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Jacobsz

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[54] **PROGRAMING BURNER CONTROL DEVICE**

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[73] Assignee: **Honeywell Inc.,** Minneapolis, Minn.

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[52] **U.S. Cl.** **431/29,** 431/26, 432/41, 432/46

[51] **Int. Cl.** **F23m 5/00**

[58] **Field of Search** 431/29, 26; 432/41, 46, 432/54

[56] **References Cited**

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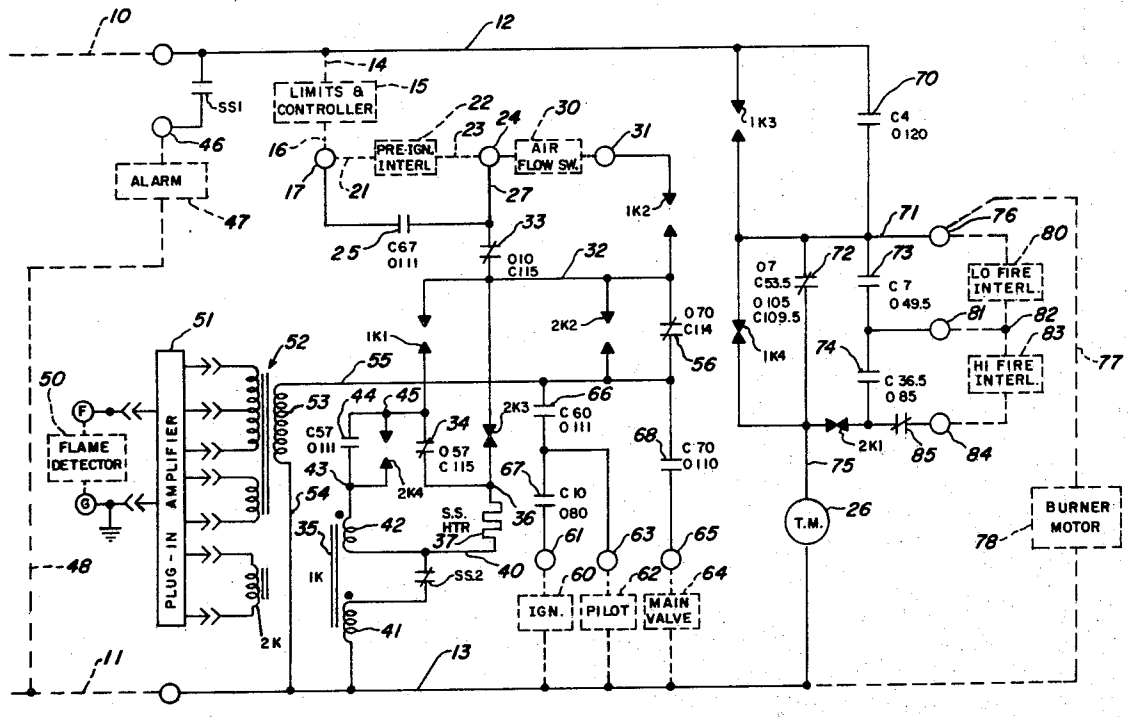
[57] **ABSTRACT**

A programing burner control device is disclosed which responds to a flame detector, condition responsive interlocks, and initiating control to properly sequence a fuel burner system through prepurge, ignition, burner operation, and post purge periods. The burner control device utilizes relay means which respond to the flame sensor and the initiating control, along with a number of cam operated switches to provide the necessary sequencing of the device. The burner control device utilizes a pair of flame relay contacts in the motor driven cam circuit, and the safety switch heater circuit, so that the present burner control device can monitor proper operation of the burner during both the prepurge and the normal operating period of the burner system.

