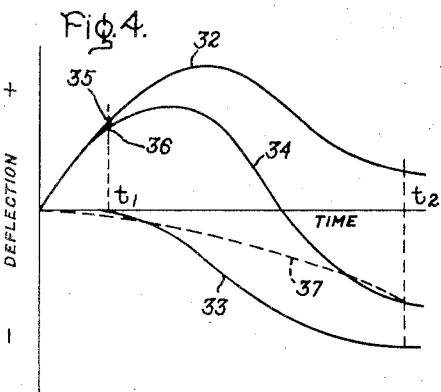
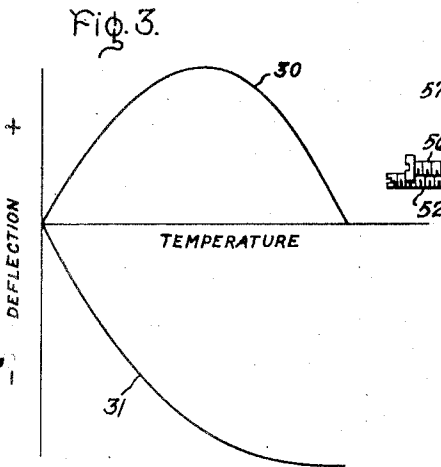
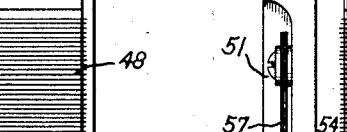
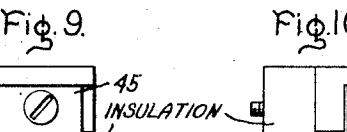
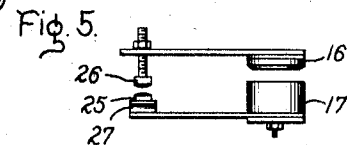
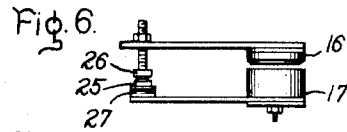
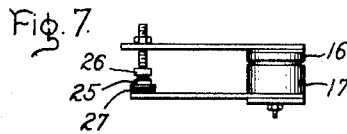
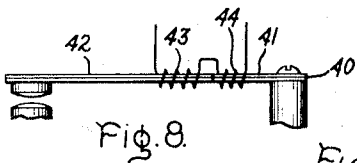
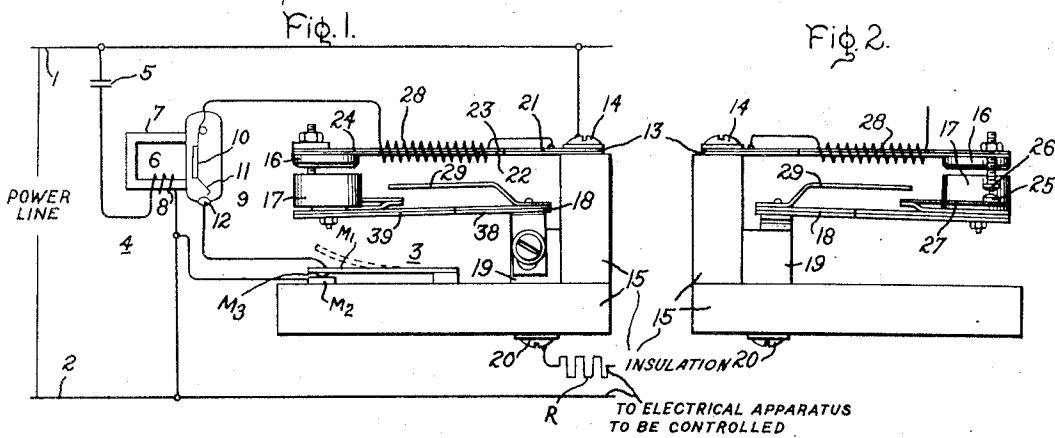


CARRIER CURRENT CONTROLLER

Filed March 26, 1941



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CARRIER CURRENT CONTROLLER

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3 Claims. (Cl. 200—122)

My invention relates to carrier current systems for controlling the connection of electrical apparatus to a circuit from a remote point.

