly attached thereto by shrinking, welding or other suitable means, the position of the collar 51 preferably being such that the electrode extends beyond the extremity thereof. The outside diameter of the collar 51 is somewhat greater than the diameter of the electrode 48 and is provided with external threads designated 52.

A cylindrical metal cap 53 having an open end and an axial bore 54 is provided internally with threads 56 extending inwardly from the open end for suitably half the length of the bore 54 and adapted to receive the threads 52 on the metal collar 51. The solid end portion of the cap 53 is provided with a transverse opening 55 to receive one leg of an L-shaped spring member 57, the other leg of which extends rearwardly along the cap 53 and engages the threads of the collar 51 through an opening 58 provided in the wall of the cap 53 adjacent the open end. The resiliency of the spring 57 retains the free end of the spring in engagement with the threads 52 on the collar 51, preventing accidental removal or displacement of the cap 53. The closed end of the cap 53 may be provided with a transverse slot 59 to facilitate installation.

When properly assembled, the collar 51 and the end of the electrode 48, in conjunction with the cap 53 define a container, designated 61, which is filled with mercury. A transverse pin 62 extends through the container and is journalled through alined transverse openings 63 provided in the walls of the cap 53 adjacent the container 61. The pin 62 may be of any suitable electrically conductive material and fits closely

into the openings 63 but with sufficient clearance to permit free movement, the clearance preferably being on the order of .001 to .003 inch. When the clearances are of this magnitude, the surface tension of the mercury will prevent leakage. I prefer to form the pin 62 of nickel or some other metal which will amalgamate with mercury, thereby improving the contact existing between the pin 62 and the mercury in the container 61, or, as an alternative, either all or only the central portion of the pin 62 may be plated with nickel, but all other metal parts within the envelope should be resistant to amalgamation with mercury.

A contact arm, generally designated 64, is rigidly secured to the pin 62 by parallel lugs 66 extending downwardly from the arm 64, or if desired, the pin may be formed in two sections, each section being integral with a lug. The lugs 66 are positioned approximately at the point of balance of the arm 64 and are preferably integral therewith. The arm 64 is adapted to rock on the pivot pin 62 approximately in a plane defined by the electrodes 47 and 48 and extends forwardly beyond the lugs 66 a distance sufficient to dispose the forward end of the arm 64 substantially over a mercury fill 67 ordinarily confined to the top portion of the envelope 46 by securing the switch in a tilted position. The arm 64 may also extend rearwardly from the lugs 66 and may suitably be shaped to resemble a longitudinal section of a right cylinder, the width of the section preferably being in excess of the width of the forward section of the arm in order to provide balance for the assembly.

Adjacent the rear portion of the contact arm is formed a boss 68 of relatively sharp curvature adapted to contact the wall of the envelope 46 when the forward end of the arm 64 is lowered, thereby preventing possible sticking of the arm 64 to the wall of the envelope. Because of space limitations it is usually desirable to curve or bend the forward end of the arm 64 downwardly adjacent the bosses 66.

A downwardly extending contact pin 69 is secured to the forward end of the contact arm 64 and is positioned to engage the mercury fill 67. The pin 69 may be formed of molybdenum, tungsten, or other suitable material which will resist amalgamation with mercury as well as the destructive effects of an electric arc.

Inasmuch as I prefer to operate my switch by the application of external magnetic force, it is preferable that the contact arm 64 be formed of iron or other suitable ferromagnetic material adapted to carry relatively heavy currents without excessive electrical resistance. In certain instances, however, it may be desirable to use a material having a relatively greater conductivity than iron and in such instances, an iron or other magnetic armature (not shown) may be attached to the contact arm 64 in any desired position, although in such instance suitable means should be employed to counterbalance the weight of the armature.

For maximum sensitivity one terminal of the iron circuit 32 is preferably disposed substantially over the pin 62 while the other end of the iron circuit, i. e., the core 33, may be disposed either over the boss 68 or the forward end of the contact arm 64, depending upon whether the switch is intended to be normally open or normally closed.

For convenience in mounting, lead-in wires 71 may be secured to the external portions of the electrodes 47 and 48 as well as to the binding

posts 38 mounted on the panel 37. The lead wires from the coil 31 may also be secured to suitable binding posts 38.

