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SAFETY CONTROLS FOR GAS-FIRED INDUSTRIAL BURNERS

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2 Sheets-Sheet 1

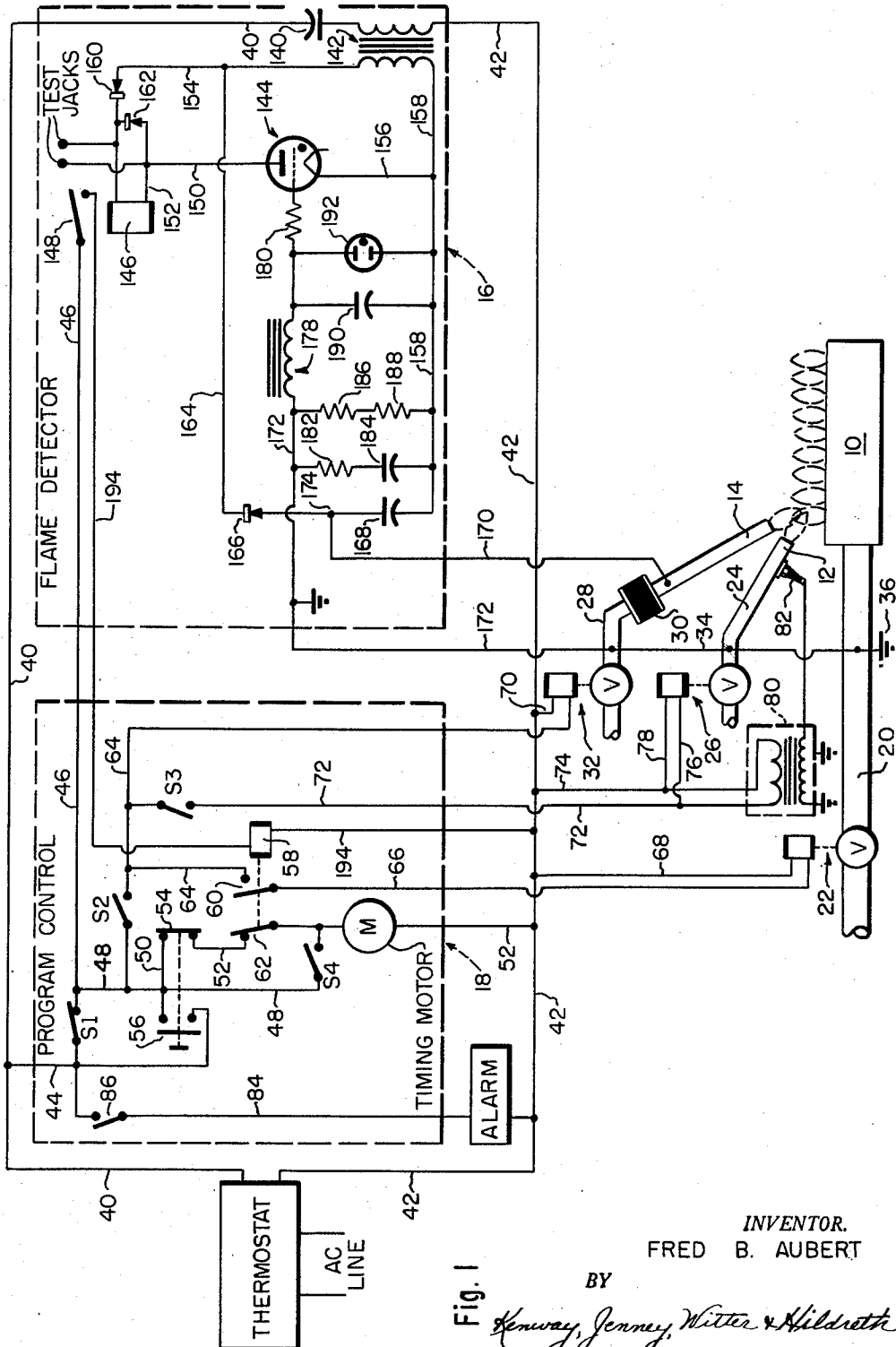


Fig. 1

