Oct. 19, 1948. W. SAMBUR 2,451,778

THERMOTEMPORAL RESPONSIVE DEVICE

Filed Nov. 13, 1942

2 Sheets-Sheet 1

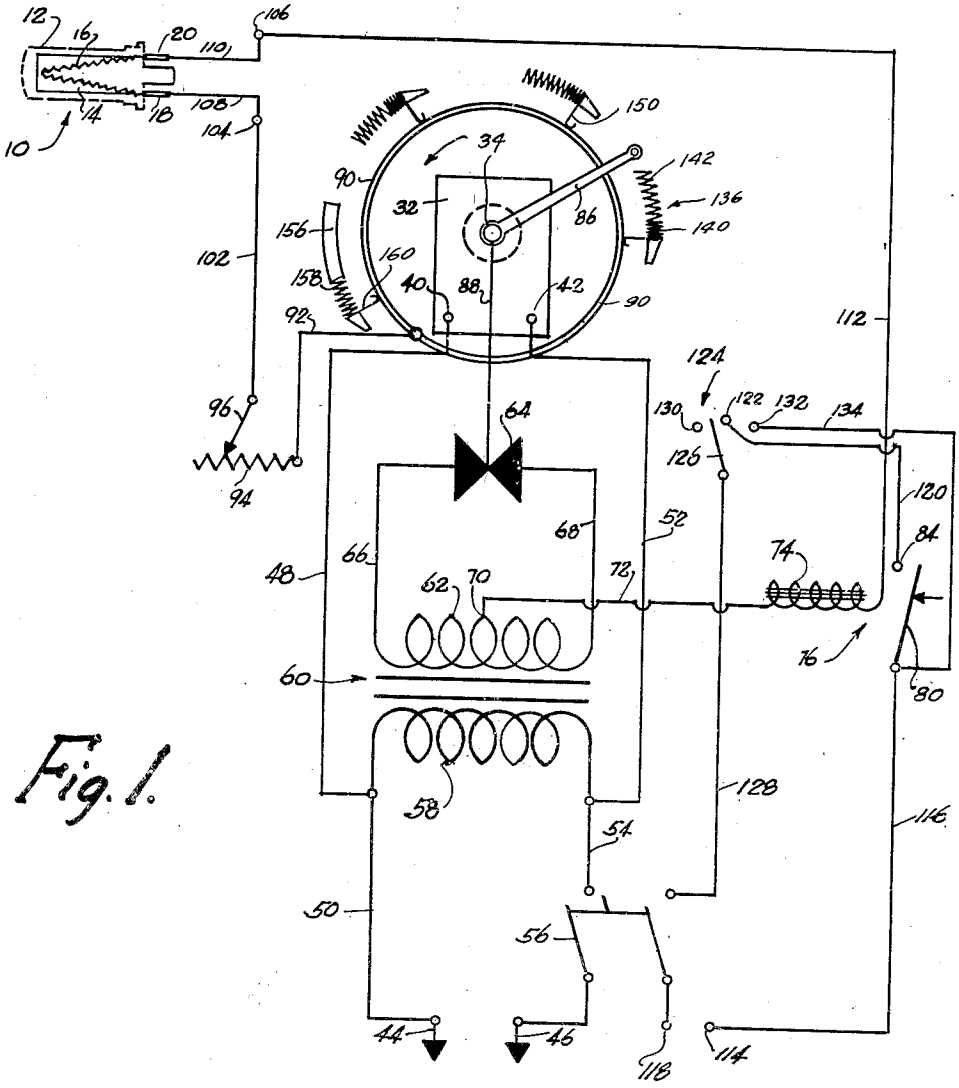


Fig. 1.