The type of switch illustrated in Figs. 3 and 4 is particularly adapted for use as a normally open or front contact switch, but only slight modification is necessary to adapt this structure to a normally closed contact such as that shown in Fig. 7. In this modification the various parts of the structure are substantially similar to those previously described with the exception of a contact arm, generally designated 72, which in this modification is provided with parallel lugs 73 similar to the lugs 66 extending downwardly from the rear end of the contact arm 72 and adapted for rigid attachment to the pin 62. The arm 72 is preferably formed of iron and is provided adjacent its forward end with a contact pin 74 having enlarged heads 76.

A ceramic collar 77 is interposed between the contact arm and one of the enlarged heads 76. The ceramic collar 77 is formed of a relatively light weight arc resistant material which, by virture of its displacement, limits the downward movement of the contact arm 72 into the mercury fill 67. The exposed enlarged head portion 76 of the contact pin 74 forms an electrical contact between the mercury fill 67 and the contact arm 72 and inasmuch as the head 76 will always be immersed to a constant depth, the pick-up and drop-away values of the relay will remain constant. The heel electrode 47 is at all times immersed in the mercury fill 67, whereby when the coil 31 is not energized the circuit through the switch will extend through the heel electrode 47, the mercury fill 67, the contact pin 74, the contact arm 72, the pin 62, the mercury in the chamber 81, and the toe electrode 48. Energization of the coil 31 will attract the contact arm 72 causing the circuit between the electrodes to be broken.

Fig. 9 illustrates a simplified modification of my switch wherein the toe electrode 48 may terminate more nearly adjacent the base of the envelope 46. In this modification a cap 78, preferably of iron, is formed with an axial bore 79 at one end adapted to receive the inner end of the electrode 48 and is attached thereto by shrinking, welding or other suitable means. The other end of cap 78 is counter-bored, as at 80, forming a relatively elongated container 81 in which is placed a quantity of mercury 82. The counter-bore 80 may be provided adjacent its open end with internal threads adapted to receive a screw cap 83, although other closure means may be employed if desired. Alined transverse openings 84 are provided in the walls of the cap 78 intermediate the ends of the counter-bore 80 to receive a transverse portion 85 of a contact arm generally designated 86. One end of the transverse portion 85 is preferably enlarged as shown at 87, and a washer 88 is interposed between the enlarged end 87, and wall of the cap 78. The transverse portion 85 of the arm 86 extends through the mercury 82, and immediately adjacent the other side of the cap 78 the contact arm 86 is bent laterally, extending parallel to the major axis of the cap to a point beyond the screw cap 83 at which point it may again be bent laterally to form an end portion 89 adapted to move parallel to a plane defined by the electrodes 47 and 48. If desired, a washer 91 may be interposed between the wall of the cap 78 and the contact arm 86. The forward extremity 92 of the contact arm 86 is bent downwardly to engage the mercury fill 67 and, if desired, may be tipped with a suitable metal such as nickel, tungsten, molybdenum or platinum to increase its durability. As the contact arm 86 is preferably formed of iron, energization of the coil 31 will move the arm upwardly out of contact with the mercury fill 67 thereby breaking the electric connection ordinarily existing between the elecrodes 47 and 48.

Fig. 11 illustrates an alternative type of closure means employing a plug 93 fitting closely into the chamber 81 to confine the mercury 82 therein. An L-shaped spring member having legs 94 and 96 is secured to the cap 78 at one end of the leg 94 by welding or other suitable means. The position of the L-shaped spring member is such that after attachment the leg 96 will extend transversely to the axis of the cap 78, engaging the outer end of the plug 93, thereby retaining the plug 93 firmly in place. The plug may be inserted or removed by bending the L-shaped spring member downwardly until sufficient clearance exists to insert the plug. With the exception of the closure means described, the structure is similar to that illustrated in Fig. 9.

