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HEAT-CONTROLLED LIQUID SWITCH

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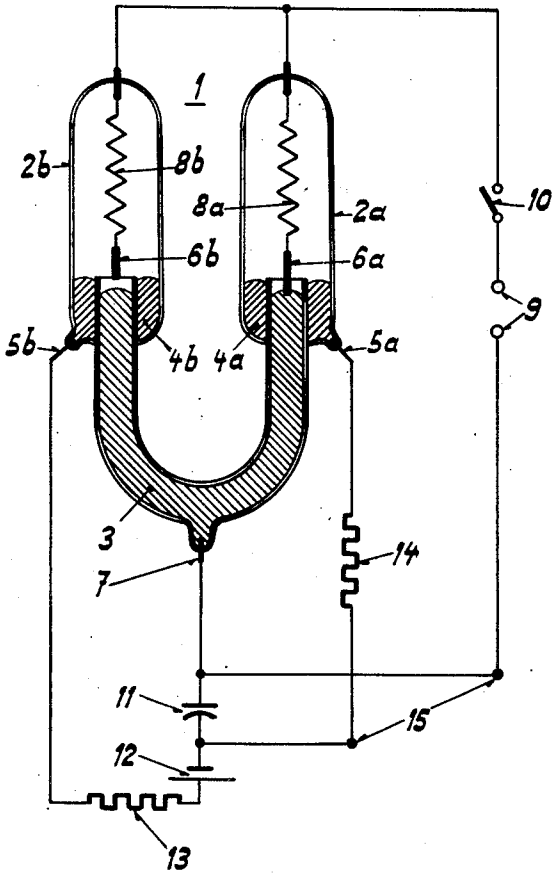

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HEAT-CONTROLLED LIQUID SWITCH

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My invention relates to thermally-operated liquid-containing switches for the control of electric circuits, and preferably to mercury switches, which have a U-shaped envelope in whose limbs the mercury or other conductive liquid is driven back and forth by the alternate heating and cooling of a gaseous atmosphere enclosed in the limbs above the liquid, thus alternately closing and opening the electric circuits of the gas heating means as well as the circuit proper to be controlled.

In the known switches of this kind, the electric switching occurs between a contact pin in each of the respective limbs of the U-shaped envelope and the reciprocating conductive column of liquid. With currents above a certain magnitude, depending among other things upon the thickness of the contact pins, the current closing performance is not immediately completed. When the contact pins are first touched by the ascending conductive liquid, a temporary sparking occurs, similar to that of a Wehnelt interrupter, resulting in high-frequency oscillations. Only when the contact pin more deeply submerges in the rising liquid does the sparking cease, then completing the electric contact engagement.

From some applications, such as the control of blink lights, the sparking at the switch contacts is not detrimental to the operation proper, although it may then be necessary to provide suitable means for suppressing radio interference in the vicinity. However, for other purposes, for instance when using the switch for the control of condenser discharges, the occurrence of sparking is a direct detriment to the desired operation because the condenser discharge is often terminated before the electric contact engagement between the fixed electrode and the liquid is perfected. During the sparking interval, the voltage drop at the contact is relatively large so that a considerable portion of the discharge energy is wasted.

It is an object of my invention to obviate this deficiency and to provide a liquid switch, generally of the above-mentioned type, that is virtually or completely free of sparking tendencies.

To this end, and in accordance with my invention, I provide the substantially U-shaped switch envelope, containing mercury or other conductive liquid, with two trap or overflow containers at the upper ends of the respective envelope limbs so that the liquid column, when being shifted by heat-responsive gas expansion from one limb to the other, will run into the container of the other limb to merge with the amount of liquid trapped therein, thus closing the electric circuit

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by contact engagement between two quantities of liquid.

These and more specific features of my invention will be apparent from the embodiment exemplified by the switch schematically illustrated on the drawing in conjunction with an example of a capacitor circuit to be controlled by the switch.

The illustrated switch has a sealed, substantially U-shaped vessel or envelope 1, for instance of glass. The envelope is composed essentially of two bulbous containers or head portions 2*a*, 2*b* and a U-shaped tubular connecting portion 3. The connecting portion 3 is joined with the head portions at their respective bottoms and forms a communication between them. In the illustrated operative position of the switch, the connecting portion 3 is substantially filled with conductive liquid, for instance, mercury. The tube ends enter upwardly to some extent, for instance a few millimeters, into the space of each head portion 2*a*, 2*b* so as to form an annular trap space 4*a* or 4*b*. The liquid collected in these trap spaces is electrically insulated from the liquid column in tube 3 by the insulating tube wall. Two sealed-in electrodes 5*a* and 5*b* traverse the wall of the respective head portions 2*a* and 2*b* and are contacted by the trapped amounts of liquid. Another electrode 7 traverses the wall of the tubular connecting portion 3 and is in contact with the column of liquid contained therein.

Each head portion 2*a* and 2*b* is equipped with an electric heater 8*a* or 8*b*. The upper ends or terminal wires of these heaters are sealed through the walls of the respective head portions 2*a* and 2*b*. The lower terminal wires 6*a* and 6*b* of the respective heaters terminate near the ends of the connecting tube 3. The terminal piece 6*a* is sufficiently long to dip into the liquid column of tube 3 when the switch is not in operation, while the terminal wire 6*b* is shorter and normally out of contact with the liquid column.