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2 Sheets-Sheet 2

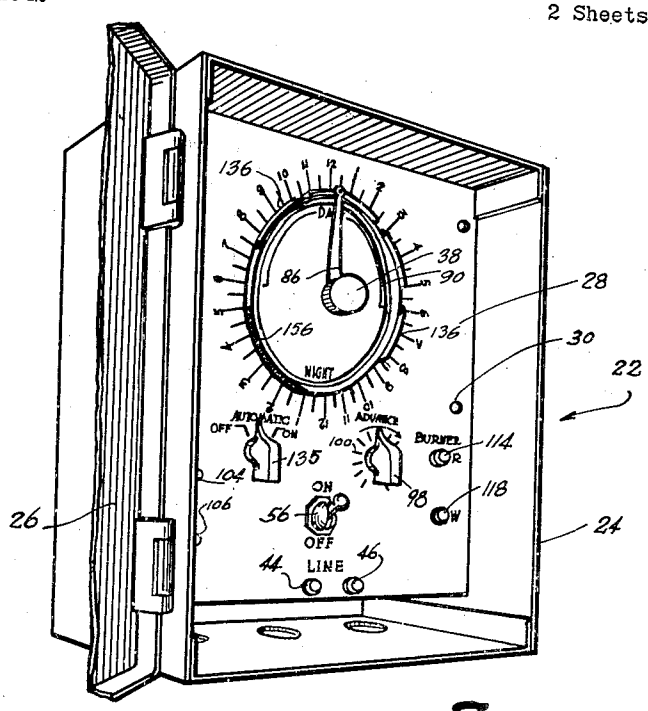


Fig. 2.

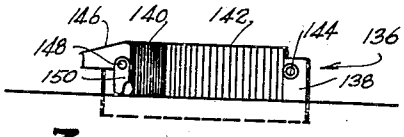


Fig. 3.

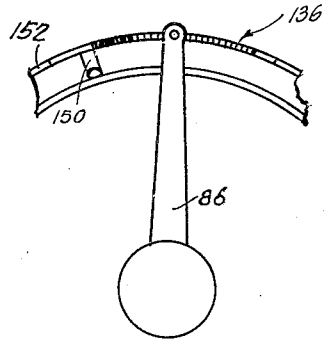


Fig. 4.

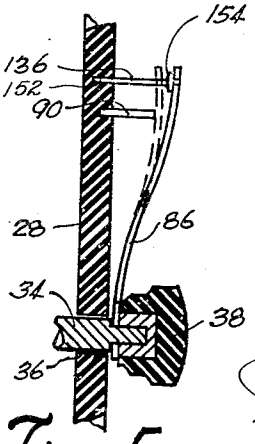


Fig. 5.

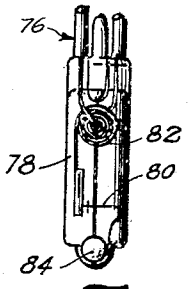


Fig. 6.

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UNITED STATES PATENT OFFICE

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THERMOTEMPORAL RESPONSIVE DEVICE

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Application November 13, 1942, Serial No. 465,437

11 Claims. (Cl. 236—46)

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This invention relates to thermo-temporal responsive devices. More particularly the invention pertains to a control adapted to be used with intermittently operated mechanisms, such as furnaces, for altering the duration of the operating periods, set in accordance with a predetermined but variable temporal schedule, to compensate for changes in ambient temperature.

The prime object of the invention is to provide an improved control device of the character described which shall be simple in design, relatively inexpensive to manufacture and install, easy to assemble, rugged in construction, neat in appearance, and which at the same time shall operate with a high degree of usefulness and efficiency.

Other objects of the invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists of the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter described, and of which the scope of application will be indicated in the appended claims.

In the accompanying drawings, in which is shown one of the various possible embodiments of the invention,

Fig. 1 is a schematic circuit diagram of the improved control device;

Fig. 2 is a perspective view of the indoor control box;

Fig. 3 is a detail view of one of the variably positioned temporally responsive control elements mounted in the control box;

Fig. 4 is a detail face view which is illustrative of the cooperation between such element and a clock-controlled contact arm;

Fig. 5 is a sectional view through said element and arm and further shows in dotted lines the position the arm assumes when it is out of contact with the element; and

Fig. 6 is a front view of a control switch used in the control device.

