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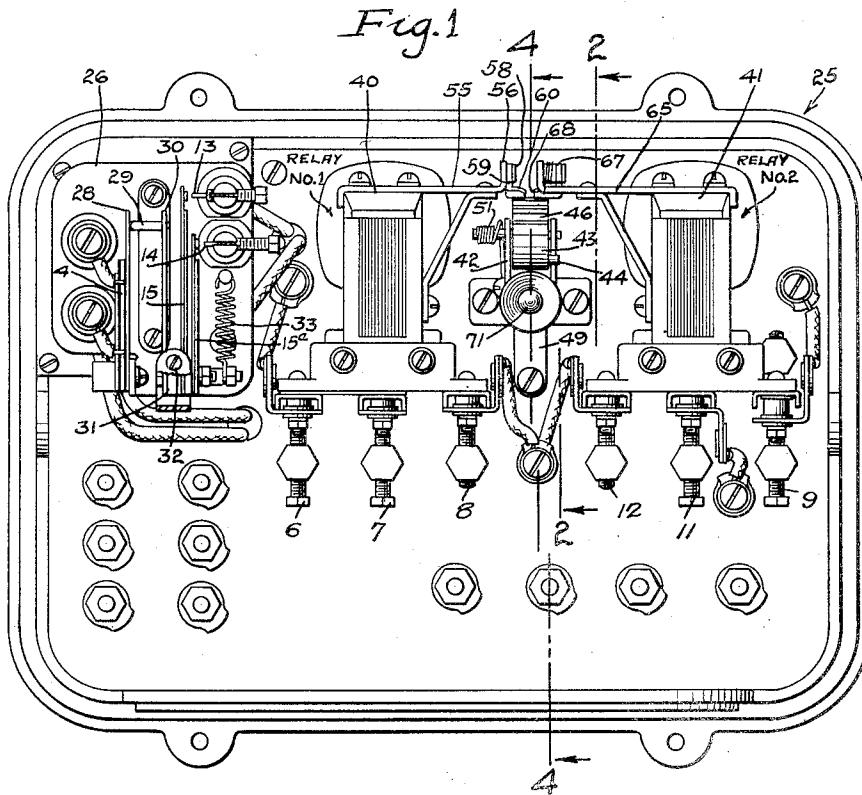
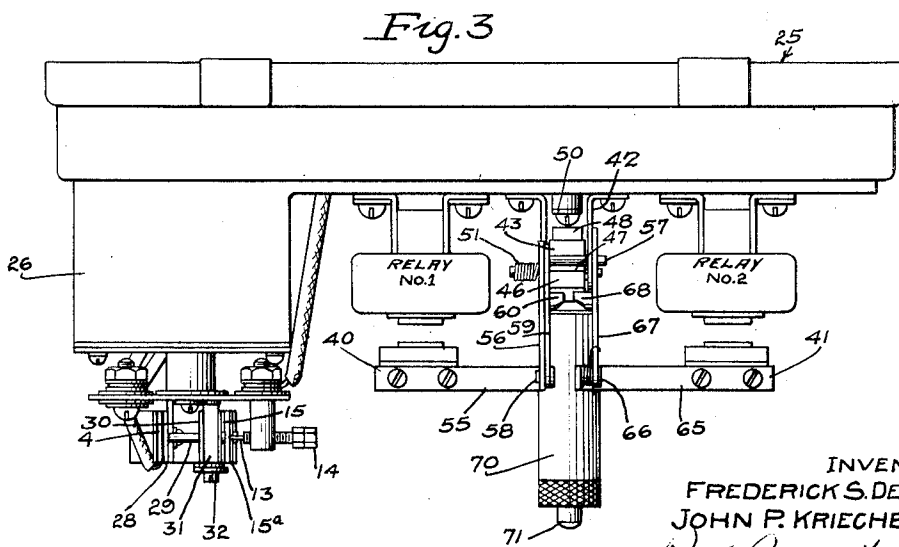
F. S. DENISON ET AL

2,070,118

BURNER APPARATUS CONTROL MECHANISM

Filed June 18, 1931

5 Sheets-Sheet 1



INVENTORS
 FREDERICK S. DENISON
 JOHN P. KRIECHBAUM
 By *Paul, Paul & Moore*
 ATTORNEYS

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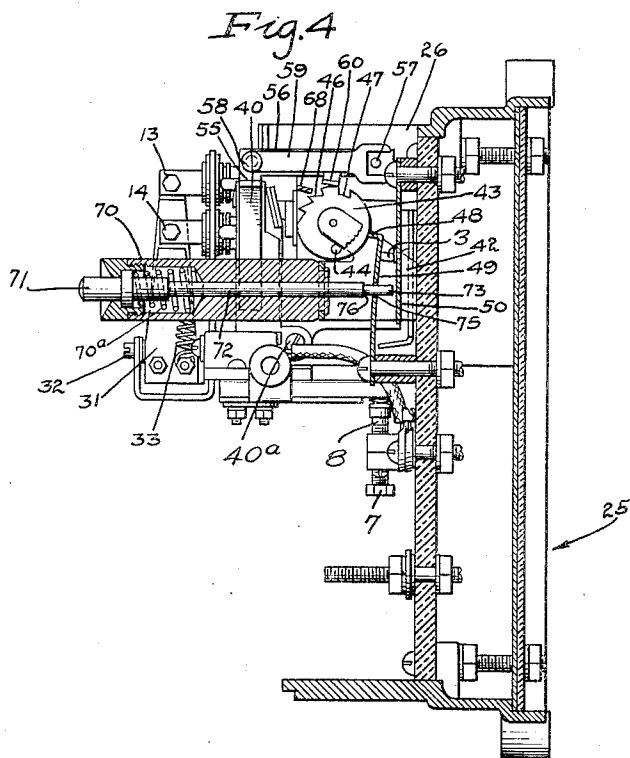
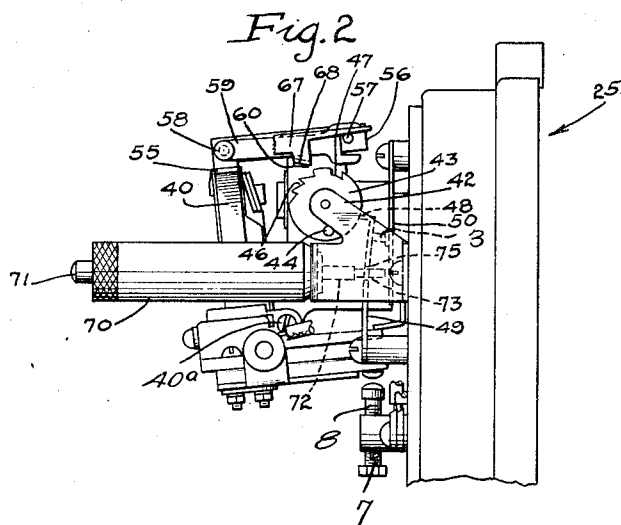
F. S. DENISON ET AL

2,070,118

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5 Sheets-Sheet 2



INVENTORS
FREDERICK S. DENISON
JOHN P. KRIECHBAUM
By *Paul R. Kriechbaum*
ATTORNEYS

Feb. 9, 1937.