Another suitable closure means is illustrated in Fig. 12 in which the cap 78 is counterbored adjacent its open end, forming an internal shoulder 97. A plug 98 is fitted into the open end of the cap 78 abutting the shoulder 97 and may be retained in place by a metal member 99 attached to, or formed integrally with, the end of the cap 78, and bent inwardly into contact with the head of the plug 98. The contact arm illustrated in this modification is substantially similar to that illustrated in Fig. 8, and the cap 78, containing the mercury 82, is similar to the cap illustrated in Figs. 9 and 11, except as modified to receive the above described closure means.

In the previous modifications it will be noted that the mercury retaining member has been rigid with the toe electrode 48. While this structure is often advantageous it is equally feasible to form the mercury container rigid with the movable portion of the electrode. Such a structure is illustrated in Figs. 13 and 14, and includes a toe electrode 101 sealed through the base of the envelope 46. The electrode 101 is offset laterally within the envelope to form a relatively short parallel section 102, the extremity of the electrode being bent laterally to form a section 103 transverse to the major axis of the envelope. A hollow metal cap 104 having an open end is provided with alined transverse openings 106 approximately midway between top and bottom, and is journalled on the trasnverse section 103 of the electrode 101, the extremity of the electrode section 103 being enlarged as shown at 107 to confine the cap 104 to the desired position. As previously mentioned, the clearance between the walls of the openings 106 and the section 103 is held to close tolerances, for example, between .001 inch to .003 inch, to permit free movement, but to prevent escape of the mercury. The section 103 may be plated with nickel which amalgamates with mercury, improving the electrical connection, and lubricating the bearing surfaces.

Washers 108 may be employed adjacent the external walls of the cap 104. The open end of the cap 104 is threaded to receive a threaded plug 109 to which is rigidly attached a contact arm 111 extending outwardly from the plug 109 a distance sufficient to bring the extremity of the contact arm into engagement with the mercury fill 67. If desired, the extremity of the contact arm may be bent downwardly forming a vertical section 112. The metal cap 104 is filled with mercury,

immersing the transverse electrode section 103 to establish a satisfactory connection between the contact arm 111 and the toe electrode 101. The contact arm 111 is preferably formed of iron whereby energization of the coil will move the arm upwardly, pivoting the cap 104 about the electrode 101, and breaking the contact normally existing between the electrodes 101 and 48.

Figs. 15 and 16 illustrate another form of attachment wherein the toe electrode 48 extends only a short distance into the envelope 46. The metal collar 51 is telescoped over the electrode 48 and abuts the base of the switch envelope 46, the relationship between the length of the collar 51 and the electrode 48 being such that the inner end of the electrode 48 protrudes from the collar. The external portion of the collar 51 is threaded to receive the cap 53, substantially similar to the cap illustrated in Fig. 4 which contains a quantity of mercury. The contact arm 86, as well as its means of attachment to the cap 53, is substantially similar to that illustrated in Fig. 10. In this modification, however, a coil spring 113 is telescoped over the collar 51 and abuts the base of the envelope 46 and the base of the cap 53 thereby replacing the function of the spring member 57 in Fig. 4, and preventing accidental removal of the cap 53.

Ceramic caps, such as those shown in Figs. 16 to 18, may be attached to the extremity of any of the various contact arms illustrated, as the contact arm 86, to provide a mercury to mercury contact when the circuit is made or broken or to serve as a float, normally retaining the contact arm out of electrical contact with the mercury fill 67. In the latter instance a closely fitting collar 114 of ceramic material is telescoped over the end of the contact arm and a cap 116 of similar material is fused thereto, enclosing the end of the contact arm. Known means of attachment may be employed to secure the ceramic pieces to the contact arm, such as screw threads or mechanical joints or, if the ceramic material has a coefficient of expansion similar to that of the contact arm, the collar 114 and cap 116 may be fused to the contact arm, the latter structure being preferable. If desired, the collar 114 and cap 116 may be formed in one piece. The height of the collar 114 is such that when the contact arm 86 rests on the mercury fill 67 the buoyancy of the collar 114 and cap 116 will be sufficient to support the contact arm out of contact with the mercury. Upon energization of the coil 31, the contact arm 86 will be drawn downwardly into the mercury fill 67, as shown by dotted lines in Fig. 16, thereby establishing contact between the electrodes 47 and 48.