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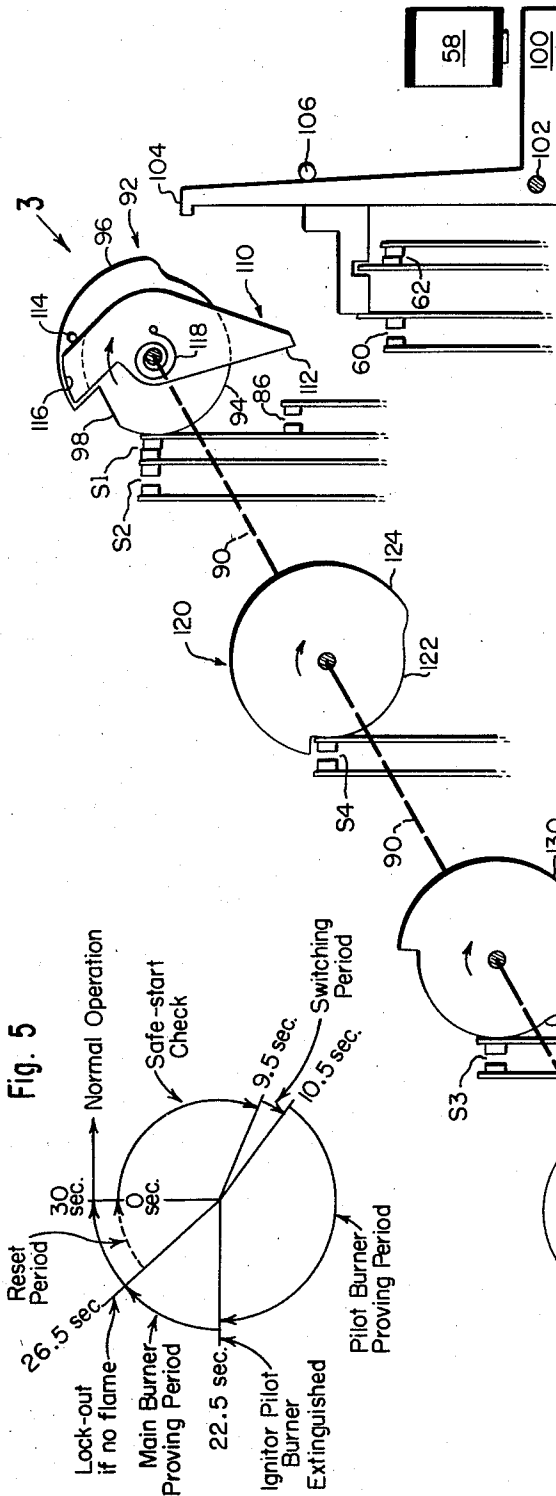
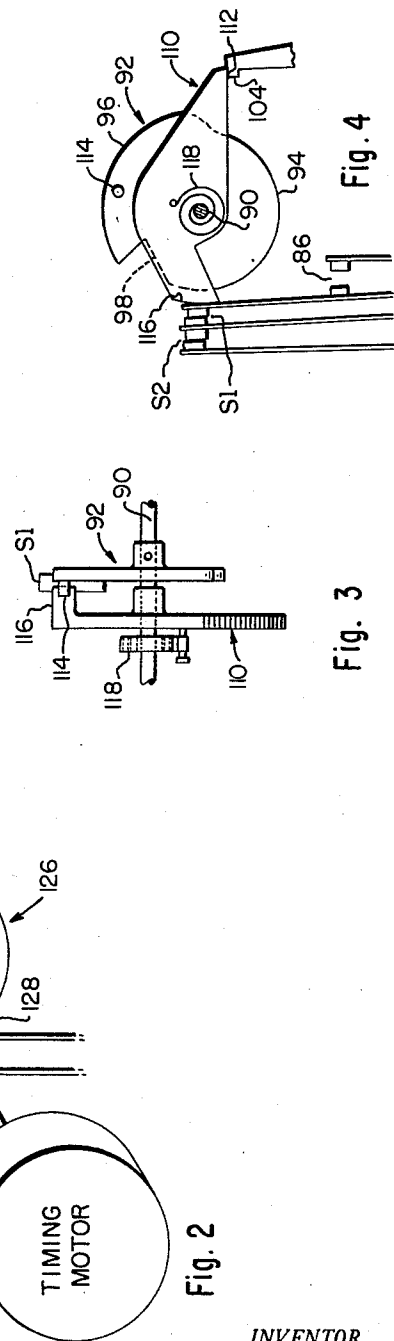
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SAFETY CONTROLS FOR GAS-FIRED INDUSTRIAL BURNERS

