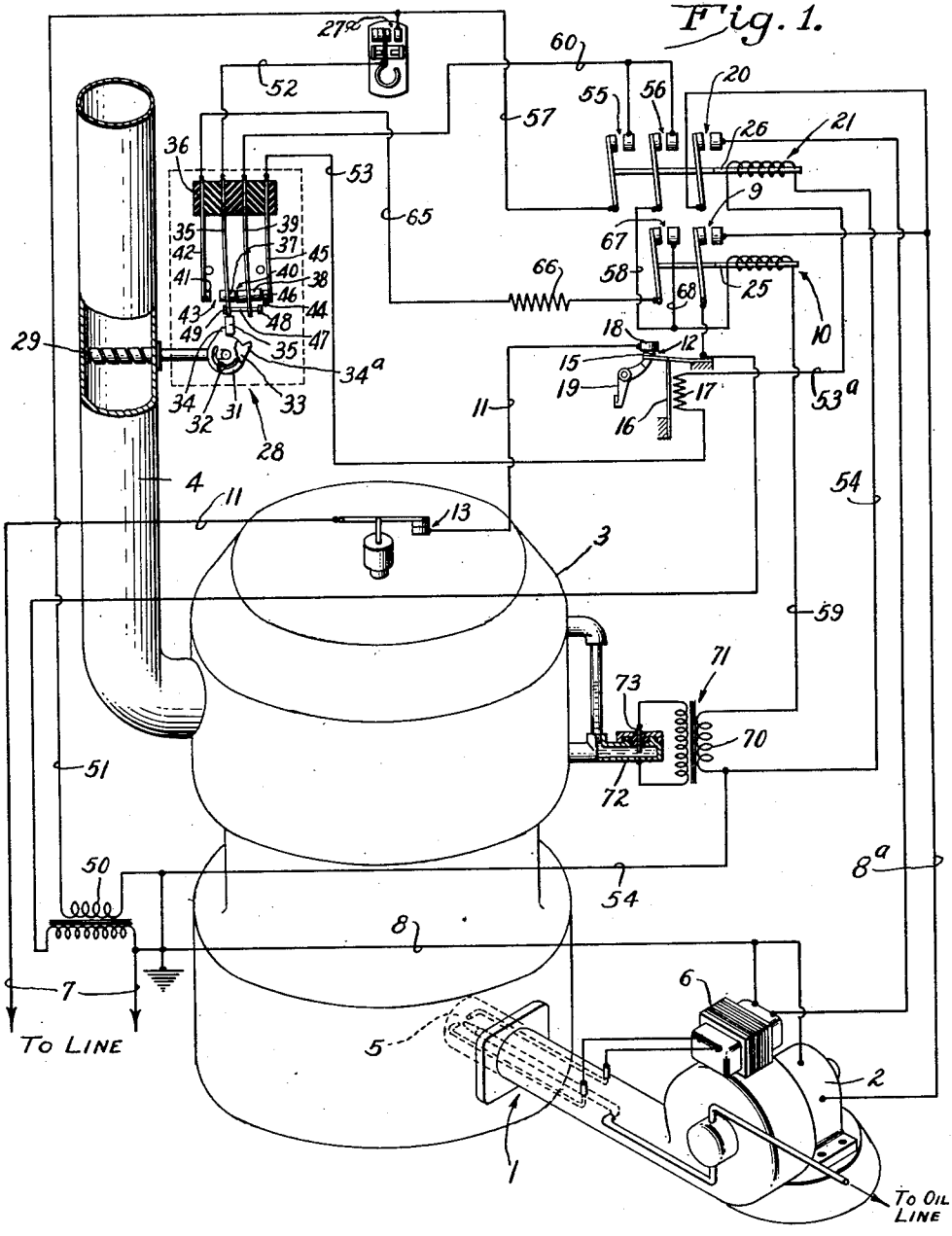
May 9, 1939. H. E. LAKE 2,157,710

SYSTEM OF CONTROL FOR BURNERS

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Fig. 1.