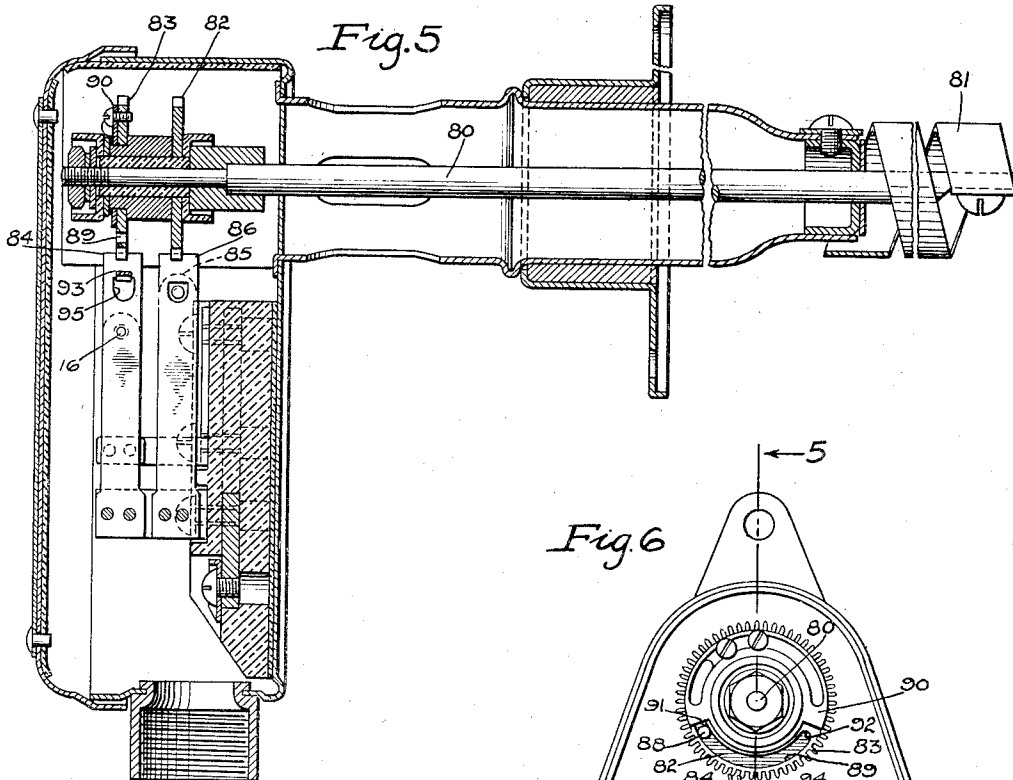
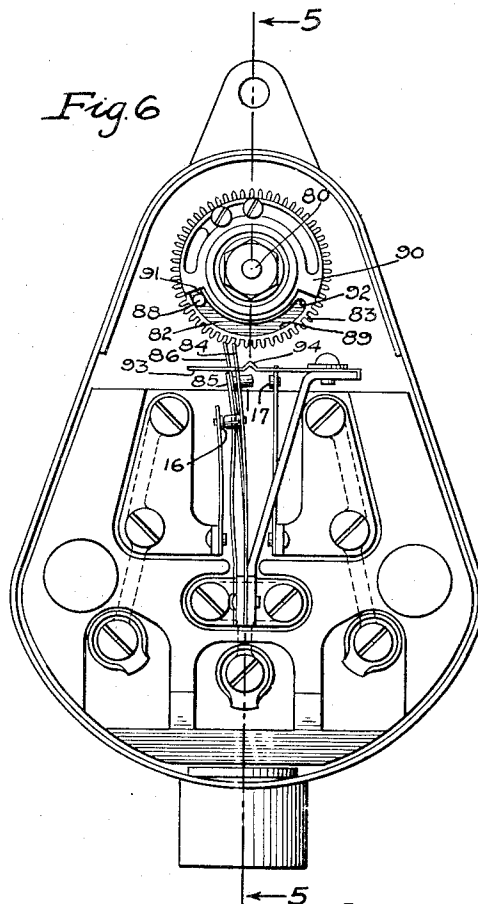
F. S. DENISON ET AL

2,070,118

BURNER APPARATUS CONTROL MECHANISM

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5 Sheets-Sheet 3



INVENTORS
FREDERICK S. DENISON
JOHN P. KRIECHBAUM
By *Paul Reup & Moore*
ATTORNEYS

Feb. 9, 1937.

F. S. DENISON ET AL

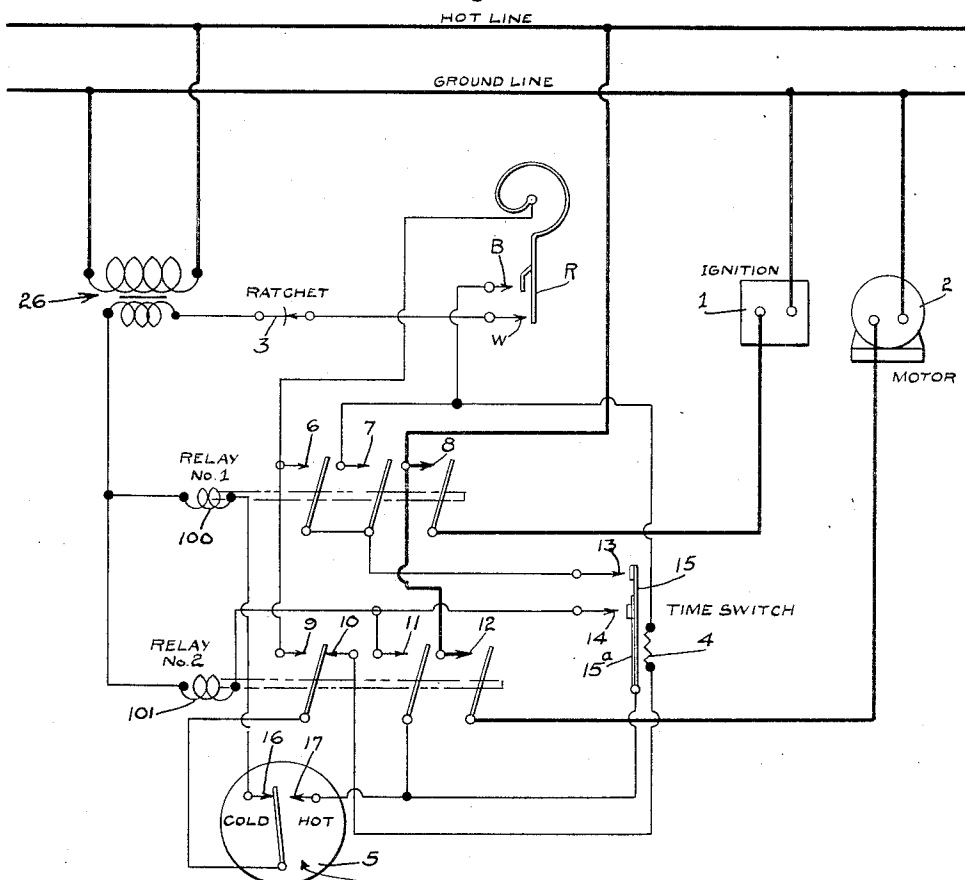
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BURNER APPARATUS CONTROL MECHANISM

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5 Sheets-Sheet 4

Fig. 7



ST. SW. MECH.
ON HEATING 17 CLOSES BEFORE 16 OPENS
ON COOLING 17 OPENS BEFORE 16 CLOSES.

