

[54] **BURNER CONTROL SYSTEM**

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[57] **ABSTRACT**

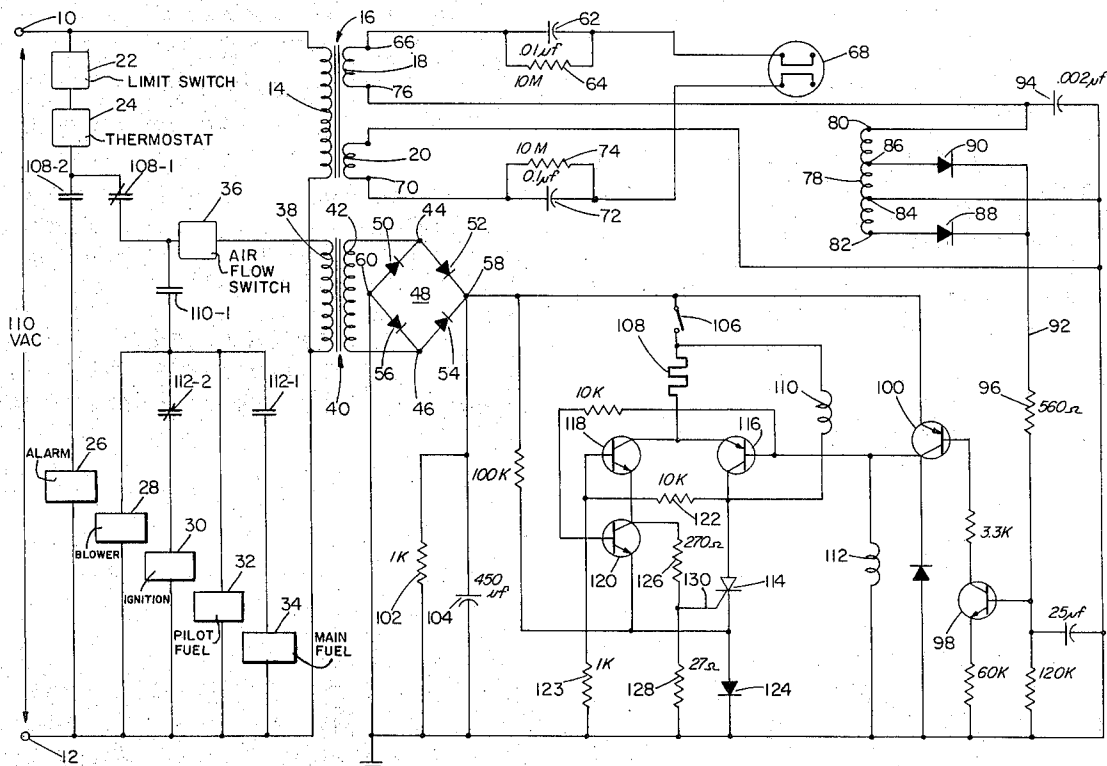
Burner control apparatus having alternate solid state circuits for actuating a lock-out switch in response to specified burner conditions. The circuits are cross-coupled to override certain actuating signals and thereby prevent unnecessary lock-outs, one of the circuits also being employed to energize an ignition and fuel supply control.