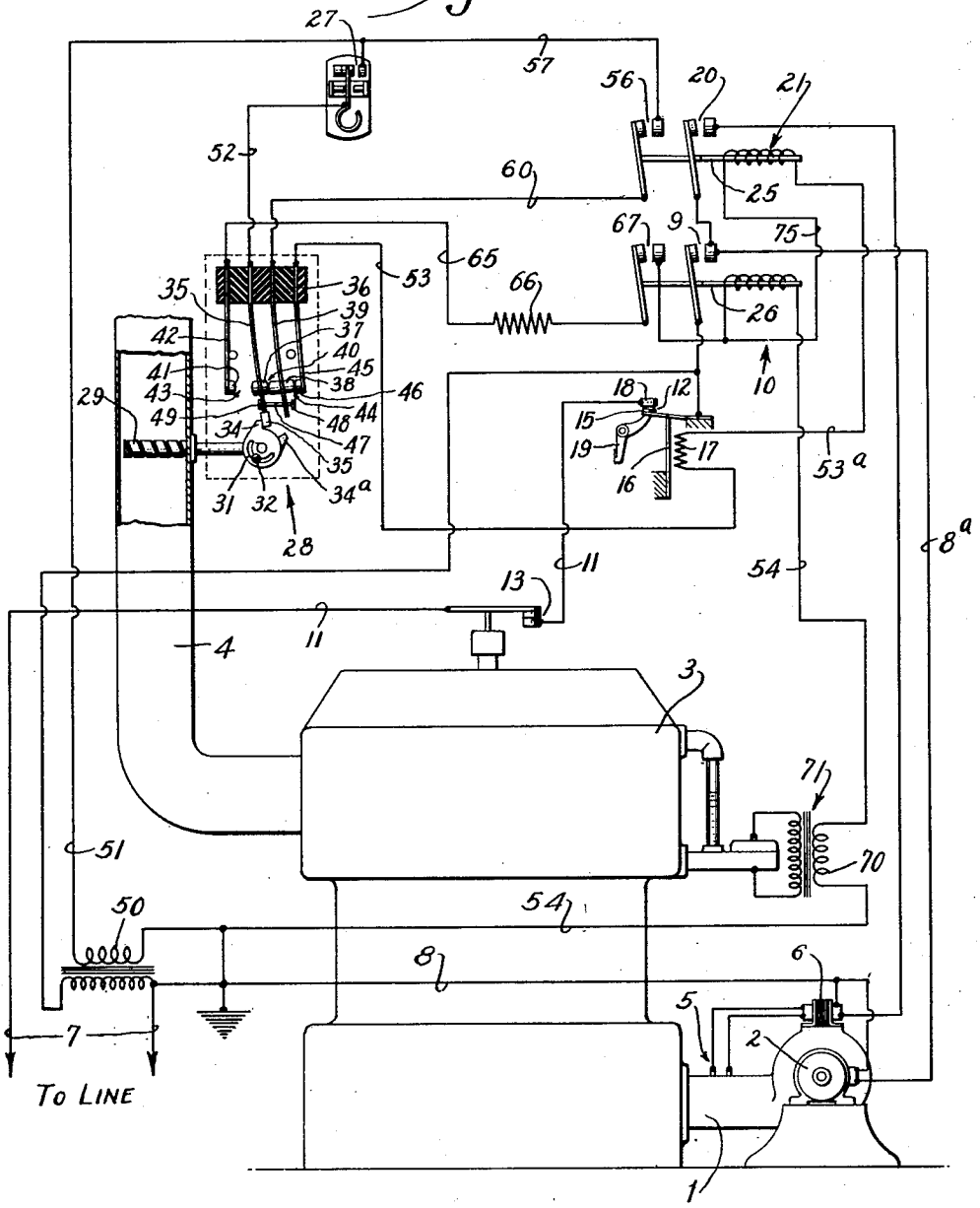
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Fig. 2.



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UNITED STATES PATENT OFFICE

2,157,710

SYSTEM OF CONTROL FOR BURNERS

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Application December 7, 1935, Serial No. 53,334

9 Claims. (Cl. 158—28)

This invention relates generally to control equipment for governing the cyclic operation of burners of the intermittent type.

The general object is to provide a novel burner control system which is simple and inexpensive in construction, which is reliable in operation, which embodies all of the features necessary for safe operation of the burner under all abnormal conditions ordinarily encountered in service use, and which effects automatic recycling of the burner at the time and under the conditions when such recycling may safely occur.

The invention also resides in the novel character of the construction employed for carrying out the foregoing object.

Other objects and advantages of the invention will be apparent from the following detailed description taken in conjunction with the accompanying drawings in which

Figure 1 is a schematic view and wiring diagram of part of a heating system having a burner control embodying the features of the present invention.