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9 Claims. (Cl. 158—125)

This invention relates to safety control apparatus for fuel burners and comprises new and improved control equipment specifically designed for gas-fired industrial burner installations.

It has long been understood and appreciated that a flame will conduct electrical energy, presumably because of the ionized condition of the hot gases constituting the flame. For example, reissue Patent No. 20,210 to Knowles, reissued December 22, 1936, discloses a combination control system including a flame and a pair of electrodes mounted in the path of the flame, the arrangement being such that the supply of fuel to a burner was cut off in the event the flow of electrical energy between the electrodes terminated, if for any reason the flame failed. It was later discovered that such an arrangement was unsatisfactory because the electrical behavior of flames of different gases varied widely. The single flame proved particularly undependable in a direct current circuit, for some gases produce a flame in which the outer envelope is positively charged while the interior of the flame is negatively charged, while other gases display the opposite arrangement of charges.

This difficulty is overcome in the apparatus disclosed in the instant application by providing at least two flames which mutually impinge and together form a path for the flow of current.

The primary object of this invention is to provide safer and more efficient controls for gas-fired industrial burners.

Another object of this invention is to provide a device that is self-protecting against short circuits.

Another object of this invention is to eliminate in control equipment for gas burners sensitivity to transient conditions.

Another object of this invention is to reduce the cost of control equipment for industrial burner installations.

To these ends my new and improved control equipment includes an ignition pilot burner and a detector pilot burner which produce mutually impinging flames within the flame of a main burner. The mutually impinging pilot burner flames form part of a flame sensing circuit which energizes a relay in a unit called a flame detector and opens a valve controlling the flow of fuel to the main burner. After the pilot burners ignite the main burner, the ignition pilot burner is extinguished, and the mutually impinging main burner and detector pilot burner flames complete the flame sensing circuit to hold the main burner valve open. In this manner, the detector pilot burner polices the main burner after normal operation is established. Besides policing the system during normal operations, the detector makes a preliminary check for short circuits before the burners are ignited and if such a short is sensed, the burner valves are prevented from opening.

As another important feature my control equipment includes a programmer which controls the sequence of operation of the burners. Upon a demand for heat, the programmer cycles once, first opening valves in each of the pilot burner fuel supply pipes, then opening the

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main burner valve, and before stopping, extinguishes the ignition pilot burner. The programmer is subordinate to the flame detector in that it cannot complete its cycle unless the relay controlled by the flame sensing circuit is energized. If the first cycle fails to produce a normal flame at the main burner, the programmer shuts down the system and actuates a lockout alarm switch. If the main and/or detector pilot burners fail after a period of normal operation, the programmer automatically recycles once in an effort to restore normal operation and if unsuccessful, it locks out the system.

The flame detector and the programmer, fabricated as separate units, are free of costly components, and each has uses independent of the other.

These and other objects and features of my invention along with its incident advantages will be better understood and appreciated from the following detailed description of one embodiment thereof, selected for purposes of illustration and shown in the accompanying drawing, in which:

Fig. 1 is a view, partially diagrammatic and partially schematic, of a safety control system constructed in accordance with my invention,

Fig. 2 is a diagrammatic view of a cam actuating assembly forming part of the safety control system of my invention, showing the components in this starting position,

Fig. 3 is a fragmentary view in elevation of a portion of the assembly illustrated in Fig. 2,

Fig. 4 is a diagrammatic view of part of the cam assembly illustrated in Fig. 2, showing the components in the normal operating position, and

Fig. 5 is a timing diagram of the safety control system.