In general, the functions of a control device, of the type to which the instant invention pertains, are to operate a mechanism, such as a furnace during preselected minimum periods of the day which are determined by the minimum demands on the mechanism at the higher of two preselected ambient temperatures; to enable the preselected periods to be easily and readily varied to accommodate for long range changes in the quantity of demand; to automatically shut off the mechanism when the ambient temperature exceeds the preselected higher temperature; to automatically continuously operate the mechanism when the ambient temperature falls below the lower of the two preselected ambient temperatures; to enable the preselected temperatures to be easily and readily varied to accommodate for long range changes in the quality of demand; and to lengthen the periodic operations of the device in proportion to the fall of ambient temperature when the ambient temperature fluctuates between the higher and lower preselected temperatures.

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Heretofore, these several functions were carried out by control devices comprising a combination of a large number of means of which certain, such as the high temperature shut off, were independently operating mechanisms, and of which practically all were complicated mechanical structures requiring many accurately machined parts. As a result previous controls of the character described were large and bulky mechanisms which were difficult and expensive to manufacture, install and repair and often broke down during use.

In accordance with the present invention there is provided a control device of the character described which avoids the foregoing difficulties and drawbacks by employing a thermally responsive electrical means and a plurality of temporally responsive electric means all of which mutually coact in combination with other electrical means to obtain the desired functions. The thermally and temporally responsive means may be mechanically operated by simple, rugged mechanisms but, preferably, only the temporally responsive means is so actuated and the thermally responsive means instead employs a well-known, non-mechanical, thermoelectric phenomenon.

More specifically the improved control device comprises an outdoor element which includes an electrical means whose impedance varies to conform to changes in ambient temperature. Such means can comprise an inductance, a capacitance, or a resistance where alternating current is used as a source of power. For reasons which will shortly be apparent, the preferred form of the invention, hereinafter described in detail, employs a resistance. The impedance value of the electrical means can be varied by any simple, rugged mechanism, such as a bellows or bimetallic element; but as previously noted, it is desirable although the invention is not so limited, to employ a well-known thermoelectric phenomenon, to wit: the variation in resistance of a resistor with change of temperature.

The control device also comprises an indoor control box which essentially includes a plurality

of electric means whose impedance varies with the passage of time. Such means can, like the outdoor element comprise an inductance, a capacitance or a resistance, although the invention is most easily carried out by use of a resistance. The impedance value of the electrical means is preferably varied by a clock-controlled mechanism, it being understood however, that other time measuring means are within the scope of the invention.

The indoor control box further includes a switch which closes upon application of a certain potential. Examples of such switches are the glow heated bimetallic switch and electronic tube. When switches such as these are employed it is additionally necessary to use an independent high ambient temperature cut-off or low ambient temperature lock-in means. There is, therefore, preferably employed a switch which in addition to the foregoing characteristic opens when, after closing, the applied potential drops below a certain potential, lower than the potential required to close the switch. Switches of the electro-magnetic type have both these characteristics.

The switch, thermally responsive electrical means, and temporally responsive electrical means are electrically connected in a circuit such that the period of operation of the mechanism being controlled, following a minimum period of operation, is a function of the ambient temperature. To this end the thermally responsive and temporally responsive electrical means may be connected in a series, parallel, or series-parallel circuit depending upon whether in these various electrical means the impedance increases or lowers with a rise in temperature and the passage of time.

Finally the indoor control box includes sundry means for rendering the operation of the control device highly flexible, for increasing safety, and for simplifying installation.

