Nov. 10, 1931. C. I. HALL 1,831,558

THERMAL RESPONSIVE DEVICE

Filed April 4, 1925

Fig. 1.

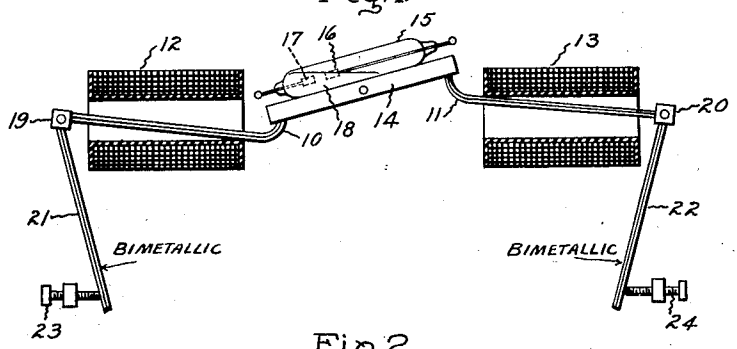


Fig. 2.

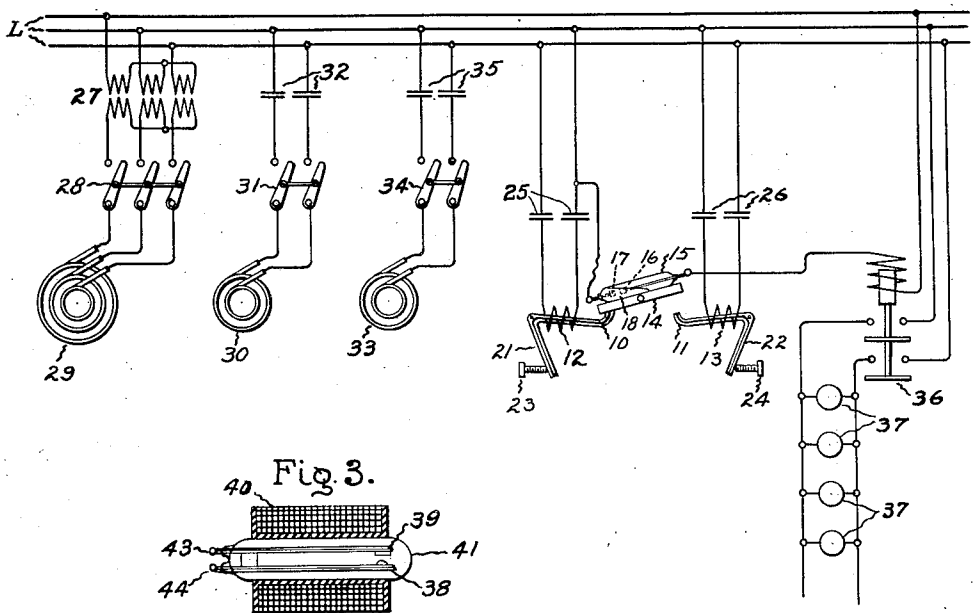


Fig. 3.

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UNITED STATES PATENT OFFICE

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THERMAL RESPONSIVE DEVICE

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This invention relates to thermal-responsive devices, and more particularly to alternating current thermal-responsive controlling devices, and to selective control systems employing the same.

One of the objects of the invention is to provide an improved form of alternating current thermal-responsive device which is operated responsively only to energizing current of predetermined frequency.

Another object of the invention is to provide a device of the above character which requires a small energizing current of a predetermined frequency to effect operation thereof.

Briefly, these objects are attained in accordance with my invention by associating a thermal-responsive element with a tuned resonant circuit in such manner that the element is heated only when the tuned circuit is energized by a current of substantially resonant frequency.

Although well adapted for use in telephone, telegraph and other service of like nature, the present invention is particularly advantageous when employed in carrier current selective control systems for power lines where it is desired to operate switch mechanism responsively to high frequency currents superimposed upon the ordinarily low frequency current of the power line in order to remotely control the connection of branch circuits to the power lines or to perform other desired controlling service.

