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MEANS FOR OPERATING MERCURY SWITCHES

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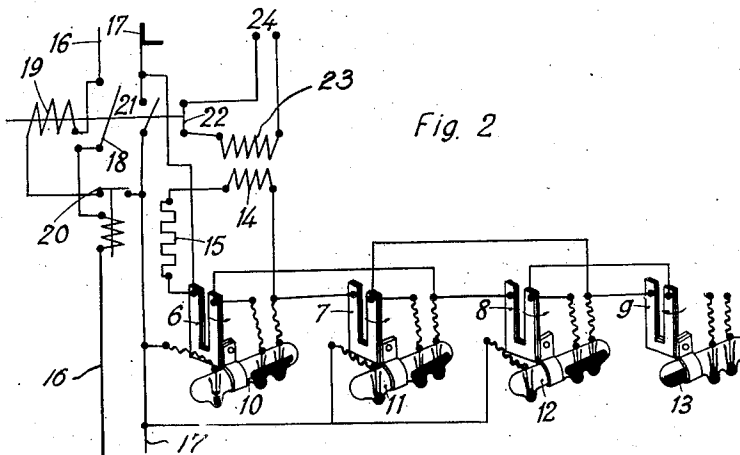
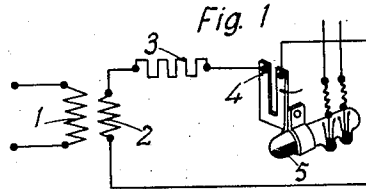


Fig. 3

Fig. 4

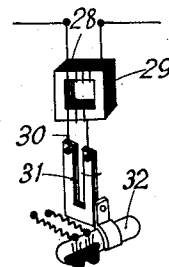
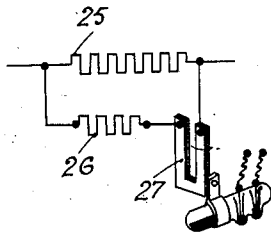
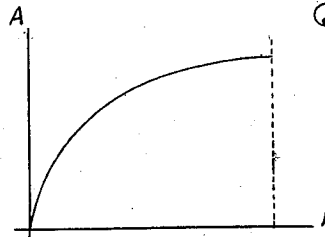


Fig. 5



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MEANS FOR OPERATING MERCURY SWITCHES

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My invention relates to means for operating mercury switches of the tilting type combined with bimetallic thermo-electric elements and is an improvement in or modification of the invention set forth in the specification of my pending U.S. application Serial No. 198,612 filed on the 13th June 1927. It relates more particularly to apparatus wherein the heating of the bimetallic thermo-electric element combined with the mercury switch is caused by the passage of an electric current through the bimetallic thermo-electric element itself or through a resistance wound around it, the strength of the heating current in the bimetallic thermo-electric element being caused to vary according to a fixed law, such that it is rendered independent of the supply voltage or of the resistance of the circuit traversed by it.

In a first series of applications the strength of the heating current for the bimetallic thermo-electric element is made independent of the supply voltage of the circuit into which the apparatus is inserted; this result is obtained by adding to the bimetallic switch relay a self-regulating resistance traversed by the heating current of the bimetallic thermo-electric element.

In a second series of applications the heating current of the bimetallic thermo-electric element is caused to increase much more slowly than the current in the control or supply circuit, and for this purpose there is used either a self-regulating resistance in series in the heating circuit and connected together with the bimetallic thermo-electric element in shunt to the terminals of a fixed resistance inserted in the control circuit, or a saturated current transformer, the primary of which is placed in the control circuit and the secondary in the heating circuit of the thermal bimetallic switch relay.

The subject of the invention will be more clearly understood by the following description with reference to the accompanying drawings, in which:

Figs. 1 and 2 show two different applications of the first series of apparatus,

Figs. 3 and 4 two other applications of the second series of apparatus,

Fig. 5 is a diagram relating to Fig. 4.

In the body of the text there is to be understood by the term "self-regulating resistance" a resistance such that a relative change of the voltage applied between its terminals causes only a much smaller relative change of the current, which passes through it. Resistances of this kind are constituted by a wire of a resistant metal with a high temperature coefficient, reaching during use a sufficiently high working temperature. In these conditions a relative change of the voltage applied to the terminals of the resistance causes only a much smaller relative change in the permanent working current, which passes through it. If furthermore the thermal capacity of the resistant wire be chosen sufficiently low, this permanent normal working is reached very quickly and the self-regulating resistance is traversed by a current varying very little as a function of the applied voltage, provided this latter does not change too rapidly.

The combination of these self-regulating resistances with one or more mercury switches combined with bimetallic thermo-electric elements heated by the current passing through the resistances allows, more particularly, of obtaining relays effecting operations as determined time intervals and substantially independent of the supply voltage as shown for example in the apparatus of Figs. 1 and 2.