INVENTORS
FREDERICK S. DENISON
JOHN P. KRIECHBAUM
By *Paul R. Moore*
ATTORNEYS

Feb. 9, 1937.

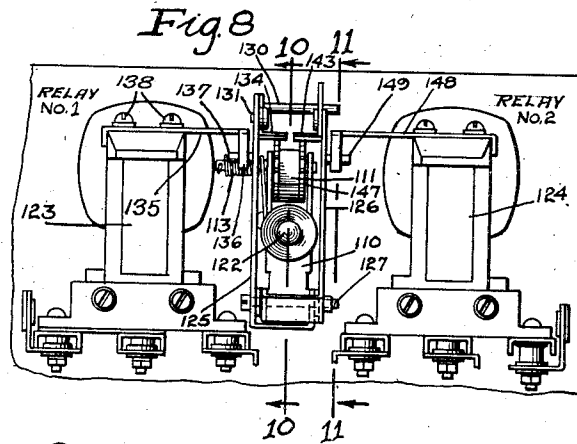
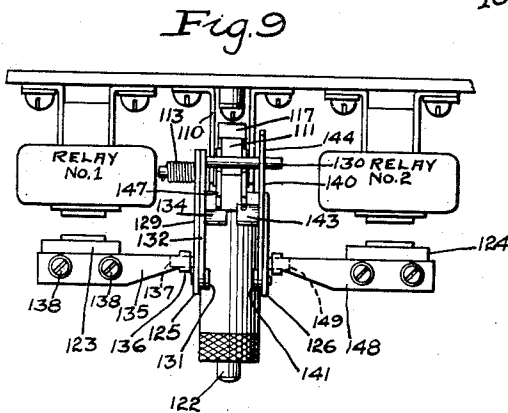
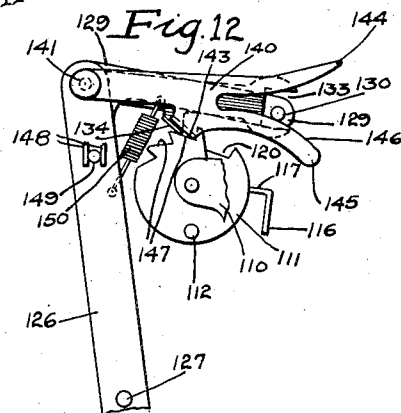
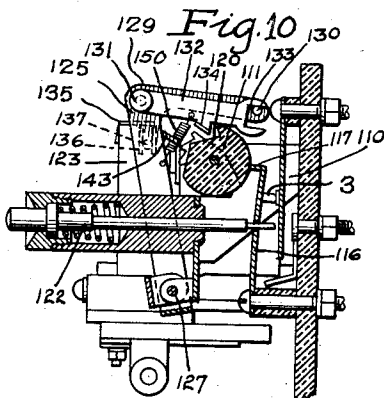
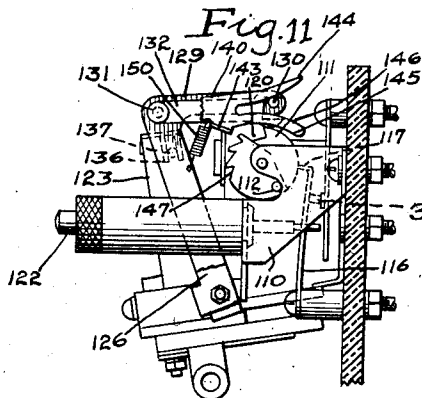
F. S. DENISON ET AL

2,070,118

BURNER APPARATUS CONTROL MECHANISM

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5 Sheets-Sheet 5



INVENTORS
 FREDERICK S. DENISON
 JOHN P. KRIECHBAUM
 BY *Paul, Paul, Kline*
 ATTORNEYS

UNITED STATES PATENT OFFICE

2,070,118

BURNER APPARATUS CONTROL
MECHANISM

Frederick S. Denison and John P. Kriechbaum,
Minneapolis, Minn., assignors to Minneapolis-
Honeywell Regulator Company, Minneapolis,
Minn., a corporation of Delaware

Application June 18, 1931, Serial No. 545,350

15 Claims. (Cl. 158—28)

This invention relates to control systems for heat producing apparatus, and has as an important object the provision of a burner control system, by means of which a series of trial ignition operations can be obtained at the end of which series, if flame is not produced, the entire system is automatically rendered inoperative. Another object is to provide a pre-ignition timing period before fuel delivery is started, and also to provide a predetermined post-ignition timing period after fuel delivery starts and during such delivery. Other objects are: to maintain ignition means activation until combustion results, or until combustion fails after repeated trials; to stop the burner motor substantially immediately, in case of unsuccessful combustion after repeated ignition trials; to provide a timed interval between the stopping of fuel feed, and the resumption of the same between the trial ignition periods; and to provide means whereby on power failure the system will, on resumption of power, automatically re-cycle after a predetermined standby interval; and to provide means whereby on flame failure, after successful combustion, fuel feed is interrupted, the burner motor is stopped, and re-cycling occurs after a predetermined "standby" period.

The present invention finds valuable application in controlling oil burners of the rotary or vertical shaft revolving cup type, in conjunction with a resistance ignition element. This element is a wide thick band of metal ribbon. A special current regulating transformer is used, and the ignition element ordinarily receives approximately eighty amperes at four volts. It requires from a minute to a minute and a half for the temperature of this ignition element to rise sufficiently to ignite oil, and after having reached this point, if its temperature is lowered too much, ignition will not be successful. If the temperature is too great, the ribbon deteriorates rapidly.

The system is operated as follows: The ribbon is energized for a period of one and one-half to two minutes while the oil burner motor is not running and, therefore, not delivering oil, nor blowing air across the ignition element to interfere with the heating operation. The burner motor is then operated, the oil valve is opened and a spray of mixed oil and air is thrown into the fire box, and in close proximity to the ignition element. After about a minute (during which ignition frequently does not occur) the burner motor is rendered inoperative.