The invention is directed particularly to thermal switch means employed selectively to connect the remotely controlled apparatus to a circuit and subsequently to disconnect the apparatus therefrom.

It is the general object of the invention to provide a simple, low cost, and dependable switch means of this character, and so arranged that upon sending a carrier current impulse from the remote point to the switch means for a predetermined, preferably short time interval the electrical apparatus is caused to be connected through the switch means to the circuit, and upon sending a similar carrier current impulse to the switch means from the remote point but for a different, preferably long time interval, the electrical apparatus is caused to be disconnected from the circuit.

In accordance with my invention a thermal switch is provided comprising a thermostatic bar for operating the switch contacts including two sections connected end to end, one of the sections being adapted to be heated by conduction from the other section and having a temperature-deflection characteristic increasing through a temperature range, and the other section being associated with a heating winding and having a temperature-deflection characteristic first increasing and later decreasing through the temperature range.

In a modification of the invention the two sections of the thermostatic bar have substantially the same temperature-deflection characteristic, increasing through the temperature range, but the heating means comprises two portions in heating relationship respectively with one and the other of the thermostatic bar sections, one of the heater portions having a constant resistance with temperature rise and the other portion having an increasing resistance with temperature rise.

Means are preferably provided, comprising a contact or contacts of magnet material or comprising a resilient member operatively associated with the thermostatic bar, for ensuring quick or snap-action operation of the contacts in opening and closing the circuit. Means in the form of auxiliary contacts are also preferably provided, especially in case main contacts comprising magnet material are employed, to protect the main contacts from the effects of burning or arcing and thereby to ensure the maintenance of proper

calibration of the switch means. Means in the form of an auxiliary thermostatic bar associated with one of the contact members is further preferably provided so arranged as to aid in compensating for change in operation of the switch means due to variation of ambient temperature.

The novel features which are considered to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof may best be understood by reference to the following description taken in connection with the accompanying drawing wherein Fig. 1 is a semi-diagrammatic representation of a carrier current system employing a thermal switch embodying the invention and which is shown in side elevation; Fig. 2 is a side elevational view of the reverse side of the thermal switch; Fig. 3 shows temperature-deflection characteristics of the two sections of the thermostatic bar; Fig. 4 shows time deflection characteristics of the thermostatic bar; Figs. 5 to 7 are end elevational views illustrating positions of the contacts employed in the thermal switch; Fig. 8 illustrates a modified form of thermostatic bar and heating means; Figs. 9 and 10 are respectively front and side elevational views of a modification of the invention shown in Figs. 1 and 2; and Fig. 10a illustrates an alternative arrangement to that shown in Fig. 10.

Referring to the embodiment illustrated in Fig. 1, for remotely controlling the supplying of an electrical apparatus (not shown) from a power line 1, a thermal switch 2 is provided the energization of which is controlled by a relay means 4 or other suitable control means. The relay means 4 may comprise a coupling capacitor 5 and a reactor 6 having a core 7 and a winding 8 arranged to operate a mercury switch 9 having an armature member 10 for moving a switch member 11 into engagement with a mercury contact 12. The capacitor 5 and reactor winding 8 are connected across the power line and are in series resonance for carrier current frequency.

The thermal switch 2 comprises a thermostatic bar or strip 13 mounted at one end by a terminal screw 14 on a preferably insulating support 15 and carrying at its free end one member 16 of a pair of cooperating main contacts the other member 17 of which is preferably mounted on the free end of a compensating thermostatic bar or strip 18 secured adjustably to a base member 19 of conductive material having a terminal screw 20 attached thereto. One of the contact

members, as 17, is preferably a magnet and the other contact member 16 is of such material, as iron, as to operate as an armature for the magnet. The thermostatic bar 13 is constituted by two sections 21 and 22 welded or otherwise connected end to end in heat conductive relation, and the material of the sections is so arranged that for small or ambient temperature changes the outer ends 23 and 24 of the sections tend to deflect at a certain rate in opposite directions. The deflection of the sections 21 and 22 for larger temperature changes extending over a considerable range will be explained hereinafter.