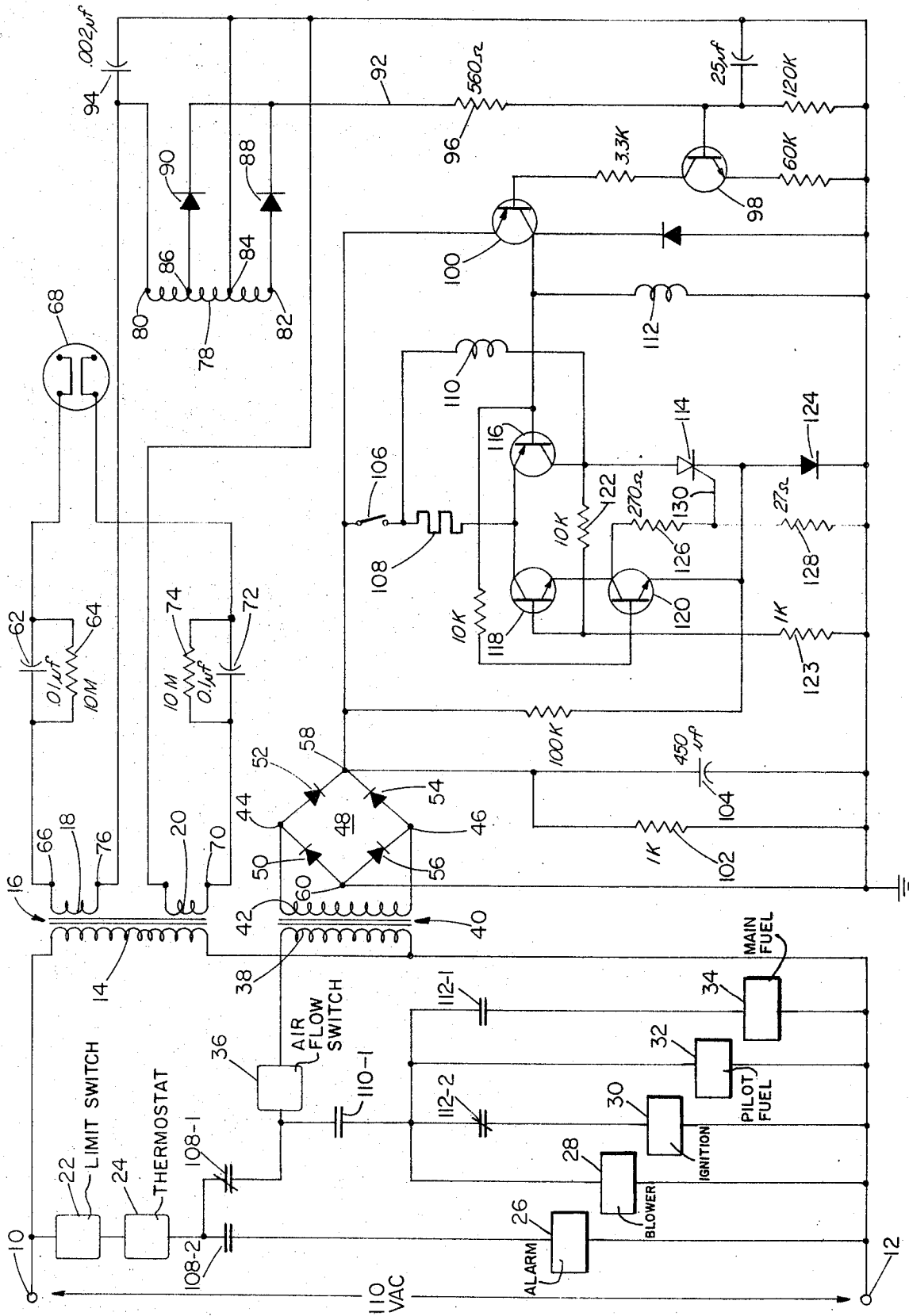
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13 Claims, 1 Drawing Figure





BURNER CONTROL SYSTEM

BACKGROUND

1. Field of the Invention

This invention relates to electrical circuitry for controlling a burner system.

2. Description of the Prior Art

Large scale burner systems, such as those used with boilers in fossil fuel power plants, generally include control apparatus to both operate the burner in accordance with the installation requirements, and to supervise the burner system for dangerous conditions. The supervisory aspect is highly important, as the burner fuel is normally confined within a combustion chamber and therefore poses the possibility of an explosion should the system malfunction. In particular, three conditions have been judged to pose a sufficient danger to warrant shutting the burner down should any of the conditions be present. The first occurs when the existence of a flame in the combustion chamber is indicated immediately prior to initiation of burner operation. This generally indicates either a failure to establish the desired preignition situation of no fuel being supplied to the combustion chamber, and consequently of no flame existing there, or a malfunction in the flame sensor circuitry. The second condition involves an unplanned failure of an established flame, and the resulting need to shut off the supply of fuel to the chamber in order to prevent the accumulation of an explosive quantity of fuel therein. The third condition arises when there is a failure to ignite a flame in the chamber despite efforts to do so; again, an explosion may occur if the ignition attempt is not stopped after a certain time, and at the least some malfunction in the system is indicated.

