

Sept. 16, 1952

J. L. SLONNEGER

2,611,057

THERMALLY ACTUATED MERCURY SWITCH

Filed Dec. 29, 1949

Fig. 1.

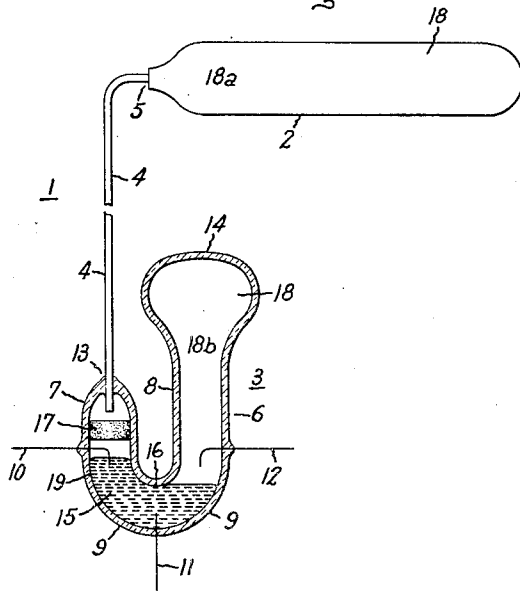


Fig. 3.

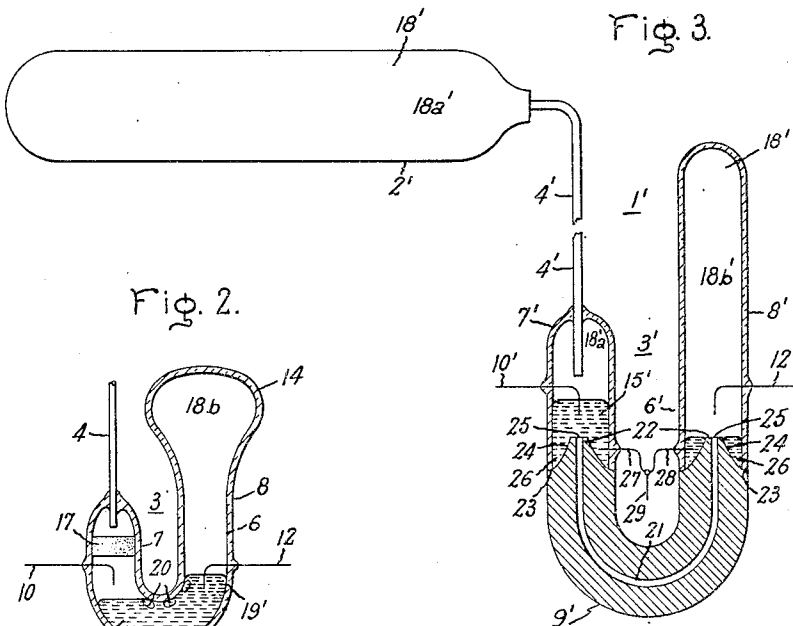
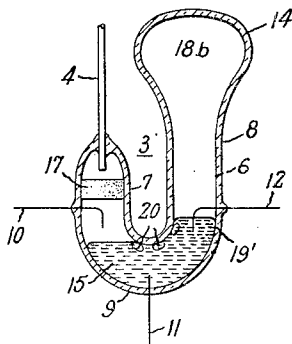


Fig. 2.



Inventor:
John L. Slonneger,
by *Charles H. Mott*
His Attorney.

UNITED STATES PATENT OFFICE

2,611,057

THERMALLY ACTUATED MERCURY SWITCH

John L. Slonneger, Scotia, N. Y., assignor to General Electric Company, a corporation of New York

Application December 29, 1949, Serial No. 135,753

1 Claim. (Cl. 200-140)

1

My invention relates to electric switching devices and, more particularly, to switching devices which are responsive to temperature changes, either increases or decreases, without regard to the exact temperature at which such changes occur.

Switching devices of the type mentioned are frequently employed in control apparatus for oil burning furnaces and the like to indicate whether or not combustion is established therein. In such a switch a "slip-clutch" action is generally employed. For example, the switch may be actuated in response to a relatively small initial increase in temperature. Following actuation, the switch remains in the actuated condition during continuing temperature increases and at steady-state temperatures established during or following the increase. Subsequently, at an increased temperature the switch may be actuated in the reverse direction in response to a relatively small initial decrease in temperature. Following actuation of the switch the temperature may continue to be decreased without further action of the switch.

One means whereby such slip-clutch action has been obtained heretofore is by the use of a slipping mechanical device. In such a device an actuating force from a bimetallic element or the like is transmitted through a frictional clutch to a switching element which requires relatively little force for the actuation thereof. In response to a relatively small change in temperature in one direction, as for example an increase, actuation of the switch is effected, following which the switching element is mechanically stopped from further motion. Additional actuating force which may be provided by further change in temperature of the actuating element is spent in slipping the clutch without moving the switch element. However, should the temperature change slightly in the reverse direction the switch element is immediately actuated in the opposite direction following which slipping of the clutch again occurs.