Referring now in detail to the drawings, there is disclosed an outdoor element **10** (Fig. 1) comprising a weatherproof, watertight housing **12** of an electrically non-conductive material such as "Bakelite" or mica, on which is supported in conventional manner, as by winding or traversing, a coiled resistor **16** of a material whose resistance varies with its temperature. A typical material which is satisfactory for this purpose is an iron-nickel alloy consisting of 70% nickel and 30% iron. This alloy has about twice the resistance of commercially pure nickel and the slope of its temperature-resistance curve is straight from 20° C. to over 100° C. Said alloy is known as "Balco." The two ends of the resistor **16** lead to terminals **18, 20** which are detachably received in a conventional socket (not shown). In order to facilitate description the resistance value for such resistor will now be assigned, it being understood however, that such value, as well as all other values hereinafter assigned to the various elements of the control device, are given by way of example only, and are in no way to be construed as a limitation upon the invention. The resistance value of the resistor **16** is 175 ohms at a temperature of 60° F. and 153 ohms at 20° F. The resistance value between said temperatures is a linear function of the temperature.

The indoor control box **22** (Fig. 2) comprises a metallic box **24** closed by a hinged cover **26**. A panel **28** is firmly secured to the box **24** by screws **30** and angle irons (not shown). Said panel is fabricated from an electrically non-conductive material of appreciable strength, such as "Bakelite" or "Fibreboard" and supports all indoor operative elements of the control device. The panel carries on its rear face a synchronous twenty-four hour electric clock **32** (Fig. 1) whose shaft **34** (Fig. 5) projects through an aperture **36** in said panel. A knob **38** facilitates setting of the shaft. The clock terminals **40, 42** are electrically connected to line terminals **44, 46** for an alternating current source by lead wires **48, 50, 52, 54** through a single-throw double-pole manually operated switch **56** accessibly mounted on the panel **28**. Line terminals **44, 46** are also connected by lead wires **50, 54** to the primary **58** of a step down transformer **60**. The opposite ends of the transformer secondary **62** are connected to a full wave rectifier **64** by lead wires **66, 68**. The output potential of said rectifier is 9.5 volts. The center tap **70** of the transformer is connected by a lead wire **72** to an iron-core solenoid **74** mounted on the rear of the panel **28**. Said solenoid acts as the electro-magnetic actuating element of a control switch generally indicated by the numeral **76**. This switch also includes a glass envelope **78** rigidly secured to the panel. An arm **80** is pivotally mounted in said envelope on a spiral spring **82** which biases the arm away from the solenoid **74** disposed adjacent the glass envelope **78**. An iron bar carried on the arm **80** increases its attraction for the solenoid when the same is sufficiently energized. The lower end of the envelope contains a pool **84** of mercury which with the free end of the arm **80** forms the two operating contacts of the switch **76**. When the solenoid is fully energized the free end of the arm is in the pool **84** and when the solenoid is de-energized the free end of the arm is spaced from said pool.

The switch parts are so proportioned and arranged that when a total impedance of 180 ohms is interposed between the rectifier **64** and the solenoid **74** the switch will close and that when this impedance is increased to 230 ohms, the switch will open. By virtue of the differential, the total impedance must drop to 180 ohms to close the switch and be raised to 230 ohms to open the switch.

Suitable means is provided to vary the impedance interposed between the rectifier **64** and switch **76** in accordance with a predetermined minimum control schedule, and the ambient temperature and passage of time between the minimum operation periods of such schedule. Such means comprises a contact arm **86** which rotates with the clock shaft **34**. Said arm is electrically connected by a lead wire **88** to the rectifier **64**. The arm is of a resilient electrically conductive material such as phosphor bronze and is adapted to have a portion thereof adjacent the free end ride on the surface of an electrically conductive ring **90** imbedded in the panel **28**. To simplify the wiring diagram, the bottom portion of the ring is broken away in Fig. 1. Said ring is disposed concentrically of the clock shaft **34** and projects from the front face of the panel. The ring is connected by lead wire **92** to a compensating resistance **94** of 10 ohms. The contact arm **96** associated with this resistance is manually rotated by a handle **98** having an index pointer which cooperates with temperature indicating markings **100** on the control panel. As will soon be seen, the position of the handle **98** regulates the indoor temperature of a building heated by a burner which is controlled by the device being described.

