Nov. 26, 1935. F. S. DENISON 2,022,188

APPARATUS FOR CONTROLLING COMBUSTION MECHANISMS

Original Filed June 27, 1925 3 Sheets-Sheet 1

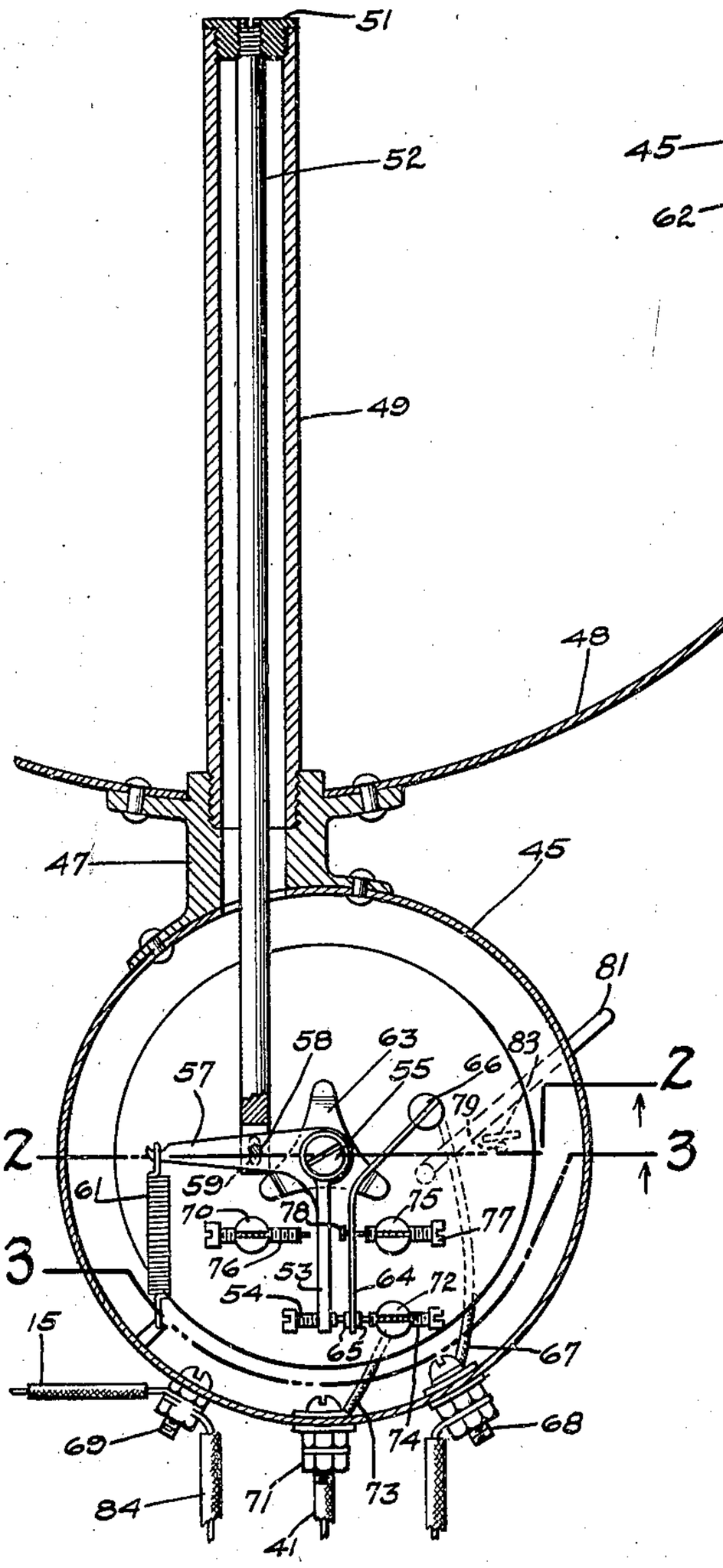

FIG. 1

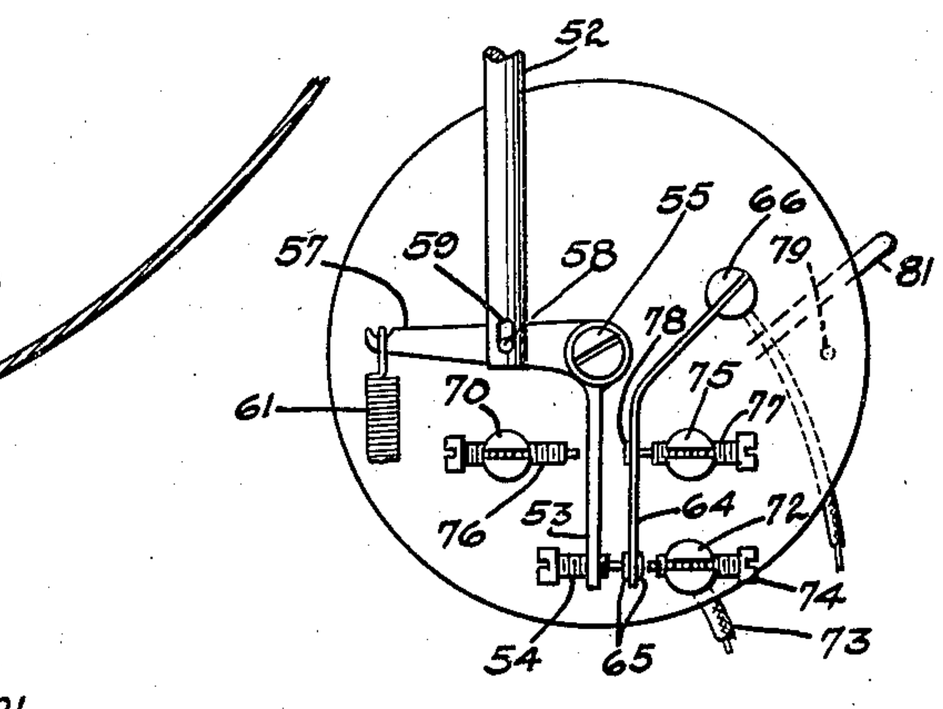

FIG. 2

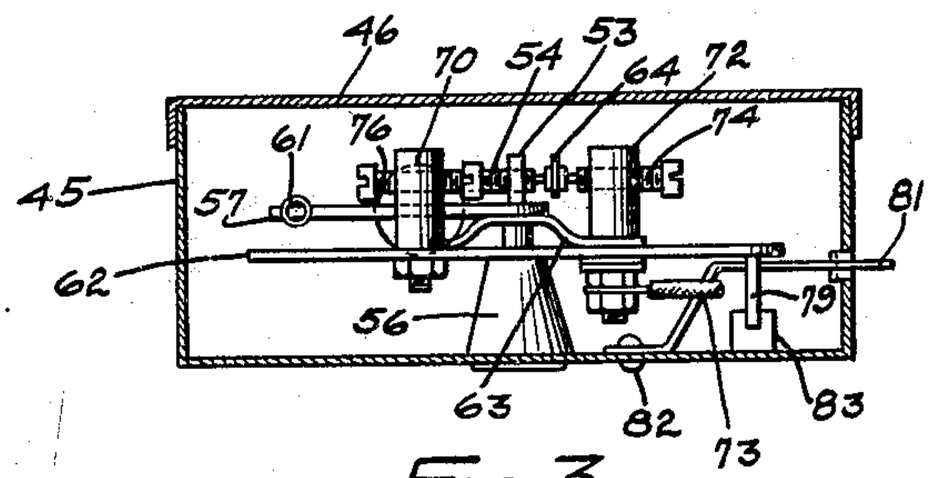

FIG. 3

FIG. 4

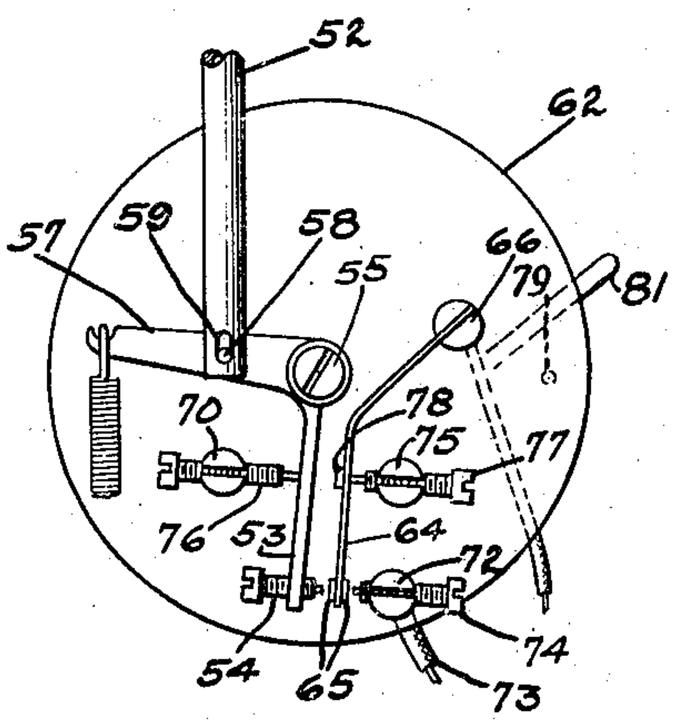

FIG. 5

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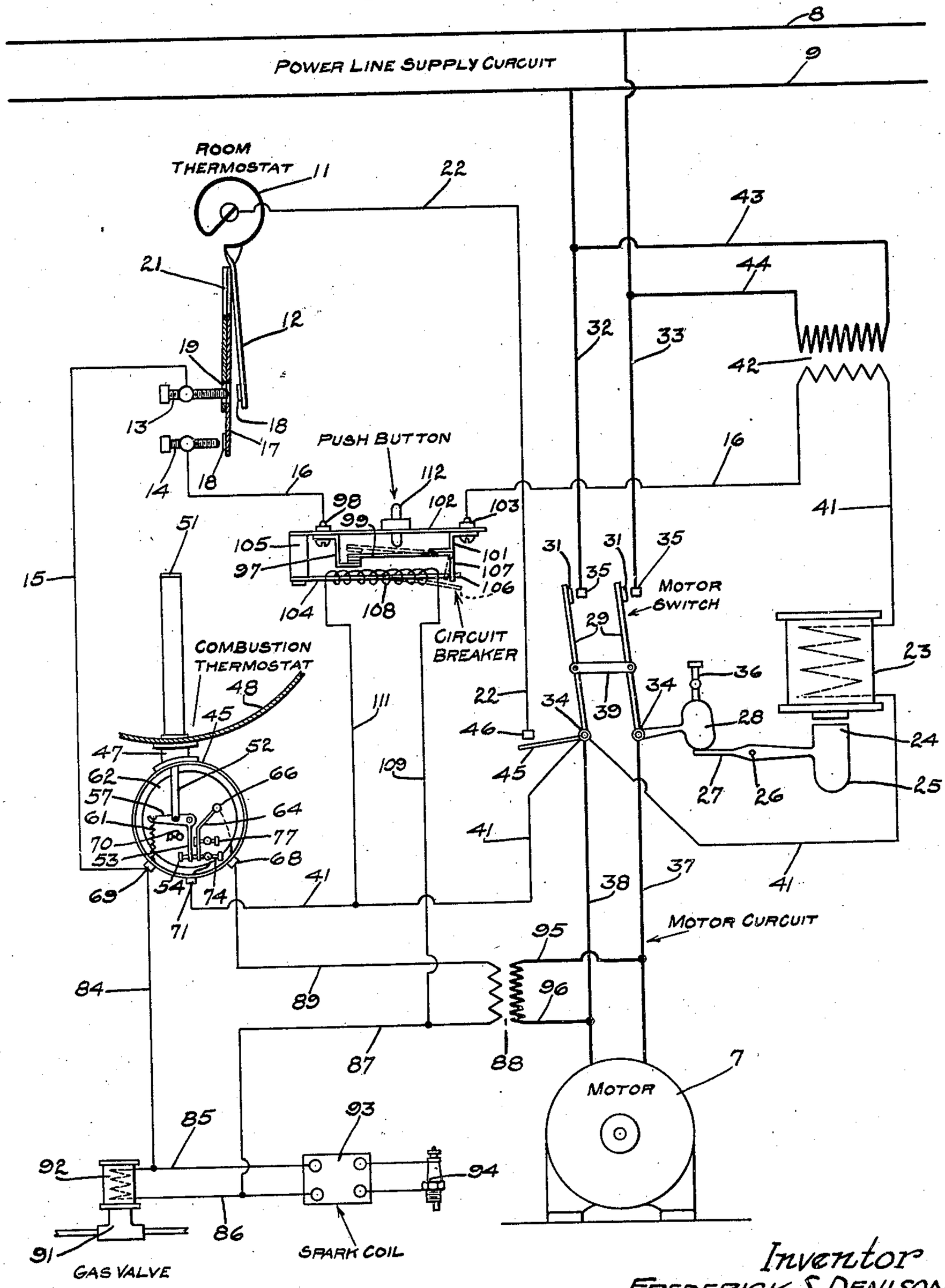

FIG. 6

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Original Filed June 27, 1925 3 Sheets-Sheet 3

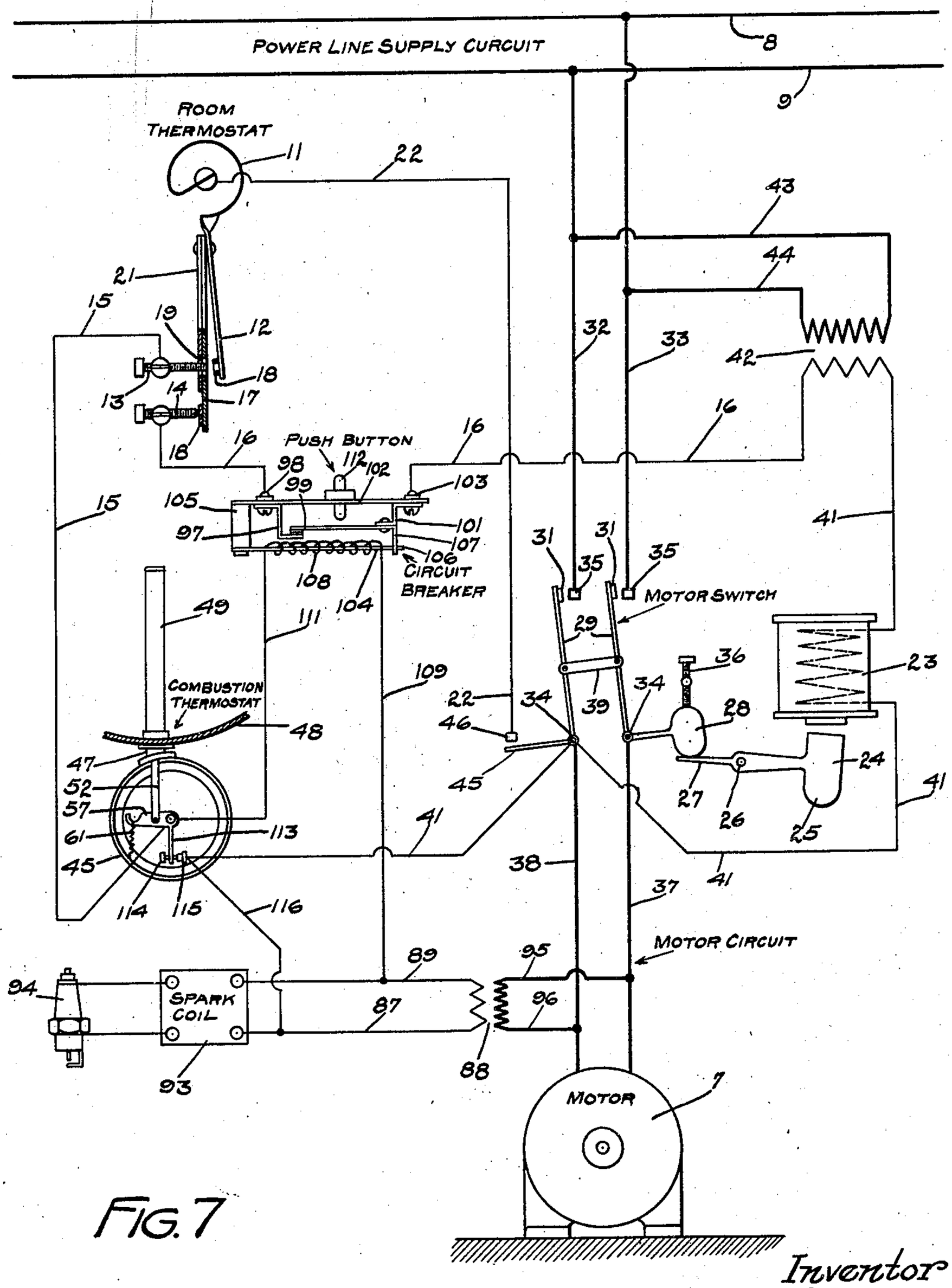

FIG. 7

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Patented Nov. 26, 1935 2,022,188

UNITED STATES PATENT OFFICE

2,022,188

APPARATUS FOR CONTROLLING COMBUSTION MECHANISMS

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Original application June 27, 1925, Serial No. 40,086. Divided and this application June 25, 1928, Serial No. 288,201

47 Claims. (Cl. 158—28)

This invention relates to new and useful improvements in the methods of and apparatus for controlling combustion mechanisms and more particularly relates to such mechanisms having a fuel feeding apparatus which is electrically controlled.

This application is divisional of my copending application for circuit maker and breaker, filed June 27, 1925, Serial Number 40,086 now Patent No. 1,732,182 issued October 15, 1929 and Reissue Patent No. 17,993 issued March 10, 1931.

It is common especially in the art of oil-burners to employ thermostatically controlled burners which control not only effects the starting and stopping of the burner operation and fuel feeding but also ignition therefor. It is highly advantageous to employ a safety means which will automatically stop the fuel feeding upon failure of combustion of the fed fuel whether such failure of combustion occurs initially or intermediately during the fuel feeding. In this novel invention, a safety means is provided which is automatically operable upon starting of the fuel feeding to stop the same after a predetermined interval. This novel process and apparatus also includes the use of the combustion of the fuel as a control medium to render the safety means inoperative before completion of its stopping function and, further, this control medium may also be used to stop operation of an ignition means.

Further, this process provides the controlling of an electrically operated fuel feeding apparatus which consists in closing a circuit to the fuel feeding means to operate the same, providing an ignition means for the feed fuel, causing the safety means upon closure of the circuit to start functioning automatically to stop the fuel feeding after a predetermined interval, using the heat of combustion of the fuel as a control medium to render the safety means inoperative before completion of its function, and using the failure of combustion while said circuit is closed as a control medium to permit said safety means to function to stop the fuel feeding after a predetermined interval.