By substantially similar means it is also possible to provide a mercury to mercury contact between the contact arm 86 and the mercury fill 67. Such a structure is illustrated in Fig. 18 and may suitably include a collar 117 having an internal diameter substantially in excess of the external diameter of the contact arm 86. A cap 118 is attached by suitable means, such as fusion, to the contact arm 86 and to the collar 117, forming a cup around the extremity of the arm. This cup contains a quantity of mercury 119 and is preferably truncated to confine the point of arcing. Use of such a structure will greatly increase the life of the switch.

By relatively minor modification the switches described may be altered to form a three pole switch as illustrated in Fig. 19 wherein a horizontal envelope 121 is provided adjacent its extremities with mercury wells 122 and 123 containing separate pools of mercury. Heel electrodes 124 and 126 extend through the walls of these wells into contact with the mercury. The toe electrode 48 is sealed through the base of the envelope 121 and has mounted on the inner extremity thereof a mercury filled cap 78 closed by a screw cap 83 substantially as illustrated in Fig. 9. In this modification, however, a double ended contact arm 127 having downwardly extending parallel lugs 128 is employed and is mounted on a transverse pin 129, similar to the pin 62 previously described, extending through the cap 78 and rigidly attached to the lugs 128. Contact pins 131 are attached to each end of the contact arm 127, the contact pin at the rear of the switch being suitably curved to clear the toe electrode 48. In this modification I have shown the contact arm as balanced in such manner as to normally establish contact between the electrode 126 and the electrode 48 through the mercury in the well 123, the rear contact pin 131, the contact arm 127, and the mercury within the cap 78; but, it is obvious that the weighting of the parts may be reversed if desired.

Upon energization of the coil 31 the rear end of the contact arm 127 will be drawn upwardly, breaking the circuit between the electrode 126 and the electrode 48, and immediately thereafter completing the circuit between the electrode 124 and the electrode 48 through the contact pin 131.

Fig. 20 illustrates a form of switch adapted to operate in a vertical position and includes a mercury containing cap 78 and a screw cap 83 substantially similar to those illustrated in Fig. 19. In this modification, however, an envelope 132 is provided having a mercury well 133 formed in the top thereof, the switch being designed to operate in an inverted position. The heel electrode 47 extends downwardly along the wall of the envelope 132 into contact with a mercury fill 67 within the well 133. A contact arm 134, may, in this instance, be formed of a straight section of iron wire attached at its upper end to a saddle member, generally designated 135, having laterally extending lugs 136 which are in turn rigidly attached to a pin 137, similar to the pin 62 previously described. The point of joinder between the pin 137 and the bosses 136 is offset from the center of gravity of the contact arm assembly a distance sufficient to dispose the lower end of the contact arm 134 in the desired position, in this instance, in engagement with the mercury within the well 133.

It may be seen that when magnetic force is applied at a point opposite the heel electrode, the contact arm 134 will be drawn upwardly and outwardly out of engagement with the mercury fill 67 thereby breaking the circuit between the electrodes 47 and 48.

If desired, suitable time delay means may be incorporated, as illustrated in Fig. 21, wherein a switch of the type illustrated in Fig. 16 is provided with a time delay device, generally designated 138, adapted to delay the completion of the circuit through the electrodes upon energization of the coil 31.

The time delay device 138 may be formed by telescoping a porous ceramic collar 139 over the downwardly extending terminal portion of the contact arm 86 and attaching the collar thereto by suitable means, such as fusion. If this method of attachment is used, however, it is important that the ceramic material chosen have a co-efficient of thermal expansion substantially equal

to that of the contact arm. The position of the collar 139 on the contact arm 86 is such that a portion of the arm will protrude from the collar. A cup 141 of non-porous ceramic material is provided with a centrally disposed opening 142 through the base thereof adapted to receive the collar 139, to which it may be attached by fusion or cement. The buoyancy of the non-porous cup 141 should, in this instance, be sufficient to maintain the end of the contact arm 86 out of contact with the mercury fill 67, thereby forming a normally open or front contact switch, or the contact arm 86 may be suitably counter-balanced to obtain the same result. Upon energization of the coil 31 the contact arm 86 will be drawn downwardly trapping a pre-determined amount of air within the cup 141. The air so trapped will gradually escape through the porous collar 139 permitting the mercury 67 to rise within the chamber until contact is established between the mercury and the contact arm 86.