Fig. 2 is a schematic view and wiring diagram of a modified form of the control system.

In the embodiment shown in Fig. 1, for the purpose of illustrating the invention, the numeral 1 indicates a liquid fuel burner of a conventional type adapted upon operation of an electric motor 2 to discharge atomized fuel into the combustion chamber within a boiler 3 indicated in dotted outline and having an outlet flue 4 through which the products of combustion are discharged. A spark igniter 5 of conventional construction is employed and arranged to be rendered operative upon energization of the primary winding of a step-up transformer 6.

The motor 2 is arranged to be energized through a circuit which extends from a high voltage power source 7 through a conductor 8, the motor 2, a conductor 8a, a normally open switch 9 of an electromagnetic relay 10, and a conductor 11 having interposed therein a normally closed safety switch 12 and a normally closed switch 13 arranged to be opened in response to an abnormally high pressure or temperature of the boiler fluid. Thus, with the switches 12 and 13 closed, as they normally are, the motor will be started and stopped and the supply of fuel to the combustion chamber will be initiated and interrupted in response to energization and deenergization of the magnet 10.

The safety switch 12 is maintained closed under normal operating conditions and is arranged to be opened after the lapse of an interval determined by the period during which a suitable slow-acting device remains electrically energized. After being opened, the switch remains in this position until reset manually. The slow-acting device comprises a strip 16 of bimetallic material normally acting as a latch to hold a movable contact 15 of the safety switch in closed position and arranged to warp, when heated by a resistance element 17, in a direction to release the contact and permit movement thereof away from the fixed contact 18. After opening of the switch, the motor circuit remains broken until the latch is reset by manual operation of a lever 19.

The primary winding of the ignition transformer 6 is connected in series with a control switch 20, and the two are arranged in parallel with the motor 2 so that the igniter 5 will be rendered effective when both of the switches 9 and 20 are closed but may be rendered ineffective by opening of the switch 20 alone. The latter is arranged to be closed upon energization of a second relay 21. The movable contacts of the switches 9 and 20 are carried respectively by the armatures 25 and 26 of the magnets 10 and 21.

The energizing circuits for the relays are preferably operated at low voltage under the control of a combustion responsive device 28 and a main switch 27 which may be operated manually or it may be operated automatically as shown by a thermostatic element 27a responsive to temperature changes within the room or space being heated. In the present instance, the device 28 comprises a thermostatic element 29 disposed within the flue 4 with its movable end connected through a slip clutch or well known equivalent mechanism (not shown) to a disk 31 connected by an adjustable pin and slot connection 32 to a disk 33. Projecting from the disks are lugs 34 and 34a receiving between them the free end of an arm 35 anchored in a block 36 of insulating material. The arm carries a contact 37 which cooperates with a contact 38 on a similarly mounted spring arm 39 to form a switch 40. The contact 37 also cooperates with a contact 41 on an arm 42 to form a switch 43.

The parts of the stack thermostat are arranged in a manner such that when the thermostatic element 29 is cool, as will be the case after the burner has been idle for a short period, the parts will be positioned as shown in Fig. 1, the lug 34 bearing against the arm 35 to hold the switch 40 closed and the switch 43 open. Upon heating of the element 29, the disks 31 and 33 are turned in a counter-clockwise direction permitting the contact 37 to move away from the contact 38

thereby opening the switch 40 substantially immediately. In the continued heating, the arm 35 remains midway between the contacts 38 and 41 until the arm is engaged by the lug 34ª whereupon the contact 37 is moved toward and finally into engagement with the contact 41 thereby closing the switch 43. The length of the interval between the opening of the switch 40 and the closing of the switch 43 may be varied as desired by changing the spacing of the lugs 34 and 34ª. After the relatively stationary contact 41 has been engaged, continued heating of the thermostatic element 29 will impart only a slight additional movement to the discs 31 and 33 due to the slippage of the clutch in the stack thermostat. Thus, upon cooling of the thermostatic element following a cessation of combustion, the lug 34ª will move reversely substantially immediately, permitting the switch 43 to open and then, after the lapse of a time interval, the lug 34 will move the arm 35 to close the switch 40. This interval is of sufficient duration to insure withdrawal of any combustible gases from the combustion chamber by the natural draft.

