Aug. 27, 1963 R. HERMEYER 3,102,179

LIQUID CONTACT SWITCH

Filed July 11, 1958

FIG. 1

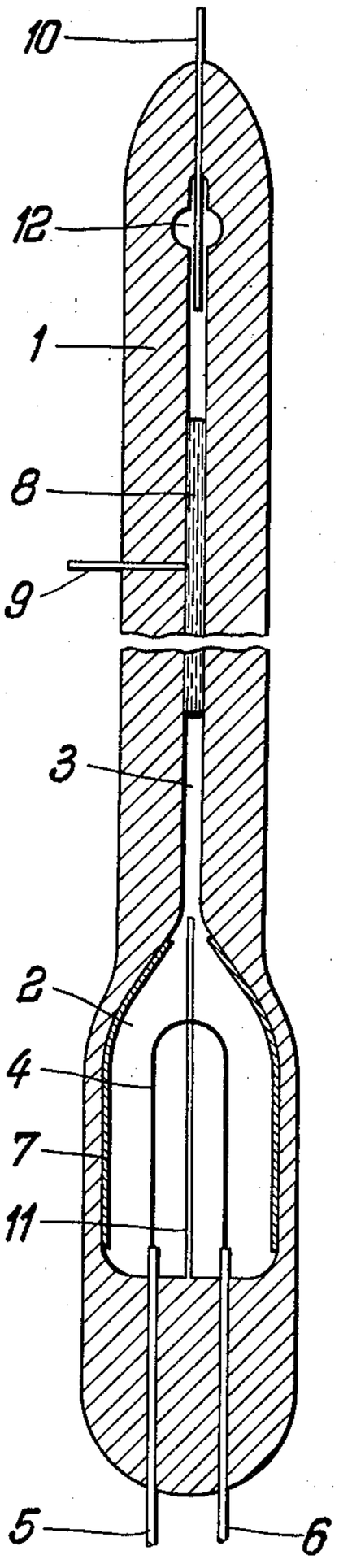


FIG. 3

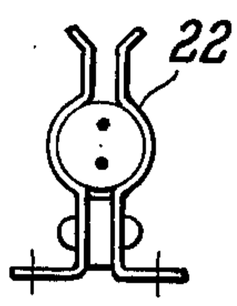
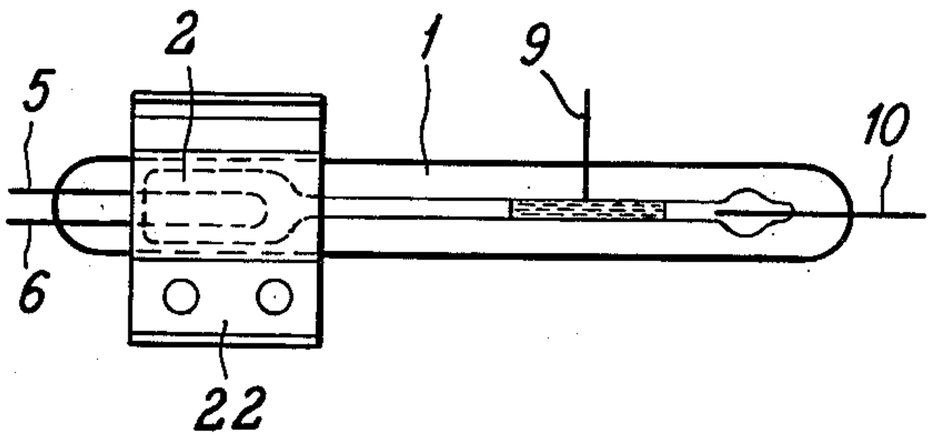


FIG. 2



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LIQUID CONTACT SWITCH

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This invention relates to an arrangement for switching on, off or over in electrotechnical apparatus, preferably in such as used in high frequency communication technique.

In electrotechnical apparatus or equipment, more particularly in such as used in high frequency communication technique, it is often desirable to have switches in the immediate vicinity of the components, e.g. electric circuits, to be affected by the switching process so as to avoid conductor extension leading to undue and uncontrollable coupling within the wiring and also to prevent the use of additional resistors and reactances. However, control knobs used to perform switching must be readily accessible and in substantially every case, disposed on a front panel of the apparatus.

In order to meet these various requirements by performing switching at places remote from the control knob, several proposals have been made, involving the use of purely mechanical arrangements and electrically actuated relays.

Mechanical arrangements comprising cable lines, chain and tooth wheel drives, shafts deflected via cone-pulley drives, Bowden wires or the like have the common disadvantage that in the building up of a high frequency communication equipment, for example, they represent foreign bodies having constructional laws subjected substantially to electrical requirements and being fitted in only with great difficulties. They are, moreover, relatively heavy and expensive. With the large number of switch points to be operated in up-to-date apparatus, the use of such mechanical arrangements is soon limited by the available space, admissible weight or allowed costs.

Hydraulic equipments are a particular form of mechanical arrangements for remote control. Such an equipment for actuating electrical components which perform switching is disclosed in the German Patent No. 816,431.