The object therefore of this invention is to provide a method of, and apparatus for, controlling combustion mechanisms.

Another object of this invention is the provision of an improved form of circuit controlling apparatus.

Other objects of the invention will more fully appear from the following description and the accompanying drawings and will be pointed out in the annexed claims.

In the drawings there has been disclosed a structure designed to carry out the various objects of the invention, but it is to be understood that the invention is not confined to the exact features shown as various changes may be made within the scope of the claims which follow.

In the drawings:

Figure 1 is a view in side elevation of a thermostatic member mounted so that its thermostatic element is responsive to the heat of combustion, the mounting being shown in section;

Figure 2 is a cross-sectional view on the line 2—2 of Figure 1;

Figure 3 is a similar view on the line 3—3 of Figure 1;

Figure 4 is a view of the disc and movable parts in the intermediate positions assumed when the two of the contacts are disengaged and two are still engaged;

Figure 5 is a view similar to the foregoing but showing all contacts disengaged,

Figure 6 is a wiring diagram of the apparatus embodying the invention; and

Figure 7 is another wiring diagram showing a modified construction.

This novel process and apparatus may be explained and illustrated in conjunction with relay control mechanism. The construction and operation of such mechanism will be first described and then the automatic cut-out or safety switch and thereafter the device which is adapted to render inoperative the safety switch when the device is affected by the heat of combustion.

The fuel feeding device may include an electric motor 7 which is adapted to operate a blower to jet the fuel, such as oil, to the burner head, or to operate a centrifugal burner head with or without an oil pump. These parts are old and well known in this art and need not be further illustrated or described. The motor 7 may receive electrical energy from the power lines 8 and 9 through a motor switch which is automatically controlled as, for example, by a thermostat in the room or other place to be heated.

In the form here disclosed the thermostat comprises a substantially ring-like bar 11 which has securely attached thereto a relatively stiff metallic member such as the blade 12 formed of a bar of suitable metal which is an electric conductor. As the mechanism is preferably mounted in an upright position, the blade 12 depends from the thermo-bar 11. This ring-like bar is mounted, as is usual upon insulating material.