It is a principal object of the present invention to provide a new and improved switching device which is responsive to relatively small changes in temperature and in which an overtravel action similar to such slip-clutch action is included.

In practicing my invention I utilize an expanding gas as a temperature-sensing element, acting upon a conducting liquid, such as mercury, in a sealed system of chambers. The liquid is transferred, in response to changing gas pressure, from an initial position to a final position,

2

in which positions fixed electrodes are contacted in various combinations by the liquid to effect switching operations. Slip-clutch or overtravel action is obtained by effecting transfer of the liquid in response to a relatively small initial change in gas pressure, following which further change in gas pressure in the same direction results only in bubbling of the gas through the liquid. However, a change in gas pressure in the opposite direction immediately results in a transfer of the liquid to its original position with subsequent bubbling resulting from further change in gas temperature and pressure.

My invention will be better understood from a consideration of the following description taken in connection with the figures of the accompanying drawing, and its scope will be pointed out in the appended claim. In the drawing, Fig. 1 is a cross-section of a switching device embodying my invention; Fig. 2 shows the device of Fig. 1 following actuation due to an increase of temperature; and Fig. 3 is a cross-section of a modification of the arrangement shown in Fig. 1.

Referring now to Fig. 1, there is shown a switching device 1 comprising principally a temperature sensing element 2, a switching element 3 and a capillary tube 4 interconnecting elements 2 and 3. Temperature-sensing element 2 may conveniently be a metal bulb of a type commonly used in thermostatic apparatus. Bulb 2 is completely sealed except for a gas-tight connection 5 to capillary tube 4. Tube 4, which may likewise be metal, may be relatively long to permit remote location of sensing bulb 2 relative to switching element 3. Switching element 3 is provided with a housing 6 which is a generally U-shaped member having end portions or legs 7 and 8 forming the side members of the U, and an intermediate bight portion 9 connecting end portions 7 and 8 and forming the lower portion of the U.

A plurality of switching electrodes 10, 11 and 12 are positioned at predetermined points in housing 6. More particularly, electrodes 10 and 12 are positioned in legs 7 and 8 in the vicinity of their junctions with bight portion 9, while electrode 11 is positioned at the lower extremity of bight 9. In this arrangement of electrodes 10, 11 and 12, a single-pole, double-throw switch is provided, electrode 11 being the common electrode. It is, of course, necessary for electrodes 10, 11 and 12 to be insulated from one another. In case housing 6 is made of metal, therefore, it is necessary for electrodes 10 and 12 to be insulated from housing 6 by the use of suitable insulating bushings. However, housing 6 may

conveniently be made of glass, which has the advantage of permitting the internal conditions of switch element 3 to be viewed. In Fig. 1 housing 6 is shown as made of glass or other insulating material and accordingly no insulating bushings are shown.

Capillary tube 4 is inserted in the outer or free extremity of end portion 7 and is fixed thereto at a gas-tight joint 13. The free or outer extremity of end portion 8 is provided with a bulb-like portion 14 having a predetermined volume and integrally formed with end portion 8. A predetermined quantity of a conducting liquid 15, preferably mercury, is placed in the lower or bight portion 9 of housing 6. The volume of the liquid is such that when the liquid surface in either end leg 7 or 8 is at the level of the top wall 16 of the bight 9, the other leg is only partially filled with liquid. The volume of liquid required is such that when liquid 15 stands at equal levels in legs 8 and 7 of housing 6, contact is not made with electrodes 10 and 12. However, under this condition the level of liquid stands appreciably above the top wall 16 of bight portion 9 between legs 7 and 8. A porous filter plug 17, which may be made of a ceramic material, is positioned in end portion 7 between the end of capillary tube 4 and electrode 10 and is preferably fixed to the inner surface of end portion 7. Plug 17 is not essential to the operation of the switch but may be included if desired to prevent liquid 15 from entering capillary tube 4 and bulb 2 when the apparatus is inverted, as for example, during shipment.

Bulb 2, tube 4 and the space in housing 6 not otherwise occupied are charged with a gas 18 which is inert relative to the liquid and the various materials employed in constructing the elements of the switch. The pressure of gas 18 under charging conditions may conveniently be approximately one atmosphere since such a pressure is readily obtainable. Following charging of the switch, the entire switching device is sealed to prevent escape of the gas when the pressure thereof is increased due to heating.