While it is important that the burner not be operated until the above conditions are removed, it is also desirable to limit the number of burner outages so that plant operation will not be impeded. To this end, the burner control apparatus should be highly reliable in both reacting to dangerous conditions and in avoiding spurious operations that shut the burner down unnecessarily. Reliability problems in both of these areas have arisen in many heretofore known systems which use relay contacts in the control circuitry. Such contacts are subject to becoming stuck in a closed mode, maintaining burner lock-out circuits after a dangerous situation has been overcome and the circuits are no longer needed, and may also become dirty enough to prevent the completion of lock-out circuits when they are needed.

A related problem frequently encountered in the prior art is the tendency of a control system to go to lock-out after a power failure if flame is present in the combustion chamber when power is restored, even though the flame might thereafter consume the remaining residual fuel and be extinguished before renewed burner operation can generate a dangerous situation. Instead of automatically restarting, the burner is idled until the cause of the lock-out can be investigated and the lock-out mechanism reset.

SUMMARY

In accordance with the above-stated considerations, it is an object of this invention to provide novel and improved burner control apparatus having a high degree of reliability with respect to both locking-out the

burner system when required and preventing unnecessary lock-outs. Another object is the provision of novel and improved burner control apparatus having alternate circuits for energizing a burner lock-out mechanism, in which the circuits are operably cross-coupled to prevent spurious lock-out operations. Still another object is the provision of novel and improved burner control apparatus that eliminates the sticking and dirt problems associated with the use of relay contacts in the control circuitry.

The burner control apparatus of the present invention is designed to be used with a fuel burner installation having a combustion chamber, means to apply a request for burner operation signal to the burner control apparatus, combustion ignition and fuel supply means, and flame sensing means for sensing the presence of flame in the combustion chamber. The apparatus includes a lock-out switch for shutting down burner operation, an actuator for the lock-out switch, control means governing the supply of fuel to the combustion chamber and the operation of an ignition device therein, and means responsive to the flame sensing means for producing a signal indicative of the flame condition in the combustion chamber. A pair of circuits are provided to energize the lock-out switch actuator when necessary, each circuit being responsive to particular sets of burner conditions. The first energizing circuit includes a latchable switch means that, once triggered to a closed (conductive) mode, is adapted to remain closed for the duration of a request for burner operation signal. The second circuit includes two series connected switches, the first of which is controlled by a request for burner operation signal to close and open respectively in response to the presence and absence of said signal, and the second of which is controlled by the flame indicating means to close and open respectively in response to flame and no-flame indications. The latchable switch means and the first switch are cross-coupled by a trigger circuit and a feedback circuit. The trigger circuit triggers the latchable switch means to a closed mode in response to the first switch closing under the influence of a request for operation signal, while the feedback circuit overrides the said request for operation signal to reset the first switch in an open mode when the latchable switch means closes.

In an additional feature of the invention the second switch is connected, when closed in response to a flame indication signal, to override the trigger circuit and prevent triggering of the latchable switch means and a resulting resetting of the first switch. The second energizing circuit is thereby enabled to complete a circuit to energize the lock-out switch actuator only when a request for burner operation signal is preceded by a flame indication signal.

According to another feature, an additional switch is adapted to close and open respectively in response to no-flame and flame indications (a response opposite that of the aforementioned second switch in the second energizing circuit) and is connected in the first energizing circuit in series with the latchable switch means. Energizing the lock-out switch actuator for a flame failure in the combustion chamber and for a failure to ignite is thereby completed through the first energizing circuit.