8 Claims, 4 Drawing Figures



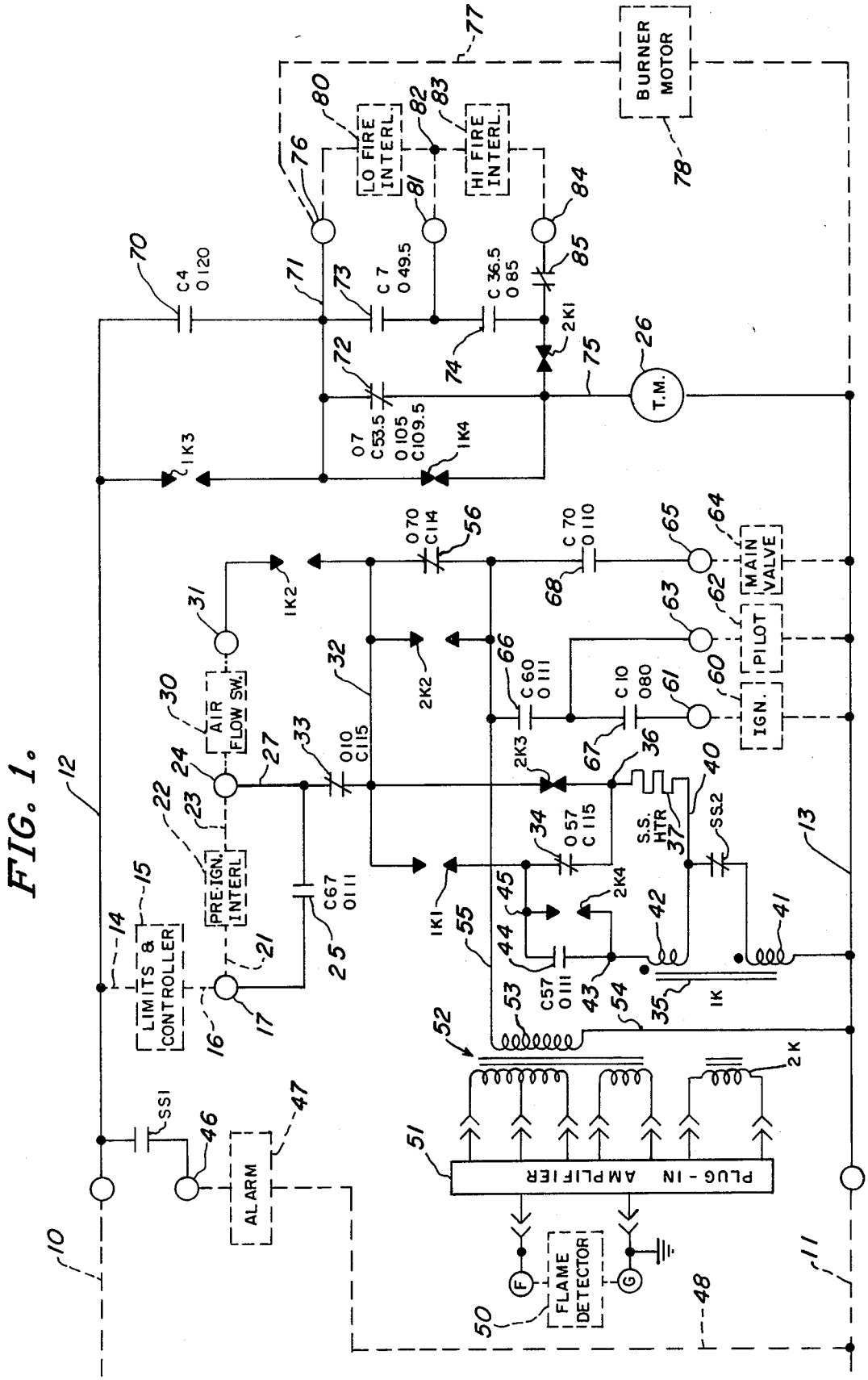
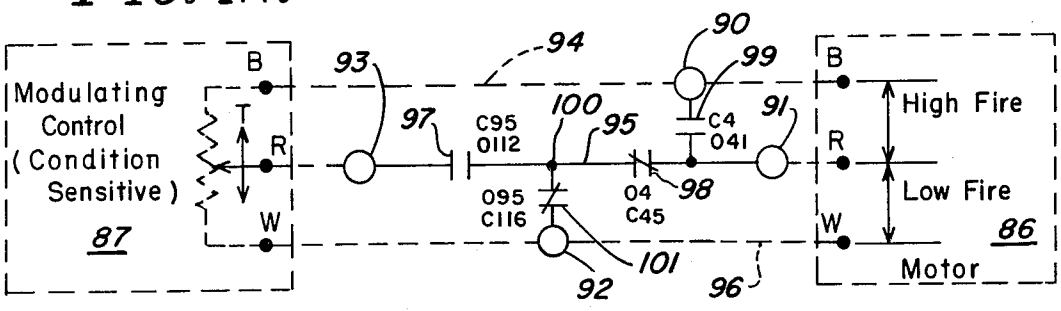

