

- [54] **BURNER SAFEGUARD CONTROL APPARATUS**
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- [51] Int. Cl.**F23q 9/08**
- [58] Field of Search.....**431/24, 25, 27, 43, 45, 46, 431/51, 52, 55, 78, 79, 80**

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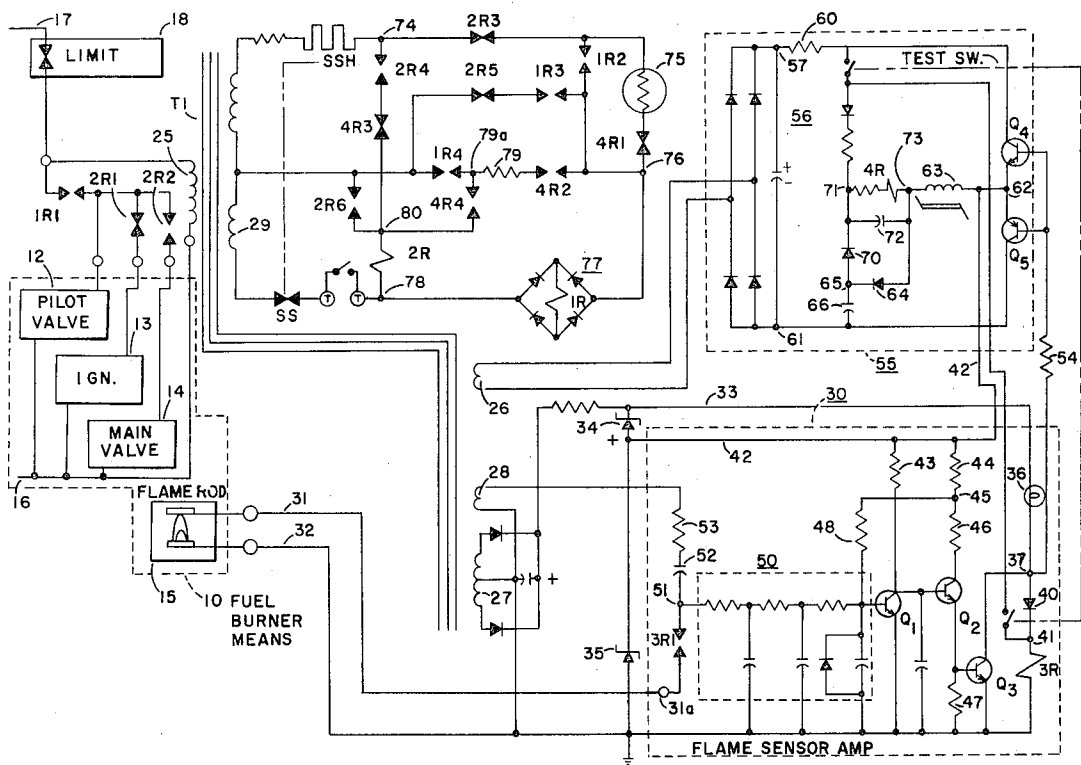
[57] **ABSTRACT**

A fuel burner control system which includes a flame detecting unit and an electrically heated safety switch for safety starting and operating a fuel burner. The system includes a control relay connected in a unique and novel way to lock out and not recycle the system in the event of a loss of flame signal after the system has properly been started. The system does, however, recycle in the event of a power failure by using a fast dropout third relay.

[56] **References Cited**
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4 Claims, 6 Drawing Figures