For the purpose of maintaining operation of the burner motor while both of the switches 40 and 43 are open during the ignition trial period, a third switch 44 is incorporated in the stack thermostat and arranged so as to be closed in the absence of combustion but opened upon heating of the thermostatic element 29 after the closed-when-hot switch 43 has been closed. To this end, an arm 45 mounted in the block 36 carries a contact 46 which cooperates with the contact 38 on the arm 39 to form the switch 44. The free ends of the arms 35 and 39 are joined by a lost motion connection which may take the form of an insulated pin 47 having heads 48 and 49 disposed outside of the arms. When the arm 35 is positioned as shown in Fig. 1, as will be the case when the stack is cool, the arm 35 acting through the medium of the contact 38 will maintain the switch 44 closed. Upon heating of the thermostatic element 29, the contacts 38 and 46 will remain engaged after opening of the switch 40 and will not become disengaged until the slack in the lost motion connection provided by the pin 47 has been taken up and the arm 35 moved by the lug 34ª to a position such as to move the arm 39 away from the arm 45. The slack in the lost motion connection is so proportioned that such disengagement of the contacts 38 and 46 will not occur until after the contact 37 has engaged the contact 41.

Assuming that the burner is idle, the parts will be positioned as shown in Fig. 1. Then, when the room thermostat calls for heat, a circuit for energizing the relay 21 will be completed extending from the secondary of a transformer 50 through a conductor 51, the thermostat switch 27, a conductor 52, the then closed switches 40 and 44 of the stack thermostat 28, a conductor 53, the resistance element 17, a conductor 53ª, the winding of the relay 21, and a conductor 54. Energization of the relay 21 closes the ignition control switch 20 and also switches 55 and 56 which cooperate to complete an energizing circuit for the winding of the relay 10 independent of the room thermostat switch and the combustion switch 40. This circuit extends through the conductor 51, a conductor 57, the switches 55 and 56, a conductor 58, the winding of the relay 10, a conductor 59, and the conductor 54.

As a result of energization of the relay 10, the burner motor switch 9 is closed which completes high voltage circuits through the motor 2 and the ignition transformer 6 thereby initiating operation of the motor and the igniter. If ignition is successful, the temperature of the thermostatic element 29 will rise whereupon the disks 31 and 33 will be turned in a counter-clockwise direction permitting substantially immediate opening of the switch 40 which has no effect upon the circuit through the motor relay. After opening of this switch, energization of the ignition relay 21 will be continued through a circuit which extends from the conductor 51, through the conductor 57, the switch 55, a conductor 60, the switch 44 of the stack thermostat, the conductor 53, the resistance element 17, the conductor 53ª, the winding of the relay 21 to conductor 54.

Near the end of the period allowed for trial ignition, the arm 35 is moved by the lug 34a into engagement with the contact 41 thereby closing the closed-when-hot stack switch 43 which completes a holding circuit for maintaining energization of the motor relay 10 while the room thermostat continues to call for heat. This circuit extends from the conductor 51, through the room thermostat switch 27, the conductor 52, the switch 43, a conductor 65, a balancing resistance 66, a switch 67 which is closed when the motor relay 10 is energized, a conductor 68, the winding of the motor relay 10, the conductor 59 to the conductor 54. Resistance 66 reduces the current flow in this circuit to the minimum necessary to hold relay 10 operative so that the relay may be maintained energized for relatively long periods without undue heating. Shortly after closure of the stack switch 43, the lug 34ª acting through the medium of the arm 35 and the pin 47 will move the arm 39 to open the switch 44 thereby interrupting the circuits through the resistance element 17 and the winding of the ignition relay 21. Operation of the igniter 5 and heating of the thermal latch 16 are thus interrupted, and control of the relay 10 is transferred back to the room thermostat and also to the closed-when-hot stack switch 43 which remains closed as the clutch in the stack switch slips during the continued rise in the stack temperature.

In normal operation, the burner is stopped when the room thermostat ceases to call for heat which will be evidenced by opening of the switch 27. This breaks the holding circuit above described through the switch 43 and the winding of the relay 10. Reenergization of the motor relay to again start the burner may take place after the furnace has cooled sufficiently to effect closure of the stack switch 40.

