

[54] LIQUID RESISTOR APPARATUS

[72] Inventor: Norbert Roger Beyrard, 24 avenue Raphael, Paris, France

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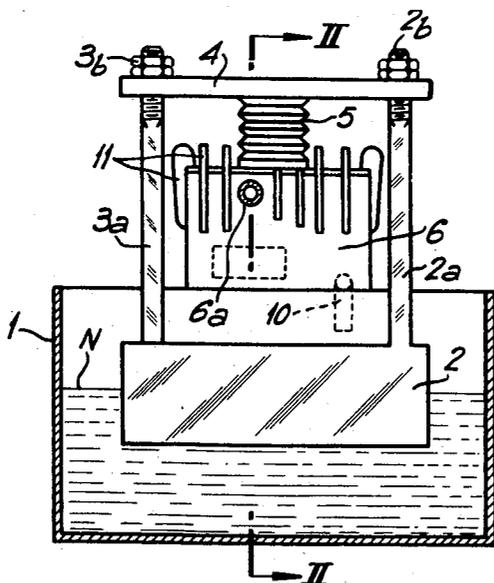
Primary Examiner—C. L. Albritton

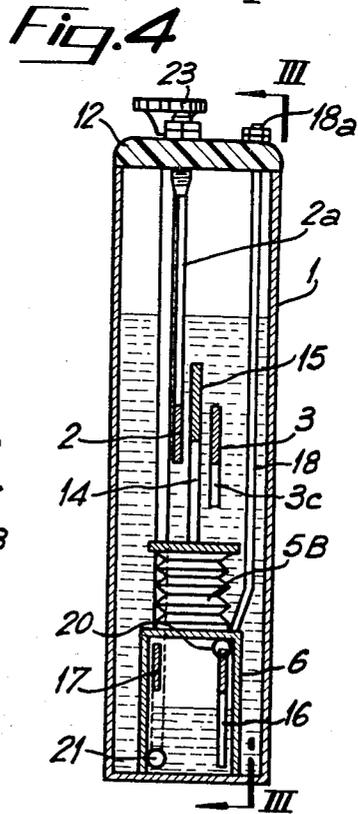
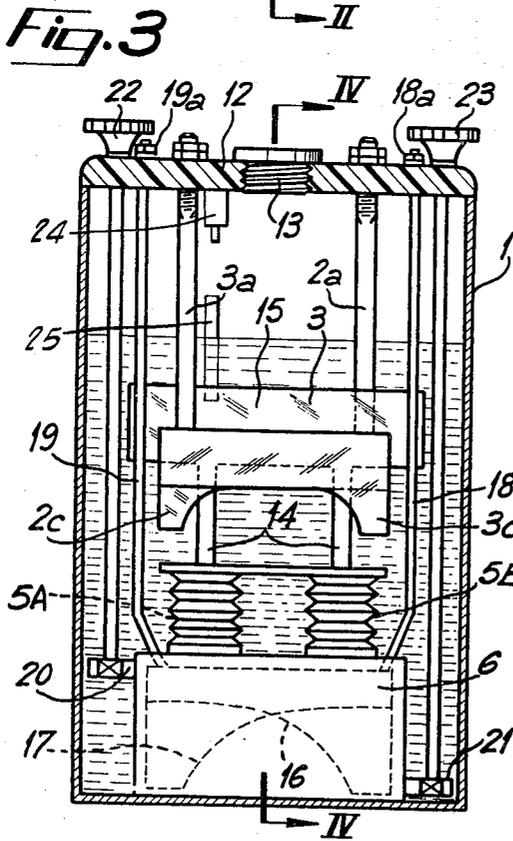
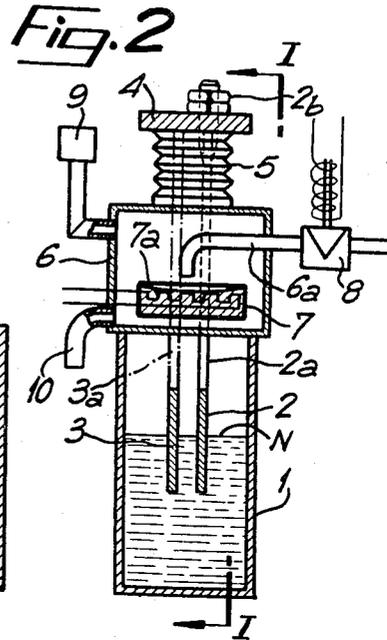
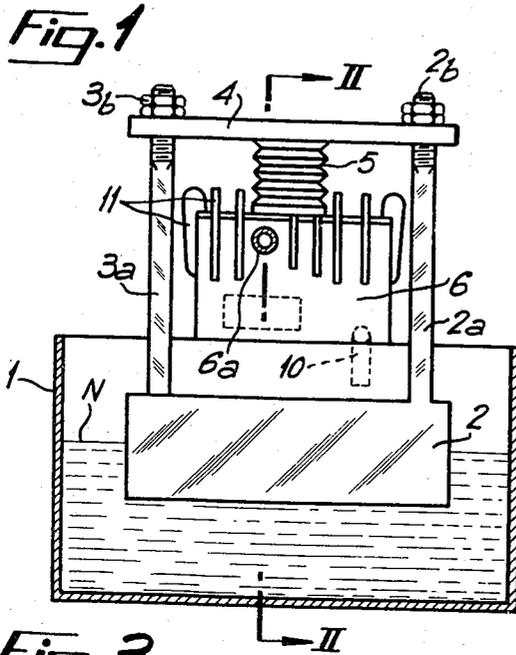
Attorney—Mauro & Lewis