The latchable switch means, according to another feature, is also connected in the energizing circuit for the fuel supply and ignition control means. The said

control means is thereby latched in an energized state when the switch means is latched, while the latchable switch means is held in for the duration of a request for operation signal by transmission of the said signal to the switch means through the control means.

In a particular embodiment of the invention solid state circuitry is employed. The latchable switch means comprises a silicon controlled rectifier (SCR) connected with its anode-cathode circuit in series with the collector-emitter circuit of a switching transistor that forms the additional switch in the first energizing circuit. The switches in the second energizing circuit are provided by a pair of series-connected switching transistors, with a voltage divider circuit connected in series with the first of the two transistors to provide a trigger signal to the SCR when the first transistor is gated into conduction by a request for operation signal. The SCR is also connected in a grounding circuit between the base of the first transistor and ground, whereby a gating signal is removed from the first transistor and the transistor reset by grounding of its base when the SCR is triggered into conduction. The second transistor is connected in a low impedance ground circuit that bridges the voltage divider circuit, thereby restraining the voltage across the voltage divider to a non-triggering level for the SCR when the second transistor is conductive, and hence preventing energization of the fuel supply and ignition control means if a flame exists in the combustion chamber when a request for burner operation is received.

Other objects, features and advantages of the invention will be seen from the following detailed description of a particular embodiment of the invention, in conjunction with the drawing in which the single FIGURE is a schematic diagram of a burner control system constructed in accordance with the invention.

DESCRIPTION OF A PARTICULAR EMBODIMENT

Having reference to the drawing, a burner control system is shown with a pair of terminals 10 and 12 adapted for connection to a suitable source of AC power. Connected directly across terminals 10 and 12 is the primary winding 14 of a transformer 16 that has a pair of secondary windings 18 and 20. Also connected across terminals 10 and 12 is a conventional control section that may include a limit switch 22 and an operating control such as a thermostat 24, an alarm device 26, a blower motor 28, an ignition device 30, a pilot fuel control 32, and a main fuel control 34. The operation of the various elements in the control section is governed by a number of relay contacts, details of which are described hereinafter.

An air flow switch 36 and the primary winding 38 of a second transformer 40 are connected in series with the limit switch 22 and thermostat 24 on one side and terminal 12 on the other side. The secondary winding 42 of transformer 40 has connected between its terminals 44 and 46 a full wave rectification circuit 48 formed by diodes 50, 52, 54 and 56. The rectifier 48 has terminals 58 and 60 connected to supply a rectified input to the control circuitry described below.

Transformer 16 powers conventional circuitry for sensing and indicating the presence of flame in the combustion chamber, the circuitry including a capacitor 62 connected in parallel with a resistor 64 between the high voltage terminal 66 of winding 18 and an ultra-

violet flame sensor 68. The flame sensor 68 is connected to the low voltage terminal 70 of secondary winding 20 through a second RC circuit comprising capacitor 72 in parallel with resistor 74.

Connected to the low voltage terminal 76 of winding 18 is an inductor 78 that has two terminals 80 and 82 and two taps 84 and 86. Terminal 82 and tap 86 are coupled via diodes 88 and 90 to a common output bus 92. A capacitor 94 is connected between terminal 80 and tap 84, tap 84 also being connected to ground.

The output bus 92 is connected via resistor 96 to an amplifier circuit for the output of flame sensor 68, the amplifier circuit including transistors 98 and 100. The output of transistor 100 is delivered to the control circuitry to indicate the flame condition in the combustion chamber.

