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VOLTAGE COMPENSATED THERMAL TIMER SWITCH

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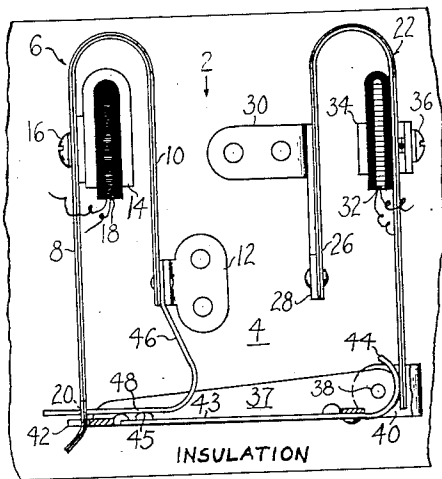


Fig. 1

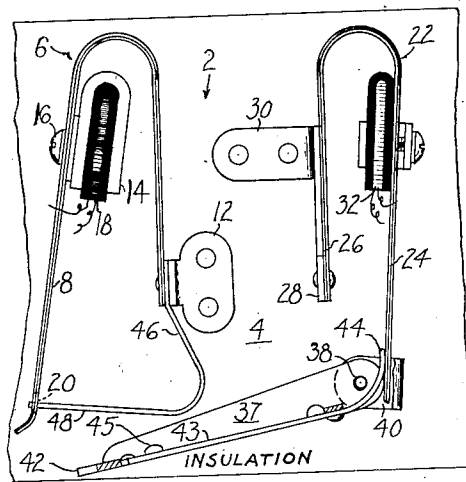


Fig. 2

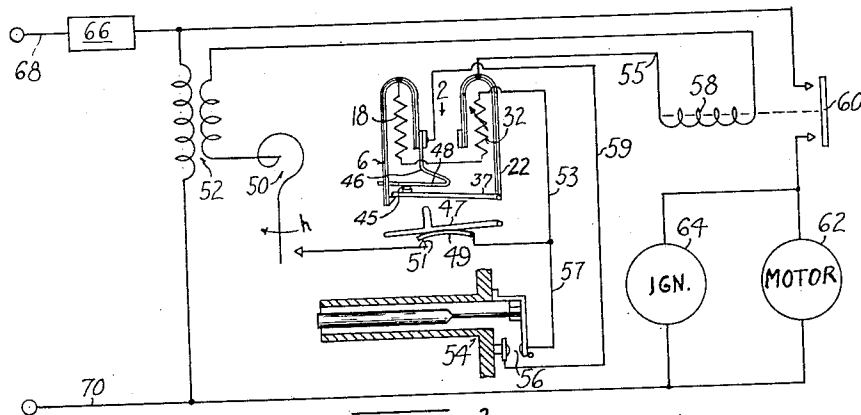


Fig. 3

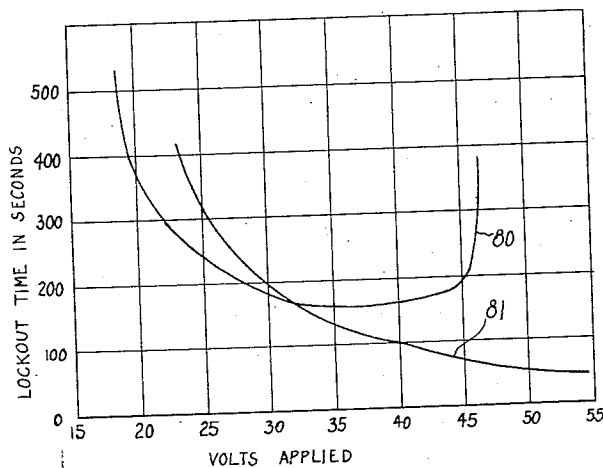


Fig. 4

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VOLTAGE COMPENSATED THERMAL TIMER SWITCH

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9 Claims. (Cl. 200—122)

This invention relates to thermal switches, and more particularly to thermal switches which employ bimetallic strips heated by electric heater elements for actuating contacts at the expiration of a predetermined time interval after the application of electric power to the switches.