In the event that ignition fails which will be evidenced by failure of the stack switch 44 to open within the allotted trial period, the circuits through the relays 10 and 21 will remain closed and the heating element 17 energized until the safety switch 12 is released. After this, recycling of the system can be effected only after manual resetting of the safety switch. Since the circuit by which the motor relay 10 is initially energized is closed during substantially the same portion of the trial ignition period as the circuit for energizing the relay 21, it will be observed that the heater 17 of the safety switch may, if desired, be connected in series with the relay 10 in the initial energizing circuit of the latter instead of in the igniter control circuit as shown in Fig. 1.

After a voltage failure or flame failure with the burner in operation, automatic recycling is per-

nissible providing this is done under the proper supervision of the combustion responsive mechanism. In case of voltage failure, the relay 10 will be deenergized thereby opening the switch 67 which, coupled with the fact that the switch 66 is at this time open, will prevent reenergization of either of the relays until the switch 40 has again been closed by cooling of the thermostatic element 29. In this way, the parts are properly reconditioned for proper timing of the different control functions before recycling may occur.

In the event of flame failure, the stack thermostat cools and the ensuing opening of the switch 43 effects deenergization of the motor relay 10 and stopping of the burner. In the meantime, that is, while the switch 43 is still closed, the motor may in some cases discharge sufficient fuel into the then hot fire pot to fill the combustion chamber with highly combustible vapors. To avoid the danger of an explosion under this condition, provision is made for preventing operation of the igniter until the lapse of an interval sufficient to permit the combustion chamber to be purged of combustible gases. For this purpose, advantage is taken of the fact that while the burner is in operation, the relay 21 is maintained deenergized and reenergization thereof is prevented until the stack switch 40 has been closed by prolonged cooling of the fire box. Thus, by arranging the stack switch 44 in series with the switch 56 controlled by the relay 21, closure of the switch 44 which occurs immediately after the cessation of combustion will not close the circuit through the relay 21 during cooling as it does during heating of the stack thermostat. In this way, the relay 21 and the stack switch mechanism operate jointly to disable the relay 10 and therefore prevent operation of the igniter and burner motor after flame failure until the proper purging interval has elapsed. When the stack switch 40 finally becomes closed, another operating cycle may occur in the regular way.

With the arrangement above described, the room thermostat cannot be manipulated accidentally in any manner such as to effect momentary operation of the burner or momentary interruption of its operation without there being the desired interval interposed between any two successive periods of motor operation. Thus, the present control effects recycling of the burner automatically at the proper times and in response to the occurrence of any abnormal condition where such recycling is permissible but only after the allotted time has transpired.

Advantage is taken of the control circuits above described to incorporate in the control system a simple and reliable mechanism for rendering the burner inoperative in the case of hot water or steam heating systems when the water in the boiler 3 falls below a predetermined safe level. For this purpose, the primary winding 70 of a transformer 71 is interposed in the low voltage circuits in series with the winding of the motor relay 10.

One terminal of the secondary winding of the transformer 71 is connected to an electrode 72 which may be a pipe communicating with the boiler at the proper level. The other winding terminal is connected to an electrode 73 which is insulated and spaced from the electrode 72 and positioned at the minimum water level to be maintained. The transformer is so constructed that the primary winding 70 will, under certain conditions, act as a choke in the low voltage supply to the motor relay 10. When the electrodes 72 and 73 are both immersed, the impedance of the primary winding will be relatively low, but when the water level falls below the electrode 73, this impedance will be increased to such an extent that the resulting reduction in the voltage applied to the winding of the motor relay will cause this relay to release its armature and permit the switches 9 and 67 to open, or in the event that the burner is idle, to prevent effective energization of the motor relay 10 in the manner above described following the next call of the room thermostat for heat. With this arrangement, electrodes of very small size may be used and the necessity of switches or other moving parts subject to deterioration is avoided.

Instead of energizing the motor relay 10 and the ignition relay 21 in separate circuits as in the system above described, these relays may, if desired, be arranged in series relation. Fig. 2 illustrates such a modification of the present invention, the switches, the relays, and other control elements of the system being numbered to correspond to Fig. 1 and shown in the positions which they will occupy when the burner is idle.