The main control circuitry is connected across the input terminals 58 and 60, with a smoothing network consisting of resistor 102 and capacitor 104 in parallel across input terminals 58 and 60 to reduce voltage fluctuations from rectifier circuit 48. A suitable time delay mechanism (diagrammatically indicated by switch 106) is provided between terminal 58 and the remainder of the control circuitry to delay energization thereof for a short period of time sufficient for the flame sensor circuitry to become operational, following the initiation of a request for burner operation. An actuating heater 108 is connected to the other side of time delay switch 106. Actuator 108 controls a normally closed system lock-out switch 108-1 located between thermostat 24 and the combustion chamber control devices 28-34, and a normally open switch 108-2 in the circuit for alarm 26. Lock-out switch 108-1 opens when actuator 108 is heated to a predetermined temperature rendering the chamber control devices 28-34 inoperative until the lock-out switches are manually reset. A control relay actuator 110, also connected to the input terminal 58 through time delay switch 106, controls normally open contacts 110-1 between the lock-out switch 108-1 and the devices 30-34. Another relay actuator 112 is connected to transistor 100 in the flame sensor amplifier circuit, and is energized in response to the flame sensor 68 detecting a flame in the combustion chamber. The flame relay actuator 112 controls normally open contacts 112-1 in the circuit for the main fuel control 34, and normally closed contacts 112-2 in the circuit for spark ignition device 30.

Two alternate circuits are provided to energize lock-out switch actuator 108 and thereby shut the burner down in case of a malfunction or dangerous condition. The first energizing circuit includes a latchable switch such as silicon controlled rectifier (SCR) 114 connected in series with the collector-emitter circuit of a switching transistor 116 and the actuator 108. The second energizing circuit includes a pair of switching transistors 118 and 120 that are also connected with their collector-emitter circuits in series with the actuator 108, with a biasing network of resistors 122 and 123 connected to the base of transistor 118. Each energizing circuit is connected to ground through a diode 124. While transistor 116 is shown as a pnp type and transistors 118 and 120 as npn, the transistor polarities may be interchanged and appropriate adjustments made to the control circuitry without materially affecting the basic operating mechanism of the invention.

The bases of transistors 116 and 120 are connected to the flame relay actuator 112, transistor 116 being

gated into conduction when the flame relay actuator 112 is de-energized and transistor 120 being gated into conduction when the flame relay actuator 112 is energized. Transistor 118 is gated into conduction when a request for burner operation signal is applied to the control relay actuator 110. The anode-cathode circuit of SCR 114 is also connected in series with the control relay actuator 110, and together with diode 124 completes a low impedance energizing path for that relay.

A voltage divider circuit consisting of resistors 126 and 128 in connection in series between ground and the junction of the emitter of transistor 118 and the collector of transistor 120, and provides a triggering voltage to the SCR 114 through lead 130 when the transistor 118 begins to conduct and transmit a signal at input terminal 58 to the voltage divider circuit. Resistor 122 is connected in a feedback circuit from the anode of SCR 114 to the base of transistor 118, by means of which any gating signal existing at the transistor 118 is removed and that transistor reset to a non-conducting mode when the SCR 114 begins to conduct. Once triggered, the SCR is held in through the control relay actuator 110 for the duration of a request for burner operation signal. It can be seen from the drawing, however, that the series combination of transistor 120 and diode 124 bridges the voltage divider trigger circuit for SCR 114; triggering of the SCR 114 is prevented when the transistor 120 is gated into conduction by a flame indication signal at flame relay actuator 112, the voltage divider circuit during such periods being effectively short circuited.

In operation, terminals 10 and 12 are normally energized, energizing flame sensor 68 via transformer 16. The main control circuitry and flame sensor amplifier circuitry are energized via transformer 40, the primary of which is controlled by the operating control 24. When a request for burner operation is signalled by thermostat 24, blower 28 is energized and produces an air flow through the combustion chamber, causing switch 36 to close and energize the primary winding 38 of transformer 40. The flame sensor electronics are energized from secondary winding 42 of the transformer during the delay provided by switch 106 and, if safe conditions (no flame) exist and the circuit is operating properly, flame relay 112 remains de-energized. In this event and at this time, SCR 114 and transistors 118 and 120 are in a non-conducting mode while transistor 116 is conducting. The request for operation signal at terminal 58 is transmitted through control relay actuator 110 when relay switch 106 closes and divided between resistors 122 and 123 to produce a voltage at the base of transistor 118 sufficient to gate the transistor into conduction. Transistor 118 thereupon completes a circuit through actuator 108 and voltage dividing resistors 126 and 128 to trigger the SCR 114, which is then latched through control relay actuator 110 for the duration of the request for operation signal. A low impedance circuit is accordingly established from the base of transistor 118 through resistor 122, the SCR 114 and diode 124 to ground, dropping the voltage at the base of transistor 118 to a level at which that transistor is brought out of conduction and reset to a non-conducting mode.