The resistor arm 96 is connected by lead wire 102 to a contact 104 for the outdoor element 10. This contact 104 and the other outdoor element contact 106 are connected to said outdoor element by a pair of thermostat wires 108, 110. Because the potential applied to these wires can never be greater than the rectified potential of 10 volts, the installation of such wires is an extremely simple affair and their short circuiting can not create a fire hazard. The second element terminal 106 is connected to the solenoid by lead wire 112 completing the energizing circuit.

The switch contact 80 is connected to the burner terminal 114 by lead wire 116. The other switch contact 84 is connected to burner terminal 118 by lead wire 120, contact point 122 of a three-way switch 124, contact arm 126 of said switch lead wire 128 and finally two-pole switch 56. Of the other two contacts of three-way switch 124, the contact point 130 is dead, and the contact point 132 and lead wire 134, when engaged by the contact arm 126, shunt switch contacts 80, 84. Thus when the handle 135 of the three-way switch 124 has its pointer registered with the "Off" indicia imprinted on the panel 28, the contact arm 126 will engage the dead contact point 130 and open the circuit connecting the burner terminals 114, 118; when the handle 135 has its pointer registered with "On" indicia, the contact arm will engage the shunting contact point 132 and close the circuit between the burner terminals; and when the handle pointer is registered with the "Automatic" indicia, the circuit connecting the burner terminals will include the switch contacts 80, 84.

There are also provided a plurality of temporally responsive control elements 136 comprising a thin flexible strip 138 of an electrically non-conductive material such as "Bakelite." Wound upon this strip are two series-connected resistors 140, 142. The resistor 140 has a value of 50 ohms and consists of high resistance wire closely wound so as to occupy a relatively small space for reasons which will soon be apparent. The resistor 142 on the other hand is of a lower resistance wire and has its turns more widely spaced. The end of said resistor 142 spaced from the resistor 140 is anchored to the strip 138 by an eyelet 144. The end of the resistor 140 spaced from resistor 142 is caught under a sloping electrically conductive clip 146 held to the strip 138 by an eyelet 148 having an integral electrically conductive tail 150. The elements 136 are removably, snugly and firmly received in a circular groove 152 having the same center as the ring 90 but of larger diameter. Said elements are so fashioned that when positioned in the groove 152 they will extend further from the panel 28 than said ring. The sloping clip 146 is designed so that its higher end is level with the top edge of the wound resistors 140, 142 and its lower edge approximately level with a silver contact 154 at the end of the clock contact arm 86 when said arm is riding on the ring 90. The tail 150 is curved to contact the ring 90.

There is also inserted in the groove 152 a night strip 156 comprising a strip of "Bakelite" for the major portion of its length. On the end of the night strip, near morning operation of the burner, a long 22 ohm resistance 158 is provided similar to the resistance 142. This resistance has a contact tail 160 similar to the tails 150 employed on the elements 136.

The several elements 136 and night strip 156 are arranged in the groove 152 so as to leave

space therebetween which, as will soon be apparent, govern the minimum schedule of operations of the mechanism governed by the control device.

The operation of the device will be considered at four different ambient temperatures, to wit: 59° F., 40° F., 61° F., and 20° F. The switch handle 135 will be deemed to be set at "Automatic."

At 59° F. the outdoor element 10 will have a resistance of approximately 174.5 ohms. The compensating resistance 94 which for ordinary operation is set midway will have a resistance of 5 ohms. Thus, when the contact arm 86 is riding on the ring 90, 179.5 ohms will be interposed in series between the rectifier 64 and the solenoid 74. Under these circumstances the switch 76 will be closed. After the arm 86 reaches the end of the short 50 ohm resistor 140 resistance will quickly be added to total 229.5 ohms so that when the arm reaches the end of said resistor 140 the switch 76 will still be closed. This marks the end of a predetermined minimum operating period. As the arm 86 travels further it will soon cut in 0.5 ohm of the long 22 ohm resistor 142 so that shortly after the arm has commenced to ride on said resistor 142 a total of 230 ohms will be in series with the solenoid 74 and cause the switch contacts 80, 84 to separate, shutting off the oil burner.