The embodiment of my invention illustrated in Fig. 1 includes in its general organization a main burner 10, an ignition pilot burner 12, and a detector pilot burner 14. A flame detector 16 polices the burners and dominates a program control 18 which controls the sequence of operation of the burners.

The main burner 10 receives its supply of fuel through a pipe 20 which is interrupted by a solenoid valve 22 while the ignition and detector pilot burners 12 and 14 are fed through pipes 24 and 28 containing solenoid valves 26 and 32, respectively. The main burner 10, the ignition pilot burner 12 and the pipe 28 carrying fuel to the detector pilot burner 14 are each connected to a grounded burner frame represented schematically by the electrical lead 34 grounded at 36. The detector pilot burner 14 is insulated from ground by an insulation block 30. As suggested in Fig. 1, the ignition and detector pilot burners 12 and 14 produce flames which mutually impinge within the flame of the main burner.

The electrical circuits within the programmer 18 controlling the sequence of operation of the burners will now be described. A timing motor M which drives the cam assembly shown in Fig. 2 is energized from any A.C. line through a circuit containing a thermostat, an electrical lead 40, a lead 44, a switch S1, leads 48 and 50, a manually actuated reset switch 54, a lead 52 interrupted by a relay switch 62 controlled by a coil 58, and a lead 42. The switches S1, 54, and 62 along with the other switches in the programmer are shown in their closed or starting positions. A normally open switch S4 interrupting lead 48 when closed bypasses the reset switch 54 and the relay switch 62 and completes an alternative energizing or running circuit for the motor.

The circuit within the programmer 18 for energizing the solenoid valve 32 in the supply pipe 28 of the detector pilot burner 14 includes between the conductors 48 and 42 a lead 64, a switch S2, and a lead 70. A circuit parallel to the circuit of the solenoid 32 and between conductors 42 and 48 which includes the switch S2, a portion

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of lead 64, a switch S3 and leads 72, 76, 78, and 74 energizes the solenoid valve 26 in the fuel supply pipe 24 of the ignition pilot burner 12. An ignition transformer 80 has its primary connected across the leads 72 and 74 and supplies current to a spark plug 82 which ignites the ignition pilot burner. A circuit connected between the leads 42 and 64 and composed of leads 66 and 68 and a relay switch 60 energizes the main burner solenoid valve 22. Within the program control 18 an alarm connected into a lead 84 which contains a normally open switch 86 signals an operator that the burner system has shut down as the result of faulty operation of the system.

The mechanical actuating mechanism within the programmer 18 controlling the sequence of operation of the switches is illustrated in Figs. 2, 3 and 4. A shaft 90 represented by the broken line in Fig. 2 carries cams 92, 110, 120, and 126 and is driven by the timing motor. The cams 92, 120, and 126 are rigidly connected to the shaft 90, while the cam 110 is merely coupled to the shaft by a coil spring 118 which urges the cam 110 to follow the cam 92 and lie against the pin 114.

When the thermostat closes in response to a demand for heat, the timing motor becomes energized, slowly turning the shaft 90 which rotates all of the cams. Approximately $1\frac{1}{2}$ seconds after starting, the cam 126, which leads the other cams, closes the switch S3 as its blade moves from the cam surface 128 to surface 130, and 8 seconds later the cam 120 closes the switch S4 as its blade moves from cam surface 122 to 124. One second after the switch S4 closes, the cam 92 moves switch S1 to the left, as viewed in Fig. 2, closing the switch S2 which causes both the pilot burner valves to open. Thus gas issues from each of the pilot burners and is ignited by the spark plug 82 which becomes energized when the ignition pilot burner valve 26 opens.

If the flame detector 16 senses the proper functioning of each of the pilot burners, the switch 148 between the leads 46 and 194 is closed the coil 58 is energized and its armature 100 pivots about a fulcrum 102, closing the switch 60 and opening the switch 62. The closed switch 60 allows the solenoid of the main burner valve 22 to become energized through its circuit and fuel flows to the main burner. In addition, movement of the armature 100 about its fulcrum shifts a seat 104 integral with the armature into the path of travel of a shoulder 112 forming part of the cam 110. If the coil 58 remains energized, the seat 104 precludes further rotation of the cam 110 and its surface 116 holds the switches S1 and S2 closed (see Fig. 4) as the raised surface 96 on the cam 92 travels beyond those switches.