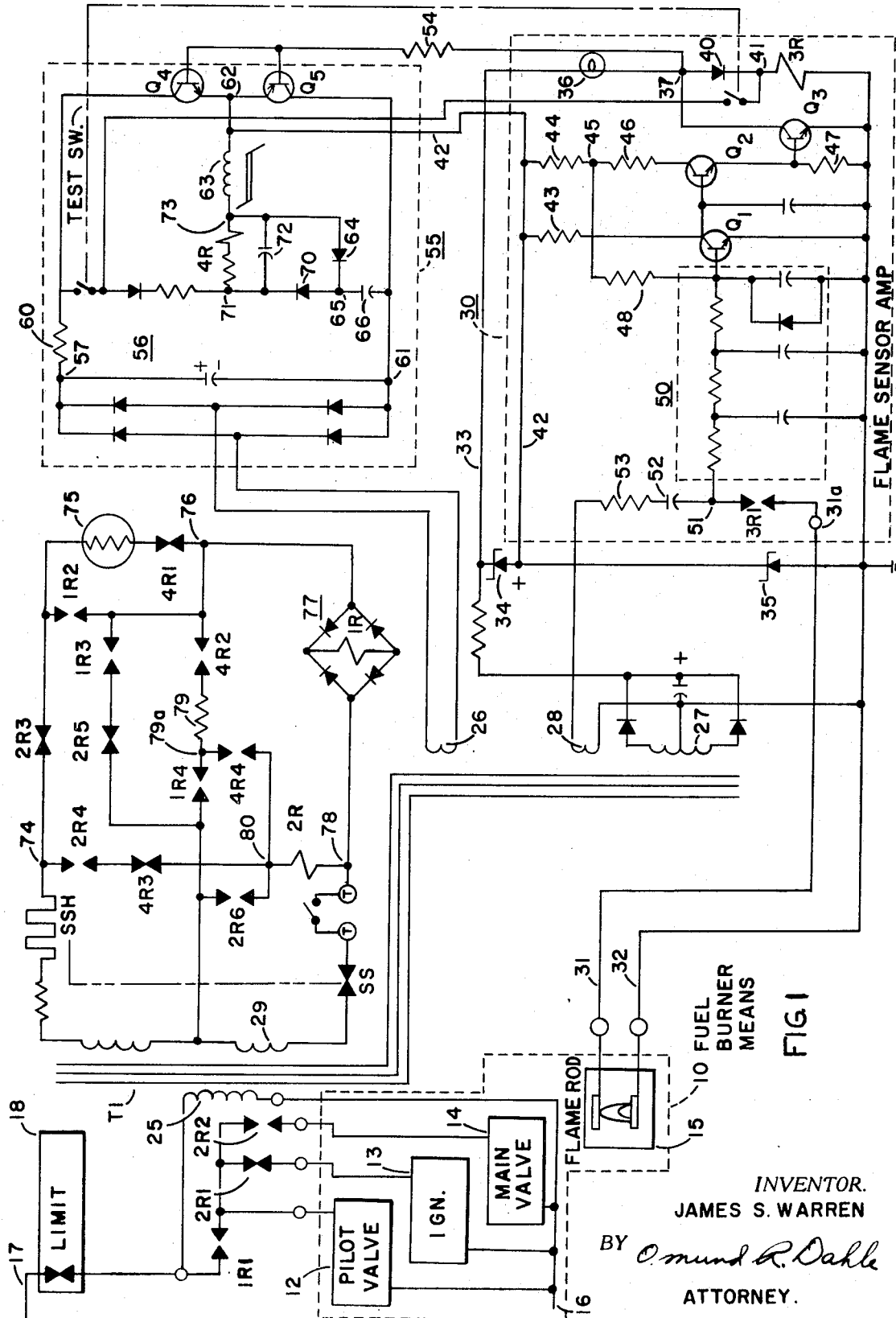
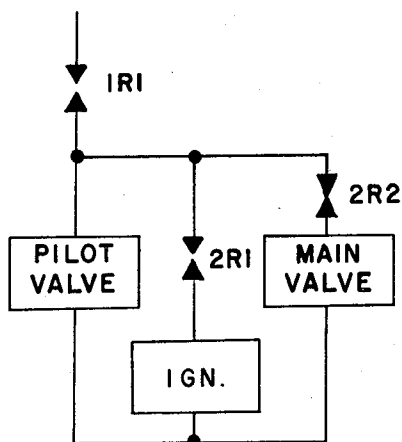
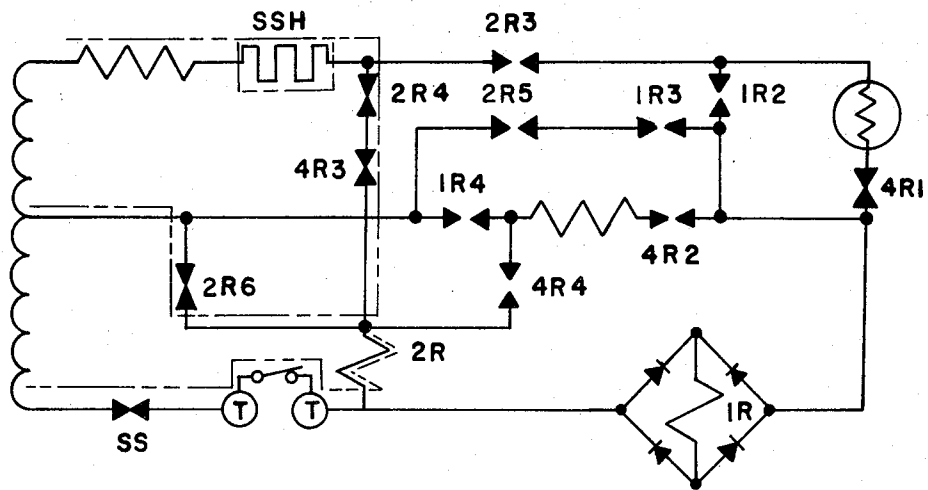