Two terminals are supported adjacent the bar 11 and are here indicated as terminally pointed contacts 13 and 14. The contact 13 is electrically connected to the wire 15 and the contact 14 is so connected to the wire 16.

A single control circuit is preferably used and it may be closed across the contacts 13—14 and, in the form shown, the circuit-closing means consists of a pair of members adapted to be successively engaged with their respective contacts. The relatively stiff blade 12 is carried by the thermo-bar 11 and is adapted to engage the contact 13 in order to form an electrical connection therewith. A flexible blade 17 is also carried by the thermo-bar 11 as by being welded to the blade 12. The blades 12 and 17 are so arranged that they terminally diverge and each bears a contact tip 18. The contact tip of the flexible blade 17 is adapted to engage the end of the lower contact 14. This flexible blade 17 is also provided with an aperture 19 so that the other contact 13 may freely be passed therethrough, the resultant air gap providing sufficient insulation between the contact 13 and the flexible blade 17. This flexible blade is also desirably provided with a reinforcing or backing plate 21. The upper ends of the backing plate 21, the flexible blade 17 and the relatively stiff blade 12 are welded together to present a substantially unitary structure in electrical connection at that end. The plate 21 and blade 12 are both of relatively stiff metal and are disposed in terminally diverging relation, the flexible blade 17 being interposed so that its flexibility permits movement of its major portion between the backing plate 21 and blade 12. It may also be noted that the backing plate 21 is provided with an aperture similar to the aperture 19 in flexible blade 17 and for the same purpose. In addition to the thermostatic circuit wires 15 and 16, which are respectively connected to the contacts 13 and 14, a supplemental wire 22 is electrically connected to the thermo-bar 11 and, hence to the blades 12 and 17.

The switch forming a portion of the relay control mechanism may next be described in conjunction with its connections. The switch is preferably borne by a panel usually mounted in a vertical position. An electro-magnetic coil 23 is mounted thereon to attract, when energized, an armature 24 having a weighted portion 25 and mounted upon a pivot pin 26. This armature lever has an arm 27 projecting beyond the pin 26 to engage and normally uphold a counterweight 28 connected to the parallel switch arms 29 each bearing a contact tip 31 for electrical engagement with the relatively fixed terminals 35 of the main lead wires 32 and 33 from the power lines 9 and 8. These switch arms are pivotally mounted upon the pivot posts 34 and the counterweight 28 normally tends to retain each tip 31 in contact with the respective terminal contacts 35 of the lead wires 32 and 33, the opening movement being limited by the adjustable screw 36. Upon close of these switch arms 29, electrical energy passes from the line 8 to the lead wire 33 to contact 35 to switch-arm contact 31, through the switch arm to post 34 and, by wire 37 to the device to be energized such as the burner motor 7, and thence returns by the wire 38 to the other post 34, other switch arm 29, contacts 31—35, wire 32 to the other power line 9.

Thus, the counterweight 28 constantly exerts a gravitational force tending to hold the switch arms 29 in closed position. But, the armature weight 25 which exerts a greater force overcomes the force of the counterweight 28 and normally holds the switch-arms in open position. However, upon energization of the electro-magnet 23, the force of the weight 25 is removed, and the counter-weight may close the switch-arms where they remain until the electromagnet is de-energized whereby the weight 25 may indirectly open the switch-arms.

The energization and de-energization of the electromagnet is effected by means of the thermostatic mechanism above mentioned. The two switch-arms 29 are conventionally represented as tied together by the bar 39 because they function as a unit in pivotal movements upon their posts 34. The electromagnet 23 is in series with the wire 41 which is terminally connected to the low voltage secondary side of a step down transformer 42 which has its primary constantly energized by its shunt circuits 43—44 from the lines 32—33. The wire 16 leads from the other end of the secondary of this transformer to the thermostat contact 14.

In the wiring diagram, the parts are represented in the positions occupied when the blower-motor 7 is shut off and the thermostat, usually positioned in the room or place to be heated, is warm enough to hold the blades from circuit-closing position so that the electromagnet circuit is open at the posts 13 and 14. As the thermo-bar cools, the blades 12 and 17 and the backing plate 21 move toward the contacts 13 and 14. Owing to the divergent relation of these two blades, the relatively flexible blade 17 first engages the lower contact 14. In such position, the upper contact 13 is freely passed through the alined apertures in the plate 21 and blade 17 and is out of electrical connection therewith while the other blade 12 is spaced from its contact 13. The electromagnet circuit thus remains open, being broken at the posts. Further movement of the cooling thermo-bar causes engagement of the stiff blade 12 with its contact 13. The backing plate maintains its spaced relation from the blade 12 while the blade 17 flexibly remains in contact with its contact 14. Thus, the contacts are successively made and the electromagnet circuit is closed across the contact screws so that the electromagnet is energized, its armature weight 25 is raised which permits the weight 28 to drop and thus to move the switch arms 29 into position closing the main line circuit to the motor. One of the switch arms 29 carries a short arm 45 which is electrically connected to the wire 41 leading from the electromagnet to the contact 13 through the combustion-affected thermo-switch as will be later described. However, this arm 45 is adapted, when the switch-arms are closed, to effect electrical engagement with the relatively fixed contact 46 which is connected by the wire 22 to the room thermo-bar 11. Thus, when the switch-arms 29 are moved to circuit-closing position, the arm 45 by contact at 46 shunts the portion of the wire 41 connecting the post 34 and its normal circuit-continuation via the wire 15 to the post 13 of the room thermostat. This condition obtains so long as the electro-magnet 23 remains energized and any accidental break in the current from the power line will de-energize the electromagnet and cause the motor circuit to be opened by force of gravity acting through the weight 25 which is heavier than the counterweight 28 and is therefore able to open the switch-arms 29 against the pull of the counterweight 28.

However, disregarding such abnormal or accidental condition, the motor-switch-arms may be

caused to be opened by movement of the thermo-bar 11 when it becomes heated and successively moves the blades 12 and 17 from their contacts. The circuit is not interrupted until the thermo-bar has moved a predetermined distance. Such a lag in the breaking is provided by the use of the relatively stiff and flexible contact blades and the supplemental connection for the thermo-bar and blades. Thus, as the heating thermo-bar moves, the stiff blade 12 is first disengaged from its post 13 and in such position, the contact 13 and its connections via wire 15 and wire 41 up to the supplementary switch arm 45 are de-energized but, the circuit from the electro-magnet is maintained across the arm 45, fixed contact 46 and wire 22 to the thermo-bar 11, and flexible blade 17, contact 14, wire 16, transformer 42, and wire 41 to the electromagnet 23. The leads from the supply or power lines are thus maintained closed and supply electrical energy to the motor 7. When the thermo-bar has continued its opening movement for the predetermined distance or lag, the flexible blade 17 is moved from its contact 14 and the circuit is opened. The relatively stiff metallic backing plate 21 being movable with the blade 12 assures the opening travel of the flexible blade 17 in timed relation to that of the stiff blade 12. When the electromagnet circuit is thus opened, the armature weight 25 drops and, through the lever 27, rocks the lighter counterweight 28 of the switch-arms, moving the latter as well as the short arm 45 to open positions for a subsequent cycle of operations.

The novel safety means featured in this invention and hereinbefore mentioned consists of an automatically operable circuit-breaker interposed in the relay circuit and also a thermostatically controlled device adapted to be mounted so as to be responsive to conditions of combustion automatically to affect the operation of the circuit-breaker to interrupt the fuel feeding means or burner motor in case of ignition failure upon initial starting of the fuel feeding means.

The thermostatically controlled device will next be described and, as shown in Figures 1, 2 and 3, comprises the casing 45 which preferably is open on one side as shown in Figures 2 and 3. A closure 46 is provided to close the open side of the casing as shown to prevent dust and foreign material from getting thereinto and affecting the operating mechanism mounted therein. A flanged bracket 47 is secured to the casing 45 to provide a means for securing it to a supporting means such, for example, as the stack 48 of the furnace or heating plant. A thermo-element 49 has one end secured to the bracket 47 and inwardly projects into the stack 48 so as to be directly affected by the products of combustion when ignition takes place. A cap 51 is secured to the end of the thermo-element 49 and has a stem 52 secured thereto which extends through the thermo-element and into the casing 45 as particularly shown in Figure 1. The coefficient of expansion of the thermo-element 49 is obviously considerably greater than that of the stem 52 so that when ignition takes place and the element 49 becomes heated it will relatively elongate sufficiently to cause the inner end of the stem 52 to be inwardly drawn towards the wall of the stack. A switch arm 53, having an adjustably mounted contact screw 54 mounted therein, is pivotally mounted upon a stud 55 mounted in a hub 56 secured to the casing wall as shown in Figure 2. The switch arm 53 has an arm 57 provided thereon which is connected to the inner end of the stem 52 by means of a pin 58 as shown. The aperture 59 in the stem 52, through which the pin 58 passes, is preferably elongated so as to permit the stem to relatively move with reference to the arm 57 when the contacts of the device are in circuit closing position as shown in Figure 1. A tension spring 61 has one end terminally secured to the arm 57 and its other end to the casing wall, thereby constantly exerting a pull on the arm which tends to move the switch arm 53, and therefore the contact 54, into circuit closing position.

A disc 62 is also mounted upon the stud 55 and is frictionally prevented from relative rotation thereon by means of a tension member 63 interposed between the lower face of the hub of the switch arm 53 and the upper face of the hub 56 in the absence of a positive drive. (See Figure 2.) A flexible contact member 64, having a contact tip 65 on each side thereof, is mounted in a stud 66, secured to the disc 62 insulated therefrom, as shown in Figure 1. A wire 67 electrically connects the stud 66 and therefore the contact member 64 with a terminal post 68 mounted in the wall of the casing in insulated relation thereto. When the thermo-element 49 is cold, as when before combustion takes place, the contact screw 54 will be moved into contact with one of the contact tips 65 of the member 64, thereby electrically connecting the terminal post 68 with a similar terminal post 69 mounted in the wall of the casing and not insulated therefrom so that current may pass from the post 68 through the wire 67, flexible member 64, contact tip 65, screw 54, switch arm 53, stud 55 and through the casing wall to the post 69. A third terminal post 71 is also mounted in the casing wall in insulated relation thereto and is electrically connected to a post 72, mounted upon the disc 62 but insulated therefrom, by means of a flexible connection 73. A contact screw 74 is adjustably mounted on the post 72 and is adapted to be engaged by the flexible contact member 64 to close a circuit between the terminal posts 68 and 71.