[57] ABSTRACT

Liquid resistor apparatus in which a conductive liquid presents an adjustable electrical resistance between two immersed electrodes, adjustment being made by raising or lowering the level of the liquid, the level of the electrodes or the level of a partition between the electrodes. The raising and lowering is effected by a mechanical linkage which is coupled to a bellows or piston actuated by vapor from a controllable vapor generator.

10 Claims, 4 Drawing Figures





LIQUID RESISTOR APPARATUS

The present invention concerns liquid resistor apparatus. Such apparatus has a liquid conductor which is usually an electrolyte. Electric current passing between electrodes immersed in the liquid conductor can be adjusted or controlled as a function of some other parameter which, advantageously, may be an electric current.

One method of resistance control is shown in my U.S. Pat. application Ser. No. 808,274, filed Mar. 20, 1969 in the specification of which there is described liquid resistor apparatus in which some of the conducting liquid, expelled by vapor pressure from a first compartment, is passed to a second compartment also containing opposed electrodes, so as to alter the extent of the immersion of the electrodes contained in this second compartment.

An object of the present invention is to provide improved liquid resistor apparatus.

According to the invention there is provided liquid resistor apparatus comprising a compartment containing electrically conductive liquid, a pair of electrodes arranged to pass current through the liquid in the compartment, a fluid-actuated mechanical control device effective to control, through a mechanical linkage, the effective cross-sectional area of the current path between the electrodes and a vapor generator arranged to generate a controllable quantity of vapor in response to a control parameter, the vapor actuating the control device.

This variation of the cross section through which the current is able to pass can be achieved by connecting the control device to a mechanism for lifting the electrodes, so varying the extent of their immersion in the compartment containing the liquid, or by connecting this control device to a movable partition located between the fixed electrodes, which partition impedes travel of the current between the electrodes, or by connecting the control device to a means for passing liquid to the compartment in which the electrodes are contained or for evacuating the liquid therefrom.

It will be seen that, depending upon requirements, the control can be direct or inverted, that is that increase in pressure can cause either a reduction in the resistance between the electrodes or an increase in said resistance.

The vapor generator may take any one of several different forms. Basically, it comprises a source of heat and a liquid, accommodated in an enclosed space, either the supply of heat or the supply of liquid being used as the agent in the control means. In particular, the source of heat can be constituted by a second liquid resistor between two electrodes submerged in the liquid contained in the generator vessel, or by a solid electric heating resistor in contact with the liquid or enclosed in a liquid-tight envelope which is more or less thermally inert. The control parameter is then the current that passes through these liquid or solid resistors.

The control parameter may also be the temperature of a fluid which passes at a constant rate through a coiled pipe inside the enclosed space containing the liquid to be vaporized.

If the control is used to adjust the supply of the liquid to be vaporized, the vapor generator may contain a body kept at a higher temperature than that at which the liquid vaporizes, whereas the control parameter may be a succession of electric impulses of variable duration or occurring at variable intervals, and these impulses, by opening an electric valve or by regulating a pump for example, control the quantity of liquid coming into contact with the heated body.

