Jan. 16, 1945. U. C. HEDIN 2,367,498

MERCURY RELAY

Filed Sept. 21, 1942

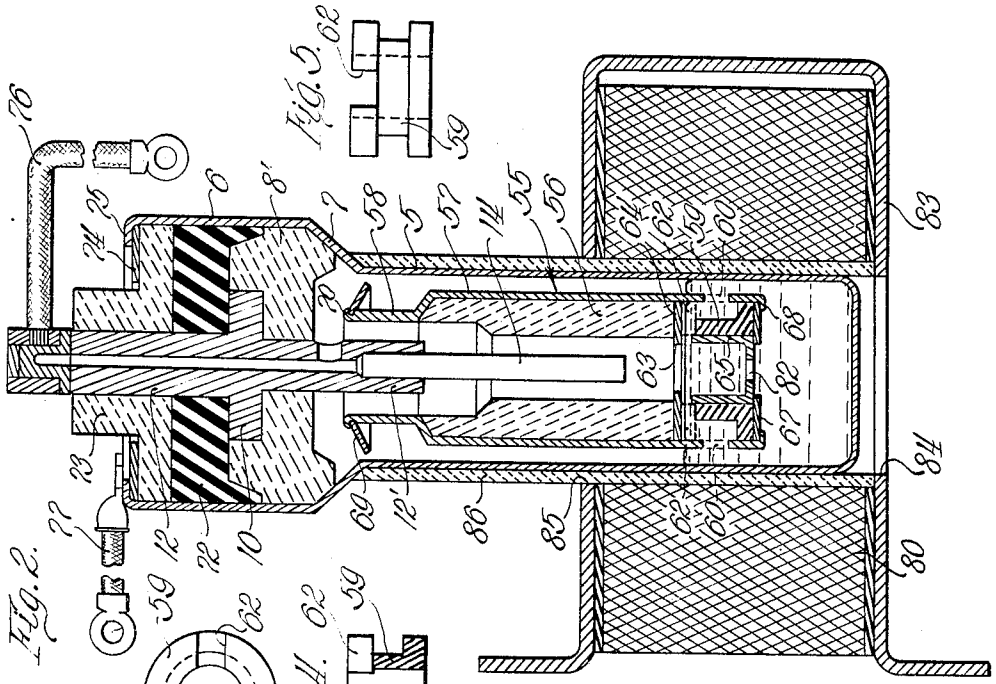


Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

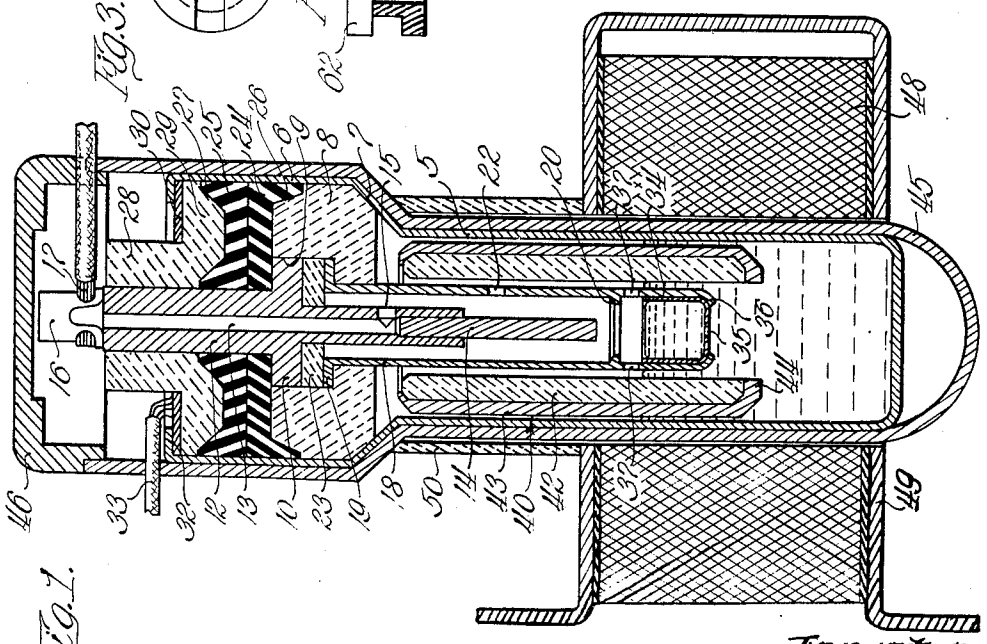


Fig. 1.