In the present device, the ignition means is not de-activated after ignition failure on the

first trial, but one or more additional trials are made, while ignition means energization is constantly maintained. During the inactive period of the motor, the ignition means gains somewhat in temperature and has a tendency to vaporize the oil close to it, and produce little flames immediately around it. This is what is known as a "wicking" action. When the burner motor is activated for the second time and oil is again delivered, there is usually a small amount of flame present around the ignition element, and this flame, in conjunction with the added heat of the element itself, combines to ignite the main oil spray.

An important feature of this invention is, therefore, to provide means for producing repeated trial-ignition operations of the system while maintaining ignition means activation, at the end of the last of which operations if flame is not produced, the system as a whole is rendered inoperative.

Features of the invention include all details of construction, as well as the broader ideas of means inherent in the disclosure, and combinations and sub-combinations of elements of the system.

Objects, features and advantages of the invention will be set forth in the description of the drawings forming a part of this application, and in said drawings

Figure 1 is a face view of the panel;

Figure 2 is a vertical section taken through the ratchet mechanism, on line 2—2 of Figure 1, looking in the direction of the arrow;

Figure 3 is a plan view further illustrating the ratchet mechanism, and showing it in its normal or "starting" position;

Figure 4 is a vertical section on line 4—4 of Figure 1 showing the position of the ratchet mechanism when the first relay is closed, and showing the pawl of the second relay conditioned for ratcheting action on closure of said second relay;

Figure 5 is a longitudinal vertical section through the flame responsive switch, "pyrostat" or stack thermostat, on line 5—5 of Figure 6;

Figure 6 is a face view of the flame responsive switching device, showing the switches positioned as when the thermal element is cold;

Figure 7 is a diagrammatic view illustrating the circuit connections of the system;

Figure 8 is a front view illustrating a modification of the ratcheting mechanism for opening the safety contact or master switch, with the parts positioned as when both relays are open;

Figure 9 is a top plan view of Figure 8, corresponding to Figure 1;

Figure 10 is a vertical section on line 10—10 of Figure 8 with relay No. 1 energized;

5 Figure 11 is a section on line 11—11 of Figure 8, showing the parts in side elevation, with part of the driving pawl-operating arm and pawl broken away; and

10 Figure 12 is an enlarged detail elevation showing the position of the driving pawl arm and pawl, when both relays are closed, and further illustrating how over-run of the ratchet wheel is prevented.

Before describing in detail the various devices 15 of the system, attention is called to the principal elements of this embodiment of the invention which are: two relays or their equivalents designated No. 1 and No. 2 (also referred to as first and second) which relays respectively control 20 ignition means generally indicated at 1, and fuel control means generally indicated at 2; a safety switch 3, which is adapted, when opened to render the entire system inoperative; ratcheting means controlled by said relays for controlling the 25 safety or master switch 3 to open it on failure to produce combustion following repeated trial ignition operations; a thermal time switch including contacts 13, 14; switch arms 15, 15^a controlling the contacts; bimetallic elements 28, 30 controlling the arms, and heater 4 controlling bimetallic 30 element 28, said heater being controlled by circuits in turn controlled by the relays, and being adapted by its heating and cooling effects to control its contacts 13, 14 which are in the thermostatic circuit, and which control relay No. 2; a flame responsive device generally indicated at 5 35 having contacts 16, 17 which are overlappingly controlled on rise of temperature, and non-overlappingly controlled on fall of temperature, for controlling the relay circuits; a room thermostat which controls the relays and has a movable element R, and contacts W—B sequentially engageable by said element R; two contacts 6—7 in the 40 thermostatic circuit, and a third contact 8 controlling energization of the ignition means 1, all controlled by said first relay; contacts controlled by the second relay as follows: contacts 9—10 overlappingly controlled in both directions and in the thermostatic circuit; and a contact 11 also 50 in the thermostatic circuit; and a contact 12 controlling the burner motor, or fuel feed apparatus 2; contacts 16—17 of the flame responsive device 5, overlappingly controlled on temperature rise and non-overlappingly controlled on temperature 55 fall; and various circuits by which the operations of the foregoing elements are co-ordinated. The circuits are not at this time described nor referred to by reference numerals, but detailed explanatory and numerical reference to the circuits is made under the headings "Operation".

60 An important device in this system is one which is controlled by the two relays (one controlling the ignition means and the other the motor) and which, in turn, controls the safety switch 3, to 35 open the switch after a plurality of opening and closing motions of that relay which controls the motor, and while the ignition means controlling relay is energized. It will be understood that in 70 the present system ignition means activation is maintained throughout the plural trial ignition periods, but that the burner motor is always deactivated after a failure to produce flame, and that after such motor de-activation a "stand-by" 75 period is provided so that explosive gases may be

dissipated before the next trial ignition operation is initiated.

One form of device for obtaining the opening of the safety contact or switch 3 after a series of trial ignition periods is shown in Figures 1 to 4. 5 In these figures is also illustrated the relay panel. Numeral 25 generally indicates a panel upon which are mounted: a transformer 26, the time switch; relays No. 1 and No. 2; and the ratcheting mechanism for controlling the time switch by 10 means of the relays.

Referring to Figure 1, which best illustrates the time switch: the heating coil or heater 4 controls a bimetallic element 28, which abuts a pin 29 carried by bimetallic compensating arm 30. 15 This arm 30 is mounted on element 31 suitably pivoted at 32. Element 31 also carries flexible switch arms 15 and 15^a respectively engageable with contacts 13 and 14. Spring 33 acts on the element 31 to automatically move the switch arms 20 15—15^a to open-circuit position, as the heater cools. During heating, the upper end of element 28 is moved to the right, resulting in motion of the switch arms to circuit-closed position.

The armature for relay No. 1 is indicated at 40 25 and that of relay No. 2 is indicated at 41. These armatures are biased to open by gravity, and each controls three contact arms operated in the manner best shown in the diagram. One of the contacts of relay No. 2 is an overlapping contact, 30 the purpose of which is hereinafter explained. Armature 40 of relay No. 2 is pivoted at 40^a.

Upon application of heat the heater element 4, the upper end of the bimetallic element 28 moves 35 to the right and rotates the assembly, comprising compensating arm 30 and switch arms 15 and 15^a, in clockwise direction about the pivotal point 32. During such movement, arm 15 first engages contact 13, and then arm 15^a engages contact 14. 40 Upon de-energization of the heater coil 4, thermostatic element 28 begins to cool, its upper end moves to the left allowing the assembly to rotate in a counter-clockwise direction as the result of biasing action of spring 33, to first move arm 15^a 45 away from contact 14, and after a time interval disengage arm 15 from contact 13. Compensating blade 30 is provided for maintaining timing action of the switch constant in spite of fluctuations in ambient temperature, in a manner known to 50 this art.