A pair of auxiliary contacts 25 and 26, better shown in Fig. 2, are provided in parallel relation with the main contacts 16 and 17. The auxiliary contacts are carried respectively by the free ends of the thermostatic bars 13 and 18, and one of the auxiliary contacts, as 25, is resiliently mounted on its supporting bar by a flexible strip or plate 27 or other suitable means.

For actuating the thermostatic bar 13 a heating means or winding 28 is provided wound insulatively on or in heating relation with, preferably, that one of the sections of the bar 13, in the present case the section 22, which carries the movable contact or contacts. The winding 28 is arranged to be connected across the power line 1, 2 by the mercury switch 9, and the switch 3 is so arranged that the power line connections to the apparatus which is to be controlled from the remote point include terminal 14, thermostatic bar 13, the pairs of contacts 16, 17 and 25, 26, the compensating bar 18, mounting member 19, terminal 20, and the circuit including the apparatus to be controlled. To avoid the conducting of current through the thermostatic bars 13 and 18, shunt conductors (not shown) may be provided for these bars.

A metal plate 29 or like member may be mounted between the thermostatic bars 13 and 18 to shield the bar 18 from heat radiated from winding 28.

In Fig. 3 the curve 30 shows the deflection of the thermostatic bar section 22 of Fig. 1 with change of temperature over a considerable range, the deflection of this bar first increasing and later decreasing throughout the range. The curve 31 similarly shows the deflection of the thermostatic bar section 21 over the same temperature range. The deflection is opposite that of the bar section 22 and increases throughout the range.

In Fig. 4, curve 32 shows the deflection characteristic of section 22 alone for an extended time period of energization of the heater winding 28, curve 33 shows the deflection of section 21 alone which is produced by the heat transmitted thereto by conduction and convection from section 22, and curve 34 shows the resultant deflection characteristic of free end 24 of bar 13.

One of the two constituent strips of section 21 is composed preferably of a material known commercially as Invar comprising 36 per cent nickel and 64 per cent iron, and the other strip of section 21 of a material known commercially as "22 per cent nickel steel" comprising 22 per cent nickel, three per cent chromium, and 75 per cent iron. One of the constituent strips of section 22 is composed preferably of Invar, and the other strip of section 22 of a material commercially known as "60 per cent nickel steel" comprising 60 per cent nickel and 40 per cent iron.

In operation, assuming that thermal switch 3 and relay 4 are in their open positions as illus-

trated in Fig. 1, a carrier voltage of the frequency to which the series circuit 5 and 8 is tuned is impressed on the power line 1, 2 of usual commercial frequency from a remote point on the line. The relay winding 8 being energized by the resulting carrier current actuates the armature 10 of mercury switch 9 to close the contacts 11 and 12, which in turn control the energization of the heater winding 28 of thermal switch 3.

Assuming first that the heater winding 28 is energized for a predetermined short time interval only, for example the time interval t_1 in Fig. 4, then during this short time interval the deflection of bar section 22, as illustrated by curve 32, tends to rise to a relatively high point as 35. But the oppositely directed deflection of section 21 shown by curve 33 tends to remain at a low value since heat is transferred to section 21 from section 22 by conduction and convection after an appreciable time delay only. The resultant deflection point of free end 24 of bar 13 for the short time interval t_1 is shown on curve 34 as point 36. It is assumed that at this point in the deflection curve of the free end 34 the movable contact member 16 is carried so close to the magnet contact member 17 that the contacts are drawn or snapped suddenly into engagement magnetically thereby connecting the power line 1, 2 to the apparatus which is to be controlled and which is connected between terminal 20 of switch 3 and conductor 2 of the power line.