My present invention provides a thermal-responsive controlling device which may be embodied in a system of the above character and arranged to be selectively operated by carrier currents of predetermined frequency and of small value, while the controlling device is unresponsive to energizing current of other frequency such as the normal low frequency current of the power lines.

In carrying the invention into effect in a preferred form, I arrange a thermal-responsive controlling element, preferably of the ordinary bi-metallic type having both magnetic and current conducting properties, in the magnetic field of an energizing winding which is tuned, preferably by means of suitable condensers to resonate when the circuit is energized with a current of predetermined frequency. Since the value of the flux in the magnetic field of the energizing winding is greatly increased under resonant conditions, the heating of the thermal element due to hysteresis and eddy currents induced therein likewise is correspondingly increased under resonant conditions in the energizing winding. Thus, by arranging the thermal-responsive element and the energizing winding so that the former is heated to the temperature required for operation thereof, only when the winding is energized with a current of resonant frequency selective operation of the thermal-responsive element may be readily obtained. Furthermore, by heat insulating the thermal element, as by enclosing the element in an evacuated container, it is possible to produce operation thereof with a very small energizing current of the proper frequency.

A better understanding of the invention may be had from the following description taken in connection with the accompanying drawings in which Fig. 1 schematically shows a thermal-responsive circuit controlling relay embodying my invention which is selectively operable between two positions; Fig. 2 is a circuit diagram illustrating a carrier current control system employing a relay of the type shown in Fig. 1, and Fig. 3 shows a modified form of thermal-responsive circuit controlling device embodying the invention.

Referring to Fig. 1 of the drawings, the two-position circuit controlling relay comprises a pair of thermal-responsive elements 10 and 11 which may be of the ordinary bi-metallic type, composed of, for example, brass and nickel steel strips suitably united altho other forms of thermal elements may be employed if desired. The respective thermal-responsive elements 10 and 11 are provided with energizing windings 12 and 13 which, as shown, surround the elements so that the elements are disposed in the magnetic field of their respective energizing winding. The elements 10 and 11 are each secured at one end to a suitable support 19 and 20 respectively and the free end of each element is arranged

to engage with the centrally pivoted movable member 14 which operates a suitable circuit controlling switch mechanism. As shown, a tilting mercury switch 15 comprising the contacts 16 and 17 enclosed within a casing with a suitable quantity of mercury 18, is mounted upon the member 14 so that the mercury 18 completes a circuit between the contacts 16 and 17 when the member 14 is tilted to the position in which it is shown by flexure of element 11. It will be evident that when the member 14 is tilted in the opposite direction by flexure of element 10 the controlled circuit will be opened.

In order to compensate the thermal-responsive movable elements 10 and 11 for variations in ambient temperature, the supports for the elements, 19 and 20 may be pivotally mounted and a compensating thermal strip 21 and 22 secured to the respective supports in the well known manner. Also the adjustable stops 23 and 24 may be provided for adjustment of the position of the thermal responsive elements 10 and 11 relative to the member 14 if desired.

In accordance with my invention the energizing windings 12 and 13 are arranged for resonance when energized with a current of predetermined frequency. To afford selective action of the elements 10 and 11, the frequency at which winding 12 is resonant is different from the frequency at which winding 13 is resonant. This may be accomplished by suitably proportioning the energizing windings 12 and 13, although preferably, as shown in Fig. 2, the condensers 25 and 26 are connected in circuit with the respective energizing windings in order to produce resonant conditions therein when an energizing current of the desired frequency is supplied to the circuit.

In the selective carrier current control system shown in Fig. 2 the energizing windings 12 and 13 of the relay shown in Fig. 1 are connected in a resonant circuit respectively with the condensers 25 and 26 across one phase of the three phase high voltage power supply lines L. The supply lines L are energized through suitable transformers 27 and a disconnecting switch 28 from a low frequency, three phase, power source indicated as 29 which may be an ordinary 60 cycle power generator. An alternating current of predetermined high frequency such as, for example, 1500 cycles, may be superimposed upon one phase of the supply lines L when the alternating current source 30 is connected thereto through the disconnecting switch 31, and the coupling condensers 32. An alternating current of different predetermined high frequency such as, for example, 3000 cycle, may be superimposed upon the power current when the alternating current source 33 is connected to one phase of the supply lines L through the switch 34 and the coupling condensers 35. The frequency of the source 30 is of the predetermined value required for resonance in the circuit including energizing winding 12 while the frequency of the source 33 is of the predetermined value required for resonance in the circuit including energizing winding 13.