Thermal timer switches of this general type are often used as safety devices in automatic control systems for heating plants and effect a lockout condition to prevent operation of the system after a predetermined time period has elapsed and the system is malfunctioning.

In the past many types of switches have been provided to effect the safety function above-described but generally some exterior condition has impaired the proper timing and operation of the switches. These conditions, such as ambient temperature changes, vibration and shock, and voltage fluctuations, have tended to impair the timing precision of the switch. This invention provides a thermal timer switch wherein the operating characteristics are improved under varying conditions of voltage and ambient temperature to provide more nearly uniform performance.

The principal object of the invention is to compensate the thermal timer switch for voltage fluctuations without substantially changing the time period of operation of the switch. Ordinarily, voltage fluctuations as applied to a thermal timer switch result in varying the time of operation of the switch. This is evident because the heat output of an electrical heater, having a fixed resistance, will vary with the applied voltage. It is generally desirable in safety applications to have a reliable and precise time period of operation to prevent the accumulation of dangerous combustible vapors if combustion has not been established or fails and at the same time to ensure a proper time interval to obtain ignition of the fuel.

Other objects and advantages will become apparent from the following description of a preferred embodiment of the invention which is illustrated in the accompanying drawing.

In the drawing:

Fig. 1 is a plan view of the invention shown in the closed contact position;

Fig. 2 is a plan view of the invention shown in the lockout position with the contacts open;

Fig. 3 is a schematic circuit diagram showing an embodiment of the switch as applied in combination with a heating control system; and

Fig. 4 is a graphic illustration of the operating characteristics of the invention under varying voltages compared to the operating characteristics of a thermal timer switch of the conventional type.

The thermal timer switch 2 as shown in Figs. 1 and 2 is preferably mounted on an insulating base 4 which is a fragmentary section of a panel containing other control components of the heating control system indicated in Fig. 3. The active portion of the switch comprises a first bimetallic element indicated generally at 6. It is

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formed into a U-shape with the higher expanding metal on the inside. The element 6 has a long leg 8 and a relatively shorter leg 10 extending substantially parallel thereto. The short leg 10 is suitably secured by riveting to an angular bracket 12. The bracket 12 is attached by screws to the base 4, so that the bimetal element 6 is supported solely from the end of the short leg 10. Nesting within the bight of the U-bend of the element 6 is a U-shaped metal block 14, one leg of which is fastened to the long leg 8 by screw 16. Clamped between the legs of the block 14 and electrically insulated therefrom is an electric heater 18 comprising several turns of resistor wire wound upon a bobbin. The heater 18 is positioned so as to effect the heating of the block 14 and subsequently the element 6 at the most advantageous point to effect a movement of the free end of leg 8. A slot 20 is cut near the free end of the leg 8 for a purpose to be further described.

A second bimetallic element 22 is also formed into a U-shape and has a long leg 24 and a relatively shorter leg 26 arranged substantially parallel thereto. The short leg 26 is riveted at its end to a bracket 28. The bracket 28 is fastened at its end 30 to the base 4 and supports the bimetallic element 22. The element 22 has the higher expanding metal on the outside to enable movement of leg 24 in the same direction as leg 8, upon the application of heat to the respective bimetallics. Nesting within the bight of the U-bend of element 22 is a heater 32 comprising several turns of temperature responsive resistor wire wound upon an insulated bobbin. The heater 32 is electrically insulated from the element 22 and secured to the leg 24 by means of a clamp 34 and screw 36. The heater 32 differs from the heater 18 in the type of resistance wire used; the heater 18 uses an ordinary resistance wire that responds to current to effect a certain wattage output substantially independent of the temperature of the wire, and the heater 32 uses a temperature responsive resistance wire, having a relatively high positive temperature coefficient of resistance, that responds to current to effect a certain wattage output and in addition responds to temperature changes to effect a resistance change to vary the wattage output. Also, the heater 32 must have a lower maximum resistance than the heater 18, such as a resistance of 60 ohms when cold and 90 ohms at its steady state temperature when a voltage of 28 volts is impressed across the heater circuit, and for heater 18 a fixed resistance of 100 ohms.