At the end of the predetermined short time interval the operator cuts off the carrier current and the heating of thermostatic bar section 22 consequently ceases. The free end 24 tends to deflect back to its original position with contact 16 out of engagement with contact 17 as the bar 13 cools off, but because of the high magnetic attraction between the closed contact members 16 and 17 these contacts remain closed. The power line 1, 2 thus remains connected to the controlled apparatus indefinitely after the above described closing of contacts 16 and 17 due to the supplying of carrier current to the switch control means for the predetermined short time interval.

Assuming next that the heater winding 28 is energized for a relatively long time interval, for example, the time interval t_2 of Fig. 4, then as illustrated by the resultant curve 34 a force is first exerted tending to maintain the contacts in their closed position. Later this force reverses as the deflection of section 22 shown by curve 32 decreases and the oppositely directed deflection of section 21 shown by curve 33 increases. At some point as t_2 the force in the reverse direction overcomes the magnetic pull of contact 17 on contact 16 and snaps the contacts open. Sections 21 and 22 of bar 13 then cool simultaneously, the resultant cooling curve 37 being such that during the cooling period no force is exerted by the bar 13 to reclose the contacts 16 and 17. The power line 1, 2 thus will remain disconnected after the opening of contacts 16 and 17 due to the supplying of carrier current to the switch means for the predetermined relatively long time interval.

The above described cycle of first closing and later reopening the circuit contacts by heating the thermostatic bar 13 for a short time interval and subsequently heating the bar for a long time interval may be repeated indefinitely.

If for any reason relay 4 should fail to open its contacts at the end of a transmitted carrier impulse, heat would continue to be generated con-

tinuously by the heater winding 28, causing an excessive temperature rise inside a casing (not shown) which may enclose the thermal switch. To prevent damage from this cause a temperature responsive fuse device may be connected in the heater circuit, of the type, for example, comprising a movable member M₁ held against a stationary member M₂ by a low melting point solder M₃. Upon occurrence of unduly high temperature the solder melts and the movable member is released thereby opening the heater circuit. The fuse may be reset, after the relay is restored to normal condition, by holding the movable member against the stationary member and applying heat to the solder.

Referring to Figs. 5 to 7 which are end-elevation views of the main and auxiliary contacts and supporting members therefor shown in Fig. 2, looking to the left in the upper portion of the latter figures, in operation of the auxiliary contacts 25 and 26, in off position of the thermal switch as shown in Fig. 5 both the main and the auxiliary contacts are open. The flexible strip or plate 27 upon the free end of which one of the auxiliary contacts, 25, is mounted is so arranged that in this open or off position the gap between the auxiliary contacts is less than the gap between the main contacts. Therefore, in passing to closed position of the main and auxiliary contacts shown in Fig. 7 the auxiliary contacts 25 and 26 close first, and in passing from closed switch position of Fig. 7 to the open position of Fig. 5, these auxiliary contacts open last. The auxiliary contacts therefore receive any arcing or pitting which may develop in energizing and de-energizing the controlled apparatus but in the normal closed position the current divides between the two pairs of contacts which are then in parallel.

In cases particularly where the thermal switch 3 is employed for the control of loads, such as a tungsten filament lamp load, characterized by a high inrush current tending to cause welding of the contacts, a suitable limiting resistance may be provided in series with the contacts. This resistance may take the form of a separate resistor R, or may be provided by forming of suitable resistance material the small flexible plate or strip 27 upon which one of the auxiliary contacts is mounted.

The compensating thermostatic bar 18 is so arranged that for ambient temperatures its free end, carrying the contact 17, moves in substantially the same direction as the free end of the main thermostatic bar 13. This movement of bar 18 improves the operation of the switch means by making the operating time to open and close the contacts more nearly constant at different ambient temperatures.