In a preferred embodiment of the invention, the vapor generator has an enclosure within the compartment containing the conducting liquid, and the liquid of the vapor generator is the conducting liquid itself, the enclosure communicating with the interior of said compartment through at least one orifice. Preferably, said communication is ensured by two orifices, preferably adjustable, one situated above the other at the top of the generator. In such an arrangement, the main requirement for the upkeep of the equipment is to maintain the level of the liquid in the compartment, the evaporation of

which liquid may be limited by a cover. The vapor produced in the vapor generator condenses directly into the mass of conducting liquid which surrounds the vapor generator.

The invention will further be described with reference to the accompanying drawings, of which:

FIG. 1 is a cross-sectional front elevation of a liquid resistor according to one embodiment of the invention;

FIG. 2 is a cross-sectional side elevation taken at 11—11 of FIG. 1;

FIG. 3 is a cross-sectional front elevation of a liquid resistor according to another embodiment of the invention; and

FIG. 4 is a cross-sectional side elevation taken at 111—111 of FIG. 3.

Referring to FIGS. 1 and 2 the liquid resistor comprises a bath 1, containing a conducting liquid up to the level N and to electrodes 2 and 3 which are in the form of plates and are suspended from a flat rod 4 by rigid conductors 2a and 3a and the terminals 2b and 3b supplying current to these plates. The flat rod is mounted on a bellows 5 charged by a vapor generator 6 mounted in the upper part of the bath 1.

In the example illustrated, this generator comprises an inlet 6a for a vaporizable liquid (for example distilled water), which inlet is situated above a dish 7 which is kept permanently hot by a resistor 7a. The control parameter is pulsed electric current actuating the electric valve 8. A safety valve 9 prevents excess pressure in the vapor generator, whereas water condensed in this generator by cooling of the vapor is discharged through a capillary drainage means 10, for example a length of cotton material enclosed in a tube. Condensation of the vapor is promoted by cooling fins 11.

Each current impulse releases a small quantity of distilled water and this vaporizes on arriving in the dish 7, and the vapor pressure thus produced inflates the bellows 5 which lifts the electrodes 2 and 3 from the conducting liquid in the vessel 1, so that the liquid resistance between the electrodes increases. The current between the electrodes thus diminishes. After condensation, the electrodes 2 and 3 are lowered and the liquid resistance falls again. Thus, on application of control current pulses, a rapid change in the current between the electrodes 2 and 3 occurs and this is followed by a more or less slow return to the original condition. This return can be accelerated by increasing the rate of condensation of the vapor in the generator by suitable cooling means.

In the embodiment shown in FIGS. 3 and 4, the bath 1 is closed by a cover 12 having a plug 13 which can be removed for topping up the liquid and which contains a vent hole. The bath accommodates the electrodes 2 and 3 which are suspended from the cover by rigid conductors 2a and 3a sheathed with insulating material. The bath also contains the vapor generator 6 and the lifting and lowering control device constituted by two bellows 5A and 5B. The distance between the electrodes 2 and 3 can be very small, in the order of 1 centimeter or less. The bellows 5A and 5B support a partition 15 on upright elements 14, which partition can thus be vertically displaced between the electrodes 2 and 3.

The vapor generator 6, filled with the same liquid as the bath, is heated either by a submerged resistor or, preferably, by the current passing between two auxiliary electrodes 16 and 17 connected by insulated conductors 18 and 19 to the terminals 18a and 19a carried by the cover. The generator 6 has an upper orifice 20 and a lower orifice 21, the effective area of each of which can be adjusted by means of a tap; the taps can be actuated from the outside by means of knobs 22 and 23 respectively, accessible on the upper surface of the cover.

When vapor is formed in the generator, the lifting and lowering control devices 5A and 5B are put under pressure, and the partition 15 is raised, thus uncovering a greater surface of the juxtaposed electrodes 2 and 3, that is to say, reducing the rating of the liquid resistor between these electrodes.

When the partition moves near its lowermost position (maximum resistance), the value of this resistance is changed disproportionately because of the configuration of the electrodes

which comprise diagonally opposite spurs 2c and 3c, only these being uncovered by the partition 15. Suitably shaped electrodes thus enable the resistance of the liquid to be varied as a function of the amount of displacement of the partition 15 in accordance with a chosen non-linear law. Similarly, the resistors 16 and 17 can be shaped as shown to have lower portions which are of reduced area and are positioned diagonally opposite each other in such manner that after intensive production of vapor, bringing the partition 15 to a predetermined position, the situation is stabilized, i.e. the quantity of vapor generated is precisely balanced by the quantity of vapor discharged through the upper orifice 20.