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MERCURY RELAY

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11 Claims. (Cl. 200—97)

This invention relates to mercury relays, and more particularly is concerned with mercury relays of the recycling type having a normally open contact with slow make and quick break features.

The present invention is concerned particularly with mercury relays of the metal envelope type in which the envelope acts as one electrode of the circuit and a second electrode is supported in sealed insulated relation within the envelope, and is arranged to be contacted by mercury carried within the envelope upon actuation of a displacer within the envelope actuated by an external energizing coil.

The present relay which, in general construction, is similar to that shown in my application, Serial No. 311,915, filed December 30, 1939, is so designed as to provide for economy of construction and ease of assembly, using substantially standard parts of relays now in production.

In the preferred form of the present invention, the time delay is built into a cylinder insulated from the envelope and electrode, and in no way is connected to the displacer. This is of distinct advantage in that the displacer has a quick free action since it is provided with a uniform bore. This gives constant repeat performance in the relay. However, the invention is not limited to this particular arrangement, since the time control element may be incorporated in the displacer and moved therewith without in any way altering the fundamental characteristics of the relay. Also, by using the cylinder and piston arrangement within the relay, the splashing action of the mercury caused by rapid movement of the displacer has no effect on the contact, thus eliminating flickering contacts or premature contacts caused by vibration or physical disturbances due to the action of the plunger moving down through the mercury. A slow rise and fast lowering of the mercury takes place in the confined space within the cylinder without regard to disturbances caused externally of the cylinder, and consequently a very strong solenoid may be used for such a construction.

In a modified form of the invention, the piston and displacer are combined in a single movable unit which is provided with a splash apron that prevents any flickering contacts. With this construction, slightly better insulation can be used which allows the increasing of the current capacity of the relay, allowing higher currents and voltages to be used under conditions where space limitations are present. This makes it possible to use a solenoid with sufficient magnetic pull to force the plunger down to the bottom of the envelope immediately. This produces a more consistent time delay action since the splash apron eliminates the previous disadvantages of premature or flickering contacts.

The objects and advantages of the present invention will appear more fully from the following detailed description which, taken in conjunction with the accompanying drawing, will disclose to those skilled in the art the particular construction and operation of a preferred form of the present invention.

In the drawing:

Figure 1 is a sectional view of a mercury relay embodying the features of the present invention;

Figure 2 is a sectional view of a modified form of relay;

Figure 3 is a top plan view of the valve member of Figure 2;

Figure 4 is a sectional view through the member shown in Figure 3;

Figure 5 is a side elevational view of the member shown in Figure 3.

Referring now in detail to Figure 1, the construction disclosed herein comprises a metal envelope 5 having an enlarged open end 6 defined by the frusto-conical shoulder 7. The envelope 5 is preferably formed of a non-magnetic steel such as stainless steel or the like, and is adapted to receive at its upper end the ceramic insert 8 having a shoulder seated on the shoulder of the envelope and having a counterbored portion 9 adapted to receive the flanged collar 10 of an electrode 12. The electrode 12 is provided with an axial bore 13, which, at its lower end, is enlarged to receive the tungsten or molybdenum tip 14. Immediately above the upper end of the tungsten electrode 14 is a radial passageway 15, which communicates with the bore 13 and provides a means for evacuating the envelope and filling the same with hydrogen or other inert gas under considerable pressure. This is provided by the tubulation 16 at the upper end of the electrode 12 which, after the evacuation and filling process, is sealed off and forms a terminal member for the conductor 17 connecting the electrode to one side of the electrode circuit.