Triggering of SCR 114 also establishes low impedance energizing circuits for lock-out actuator 108 through transistor 116, SCR 114, and diode 124, and

for control relay actuator 110 through SCR 114 and diode 124. Actuator 108 begins to heat, while control relay actuator 110 causes contacts 110-1 to close and initiate a pilot fuel ignition attempt. If flame is established successfully before the heating cycle of actuator 108 has expired, which according to the requirements of the system is generally set at between about 5 and 30 seconds, a signal is delivered to energize flame relay actuator 112 from the flame sensor amplifying circuitry, opening the ignition contacts 112-2 and closing contacts 112-1 to actuate the main fuel supply. At the same time the voltage across flame relay actuator 112 is applied to the base of transistor 116 to bring it out of conduction and break the heating circuit for lock-out actuator 108. The same voltage gates transistor 120 into conduction, but non-conducting transistor 118 prevents an alternate lock-out actuating circuit from being completed.

The operation of the transistors 116, 118 and 120 and SCR 114 during the normal ignition sequence just described is summarized in the chart below. A conducting (ON) or non-conducting (OFF) state is indicated for each of the said elements just after the closing of switch 106, just before the SCR 114 is triggered, just after the SCR 114 has been triggered, and after fuel has been ignited in the combustion chamber and detected by flame sensor 68.

Normal Ignition Sequence

	Just After Switch 106 Closes	Just Before SCR Triggered	Just After SCR Triggered	Fuel Ignited
114	OFF	OFF	ON	ON
116	ON	ON	ON	OFF
118	OFF	ON	OFF	OFF
120	OFF	OFF	OFF	ON

Should the fuel fail to ignite within the heating cycle of lock-out actuator 108, the energizing circuit of SCR 114 and transistor 116 will remain intact and actuator 108 will operate. Lock-out switch 108-1 will thereupon open, de-energizing the burner control devices 28-34 and locking-out the burner. Simultaneously therewith contacts 108-2 will close, energizing the alarm 26.

If a flame is established but later fails while transformer 40 is still energized by a request for burner operation, flame sensor 68 stops conducting, thereby bringing amplifier circuit transistors 98 and 100 out of conduction and de-energizing flame relay actuator 112. The transistor 116 thereupon begins to conduct, and together with latched SCR 114 completes a circuit to energize actuator 108 and lock the burner system out.

In the case of a third dangerous condition, i.e., a signal indicating flame already existing in the combustion chamber when burner operation is first requested, an energizing circuit for lock-out actuator 108 is established through transistors 118 and 120 as follows. Transistor 118 is gated into conduction by the request for operation signal as before. By the time this occurs, however, transistor 120 is already conducting due to flame relay actuator 112 being energized under the influence of the flame signal. Transistor 120 together with diode 124 completes a low impedance circuit to short circuit the triggering circuit of resistors 126 and 128 and prevent the SCR 114 from being triggered. The feedback circuit through resistor 122 therefore re-

mains ungrounded, and both transistors 118 and 120 continue to conduct until the lock-out actuator 108 operates.

The operation of the transistors 116, 118 and 120 and SCR 114 during each of the three lock-out conditions is summarized in the chart below.

