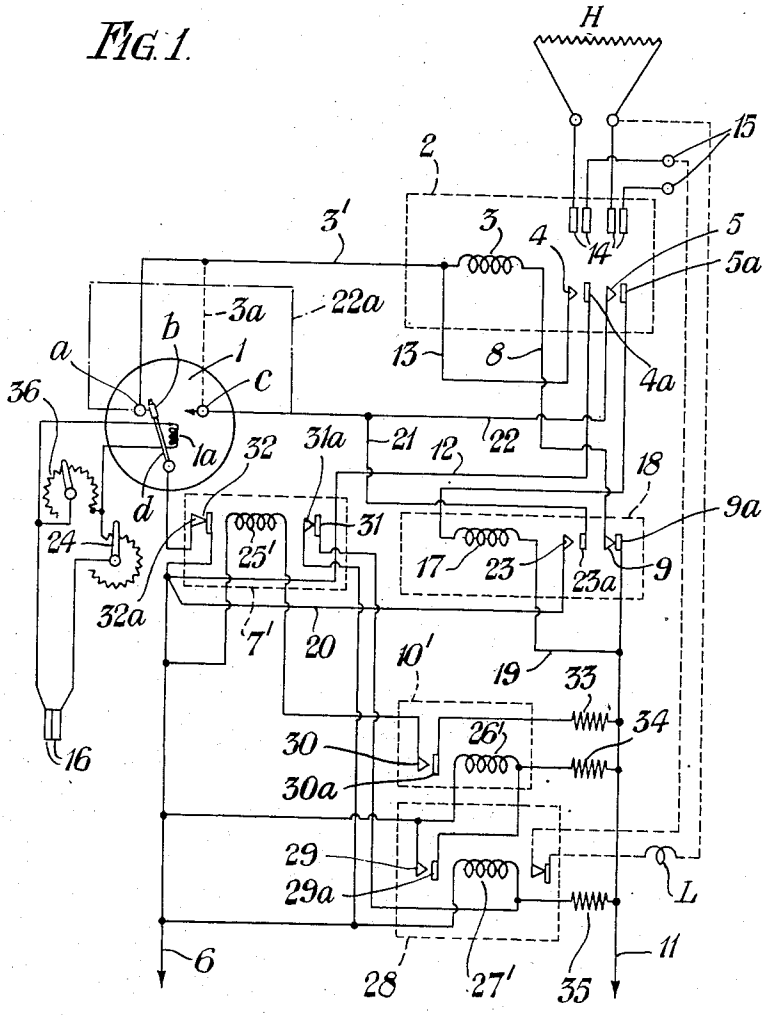
Nov. 6, 1951 W. H. RUFFLE 2,574,419

TEMPERATURE CHANGE RESPONSIVE MEANS FOR CONTROLLING ELECTRIC CIRCUITS

Filed Oct. 21, 1947

2 SHEETS—SHEET 1

FIG. 1.



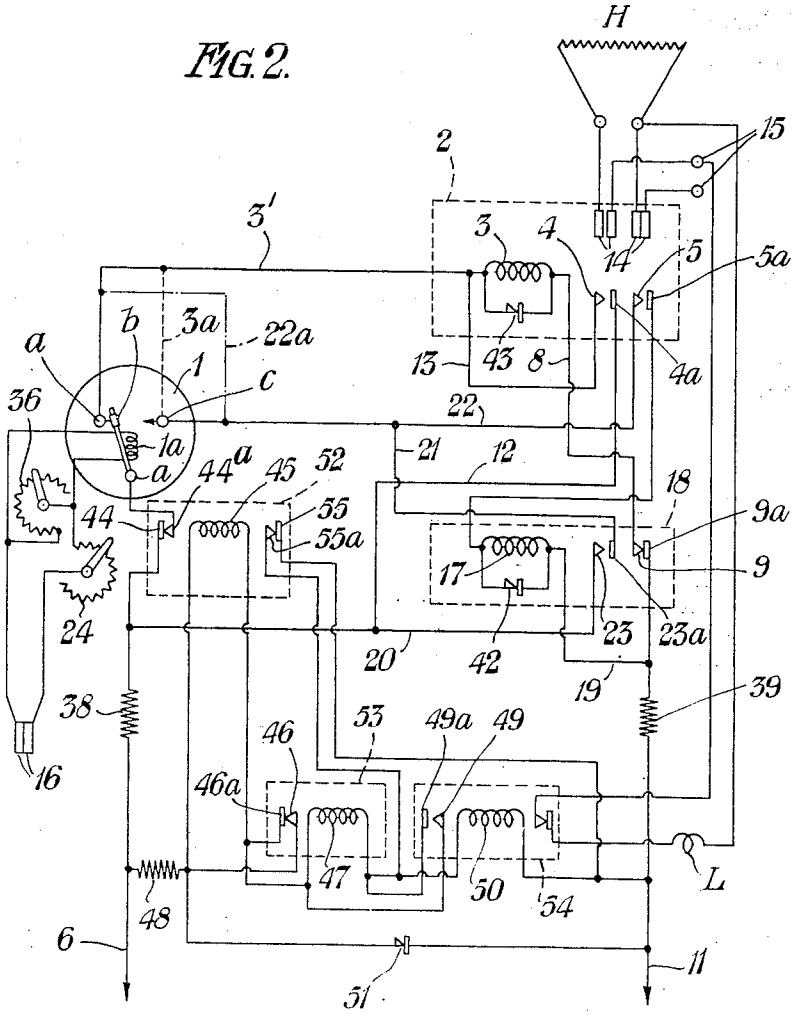
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FIG. 2.