Extending across the free ends of long legs 8 and 24 is a latch member 37 one end of which is hinged or pivoted by pin 38 to a bracket 40. The bracket 40 is riveted to the free end of leg 24. The other end of latch 37 is provided with a tongue portion 42 which extends through the slot 20 of leg 8 into latching engagement therewith (Fig. 1). The latch 37 is formed with an opening in its bottom within which is arranged a leaf spring 43 having a contact 45 at one end thereof and secured near the pivoted end of latch 37 by means of rivets as shown. An extension 44 of spring 43 is curved behind pivot 38 and normally tends to urge the end of latch 37 downward about its pivot 38 when the tongue 42 is unlatched from slot 20. The spring 43 is free to flex within the opening of the latch 37. A second leaf spring 46 is secured to the bracket 12 and has its free end provided with a contact surface 48 which is in engagement with contact 45 when the latch is in its normal position as shown in Fig. 1. In order to reset the latch 37 when it is unlatched (Fig. 2), a pivoted reset lever 47 is provided (Fig. 3). A leaf spring 49 is biased in an upward direction to open the switch 51 upon resetting of the latch 37 by the lever 47. The switch 51 prevents operation of the system during the resetting opera-

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tion by opening the low voltage portion of the circuit of Fig. 3.

In the normal operation of the foregoing elements as an electrical thermal timer switch the bimetal element 6 serves as the active element while the bimetal element 22 is the compensating element. The element 22 being constructed in exactly the same shape and characteristics as element 6, and having its expansible metal arranged reversed from that of element 6, both will be effective to move the ends of their longer legs 8 and 24 respectively in the same direction and for exactly the same distance under the influence of ambient temperatures. The latch 37 is therefore always maintained with its tongue 42 in the slot 20 in the same relative latching engagement with the element 6 when both elements are affected by the ambient temperatures only. Since the leaf spring 46 is fixed relative to the leaf spring 43 a sliding or wiping action will take place between their contact points, without, however, opening them, when both elements move together in the same direction an equal distance.

When the heater 18 is traversed by electric current it generates heat which is absorbed and conducted through the metal block 14. The block 14 has substantial mass and initially serves to provide a thermal time lag whereby it requires the lapse of a predetermined time interval before the leg 8 begins to react to the heat generated in heater 18.

When the heater 32 is traversed by electric current it generates heat which is directly and rapidly transmitted to the bimetal element 22. Thus, the element 22 reacts quickly in contradistinction to the element 6. In addition, the heater 32 grows in resistance as its temperature rises to thereby decrease the current flow through both heaters 32 and 18 (Fig. 3) below its initial inrush value.

The circuit arrangement depicted in Fig. 3 discloses a practical embodiment of the thermal timer switch in which it serves the purpose of a safety switch in an oil burner circuit for a heating system, for example. As diagrammatically illustrated in conventional form the installation comprises the usual room thermostat 50, step-down transformer 52, a combustion responsive or stack switch 54 having an arm controlling a pair of normally open contacts 56, relay 58 having contacts 60 for controlling the circuit to the burner motor 62, and an ignition means 64 to ignite the fuel projected into the furnace by motor 62. It is also desirable that a limit control 66 be provided to guard against excessive or abnormal heat generated by the furnace. A suitable source of power is connected to the incoming wires 68 and 70.

In the normal operation of the circuit assume that the thermostat 50 closes its contacts in response to a call for heat in the space in which it is located. A low voltage circuit path is thereby established extending from the secondary winding of transformer 52, closed contacts of thermostat 50, switch contact 51, spring 49, wire 53, heater 32, heater 18, bimetallic element 6, latch 37, bimetallic element 22, wire 55, winding of electromagnet 53 and back to the other side of the secondary transformer winding. A certain portion of the current may flow through the long leg 8 to the tongue 42 and latch 37, but the contactual relation between these elements is uncertain and not reliable and therefore the contact springs 46 and 43 are provided to insure a current path at all times.