Below the collar 10 of the electrode 12 there is provided a cylindrical sleeve member 18 preferably formed of 18–8 stainless steel or other non-magnetic metal which does not amalgamate with mercury, this sleeve being provided with the flange 19 at its upper end and being bored through its opposite ends to provide the intermediate collar or radially inturned shoulder 20 adjacent the lower end thereof. The sleeve is provided between the shoulder 20 and the flanged end thereof with the vent opening 22 to prevent suction therein during discharge or evacuation of the envelope. The flange 19 of the cylinder is insulated from the electrode 12 by means of the insulating washer or disc 23 interposed between the flange and the collar 10, this insulating washer being either Bakelite, hard rubber, or preferably an inorganic material such as a refractory or ceramic.

For sealing the electrode and associated ceramic 8 within the open end of the envelope there is provided two sealing gaskets 24 and 25, each hav-

ing peripheral flanges 26 and 27, respectively, increasing the surface contact with the internal wall of the enlarged end 6 of the envelope, the flange 26 being forced into a relieved portion in the outer end of the ceramic 8. Preferably, the rubber gaskets have a coating of liquid polyvinyl alcohol applied thereto, as by a brush, to give the gaskets greater density and to seal the same, this material having a density about ten times greater than rubber. A suitable compression member 28 preferably formed of Bakelite or the like is provided with an enlarged flange portion 29 bearing against the gaskets 24 and 25 to axially compress the same, thereby flowing the rubber into firm sealing engagement with the ceramic 8, with the external surface of the electrode 12, and with the internal wall of the envelope, thereby providing a tight gas-proof seal. While the compression member 28 is under axial force to provide this sealing pressure on the gaskets, the retaining ring 30 is placed in position and the end of the envelope is spun over, as indicated at 32, to retain the entire assembly under pressure. The envelope is then connected to the other side of the electric circuit through the conductor 33 electrically bonded to the retaining washer or to the spun-over end 32 of the envelope.

Disposed below the annular shoulder 20 within the sleeve or cylinder 18 is the piston or cup member 34 which has its lower end provided with the time control aperture 35. This cup member is of non-magnetic, or austenitic material, giving it high reluctance, to allow a quick cut off or release. I have found that stainless steel is best suited for this purpose. The lower end of the sleeve is spun over, as indicated at 36, to form a stop preventing movement of the cup 34 out of the end of the sleeve 18. It will be noted that the axial length of the cup 34 is such that when in lowermost position, the upper edge thereof lies below the side ports 37 formed in the sleeve 18 below the shoulder 20. It will therefore be apparent that upon raising of the cup or piston 34 relative to the sleeve 18, the piston will act as a valve to close the side ports, whereby mercury may enter into the interior of the sleeve only through the aperture 35 in the base of the piston. Similarly when the piston is dropped to the position shown in Figure 1, the ports 37 are uncovered so that any mercury within the sleeve will be drained therefrom through these ports. It is apparent that these ports, which may be two or more in number, are considerably larger in diameter than the orifice 35, whereby the time delay in opening the circuit is materially reduced, and, depending upon the number of ports and their size, can be so arranged as to provide a quick break through the relay upon deenergization of the coil.

Surrounding the sleeve 18 is the displacer, indicated generally at 40. This displacer comprises an inner ceramic sleeve 42 which insulates the displacer from the sleeve 18, and an outer magnetic sleeve 43, which has the upper end thereof spun over to retain the ceramic 42 in position against the lip 44 formed in the lower end of the sleeve 43.

It will be noted that the displacer is of such length relative to the volume of mercury in the envelope that at no time will it be completely immersed. This is of distinct value in eliminating any tendency of the mercury, by surface tension, to retard the release of the plunger upon deenergization of the coil. Thus the quick release of the plunger is effected, causing a quick break of the circuit. This is also true of the construction shown in Figure 2, which will be described in detail hereinafter.

The entire relay assembly is enclosed within a molded insulating case consisting of the main body portion 45 and a cap portion 46 which fits over the upper end thereof to close the upper end of the case. This may be formed of any molded phenol product such as Bakelite or the like, and forms a protective and insulating enclosure for the relay.

Surrounding the lower end of the insulating case is the solenoid or energizing coil 48 which is carried within a suitable bracket 49 having apertures therein for receiving the reduced end of the relay. A suitable spacer member 50 formed of insulating material, such as porcelain, Bakelite or impregnated fiber, is employed to provide a predetermined spacing between the shoulder 7 and the coil, thereby controlling the movement of the displacer downwardly through the mercury upon energization of the coil 48.