An important feature of this invention resides in the construction of the novel switch mechanism above described, and in the order in which the switch contacts 54, 65 and 74 are moved into and out of circuit-closing and circuit-opening positions by the action of the thermo-element 49 which, as before stated, is directly responsive to conditions of combustion in the burner. These switch contacts are so arranged that the time interval required to move them into circuit-opening and circuit-closing positions may be varied to any desired degree. They are also arranged to successively open and close during each cycle of operation.

The means provided for controlling the timed relation between the opening and closing of the contacts preferably consists in mounting upon the disc 62 a pair of posts 70 and 75 having stop screws 76 and 77, respectively, adjustably mounted therein. The stop screw 76 is adapted to be terminally engaged by the switch arm 53 when moved into the position shown in Figure 5. The stop screw 77 has a headed pin 78 secured thereto which extends through an aperture in the flexible member 64 so that when the contact screw 54 is moved out of contact with the tip 65 of the member 64, as particularly shown in Figure 5, the member 64 will engage the head of the pin 78 which will thereby prevent its further movement, thereby allowing the contact screw 54 to be moved out of electrical contact with its complementary

tip 65 of the member 64 as shown. Obviously the post 75 is insulated from the disc 62 in order to prevent the current from short circuiting between the posts 75 and 72. By adjusting the stop screws 76 and 77, the air gap between the contact screw 54 and its complementary contact tip 65 and also between the contact screw 74 and the other tip 65 on the opposite side of the flexible member 64, may be increased or decreased to obtain the desired time interval in the opening and closing of the contacts.

The disc carries on its lower face a pin 79 which cooperates with a stop lug 83 secured to a wall of the casing for a purpose to be more fully pointed out hereinafter, and for cooperation with a lever 81 which is pivoted to the casing at 82 and extends outside thereof through a slot as clearly shown in Figs. 2 and 3. It will be noted from these figures that the lever is so formed as to clear the stop lug 83. Its function will become more apparent as the description proceeds.

When the basement or other space in which the combustion switch is located is at normal ambient temperature and the furnace is at the same temperature the parts assume the relative positions shown in Fig. 1 wherein the pin 58 is in the middle of the slot 59 of the stem 52, pin 79 is abutting against stop lug 83 under the influence of spring 61, and the various contacts are closed. If the burner of the furnace is now started, the temperature of the thermostat will rise and stem 52 will consequently move upwardly (looking at Fig. 1).

When the temperature of the thermostat gets slightly beyond that which normally obtains in the basement the pin 58 will be engaged by the lower end of the slot 59 and upon further heating of the thermostat the bell crank switch arm 57—53 will be rotated in clockwise direction. In the course of such rotation the disc 62 and accordingly contact 74, will first be held stationary due to its frictional mounting, previously explained, with the resultant that the space between contacts 54 and 74 will be increased. Due to the flexible nature of the arm 64, contact 65 will follow contact 54 thus separating itself from contact 74. Tip 78 will also remain stationary with the result that upon further heating of the thermostat and further rotation of switch arm 53, arm 64 will engage tip 78 as shown in Fig. 4 to prevent further following movement of contact 65 so that this contact will be separated from contact 54. Further rotation of switch arm 53 causes it to engage adjustable stop 76 as shown in Fig. 5. When this occurs there is a direct driving connection between the stem 52 and the disc 62 whereby upon further heating of the thermostat the disc is rotated in spite of its frictional mounting, carrying with it the contacts in the relative positions shown in Fig. 5.

As soon as combustion within the furnace ceases the thermostat will begin to cool, stem 52 will begin to move in the opposite direction, and bell crank lever 57—53 will simultaneously begin to rotate in counter-clockwise direction under the influence of spring 61. Initially the disc will of course remain in the position it occupied when the thremostat was the hottest because of its frictional mounting. Therefore when arm 53 begins the aforementioned counter-clockwise rotation the gap between contacts 54 and 65 will be closed and these contacts will be brought into engagement. Continued rotation will push contact 65 into engagement with contact 74. When this occurs all three contacts are in engagement with each other and arm 53 has a direct driving connection with disc 62 through the contacts and post 72. Continued cooling of the thermostat therefore causes rotation of disc 62 in counter-clockwise direction. When the thermostat reaches a temperature slightly above the normal ambient basement temperature, pin 79 will engage stop 83 thereby preventing further rotation of the disc by means of spring 61. Further movement of stem 52 due to further cooling of the thermostat to basement temperature is taken up in the slot 59. All ambient temperature changes occurring while the furnace is out of operation are similarly taken up in the slot 59 without affecting the contacts by reason of engagement of pin 79 with stop 83 under the tension of spring 61.

Thus in normal operation the thermostat will upon being heated up from cold position operate to first disengage contacts 65 and 74 while leaving contacts 54 and 65 in engagement, and then separate these latter contacts whereby all of them are electrically disconnected. Upon cooling, contacts 54 and 65 are first brought into engagement and these are subsequently moved into engagement with contact 74. As previously stated, the purpose of providing adjustable screws 74, 76 and 77 is to enable adjustment of the timing of the operation of the contacts. This will now be more clearly apparent from the foregoing description of operation.

The purpose of lever 81 is to enable a manual closure of the combustion switch contacts while the stack is hot for purposes of test or inspection In the absence of this lever, it would be necessary for the inspector to open the casing and manipulate disc 62, or wait for the stack to cool. In normal operation the lever 81 performs no function.

Referring to Figure 6, it will be noted that the wire 15 leading from the contact 13 of the room thermostat is connected to the terminal post 69 of the above described switch mechanism which will hereinafter be referred to as the combustion thermostat. A wire 84 also leads from the terminal 69 to one side of an ignition circuit comprising the wires 85 and 86, the latter being connected by a wire 87 to the low voltage secondary of a transformer 88 as shown. The other side of the step down transformer secondary is connected to the terminal 68 by means of a wire 89. The form of ignition means shown in Figure 6 preferably comprises a gas valve 91 which is automatically operable by means of a relay coil 92 connected in series with the wires 85 and 86 and therefore the secondary side of the transformer 88. A spark coil 93, of ordinary construction, also has one of its windings connected in series with the transformer 88 through the combustion thermostat while the high tension winding thereof is connected in series with a spark plug 94 as shown. The above described method of ignition is commonly known as a combination gas and spark and is well known in the art. The wire 41 leading from the post 34 of the motor switch is connected to the third terminal post 71 of the combustion thermostat. It will also be noted that the high voltage primary of the transformer 88 is electrically connected to the motor leads 37 and 38 by means of the shunt wires 95 and 96, as shown, so that the transformer will be energized whenever the motor switch is closed and the motor is operating.

The circuit-breaker, which is actuated by the action of the combustion thermostat, will next

be described, after which the operation of the safety means will be described in connection with the thermostatically controlled relay circuit controlling the operation of the burner motor and therefore the fuel feeding means. The circuit-breaker, shown diagrammatically in Figure 6, comprises a conductor strip 97 secured to a terminal post 98 to which is connected one end of the portion of the wire 16 leading from the contact 14 of the room thermostat. A movable switch arm 99 is secured to a resilient member 101 mounted upon a supporting strip 102 by means of a terminal post 103. The terminal post 98 and 103 obviously are insulated from the supporting strip 102. One end of the portion of the wire 16 leading from the transformer 42 is connected to the terminal post 103. These two posts 98 and 103 are therefore electrically connected in series with the wire 16 which leads from the post 14 of the room thermostat to the transformer 42 so that the normal engagement of the switch arm 99 with the conductor strip 97 of the circuit breaker does not interrupt the thermostatically controlled circuit at the wire 16.

The means provided for automatically moving the switch arm 99 out of contact with the conductor strip 97 to break the circuit, in case of ignition failure, preferably consists of a thermo-bar 104 having one end secured to a support 105 secured to the supporting strip 102. The outer or free end of the thermo-bar has a reduced portion forming a tab 106 which is adapted normally to be received within an angular recess provided in the depending off-set end 107 of the movable switch arm 99 of the circuit breaker. A heating coil 108 is coiled about the thermo-bar and has one end connected by a wire 109 to the wire 87 leading to one side of the secondary of the transformer 88. The other end of the heating coil is similarly connected by a wire 111 to the wire 41 leading from the intermediate contact post 71 of the combustion thermostat to the post 34 of the motor switch. The circuit-breaker is so constructed and arranged that, upon the passage of current through the heating coil 108 for a predetermined interval, the thermo-bar 104 will be warped out of engagement with the off-set end 107 of the movable switch arm 99, which is mounted so that its inherent resilience will cause the arm 99 to assume the position shown in dotted lines in Figure 6 with the result that the switch arm 99 is moved out of contact with the conductor strip 97 and the thermostatic circuit is broken across the wire 16 and the relay, or electromagnet 23 is de-energized and the motor circuit is broken at the switch contacts 31. The apparatus can thereafter only be re-conditioned for normal operation by the manual re-setting of the circuit-breaker switch arm 99, such, for example, as by a push button 112, preferably mounted in the supporting strip 102 of the circuit-breaker.

In the operation of this novel safety means in connection with the thermostatically controlled relay circuit of the burner motor and fuel feeding means, the apparatus, after a predetermined room temperature is reached, will be in the position shown in Figure 6, wherein it will be noted that the contact blades 12 and 17 of the room thermostat are out of electrical contact with the contacts 13 and 14. When thus positioned the circuit through wire 16 of the relay will be broken at the room thermostat thereby causing the electromagnet 23 to become de-energized, which will cause the motor switch to be automatically opened by the gravitational drop of the weighted portion 25 of the armature 24. Such opening of the motor switch will also cause the switch arm 45 to be moved out of electrical contact with the contact 46. When the room thermostat and motor switch are in inoperative positions, as above described, the entire burner apparatus will be interrupted, thereby causing the thermo-element of the thermostat 49 to cool with the result that the contacts 54, 65 and 74 will be moved into electrical connection with one another, as shown in Figures 1 and 6.

When the contacts of the combustion thermostat are thus closed, the wire 41 of the relay circuit will be electrically connected to the wire 15 leading to the room thermostat so that current may flow from the electromagnet 23 through the wire 41, combustion thermostat, wire 15 to the contact screw 13 of the room thermostat where it will be interrupted until the tip 18 of the blade 12 is moved into contact with the contact screw 13. It will also be noted that when the contacts of the combustion thermostat are in closed position, that the heating coil 108 and also the ignition means will be connected in series with the secondary of the transformer 88 so that when the burner motor resumes operation by the automatic closing of the motor switch by the action of the room thermostat that ignition will also be simultaneously resumed.