It will be noted in the foregoing description that in each modification a quantity of mercury is confined in such manner as to interconnect the contact arm and the toe electrode, thereby eliminating the objectionable features of ordinary pivoted electrode switches wherein the metal to metal pivots pit and corrode, increasing both mechanical and electrical resistance. The quantity of mercury and the capacity of the container may be varied as desired, but should, in each instance, be sufficient in quantity to conduct the current from the contact arm to the toe electrode without excessive heating. I ordinarily prefer to form the container of metal, although insulating materials may be employed if desired, provided the contact arm and the toe electrode extend into electrical contact with the mercury within the container.

It is apparent that the various modifications of the component parts of the switch are, in many instances, interchangeable with each other, and that the specific materials and mechanical details may be modified by those skilled in the art in many instances. These changes and modifications are to be considered as within the concept and scope of this invention as defined in the appended claims.

Throughout the specification and claims, the expressions "amalgamate," "amalgamation," etc. are used in the sense of describing the property of certain materials to wet when placed in contact with mercury, particularly when under the influence of an electric current. Similarly, the expressions "non-amalgamate," "non-amalgamation," etc. are used in the sense of describing the property of certain materials to resist wetting under like conditions. So far as known now, all materials which wet when in contact with mercury also exhibit amalgamation and apparently the two terms or expressions are synonymous, but it should be understood that amalgamation is desirable in mercury switches, ordinarily, because of the intimate electrical contact achieved through the wetting property (whether amalgamation in the strict sense of the term is present or not). In the present application, non-amalgamation also has a special value in aiding the effectuation of a pivotal seal and here it is the non-wetting characteristics of that material which is important in enabling the surface tension of the mercury to keep it from seeping through a small clearance.

This application is a continuation in whole of my prior application, Serial Number 432,297, filed February 25, 1942, allowed February 12, 1947, and now abandoned.

I claim as my invention:

1. In a mercury switch, a switch envelope, a mercury fill, a toe electrode extending into the envelope, a mercury container supported by the toe electrode within the envelope and containing a quantity of mercury in electrical contact with said electrode, and a contact arm supported by the mercury container and movable with respect to the toe electrode, the contact arm also being in electrical contact with the mercury within the container whereby electrical contact between the contact arm and the electrode is established at least in part by the mercury within the container.

2. In a mercury switch, a switch envelope, a mercury fill, a toe electrode extending into the envelope, a metal container supported within the envelope by the toe electrode, and electrically separate from the envelope, a quantity of mercury within the container, and magnetically responsive contact means within the envelope movable with respect to the toe electrode, and in electrical contact with the mercury within the container.

3. In a mercury switch, a switch envelope, a mercury fill, a heel electrode in contact with the mercury fill, a substantially closed mercury container within the envelope, a quantity of mercury within the container, means for supporting the container within the envelope including a toe electrode extending into the container, a rigid contact arm supported by the container and movable with respect to the toe electrode, said arm being in electrical contact with the mercury within the container whereby electrical contact between the contact arm and the electrode is established at least in part by the mercury within the container.

4. In a mercury switch, a switch envelope, a mercury fill, a heel electrode in contact with the mercury fill, a substantially closed metal container within the envelope, a quantity of mercury within the container, means for supporting the container within the envelope including a toe electrode extending into the container, and a rigid ferromagnetic contact arm supported by the container and movable with respect to the toe electrode, said arm also being in electrical contact with the mercury within the container whereby electrical contact between the contact arm and the electrode is established primarily by the mercury within the container.

5. In a mercury switch, a switch envelope, a mercury fill, a mercury container within the envelope spaced from the mercury fill, a pivot of conductive material extending through the wall of the container with a freely rotating fit therewith, a contact arm fast on the pivot and pivotal therewith to contact or move from the mercury fill, a quantity of mercury within the container having its mercury level higher than the bottom of the hole through which the pivot extends, a first electrode having external connection and contacting the mercury in the container and a second electrode having external connection and contacting the mercury fill.