The compensating thermostatic bar 18 may be constituted by two sections 38 and 39 connected end to end and deflecting in opposite directions with ambient temperature, similarly to the sections 21 and 22 of main thermostatic bar 13. By suitably proportioning the lengths of the sections 38 and 39 of bar 18, change in ambient temperature will cause a slight variation in the separation of the contacts 16 and 17 and will also cause a slight longitudinal tilting of contact 17 tending to match a similar longitudinal tilting of contact 16 due to the effect of ambient temperature change on the sections of bar 13. Thus at all ambient temperatures the faces of contacts 16 and 17 tend to remain parallel in the open position and to meet reasonably flat in the closed

position. The forming of bar 18 in two sections also assists in making the operating time more nearly constant with ambient temperature changes.

The shield 29 interposed between the main thermostatic bars 13 and the compensating thermostatic bar 18 reduces the amount of heat transferred from heater winding 28 into the sections 38 and 39 of bar 18. The use of the shield 29 has been found to be effective in reducing the operating time required to open the contacts.

In the modified form of thermostatic bar and heater means illustrated in Fig. 8 the bar 40, like bar 13 of Fig. 1, is constituted by two sections, 41 and 42, connected end to end and deflecting in opposite directions with temperature change. In Fig. 8, however, the sections 41 and 42 are alike as to material, similarly characterized as to deflection for all temperatures throughout the temperature range. Further, instead of a single heater winding associated with one section only of the thermostatic bar, a heater winding for bar 40 is provided comprising two portions which may be in series, one of the portions 43, associated with one of the bar sections as 42, having a constant resistance with temperature and the other portion, 44, associated with the other bar section 41, having an increasing resistance with temperature. The winding is so arranged that in the cold condition the portion 43 is of higher resistance than the portion 44 and in the hot condition the resistance of portion 44 rises to a value higher than that of portion 43. The winding section 43 may be formed of a usual resistance material known commercially as Nichrome comprising 60 per cent nickel, 12 per cent chromium and 28 per cent iron. The winding section 44 may be formed of tungsten or of a material mainly comprising tungsten.

In operation of switch means such as 3 of Fig. 1 but employing the thermostatic bar and heater means of Fig. 8, when the two winding portions 43 and 44 are energized for a short time interval only, the resistance of portion 43 remains throughout this short time interval higher than the resistance of portion 44. Therefore, more heat is applied to section 42 than to section 41, and the free end of the bar 40 moves in the direction to cause closing of the contacts. When, subsequently, the heater winding is energized for a relatively long time interval, the resistance of portion 44 rises above that of portion 43. More heat is, therefore, applied to bar section 41 than to section 42 and the free end of the bar moves in the direction to reopen the contacts.

In the modification illustrated in Figs. 9 and 10 the thermal switch may comprise a main thermostatic bar 45 having two sections 46 and 47 and a heater winding 48 associated with that one 47 of the section which carries at its free end a movable contact member 49, all similarly to the corresponding elements of thermal switch 3 of Fig. 1. The movable contact 49 cooperates with a fixed contact 50 adjustably mounted in a suitable insulating support 51 by a screw 52. A resilient member 53 for assuring quick operation of the contacts is provided, preferably having the form of a U-shaped spring one end 54 of which engages the bar 45 and the other end 55 of which is associated with the support 51. Preferably spring 53 is not mounted directly on support 51 but is mounted adjustably by a screw 56 on the free end of a compensating thermostatic bar 57 which is secured to the support 51 and which deflects for ambient temperature change in the

same direction as the free end of main thermostatic bar 45. It will be understood that, as illustrated in Fig. 10a, contact 50 instead of spring 53 may be mounted on a compensating thermostatic bar such as bar 51.

The spring 53 and bar 45 may be so arranged that the end 54 of the spring engages the bar at a point thereof at or closely adjacent the extreme end 58. It is preferable, however, that the end 54 of the spring engage the bar not at the end but at an intermediate point of the bar as shown. This arrangement of the spring end 54 with relation to the bar 45 has been found to provide faster tripping of the spring in opening of the contacts.