In the operation of the construction thus far described, the relay, as shown in Figure 1, is in its normally open or de-energized position. In this position, the mercury is shown as standing within the envelope to a height just below the ports 37, and the piston or cup 34 is filled with mercury which holds it in its lowered position against the spun over edge 36 of the sleeve 18.

Upon energization of the coil 48, the displacer 40 is drawn downwardly, thereby raising the level of mercury. However, this causes the piston 34 to raise simultaneously due to the pressure of mercury on the base thereof, and the upper edge of the cup thereupon shears across the ports 37, closing the same and preventing any mercury entering the interior of the sleeve 18 except through the orifice 35. The size of this orifice will therefore determine the time delay occurring between energization of coil 48 and the raising of the mercury level within the sleeve 18 to a point at which it will contact the lower end of the electrode tip 14. This tip is preferably made of molybdenum or tungsten because of the arc resisting characteristics of such metals. Upon the mercury reaching this level, contact is completed between the envelope and the electrode, thereby closing the circuit between conductors 33 and 17. So long as the coil remains energized, this contact will remain closed.

Upon de-energization of coil 48, the displacer 40, because of its low specific gravity as compared with mercury, shoots upwardly. This immediately results in a lowering of the mercury level about the sleeve 18. Lowering of this level causes the cup 34 to drop from the stop shoulder 20 down to the bottom of the sleeve 18, thereby uncovering the ports 37 so that the mercury previously confined within the sleeve 18 in contact with the electrode will be quickly drained therefrom, thereby breaking the current between the conductors 33 and 17, and consequently opening the circuit through the relay. In this case, the orifice 35 has no effect upon the circuit opening operation, which is controlled solely by the size of the orifices 37.

It will be noted that the time delay in this form of the invention is entirely independent of the plunger 40, and the plunger itself is provided with a straight bore therethrough. This is of distinct advantage since the displacer has a quick free action by being open at the bottom so that it is drawn down to the bottom immediately upon energization of the coil. This produces a much more consistent time delay than would otherwise

be obtainable. Further, the plunger does not have lifting action on the mercury when the coil is de-energized because of its open bottom. It should also be noted that by using the cylinder inside the movable displacer, the splashing action of the mercury by the displacer has no effect on the electrode, thus eliminating flickering contacts or premature contacts due to vibration or physical disturbances caused by movement of the plunger. Thus, a very strong solenoid may be used as compared with the types where the electrode is open inside the displacer.

In the form of the invention shown in Figure 2, a substantially similar construction is provided except that in this case the time control elements are incorporated directly in the plunger and the intermediate sleeve is eliminated. Similar reference numerals denote similar parts in both figures.

Considering Figure 2 in detail, there is provided in this figure the metal envelope 5, preferably formed of the same material as that described in Figure 1.

In this form of the invention the ceramic insert 8' receives the collar portion 10 of the electrode 12 in the same manner as previously described, the electrode 12, however, being of slightly different shape than that shown in Figure 1. At its lower end the electrode is provided with the electrode tip 14 of tungsten or molybdenum, and is bored and ported in the same manner as previously described to provide for evacuation of the envelope. Disposed about the electrode is the displacer 55 which includes a ceramic member 56 having a counterbored upper end portion to allow for clearance about the lower end 12' of the electrode, and which is inserted into position through the lower end of the magnetic sleeve 57, this sleeve having a reduced or under cut portion 58 for a purpose to be hereinafter described. The sleeve 57 at its lower end is adapted to receive an iron collar 59, which has an external channel portion alined with openings 60 formed in the lower end of the sleeve 55. Above the openings 60 the iron member 59 is provided with transversely opening ports, indicated generally at 62, cooperating with the openings 60 to provide a mercury pathway from the interior of the displacer out through the enlarged aperture 63 of the stop washer 64, thence laterally above the upper edge of the piston cup 65 through the port 62 and then outwardly through the openings 60. The piston cup 65, preferably of stainless steel, is reciprocally arranged for movement from its lowermost position, as shown in Figure 2, to a position up against the upper face of the stop washer 64 whereby it closes the ports 62 to prevent discharge of mercury therethrough.