As a result of the completed circuit path the heater elements 18 and 32 are caused to generate heat. The heater 18 generates heat which slowly permeates the block 14 and gradually affects the bimetal element 6. The heater 32 generates heat which quickly affects the bimetal element 22. The electromagnet 53 also immediately energizes and closes its contacts 60 thereby establishing high voltage circuit paths for the burner motor 62 and the ignition means 64. The motor 62 projects fuel into the combustion chamber of the furnace where the ignition means 64 causes it to ignite. If combustion is established the combustion or stack switch 54 which has relative expansible

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and contractable thermostatic elements extending into the path of the combustion gases, causes its contacts 56 to close, thereby completing a shunt circuit around the heater elements 18 and 32. This shunt circuit can be traced from wire 57, contacts 56, wire 59, bimetal element 6, latch 37, bimetal element 22 and wire 55. The heaters 18 and 32 are thereby effectively deenergized while the electromagnet 53 remains energized and the control system functions normally to provide heat to a room or other enclosure.

Should it occur that the ignition means 64 fails to ignite the fuel in the combustion chamber when the circuit is closed, or there is an absence of fuel, the combustion switch 54 will not function to close its contacts 56, and the heaters 18 and 32 will not be shunted out of the circuit. Accordingly, the heaters are energized for the full time period. In this event the heater 32 will rapidly transmit heat to bimetal element 22 causing the long leg 24 to flex towards the short leg 26. The heater 18, has a higher resistance than heater 32 but initially transmits heat more slowly to its bimetal 6 because of the block 14. The block 14 initially acts as a heat retarder and subsequently as a heat conduit. Eventually the heater 18 will transmit more heat to its bimetal 6 than the heater 32 will transmit to its bimetal 22. At a predetermined time period here illustrated of, for example 120 seconds, which may be referred to as "lockout time," the deflection difference between legs 8 and 24 results in the unlatching of tongue 42 of latch 37 from the slot 20. This position is shown in Fig. 2. Note, that in Fig. 2, the deflection angle of leg 8 is greater than the deflection angle of leg 24, thereby releasing latch 37 and allowing spring extension 44 to pivot latch 37 clockwise about the pivot pin 38. This position, the lockout position of switch 2, requires manual attention to reset the latch 37. The unlatching of the switch 2 effects an open circuit condition through the heaters 18 and 32 and the relay 58 is deenergized. Thereafter, the cooling of the heaters allows the legs 8 and 24 to return to the position of Fig. 1 wherein the manual reset operation will be effective to again engage the tongue 42 in the slot 20. The control system is then ready for another cycle of operation.

In the case where flame failure occurs while the burner is running, the stack or combustion temperature will drop and as a result the combustion switch 54 will cool and open its contacts 56. The heaters 18 and 32, being no longer shunted, are effective to heat the bimetal elements to bring about the tripping of latch 37 and stop the burner as heretofore described.

Referring now to Fig. 4, the curves 30 and 31 indicate the lockout time versus applied volts relationship of a thermal timer or lockout switch which is not voltage compensated by a heater, such as heater 32, and the same relationship for the timer 2, embodying the present invention. Curve 31 represents the uncompensated timer, and indicated that for an uncompensated timer, as the applied voltage drops below 25 volts, the lockout time increases exponentially. This, of course, results from the decreased heat output of the heater (such as heater 18) at low voltage being unable to cause sufficient deflection of its bimetal leg to unlatch the switch. Increased voltage, and therefore increased heat output causes the bimetal leg to deflect and unlatch the switch more rapidly, as indicated by the curve 31.