FIG 1

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FIG. 6



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BURNER SAFEGUARD CONTROL APPARATUS

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to the field of solid state electronic flame safeguard protection for gas or oil burners. This field of controls uses the rectification principle of electronic flame detection, using a flame rod or rectifying photocell or the like. Existing systems provide protection against ignition crossover in flame rod systems, provide protection against start up if a flame simulating failure occurs in the flame detector circuit, and provide for automatic shutdown with a recycle if flame fails. In the present invention the system is modified so that in the event of a flame failure while operating the system will completely close down and not attempt to recycle.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 of the present application is a circuit diagram of a fuel burner control system incorporating the present invention, and

FIGS. 2 to 6 show relay sequences in various stages of operation of the system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A fuel burner means 10 is schematically shown and includes such items as a pilot valve 12, an ignition means 13, an electrically energizable main valve 14 and a flame sensor 15. The flame sensor is disclosed in the form of a flame rod but may be in the form of other known flame sensors. When this circuit is used for control of oil burners, the box 12 labelled Pilot Valve may be the oil burner burner motor. Electrical power is supplied to the fuel burner means 10 by conductors 16 and 17 through a normally closed limit control 18, and a plurality of relay contacts 1R1, 2R1 and 2R2. The relay contacts are sequenced by the appropriate operation of control relay 1R and further relay 2R that will be described later so as to energize the pilot valve and ignition to provide a pilot flame to in turn light fuel from the main valve 14 controlled by further relay contact 2R2. All relay contacts in the drawing are shown in the deenergized position. As long as the limit switch 18 is closed, electrical power is also supplied to the primary winding 25 of a power transformer T1 allowing energy to be provided from a plurality of secondary windings to the remainder of the control systems.

Transformer T1 includes secondary windings 26, 27, 28 and 29 of which windings 27 and 28 provide power to a flame sensor amplifier 30 of known form. The flame sensor amplifier is connected by conductors 31 and 32 to the flame rod sensor 15, the conductor 32 being a common or ground line for the system. Referring specifically to the amplifier 30, the alternating voltage from winding 27 is rectified and filtered to provide a positive B+ voltage on conductor 33 which is maintained at a regulated value by two Zener diodes 34 and 35 connected in series and across conductors 33 and 32. Conductor 33 is further connected through an indicator lamp 36, a junction 37, a diode 40, a junction 41 and a relay winding 3R to negative conductor 32. Also connected from junction 37 to conductor 32 is the collector-emitter circuit of a transistor Q3, this transistor being effective when conductive to cause relay 3R to drop out as will be described below.

A lower value of B+ voltage is taken on conductor 42 from the junction of the Zener diodes, conductor 42 being connected to energize transistors Q1 and Q2 which are connected in a switching arrangement. A circuit may be traced from conductor 42 through a resistor 43 and the collector-emitter path of Q1 to ground. The collector of Q1 is directly connected to the base of Q2. A further circuit from conductor 42 may be traced through a resistor 44, a junction 45, a resistor 46, the collector-emitter of Q2 and a resistor 47 to ground. The emitter of Q2 is also connected to the base of Q3. A feedback resistor 48 is connected from junction 45 to the base of Q1, and an RC filter network 50 connects the base of Q1 to a junction 51. A relay contact 3R1 connects junction 51 to the flame rod sensor 15, and junction 51 is also connected by series connected capacitor 52 and resistor 53 to the transformer winding 28.