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TEMPERATURE CHANGE RESPONSIVE MEANS FOR CONTROLLING ELECTRIC CIRCUITS

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1 Claim. (Cl. 175—320)

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This invention relates to temperature change responsive means for controlling electrical circuits, e. g. for actuating make-and-break devices for bringing into and out of circuit, or effective operation, a warning device or apparatus operated by electrical energy. In the former connection the present invention is particularly useful in the operation of a temperature change warning device on aircraft or elsewhere employing low voltage e. g. 24 volts, supply sources, whilst in the latter connection the invention can include in its scope of adaptation many forms of heating apparatus, e. g. as used in the heat treatment of articles, where it is desirable to control the operation stages of an electrical motor or other unit operated from a source of electrical energy in accordance with conditions in a heat treatment chamber or ash pit, or in gaseous, liquid or solid fuel supply means, in such manner that the apparatus consuming the electrical energy only operates when it is required to maintain a supply of fuel, re-adjust the level of ash in an ash pit, actuate a control valve or for like purposes. The object of the invention is to prevent overloading of the contacts of the very sensitive switch and to obtain a very prompt response of the circuit to temperature change at a source to be controlled or safeguarded against rise or fall in temperature, so as to bring into operation a warning device or a temperature regulating device or for analogous purposes.

Certain known warning and other electrically operated devices making use of a very sensitive type of device adapted to respond to small changes in temperature to bring about a change in potential difference for the actuation of a highly sensitive switch, e. g. of the milli-volt meter type have not proved reliable in operation owing to a moving contact of the switch (which contact, in previously proposed apparatus, is very fine, e. g. hair-like or a very thin wire member) carrying the load to a relay, and maintaining the carrying of this load during the operation of this relay. The said sensitive device is for temperatures above 0° C., usually a thermo-couple. With such an arrangement the circuit frequently fails or does not function accurately owing to vibrations and shocks causing separation or making of the hair-like contacts, and also of course owing to the somewhat erratic nature of the operation of contacts of hair-like form which are moved into engagement by an extremely low electro-motive form and yet have to carry a relatively very high load. By means of the present invention this disadvantage is obviated.

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According to the present invention a relay control circuit for controlling the supply of electrical energy to apparatus comprises a milli-volt type of switch, means responsive to temperature changes so as to develop a very small E. M. F. or change in electrical characteristics consequent upon an increase in temperature ambiently of said means and connected to said switch so as to operate the switch upon a change in potential difference due to changes in ambient temperature, the said means being adapted to be located in the temperature change zone constituting the control source, a normal current supply connection to said switch, a relay connected via said switch to said normal current supply connection for making and breaking the circuit of the apparatus, means operated by said relay when energised to transfer the electrical load from the switch to the relay circuit, and pulsating relay means connected in series with the switch contacts and said relay to ensure that the resultant inductive circuit is finally completed by the pulsating relay means and not by the switch contacts.

In order that the invention may be clearly understood and readily carried into effect reference will now be made to the drawings wherein,

Figure 1 is a diagram of the circuit for use with a low voltage, e. g. 24 volts D. C. supply as adopted on aircraft and in which the pulsing relay is provided for building up the E. M. F. momentarily across the switch contacts so as to ensure positive engagement of the contacts when the appropriate relay is to be brought into circuit, and

Figure 2 is a diagram showing the circuit adapted for A. C. supply.