Inspection of curve 30 indicates that, as in the case of curve 31, for low voltages, the lockout time increases exponentially as the voltage decreases, for the same reasons discussed above with reference to curve 31. At the high voltage end of curve 30, the lockout time also increases exponentially as the voltage increases, in this characteristic being different from the uncompensated timer curve 31. This would seem to occur because (as will subsequently be further explained) with increased voltages, the heat output of compensating heater 32 increases at a

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greater rate than does the heat output of heater 18 until the differential in heat output between heaters 18 and 32 is no longer sufficient to deflect bimetal leg 8 sufficiently, with relation to leg 24, to allow the switch to unlatch. In the apparatus embodying this invention an increase in voltage, above some reference voltage, across heaters 18 and 23 results in an increased output of both heaters 18 and 32. The initial effect of the increased voltage across heaters 18 and 32 is to cause an increased current to flow through them. Because of the thermal lag effect of block 14, however, before this increased current value is reflected in an increased deflection of bimetal 6, the additional heat produced at heater 32 by the increased current causes its resistance to increase which, in turn, reduces the increase in current flowing through both heaters 18 and 32. Since the resistance of heaters 18, even at the new voltage, is greater than the resistance of heater 32, the effect of the reduction in increase in current (because of the increase in resistance of heater 32) on the heat output of heater 18 is greater than the effect of the reduction in current increase on the heat output of heater 32. Thus at an increased voltage above the reference voltage, the heat output of heater 18, and consequently the deflection of bimetal 6, is increased but by an amount considerably less than its heat output would be increased if heater 32 were not in circuit with it and had not reduced the current flowing through the heaters. Also the heat output of heater 32 will increase at the new, higher voltage but by an amount proportionally greater than the increase in heat output of heater 18, this being so because, as previously pointed out, since the resistance of heater 18 is greater than that of heater 32, the heat output of heater 18 varies more widely with current variations than does the heat output of heater 32. In other words, with heater 18 and 32 in series, the heat output of heater 32 increases at a greater rate with increases in voltage than does the heat output of heater 18, this effect being utilized to compensate the lockout timing for voltage variations. As will be apparent from curve 80 of Fig. 4, when the voltage has increased to the point where the increased heat output of heater 32 overbalances the heat output of heater 18, the bimetal 22 will deflect to such an extent that deflection of bimetal 6 will be unable to unlatch the switch.

If the timer switch is caused to operate at a voltage less than some reference voltage, the heat output of both heaters 18 and 32 will be less than when operated at the reference voltage. The decreased operating temperature of heater 32 and its consequent reduced resistance prevents the current through the heaters from falling to the value it would have assumed if the resistance of heater 32 had not decreased. This, in effect, increases the heat output of heater 18. Because the resistance of heater 18 is greater than the resistance of heater 32, the increase has less effect on the heat output of heater 32, with the result that, upon a decrease in voltage, bimetal leg 6 deflects somewhat more, and leg 22 deflects somewhat less than would be the case if the heater 32 had a resistance of fixed value. These modified deflections of legs 22 and leg 6 are cumulative in their effect on the switch lockout timing and act in a direction to decrease the time required to unlatch the switch thereby compensating for the lengthening of the switch timing because of the low voltage.

As shown by curve 80 of Fig. 4, compensation for variations in voltage is obtained only over a range of voltage values. For example curve 80 is relatively flat only in the range of 30 to 45 volts and indicates that for a given timer design, only a portion of the lockout time versus applied volts curve will be relatively flat, this relatively flat portion of the curve, of course, being shiftable to different voltage values with changes in the design characteristics of the thermal timer.

It will be apparent, as previously pointed out, that in timing switches of the type here disclosed, using only one heater, changes in the operating voltage will result

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in substantial timing changes. Further, a lockout switch of the type disclosed herein, in which the heater 32 having a substantial temperature coefficient of resistance is not placed in heat exchange relation with bimetal 22 but is used merely as a compensating resistor in series with the heater 18, would give an improved lockout timing compensation (since the current through heater 18 would be varied with operating voltage changes) but would not be as satisfactory as the arrangement of the present invention which compensates for operating voltage changes by utilizing two additive effects (1) the variation in current through heater 18 to change its heat output, and (2) the change in resistance of heater 32 to change its heat output. Utilization of these two effects results in a relatively flat lockout time versus applied volts curve for a given range of voltage values.