The cylinder 59, as well as the stop washer 64, are retained in abutting engagement against the lower end of ceramic 56 by means of retaining washer 67 held in position by the spun-over end 68 of the displacer sleeve 55. Thus the piston 65 is limited in its movement between the washers 64 and 67.

The magnetic sleeve 57 adjacent its upper end is reduced, as indicated at 58, to provide an under cut for receiving mercury when the displacer is drawn downwardly and, at the upper end of the sleeve, a suitable splash apron 69 is provided which is held in position by spinning over the upper end of the sleeve 57, as indicated at 70.

The entire envelope is sealed against leakage of gas by means of the gasket 72 compressed in position by the compression member 73, which in turn is held in compressed position by the retaining washer 74 and the spun-over end 75 of the envelope. The electrode 12 is connected through conductor 76 to one side of an electric circuit of which the other side is connected to the envelope by the conductor 77.

In the operation of this type of relay energization of coil 80 results in the plunger 55 being drawn downwardly. This in turn causes piston 65 to move upwardly relative to the plunger abutting against the stop washer 64, and thereby closing the discharge ports 62. As a result, mercury cannot enter into the interior of the plunger except through the aperture or orifice 82 in the lower end of the piston 65. The size of this orifice will therefore control the time required for the mercury to fill the interior of the displacer up to a point where it contacts the electrode tip 14, closing the circuit between the conductors 76 and 77. Upon de-energization of coil 80, the displacer rises rapidly, causing the piston cup 65 to drop relative to the displacer. This causes it to move down against retaining washer 67, opening the lateral discharge ports 62 so that mercury may rush therethrough and out through openings 60 of the displacer, causing quick opening of the circuit through the relay. The splash apron 69 prevents any mercury which rises upwardly around the outside of the displacer 55 from splashing against the electrode 12. This prevents any flickering or premature contacts with the electrode during energization of the relay.

Another novel feature of this particular construction is the means by which the relay envelope is supported relative to the coil 80. It will be noted that the coil 80 is confined within a U-shaped bracket 83 which has an upper and lower aperture therein, the lower aperture 84 being of smaller diameter than the upper aperture 85. Supported on the lower aperture 84 within the coil 80 is an insulating spacing member 86 which may be formed as a fiber sleeve or the like, and which extends upwardly through the opening 85 and engages against the shoulder 7 of the envelope at its upper end. By predetermining the axial length of the sleeve 86, the relationship of the relay with respect to the coil can be selected, which in turn will select the distance through which the plunger is drawn upon energization of the coil.

The splash apron which prevents the mercury from spilling over makes it possible to use a solenoid with sufficient magnetic pull to force the plunger down to the bottom at once. Actual tests on a relay of this type show that the fastest discharge is approximately .05 second, and the longest delay that is practicable for production purposes is 300 seconds, or about five minutes. However, the size of the tube is also a factor in connection with such tests, and obviously by variations of the port sizes and orifice openings, variation of the time delay and quick release limits are obtainable. It will be noted that by the particular shape of the displacer used, it is possible to make the portion of the plunger above the mercury as light as possible, and the portion which is submerged greater in volume without adding any material weight. This provides a balanced construction, and the increased volume insures quicker displacement of the mercury,

thereby also improving the constant operating characteristics of the relay.

In the embodiments shown in both Figures 1 and 2 of the present invention, the envelope is filled with an inert gas, such as hydrogen, under considerable pressure.

I am aware that various changes may be made in certain features of the present construction, and I therefore do not intend to be limited except as defined by the scope and spirit of the appended claims.

I claim:

1. In a mercury relay, a non-magnetic metal envelope forming one side of a relay circuit, an electrode projecting axially into said envelope and forming the other side of said circuit, a body of mercury in said envelope, a displacer in said envelope surrounding said electrode and reciprocable to raise and lower the level of mercury in said envelope, and a piston-like reciprocable cup member movable upwardly in said envelope responsive to movement of said mercury and having a metering port in the base thereof for restricting the flow of mercury upwardly to close said circuit said member being movable downwardly upon release of said displacer to allow quick release of said mercury from contact with said electrode.