The flame sensor amplifier 30 is designed to have a slow cyclic pattern in which the relay 3R is caused to continually energize and drop out. When power is applied to transformer T1, the transistor Q1 turns on, Q2 and Q3 are off and the B+ current flowing through lamp 36 and diode 40 causes relay 3R to pull in. Contact 3R1 closes and when there is flame, the flame rod rectifies the current from winding 28, charging capacitor 52 with a DC voltage and causing Q1 to tend to turn off. As Q1 turns off, Q2 and Q3 turn on, Q3 being effective to ground point 37 lighting the lamp 36 and causing relay 3R to drop out whereupon contact 3R1 opens. The cycle is repetitive.

Output terminal 37 of the flame sensor amplifier is connected through a resistor 54 to the base electrodes of a pair of complementary transistors Q4 and Q5 of a fail-safe circuit 55 which is of the type disclosed in the U.S. Pat. No. 3,569,793, assigned to the same assignee as the present invention. Alternating current from winding 26 is rectified and filtered at 56 to provide a direct current from a positive terminal 57 through a resistor 60, the collector-emitter of Q4, and the emitter-collector of Q5 to the negative terminal 61. This power supply 56 is floating with respect to the supply described earlier for amplifier 30, positive conductor 42 of amplifier 30 being directly connected to the emitters of Q4 and Q5 at junction 62. Junction 62 is connected through saturable reactor 63, diode 64, junction 65 and capacitor 66 to the negative terminal 61. Another current path from the capacitor 66 may be traced from junction 65 through a diode 70, a junction 71, a resistor, a flame relay winding 4R and the reactor 63 to junction 62. A capacitor 72 parallels the relay 4R and the resistor. Relay 4R is a double-pole double throw relay having contacts 4R1, 4R2, 4R3 and 4R4 to be discussed below.

Finally, tapped secondary winding 29 energizes a circuit having the control or load relay 1R and a further relay 2R so arranged with relay contacts that on flame failure there is no recycle. A circuit for initially energizing control relay 1R may be traced from the upper terminal of winding 29 through a current limiting resistor, a safety switch heater SSH, a junction 74, normally closed contacts 2R3, a thermistor 75 for delaying current buildup, normally closed contacts 4R1, a junction 76, full wave rectifier 77 and relay 1R, a junction 78, thermostat contacts T—T, and normally closed safety switch contacts SS to the lower terminal of winding 29.

Connected in parallel with thermistor 75 and contact 4R1 is normally open contact 1R2 for bypassing thermistor 75 after energization of 1R. Another circuit may be traced from the tap of winding 29 through normally open contact 1R4, a junction 79a, a current limiting resistor 79 and open contact 4R2 to the junction 76. Another circuit in parallel can be traced from the tap through closed contact 2R5 and open contact 1R3 to junction 76. These last two circuits including contacts 1R3 and 1R4 provide a holding circuit function for relay 1R. Also from contact 1R4 at junction 79a is a circuit including an open contact 4R4, a junction 80 and a further relay 2R to junction 78 for energizing relay 2R. Holding contact 2R6 is connected between junction 80 and the tap of winding 29, and junction 80 is further connected through closed relay contact 4R3 and open contact 2R4 to the junction 74.

OPERATION

In considering the operation of the above-described circuit it will be appreciated that as long as the limit control 18 has closed contacts, power will be applied to the primary winding 25 of the power transformer T1. Upon the occurrence of a call for heat, that is, by the closing of the thermostat contact, T—T, a current path is established from the upper terminal of transformer winding 29 through the safety switch heater SSH, relay contact 2R3, the thermistor 75, the relay contact 4R1, the rectifying bridge 77, relay 1R, the thermostat contacts T—T and the safety switch contact SS back to the winding. As the current flows through the circuit, the thermistor heats up and its resistance becomes significantly less allowing the current to increase until relay 1R pulls in after about a 3 second safe start time delay. This current path is emphasized in FIG. 2. The purpose of normally closed relay switch means 4R1 is to insure that relay 4R is deenergized at the time the thermostat contacts close indicating a need for heat since contacts 4R1 must be closed to complete the circuit for 1R.