BURNER MOTOR
LO FIRE INTERL.
HI FIRE INTERL.
C4 0120
C 7 0 49.5
C 36.5 0 85
2K1
T.M.
0 7 C53.5 0 105 C109.5
1K4
1K3
0 70 C14
C 70 0110
MAIN VALVE
PILOT
IGN.
1K2
2K2
C 60 0 111
C 10 080
2K3
0 10 C115
AIR FLOW SW.
PRE-IGN. INTERL
0 57 C 115
S.S. HTR
SS2
2K4
C67 0111
LIMITS & CONTROLLER
1K1
C57 0111
1K
2K
SSI
ALARM
PLUG - IN AMPLIFIER
FLAME DETECTOR

FIG. 1.

FIG. 1A.



Equipment External to Burner Control Device (shown dashed) - - - - -

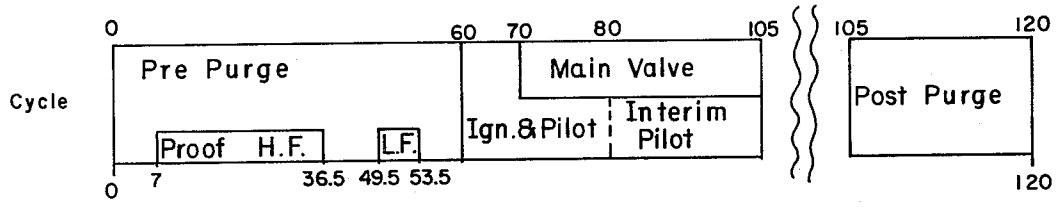
All Contacts Shown at Time = 0 Seconds.

Relay Contacts - N.O. → ← ; N.C. →|←

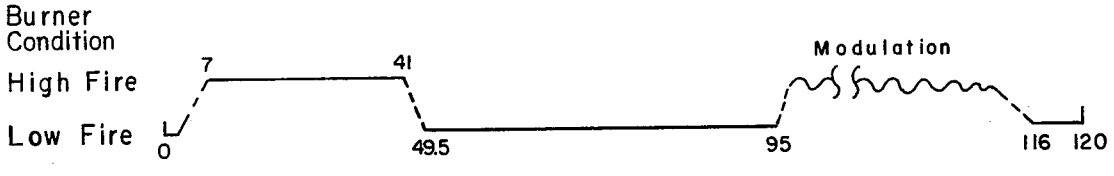
Timer Contacts - N.O. —| |— ; N.C. —|/|—

Timer contacts each are shown with times of operation.

FIG. 2.



Programmer Time in Seconds



Programmer Time in Seconds

FIG. 3.