Referring to the drawings, in the embodiments shown in Figure 1 the contact *a* of the highly sensitive meter-type switch 1 is connected to a relay 2 by a lead 3' so as to momentarily energise the coil 3 of the relay via the circuit embodying lead 6 connected to the normal supply source for the control circuit via contacts 32, 32*a*, very fine, e. g. hair-like or very thin wire swinging pointer or arm *d* and contacts *b* and *a* of a very sensitive milli-volt switch 1, relay coil 3, lead 8, contacts 9, 9*a*, and return lead 11, and to displace an armature of the relay 2, this displacement of the armature causing closure of contacts 4, 4*a* and 5, 5*a* and transferring the supply of electrical energy for the relay 2 from contacts *a* and *b* of the switch 1 to contacts 4 and 4*a* of the relay, whereby the electrical load is transferred from the switch 1 to this specially provided cir-

cuit of the relay, as follows: lead 6, lead 12, contacts 4a and 4, lead 13, relay coil 3, lead 8, contacts 9, 9a, and return lead 11. The relay operates a multiple point contact 14 for bringing into operation an apparatus which may be a heater H, or an apparatus connected to terminals 15, or a warning device or other suitable apparatus.

When a predetermined temperature within the treatment zone has been reached, it is desirable to actuate the warning device to isolate the motor from the source of electrical energy or to close a valve or effect an equivalent operation, and at this stage the contact *b* of the arm *d* of the switch 1, by reason of the influence of energy generated in a thermo-couple 16 energising the coil 1a of the switch 1, engages another contact *c* which is connected in series with a coil 17 of a second relay 18, the circuit being as follows: lead 6, contacts *b* and *c* of switch 1, lead 22, contacts 5 and 5a of relay 2, coil 17 of relay 18, lead 19, and return lead 11. The coil 17 of relay 18 is energised and the armature of relay 18 is displaced, causing contacts 23 and 23a to close which again removes the electrical load from contacts *b* and *c* of the sensitive switch 1 and provides a circuit for coil 17 as follows: lead 6, lead 20, contacts 23 and 23a, lead 21, lead 22, contacts 5 and 5a of relay 2, coil 17, lead 19, and return lead 11. After contacts 23 and 23a are closed, the further movement of the armature of relay 18 to the limit of its travel causes contacts 9 and 9a to open, thus breaking the circuit of relay 2, which in turn breaks the circuit of relay 18, via contacts 5 and 5a. Thus there are provided two relays which transfer the electrical load from the switch 1 to the aforesaid specially provided circuits, immediately contacts *a* and *b* or *b* and *c* engage.

If desired, the connections to the high and low temperature contacts of the switch 1 can be reversed, in which case the appropriate relay will cut in at the higher temperature, and cut out at the lower temperature. This arrangement is particularly suitable when the invention is applied to a fire warning or temperature control or equivalent apparatus, and other conditions where it is desired to bring, e. g. a warning light or cooling device into operation when the high temperature contact of the switch 1 is engaged by the pointer or needle.

A variable potentiometer 24 is introduced in the thermo-couple circuit either in series with the thermo-couple lead or in parallel across the coil 1a of the meter, in order to vary the responsiveness of the meter 1 to the energy generated in the thermo-couple 16 and to act as a range controller.

Means is provided to compensate for the effect of a low electro-motive force across the contacts of the highly sensitive switch 1 when the supply is a low voltage one, e. g. 24 volts as in aircraft. It will be understood that assuming the contacts 32, 32a are in permanent contact, the circuit for the relay 2 is completed on engagement of the moving contact *b* of the switch 1 with the appropriate fixed contact *a* or *c*, but as under this condition the load across the switch contacts is inductive and may have a very adverse effect on them owing to the very light contact pressure prevailing, a pulsating circuit is provided whereby the actual circuit completion is carried by the much heavier contacts 32, 32a. In this connection it will be readily understood that when opening and closing inductive circuits there is a

considerable surge and consequent sparking at the moment of making and breaking. This pulsating circuit embodies a relay 7' incorporating a coil 25' actuating the contacts 32, 32a thus providing a pulsing current to energise the coil 17 of the relay 18, the arrangement being such that when the thermo-couple 16 reaches a predetermined temperature and thereupon generates sufficient electro-motive force to move the centre contact *b* of the switch 1 over to the other appropriate contact, the two engaging switch contacts serve only to momentarily complete the circuit to the relay 2 and only after the relay contacts 32, 32a (connected in series with the switch contacts and the coil 3 of relay 2) have closed to complete the circuit. Also, the moving contact of the switch 1 carries no P. D. except for a very short portion of the cycle of operation of the pulsing circuit.