Fig. 1 shows a constant time limit relay connected to a small transformer the primary winding 1 of which is supplied, for example, by the voltage of the control circuit, the secondary winding 2, for very low voltage being connected in series with a self-regulating resistance 3 and a bimetallic thermo-electric element 4 carrying the mercury switch 5. In this latter the mercury is shown in its position when the bimetallic thermo-electric element is cold; the arrow indicates the direction in which the latter moves when deformed on heating. If it be supposed that the primary of the transformer is supplied from and after a given instant, for example, after the operation of another relay, a current will be set up in the secondary circuit which is substantially independent of the

supply voltage and consequently the contacts of the mercury switch 5 will be closed at the end of a substantially constant time interval from and after the closing of the circuit 1. This time interval may be regulated, for example by the rotation of the seat of the bimetallic thermo-electric element.

Fig. 2 shows a relay based upon the same principle and intended to bring about on a feeder, at time intervals adjustable at will, a series of three attempts at reengagement after a break, and a starting up of a warning device in the event of persistent excess current. The apparatus comprises four bimetallic thermo-electric elements 6, 7, 8, 9 each carrying a mercury switch; the position of the mercury in each of said switches when the bimetallic thermo-electric elements are cold being indicated; the arrow shows the direction of deformation of the latter. Of the four mercury switches, the first three 10, 11, 12 have three contacts and the quantity of mercury in them is such that a permanent contact can be set up between the two closest of them (as shown in the figure), whilst only a momentary contact can be set up between one of these two and the third contact. The fourth switch 13 is a two-contact switch and allows of making a permanent connection between these two contacts. The bimetallic thermo-electric elements and the mercury switches are connected up as shown in the figure. The relay circuit is supplied by the secondary winding 14 of a small transformer in series with a self-regulating resistance 15. Moreover in one of the two bus-bars 16 and 17 of the circuit to be controlled there is inserted a contactor 18 the operating coil 19 of which is energized by the voltage existing between the bus-bars 16 and 17 through the contacts 20 of a maximum current relay and an auxiliary contact 21, which is closed simultaneously with the contactor 18. Finally the primary winding 23 of the transformer supplying the thermal relays is supplied by an auxiliary alternating current supply 24 through a second auxiliary contact 22 provided on the contactor 18 and opening when the latter closes.

The operation of the apparatus is as follows:—

When an excess current occurs causing the opening of the contacts 20 of the maximum current relay, the contactor 18 (presumed to be closed) opens and thus closes the circuit of the winding 23. The winding 14 then supplies in the bimetallic thermo-electric element 6 through the contacts of the switch 10 a current rendered substantially independent of the voltage of the supply 24 by the self-regulating resistance 15. The bimetallic thermo-electric element 6 is curved inwards thus causing the rotation of the mercury switch and at the expiration of a time substantially independent of the supply

voltage the mercury flows in the switch causing the opening of its permanent contact and, as can be seen readily from Fig. 2, a momentary connection between the contacts 21. The winding 19 is thus supplied with current from the bus-bars 16 and 17 and the contactor 18 is closed, opening the contact 22.

If the cause of the excess current has disappeared the contactor 18 remains closed and the winding 23 ceases to be supplied. The bimetallic thermo-electric element 6 ceases to be heated and the switch 10 returns to its original position.

If on the contrary the cause of the excess current persists, the contactor 18 opens again and causes the closing of the winding 23; the winding 14 again supplies the circuit of the thermal relays, this time passing through the bimetallic thermo-electric elements 6 and 7 and the right-hand contacts of the mercury switch 11. This latter is tilted in its turn by the operation of the bimetallic thermo-electric element 7 and at the expiration of another time interval a new momentary circuit is established between the terminals of the contact 21 causing a new tendency to close the contactor. If the excess current has disappeared, everything comes back to the original state; if on the contrary it persists, the switch 12 is moved in its turn by the bimetallic thermo-electric element 8 and causes at the expiration of a new time interval another tendency to re-connection. If this succeeds everything comes back to its original state; if on the contrary it fails, the bimetallic thermo-electric element 9 operates in its turn and causes by means of the mercury switch 13 the closing of an alarm circuit. In all that precedes it has been presumed that the impedance of the winding 19 is large compared with that of the heating circuit of the bimetallic thermo-electric elements which generally is the case.

It is to be noted that in the above-described relay the self-regulating resistance opposes the variations of current due to the variation of the supply voltage as well as those due to the variation of the resistance of the heating circuit, owing to the successive insertions into this latter of one, or two, or three, or four bimetallic thermo-electric elements; it follows that the aforesaid relay could be adapted for any number of attempts to re-establish connection. The time intervals elapsing between the several attempts may be regulated separately for each bimetallic thermo-electric element.