PROGRAMING BURNER CONTROL DEVICE

BACKGROUND AND SUMMARY OF THE INVENTION

Programing types of burner control systems are widely used in the fuel burner system market. These programing type burner control devices normally utilize a motor driven cam arrangement which programs a number of cam operated switches. Along with the switch functions derived from the cams, two or more relays are normally used in response to various condition sensing and initiating circuits. The most common devices utilize a relay for operating the load, such as the ignition transformer, pilot valve and main valve. The second relay normally responds to a flame sensor and is controlled through an amplifier circuit to cooperate with the cam operated switches and other relay contacts to provide the necessary safe sequencing control of a burner system. In some prior art devices the amplifier normally was a tube type of amplifier and required continuous energization of the filament circuit and the balance of the circuitry so that it could be operated promptly upon initiation of a burner cycle.

The present invention is directed to an improved programing burner control device. The normal relay contacts and cam operated switches that energize the amplifier's flame relay have been replaced by a relay contact which energizes the solid state amplifier at the instant it is needed for use rather than keeping it in an energized, standby condition. A pair of flame contacts are arranged so that the energizing circuit for the motor of the cam operated switches flows through one of the flame relay contacts during part of the operation to thereby stop the timer motor and allow the device to lock out on safety in the event of a false indication of a failure in the flame detector and amplifier circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 and FIG. 1A disclose in complete detail the internal circuitry of a programing burner control device along with the other elements which make up a complete burner system;

FIG. 2 is a bar chart showing the operating cycle plotted against the programer time in seconds, and;

FIG. 3 is a graph of the position of the damper of the burner as plotted against the programer time in seconds.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. 1 and 1A a complete schematic diagram of a programing burner control device incorporated in a burner system is disclosed. Before a description of the actual embodiment, an explanation of some of the notations used in the drawing is believed warranted. All of the equipment which is external to the claimed burner control device are shown in phantom. The burner control device of the present invention, and the external equipment shown in phantom, constitute a complete burner system. All of the contacts of the programing timer and of the two relays contained in the device are shown at the time when the programer is at zero seconds of operation. For convenience in understanding the operation of the device, each of the timer contacts has shown next to it the appropriate opening and closing times of the contact.

In FIG. 1 an entire burner system is disclosed as connected to a pair of conductors **10** and **11** which supply operating power to the system. Conductor **10** is connected to a conductor **12** of the burner control device while conductor **11** is connected to conductor **13** of the burner control device. A conductor **14** connects conductor **12** through a group of limits and controller **15**, and a conductor **16** to a terminal **17** of the burner control device. The limits and controller **15** are conventional safety limits and the starting controller for the burner system.

At terminal **17**, a pair of parallel paths are provided. Conductor **21**, a preignition interlock **22**, and a conductor **23** to a terminal **24** provide a first path. In parallel with the preignition interlock **22** is a normally open cam operated switch means or contact **25**. The normally open cam operated switch means is driven by a motor driven cam means indicated at **26**, which contains a conventional synchronous type clock motor and shaft that rotates the number of cams that in turn operate various switch means. Each of the various cam operated switch means later disclosed will be identified by a reference number and will have the opening and closing times noted on the drawings adjacent the contact itself. The contact **25** is connected back via conductor **27** to the terminal **24**.

A further part of the initial energizing path for the device includes an air flow sensitive switch **30** that is connected between the terminal **24** and a further terminal **31**. The air flow responsive switch closes to short the terminals **24** and **31** together when sufficient air flow has been proved in the burner system, as is well known in the art. Terminal **31** of the burner control device is connected through a normally open relay contact **1K2** to a conductor **32**. Conductor **32** is connected through a normally closed contact **33** of the timer which in turn is connected back to conductor **27**. Conductor **32** is further connected through a relay contact **1K1** and a normally closed timer contact **34** that is paralleled by a normally closed contact **2K3**. The designation of the relay contacts firstly indicates the particular relay and then the number of the contact of that particular relay. For example, the **1K1** relay is the first contact of the **1K** relay itself. The **1K** relay is disclosed at **35** and is a relay that has two windings that are used for pull-in, and the retaining energization of the relay. This general type of relay configuration and its operation can generally be found in the U.S. Pat. No. 3,082,813 to W. B. Hamelink, assigned to the assignee of the present invention.