Lock-Out Conditions

	Ignition Failure	Flame Failure	Pre-existing Flame Signal
114	ON	ON	OFF
116	ON	ON	OFF
118	OFF	OFF	ON
120	OFF	OFF	ON

The present control circuitry also offers the advantage of recycling to a new ignition sequence, rather than locking-out, when a flame momentarily remains in the combustion chamber following a power interruption but is extinguished before the lock-out actuator 108 has operated. Under these circumstances a lock-out circuit is initially established through transistors 118 and 120 while the flame continues to burn, the trigger circuit for SCR 114 being short-circuited by transistor 120 and diode 124. When the flame goes out transistor 120 ceases conducting; transistor 116 begins to conduct; and SCR 114 is triggered, energizing the control relay actuator 110 and resetting transistor 118. Actuator 108 continues to heat through the circuit newly established by SCR 114 and transistor 116, but lock-out is prevented by transistor 116 being brought out of conduction if flame is established before the remainder of the heating cycle has run.

While a particular embodiment of the invention has been shown and described, various modifications thereof will be apparent to those skilled in the art. Therefore it is not intended that the invention be limited to the disclosed embodiment or to details thereof, and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

What is claimed is:

1. Burner control apparatus for use with a fuel burner installation having a combustion chamber, means to apply a request for burner operation signal to the burner control apparatus, combustion chamber ignition and fuel supply means, and flame sensing means for sensing the presence of flame in the combustion chamber, comprising:

a burner lock-out switch and a lock-out switch actuator,

control means for said combustion chamber ignition and fuel supply means,

flame indication means responsive to said flame sensing means to produce a signal indicative of the flame condition in said combustion chamber,

first and second energizing circuits for said lock-out switch actuator, said first energizing circuit including a latchable switch means adapted when triggered to latch in a closed mode for the duration of a request for operation signal, said second energizing circuit including first and second switch means connected in series, said first switch means adapted to close and open respectively in response to the presence and absence of a request for operation signal, said second switch means adapted to close and open respectively in response to flame and no-

flame indications from said flame indication means, and

circuitry cross-coupling said latchable switch means with said first switch means, said circuitry including a trigger circuit responsive to said first switch means being closed to trigger said latchable switch means, and a feedback circuit responsive to said latchable switch means closing to reset said first switch means in an open mode.

2. The burner control apparatus of claim 1, wherein said second switch means is connected in a circuit to override said trigger circuit and prevent triggering of said latchable switch means when said second switch means is closed.

3. The burner control apparatus of claim 1, and further including an additional switch means connected in said first energizing circuit in series with said latchable switch means, said additional switch means adapted to close and open respectively in response to no-flame and flame indications from said flame indication means to respectively enable and prevent completion of said first energizing circuit.

4. The burner control apparatus of claim 1, wherein said latchable switch means is connected to said control means to enable latching of said control means in an energized state when said latchable switch means is latched.

5. Burner control apparatus for use with a fuel burner installation having a combustion chamber, means to apply a request for burner operation signal to the burner control apparatus, combustion chamber ignition and fuel supply means, and flame sensing means for sensing the presence of flame in the combustion chamber, comprising:

a burner lock-out switch and a lock-out switch actuator,

control means for said combustion chamber ignition and fuel supply means,

flame indication means responsive to said flame sensing means to produce a signal indicative of the flame condition in said combustion chamber,

first and second switch means connected in series to complete a first energizing circuit for said lock-out switch actuator, said first switch means also being connected to said control means and adapted to latch said control means for the duration of a request for operation signal, said second switch means adapted to close and open respectively in response to no-flame and flame indications from said flame indication means, and

third and fourth switch means connected in series to complete a second energizing circuit for said lock-out switch actuator, said third switch means also being connected in a trigger circuit for said first switch means and responsive to a request for operation signal to complete said trigger circuit, said fourth switch means adapted to close and open respectively in response to flame and no-flame indications from said flame indication means.

6. The burner control apparatus of claim 5, said fourth switch means in addition being connected when closed to override said trigger circuit and prevent triggering of said first switch means.