Adjustment of the outlet cross sections of the orifices 20 and 21 by means of taps enables the period during which the generator is put under pressure and the level of the excess pressure obtained for a given power dissipated in the vapor generator to be established. Adjustment of the tap controlling the cross section of the orifice 21 also renders it possible to deal with temporary phenomena (oscillations) resulting from the return of the liquid.

In short, variation in the control characteristics can be achieved by the shape of the main and auxiliary electrodes, by the choice of the dimensions of the elements of the equipment, by regulating the current effecting the control by means of outside resistors, and by means of the taps which can be actuated with the help of the knobs 22 and 23.

For the purpose of starting up an asynchronous electric motor, for example, the electrolytic resistance is raised at the initial moment when voltage is applied to the motor or when derived current passing through the motor is fed to the vapor generator. The vapor is formed very rapidly in the generator and this causes liquid to be expelled from the generator and the lifting and lowering control device to be pressurized so that the partition 15 is displaced upwardly; the resistance of the liquid resistor is thus reduced until start-up has been completed.

If the area of the electrodes is great enough, it is possible to bring the liquid resistor into the circuit without causing a voltage drop of more than 1 volt, by keeping the pressure level in the generator at a sufficiently high value by the passage of current.

For this particular application of starting up an asynchronous motor, the movement of the lifting and lowering control device can also be adjusted so that it is fully extended upon completion of the start-up period of the motor and, having been fully extended, this control device could be arranged to actuate contacts which short-circuit the electrodes.

To this end, partition 15 may be provided with a vertical extension 25 protruding in the direction of the push button of a micro-switch 24 secured to the under face of the cover 12, which switch may be protected by a distortable cap.

The invention can be applied in the heavy-current field when it is necessary to vary a current as a function of an adjustment or control parameter. In the case of multi-phase current, a pair of electrodes is of course associated with each current phase.

The invention is not restricted to the details of the embodiments described above with reference to the accompanying drawings. For example, modifications of the apparatus of

FIGS. 1 and 2 could be as follows:

In the interests of safety, the current for heating the dish 7 can likewise pass through electrodes submerged in the liquid of the bath 1 and attached to the bar 4 so as to prevent heating of the dish when the lifting and lowering control device 5 is extended to the maximum.

This lifting and lowering control device 5 could also comprise, in the usual manner, a piston which moves in a cylinder and which would guide the bar 4 as it is being raised. The arrangement shown in FIGS. 1 and 2 can also include a guide means for the lifting movement.

The lifting and lowering control device 5 can also be devised to lift the bath 1 relatively to the electrodes 2 and 3 which would remain stationary, or to lift an additional receptacle communicating with the bath 1 so as to vary the level of the liquid in this bath.

I claim:

1. Liquid resistor apparatus comprising a compartment containing electrically conductive liquid, a pair of electrodes arranged to pass current through the liquid in the compartment, a fluid-actuated mechanical control device effective to control, through a mechanical linkage, the effective cross-sectional area of the current path between the electrodes and a vapor generator arranged to generate a controllable quantity of vapor in response to a control parameter, the vapor actuating the control device.

2. Apparatus according to claim 1, wherein the control device displaces an insulating partition between the two electrodes.

3. Apparatus according to claim 1 wherein the control device comprises a linkage coupled to a deformable wall or walls of the vapor generator.

4. Apparatus according to claim 1 wherein the control parameter controls the thermal power passed to the vapor generator.

5. Apparatus according to claim 1, wherein the control parameter controls the quantity of vaporizable liquid admitted to the vapor generator.

6. Apparatus according to claim 1, wherein the vapor generator has an enclosure within the compartment and the vapor generator is initially filled with the same conducting liquid as is the compartment, the enclosure having at least one orifice for this purpose.

7. Apparatus according to claim 6, wherein the enclosure has an upper orifice and a lower orifice, the cross section of at least the upper orifice being adjustable.

8. Apparatus according to claim 6 wherein the enclosure includes two electrodes connected to pass current through the liquid in the enclosure corresponding to the control parameter.

9. Apparatus according to claim 2, wherein the partition has two parallel edges and is displaced perpendicularly to these edges, and the shape and juxtaposition of the electrodes are such as to determine the degree of variation in the areas of the electrodes permitting passage of the current as a function of the linear displacement of said partition.

10. Apparatus according to claim 1, wherein at the end of its stroke, the control device actuates at least one electric contact.

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