Between the relays and mounted on a suitable bracket 42 is a ratchet wheel 43 having a stop pin 44 engageable with the bracket to limit ratchet 55 wheel rotation at its initial position as before its ratcheting operation begins. This wheel is provided with a plurality of teeth indicated at 46, and with a peripheral radial groove 47 which is adapted to receive an extension 48 of the movable switch arm 49 cooperative with corresponding 60 contact member 50 and biased to move automatically to switch open position. The extension normally engages the periphery of the ratchet wheel, and when so engaged, the switch is held in closed position. When the radial groove 47 registers 65 with the extension, the switch arm 49 snaps to open position and the ratchet wheel 43 is held in this position, until manually released. A spring 51 acts to move the ratchet wheel to its initial position, as before the ratcheting operation has 70 begun. The ratcheting action is controlled by both relays. Armature 40 of relay No. 1 has a bracket 55 having an extension 56 at the outer end of which is a laterally projecting pin 57 substantially parallel with the axis of rotation of the 75 ratchet wheel. Pivoted as at 58 to the extension

56 is a check-pawl arm 59 having pawl 60 adapted to engage a ratchet tooth to secure the ratchet wheel in advanced position after being brought to that position by the action of a driving pawl operated by relay No. 2. The outer end of arm 59 rests on pin 57, by which pin its downward motion is initially prevented. Armature 41 of relay No. 2 has a bracket 65 to which is pivoted as at 66, a pawl arm 67, having pawl 68, by means of which the ratchet wheel is given a step-by-step motion, toward switch-release position. The outer end of arm 67 rests upon pin 57, and when relay No. 1 is open the pawl arm 67 is raised to inoperative position. When relay No. 1 closes, the check pawl 60 moves downwardly and rearwardly to operative position, and the ratcheting or driving pawl 68 of relay No. 2 is lowered to operative position, and conditioned so that on the first closure of relay No. 2, the ratchet 43 is advanced one tooth, against the action of the spring 51. After this advance has been accomplished, the check pawl 60 of relay No. 1 engages the tooth to secure the ratchet wheel 43 against reverse rotation under the action of the spring. On the second closure of relay No. 2, the ratchet wheel is advanced another tooth, where it is again held by the check pawl. On the third closure of relay No. 2 the ratchet wheel is advanced another tooth, and at the end of the advance movement the groove 47 is brought into register with the extension 48 of the switch arm 49, and the switch 3 automatically opens; thereafter the switch extension 48, cooperating with the groove 47, latches the wheel 43 to prevent its counter-rotation to initial position under action of spring 51.

Additional means is provided for manually closing the safety switch after it has been automatically opened at the end of failure of ignition after repeated trial ignition periods. It will be noted that the switch arm extension 48 engages the side of the groove 47 of the ratchet wheel 43, to hold the wheel against automatic counter-rotation after both relays open. Mounted on the bracket 42 which carries the ratchet wheel, is a barrel 70 having therein a plunger 71 which projects at one end to be engaged by the finger of the operator, and which at the opposite end projects to engage the movable switch member 49. A spring 70^a urges the plunger in a direction away from the switch arm 49. The plunger has an insulated portion 72, having a reduced terminal portion 73 which passes loosely through an opening 75 in the switch arm 49, the reduced extension 73 forming a shoulder 76 which engages the switch arm in a manner to move it sufficiently to withdraw the extension 48 from the radial groove 47 of the ratchet wheel 43 and release the wheel for a return to its initial position. The terminal of the reduced portion 73 first engages the blade 50 and moves it to maintain switch-open position, and then shoulder 76 engages blade 49, moving it until the extension 48 is withdrawn from groove 47 to release the ratchet wheel 43. After engagement of shoulder 76 with blade 49, the blades move in unison, in switch-open relation. After release of the ratchet wheel, and during reverse motion of element 72, to the position shown in Figure 4, the blades also move in unison in switch-open relation, until 48 engages the periphery of the wheel 43, after which on continued reverse motion of 72, blade 50 assumes the circuit-closed position shown.

It is conceivable that other mechanisms could be employed for opening the switch after ignition failure following repeated trial ignition periods.

There is no intention to limit the broader aspects of the invention to this particular feature, although certain of these details are claimed.

The flame responsive device, generally designated 5, herein has the form of a stack thermostat having two switches ("cold" contact 16 and "hot" contact 17) controllable by a single thermal means. This device is illustrated in Figures 5 and 6, and its application is shown in the diagram, Figure 7. The device is so constructed that on temperature rise, hot contact 17 is closed prior to the opening of cold contact 16; in other words, so that the contacts are operated in overlapping relation on temperature rise. Upon temperature fall, that contact which was first to close on rise in temperature, opens before the closing of that contact which was last to open on temperature rise. In this instance, the hot contact closes prior to the breaking of the cold during temperature rise, and the hot contact is opened before the cold contact closes during temperature fall. Numeral 80 indicates a shaft suitably mounted for rotation and 81 indicates a thermal element by which the shaft is rotated in opposite directions conformably to rise and fall in temperature. Suitably fixed to the shaft 80 is a toothed disk 82 and suitably rotatably mounted on the shaft is a disk 83. These disks are insulated from the shaft. Separately mounted on a suitable insulating base are contacts 16—17 in the form of flexible blades, and mounted on a common support and cooperative with respective contacts 16—17 are contact arms or blades 84—85. These arms are biased to move to circuit closed position respectively in opposite directions. Arm 84 is engaged and operated by the teeth of the rotatable disk 83. A control member 86 is engaged and operated by the teeth of the fixed disk 82, and this control member is adapted to hold the arm 85 normally in open position against its biased action, and the arm 85 is adapted to follow the control member 86 as the disk moves in counter-clockwise direction.

A lost motion connection is provided between the disks 82—83, the disk 82 having a pin 88 which loosely traverses the slot 89 of the disk 83, said disk 83 having an adjustable plate 90 held in adjusted position by set screws. This plate provides a radial stop shoulder 91 against which the pin engages during clockwise motion of the disk 82, the opposite end 92 of the slot being engaged by the pin when the shaft moves in counter-clockwise direction. By means of the plate, this lost motion connection is adjustable so that a timed interval may be provided during which the disk 83 is not rotated.

Associated with switch arm 84 is a spring arm 93 having a cam 94, and this arm 93 passes through an opening 95 of the switch arm 84. When arm 84 is moved sufficiently by disk 83, it cooperates with the cam to flex the spring arm. Just after the peak of the cam 94 is reached, the resilient action of the spring arm 93 causes the cam to quickly move the blade 84 to the corresponding circuit control position where it is held by the cam until after a predetermined degree of rotation of the disk 83 in an opposite direction. In this instance, the arm 84 is moved to circuit-closed position, on clockwise motion of disk 83, due to cooling of the thermostatic element.