In operation of the thermal switch illustrated in Figs. 9 and 10, assuming the contacts 49 and 50 to be in open position as shown, if the bar 45 is heated for a short time interval the bar section 47 deflects in a direction to move the contact 49 against the pressure of the spring until the latter is in position to close the contacts with a snap action. Upon cooling of the bar 45 the contacts remain closed by the spring pressure. If, later, the bar is heated for a long time interval, the bar sections 47 and 48 tend to deflect in directions such that the free end of the bar tends to move contact 49 out of engagement with contact 50. When the resultant deflecting force in bar 45 overcomes the spring pressure the contacts reopen with a snap action. Upon cooling of the bar 45 the contacts remain in open position.

My invention has been described herein in particular embodiments for purposes of illustration. It is to be understood, however, that the invention is susceptible of various changes and modifications and that by the appended claims I intend to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. A thermal switch for controlling the energizing of a circuit comprising a thermostatic bar having two portions in thermally conductive relation end to end, and heating means associated with said bar to bend one of said portions to close said circuit after a predetermined short time interval and to bend the other of said portions to open said circuit after a predetermined long time interval.

2. A thermal switch for controlling the energizing of a circuit comprising a thermostatic element constituted by two metallic strips connected in thermally conductive relation end to end, one of said strips having a temperature-deflection characteristic increasing throughout a temperature range, the other of said strips having a temperature-deflection characteristic first increasing and later decreasing throughout said range, and heating means associated with said last-named strip for bending said last-named strip to close said circuit after a short time interval and for bending said first-named strip by heat conduction from said last-named strip to assist in opening said circuit after a long time interval.

3. A thermal switch for controlling the energizing of a circuit comprising a thermostatic bar

having two sections connected end to end, a second thermostatic bar for compensating the movement of said first-named bar, the free ends of said bars moving in the same direction with ambient temperature changes, a pair of contacts in said circuit connected respectively to said free ends of said bars, and heating means for bending one of said sections to close said circuit at said contacts after a short time interval and for bending the other of said sections to reopen said circuit at said contacts after a long time interval.

4. A thermal switch for controlling the energizing of a circuit comprising a thermostatic bar having two sections connected end to end, a second thermostatic bar for compensating the movement of said first-named bar due to ambient temperature changes, a pair of contacts in said circuit connected respectively to the free ends of said bars, one of said contacts being a magnet and the other being an armature for said magnet, a pair of auxiliary contacts in said circuit arranged to close before and to open after said first-named contacts, one auxiliary contact being connected resiliently to the free end of one bar and the other auxiliary contact being connected to the free end of the other bar, and heating means for bending one of said sections to close said circuit at said pairs of contacts after a short time interval and for bending the other of said sections to open said circuit at said contacts after a long time interval.

5. A thermal switch for controlling the energizing of a circuit comprising a thermostatic bar having two sections connected end to end, a second thermostatic bar for compensating the movement of said first-named bar due to ambient temperature changes, a pair of cooperating contacts in said circuit, one of said contacts being fixed and the other being connected to the free end of said bar, a resilient member connected between the free end of said second bar and a point of said first bar for biasing said other contact into and out of engagement with said one contact, and heating means for bending one of said sections to cause said resilient member after a short time interval to close and maintain closed said contacts and for bending the other of said sections to cause said resilient member after a long time interval to open and maintain open said contacts.

6. A thermal switch for controlling the energizing of a circuit comprising a thermostatic bar including two sections having substantially the same temperature-deflection characteristic throughout a temperature range, and a heating means for bending one of said sections after a short time interval to close said circuit and for bending the other of said sections after a long time interval to open said circuit, said heating means having two portions, one of said portions being in heating relationship with said one section and having a substantially constant resistance with rise of temperature, the other of said portions being in heating relationship with said other section and having an increasing resistance with rise of temperature.

JOHN L. WOODWORTH.