As a result of relay 1R becoming energized, all the normally opened contacts 1R1, 1R2, 1R3 and 1R4 close as is shown in FIG. 3. The closing of switch means 1R2 shorts out the thermistor 75 allowing it to cool and be ready for the next safe start time delay. The closing of switch means 1R3 energizes the safety switch heater SSH from the tap of winding 29 for consistent timing, and until relay 2R pulls in it also provides a holding contact for relay 1R. Contact 1R4 together with the contact 4R2, when closed, provides a holding contact for relay 1R. Before the flame rod senses flame, the transistor Q1 is conductive and transistors Q2 and Q3 are turned off allowing the relay 3R to be energized from the B+ conductor 33 through the indicator lamp 36 and diode 40. When relay 3R is energized the contacts 3R1 are closed completing the circuit to the flame rod sensor 15. As contact 1R1 closes, power is applied to the pilot valve and to the ignition means 13 and as soon as the pilot light is burning, the flame rod sensor 15 begins to rectify current through the flame. This will initiate the cycling of the flame sensor amplifier 30. When rectification by the flame commences, the result is that transistor Q1 turns off, transistor Q2 and Q3 turn on, transistor Q3 being effective to short out the relay 3R causing it to drop out. Contact 3R1 then opens disconnecting the flame rod sensor from the flame sen-

sor amplifier and transistor Q1 soon becomes conductive again to repeat the cycle.

The cycling of transistor Q3 causes a square wave output at terminal 37 which is applied through resistor 54 to the base electrodes of transistors Q4 and Q5 in parallel. These transistors are not simultaneously conductive, but alternately conductive. Transistor Q4 is of npn type and a positive going signal to its base renders it conductive so that current flows from the B+ supply at junction 57 through the transistor Q4, saturable reactor 63 and diode 64 to charge the capacitor 66. The negative going portion of the wave from the flame sensor amplifier turns off Q4 and turns on transistor Q5, a pnp transistor, and the capacitor 66 now discharges through a path including a diode 70, relay 4R, saturable reactor 63, transistor Q5 to the lower terminal of capacitor 66. It can thus be seen that as long as the flame sensor amplifier 30 is cycling, the alternating type signal applied to transistors Q4 and Q5 causes them to conduct alternatively, capacitor 66 first being charged through Q4 from the power supply 56 followed by the discharge of capacitor 66 flowing through and energizing relay 4R when transistor Q5 is conductive so that as long as the alternating type signal is applied to these transistors, the charge on capacitor 66 is cyclically being replenished and the relay 4R remains energized. Thus whenever there is flame, the flame sensor amplifier cycles and relay 4R is energized.

The energization of flame relay 4R described above, positions the 4R switch means as shown in FIG. 4 in which 4R1 and 4R3 are open and 4R2 and 4R4 are closed. A circuit is now established from the tap of transformer winding 29 through closed contacts 1R4 and 4R4 to energize the further relay 2R. Up until this time current has been continuing to flow through the safety switch heater SSH by means of a circuit existing through contacts 2R3, 1R2, 1R3, 2R5 back to the tap of the winding 29. Relay 2R now pulls in, and the contact positions are shown in FIG. 5 in which 2R1, 2R3 and 2R5 are open and 2R2, 2R4, and 2R6 are closed. The closing of contact 2R6 provides a holding circuit for 2R directly across the lower portion of winding 29 subject only to the thermostat contacts and the SS contacts and power interruptions. The opening of contacts 2R3 disconnects the circuit for the safety switch heater SSH. The opening of contact 2R5 introduces a slightly different path for the continued energization of relay 1R and this may be traced from the tap of the winding 29 through 1R4, the current limiting resistor 79, contact 4R2, the relay 1R, the thermostat contacts and the SS contacts back to the lower terminal of the winding. With 2R5 open, the holding circuit for 1R is subject to switch means 4R2 so a flame failure can drop out 1R. The opening of 2R1 and the closing of 2R2 turns off the ignition and turns on the main gas valve. The system has now been brought to a fully operative condition.