At 40° F. the outdoor element will have a resistance of about 164 ohms so that the switch 76 will remain closed until the contact arm 86 has moved far enough along the resistor 142 to cut in 11 ohms and open the contacts 80, 84. It will thus be seen that the length of the resistance 142 governs the length of operation added to the minimum period of operation. The elements 136 may be set in accordance with the known demand for the mechanism (oil burner) regulated by the control device.

At 20° F. the outside element has a resistance value of 153 ohms so that when the contact arm 86 reaches the end of the resistance 142 230 ohms will be cut in to open the switch 76. However as soon as this happens the arm 86 will drop back to the ring 90 and immediately reclose the switch thus obtaining continuous operation of the oil burner.

At 61° F. the outside element has a resistance value of 175.5 ohms so that with the 5 ohms compensating resistance 94, 180.5 ohms will be in circuit. This however is not sufficient to close the switch 76 after it has been opened. At this temperature, therefore, the oil burner will remain off.

By increasing or decreasing the value of the compensating resistor the high and low ambient temperature will be respectively decreased and raised. It will also decrease and raise, respectively, the mean temperature of a building heated with an oil burner governed by the control device.

The action of the night strip 156 is as follows: When the contact arm 86 rides on the bare portion of the strip 156 it will be raised off the ring 90 and open the energizing circuit for the solenoid 76 so that for a given period of time, for example from 1 a. m. to 5 a. m. (Fig. 2) the oil burner will be shut off regardless of ambient temperature.

The foregoing is true if no resistance winding 158 is employed. If such winding is used, then, when the arm 86 rides thereon, a resistance equalling the sum of the outdoor resistance 16, the compensating resistance 94, and the resistance

158 is again placed in circuit. It should be noted that movement of the arm 86 along the resistance 158 decreases the resistance in circuit as contrasted to movement of the arm 86 along one of the resistances 142 which increases the resistance in circuit.

To explain the operation of the resistance 158 an ambient temperature of 40° F. will be considered. At this temperature the outside element 10 has a resistance value of 164 ohms, the compensating resistance a value of 5 ohms, and when the arm 86 first rides on the resistance 158, said resistance has a value of 22 ohms. Thus when said arm 86 first touches the resistance 158 a total of 191 is in circuit and the switch 76 will remain open. When the arm 86 reaches the middle of the resistance 158 the total resistance will have decreased to 180 ohms, enough to close the switch 76 and start the oil burner. At higher temperatures the burner will start later, and at lower temperatures earlier.

If any surge potential is noted which tends to start operation when the arm 86 first contacts the resistance 158, an additional short high resistance (not shown) similar to the resistance 140 can be placed at the end of the resistor 158 remote from the tail 150.

It will be understood, of course, that as long as the switch 56 is open, the control device will not function.

It may be mentioned that variation in the rectified potential arising from aging of the rectifier 64 over long periods of time (12,000 hours) can be corrected by adjusting the compensating resistance 94.

It will thus be seen that there is provided a device which achieves the several objects of this invention and which is well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention and as various changes might be made in the embodiments above set forth, it is to be understood that all matters herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including time controlled means to render said actuating means operative to set said mechanism in operation at a preselected time of the day, means to vary the potential applied to said actuating means in proportion to temperature, and time controlled means to vary the potential applied to said actuating means in proportion to the time elapsed after a preselected period of time following the beginning of a period of operation of the mechanism at said preselected time so as to stop operation of said mechanism after a time lapse following the preselected period of time, said lapse being proportional to temperature.

2. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including time controlled means to render said actuating means operative to set said mechanism in operation at a preselected time of the day, means to vary the potential applied to said actuating means in proportion to temperature, and time controlled means to vary the potential applied to said actuating means in proportion to the time elapsed after a preselected period of time following the beginning of a period of operation of the mechanism at said preselected time so as to stop operation of said mechanism after a time lapse following the preselected period of time, said lapse being proportional to temperature, said last named means varying the potential in a direction opposite to that in which it is varied by a decrease in temperature.

3. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including time controlled means to render said actuating means operative to set said mechanism in operation at a preselected time of the day, means to vary the potential applied to said actuating means in proportion to temperature, and time controlled means to vary the potential applied to said actuating means in proportion to the time elapsed after a preselected period of time following the beginning of a period of operation of the mechanism at said preselected time, said last named means varying the potential in a direction opposite to that in which it is varied by a decrease in temperature so as to stop operation of said mechanism after a time lapse following the preselected period of time, which lapse is inversely proportional to temperature.

4. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including a plurality of time controlled means to render said actuating means operative to set said mechanism in operation at different preselected times of the day, means to vary the potential applied to said actuating means in proportion to temperature, and a plurality of time controlled means to vary the potential applied to said actuating means in proportion to the time elapsed after preselected periods of time following the beginnings of periods of operation of the mechanism at said preselected times so as to stop operations of said mechanisms after time lapses following the preselected period of time, which lapses are inversely proportional to temperature, said last named means varying the potential in

a direction opposite to that in which it is varied by a decrease in temperature.

5. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including time controlled means to render said actuating means operative to set said mechanism in operation at a preselected time of the day, means to vary the potential applied to said actuating means in proportion to temperature, and time controlled means to vary the potential applied to said actuating means in proportion to the time elapsed after a preselected period of time following the beginning of a period of operation of the mechanism at said preselected time so as to stop operation of said mechanism after a time lapse following the preselected period of time, which lapse is proportional to temperature, said last named means varying the potential in a direction opposite to that in which it is varied by a decrease in temperature, the over-all change in potential effected by the potential varying temperature responsive means over its full range of operation being of the same order as the over-all change in potential effected by the potential varying time controlled means over the latter's full range of operation.

6. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including time controlled means to render said actuating means operative to set said mechanism in operation at a preselected time of the day, means to vary the potential applied to said actuating means in proportion to temperature and in such direction upon a decrease in temperature as to inhibit an actuation of the switch which would stop the mechanism from operating, and time controlled means to vary the potential applied to said actuating means in proportion to the time elapsed after a preselected period of time following the beginning of a period of operation of the mechanism at said preselected time and in a direction opposite to that in which it is varied by a decrease in temperature so as to stop operation of said mechanism after a time lapse following the preselected period of time, which lapse is inversely proportional to temperature, whereby a change in the potential applied to said actuating means, which change is effected by the potential varying temperature responsive means and results from a decrease in temperature, is counteracted with the passage of time following said preselected period of time by the change in potential which is effected by the potential varying time controlled means, and the period of operation of said mechanism thus increased upon a decrease in temperature.

7. A control device as set forth in claim 6 wherein the potential varying temperature responsive means and the potential varying time controlled means are variable impedances.

8. A control device as set forth in claim 6 wherein the potential varying temperature responsive means and the potential varying time controlled means are variable resistances.

9. A control device as set forth in claim 6 wherein the potential governing the operation of the actuating means is such that the change in potential effected by the potential varying temperature responsive means at temperatures above the predetermined temperature range renders the first named time controlled means ineffective to set the mechanism in operation at a preselected time of the day.

10. A control device as set forth in claim 6 wherein the potential governing the operation of the actuating means is such that the change in potential effected by the potential varying temperature responsive means at temperatures below the predetermined temperature range renders the potential varying time controlled means ineffective to stop operation of the mechanism.

11. A control device for intermittently operating a mechanism with respect to a predetermined outdoor temperature range for periods of time which increase in proportion to decreases of temperature within said range, said device comprising a control switch for turning said mechanism off and on and an energizing circuit including an electric actuating means for said switch, the operation of said actuating means being governed by the value of the potential applied thereto, said circuit including time controlled means to render said actuating means operative to set said mechanism in operation at a preselected time of the day, and time controlled means for varying the potential applied to said actuating means in such manner as to cause interruption of the operation of said mechanism after an interval, determined by temperature, starting after a preselected period of time following the beginning of a period of operation of the mechanism at said preselected time.

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