As soon as the room temperature begins to lower the contacts 18 of the blades 12 and 17 of the room thermostat will move towards the contact screws 13 and 14 until the tip 18 of the blade 17 is moved into electrical connection with the contact 14. Such connection, however, will have no effect on the apparatus as a result of the blade 12 being out of contact with the contact 13, and also as a result of the separated relation of contact 46 and the blade 45. Further cooling of the room will cause the tip 18 of the blade 12 to be moved into electrical connection with the contact screw 13 thereby completing or closing the relay circuit which will be as follows: From the secondary of the transformer 42 through the wire 16 and circuit breaker interposed therein, contact screw 14, blades 17 and 12, contact screw 13, wire 15, to the terminal post 69 of the combustion thermostat; through the casing of the latter to the contact screw 54, tips 65 of the switch member 64, post 72, connection 73 to the intermediate terminal post 71; thence through the wire 41 to the electromagnet 23 and back to the other side of the transformer secondary. Closing of the above circuit will cause the electromagnet 23 to become energized resulting in the armature 24 being upwardly drawn thereby resulting in the weight 28 dropping and automatically closing the switch arms 29. Such closing of the motor switch will cause the motor 7 and the ignition means to resume operation with the resultant operation of burner under normal conditions. As soon as combustion has thus been started, the heat of combustion will affect the thermo-element 49 causing it to elongate and thereby actuating the switch mechanism mounted in the combustion thermostat. The first movement of the thermo-element 49, upon combustion resumption, will cause one of the tips 65 of the blade 64 to be moved out of electrical contact with the contact screw 74 as shown in Figure 4, thereby breaking the circuit to the wire 41 at the combustion thermostat, which will interrupt the flow of current through the heating coil 108 and will therefore render the circuit-breaker inoperative. Such breaking of the

circuit to the wire 41 at the combustion thermostat will also open the previously described relay circuit including the wire 15. The electromagnet 23, however, will remain energized to attract the armature 24 as a result of the switch arm 45 being in engagement with the contact 46 and the blade 17 still being in contact with the screw 14. When the above condition exists the electromagnet circuit will be as follows:—From one side of the secondary of the transformer 42 through the wire 16 and circuit-breaker to the contact screw 14 of the room thermostat; thence through the blade 17, coiled thermo-bar 11, wire 22, contact 46, switch arm 45, wire 41 to the electromagnet 23 and thence back to the other side of the transformer 42.

Referring further to the operation of the combustion thermostat, after combustion has been resumed and the heating coil 108 has been de-energized, as above described, the contact screw 54 of the switch arm 53 will be moved out of electrical connection with its complementary tip 65 of the flexible switch member 64, as shown in Figure 5, thereby also interrupting the ignition means which condition will obtain until the room temperature rises and the electromagnet circuit is broken through the room thermostat, after which the entire apparatus will be rendered inoperative and combustion will cease. Upon such interruption of combustion the thermo-element 49 of the combustion thermostat will begin to cool, and first condition the ignition circuit for re-energization after which the heating coil 108 will be conditioned for re-energization and the combustion thermostat positioned for the next cycle of operation.

An important feature in the operation of the safety means including the combustion thermostat and circuit-breaker is that in case of temporary power failure and immediate resumption thereof when the burner is normally running and the room thermostat is in electrical contact with the contact screws 13 and 14, it will be impossible for the burner to resume operation until after the thermo-element 49 of the combustion thermostat has cooled sufficiently to present or close the ignition circuit before the electromagnet becomes energized to close the motor switch. This is accomplished by the timed relation of the opening and closing of the switch contacts in the stack thermostat which are so arranged that the ignition circuit is always closed before the motor or power feeding means is started after having been accidentally interrupted.

In the event of ignition failure when the fuel feeding means is started by the closing of the main motor switch by the indirect action of the electromagnet 23 and the room thermostat, the thermo-element of the combustion thermostat will not become heated, thereby causing the contacts 54, 65 and 74 thereof to remain in circuit-closing position so that current will flow through the heating coil 108 which will cause the thermo-bar 104 to warp and be moved out of contact with the off-set end portion 107, thereby causing the switch arm 99 to be moved out of electrical contact with the conductor strip 97 and thus opening the relay circuit with the resultant opening of the motor switch and therefore interruption of the fuel feeding means. After the circuit-breaker has thus opened the wire 16 the apparatus can only be re-conditioned or rendered operative again by the manipulation of the push button 112 to re-set the switch arm 99 in circuit-closing position. It is also to be understood that the time required to open the circuit-breaker by the flow of current through the heating coil 108 is greater than that required by the thermo-element 49 of the combustion thermostat to open the circuit-breaker circuit to render it inoperative, so that upon normal operation of the burner the circuit-breaker will always remain in closed position. The initial starting operation of the burner ignition under normal conditions will be started simultaneously with the starting of the motor or fuel-feeding means, and at the same time current will be caused to flow through the heating coil 108 of the circuit breaker which circuit, however, will soon thereafter be opened through the combustion thermostat after combustion is started, after which ignition will subsequently be interrupted and the burner will continue to function until interrupted by the action of the room thermostat.

In Figure 7 there is shown slightly modified construction wherein the ignition means is connected in series with the secondary of the transformer 88 and is not controlled by the operation of the combustion thermostat, which in the construction here shown is provided with two contacts only instead of three as shown in the previous figures. In the arrangement of the parts as here shown, the ignition, under ordinary conditions, will function each time the burner motor 7 is started and will continue to function as long as the motor is operating, it being interrupted only when the motor or fuel feeding means is interrupted.

In the construction here shown, the heating coil 108 is similarly connected in series with the secondary of the transformer 88. A wire 109 connects one end of the coil to the wire 89 of the transformer, and a wire 111 connects the other end thereof to the movable switch arm 113 of the combustion thermostat having the contact screw 114 adjustably mounted therein adapted to engage a stationary contact 115 mounted upon the disc 62, which disc is mounted in a manner similar to that shown and described with reference to the previous figures. A wire 116 leads from the stationary contact 115 to the wire 87 leading to the other side of the secondary of the transformer 88. In the wiring diagram, Figure 7, the parts are shown in the position assumed when the desired room temperature has been reached and the blades of the room thermostat have been moved out of electrical contact with the contact screws 13 and 14. When the blades of the room thermostat are moved into electrical contact with the screws 13 and 14, a circuit will be completed through the electromagnet which will be as follows:

From one side of the secondary of the transformer 42, through the wire 16 and the circuit-breaker to the contact screw 14, through the blades 12 and 17 of the room thermostat to the contact screw 13, wire 15, through the movable switch arm 113 of the combustion thermostat; thence through the contacts 114 and 115 to the wire 41; to the electromagnet 23 and thence back to the other side of the secondary of the transformer. The closing of the above circuit will cause the electromagnet 23 to become energized, thereby attracting the armature 24 with the resultant closing of the main motor switch by the gravitational drop of the weight 28.

It will also be seen that when the parts are positioned, as above described, the heating coil 108 will be connected in series with the secondary of the transformer 88 and current will there-

by flow through the heating coil 108, tending to warp the thermo-bar 104 to cause the circuit breaker to open the wire 16 upon closure of motor switch 29. Should combustion take place, however, then the contact screw 114 mounted in the movable switch arm 113 will be moved out of electrical connection with the stationary contact 115 as a result of the heating of the thermo-element 49, thereby opening the heating coil circuit and rendering the circuit-breaker inoperative which condition will obtain as long as the burner continues to normally function.

The above parts are also so arranged that in case of temporary power failure, the relay circuit will be opened and the burner or fuel-feeding means cannot possibly again be started before the thermo-element of the combustion thermostat has cooled sufficiently to allow the contact screw 114 thereof to be moved into engagement with the contact 115, thereby closing the relay circuit with the resultant starting of the burner motor and therefore the ignition.

I claim as my invention:

1. In a burner control system, fuel feeding means, a thermostatically controlled circuit which renders the fuel feeding means operative to feed fuel when completed, a circuit to maintain operation of said fuel feeding means, said circuit being rendered operative as a result of completion of said thermostatically controlled circuit, a safety means including a circuit-breaker in said first mentioned control circuit operable automatically upon closure of the circuit to break the circuit after a predetermined interval, and a device responsive to combustion conditions operative upon the establishment of combustion to render said circuit-breaker and starting circuit inoperative.

2. In a burner control system, fuel feeding means, a thermostatically controlled circuit which renders the fuel feeding means operative to feed fuel when completed, a safety means including a circuit-breaker in said control circuit normally operable automatically to break the circuit after a predetermined interval, electrically controlled ignition means, and a device responsive to combustion conditions and electrically connected in said control circuit and to said ignition means effective upon completion of said thermostatically controlled circuit to render inoperative both the circuit-breaker and ignition means upon the establishment of combustion.

3. The combination of an electrically operable fuel feeding apparatus and a circuit therefor with a switch in the circuit, a relay to control the switch, a thermostatic means and starting circuit therefor to energize the relay, a holding circuit operative after relay closure, a cut-out mechanism automatically operable after a time period to interrupt the relay starting circuit upon closure thereof, a device responsive to conditions of combustion automatically to render the cut-out mechanism and starting circuit inoperable whereby the switch remains closed when combustion takes place and is opened upon failure of combustion.

4. The combination of an electrically operable fuel feeding apparatus and a circuit therefor with a switch in the circuit, a relay to control the switch, a thermostatic means and circuit therefor to control the relay, a cut-out mechanism automatically operable after a time period to interrupt the relay circuit upon closure of said relay switch, ignition means electrically operable upon closure of said switch and a device responsive to the presence or absence of combustion automatically operable upon the establishment of combustion to render first the cut-out mechanism inoperable and then render the ignition means inoperable.

5. A combustion apparatus including a burner motor and a power circuit for the motor including an electrically operable switch, an electrically operable timing switch and a control circuit therefor operative to open the time switch when completed for a time period, starting and holding circuits for the motor switch controllable by the timing switch, a switch responsive to the establishment of combustion at the burner and having contacts controlling the starting and timing switch control circuits, said contacts being normally closed in absence of combustion, the circuit arrangement thereby being such that when said contacts are so closed the resulting energization of the timing switch circuit will open the motor switch control circuit at the end of a predetermined time, if combustion is not established.