The operation of the device in the present system is as follows, referring to Figure 6: Assume a heating of the thermal element 81 by heat produced by combustion as a result of successful ignition, and consequent rotation of the shaft 80

in counter-clockwise direction, due to this rise in temperature. During the first part of this rotation, the lost motion connection between the disks permits a movement of the fixed disk 82 without movement of the disk 83. The control member 86, therefore, moves to the right and the switch arm 85 follows it until this arm reaches switch-closed position. After this closure, the pin 88 which has been travelling in the slot 89, engages the stop 92 and on continued motion of the shaft in counter-clockwise direction, due to continued rise in temperature, the disk 83 begins to move in the same direction and arm 84 begins to move but does not open its contact until said arm has just passed beyond the peak of the cam, at which time the arm is suddenly snapped to switch-open position, where it is releasably locked in open position, by the cam. It is thus seen that on rise in temperature, the "hot" contact is closed before the "cold" contact is opened and, therefore, the contacts are overlappingly controlled. When the temperature falls, the direction of shaft rotation is reversed, and is clockwise. During the forepart of this motion, disk 83 is held against rotation as the result of engagement of its teeth with the arm 84 which is temporarily held from motion toward the left by cam 94. The first action is by the disk 82 which moves the control member 86 against the switch arm 85 and opens the switch. During this movement, the pin 88' is moving in the slot 89 in a direction away from the stop 92 formed by the end of the slot, and after a timed interval, determined by stop spacing, the pin engages the stop 91 and the disk 83 begins to rotate, also in clockwise direction, resulting in movement of the switch arm 84, against the cam. This action closes switch 16, and further clockwise motion of the disk 63 results in the depression of the spring arm, and after movement of arm 84 to a point just beyond the peak of the cam the spring arm is suddenly released to result in a quick movement of the switch arm to condition it for a snap movement on subsequent rise in temperature. It is thus seen that on a fall in temperature, the hot contact is broken before the cold contact closes.

The function performed in this system by the flame responsive device above described (which provides overlapping contacts on temperature rise and non-overlapping contacts on temperature fall) is more fully explained under the headings "Operation".

NORMAL OPERATION

Ignition produced on first trial

Assume a call for heat by the room thermostat and a closure at W, R, B. Relay No. 1 is closed through the following circuit: secondary of transformer 26, safety contact 3, W, R, B, time switch heater 4, contact 10 of relay No. 2, contact 16 of the flame responsive device, coil 100 of relay No. 1 to the opposite side of the secondary. The time switch now begins to move to the left under the action of its energized heating element. By closure of relay No. 1, contacts 6, 7, and 8 are closed, the ignition means being activated through closure of contact 8. The circuit for the ignition means is as follows: hot line, contact 8, ignition means 1 to the ground line. Contacts 6 and 7 complete a holding circuit for No. 1 relay as follows: one side of the secondary of the transformer 26, safety contact 3, W, R, 6, 7, heater 4, contact 10 of relay No. 2, contact 16 of the flame responsive device, 100 to the opposite

side of the secondary. Closure of relay No. 1 marks the beginning of the pre-ignition period, at the end of which the time switch closes its holding contact 13 and then its starting contact 14 for relay No. 2, which relay is energized through the following circuit: one side of the transformer secondary, safety contact 3, W, R, contact 6 of relay No. 1, contacts 13—14 of time switch, coil 101 of relay No. 2 to the opposite side of the secondary. On closure of relay No. 2, 101 starting contact 10 for relay No. 1 is opened and heater 4 is deenergized, and a holding contact 9 for relay No. 1 is closed. On closure of No. 2 relay, the ratchet wheel is rotated one tooth in safety switch release direction. It will be noted that the burner motor is started by closure of contact 12, which marks the end of the pre-ignition period. Contacts 9 and 10 are overlappingly controlled so that contact 9 maintains a holding circuit through No. 1 relay as follows: one side of the secondary, 3, W, R, 9, 16, 100 to the opposite side of the secondary. The fuel control means (motor) is now energized because on closure of relay No. 2, contact 12 was closed.

The contact 11 is now closed, and a holding circuit for relay No. 2 is established, which bridges the contact 14 of the time switch to maintain energization of the relay No. 2 until opening of the contact 13 of the time switch. This holding circuit is as follows: one side of the secondary of transformer 26, relay No. 2, contact 11, contact 13, contact 6, R, W, safety switch 3, to the opposite side of the secondary.

At this stage, (post ignition period) ignition means and motor are both energized, the ignition having been active for a predetermined pre-ignition period.

The expression "post-ignition period", as used herein, means that period following the pre-ignition period, and at the beginning of which fuel feed is started and which fuel is delivered while the ignition means is active, and until ignition is successful or until a shut-down occurs due to failure to produce flame after repeated attempts.

It will now be assumed that combustion is successful. The flame-responsive device promptly closes contact 17. The closure of 17 establishes a holding circuit for relay No. 2 as follows: one side of the transformer, coil 101 of relay No. 2, 11, 17, 9, R, W, safety switch 3, to the opposite side of the secondary. Contact 13 may now be opened, without effecting an opening of relay No. 2. When the flame responsive device has heated sufficiently to break contact 16, the circuit to relay No. 1 is opened, the ignition means is de-energized and relay No. 2 remains energized. This breaking of 16 occurs at the expiration of the post-ignition period which is determined by the setting of the flame responsive device. The burner is now normally operating with the motor running and flame present. When relay No. 1 drops out, the check pawl controlled thereby moves away from check position, and disengages the driving pawl, allowing the wheel to move to its initial position.

In further explanation of the operation of the electro-thermal time switch: On heating contact 13 is first closed, and a time period thereafter contact 14 is closed. Both contacts 13 and 14 70 and are in the starting circuit of relay No. 2 but contact 13 only is in the holding circuit, which circuit is: 26, 101, 11, 13, 6, R, W, 3, 26. Thus on cooling of the time switch mechanism, contact 14 opens a time period before contact 13 75

opens. When contact 13 opens, relay 2 is de-energized first closing contact 10 and then opening contact 9. Closure of contact 10 re-energizes heater 4, but a distinct time interval intervenes before relay 2 is re-energized, due to the above noted fact that contact 14 is closed a time interval after contact 14 closes.

OPERATION ON FAILURE TO PRODUCE FLAME

As in the first case, on closure of the room thermostat, the ignition means and time switch heater are energized, and the ignition timing period begins. As soon as both contacts 13—14 of the time switch have closed (end of pre-ignition timing period), relay No. 2 is energized to give the wheel 43 a first movement and the motor is energized, while ignition is maintained. On closure of relay No. 2, the circuit to the time switch heater is broken at contact 10, and a cooling motion of the time switch begins, to time the post-ignition period. If flame is not produced before the time switch opens contact 13 at the end of this cooling period, in other words, if holding contact 17 for relay No. 2 has not been closed at this time, relay No. 2 will open, and in so doing will again close the starting circuit for No. 1 relay at contact 10, and the time switch heater will again be energized for another timed trial ignition operation.