The contacts **34** and **2K3** have a common juncture **36** at a safety switch heater **37** which in turn is connected by conductor **40** through a normally closed safety switch contact designated as **SS2** and through a coil **41** that is a part the **1K** relay **35**. The **1K** relay has a further winding **42** that is connected to conductor **40** and to a junction **43** between a normally opened relay contact **2K4** and the normally open timer contact **44**. The junction of the contacts **44** and **2K4** is at **45** which is connected to the junction between the **1K1** relay contact and the timer contact **34**.

As previously indicated, the operation of the **1K** relay and the safety switch heater along with the safety switch contact follow generally the teaching of the earlier mentioned Hamelink patent. At this point it is only necessary to indicate that once the conventional safety switch heater is energized by current flowing through

it, it is capable of opening the normally closed safety switch contact SS2 and closing an alarm contact designated as SS1. The safety switch is of a conventional design where the heater operates the switches, and wherein the switch members are then locked into the operated position until a manual reset button is pushed. As was just mentioned a safety switch contact designated SS1 is connected between the line 12 and a terminal 46 along with an alarm designated 47 and a conductor 48. When the switch SS1 closes, power is supplied to the alarm 47 to indicate that the safety switch has operated and that the device requires attention and reset.

A flame detector 50 is provided in the burner system and is connected between a pair of terminals F and G. The F and G terminals are input terminals to a plug-in amplifier 51, which is a solid state amplifier, selected to amplify a flame detection signal from the flame detector 50. The flame detector 50 can be a photocell, ultraviolet sensor, or flame rod and is matched to an appropriate solid state amplifier 51. The amplifier 51 receives its energy from a transformer 52 of a conventional design having a primary 53. The amplifier 51 further supplies, as its output, current to a 2K relay which is referred to as the flame relay. The 2K or flame relay is deenergized in the absence of flame and is energized when the flame detector 50 senses the presence of a flame. Unfortunately, occasional flame detector malfunctions cause the 2K relay to be energized when it should not be energized, and the present invention is directed to an arrangement which overcomes this false indication and shuts the system down in a safe manner. A description of that function will be provided after a description of the complete device has been outlined.

The primary winding 53 is connected by conductor 54 to conductor 13 and by conductor 55 to a parallel combination of the normally open 2K2 contact and the normally closed timer contact 56. The 2K2 contact and the timer contact 56 connect to conductor 32 to supply energizing power to the transformer primary 53 after the system is put into operation by the closing of the controller 15. This differs from the conventional, prior art devices which have a continuously energized amplifier circuit. In the present invention, the system can be put into operation concurrently with the operation of the controller 15 since the plug-in amplifier 51 is all solid state. This same function could be accomplished by continuously energizing the filaments of a conventional tube type of amplifier, and then applying only the high voltage when the controller 15 was activated.

An ignition device 60 is connected at terminal 61 and at conductor 13, as is a pilot valve 62 connected to terminal 63 and conductor 13, along with a main fuel valve 64 connected to a terminal 65. The ignition device 60, the pilot valve 62, and the main valve 64 all are common at the conductor 13 and are supplied with electric power through the 2K2 contacts when closed, or through the timer contact 56 when it is closed. This is accomplished by the use of a normally open timer contact 66, a normally open timer contact 67, and a further normally opened timer contact 68. The sequencing of the timer contacts 66, 67, and 68 is substantially the same as that disclosed in the previous mentioned Hamelink patent or in the line of products sold by the assignee of the present invention and known as the R4150G flame safeguard programer. Since this type of arrangement is well known in the art, no further description will be directed to these devices but they will be mentioned only in connection with the description of operation.