6. An electrical system for liquid fuel burners comprising a burner motor, a circuit for the motor, a main switch for controlling the circuit which switch opens automatically when released, electrically operated means for closing the main switch and holding it closed, a second circuit including said switch closing means, and a normally closed safety switch, and a safety circuit including a timing device for opening said safety switch, and a switch responsive to combustion conditions, said last mentioned switch being closed in the absence of and open in the presence of combustion.

7. In a combustion system, the combination of a combustion chamber, means for feeding fuel thereto including an electric motor, means for igniting said fuel, an electric circuit for said motor including a switch, means for maintaining said switch closed including an electric circuit having a normally closed safety switch therein, and means for opening said safety switch comprising an electric circuit and a switch therein responsive to combustion conditions and closed in the absence of and open in the presence of combustion in said combustion chamber.

8. An electrical control system for liquid fuel burners comprising a burner motor, a motor circuit in which said motor is connected, a main switch in said motor circuit which opens automatically when released, electrically operated means for closing the main switch and holding it closed, a secondary circuit including said switch-closing means and a normally-closed safety switch, and a safety circuit including a timed device for opening said safety switch and a switch responsive to combustion conditions, said last mentioned switch being closed in the absence of and open in the presence of combustion.

9. An electrical control system for liquid fuel burners comprising a burner motor, a main circuit in which said burner is connected, a switch for controlling the main circuit, a solenoid for operating said switch, the latter being maintained closed when the solenoid is energized and opening automatically when it is de-energized, a secondary circuit including said solenoid, a source of current, and a normally closed safety switch, timed means for automatically opening said safety switch at the end of a predetermined interval after the energizing of said solenoid, said means being ineffective to close the switch,

and means for rendering said timed means inoperative upon the establishment of combustion.

10. In a combustion system comprising a combustion chamber, means for supplying fuel to said chamber, and means for igniting said fuel, an electrical control system including a main circuit, a main switch in said circuit, a second circuit controlling the closing of said main switch, a normally-closed safety switch in said second circuit, and means, including a circuit closer responsive to combustion conditions and closed in the absence of and open in the presence of combustion in the combustion chamber, for opening said safety switch automatically and thereby cutting off the fuel to the combustion chamber upon initial failure of combustion within a predetermined time after said main switch has been closed.

11. In a combustion system comprising a combustion chamber, means for supplying fuel to said chamber, and means for igniting said fuel, an electrical control system including a main electric circuit, a main switch in said circuit, a secondary circuit controlling the closing of said main switch, a normally closed safety switch in said secondary circuit, and means for automatically opening said safety switch upon initial failure of combustion within a predetermined time after said main switch has been closed, thereby causing the opening of the main switch, said means being ineffective to close the safety switch.

12. An electrical control system for liquid fuel burners comprising electrically operated means for projecting fuel into a zone of ignition, means for igniting said fuel, a main electric circuit including said fuel projecting means, a main switch in said circuit, means for automatically opening said main switch including a normally-closed safety switch, means for automatically opening said safety switch, thereby causing the opening of the main switch including an electric circuit and a heating coil therein, said means being timed to open said safety switch at the end of a predetermine interval after the closing of the main switch, and said circuit including the heating coil being closed upon the closing of the main switch, and means for breaking said circuit including the heat coil upon the initiation of combustion.

13. An electrical control system for liquid fuel burners comprising electrically operated means for projecting fuel into a zone of ignition, means for igniting said fuel, a main electric circuit including said fuel projecting means, and safety means for automatically breaking said main circuit upon the failure of combustion, said safety means including a secondary circuit and means, including a circuit closer responsive to combustion conditions and closed in the absence of and open in the presence of combustion in the combustion chamber, for automatically breaking said secondary circuit and thereby breaking the main circuit at the end of a predetermined interval after the closing of the main circuit, in the absence of combustion.

14. In a combustion system compriisng a combustion chamber, means for supplying fuel to said chamber and means for igniting said fuel, an electrical control system, including a main circuit, a main switch in said circuit, a second circuit controlling the closing of the main switch, a normally closed safety switch in said second circuit and means for opening said safety switch automatically, a switch, responsive to combustion conditions, controlling said second circuit, which switch is closed in the absence of and open in the presence of combustion in the combustion chamber, said last named switch also controlling the normal starting of the fuel supply means.

15. In a combustion system comprising a combustion chamber, means for supplying fuel thereto, and means for igniting said fuel, an electrical control system comprising a main circuit including said fuel projecting means, safety means for automatically breaking said main circuit upon the failure of combustion, said safety means including a second circuit and a normally closed safety switch therein, means for automatically opening said safety switch, and a switch responsive to combustion conditions, closed in the absence of and open in the presence of combustion in the combustion chamber, said last named switch controlling the automatic opening of the safety switch and the closing of the main circuit in normal starting of the fuel supply means.

16. In a combustion system comprising a combustion chamber, means for supplying fuel to said chamber and means for igniting said fuel, an electrical control system, including a main circuit, a main switch in said circuit, a second circuit controlling the closing of the main switch, a normally closed safety switch in said second circuit and means for opening said safety switch automatically, a switch responsive to combustion conditions controlling said second circuit, which switch is closed in the absence of and open in the presence of combustion in the combustion chamber, a second switch in the second circuit which is automatically closed at the time the main switch operates to close, said second switch being for the purpose of establishing a parallel circuit to the switch which is responsive to combustion conditions, said switch which is responsive to combustion conditions also controlling the normal starting of the fuel supply means.

17. In a burner control system, a main switch, a burner motor, means to start the motor in response to closure of said main switch and to stop the same in response to opening thereof, and including means controlled by the temperature of combustion interposing a delay between successive motor energizations when said main switch is closed.

18. In a burner control system, a main switch, a burner motor, ignition means, means to place said burner motor and ignition means in operation in response to closure of said main switch and to stop operation of the burner motor in response to opening thereof, and including means controlled by the temperature of combustion interposing a delay between successive motor energizations and terminating operation of the ignition means upon the establishment of combustion while said main switch is closed.

19. In a burner control system, a main switch, a burner motor, means to start the burner motor in response to closure of said main switch and to stop the same in response to opening thereof, and including means controlled by the temperature of combustion for preventing re-energization of said burner motor until the temperature of combustion has lowered at least a predetermined amount after cessation of combustion resulting from a temporary failure in electrical power.

20. In a burner control system, a main switch, a burner motor, means to start said burner mo-

tor in response to closure of said main switch and to stop the same in response to opening thereof, a thermal-electric safety timer including an electric heating element for terminating operation of said burner motor after a predetermined time and until manual intervention if combustion is not established, said electric heating element being energized by said means in response to closure of said main switch, and including means controlled by the temperature of combustion for operatively de-energizing said safety timer if combustion is established and for interposing a delay between successive energizations of said burner motor.

21. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, an energizing circuit therefor, a switch in control of said circuit, electrically operated means operable to move said switch to closed position when energized, said switch moving to open position upon de-energization of said electrically operable means, a main control switch, switching means controlled by the temperature of combustion and including a switch which is open in the presence of and closed in the absence of combustion, an energizing circuit for said electrically operable means controlled by said switch of the combustion responsive switching means and said main control switch in series, and connections for maintaining energization of said electrically operable means after the establishment of combustion.

22. An oil burner control system comprising, a burner motor, a burner motor circuit, a motor switch, electromagnetic means for closing said motor switch when energized and for opening the same when deenergized, a safety switch mechanism comprising a thermally operated switch and an electrical heating means therefor, means for maintaining said thermally operated switch in open position until manual intervention when the same is opened as a result of a predetermined heating by said electrical heating means, a main control switch, e'ectrical ignition means, combustion responsive switching mechanism closed in the absence of and open in the presence of combustion, circuit connections for said electromagnetic means, electrical heating means and ignition means controlled by said main control switch and combustion responsive switching mechanism, a holding switch moved to closed position upon energization of said electromagnetic means, and a holding circuit for said electromagnetic means independent of said combustion responsive switching mechanism and controlled by said main control switch and said holding switch.

23. A combustion control system including in combination, a room thermostat having sequentially engageable contacts, a relay coil, a motor switch, a holding switch, said motor switch and holding switch both being operated by the relay coil to close upon energization of the coil and automatically open when the coil is de-energized, a burner motor, a combustion responsive switch having contacts closed in the absence of and open in the presence of combustion, a circuit for initially energizing the relay coil including in series the contacts of the combustion switch and the last to close contact of said sequentially engageable room thermostat contacts, and a holding circuit for the relay coil including in series the contacts of said holding switch and the first to close contact of said sequentially engageable room thermostat contacts, said holding circuit being independent of said combustion switch contacts.

24. A system of the class described for heating a space, comprising, in combination, a heater, an electrically operable fuel supply controlling device for heating said heater, an energizing circuit therefor, a switch in control of said circuit, a holding switch, electrically operated means operable to move said switches to closed position when energized, said switches moving to open position upon de-energization of said electrically operable means, a space temperature responsive main control switch that closes upon a fall in the space temperature, switching means controlled by a heater condition and including a switch which is opened upon an increase in the value of said heater condition and is closed upon a fall in the value of said heater condition, an energizing circuit for said electrically operable means controlled by said switch of the heater condition responsive switching means and said main control switch in series, and connections including the main control switch and holding switch in series for maintaining energization of said electrically operable means after said switch of the heater condition responsive switching means opens as a result of operation of said fuel supply controlling device.

25. The combination of an electrically operable fuel feeding apparatus and circuit therefor with a switch in the circuit, a relay to control the switch, starting and holding circuits for said relay including a thermostatic means, a cut-out mechanism automatically operable after a timed period to interrupt said relay circuits upon closure of said relay switch, said holding circuit being rendered operative as a result of completion of said starting circuit, and a combustion responsive switching device automatically operable upon the establishment of combustion to render said cut-out mechanism and starting circuit inoperable and upon subsequent combustion failure, to again render said cut-out mechanism operable whereby to stop fuel feeding.

26. The combination of an electrically operable fuel feeding apparatus and a circuit therefor with a switch in the circuit, a relay to control the switch, a thermostatic means and circuit therefor to control the relay, a cut-out mechanism automatically operable after a timed period to interrupt the relay circuit upon closure of said relay switch, electrically operable ignition means, and a combustion responsive device automatically operable upon the establishment of combustion to render said cut-out mechanism and said ignition means inoperable.

27. In a burner control system, in combination, a burner motor, a burner motor circuit, a burner motor switch operative to complete the burner motor circuit when closed, a control circuit operative to close said burner motor switch when completed, a room thermostat operative to complete said control circuit upon a call for heat and to interrupt the same when the room thermostat becomes satisfied, said burner motor switch automatically moving to opened position upon interruption of said control circuit, and means responsive to combustion conditions operative to permit closure of the burner motor switch only after the temperature of combustion has decreased a predetermined amount as the result of a prior cessation of combustion.