The contacts 16 and 17 of the mercury switch mechanism are connected to control the energizing circuit of the electromagnetic line switch or the contactor 36 which controls the connection of the electric translating devices 37 to the power supply lines L.

Thus with the several parts of the control system in their respective positions shown in the drawings closure of disconnecting switch 28 to connect the three phase source 29 to the supply lines L, serves to energize the operating winding of the electromagnetic switch 36. Switch 36 at once closes and connects the translating devices 37, which may be assumed to be electric lights, to the power supply lines L. Due to the fact that the energizing windings 12 and 13 of the controlling relay are non-resonant and therefore relatively unresponsive to the current of relatively low frequency supplied by the source 29, the thermal responsive elements 10 and 11, as well as the mercury switch 15, remain in the relative positions in which they are shown.

When it is desired to operate the electromagnetic switch 36 so as to disconnect the translating devices 37 from the supply lines L, the switch 31 is closed to connect the high frequency source 30 to one phase of the supply lines L. Since the resulting current superimposed upon the power current of the supply lines is of the predetermined frequency required for resonance in the circuit including the energizing winding 12 of the control relay, the flux in the magnetic field of the winding 12 at once is increased to a relatively large value. The resulting hysteresis loss, as well as the eddy currents set up in the metallic thermal-responsive element 10, serve to heat the element. The consequent increase in temperature of the element 10 causes the free end to flex and gradually raise the left hand end of pivoted member 14. When the member 14 is tilted beyond the horizontal position the mercury 18 flows away from the contacts 16 and 17, thereby interrupting the energizing circuit of electromagnetic switch 36 to permit the latter to return to the open position in which it is shown. Upon opening the switch 31 to disconnect the source 30 from the supply lines 27, winding 12 is no longer supplied with resonant energizing current and consequently the thermal element 10 is permitted to cool and return to its normal position in which it is shown. However, the member 14 is maintained tilted in the opposite direction

by the weight of the mercury 18 in the right hand end of the mercury switch 15.

When it is desired to reconnect the translating devices 35 to the supply lines L, this may be accomplished by closing the switch 34. This superimposes upon the low frequency power current of the supply lines, a carrier current of the predetermined frequency required for resonance in the circuit including the energizing winding 13. Under these conditions, the flux in the magnetic field of winding 13 is increased to a relatively large value without, however, substantially varying the flux in the magnetic field of winding 12 since the latter is non-resonant to the frequency of source 33. In this way, the thermal-responsive element 11 is heated by hysteresis and eddy currents in the manner previously described in connection with the element 10 and as the temperature of element 11 increases the free end thereof flexes to raise the right hand end of the pivoted member 14. When the pivoted member 14 has been tilted sufficiently to permit the mercury to bridge the contacts 16 and 17, the energizing circuit for electromagnetic switch 36 is reestablished and the switch at once closes to reconnect the electric lamps 37 to the supply lines.

While not shown in the drawings, it will be evident that the automatic controlling apparatus comprising the thermal-responsive relay and the electromagnetic switch 34 may be duplicated any desired number of times and arranged to control the connection of additional translating devices to the supply lines L if desired. The resonant energizing windings of the additional controlling apparatus may be connected to the same phase of the supply lines L and thereby arranged to be controlled simultaneously with the operation of the apparatus shown or may be arranged in another phase of the supply lines for separate actuation if desired.

The modified form of thermal responsive controlling device shown in Fig. 3 is arranged to be energized in a similar manner to the device described in connection with Fig. 1, although the arrangement shown in Fig. 3 is considerably more efficient and hence requires an energizing current of relatively small value. As shown, the modified thermal-responsive device comprises a pair of cooperating movable thermal-responsive circuit controlling elements 38 and 39, which are of the usual bi-metallic type, having magnetic and current conducting properties, and are mounted within a heat insulating container in order to conserve the heat produced therein upon energization of the winding 40 at resonant frequency. Preferably the thermal-responsive elements are enclosed within an evacuated casing 41, to which one end of each of the elements is secured with the other ends of the elements normally biased out of circuit controlling engagement. In the preferred embodiment illustrated the evacuated casing 41 is surrounded by the energizing winding 40 which is arranged for resonance when energized with a current of predetermined frequency in the same manner as the energizing windings 12 and 13 of the relay shown in Fig. 1. This may be accomplished if desired by connecting a suitable condenser 42 to the terminals of the energizing winding 40, as indicated in the drawings.