Conductor 12 is connected through a parallel combination of the 1K3 contact and the normally opened timer contact 70. This parallel combination supplies power to a conductor 71 that branches through the normally closed 1K4 contact, the normally closed timer contact 72, and the series pair of normally open timer contacts 73 and 74 along with the normally closed contact 2K1. These three paths provide an energizing path to the conductor 75 which in turn connects the timer motor of the motor driven cam means 26 to conductor 13 to energize the timer motor when it is necessary for the timer contacts to advance in the program within the device.

A conductor 71 is further connected to a terminal 76 which provides line voltage to a conductor 77 to provide a burner motor 78 with power through to the conductor 13. The burner motor 78 supplies air flow which in turn operates the air flow switch 30 along with providing the necessary purge air flow and burner air for the overall burner system. Terminal 76 is connected through a low fire interlock switch 80 to a terminal 81 and to junction 82 which is connected to a high fire interlock switch 83. The high fire interlock switch in turn is connected to a terminal 84. The terminal 84 is connected to a normally closed timer contact 85.

The device of FIG. 1 also in reality includes a portion disclosed in FIG. 1A. The portion of the circuit disclosed in FIG. 1A is a control circuit for a modulating control 87 and the motor 86 operated from the burner system. The motor 86 is used to position dampers for control of the air flow between a high fire (full air flow capability) to a low fire (a minimum air flow capability) position. The modulating control 87 associated with this provides the necessary rebalance for the position sensitive motor. These devices are of a conventional design, and are used in the conventional manner in the present invention. Four terminals 90, 91, 92 and 93 are provided along with the conductors 94, 95, and 96.

Connected between terminals 93 and 91 is a normally open timer contact 97 and a normally closed contact 98. Connected between terminal 90 and terminal 91 is a normally open contact 99, whereas between the terminal 92 and a common junction 100 between the contacts 97 and 98, is connected a normally closed contact 101. This arrangement of contacts and wiring provides for the necessary positioning of the air flow damper within the burner system between the high and the low fire positions. A modulating operation in between the high and low positions is provided in the normal run condition. By normal run it is meant that the device is not sequencing to try and light the burner, but is allowing the burner to operate fully to provide the heat necessary to the control 87.

Before describing the operation of the system, FIGS. 2 and 3 will be described since their description will aid in understanding the present invention.

In FIG. 2 there is disclosed a bar chart of the portion of the cycle versus the programer time in seconds. The bar chart is substantially self explanatory. The bar chart shows the device going through a prepurge period, ignition and pilot period, a main valve energized period, and then a modulating control between the startup and

the satisfaction of heat to the controller **15.** Once the system reaches **105** seconds of operation, the timer motor **26** ceases to operate and the system operation continues on until the heat supplied by the burner satisfies the demand at the controller **15.** At shut down (controller **15** opening), the sequence picks up at 105 seconds and goes through a post purge period to 120 seconds. The 120 second mark in fact again is the zero point, and the cycle is ready to start over again.

FIG. **3** discloses a graph of the burner damper position, between the high and low fire positions, as a function of the programer time in seconds. The graph of FIG. **3** shows that the damper or burner starts in the low fire and then moves to the high fire position at 7 seconds, where it remains until 41 seconds. At 41 seconds it returns to the low fire position and stays at the low fire position during the entire low fire proof and ignition of the main valve. The device at 95 seconds then goes into a modulating condition where the burner damper and operating level varies with demand until the controller **15** is operated to open circuit to shut the system down. At that time the modulation ceases and the device returns the damper to the low fire position at 116 seconds so that the system is ready to start at the next call for heat.

OPERATION

If power supplied on conductors **12** and **13,** and all of the limits and interlocks are properly positioned, the controller **15** closes to supply electrical energy to the preignition interlock **22** through terminal **24.** Power is then supplied through the normally closed switch **33** and the normally closed switch **56** to the conductor **55.** This supplies the electrical energy to the transformer **52** to energize the plug-in amplifier **51** so that any flame detected at the flame detector **50** is appropriately amplified to control the **2K** relay.