Various modifications coming within the spirit of the invention may suggest themselves to those skilled in the art and hence the invention is not to be limited to the specific form shown, except to the extent indicated in the appended claims.

What is claimed is:

1. A thermal timer switch including first and second temperature responsive elements, a first electric resistance heater mounted in heat conducting relationship to a first one of said elements to cause the first element to move upon being heated, a second electric resistance heater having a relatively large thermal coefficient of resistance and electrically connected in series with the first heater, said second heater being mounted in heat conducting relationship to the second element to cause the second element to move upon being heated, and control means jointly connected to said elements and operated thereby a predetermined time after said heaters are energized, the coefficient of resistance of said second heater being larger than the coefficient of resistance of said first heater.

2. A thermal timer switch including first and second temperature responsive elements both having portions moveable in the same direction when heated, a first electric resistance heater mounted in heat conducting relationship to a first one of said elements to cause movement of said portion of the first element, a second electric resistance heater having a relatively large thermal coefficient of resistance and electrically connected in series with the first heater, said second heater being mounted in heat conducting relationship to the second element to cause said portion of the second element to move upon being heated, and control means jointly connected to said elements including electrical contacts operated to open position a predetermined time after said heaters are energized, the coefficient of resistance of said second heater being larger than the coefficient of resistance of said first heater.

3. A thermal timer switch including a pair of bimetal elements each supported at one of their ends, a first electric resistance heater mounted in heat conducting relationship to one of said elements for causing movement of the free end of said one element, a second electric resistance heater mounted in heat conducting relationship to the other element for causing movement of the free end of the other element, said first and second heaters being electrically connected in series, the first heater having a relatively small thermal coefficient of resistance and the second heater a relatively large thermal coefficient of resistance, the first heater having a greater electrical resistance than said second heater, and control means jointly connected to said elements and operated thereby a predetermined time after said heaters are energized.

4. A thermal timer switch including a pair of bimetal elements each supported at one of their ends, a first electric resistance heater mounted in heat conducting relationship to one of said elements for causing movement of the free end of said one element, a second electric resistance heater mounted in heat conducting relationship to the other element for causing movement of the free end of the other element, said first and second heaters being electrically connected in series, the first

heater having a relatively small thermal coefficient of resistance and the second heater a relatively large thermal coefficient of resistance, the first heater having a greater electrical resistance than said second heater, a member mounted between said first heater and said one element and providing a time lag in the transmission of heat from said first heater to said one element, and control means jointly connected to said elements and operated thereby a predetermined time after said heaters are energized.

5. A thermal timer switch including a pair of bimetal elements each supported at one of their ends, a latch pivoted to the free end of one element and having latching engagement with the free end of the other element, first and second electric resistance heaters each mounted in heat conducting relation to corresponding ones of said elements for causing relative movement of the free ends of the elements to release the latch, said first and second heaters being electrically connected in series, the first heater having a relatively small thermal coefficient of resistance and the second heater a relatively large thermal coefficient of resistance, the first heater having a greater electrical resistance than said second heater, a member mounted between said first heater and its corresponding element and providing a time lag in the transmission of heat from said first heater to its corresponding element, and control means operated by said latch including electrical contacts moved to open position upon release of said latch.

6. A thermal timer switch including a pair of bimetal elements each supported at one of their ends, a latch pivoted to the free end of one element and having latching engagement with the free end of the other element, first and second electric resistance heaters each mounted in heat conducting relation to a corresponding one of said elements for causing relative movement of the free ends of the elements to release the latch, said first and second heaters being electrically connected in series, the first heater having a relatively small thermal coefficient of resistance and the second heater a relatively large thermal coefficient of resistance, the first heater having a greater electrical resistance than said second heater, a member mounted between said first heater and its corresponding element and providing a time lag in the transmission of heat from said first heater to its corresponding element, and a switch connected in series with said first and second heaters and operated by said latch, said switch being moved by said latch to open position to disconnect said heaters upon release of said latch.