28. In a burner control system, in combination, a burner motor, a burner motor circuit, a burner motor switch operative to complete the burner motor circuit when closed and automatically movable to open position, a control circuit operative

to close the burner motor switch when completed, a combustion responsive device including a switch which closes upon a predetermined lowering in the temperature of combustion and opens upon the establishment of combustion, a room thermostat, said control circuit including the room thermostat and said switch of the combustion responsive mechanism, whereby the control circuit can only be completed by the room thermostat if the temperature of combustion has decreased at least said predetermined amount, and means controlled by said room thermostat operative to maintain said burner motor switch closed after opening of said switch of the combustion responsive mechanism.

29. In a burner control system in combination, a burner motor, a burner motor circuit, a motor switch in control of said circuit, an electro-magnet operative to close the motor switch when energized, the motor switch automatically moving to open position upon deenergization of the electro-magnet, a combustion responsive mechanism including a switch that closes only after the temperature of combustion lowers at least a predetermined amount and which opens upon the establishment of combustion, a room thermostat, a circuit for the electro-magnet controlled by the room thermostat and said switch of the combustion responsive mechanism whereby the motor switch can be closed only after the temperature of combustion has decreased at least said predetermined amount, and means including electrical connections controlled by the room thermostat operative to maintain said motor switch closed after opening of said switch of the combustion responsive mechanism as a result of the establishment of combustion.

30. An electrical control system for liquid fuel burners comprising a burner motor, a motor circuit in which said motor is connected, a motor switch in said motor circuit which opens automatically when released, electrically operated means operative to close the motor switch and to hold it closed when energized, a control circuit including said electrically operated means, a safety switch including a timed device operative to render the system inoperative if energized for a timed period, and a combustion responsive switch in control of the energization of said timed device, said last-mentioned switch being closed in the absence of and open in the presence of combustion.

31. An electrical control system for liquid fuel burners comprising a burner motor, a motor circuit in which said motor is connected, a motor switch in said motor circuit which opens automatically when released, electrically operated means operative to close the motor switch and to hold it closed when energized, a control circuit including said electrically operated means, a safety switch including a timed device operative to render the system inoperative if energized for a timed period, a combustion responsive switch in control of the energization of said timed device, said last-mentioned switch being closed in the absence of and open in the presence of combustion, and also controlling the initial energization of said electrically operated means, and means to maintain said motor switch closed after opening of said combustion responsive upon the establishment of combustion.

32. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, a main control switch, a combustion responsive switching mechanism including a switch which is open in the presence of and closed in the absence of combustion, a thermal safety switch including an electrical heating element operative to render the system inoperative if energized for a predetermined length of time, and means including circuit connections controlled by said switch of the combustion responsive switching mechanism and said main control switch in series operative to initially energize said fuel supply controlling device and heating element, and including circuit connections completed through said main control switch operative to maintain energization only of said fuel supply controlling device after combustion is established.

33. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, a manually resettable thermal time switch including a thermal element to mechanically actuate said time switch to open position when heated to a predetermined degree and an electrical heating element to heat said thermal element, a combustion responsive switch operable to open circuit position upon the establishment of combustion, a main control switch, and means including circuit connections completed through said main control switch, time switch and combustion responsive switch for energizing said fuel supply controlling device and heating element upon a call for heat during the absence of combustion and for maintaining energization only of said fuel supply control device after combustion is established.

34. A burner control system comprising, in combination, a burner motor, ignition means, electrically operated safety means operative to render the system inoperative after a time period and including means which must be deenergized before said period elapses if the system is to continue in operation, combustion responsive switching mechanism including first and second switches which open in the order named upon the establishment of combustion and close upon the cessation of combustion, a main control, circuit connections including the foregoing elements and controlled by the main control and first switch operative to energize the burner motor and ignition means and to energize said means of the safety means upon a call for heat, and to maintain energization of the ignition means until opening of said second switch, and means to maintain energization of the burner motor after opening of said first and second switches.

35. A burner control system comprising, in combination, a burner motor, electrically operated ignition means, a motor switch, electrically energizable means operative to close the motor switch when energized, the motor switch automatically moving to open position when the electrically energizable means is deenergized, combustion responsive switching means which opens upon the establishment of combustion and which closes only after the temperature of combustion has decreased at least a predetermined amount, a main control switch, an initial energizing circuit for the electrically energizable means controlled by the main controlled switch and combustion responsive switching means in series, circuit connections operative to maintain energization of said electrically energizable means after opening of the combustion responsive switching means controlled by said main control switch, a burner motor circuit controlled by the motor switch, and an ignition means circuit controlled

tor in response to closure of said main switch and to stop the same in response to opening thereof, a thermal-electric safety timer including an electric heating element for terminating operation of said burner motor after a predetermined time and until manual intervention if combustion is not established, said electric heating element being energized by said means in response to closure of said main switch, and including means controlled by the temperature of combustion for operatively de-energizing said safety timer if combustion is established and for interposing a delay between successive energizations of said burner motor.

21. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, an energizing circuit therefor, a switch in control of said circuit, electrically operated means operable to move said switch to closed position when energized, said switch moving to open position upon de-energization of said electrically operable means, a main control switch, switching means controlled by the temperature of combustion and including a switch which is open in the presence of and closed in the absence of combustion, an energizing circuit for said electrically operable means controlled by said switch of the combustion responsive switching means and said main control switch in series, and connections for maintaining energization of said electrically operable means after the establishment of combustion.

22. An oil burner control system comprising, a burner motor, a burner motor circuit, a motor switch, electromagnetic means for closing said motor switch when energized and for opening the same when deenergized, a safety switch mechanism comprising a thermally operated switch and an electrical heating means therefor, means for maintaining said thermally operated switch in open position until manual intervention when the same is opened as a result of a predetermined heating by said electrical heating means, a main control switch, e'ectrical ignition means, combustion responsive switching mechanism closed in the absence of and open in the presence of combustion, circuit connections for said electromagnetic means, electrical heating means and ignition means controlled by said main control switch and combustion responsive switching mechanism, a holding switch moved to closed position upon energization of said electromagnetic means, and a holding circuit for said electromagnetic means independent of said combustion responsive switching mechanism and controlled by said main control switch and said holding switch.

23. A combustion control system including in combination, a room thermostat having sequentially engageable contacts, a relay coil, a motor switch, a holding switch, said motor switch and holding switch both being operated by the relay coil to close upon energization of the coil and automatically open when the coil is de-energized, a burner motor, a combustion responsive switch having contacts closed in the absence of and open in the presence of combustion, a circuit for initially energizing the relay coil including in series the contacts of the combustion switch and the last to close contact of said sequentially engageable room thermostat contacts, and a holding circuit for the relay coil including in series the contacts of said holding switch and the first to close contact of said sequentially engageable room thermostat contacts, said holding circuit being independent of said combustion switch contacts.

24. A system of the class described for heating a space, comprising, in combination, a heater, an electrically operable fuel supply controlling device for heating said heater, an energizing circuit therefor, a switch in control of said circuit, a holding switch, electrically operated means operable to move said switches to closed position when energized, said switches moving to open position upon de-energization of said electrically operable means, a space temperature responsive main control switch that closes upon a fall in the space temperature, switching means controlled by a heater condition and including a switch which is opened upon an increase in the value of said heater condition and is closed upon a fall in the value of said heater condition, an energizing circuit for said electrically operable means controlled by said switch of the heater condition responsive switching means and said main control switch in series, and connections including the main control switch and holding switch in series for maintaining energization of said electrically operable means after said switch of the heater condition responsive switching means opens as a result of operation of said fuel supply controlling device.

25. The combination of an electrically operable fuel feeding apparatus and circuit therefor with a switch in the circuit, a relay to control the switch, starting and holding circuits for said relay including a thermostatic means, a cut-out mechanism automatically operable after a timed period to interrupt said relay circuits upon closure of said relay switch, said holding circuit being rendered operative as a result of completion of said starting circuit, and a combustion responsive switching device automatically operable upon the establishment of combustion to render said cut-out mechanism and starting circuit inoperable and upon subsequent combustion failure, to again render said cut-out mechanism operable whereby to stop fuel feeding.

26. The combination of an electrically operable fuel feeding apparatus and a circuit therefor with a switch in the circuit, a relay to control the switch, a thermostatic means and circuit therefor to control the relay, a cut-out mechanism automatically operable after a timed period to interrupt the relay circuit upon closure of said relay switch, electrically operable ignition means, and a combustion responsive device automatically operable upon the establishment of combustion to render said cut-out mechanism and said ignition means inoperable.

27. In a burner control system, in combination, a burner motor, a burner motor circuit, a burner motor switch operative to complete the burner motor circuit when closed, a control circuit operative to close said burner motor switch when completed, a room thermostat operative to complete said control circuit upon a call for heat and to interrupt the same when the room thermostat becomes satisfied, said burner motor switch automatically moving to opened position upon interruption of said control circuit, and means responsive to combustion conditions operative to permit closure of the burner motor switch only after the temperature of combustion has decreased a predetermined amount as the result of a prior cessation of combustion.

28. In a burner control system, in combination, a burner motor, a burner motor circuit, a burner motor switch operative to complete the burner motor circuit when closed and automatically movable to open position, a control circuit operative

to close the burner motor switch when completed, a combustion responsive device including a switch which closes upon a predetermined lowering in the temperature of combustion and opens upon the establishment of combustion, a room thermostat, said control circuit including the room thermostat and said switch of the combustion responsive mechanism, whereby the control circuit can only be completed by the room thermostat if the temperature of combustion has decreased at least said predetermined amount, and means controlled by said room thermostat operative to maintain said burner motor switch closed after opening of said switch of the combustion responsive mechanism.

29. In a burner control system in combination, a burner motor, a burner motor circuit, a motor switch in control of said circuit, an electro-magnet operative to close the motor switch when energized, the motor switch automatically moving to open position upon deenergization of the electro-magnet, a combustion responsive mechanism including a switch that closes only after the temperature of combustion lowers at least a predetermined amount and which opens upon the establishment of combustion, a room thermostat, a circuit for the electro-magnet controlled by the room thermostat and said switch of the combustion responsive mechanism whereby the motor switch can be closed only after the temperature of combustion has decreased at least said predetermined amount, and means including electrical connections controlled by the room thermostat operative to maintain said motor switch closed after opening of said switch of the combustion responsive mechanism as a result of the establishment of combustion.