In operation, liquid 15 is first made to assume the position shown in Fig. 1 wherein a column 19 of liquid 15 is established in leg 7 causing contact of liquid 15 with electrode 10. Column 19 is established by tilting switch element 3 in the direction of leg 7. In the tilted position liquid 15 provides a seal between the portion of gas 18a in the space enclosed by bulb 2, tube 4 and leg 7, and the portion of gas 18b in the space enclosed by leg 8 and bulb 14. For convenience these spaces are referred to hereinafter as bulbs 2 and 14, respectively. When element 6 is returned to the upright position liquid 15 moves to the position shown in Fig. 1 causing a slight reduction in the pressure of gas 18a and an increase in the pressure of gas 18b, the difference in these pressures being sufficient to maintain column 19.

As bulb 2 is heated gas 18a therein expands through capillary tube 4 and filter plug 17 and forces liquid 15 from the position shown in Fig. 1 to the position shown in Fig. 2. It will be seen that the position of Fig. 2 is substantially reversed from the position of Fig. 1 and a column 19' exists in leg 8. When the transfer of liquid 15 occurs, contact thereof with electrode 10 is broken and contact with electrode 12 is established. Thus a conducting path between electrodes 10 and 11 is interrupted and a conducting path is established between electrodes 11 and

12 or, in other words, switching action occurs. As the temperature of bulb 2 and gas 18a is increased, further expansion of gas 18a occurs. However, the only effect of such expansion is to cause bubbles 20 of gas 18a to pass through liquid 15 and to be added to gas 18b in bulb 14. No further actuation of switch element 3 may occur under such conditions.

When the temperature of bulb 2 ceases to rise, steady-state conditions are achieved and no further transfer of gas from bulb 2 to bulb 14 occurs. Liquid 15 thus remains in the position shown in Fig. 2 and the switch remains in the actuated condition shown therein. Under this condition the pressure provided by the gas in bulb 14 and column 19' equals the pressure in bulb 2. Regardless of the final temperature of bulb 2 and the gas 18a therein, when gas 18a is cooled a relatively few degrees contraction thereof occurs, with accompanying reduced pressure, and liquid 15 is transferred to its original position as shown in Fig. 1. Further reduction of temperature of the gas in bulb 2 results in bubbling of the gas through liquid 15 without further effect on the position of liquid 15. Depending on their direction, changes in the temperature of bulb 14 and gas 18b may assist or oppose normal actuation of the switch in response to temperature changes of bulb 2, as described. It is desirable, therefore, in the operation of the switch, that the temperature of bulb 14 remain substantially constant to prevent spurious actuation of the switch.

It will be seen that an overtravel or slip-clutch action is provided by switch element 3. Liquid 15 may be transferred in either direction by a relatively small change in the temperature of gas 18a in bulb 2 but further change of temperature in the same direction results in "slipping" which is in the form of bubbling of gas 18 through liquid 15 without effect on the position of the latter. To effect actuation of the switch in response to a relatively small change or differential in temperature it is desirable that the volume of bulb 2 be relatively large with respect to the total volume of the space containing gas 18a, this space comprising bulb 2, tube 4 and leg 7. Thus the volumes of tube 4 and leg 7 are preferably made small relative to the volume of bulb 2. The volume of the space enclosed by leg 8 and bulb 14 is preferably approximately one-half of the volume of bulb 2. The exact proportions of the various elements of the switch may readily be determined in actual practice to obtain desired operating characteristics.

Attention is now directed to Fig. 3 in which there is shown a modification of the embodiment of my invention previously described. There is shown a switching device 1' provided with a temperature-sensing bulb 2' and a capillary tube 4' which are generally similar to corresponding elements in Fig. 1. Housing 6' of switching element 3', however, differs in construction from housing 6 of switch element 3 in Fig. 1. Housing 6' is a generally U-shaped member provided with a pair of vertically disposed end portions or legs 7' and 8' having gas chambers therein and a bight portion 9'. The latter comprises a relatively heavy-walled capillary tube 21 interconnecting the chambers in legs 7' and 8'. Bight portion 9' terminates in generally tapered extremities 22, the larger portions of which are sealed at gas-tight joints 23 to legs 7' and 8'. The reduced portions 24 of tapered extremities 22 extend into the chambers in legs 7' and 8' as shown in Fig. 3. Thus the extremities 25 of capillary tube 21 are

positioned above joints 23, thereby providing reservoir spaces 26 between tapered portions 24 and the inner surfaces of legs 7' and 8', respectively.