The space above the liquid within the head portions 2*a* and 2*b* is preferably filled with hydrogen although another gaseous atmosphere may be used instead. As mentioned, mercury is preferably provided as a conductive liquid but it will be understood that other conductive liquids are also applicable.

The device is shown to be connected to a control circuit which includes terminals 9 for connection to a source of heating current for devices 8*a* and 8*b*, and a switch for placing the device in and out of operation.

Also shown is a capacitor charging and discharging circuit to be controlled by the device.

The latter circuit has a capacitor 11, a schematically represented current source 12, two resistors 13 and 14 that determine the time constants of the charging and discharging performance, and terminals 15 at which the capacitor 11 may be connected to some other apparatus in which its periodic change in condition is to be utilized.

The device operates as follows. Immediately after closing of the switch 10, the current from the source connected to terminals 9 flows at first through the heater 8*a* in head portion 2*a*, the pertaining contact wire 6*a* and the liquid column of tube 3 to the electrode 7, and thence back to the current source. The gas within head portion 2*a* is heated and expands. This forces the liquid column in tube 3 into the head portion 2*b*. As a result, the electric contact between the liquid column and contact wire 6*a* is interrupted so that the heater 8*a* becomes deenergized. As the conductive liquid in the left-hand portion of tube 3 rises sufficiently, it contacts the wire 6*b* and also overflows the tube end, thus merging with the amount of liquid in the annular space 4*b*. As a result, an electric circuit is closed between the terminals 7 and 5*b*. The energization of heater 8*b* has the effect of forcing the conductive liquid back through tube 3 into the head portion 2*a* so that the circuit between electrodes 7 and 5*b* becomes interrupted while a circuit is now closed between electrodes 7 and 5*a*. This operation is repeated as long as the switch 10 remains closed. Each time the rising liquid in the connecting tube portion 3 overflows into the trap space of the adjacent head portion, it closes one of the two circuits available for control by the device. The number of alternating closing operations per second can be influenced by various means, for instance, by properly dimensioning the length of the tube portion 3.

Due to the absence of spark discharges at the contact closing moments, the above-described device may be used, for instance, for the practically loss-free charging and discharging of capacitors. Thus, in the illustrated capacitor circuit the charging of capacitor 11 occurs when the conductive liquid flows into the trap space 4*b* thus closing the circuit between electrodes 5*b* and 7, while the discharge of the capacitor occurs when the liquid flows into the space 4*a* and interconnects the terminals 5*a* and 7.

It will be obvious to those skilled in the art that a switch according to my invention may be modified in various ways, especially as regards the materials used for the envelope structure and the specific shape given thereto, without departure from the essential features of my invention and within the scope of the claims annexed hereto.

I claim:

1. A heat-controlled electric switch, comprising a substantially U-shaped envelope having a bight portion and two limbs and having two head portions forming respective overflow chambers at the respective ends of said two limbs, a quantity of conductive liquid enclosed in said envelope and a gaseous medium above said liquid in each of said limbs, two electric heaters disposed in said respective head portions, each of said heaters having a first terminal extending to the outside of said envelope and a second terminal disposed at the end of the pertaining limb and engageable by the liquid contained in said bight portion and limbs, an exteriorly accessible contact member mounted on said bight portion in contact with the liquid contained in said bight portion and limbs, and two contact members mounted on said envelope in said two overflow chambers respectively for engagement only by liquid collected in said respective chambers.

2. A heat-controlled liquid-containing electric switch, comprising a sealed and insulating, substantially U-shaped envelope structure having two containers and having a tubular connecting portion extending downwardly from said containers and forming a communication between them, said portion extending upwardly into each of said containers and forming therewith an annular trap space at the container bottom, a quantity of conductive liquid normally disposed in said annular trap spaces and in said connecting portion, a gaseous medium enclosed in said envelope structure above said liquid, respective contact means engageable by said liquid in said connecting portion and in said annular trap spaces, two alternately operable heating means joined with said respective containers for heating said gaseous medium in either container to thereby displace the liquid in said portion into merger with the liquid in said annular trap space of the other container, each of said heating means having a terminal electrode disposed in one of said respective containers substantially in the center of said annular space and extending downwardly to below the respective upper ends of said connecting portion so as to be engageable by the liquid in said connecting portion before said liquid merges with that in the respective trap spaces.

3. A heat-controlled electric switch, comprising a sealed and substantially U-shaped envelope having a bight portion and two limb portions extending upwardly from said bight portion, said envelope having two head portions adjacent to the upper ends of said respective limb portions and communicating with each other through said bight portion, each limb portion having an overflow rim in the adjacent head portion and forming with said head portion a trap space for liquid, a quantity of liquid disposed in said trap spaces and in said bight portion when said envelope is in normal position, three mutually insulated contact members disposed respectively in said two trap spaces and in said bight portion and being engageable by said liquid, a gaseous medium disposed in said envelope above said liquid, two electric heaters disposed in said respective head portions, each of said heaters having two terminals of which one is disposed above the pertaining limb portion and engageable by said liquid in said limb portion when said liquid rises up to a given height near said overflow rim, a heating circuit connected to said other terminals of said heaters and to said contact member disposed in said bight portion, whereby said heaters when in operation are alternately effective to cause said gaseous medium in either head portion to displace the liquid in said bight portion toward contact engagement with the liquid in said trap space of the other head portion.

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