When the winding 40 is energized by the current of the frequency required for resonance conditions, the flux in the magnetic field of the winding is increased to a high value. The heating effect of the resulting hysteresis and eddy currents in the thermal-responsive elements 38 and 39 serve to rapidly increase the temperature thereof to a high value, due to the fact that the heat losses from the elements are reduced to a practically negligible value by the evacuated container 40. Since the thermal elements 38 and 39 operate at a relatively high temperature it is unnecessary to provide means for compensating for changes in the ambient temperature.

While not shown in the drawings, it will be evident that a pair of thermal-responsive devices, such as shown in Fig. 3, may be tuned for resonance with energizing currents of different frequency and connected through suitable terminals 43 and 44 to control the opening and closing windings of an electromagnetic line switch or contactor in substantially the same manner as described in connection with Fig. 2.

While I have described the invention as embodied in selective relays for carrier current control systems, in which the thermal responsive elements are heated by inductive or transformer action from a tuned electric circuit it will be understood that the thermal elements also may be connected in the tuned circuit to be heated directly by the resonant current therein if desired.

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

1. A thermal-responsive device comprising a winding arranged to be energized, a thermal-responsive movable element disposed in the magnetic field of said winding and arranged to be operatively heated responsively to the flux therein when the winding is energized, and a heat insulating casing for said movable element arranged within the winding.

2. A thermal-responsive circuit controlling device comprising a current conducting movable thermal-responsive element, a hermetically sealed container enclosing said element, and a winding surrounding said container and arranged for resonance when energized with a current of predetermined frequency, said element being arranged to be operatively heated by induction from said

winding, only when the frequency of the energizing current of the winding is substantially at said predetermined value.

3. A thermal-responsive device comprising a winding arranged to be energized, a thermal-responsive movable element disposed in the magnetic field of said winding and arranged to be operatively heated responsively to the flux therein when the winding is energized, and an evacuated container enclosing said movable element arranged within the winding.

4. A thermal-responsive circuit controlling device comprising a bi-metallic thermal-responsive movable circuit controlling element, an evacuated container enclosing said element, a winding surrounding said container arranged for resonance when energized with a current of predetermined frequency, said thermal-responsive element being arranged to be heated by the hysteresis and eddy currents induced therein when the frequency of the energizing current of said winding is substantially at said predetermined value.

5. A thermal-responsive device comprising a pair of cooperating movable thermal-responsive circuit controlling members normally biased out of circuit controlling engagement and arranged to move into circuit controlling engagement when heated to a predetermined temperature, a common energizing winding surrounding said elements and arranged for resonance when energized with a current of predetermined frequency said elements being adapted and arranged to be heated to said predetermined temperature responsively to the resonant flux of said winding.

6. A thermal-responsive device comprising a pair of cooperating bi-metallic thermal-responsive circuit controlling members biased out of circuit closing engagement, and arranged to flex into circuit closing engagement when heated to a predetermined temperature, a heat-insulating casing for said elements, and a winding surrounding said casing and arranged for resonance when energized with a current of predetermined frequency said elements being adapted and arranged to be heated to said predetermined temperature responsively to the resonant flux of the winding.

7. A thermal-responsive device comprising an evacuated container, a pair of cooperating bi-metallic thermal-responsive circuit controlling movable elements, each having one end fixed within said container, the free ends of said elements being arranged to flex into circuit closing engagement when the elements are heated to a predetermined temperature, and a common energizing winding surrounding said container and arranged for resonance when energized with a current of predetermined frequency said elements being arranged to be inductively heated responsively to the resonant flux of the winding.

In witness whereof, I have hereunto set my hand this 31 day of March, 1925.

CHESTER I. HALL.