6. In a mercury switch, a switch envelope, a mercury fill, a mercury container within the envelope spaced from the mercury fill, a pivot of conductive material extending through the wall of the container with a freely rotating fit therewith, a contact arm fast on the pivot and pivotal therewith to contact or move from the mercury fill, a quantity of mercury within the container having its mercury level higher than the bottom of the hole through which the pivot extends, a

first electrode having external connection and contacting the mercury in the container and a second electrode having external connection and contacting the mercury fill, a portion of the surface of the pivot within the mercury being formed of a material which amalgamates with mercury.

7. In a mercury switch, a switch envelope, a mercury fill, a mercury container within the envelope spaced from the mercury fill, a pivot of conductive material extending through the wall of the container with a freely rotating fit therewith, a contact arm fast on the pivot and pivotal therewith to contact or move from the mercury fill, a quantity of mercury within the container having its mercury level higher than the bottom of the hole through which the pivot extends, a first electrode having external connection and contacting the mercury in the container and a second electrode having external connection and contacting in mercury fill, a portion of the surface of the pivot within the mercury being formed of a material which amalgamates with mercury, the inner surface of the container surrounding the pivot being formed of a material which does not amalgamate with mercury whereby leakage of mercury through the container around the pivot is reliably prevented.

8. In a mercury switch, a switch envelope, a mercury fill, a mercury container within the envelope spaced from the mercury fill, a pivot of conductive material extending through the wall of the container with a freely rotating fit therewith, a contact arm fast on the pivot and pivotal therewith to contact or move from the mercury fill, a quantity of mercury within the container having its mercury level higher than the bottom of the hole through which the pivot extends, a first electrode having external connection and contacting the mercury in the container and a second electrode having external connection and contacting the mercury fill, a portion of the surface of the pivot within the mercury being formed of a material which amalgamates with mercury, but one of the surfaces adjacent the line of demarkation between the pivot and the container being formed of a material which does not amalgamate with mercury whereby leakage of mercury through the container around the pivot is reliably prevented by the surface tension of the mercury.

9. In a mercury switch, a switch envelope, a mercury fill, a second body of mercury, a pivot rotatably mounted in the second body of mercury, a contact arm substantially entirely out of the body, fast on the pivot and moving with it to make contact with or to separate from the mercury fill, a first electrode having external connection and making contact with the body of mercury, and a second electrode having external connection and making contact with the mercury fill.

10. In a mercury switch, a switch envelope, a mercury fill, a second body of mercury, a pivot rotatably mounted in the second body of mercury, a contact arm substantially entirely out of the body, fast on the pivot and moving with it to make contact with or to separate from the mercury fill, a first electrode having external connection and making contact with the body of mercury, and a second electrode having external connection and making contact with the mercury fill, a portion of the surface of said pivot being formed of a material which amalgamates with mercury.

11. In a mercury switch, a switch envelope, a mercury fill, a second body of mercury, a pivot

rotatably mounted in the second body of mercury, a contact arm substantially entirely out of the body, fast on the pivot and moving with it to make contact with or to separate from the mercury fill, a first electrode having external connection and making contact with the body of mercury, and a second electrode having external connection and making contact with the mercury fill, said pivot being formed of a material having an electrical resistance at least as low as that of ordinary steel.

12. In a mercury switch, a switch envelope, a mercury fill, a second body of mercury, a pivot rotatably mounted in the second body of mercury, a contact arm substantially entirely out of the body, fast on the pivot and moving with it to make contact with or to separate from the mercury fill, a first electrode having external connection and making contact with the body of mercury, and a second electrode having external connection and making contact with the mercury fill, said pivot being formed of a material having an electrical resistance at least as low as that of ordinary steel, and being journalled in an electrical conductor which is electrically connected on the first electrode.

13. In a switch, an articulated joint comprising a substantially closed container, a conductive pivot extending pivotably through a wall of the container, a mercury fill within the container engaging the pivot, a conductor outside of the container fast on the pivot and connected to the mercury therethrough and a conductor rigidly associated with the container and connected to the pivot through the mercury in the container, one of said conductors comprising a contact arm for controlling a circuit through it and the other conductor, said pivot being wet by the mercury.