The pulsing relay circuit incorporates limiting resistors 33, 34 and 35, and also relays 10', 28 and 7', the latter relay as aforesaid carrying the contacts for the supply to the moving contact *b* of the highly sensitive switch 1, and in addition to the variable potentiometer 24 aforesaid another potentiometer 36 is introduced, these two potentiometers being in series and parallel with the thermo-couple to allow adjustment of range and point of temperature working of the instrument.

The operation of the circuit shown in Figure 1 is as follows:

The circuit for relay 2 is completed momentarily on engagement of moving contact *b* of the switch 1, with the fixed contact *a* at the end of the first cycle of the pulsing circuit, thus giving a pulsating current to energise the coil 3 of the said relay 2 as follows: lead 6, contacts 32, 32a of pulse relay 7', moving arm *d* and contacts *b* and *a* of the switch, lead 3', coil 3, lead 8 contacts 9, 9a of relay 18 and lead 11. The energising of coil 3 causes displacements of the armature of relay 2, which closes contacts 4, 4a thus removing the load from contacts 32, 32a of pulsing relay 7', and contacts *b* and *a* of the switch 1, and providing a steady energising current for coil 3 as follows: lead 6, lead 12, contacts 4a, 4, lead 13, coil 3, lead 8, contacts 9, 9a and lead 11. Displacement of the armature of the relay 2 will also operate the multi-contact switch 14 to complete the circuit to a supply for e. g. an electrical heater or the like, and/or remove the supply from any other apparatus, e. g. a fan, blower, or motor.

When the zone in which the thermo-couple 16 is located reaches a predetermined temperature, the thermo-couple generates sufficient electro-motive force to move the centre contact *b* of switch 1 over to contact *c*, and upon contact being established momentarily completes the circuit for relay 18 via contacts 32, 32a of the pulse relay circuit, thus providing a pulsating current to energise coil 17 of said relay, as follows: lead 6, contacts 32, 32a moving arm *d* and contact *c* of switch 1, lead 22, contacts 5, 5a (closed by operation of relay 2), coil 17, lead 19 and return lead 11. Thus the armature of relay 18 is displaced, causing contacts 23, 23a to close, which remove the load from contacts 32, 32a of pulsing relay 7' and *b* and *c* of the switch 1 and provide steady current for coil 17 as follows: lead 6, lead 20, contacts 23, 23a, lead 21, lead 22, contacts 5, 5a, coil 17, lead 19 and return lead 11. Instantly contacts 23, 23a are closed and the armature of relay 18 reaches its limit of travel.

such armature causes contacts 9, 9a to open, thus breaking the circuit of relay 2 and contact switch 14. Relay 2, in turn, breaks the circuit of relay 18 via contacts 5 and 5a, and when the temperature of thermo-couple 16 falls to a predetermined point, the cycle of operation starts again.

It will be appreciated from the foregoing that the pulse relay circuit operates as follows: coil 26' of relay 10' is energised via resistor 34 and attracts its armature which closes contacts 30, 30a. Contacts 30, 30a complete the circuit for coil 25' of relay 7' through resistor 33 and as the coil 25' is energised, the armature of relay 7' opens contacts 31 and 31a thus removing the short circuit across coil 27' of relay 28. Coil 27' is thus energised and closes contacts 29 and 29a which short circuit coil 26' of relay 10'. Coil 26' is thus de-energised, which in turn de-energises coil 25' of relay 7 and coil 27' of relay 28 is again shorted by contacts 31 and 31a. The operation cycle immediately starts again and thus each relay pulses regularly and contacts 32 and 32a on relay 7' are made to supply and cut off the potential to the contact b of meter 1 at regular intervals. The short circuiting of relay coils 26' and 27' at the releasing stage is introduced to close the electro-magnetic field and slow up the collapse of the flux. This consequently slows up the release time of the relays which increases the length of the pulse, and decreases the frequency of operation of the relays.