Energy is also supplied through the normally closed contact **2K3,** through the safety switch heater **37** and the safety switch contact SS2 (which is normally closed), and through the **1K** relay coil **41** to conductor **13.** The energy supplied to coil **41** pulls the relay **1K** in at which time the contact **1K2** closes along with relay contact **1K3** and **1K1.** The **1K3** relay supplies energy on conductor **71** to the burner motor **78** to supply the air flow necessary to close the air flow switch **30.** Upon closing the air flow switch **30,** energy is supplied to terminal **31,** through the relay contact **1K2** which shunts the normally closed contact **33,** to power the plug-in amplifier **51.** The contact **1K2** upon closing locks in the **1K** relay during normal operation of the burner control device. The timer contacts **73** and **74** along with the low fire interlock **80** and the high fire interlock **83** provide a continuous supply of energy to the timer motor **26** in a normal operating sequence. This allows the timer to progress through operation thereby closing the timer contacts **66, 67** and **68** in the proper sequence to create ignition, light the pilot, and then light the main burner.

In a normal sequence of operation the flame detector **50** is exposed to and will sense the operation of the pilot flame and the main burner. In the prepurge sequence, the normally closed switch **72** has gone through a cycle of opening and closing, and will again have closed to complete an energizing circuit for the timer motor **26** thereby keeping the timer motor in operation even though the switch **2K1** opens at the time the flame detector senses the existence of flame. The existence of flame at 60 seconds or shortly after closes the normally open relay contact **2K2** to provide a source of continuing energization for the transformer **52** and the plug-in amplifier **51,** as well as for the ignition device **60,** the pilot valve **62,** and the main valve **64.** At 57 seconds the energizing circuit for the safety switch heater **37** has been activated by closing the normally open contact **44** and will remain active until the flame detector **50** senses the existence of flame at which time the normally closed **2K3** flame relay contact opens. As long as switch **34** is open and the relay contact **2K3** is also open, no heating circuit is completed for the safety switch heater **37.**

As soon as the system reaches 105 seconds, the operation is in full normal modulating control. The modulating control **87** varies with temperature to move the wiper of the potentiometer to cause the motor **86** to in turn operate a modulating valve and damper to supply the proper level of burner operation. This will go on until the controller **15** opens, until some malfunction occurs which opens one of the limit switches, or a failure in the sensed flame occurs and is detected by the novel circuit configuration of the present invention.

ABNORMAL OPERATION

The invention in the present application is directed to a unique function within the system which detects an abnormal type of operation. In the event that the flame detector **50,** plug-in amplifier **51,** or the 2K relay operates in a manner to close the **2K** relay contact during the prepurge portion of the cycle, the unit senses this malfunction and shuts the device down on safety. Any failure in the flame detector system which causes the **2K** relay to be energized during a substantial portion of the prepurge cycle causes the safety switch heater **37** to be operably energized to time out on safety. This opens the safety switch contact SS2 and closes the safety switch contact SS1 to the alarm **47.** Since the safety switch means of the present invention is a manual reset type of safety switch, this operation shuts down the system and causes an alarm to be given requiring the system to be reset manually.

The safety function is accomplished by the normally closed **2K1** relay contact opening, and the normally open **2K4** contacts closing. The opening of the **2K1** contact during the prepurge portion of the cycle removes the energizing circuit for the timer motor **26** and the timer stops operating. At the same time the closing of the **2K4** relay contacts completes a circuit through contact **34** and the safety switch heater **37** to the winding **42** of the relay **1K.** As was explained in the previously mentioned Hamelink patent, this creates a heating cycle for the safety switch heater **37** and causes the safety switch contacts SS2 to open and lock themselves in an open condition.