On closure of the time switch contact 14 at the end of this second trial ignition period, relay No. 2 will again be energized to give ratchet 43 a second movement, opening contact 10 and de-energizing the heater. The heater will now cool, to first open contact 14 and after a timed period will open to again de-energize relay No. 1, if flame is not produced before such opening. When relay No. 2 is energized for the third time, the ratchet wheel 43 is given a third movement which results in automatically opening the safety switch 3 to de-energize both relays, and resulting in the movement of the ratcheting pawls to release position, leaving the ratchet wheel locked and the safety switch open.

Inspection and repair is now in order, and after this has been attended to the movable switch element is manually moved to circuit closed position by the means previously described, and the ratchet wheel is released to assume its initial position.

It is, therefore, seen that means has been provided for obtaining a plurality of timed ignition periods at the end of which, if flame is not produced, the apparatus is locked against further automatic operation.

OPERATION ON FLAME FAILURE AFTER SUCCESSFUL IGNITION

On flame failure after successful ignition, (and while heat is being supplied and while the thermostat is closed) contact 17 is opened, due to cooling of thermostatic element 81. The opening of this contact results in de-energization of relay No. 2 and in closure of contact 10. However, energization of relay No. 1 and, therefore, activation of ignition 1, does not immediately take place because the contacts 16 and 17 are so controlled that a timed period is provided between the opening of contact 17 and the closing of contact 16. Closure of 16 results in energization of relay No. 1 through the circuit previously described and including safety switch 3, room thermostat, heater 4, and contacts 10 and 16. This delayed closure period is for the purpose of allowing the natural draft to dissipate

accumulated gases, to prevent explosion on resumption of ignition. On closure of No. 1 relay, a trial ignition operation is initiated (or a series of such operations) in the manner previously described.

It is conceivable that other means than relays may be employed for controlling ignition and fuel feed, and that a single means may be thus employed, and that this single means may operate the ratcheting mechanism after each ignition failure, and that this means may be thermally controlled. We believe ourselves the first to use a thermally controllable timing means to bring about a plurality of trial ignition periods, and the first to operate a switch by a ratcheting device, in a system of this kind.

Figures 8 to 12, inclusive, illustrate a modification of the ratcheting mechanism, particularly designed to prevent momentum over-run of the ratchet wheel, at the end of any forward stroke of the pawl, due to rapid motion of the armature as it closes. The general arrangement of the parts of the ratcheting means is substantially the same as previously described for Figures 1 to 4, inclusive. An important feature relates to means by which movement of the driving pawl, away from the wheel, at the end of the forward stroke, is prevented.

There are also certain features which relate to the manner of assembling the parts. One relates to the mounting of the ratcheting mechanism on a common support, instead of having the pawls (or pawl arms) mounted directly on the relay armatures.

The support for the ratcheting mechanism is indicated at 110. The ratchet wheel is indicated at 111 and the stop pin at 112. The spring for automatically moving the ratchet to initial position is indicated at 113. The movable switch arm of the safety or master switch 3 is indicated at 116 and the extension at 117.

Means for moving the extension 117 from notch or channel 120 to close the switch, is generally indicated at 122. This construction is not described in detail because it is substantially the same as that previously described.

The armature of relay No. 1 is indicated at 123 and that of relay No. 2 at 124. The check pawl-operating arm for relay No. 1 is indicated at 125 and the driving pawl-operating arm for relay No. 2 is indicated at 126. These pawl arms swing on a common pivot 127 carried by support 110. The pawl arm 125 has an angular extension 129 having at its inner terminal a laterally extending pin 130. Pivoted as at 131 to the arm 125 is a pawl 132 having a terminal bifurcation 133 normally disposed as shown in Figure 10. The tooth-engaging portion is indicated at 134. When relay No. 1 is closed as shown in Figure 10, 134 is operatively conditioned as previously described for the other form.

An arm 135, secured to the armature 123 as at 138, is forked to provide projections 136, see dotted lines in Figure 10, cooperative with pin 137, carried by arm 125 to control the arm.

The arm 126 has pivoted at its upper end as at 141 a driving pawl 140. This pawl is best shown in Figure 12 in which figure the parts are positioned as at the end of the forward stroke, corresponding to closed position of the armature of relay No. 2. The tooth-engaging portion of the pawl is indicated at 143. The outer end of the arm 140 is bifurcated as shown to provide spaced upper and lower arms 144—145. Before relay No. 2 closes, see Figure 11, the upper arm 144 rests

upon the pin 130. The arm 145 is curved to provide an inclined plane indicated at 146, see Figure 12, adapted to engage the pin 130 to prevent pawl motion in a direction away from the ratchet wheel, at the end of the stroke. With 143 engaging a tooth and resting on inclined surface 147 between consecutive teeth, it is seen that, due to the direction of inclination of the surface 147, and to the engagement of the arm 145 with pin 130, no forward motion of the wheel, due to momentum, can occur. The position shown in Figure 12 is assumed for each stroke.

An operating connection 148 similar to that of the connection 135 is provided between the armature 124 of relay No. 2 and the pin 149 of the pawl-operating arm 126.

Spring 150 acts to yieldably hold pawl 132 against pin 130.

We claim as our invention:

1. A heating system including a fuel feeder and means for controlling it, an igniter and means for controlling it, a safety switch adapted to render the system inoperative, and means controlled by the combined action of the fuel feeding and ignition control means for opening the safety switch after a plurality of fuel feeding operations while the igniter is active.

2. A heating system including a fuel feeder and means for controlling it, an igniter and means for controlling it, a safety switch adapted to render the system inoperative, means controlled by the combined action of the fuel feeding and ignition control means for opening the safety switch after a plurality of fuel feeding operations, and means for continuously maintaining igniter activation during and between the fuel feeding operations.

3. A heating system including a fuel feeder and means for controlling it, an igniter and means for controlling it, a safety switch adapted to render the system inoperative, means controlled by the combined action of the fuel feeding and ignition control means for opening the safety switch after a plurality of fuel feeding operations while the igniter is active, and means responsive to successful ignition adapted to render the igniter control means inoperative if flame is produced.

4. A heating system including a fuel feeder and means for controlling it, an igniter and means for controlling it, a safety switch adapted to render the system inoperative, means controlled by the combined action of the fuel feeding and ignition control means for opening the safety switch after a plurality of fuel feeding operations while the igniter is active, means responsive to successful ignition adapted to render the igniter control means inoperative if flame is produced, and thermostatic means adapted to control the fuel feeder and igniter control means.

5. A heating system including an igniter and a relay for controlling it, a fuel feeder and relay for controlling it, a safety switch for rendering the system inoperative, means controlled by the conjoint action of said relays for opening said safety switch after repeated energizations of said fuel feeder controlling relay, means for energizing the igniter controlling relay and for energizing the fuel feeder controlling relay at the end of a predetermined timed period after energization of the igniter feeder controlling relay, and for temporarily deenergizing the fuel controlling relay after a predetermined timed period of energization, and means for preventing deenergization of said fuel feeder controlling relay if

ignition is successful within the period for which it is timed to be deenergized.