It is obvious that the bimetallic-mercury-switch thermal relays combined with the self-regulating resistances may be constituted in all the ways described in the main patent.

The applications of the invention shown in Figs. 3 to 5 will now be described but it is useful in the first place to give some details on the working of the bimetallic-mercury-

switch thermal relays. It has been seen that the working depends substantially on the angle of rotation through which the free end of the bimetallic thermo-electric element turns under the influence of heating, and consequently is dependent upon the duration of heating and the strength of the heating current.

Experience shows that if the strength of the heating current remains constant the angle of rotation of the end of the bimetallic thermo-electric element increases in proportion to the time according to an exponential law and tends towards a limit proportional to the square of the heating current.

If on the contrary the strength of the heating current be variable, it may yet remain during a certain time in the neighbourhood of a determined value, and fixed operations may be carried through during this certain time.

For this purpose the heating circuit of the thermal relay may be traversed by the control current or by a current proportional thereto; but this method is not always applicable; this is the case for example when the operation to be carried out has to be done for a current much less than the maximum current. In fact the angle of rotation for permanent operation of the mercury switch being proportional to the square of the heating current, the rotation obtained for the critical current will be too small to allow of an exact operation.

It is thus necessary in this case to have recourse to a method causing the heating current of the thermal relay to increase much more slowly than the current in the circuit to be controlled. Various devices can be used for this purpose.

A first arrangement shown in Fig. 3 consists in inserting in the circuit to be controlled a fixed resistance 25, traversed by the greater part of the current, to which there is connected in shunt a thermal relay 27 in series with a self-regulating resistance 26. It is clear that if the current increases in the main circuit, the potential difference at the terminals of the resistance 25 increases substantially in the same proportion; but that this does not apply to the current passing in the shunt circuit owing to the increase of the self-regulating resistance 26.

A second arrangement as shown in Fig. 4 consists in inserting in the circuit traversed by the variable current (assumed to be alternating) the primary winding 28 of a transformer the magnetic circuit 29 of which works at high induction when the current circulating in the primary winding reaches its maximum value. The secondary winding 30 of the transformer is connected to a bimetallic thermo-electric element 31 carrying a mercury switch 32. The operation of the apparatus is as follows: the current

circulating in the secondary winding is determined by the excess of the primary ampere-turns over the magnetizing ampere-turns; now these latter increase very quickly with the induction at which the magnetic circuit works; it follows that the current circulating in the thermal relay increases much more slowly than the primary current, a curve having the path of Fig. 5 is obtained definitively to represent the variations in the angle of rotation A for permanent working of the end of the bimetallic thermo-electric element as a function of the primary current I . Such a device thus allows of exact operation of a mercury switch for current much weaker than the maximum current which it can carry.

Claims:

1. A switch apparatus of the type described, comprising in combination, a mercury switch of the tilting type, a bimetallic thermo-element operating the mercury switch, a heating circuit for the bimetallic thermo-element, and means for limiting the heating current in the heating circuit to a substantially fixed value during the major portion of the interval required to heat said element.

2. A switch apparatus of the type described, comprising in combination, a mercury switch of the tilting type, a bimetallic thermo-element operating the mercury switch, a heating circuit for the bimetallic thermo-element, and means for limiting the heating current in the heating circuit to a substantially fixed value whereby said heating current is rendered independent of the supply voltage impressed upon the heating circuit during the major portion of the interval required to heat said element.

3. A switch apparatus of the type described, comprising in combination, a mercury switch of the tilting type, a bimetallic thermo-element operating the mercury switch, a heating circuit for the bimetallic thermo-element, and means for limiting the heating current in the heating circuit to a substantially fixed value whereby the heating current is rendered independent of the resistance of the remainder of the heating circuit during the major portion of the interval required to heat said element.

4. A switch apparatus of the type described, comprising in combination, a mercury switch of the tilting type, a bimetallic thermo-element operating the mercury switch, a heating circuit for the bimetallic thermo-element, and a self-regulating resistance inserted in the heating circuit, the said resistance consisting of a metallic wire the resistance of which increases quickly with the temperature, whereby the heating current is limited to a substantially fixed value during the major portion of the interval required to heat said element.

5. A relay comprising, in combination, a fluid flow switch, a thermal element operating said switch, a heating circuit for said thermal element, and means effective to limit the current through said heating circuit to a substantially constant value during the major portion of the interval required to heat said element.

In testimony whereof I affix my signature.
MAURICE AUGUSTE EUGÈNE LEBLANC.

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