The call of the room thermostat for heat completes a circuit from the secondary of the transformer 50 through the conductor 51, the thermostat switch 27, the conductor 52, the stack switches 40 and 44, the conductor 53, the resistance element 17, the conductor 53a, the winding of the relay 21, a conductor 75, the winding of the relay 10, the conductor 54, and the winding 70 of the low water cut off mechanism. As a result of energization of the relay 21, the ignition control switch 20 and the low voltage control switch 56 are closed. Closure of the switch 56 completes a carry-over circuit for the motor relay 10, ignition relay 21 and resistance heater 17 independently of the room thermostat for maintaining energization of these elements after the combustion responsive switch 40 opens. This circuit extends from the transformer through the conductors 51 and 57, the switch 56, the conductor 60, the switch 44, the conductor 53, the resistance element 17, the conductor 53a, the windings of the relays 21 and 10 to the conductor 54.

Closure of the motor switch 9 as a result of energization of the relay 10 initiates the operation of the burner motor and the igniter whereupon combustion will normally occur resulting in substantially immediate opening of the switch 40 followed, after the lapse of the trial ignition period, by closure of the switch 43. Closure of the latter switch completes the holding circuit through the room thermostat switch 27, the switch 43, the balancing resistance 66, the then closed switch 67, and the winding of the relay 10 whereupon operation of the burner continues under the control of the room thermostat and closed-when-hot stack switches. In addition to its previously described function, the resistance 66 in the present instance performs the additional function of preventing the closure of this circuit from shunting out the ignition relay 21. Shortly after closure of the switch 43, the switch 44 is opened in the manner previously described whereupon the resistance element 17 and the ignition relay 21 are deenergized to interrupt heating of the safety switch and to open the ignition circuit.

When the room thermostat ceases to call for heat, when the switch 43 is opened in response to flame failure with the burner in operation, or when the switch 67 is open in response to a volt-

age failure with the burner in operation, automatic recycling of the system will take place in the same manner as with the system shown in Fig. 1.

I claim as my invention:

1. A control system for a fuel burner comprising, in combination, a motor for supplying fuel, an igniter, a first relay adapted when energized to maintain operation of said motor, a second relay adapted when energized to maintain operation of said igniter, a main control switch, a combustion responsive device having a first switch which is closed in the absence of combustion and opened substantially immediately upon the occurrence of combustion, a second switch which is closed in the presence of combustion and opened substantially immediately upon the cessation of combustion, and a third switch which is closed in the absence of combustion and opened after initial combustion following closure of said second switch, a circuit for effecting initial energization of said second relay including said control switch and said first combustion switch, a circuit for maintaining energization of said second relay including said third combustion switch and a switch which is closed when the second relay is energized, a circuit for effecting initial energization of said first relay independently of said control switch including said switch which is closed when said second relay is energized, and a circuit for maintaining energization of said first relay following the establishment of combustion including said control switch, said second combustion switch and a switch which is closed when said first relay is energized.

2. A control system for a fuel burner comprising, in combination, a burner motor, an igniter, a first relay adapted when energized to maintain operation of said motor, a second relay adapted when energized to maintain operation of said igniter, a main control switch, a safety switch having an operating element adapted to be electrically energized to open the switch, a combustion responsive device having a first switch which is closed in the absence of combustion and open substantially immediately upon the occurrence of combustion, a second switch which is closed in the presence of combustion and opened substantially immediately upon the cessation of combustion, and a third switch which is closed in the absence of combustion and opened after initial combustion following closure of said second switch, a circuit for effecting initial energization of said second relay including said control switch, said first combustion switch and said operating element, a circuit for maintaining energization of said second relay and said operating element including said third combustion switch and a switch which is closed when the second relay is energized, a circuit for effecting initial energization of said first relay independently of said control switch including a switch which is closed when said second relay is energized, and a circuit for maintaining energization of said first relay following the establishment of combustion including said control switch, said second combustion switch and a switch which is closed when said first relay is energized.

3. A control system for a fuel burner comprising, in combination, a burner motor, an igniter, a first relay adapted when energized to maintain operation of said motor, a second relay adapted when energized to maintain operation of said igniter, a main control switch, a safety cut-out switch, an operating element therefor, a combustion responsive device having a first switch which is closed in the absence of combustion and opened substantially immediately upon the occurrence of combustion, a second switch which is closed in the presence of combustion and opened substantially immediately upon the cessation of combustion, and a third switch which is closed in the absence of combustion and opened in the presence of combustion following closure of said second switch, a circuit for effecting initial energization of said relays including said control switch, the windings of the relays in series, said first and third combustion switches, and said operating element, a circuit for maintaining energization of said relays independently of said control switch including said third combustion switch and a switch which is closed when the second relay is energized, and a circuit for maintaining energization of said first relay following the establishment of combustion including said control switch, said second combustion switch, and a switch which is closed when said first relay is energized.