Although such a hydraulic system can meet the requirements of an electric communication equipment more closely than most other mechanical systems, great expenditure is still involved in the pipe connections from the control knob cooperating with the pump to the component to be controlled by said knob. Generally, such arrangements can only be used in special applications. Apparatus where mercury is employed as the connecting medium are generally vibration sensitive. In many cases, difficulties arise because of leakage in the pipes connecting the control knobs to the various components.

Arrangements comprising electrically actuated contact relays are of general use, owing to their reliability and moderate expenditure. When, however, many switch points must be operated independently and the number of contact relays to be employed is correspondingly large, the heavy weight and considerable bulk of such arrangements are undesirable features. Since relay armatures energising the contacts have considerable mass and hardness of the restoring springs used is limited on account of the high response sensitivity desired, such contact relays cannot be made sufficiently vibration insensitive without being subjected to certain disadvantages in other respects.

Therefore, there always remains the need for a switching device which allows for switching operation at any place remote from the control knob and which is free

from the above mentioned disadvantages of the conventional arrangements. More particularly, such a device should comprise a single lightweight unit, which can be manufactured easily and economically and be employed in any fixed installation as well as under vehicle service conditions, i.e. where relatively high speeds are involved.

The object of the invention is to provide a device for switching on, off or over in electrotechnical apparatus, preferably such as used in high frequency communication technique, the electrically conductive parts of said device consisting of a metal which is liquid at the operating temperature and lies in an insulating walled chamber under the influence of a controllable gas pressure that causes said metal to be displaced in such a manner that a conductive connection between the leads passed through said insulating walls is selectively established or interrupted.

In such an arrangement, control of gas pressure is ensured, according to the invention, by means of an electric heater which causes the temperature of the gas enclosed in a gastight chamber to vary. If said heater is connected to a heating current source via connecting leads and a remote switch, it causes the gas filling within the chamber to warm up so that pressure increases. The electrical energy supplied for warming up the gas is fully utilised, according to a preferred embodiment of the invention, by providing a wire- or strip-shaped heater and accommodating the same within the chamber in such a manner that it is wholly surrounded by gas. Furthermore, a reflecting coating, such as a gold layer, can be deposited on portions of the inner walls of the chamber, at least on such portions where the heater radiates. The use of a reflecting coating has the advantage that heat is thus concentrated for the major part on the gas mass enclosed, so that efficiency of the device is increased. Moreover, the portions of the insulating body outside the reflecting coating are prevented from being heated up through heater radiation, with the result that response velocity of the arrangement is increased while heat lag and inertia in resuming the initial condition are reduced.

It will be noted that thermal lag switches for regulating room temperatures are already known, which function like mercury or liquid thermometers and respond to the temperature of the surroundings. These devices are also provided with contact means which close or re-open, for example owing to the displacement or extension of a mercury column in response to the room temperature. Said contact means are used however to switch on and off the heating of the room where the thermal lag switch is placed. On the other hand, such arrangements have not been used heretofore to switch in, off or over in electrotechnical apparatus.

In a particularly suitable form of embodiment of the invention, the heater comprising an electrical strip- or wire-shaped conductor is bent in U-shape and placed in such a manner that the relatively long limbs of the U lie on both sides of the axis of the substantially cylindrical chamber. To said chamber there is connected a tube, which is narrow as compared with the width of the chamber and is partly filled with mercury. In accordance with this preferred form of embodiment, two contact means are inserted through the wall of the narrow tube at a distance from each other which is slightly smaller than the length of the mercury column. The tube containing the mercury column is provided at the end thereof remote from the first mentioned chamber containing the gas to be heated with a second, smaller, gas-filled chamber whose volume is calculated so small on account of the gas pressure applied—which is preferably higher than the atmospheric pressure—that the resilience constant given by the gas elasticity in said second chamber and determinative for displacements of the mercury column is sufficiently high to prevent any

undesirable contact making resulting from vibrations, e.g. in vehicles, without, however, unduly increasing response sensitivity with respect to heat power and response time.

Thread-shaped stoppers are suitably introduced into the ends of the tube containing the mercury column so as to prevent mercury from flowing out and entering the chambers. At the end of the tube adjacent to the first, larger chamber, said stopper may comprise a glass thread. At the end of the tube adjacent to the second, smaller chamber, said stopper may comprise a metal wire, preferably platinum wire, which serves simultaneously as a terminal.

A particularly simple and economical construction of the arrangement according to the invention involves an insulating body made of glass. Said arrangement can then be manufactured according to the technique known for thermometers. It can be so designed as to be held in any place without any particular supporting means, only by its connecting wires and be soldered with said wires as a component in a circuit wiring.

The filling gas may be nitrogen or an inert gas, in order to avoid oxidation.

The invention relates also to a circuit comprising a plurality of devices of the aforedescribed type, wherein the heaters of the various devices to be actuated simultaneously are parallel- or series-connected. Such a circuit may also be so designed that the device according to the invention is located in the vicinity of the circuit to be switched by means of the mercury contact, but at any desired distance from the switch closing its heating circuit.