2. In a mercury relay, a non-magnetic cup-shaped metal envelope having a body of mercury in the closed end thereof, an electrode sealed in the open end of said envelope and extending axially toward said body of mercury, an axially reciprocal displacer in said envelope, and valve means controlling flow of mercury upwardly to said electrode responsive to movement of said displacer including laterally opening discharge ports, a metered inlet opening, and a reciprocable member operable upon raising of the mercury level to move upwardly close off said lateral ports and having a metering bore therethrough whereby mercury is metered through said member into contact with said electrode, and operable upon lowering of said level to open up said ports for allowing quick lowering of said mercury away from said electrode.

3. Valve means for an enclosed metal envelope mercury relay of the slow operate quick release type comprising a cylindrical sleeve member anchored within said envelope and provided adjacent its lower end with lateral discharge ports, a valve member of non-magnetic material slidable in the lower end of said sleeve and having a restricted orifice extending axially therethrough, said member being movable upwardly in said sleeve to close off said ports upon upward movement of mercury whereby mercury can enter said sleeve only through said orifice, and movable downwardly in said sleeve upon downwardly movement of mercury to uncover said discharge ports.

4. In a mercury relay having an elongated cup-shaped non-magnetic metallic envelope forming one side of the relay circuit, an electrode extending into said envelope from the open end thereof, means for sealing said electrode in insulated relation in said end of said envelope including rubber gaskets having enlarged peripheral flange surfaces engaging the internal annular surface of said open end, said gaskets being coated with polyvinyl alcohol, a displacer in said envelope surrounding said electrode, and a body of mercury in said envelope adapted to engage said electrode upon operation of said displacer.

5. In a mercury relay, a cylindrical metal envelope open at its upper end, an electrode projecting into said envelope from said end and maintained in sealed insulated relation in said end, a sleeve fixed in said end and enclosing said electrode, the lower end of said sleeve below said electrode having lateral discharge ports, a cylindrical member slidably mounted in the lower end of said sleeve and having a restricted orifice extending axially therethrough, a body of mercury normally below said sleeve and member, and a displacer surrounding said sleeve and operable to displace mercury upwardly whereby said member is raised to close off said discharge ports and allow mercury to enter said sleeve only through said orifice.

6. A mercury relay comprising a metallic non-magnetic envelope having an electrode sealed in the open end thereof, said electrode projecting axially downwardly in said envelope, a body of mercury in the bottom of said envelope normally out of contact with said electrode, a displacer surrounding said electrode, said displacer at its lower end having lateral discharge ports, a hollow valve body in said end of said displacer having a transverse channel communicating with said ports, and a plunger member slidable in said body having a restricted orifice in its base forming a time delaying inlet opening, said plunger member being forced upwardly to close off said channel upon depression of said displacer into said mercury whereby said mercury flows upwardly within said displacer at a reduced rate to delay the contact thereof with said electrode.

7. The relay of claim 6 further characterized in the provision of means limiting axial movement of said plunger member.

8. The relay of claim 6 wherein said plunger member is of cup-like shape and has a close sliding fit in the bore of said valve body, said member being filled with mercury and normally maintained thereby in lowered position.

9. The relay of claim 6 wherein said displacer has a reduced upper end provided with a disc-like radially outwardly extending splash apron preventing mercury flowing over the upper end of said displacer.

10. A slow make quick break mercury relay comprising an envelope, having a body of mercury therein, a depending electrode sealed in one end of said envelope and terminating short of the normal level of said mercury body, a displacer axially reciprocable in said envelope, a cylindrical sleeve surrounding said electrode and terminating in said mercury body, lateral ports in said sleeve above the mercury level, a piston member in the lower end of said sleeve having a metering orifice therethrough, and means for drawing said displacer downwardly into said mercury to raise the level thereof whereupon said piston member moves upwardly in said sleeve to close said ports so that mercury flows upwardly solely through said orifice into contact with said electrode.

11. A mercury relay comprising an elongated metal cylinder closed at one end, an electrode extending axially into said envelope from the opposite end, means for sealing said electrode in insulated relation in said end including rubber gasket means having a peripheral flange portion engaging the inner annular surface of said end, a coating of polyvinyl alcohol on said gasket means, a displacer in said envelope surrounding said electrode, and a body of mercury in said envelope adapted to engage said electrode upon actuation of said displacer.

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