An important feature of this invention is that if there is a flame failure during operation, the system must not recycle and try to relight but must shut down. Referring to FIG. 1, and assuming a flame failure it can be seen that the flame sensor amplifier will cease recycling and a cyclic voltage will no longer be applied to the switching circuit 55 whereupon the flame relay 4R will drop out. When this happens, the contacts 4R2 and 4R4 will open and contacts 4R1 and 4R3 will close as

shown in FIG. 6. The further relay 2R is held in by its holding contact 2R6. The opening of contact 4R2 causes control relay 1R to drop out whereupon all the 1R contacts open. With contact 1R1 open the pilot valve, the ignition and main valve are all deenergized. 5

The closing of contact 4R3 with flame failure initiates a circuit for the safety switch heater SSH which may be traced from the top terminal of winding 29 through SSH 2R4, 4R3 and 2R6 to the tap of the winding. As soon as the safety switch times out, the contact 10 SS will open, dropping relay 2R and the entire system is shut down until the safety switch is manually reset.

If there is a power failure rather than a flame failure, it is desired that the circuit should recycle and attempt to restart. This is accomplished in part by making the further relay 2R and AC relay having a fast dropout, the relay 1R is somewhat slower, and the relay 4R is much slower having a dropout time measured in seconds by reason of the large capacitor connected across it. Therefore, in the event of a momentary power failure only the relay 2R will drop out; if power is reestablished before 1R drops out, the power to relay 2R will be continued through the contacts 1R4 and 4R4 to pull in 2R again immediately. Upon a slightly longer power failure in which both relay 2R and 1R have dropped out, the system will still recycle, however, it must wait until 4R also drops out allowing 4R1 to close before the recycle can take place. 25

The embodiments of the invention in which an exclusive property or right is claimed are defined as follows: 30

1. Nonrecycle burner control apparatus for use with a fuel burner having spark ignition means, a pilot valve, and having an electrically energizable valve to control the flow of fuel to a main burner, the control apparatus being adapted to shut down and not recycle in the event of a flame failure, the control apparatus comprising: 35

a control relay having a winding and normally open switch means;

a flame detector circuit the input terminals of which are connected to means adapted to be subjected to the presence or absence of flame at the fuel burner, and the output terminals of which are connected to the winding of a flame relay having normally closed switch means and normally open switch means, said circuit being constructed and arranged to energize the winding of said flame relay in the presence of flame at the fuel burner 40

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and deenergize upon the absence of flame at the fuel burner;

a further relay including a winding, normally closed switch means and normally open switch means, said normally closed switch means being connected to supply operating voltage to said spark ignition means, said normally open switch means being connected to supply operating voltage to said electrically energizable valve when said further relay is energized;

circuit means under control of means responsive to the need for operation of the fuel burner including a normally closed switch means of said further relay and arranged to supply operating voltage to said control relay winding upon such a need to cause said control relay to pull in;

holding circuit means for the winding of said control relay including normally open switch means of said control relay and normally open switch means of said flame relay; so that said control relay drops out on the occurrence of a flame failure;

second circuit means energized responsive to the energization of said flame relay and including normally open switch means of said flame relay for supplying operating voltage to the winding of said further relay; and

holding circuit means for the winding of said further relay including normally open switch means of said further relay, said holding circuit means arranged and connected so as not to be interrupted by any switch means of said control relay and flame relay whereby when said further relay has been energized in response to the energization of said flame relay said further relay will not drop out on a flame failure.

2. The invention as described in claim 1 wherein the flame detector circuit input terminals are connected to a flame rod.

3. The invention as described in claim 1 in which the flame detector circuit has a first portion thereof which generates a cyclic signal when sensing flame and has a second portion thereof for energizing the flame relay only when said cyclic signal is present.

4. The invention as described in claim 1 wherein said second circuit means further includes normally open switch means of said control relay in series with said normally open switch means of said flame relay.

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