14. In a switch, an articulated joint comprising a substantially closed container, a conductive pivot extending pivotably through a wall of the container, a mercury fill within the container engaging the pivot, a conductor outside of the container fast on the pivot and connected to the mercury therethrough and a conductor rigidly associated with the container and connected to the pivot through the mercury in the container, one of said conductors comprising a contact arm for controlling a circuit through it and the other conductor, said mercury being above the level of the pivot opening through said wall but said wall adjacent said pivot being of a material not wet by mercury and fitting said pivot closely enough, without binding, to prevent the loss of mercury by seepage along the pivot.

15. In a switch, an articulated joint comprising a substantially closed container, a conductor pivot extending pivotably through a wall of the container, a mercury fill within the container engaging the pivot, a conductor outside of the container fast on the pivot and connected to the mercury therethrough and a conductor rigidly associated with the container and connected to the pivot through the mercury in the container, one of said conductors comprising a contact arm for controlling a circuit through it and the other conductor, said wall adjacent said pivot being of a material not wet by mercury and fitting said pivot closely enough, without binding, to prevent the loss of mercury by seepage along the pivot.

16. In a switch, an articulated joint comprising a container, a conductive pivot extending pivotably through a wall of the container, a mercury fill within the container engaging the

pivot, a conductor outside of the container fast on the pivot and connected to the mercury therethrough and a conductor rigidly associated with the container and connected to the pivot through the mercury in the container, one of said conductors comprising a contact arm for controlling a circuit through it and the other conductor, said mercury being above the level of the pivot opening through said wall but said wall adjacent said pivot being of a material not wet by mercury and fitting said pivot closely enough, without binding, to prevent the loss of mercury by seepage along the pivot.

17. A pivotal electrical connection including a container having an electrode surface within the container and connected to a conductor external thereof, a mercury fill within the container engaging said electrode surface, a conductive pivot passing pivotably through a wall of the container and engaging the mercury fill, and a second conductor fast on said pivot outside of said wall whereby said conductors are pivotally associated with one another and are electrically connected through said mercury, said mercury being above the level of the pivot opening through said wall but said wall adjacent said pivot being of a material not wet by mercury and fitting said pivot closely enough, without binding, to prevent the loss of mercury by seepage along the pivot.

18. In a mercury switch, a switch envelope, a mercury fill in the switch envelope, spaced electrodes in the switch envelope, and means for electrically connecting said electrodes through said mercury fill including a contact member movable into and out of contact with said mercury fill and a hinge for the contact member out of the mercury fill when the switch is closed, and having a bearing part of material that amalgamates with mercury, said hinge being coated with

mercury, whereby the amalgam thus formed insures a low electrical resistance through the hinge.

19. In a mercury switch, a switch envelope, a mercury fill in the switch envelope, spaced electrodes in the switch envelope, and means for electrically connecting said electrodes through said mercury fill including a contact member movable into and out of contact with said mercury fill and a hinge for the contact member out of the mercury fill when the switch is closed, and having a bearing part of material that amalgamates with mercury, and through which the entire electrical load of the switch is conducted, said hinge being coated with mercury, whereby the amalgam thus formed insures a low electrical resistance through the hinge.

20. In a mercury switch of the type having an envelope, a mercury fill and spaced electrodes therein one of which is electrically disconnected with the mercury fill in the open position of the switch, a connector for the last mentioned electrode including two metal parts normally out of contact with the mercury fill, and a hinge joint between said parts having metal that amalgamates with mercury forming the electrical and mechanical connection between the two metal parts, said hinge joint being coated with mercury, whereby the malgam thus formed insures a low electrical resistance through the hinge joint.

CARL H. LARSON.

REFERENCES CITED

The following references are of record in the file of this patent:

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Number	Name	Date
1,558,277	Phelan	Oct. 20, 1925
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Certificate of Correction

Patent No. 2,491,986 December 20, 1949

CARL H. LARSON

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 11, line 20, for "in mercury", read *the mercury*; column 14, line 29, for "malgam" read *amalgam*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of April, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.