It is thus apparent that the present arrangement provides with a simple set of contacts a safety feature that has not hitherto been available on programing types of burner control devices. The present system provides for the monitoring of the flame detector circuit during the prepurge portion of the cycle, and thereby provides safety over a large portion of the operation of the programer.

In addition to the function above noted for safety, the present system includes two other desirable features. The use of the relay contact **2K2** in parallel with the

normally closed timer contact **56** provides an energizing path for the plug-in amplifier **51** through the transformer **52** after the controller **15** has closed. This means that the plug-in amplifier **51** and its associated equipment is energized only when the controller is calling for operation of the device and no unnecessary energy is drawn by this system. This can be accomplished with solid state systems or with tube type of equipment where the filaments only have been provided with a continuous source of heating current.

The present invention is very broadly directed to a safer type of flame safeguard burner control device for operating a burner system. By utilizing flame responsive contacts in the safety switch circuit and the timer motor circuit it is possible to detect failures in the flame detection circuit prior to the end of the purge period thereby providing for a safe start up. This is further reinforced by a circuit which provides for a guarantee that the fuel supply is at its proper position, that is that the high fire interlock switch has operated. These and other aspects of the present invention will become obvious when the present specification is considered in light of the appended claims.

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

1. A programing burner control device adapted to be connected as part of a burner system which includes flame sensor means, ignition and fuel supply means, condition responsive interlocks, and initiating control means whereby said programing burner control device is adapted to be connected to a source of operating power when said interlocks and said control means are properly actuated, including: motor driven cam means and cam operated switch means with said switch means operated in a sequence to program said burner system in a predetermined operating mode; safety switch means including heater means and normally closed safety switch contacts with said heater means capable of opening said safety switch contacts upon said heater means being operatively energized for a period of time; load control relay means including a plurality of load control contacts with at least one of said control contacts controlling the energization of said motor driven cam means upon initiation of operation of said burner system; amplifier means and flame relay means wherein said amplifier means is adapted to be connected to said flame sensor means with said flame relay means normally operated in response to said flame sensor means detecting the presence of flame; said flame relay means including a normally open contact which when closed completes a circuit for energizing said safety switch heater means in a prepurge portion of said burner system operation; and said flame relay means further including a normally closed contact which when opened interrupts power to said motor driven cam means in a prepurge portion of said burner system operation; said flame relay means operation causing said programing burner control device to stop the operation of said motor driven cam means with the concurrent heating of said safety switch heater means in the event of operation of said flame relay means during said prepurge portion of operation to safely stop said burner system.

2. A programing burner control device as described in claim **1** wherein said relay means are electromagnetic relays.

3. A programing burner control device as described in claim **2** wherein said amplifier means is capable of full operation immediately upon application of electrical power by way of operation of said initiating control means.

4. A programing burner control device as described in claim **3** wherein said flame relay means further includes a second normally open contact in parallel circuit with a first cam operated switch of said cam operated switch means; and said cam operated switch being normally closed during said prepurge portion of said burner system operation and an initial ignition portion of said burner system operation; said cam operated switch opening after said second flame contact has closed; said energized flame relay means insuring that said control device is energized; said second flame contact opening if the flame is lost to thereby deenergize said control device.

5. A programing burner control device as described in claim **4** wherein said amplifier means is a solid state amplifier.

6. A programing burner control device as described in claim **3** wherein said amplifier means is a solid state amplifier.

7. A programing burner control device as described in claim **6** wherein said safety switch means further includes latching means with manual reset to latch said normally closed safety switch contacts in an open condition when said heater means has been energized sufficiently to open said closed safety switch contact means.

8. A programing burner control device as described in claim **7** wherein said cam operated switch means includes second cam operated switch means which is adapted to complete a circuit through a high fire interlock switch to energize said motor driven cam means during said prepurge portion of said burner system operation to insure that said system is in a high fire operating mode.

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