As in the device previously described a predetermined quantity of a conducting liquid 15', preferably mercury, is introduced in housing 6', and the space in the system not otherwise occupied is charged with an inert gas 18'. Capillary tube 4' preferably extends a substantial distance into leg 7' to minimize the possibility of liquid 15' entering capillary tube 4' and bulb 2' when switch 1' is inverted. The portion of gas 18' in bulb 2', tube 4' and leg 7' is designated as 18a', while the portion of gas in leg 8' is designated as 18b'. Housing 6' is again shown as being made of an insulating material such as glass, and accordingly insulating bushings are not employed in connection with the switch electrodes. A pair of electrodes 10' and 12' are positioned in legs 7' and 8' respectively as in Fig. 1. However, in the arrangement of Fig. 3 a pair of electrodes 27 and 28, rather than a single electrode, such as electrode 11, are provided to act cooperatively with electrodes 10' and 12', respectively. Electrodes 27 and 28 are positioned in legs 7' and 8' so as to extend into reservoirs 26 and are provided with a common connection 29. It will be seen that regardless of the position of liquid 15', that is, whether the bulk of liquid 15' is in leg 7' or leg 8', portions of liquid 15' remain permanently in reservoirs 26 since the sole outlets of legs 7' and 8' are through extremities 25 of capillary tube 21 which are at the upper levels of reservoirs 26. Thus electrodes 27 and 28 are in continuous contact with the portions of liquid 15' in reservoirs 26.

Operation of switch 1' is generally similar to the operation of switch 1 in that liquid 15' is forced in response to pressure changes in gas 18a' through capillary tube 21 between legs 7' and 8'. When liquid 15' is in leg 7' as shown in Fig. 3 a conducting path is formed between electrodes 10' and 27 thus completing the circuit therebetween. Under this condition the circuit between electrodes 12' and 28 is open. When, on the other hand, liquid 15' is transferred to leg 8' the reverse is true and a circuit is completed between electrodes 12' and 28 and the circuit between electrodes 10' and 27 is open.

The arrangement of Fig. 3 which makes use of a capillary tube 21 to interconnect legs 7' and 8' is particularly useful to prevent surging of liquid 15' due to relatively rapid changes in the pressure of gas 18a'. In general liquid 15' is forced completely out of tube 21, as shown in Fig. 3. Regardless of the rate of change of pressure, tube 21 acts as a dampening medium to enable gas 18' to pass through liquid 15' without undue agitation and violence. While the volume of the chamber containing gas 18b' is shown as comprising only leg 8' without a bulb portion similar to bulb 14 in Fig. 1 at the extremity thereof, it will be obvious that it is only necessary to provide the desired volume therein and that the particular configuration employed in the construction of housing 6 is principally a matter of convenience. It will be further obvious that by sealing the end of leg 7' and by suitably increasing the volume thereof, leg 7' may be employed as the temperature-sensing element of switch 1' without the use of bulb 2' and tube 4'. In this case it is necessary to provide thermal insulation between legs 7' and 8', as by lengthening intermediate portion 8' and capillary tube 21, to permit changes in the

temperature of leg 7' without appreciably affecting the temperature of leg 8'.

While I have shown and described a preferred embodiment of my invention, it will be understood that my invention may well take other forms and I, therefore, aim in the appended claim to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

An electric switch responsive to temperature changes comprising, a U-shaped housing positioned with the leg portions thereof vertically disposed and with its bight portion at the bottom, a pair of gas chambers forming parts respectively of said leg portions, a capillary conduit in the said bight portion interconnecting said chambers, a pair of reservoirs within said chambers forming respectively portions thereof with each reservoir located adjacent the connection between said conduit and the chamber in which it is located, a quantity of electrically conductive liquid only partially filling said housing but of sufficient volume to more than fill both said reservoirs, an inert gas filling said housing above said liquid, a pair of electrodes extending through said housing respectively into said reservoirs, a second pair of electrodes extending through said housing above said reservoirs respectively in said two chambers, whereby an upper and a lower electrode are provided in each chamber, a predetermined increase in the pressure of the gas in a first of said chambers relative to the pressure of the gas in the second chamber produced by a change in the temperature of the gas in one of said chambers causing said liquid to flow through said capillary conduit from said first chamber to said second chamber whereby to raise the level of the liquid in said second chamber sufficiently to produce an electrical connection through said liquid between the upper and lower electrodes in said second chamber, and a predetermined inverse change in said relative pressure produced by an oppositely effective temperature change causing said liquid to flow from said second chamber to said first chamber whereby to raise the liquid level in said first chamber sufficiently to produce an electrical connection through said liquid between the electrodes in said first chamber, said chambers and the reservoirs therein being so constructed and arranged that all of the liquid in one chamber except that remaining in the reservoir may flow through said conduit from said one chamber to the other chamber and that upon such an occurrence gas flows from said one chamber through said conduit to the other chamber until the gas pressure in said one chamber is substantially equal to the gas pressure plus liquid head pressure in said other chamber.

JOHN L. SLONNEGER.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,691,016	McCabe et al.	Nov. 6, 1928

FOREIGN PATENTS

Number	Country	Date
277,344	Great Britain	Dec. 7, 1928
407,861	Great Britain	Mar. 29, 1934
501,592	Great Britain	Feb. 27, 1939