It will be seen from the foregoing that at the moment of engagement of the moving contact b with either of the fixed contacts a or c no potential is carried by the moving contact b until the pulsating relay cycle is complete, and the potential is then supplied via contacts located on one of these relays to the moving contact b, a distinctive feature of the present embodiment of the invention being that the supply to the centre or moving contact d of the switch 1 is carried via a pulsating relay circuit which supplied the potential to energise relay 3 or 17 depending upon the position of the moving contact b. It will be evident that upon the operation of relay 3 or 17, the holding contacts 4 and 4a or 23 or 23a come into operation and remove the load from the contacts a and b or b and c of the switch 1 so that the contacts of the switch do not carry any operative load otherwise than of course that which occurs during the momentary closing of the appropriate pair of such contacts.

When the apparatus is intended for use as a fire warning device L the leads 3' and 22 will be connected respectively to the contacts c and a, that is to say the connections as shown in Figure 1 would be reversed as shown by the broken lines 3a and 22a.

In the use of the invention with an A. C. supply, as shown in Figure 2, limiting resistors 38 and 39 are included in supply leads 6 and 11, and coils 3 and 17 of relays 2 and 18 are shunted by rectifiers 43 and 42. An alternative pulsing relay circuit may be used and this circuit consists of resistor 48, relays 52, 53 and 54, and rectifier 51. The operation is as follows: coil 47 of relay 53 is energised via lead 6, resistor 48, contacts 46 and 46a, the coil 47, contacts 55a and 55 and lead 11. As the armature of relay 53 is displaced, contacts 46 and 46a are opened, removing the short circuit from coil 45 and relay 52, which is energised, and, upon displacement of its armature, contacts 55 and 55a open to allow coil 50 of relay 54 to be energised. Contacts 49 and 49a close and short-circuit coil 47 of relay 53, which is de-energized and thus de-energizes relays 52 and 54. The cycle of operation then starts again. The supply to the moving contact b of meter 1 is carried via the pulsing contacts 44 and 44a of relay 52.

When operating on D. C. supplies substantially higher than the relatively low voltage, e. g. 24 volts aforesaid, limiting resistors can be included in the supply leads 6 and 11.

By introducing the warning lamp L in the manner shown in Figures 1 and 2 it will be apparent that an intermittent flashing effect will be obtained thereby ensuring a form of warning which normally would immediately attract attention.

It will be appreciated from the foregoing that the contacts 32, 32a on the pulsing relay by being used to switch contacts of electrical load at their moment of contact and also for supplying a momentary pulsating current for the relays 2 and 18 via the switch contacts a—b or b—c, supply energising current for only a small portion of the cycle of operations of the pulsing relay circuit, thereby practically eliminating the possibility of false operation of the switch 1, e. g. as the result of vibration or shock, even though the contacts of the switch 1 may make without the switch receiving the required electro-motive force from the thermo-couple.

In referring to the means by which small changes in the "potential difference" are applied to the apparatus as a "thermo-couple" it will of course be appreciated that where circumstances render it desirable any suitable device may be employed instead of the conventional form of "thermo-couple." For example where it is desired for the apparatus to respond to changes in temperature in a range below 0° C. a bridge resistance circuit may be employed instead of the thermo-couple, a field of use to which such an arrangement would be adopted being in refrigerating plant or with apparatus or craft operating in below 0° C. zones.

I claim:

Temperature change responsive means for controlling electric circuits including a warning device, an electric motor, heater or equivalent electrical energy consuming means fed from a normal source of supply of electrical energy, comprising a thermal couple adapted to be located in the zone constituting the control source, a highly sensitive milli-volt switch constructed similarly to a moving coil milli-volt meter, a relay connected across the switch and the said energy consuming means, holding contacts with said relay, means with the relay producing, when the relay is energised, a transferrance of the electrical load appropriate to the said normal source from the switch contacts to the "holding" contacts on said relay and the closing from the relay of the circuit for the motor or its equivalent, a further relay adapted to be energised when the thermal couple generates a potential difference which influences the switch so as to set into operation a change in the circuit, the energising of the said further relay breaking the circuits of the first-mentioned relay, which latter relay in turn automatically breaks the circuit of the second-mentioned relay, and pulsating relay means connected in series with said moving contact of the switch and the first-mentioned relay via one of the fixed contacts of the switch to ensure that the resultant inductive circuit is finally com-

pleted by the pulsating relay means and not by the switch contacts.

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