7. A voltage compensated thermal timing mechanism including a pair of bimetal elements each supported at one of their ends, a first electric resistance heater mounted in heat conducting relationship to one element for causing movement of the free end of said one element, a second electric resistance heater mounted in heat conducting relationship to the other element for causing movement of the free end of the other element, control means operated by a predetermined relative movement of said free ends, said first and second heaters being electrically connected in series and adapted to be connected across a voltage source which is subject to voltage variations, said first and second heaters having relatively small and relatively large thermal coefficients of resistance respectively, the first heater having a greater electrical resistance than said second heater, and a member mounted between said first heater and said one element and providing a time lag in the transmission of heat from said first heater to its adjacent element whereby upon a variation in voltage available at said voltage source the resulting change in resistance of said second heater produces a corrective change in the heat output of both of said heaters to maintain substantially constant the time in which said predetermined relative movement of said free ends occurs.

8. A voltage compensated thermal timing mechanism including a pair of bimetal elements each supported at one of their ends, a first electric resistance heater mounted in heat conducting relationship to one of said elements for causing movement of the free end of said one element, a second electric resistance heater mounted in heat conducting relationship to the other element for causing movement of the free end of the other element, a latch pivotally connected to the free end of one element and having latching engagement with the free end of the other element, said latch being released by a predetermined relative movement of said free ends, a switch having an element thereof mounted on said latch and controlled by the release of the latch, said first and second heaters being electrically connected in series and adapted to be connected across a voltage source which is subject to voltage variations, said first and second heaters having relatively small and relatively large thermal coefficients of resistance respectively, the first heater having a greater electrical resistance than said second heater, and a member mounted between said first heater and said one element and providing a time lag in the transmission of heat from said first heater to said one element whereby upon a variation in voltage available at said voltage source the resulting change in resistance of said second heater produces a corrective change in the heat output of both of said heaters to maintain substantially constant the time in which said predetermined relative movement of said free ends occurs.

9. A voltage compensated thermal timing mechanism including a base, two U-shaped bimetal elements, means for mounting one leg of each element on the base, first and second electric resistance heaters each mounted within the bight of said elements and adapted to transmit heat to said elements for causing movement of the free ends thereof, a latch pivotally connected to the free end of one element and releasably engaging the free end of the other element, said latch being released by a predetermined relative movement of said free ends, a switch controlled by the release of the latch, said first and second heaters and said switch being electrically connected in series and adapted to be connected across a voltage source which is subject to voltage variations, said first and second heaters having relatively small and relatively large thermal coefficients of resistance respectively, the first heater having a greater electrical resistance than said second heater, mounting means for said first heater including a member providing a time lag in the transmission of heat from said first heater to its adjacent element whereby upon a variation in voltage available at said voltage source the resulting change in resistance of said second heater produces a corrective change in the heat output of both of said heaters to maintain substantially constant the time in which said predetermined relative movement of said free ends occurs.

References Cited in the file of this patent

UNITED STATES PATENTS

1,822,191	Appleberg	Sept. 8, 1931
1,920,806	Rich	Aug. 1, 1933
1,957,085	Taylor	May 1, 1934
1,974,188	Martin	Sept. 18, 1934
2,002,467	Blodgett	May 21, 1935
2,216,748	Lindeman	Oct. 8, 1940
2,242,183	McGrath	May 13, 1941
2,269,443	Deubel	Jan. 13, 1942
2,294,191	Lord	Aug. 25, 1942
2,371,018	Ashworth et al.	Mar. 6, 1945
2,499,906	Crise	Mar. 7, 1950
2,581,636	Cunningham et al.	Jan. 8, 1952