4. A control system for a fuel burner comprising, in combination, a fuel supply motor, an igniter, a first relay adapted when energized to maintain operation of said motor, a second relay adapted when energized to maintain operation of said igniter, a thermostatically controlled switch, a combustion responsive device having a first switch which is closed in the absence of combustion and opened substantially immediately upon the occurrence of combustion, a second switch which is closed in the presence of combustion and opened substantially immediately upon the cessation of combustion, and a third switch which is opened after combustion is established and subsequent to the closure of said second switch, a circuit for effecting initial energization of said second relay including said thermostatic switch and said first combustion switch, a circuit for maintaining energization of said second relay including said third combustion switch and a fourth switch which is closed when the relay is energized, a circuit for effecting initial energization of said first relay including said fourth switch and a fifth switch which is closed when said second relay is energized, and a circuit for maintaining the energization of said first relay following the establishment of combustion including said thermostatic switch, said second combustion switch and a sixth switch which is closed when said first relay is energized.

5. A control system for fuel burners comprising, in combination, a fuel supply motor, an igniter, a first relay adapted when energized to maintain operation of said motor, a second relay adapted when energized to maintain operation of said igniter, a normally closed safety switch adapted to be opened by prolonged energization of an operating element, a combustion responsive switching mechanism, a thermostatically controlled switch, circuit connections under the control of said thermostatic switch and said mechanism for initially energizing both of said relays and said operating element, switching means acting under the control of said mechanism during a trial ignition period to maintain energization of said relays and said operating element independently of said thermostatic switch, said switching means operating at the end of said period to deenergize said operating element and said second relay, and other switching means controlled by said mechanism and operating during said trial period in the event of successful ignition to establish a hold-

ing circuit for said first relay through said thermostatic switch.

6. A control system for burners comprising, in combination, a fuel supply motor, an igniter, a first relay adapted when energized to maintain operation of said motor, a second relay adapted when energized to maintain operation of said igniter, a main control switch, a combustion device having a first switch which is closed in the absence of combustion, opened substantially immediately upon the occurrence of combustion and reclosed after a predetermined delay upon the cessation of combustion, a second switch which is closed after a predetermined delay upon initiation of combustion, which remains closed in the presence of combustion and which is opened substantially immediately upon the cessation of combustion, and a third switch which is closed in the absence of combustion and maintained closed during the interval when said first and second switches are both open, means controlled by said control switch and said first and third switches for effecting energization of both of said relays to initiate operation of the burner, means controlled by said third switch to maintain energization of said relays after said first switch is opened, and means controlled by said control switch and said second switch for maintaining energization of said first relay after said third switch has opened.

7. A control system for a burner comprising, in combination, a burner motor, an igniter, a main control switch, a relay for controlling said motor, a second relay for controlling said igniter, means responsive to operation of said switch to energize said relays to initiate the operation of said motor and igniter, means for maintaining said relays energized independently of the control switch to continue the operation of the fuel supply and igniting means while combustion is being established in the burner, and means responsive to the establishment of combustion in the burner for deenergizing said second relay and for maintaining said first relay energized under control of said control switch whereby to interrupt the operation of the igniting means and to continue the operation of said motor.

8. A control system for a fuel burner comprising, in combination, means for supplying fuel to the burner, means for igniting the fuel, a main control switch, a combustion responsive device, means controlled by said switch and said device in the absence of combustion in the burner for initiating the operation of the fuel supply means, means for continuing the operation of the fuel supply means under control of said device but independently of said control switch while combustion is being established in the burner, and means controlled by said device responsive to the establishment of combustion in the burner for continuing the operation of the fuel supply means under control of said control switch and said combustion responsive device.

9. A control system for a fuel burner comprising, in combination, means for supplying fuel to the burner, means for igniting the fuel, a room thermostat, means responsive to a call for heat by said thermostat for initiating the operation of said fuel supply and igniting means, means for continuing the operation of said fuel supply and igniting means independently of said thermostat until combustion is assured in the burner, and means responsive to the establishment of combustion in the burner for interrupting the operation of said igniting means and for continuing the operation of said fuel supply means under the control of said thermostat.

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