30. An electrical control system for liquid fuel burners comprising a burner motor, a motor circuit in which said motor is connected, a motor switch in said motor circuit which opens automatically when released, electrically operated means operative to close the motor switch and to hold it closed when energized, a control circuit including said electrically operated means, a safety switch including a timed device operative to render the system inoperative if energized for a timed period, and a combustion responsive switch in control of the energization of said timed device, said last-mentioned switch being closed in the absence of and open in the presence of combustion.

31. An electrical control system for liquid fuel burners comprising a burner motor, a motor circuit in which said motor is connected, a motor switch in said motor circuit which opens automatically when released, electrically operated means operative to close the motor switch and to hold it closed when energized, a control circuit including said electrically operated means, a safety switch including a timed device operative to render the system inoperative if energized for a timed period, a combustion responsive switch in control of the energization of said timed device, said last-mentioned switch being closed in the absence of and open in the presence of combustion, and also controlling the initial energization of said electrically operated means, and means to maintain said motor switch closed after opening of said combustion responsive upon the establishment of combustion.

32. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, a main control switch, a combustion responsive switching mechanism including a switch which is open in the presence of and closed in the absence of combustion, a thermal safety switch including an electrical heating element operative to render the system inoperative if energized for a predetermined length of time, and means including circuit connections controlled by said switch of the combustion responsive switching mechanism and said main control switch in series operative to initially energize said fuel supply controlling device and heating element, and including circuit connections completed through said main control switch operative to maintain energization only of said fuel supply controlling device after combustion is established.

33. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, a manually resettable thermal time switch including a thermal element to mechanically actuate said time switch to open position when heated to a predetermined degree and an electrical heating element to heat said thermal element, a combustion responsive switch operable to open circuit position upon the establishment of combustion, a main control switch, and means including circuit connections completed through said main control switch, time switch and combustion responsive switch for energizing said fuel supply controlling device and heating element upon a call for heat during the absence of combustion and for maintaining energization only of said fuel supply control device after combustion is established.

34. A burner control system comprising, in combination, a burner motor, ignition means, electrically operated safety means operative to render the system inoperative after a time period and including means which must be deenergized before said period elapses if the system is to continue in operation, combustion responsive switching mechanism including first and second switches which open in the order named upon the establishment of combustion and close upon the cessation of combustion, a main control, circuit connections including the foregoing elements and controlled by the main control and first switch operative to energize the burner motor and ignition means and to energize said means of the safety means upon a call for heat, and to maintain energization of the ignition means until opening of said second switch, and means to maintain energization of the burner motor after opening of said first and second switches.

35. A burner control system comprising, in combination, a burner motor, electrically operated ignition means, a motor switch, electrically energizable means operative to close the motor switch when energized, the motor switch automatically moving to open position when the electrically energizable means is deenergized, combustion responsive switching means which opens upon the establishment of combustion and which closes only after the temperature of combustion has decreased at least a predetermined amount, a main control switch, an initial energizing circuit for the electrically energizable means controlled by the main controlled switch and combustion responsive switching means in series, circuit connections operative to maintain energization of said electrically energizable means after opening of the combustion responsive switching means controlled by said main control switch, a burner motor circuit controlled by the motor switch, and an ignition means circuit controlled

by the conjoint action of the motor switch and combustion responsive switching means.

36. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, electrically operable ignition means for igniting the fuel supplied by said device, first and second switches, a fuel supply controlling device energizing circuit controlled by said first switch, an ignition means energizing circuit controlled by said second switch, an element responsive to combustion conditions operative to close said second and first switches sequentially in the order named upon cessation of combustion, and means including a main control switch operative to render said circuits operable and to maintain energization of said fuel supply controlling device after opening of said first switch upon the establishment of combustion.

37. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, ignition means operative to ignite the fuel supplied by said fuel supply controlling device, switching means responsive to combustion conditions and including first and second switches which are closed in the order named upon cessation of combustion, a main control switch, said first switch being in circuit with said iginition means, means including circuit connections controlled by said main control switch and second switch in series operative to initially energize said fuel supply controlling device and ignition means whereby said ignition means is conditioned for operation by closure of said first switch before the entire system is conditioned for operation by closure of said second switch, and means operative to maintain energization of said fuel supply controlling device after combustion is established.

38. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, an energizing circuit therefor, a switch in control of said circuit, electrically operable means operable to move said switch to closed position when energized, a main control switch, switching means controlled by the temperature of combustion and including first and second switches closed in the order named upon cessation of combustion, electrically operable ignition means, a circuit therefor controlled by the conjoint action of said first-named switch and the first switch of said combustion responsive switching means, an energizing circuit for said electrically operable means controlled by the conjoint action of said second switch of the combustion responsive switching means and said main control switch, and means controlled by said main control switch operative to maintain energization of said electrically operable means after the establishment of combustion.

39. A system of the class described, comprising, in combination, a fuel control device, ignition means, a cut-out mechanism automatically operable to interrupt the supply of fuel if operated for a predetermined length of time, a main control, an element responsive to the presence or absence of combustion, means including circuit connections between said main control and element and said fuel control device, cut-out mechanism and ignition means operative to place said fuel control device, cut-out mechanism, and ignition means into operation upon a call for heat by said main control in the absence of combustion and to first render said cut-out mechanism inoperative and then said ignition means inoperative while maintaining the supply of fuel upon the establishment of combustion.

40. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, ignition means, a safety mechanism comprising a thermal switch adapted to open when heated to a predetermined degree and an electrical heating element therefor, combustion responsive switching mechanism including first and second switches which open sequentially in the order named upon establishment of combustion, the second switch closing prior to closing of the first switch upon cessation of combustion, a main control switch, and means including circuit connections for energizing said fuel supply controlling device, electrical heating element and ignition means upon closure of said main control switch only if said first switch is closed, for maintaining energization of said fuel supply controlling device after combustion is established and for respectively interrupting the circuits for said heating element and ignition means upon the sequential opening of said first and second switches.

41. A burner control system of the class described, comprising, in combination, a burner motor, electrically operated ignition means, a relay including an electromagnetic coil, and a motor switch and a control switch that are closed and held closed by said electromagnetic coil when energized, a burner motor circuit controlled by said motor switch, first and second switches responsive to combustion conditions which close in the order named upon the cessation of combustion and open upon the establishment of combustion, an ignition means circuit controlled by the conjoint action of the motor switch and said first switch, a main control switch, an initial energizing circuit for the electromagnetic coil controlled by the main control switch and said second switch in series, and a holding circuit for the electromagnetic coil which is independent of said second switch but includes the main control switch and holding switch in series.

42. A burner control system of the class described, comprising, in combination, a burner motor, electrically operated ignition means, a relay including an electromagnetic coil, and a motor switch and a control switch that are closed and held closed by said electromagnetic coil when energized, a burner motor circuit controlled by said motor switch, first and second switches responsive to combustion conditions which close in the order named upon the cessation of combustion and open upon the establishment of combustion, an ignition means circuit controlled by the conjoint action of the motor switch and said first switch, a main control switch, a thermo-electric safety switch including an electric heating element and operative to shut down the system if its heating element is operatively energized for a timed period, energizing circuits for said electromagnetic coil and heating element completed only by closure of both the main control switch and said second switch, and a holding circuit for the electromagnetic coil controlled by the main control switch and holding switch but independent of said second switch.

43. In a burner control system; in combination; a high voltage burner motor; ignition means; a step-down transformer; a motor switch; an energizing circuit for the burner motor and said transformer controlled by said motor switch; an electromagnetic coil operable to close said motor switch and maintain the same closed when

energized; a low voltage main control switch; low voltage switching means responsive to combustion conditions closed in the absence of and open in the presence of combustion; a low voltage circuit for the electromagnetic coil controlled by the main control switch and said switching means; a circuit including said ignition means, the secondary of said transformer and said switching means; and means under the control of said main control switch operative to maintain energization of said electromagnetic coil after the opening of said switching means by reason of the establishment of combustion.

44. In a burner control system, a motor controlling fuel feed, a room thermostat circuit, means rendered operative to start said motor in response to the closure of said circuit and to stop said motor upon the opening thereof, and combustion responsive means controlling said first mentioned means and operative when combustion terminates to delay for a time interval reenergization of said motor when said circuit is closed.

45. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, ignition means operative to ignite the fuel supplied by said fuel supply controlling device, first and second switches controlled by combustion conditions, upon cessation of combustion said first switch moving to a new control position and said second switch thereafter closing, a main control switch, means including circuit connections controlled by the main switch and second switch in series operative to initially energize said fuel supply controlling device and ignition means, means operative to maintain energization of said fuel supply controlling device and ignition means after opening of said second switch, and means controlled by said first switch to deenergize said ignition means when the first switch is moved to a new control position after opening of said second switch as a result of the establishment of combustion.

46. A system of the class described, comprising, in combination, an electrically operable fuel supply controlling device, ignition means, a safety mechanism comprising a thermal switch adapted to open when heated to a predetermined degree and an electrical heating element therefor, combustion temperature responsive switching means including a first switch that closes upon a lowering of the combustion temperature a predetermined amount and opens upon a rise in combustion temperature and a second switch moved to a new controlling position upon a rise in combustion temperature greater than that required to open said first switch, a main control switch, and circuit connections including the foregoing elements and means for energizing said fuel supply controlling device, electrical heating element and ignition means upon closure of said main control switch only if said first switch is closed, for maintaining energization of said fuel supply controlling device after combustion is established and for respectively and sequentially interrupting the circuits for said heating element and ignition means upon opening of said first switch and movement of said second switch to its new controlling position whereby said heating element is deenergized prior to said ignition means if combustion is established.

47. A burner control system of the class described, comprising in combination, a burner motor, electrical ignition means, a burner motor switch, energizing circuits for said burner motor and ignition means controlled by closure of said burner motor switch, a holding switch, electromagnetic means to close said burner motor and holding switches, a main control switch, a first combustion responsive switch that closes upon cessation of combustion and opens upon the establishment of combustion, a circuit for energizing said electromagnetic means to cause closure of said burner motor and holding switches and controlled by said main switch and first combustion responsive switches in series, a circuit for energizing said electromagnetic means to maintain said burner motor and holding switches closed after opening of said first combustion responsive switch upon the establishment of combustion controlled by said main control switch and holding switch in series, and a second combustion responsive switch which moves to a new control position after opening of said first combustion responsive switch operative to interrupt said ignition means circuit.

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