7. Burner control apparatus for use with a fuel burner installation having a combustion chamber, means to apply a request for burner operation signal to the burner control apparatus, combustion chamber igni-

tion and fuel supply means, and flame sensing means for sensing the presence of flame in the combustion chamber, comprising:

a burner lock-out switch and a lock-out switch actuator,

control means for said combustion chamber ignition and fuel supply means,

a first circuit responsive to the combination of a request for operation signal and a no-flame indication signal from said flame sensing means to complete energizing circuits for said lock-out switch actuator and said control means, said first circuit including a solid state latchable means connected to latch a completed control means energizing circuit for the duration of a request for operation signal,

a second circuit responsive to the combination of a request for operation signal and a flame indication signal from said flame sensing means to complete an energizing circuit for said lock-out switch actuator, and

said latchable means being coupled with said second circuit to latchably override a request for operation signal applied thereto and thereby inhibit completion by said second circuit of an energizing circuit for said lock-out switch actuator, whereby said second circuit is enabled to complete an energizing circuit for said lock-out switch actuator in response to a request for operation signal only when said request for operation signal is preceded by said flame indication signal.

8. The burner control apparatus of claim 7, including a trigger circuit for said latchable means coupling said second circuit and said latchable means, said trigger circuit being actuable in response to the combination of a request for operation signal and said no-flame indication signal.

9. The burner control apparatus of claim 8, wherein said second circuit includes flame indication signal responsive means to override said trigger circuit and prevent triggering of said latchable means.

10. Burner control apparatus for use with a fuel burner installation having a combustion chamber, means to apply a request for burner operation signal to the burner control apparatus, combustion chamber ignition and fuel supply means, and flame sensing means for sensing the pressure of flame in the combustion chamber, comprising:

an input terminal to receive a request for burner operation signal,

a burner lock-out switch and a lock-out actuator, said actuator connected to said input terminal for energization by a request for burner operation signal, control means for said combustion chamber ignition and fuel supply means, connected for energization to said input terminal,

flame indication means responsive to said flame sensing means to produce a signal indicative of the flame condition in said combustion chamber,

a silicon controlled rectifier connected with its anode-cathode circuit in a first energizing circuit for said lock-out actuator in series with said lock-out actuator,

a latching circuit connected to the anode of said silicon controlled rectifier and adapted to apply a latching signal thereto from said input terminal for the duration of a request for operation signal,

first and second switching transistors connected with their collector-emitter circuits in series in a second energizing circuit for said lock-out actuator, said first switching transistor connected for gating in response to a request for operation signal at said input terminal, said second switching transistor connected to said flame indication means for gating in response to a flame signal,

a voltage divider circuit connected in series with the collector-emitter circuit of said first switching transistor, said voltage divider circuit adapted to provide a trigger signal to the gate of said silicon controlled rectifier in response to gating of said first switching transistor,

the anode-cathode circuit of said silicon controlled rectifier in addition being connected in a grounding circuit between the base of said first switching transistor and ground potential, whereby said silicon controlled rectifier when conductive completes said grounding circuit to remove a gating signal from said first switching transistor and reset said first switching transistor in a non-conductive mode.

11. The burner control apparatus of claim 10, wherein said second switching transistor is connected in a low impedance ground circuit bridging said voltage divider circuit, whereby the voltage across said voltage divider circuit is restrained to a non-triggering level for said silicon controlled rectifier during conduction of said second switching transistor.

12. The burner control apparatus of claim 10, and further including an additional switching transistor in said first energizing circuit in series with the anode-cathode circuit of said silicon controlled rectifier, said additional switching transistor connected to said flame indication means to be gated in response to a no-flame signal and thereby enable completion of said first energizing circuit when said silicon controlled rectifier is conductive.

13. The burner control apparatus of claim 10, wherein the anode-cathode circuit of said silicon controlled rectifier is connected in series with said control means in said latching circuit for said silicon controlled rectifier.

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