Other objects, features and advantages of this invention will appear from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a preferred form of embodiment of a device according to the invention, shown in cross-section;

FIG. 2 is a modification of the device of FIG. 1; and

FIG. 3 is an end view of the device of FIG. 2.

In FIG 1, there is illustrated a device according to the invention in a magnified scale. Although the drawing has not been accurately dimensioned, it will be noted that a practical embodiment manufactured for testing purpose was about ten times smaller than the ilustration of FIG. 1. The reference **1** denotes an elongated cylindrical glass body having a chamber **2** at one end thereof. From said chamber there extends in the upward direction a tube which is substantially narrower than the chamber itself. The chamber **2** is filled with a gas which may be nitrogen and is under normal atmospheric pressure or preferably higher pressure. Within the chamber **2** there is arranged a U-shaped electrical conductor **4** comprising a resistance wire. The ends of said conductor are connected to the lead-in wires **5** and **6** which are tightly sealed in known manner in the glass body.

The reference **7** denotes the reflecting coating applied to the inner surface of the chamber **2**. Said coating may be produced e.g. by spreading burnished gold and annealing the same at 600° C. for obtaining a reflector surface. The mercury column **8** within the tube **3** is positioned so as to make contact with the terminal **9** but not yet with the upper terminal **10**, as shown in FIG. 1. The upper end of the tube **3** is widened into a second chamber of small volume **12**. The gas filling said second chamber may be the same as in the first chamber **2**. The filling pressure determines the degree of elasticity of the spring means constituted by said chamber and said filling gas. In turn, the degree of elasticity determines the amount of shock resistance, i.e. the amount of acceleration that the device can bear in axial direction, without that owning to its mass inertia the mercury column is moved so far upward against the elastic force of the filling gas enclosed in the chamber **12** that contact is established with the terminal **10**.

In normal operation, this contact will only be established by causing a heating current to flow through the heater **4**. This results in the filling gas contained in the chamber **2** being heated up without any substantial rise of temperature at the outer walls of the insulating body **1**, since the reflecting coating **7** prevents heat from radiating outwardly. The gas pressure in the chamber **2** is increased so that the mercury column overcomes the gas pressure in the chamber **12** and is forced upward to establish contact between the terminals **9** and **10**.

In order to prevent the mercury from flowing out of the tube **3** in case of severe shocks, a glass thread **11**, connected at the lower end thereof to the glass body **1**, has its upper end slightly projecting into the lower end of the tube **3** in such a manner as to prevent mercury from flowing off while providing for the flowing up of the gas from the chamber **2**. At the upper end of the tube **3**, the terminal wire **10** serves at the same time as a stopper limiting the upper position of the mercury surface.

In one practical form of embodiment of the invention, it has been found that an energy of 200mW was sufficient for heating. Delay in switching on is then substantially smaller than one second and delay in switching off is smaller than half a second. Shock tests have shown that devices according to the invention are suitable for use in any position also on vehicles. Said devices are operated satisfactorily within a temperature range from −30° C. to +60° C. Maximum transfer resistance of a practical device was found to be smaller than 0.5 ohm, while insulation resistance with open contacts was higher than 10 megohms. A particular advantage of a device according to the invention consists in the very small capacity between open contacts, which can be maintained below 0.2 μf. The practical embodiment, whose data have just been given, was made for a switching efficiency of 50 ma. at 100 v.

FIGURE 2 illustrates an arrangement comprising a switching device according to the invention, wherein however the gold reflector **7** on the inner side of the chamber **2** has been omitted. The purpose of the gold reflector **7** of FIGURE 1 was to avoid warming up of the chamber walls resulting in switching delays. The same effect is now achieved in the arrangement of FIGURE 2 by surrounding the portion of the device containing the chamber **2** by a good heat conductor body closely in contact with said portion. In the form of embodiment illustrated in FIGURE 2, said body forms a heat sink comprising a clamping coller **22** which serves at the same time to support the tubular body of the switching device. The great dissipation of heat via the collar **22** prevents the walls of the chamber **2** from being substantially influenced by the surrounding temperature. Owing to this feature, switching delays can be maintained so small that 15 switch steps per second can be performed without any difficulty.

I claim:

1. A remote control switch comprising a housing of insulating material, a first and a second chamber in said housing, said first chamber having a greater volume than said second chamber, a quantity of gas in each of said chambers, said gas being filled at a pressure greater than atmospheric pressure, a substantially straight, narrow capillary bore communicating with said chambers, an electric heating device in said first chamber, at least two electrical contacts extending into said bore, a switching mercury column for the contacts in said bore normally positioned in suspended state and serving as a bridge for the contacts, gas pressure of the second chamber serving as a cushion for the mercury and serving rapidly to return the mercury to its normal position after the heating device is de-energized.

2. A switching device according to claim 1, having a reflected metal layer on the inner wall of said first chamber to increase the switching speed by reflecting the radiated energy from said heating device onto said gas.

3. A switching device according to claim 1, further comprising a heat conducting body encircling said insulating housing to define a heat sink rapidly to dissipate the heat radiated from said first chamber thereby improving the switching speed.

4. A switch according to claim 1, wherein said switch is so light that it may be supported by only its terminal wires.

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