6. A heating system including an igniter and a relay for controlling it, a fuel feeder and relay for controlling it, a safety switch for rendering the system inoperative, means controlled by the conjoint action of said relays for opening said safety switch after repeated energizations of the fuel feeder controlling relay, means for energizing the igniter controlling relay and for energizing the fuel feeder controlling relay at the end of a predetermined time after energization of the igniter controlling relay, and for temporarily deenergizing the fuel feeder controlling relay after a predetermined period of energization, said last named means including a thermally operable switch adapted to close a circuit when heated and a heater element adapted to be energized on energization of the igniter controlling relay, and to be de-energized on energization of the fuel feeder controlling relay.

7. A device of the class described including fuel feeding means, ignition means, a first relay adapted to control the ignition means, a second relay adapted to control the fuel feeding means, a safety switch and means controlling it by both relays to open it after a plurality of closing movements of the second relay while the first is closed, a flame responsive switch having first and second contacts and means overlappingly controlling them on temperature rise, a thermally operable time switch having first and second contacts, a heater for controlling said time switch, a room thermostat having first and second contacts, first and second contacts controlled by the first relay, first, second and third contacts controlled by the second relay, the first and second being overlappingly controlled, a starting circuit for said first relay including therein said safety switch, both contacts of said room thermostat, said heater, the second contact of said second relay, and the first contact of said flame responsive switch, a holding circuit for said first relay including therein said safety switch, the first contact of said room thermostat, the first contact of said second relay, and the first contact of said flame responsive device, a starting circuit for said second relay including said safety switch, a contact of said room thermostat, the second contact of the first relay, and both contacts of the time switch, and a holding circuit for said second relay including said safety switch, the first contact of said room thermostat, the first contact of said second relay, the second contact of said flame responsive device, and the third contact of said second relay.

8. A control device comprising an element advanceable step-by-step from an initial to a final position, means biasing said element to initial position, ratchet driving means for advancing said step-by-step element, a relay for actuating said ratchet mechanism, a temperature-responsive element, an electric heater for said temperature-responsive element, an energizing circuit for said relay controlled by the temperature-responsive element, and an energizing circuit for the heater including a switch controlled by the relay.

9. A control device comprising an element advanceable step-by-step from an initial to a final position, means biasing said element to initial position, ratchet driving means for advancing said step-by-step element, a relay for actuating said ratchet mechanism, a temperature-responsive element, an electric heater for said tempera-

ture-responsive element, an energizing circuit for said relay controlled by the temperature-responsive element, a holding circuit for said relay controlled jointly by the temperature-responsive element and the relay, and an energizing circuit for the heater including a switch controlled by the relay.

10. A control device comprising an element advanceable step-by-step from an initial to a final position, means biasing said element to initial position, ratchet driving means for advancing said step-by-step element, a relay for actuating said ratchet mechanism, a temperature-responsive element, an electric heater for said temperature-responsive element, an energizing circuit for said relay controlled by the temperature-responsive element, an energizing circuit for the heater including a switch controlled by the relay, a releaser normally checking return of said step-by-step element, a second relay acting to retract said releaser and having switch elements, and a circuit for the heater including a switch controlled by the first relay and a switch controlled by the second relay.

11. A control device comprising an element advanceable step-by-step from an initial to a final position, means biasing said element to initial position, ratchet driving means for advancing said step-by-step element, a relay for actuating said ratchet mechanism, a temperature-responsive element, an electric heater for said temperature-responsive element, an energizing circuit for said relay controlled by the temperature-responsive element, a holding circuit for said relay controlled jointly by the temperature-responsive element and the relay, an energizing circuit for the heater including a switch controlled by the relay, a releaser normally checking return of said step-by-step element, a second relay acting to retract said releaser and a circuit for the heater comprising a switch controlled by the first relay and a switch controlled by the second relay.

12. In combination, an electrically operable fuel supply controlling device, electrical ignition means, a safety switch for rendering the system inoperative, an element biased to initial position and advanceable step-by-step to a position for opening said safety switch, a releaser for checking return of said step-by-step element to initial position, electromagnetic means operative when energized to move said releaser to its non-releasing position, a switch controlled by said electromagnetic means, an ignition circuit including said switch, timing means for intermittently actuating said step-by-step element and the fuel supply controlling means, a main control for operating said electromagnetic means and timing means upon a call for heat, and means for maintaining operation of the fuel supply controlling means and discontinuing the intermittent actuation of the step-by-step element if combustion is established within a predetermined number of attempts.

13. In combination, an electrically operable fuel supply controlling device, electrical ignition means, a safety switch for rendering the system inoperative, an element biased to initial position and advanceable step-by-step to a position for opening said safety switch, a releaser for check-

ing return of said step-by-step element to initial position, electromagnetic means operative when energized to move said releaser to its non-releasing position, a switch controlled by said electromagnetic means, an ignition circuit including said switch, a second electromagnetic means operable when energized to advance said step-by-step element a predetermined amount, electrical timing means for intermittently energizing said second electromagnetic means, a switch in circuit with the fuel supply controlling means and moved to closed position upon energization of said second electromagnetic means, a main control switch for energizing the first electromagnetic means and timing means upon a demand for heat, and means responsive to the temperature of combustion for maintaining energization of said second electromagnetic means if combustion is successfully established.

14. In combination, a control system comprising, fuel supply means, ignition means, hot and cold switches, means responsive to combustion conditions for opening said hot switch substantially immediately upon cessation of combustion and for closing said cold switch a delayed interval after opening of said hot switch and for opening said cold switch upon the establishment of combustion, a main control, means under the control of said main control and cold switch for repeatedly operating said fuel supply means in an attempt to establish combustion, means controlled by said main control and hot switch for maintaining operation of the fuel supply means if combustion is established, and means for rendering the system inoperative until manual intervention if combustion is not established after a predetermined number of attempts.

15. A system of the class described, comprising, in combination, ignition means, a first relay in control of said ignition means, a first relay switch moved to closed position thereby when energized, fuel control means, a second relay in control of said fuel control means, a second relay switch moved to open position and a third relay switch moved to closed position by said second relay when energized, said second and third relay switches being overlappingly controlled, combustion responsive switching mechanism including hot and cold switches overlappingly controlled upon establishment of combustion, a main control switch, a safety switch and means controlling it by both relays to open it after a plurality of closing movements of said second relay while the first is closed, a thermal time switch and a heating element therefor, an initial energizing circuit for the first relay and heating element including the main control switch, safety switch, second relay switch and cold switch in series, a holding circuit for the first relay and independent of the heating element including the main control switch, safety switch, cold switch, and first and third relay switches in series, an energizing circuit for the second relay controlled by the safety switch, main control switch and time switch in series, and a holding circuit for the second relay including the main control switch and hot switch in series.

FREDERICK S. DENISON.
JOHN P. KRIECHBAUM.