Approximately 12 second elapse between the closing of switch S2 and the igniting of the main burner 10. After the 12 second period, the switch S3 opens, closing the ignition pilot burner valve 26 and deenergizing the ignition transformer 98. During the following four seconds, the flame detector proves the main burner flame. If the main burner operates properly, the coil 58 remains energized, and the shaft 90 continues to rotate until the cam 120 releases the switch S4, opening the circuit to the timing motor. If on the other hand the main burner 10 fails to function normally during the four second proving period, the coil 58 deenergizes, releasing the armature 100, which then moves against its stop 106 and releases the cam 110. Subsequently, the surface 116 of the cam 110 moves out from behind the switches S1 and S2 under the influence of the coil spring 118. The step 98 on the surface of the cam 92 lies opposite those switches at the end of the main burner proving period and permits them to open at the same time the alarm switch 86 closes. The opening of switch S1 closes each of the solenoid valves and stops the timing motor. Thus, the programmer assumes the "lock-out" position, and the alarm which is energized when the switch 86 closes informs the operator that lock-out has occurred.

Coming now to the details of the flame detector 16,

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a capacitor 140 is connected in series with the primary of a transformer 142 in the circuit of the leads 40 and 42. The capacitor 140 develops a high primary voltage for the transformer while voltage regulation is acquired by the use of a saturable core. Therefore, although the line voltage may vary between 90 and 127 volts, the potential across the transformer secondary is a constant 125 volts.

A relay coil 146 controlling a switch 148 forms part of the plate circuit of a cold cathode gas triode tube 144 which is connected across the secondary of the transformer 142 by leads 150, 152, 154, 156, and 158. Because a cold cathode tube does not give 100% rectification, a rectifier 160 is included in the circuit to cause the current to flow only from the plate to the cathode. A second rectifier 162 connected in parallel with the relay coil 146 in polarity opposition to the rectifier 160 provides a path for the current induced by collapse of the magnetic field during the half cycles when the plate terminal of the transformer secondary is negative.

A lead 164, a rectifier 166 and a capacitor 168 connected across the relay coil and the gas tube form a second circuit in the flame detector. The capacitor 168 lying across the secondary coil of the transformer 142 develops approximately 160 volts between the cathode of the gas tube and the junction 174 between the rectifier 166 and the capacitor.

The grid circuit may be traced from the junction 174 through a lead 170, the detector pilot burner 14, the ignition pilot burner 12 and the impinging flames of the pilot burners, the lead 34, and a lead 172 containing a choke 178 and a resistor 180. Alternatively the grid circuit may be completed through the main burner 10 and its flame which impinges upon the flame of the detector pilot burner 14. From the foregoing description of the grid circuit it will be appreciated that the gas tube can fire only when the flames of the pilot burners or the detector pilot burner and the main burner impinge, for these flames function as switches in the grid circuit. Thus, relay coil 146 energizes to close the switch 148 only when the gas tube 144 detects the existence of impinging flames at the burners.

To prevent transient conditions such as flame fluttering from deenergizing the relay coil 146, a resistor 182 and a capacitor 184 are connected between the grid circuit and the cathode of the gas tube. The resistor and the capacitor in series introduce into the system a delay of from two to four seconds between the opening of the grid circuit and the deionization of the gas in the tube 144. Therefore, the flame detector does not report flame failure upon an instantaneous break of the grid circuit due to transient conditions. A capacitor 190 connecting the grid with the cathode prevents the spontaneous firing of the tube if for any reason the resistor 182 is removed from the circuit. Resistors 186 and 188 each rated at 22 megohms reduce the sensitivity of the circuit. In their absence, the grid circuit would sense the smallest amount of current flow and the tube would fire.

In the event a short develops across the leads 170 and 172, the voltage between the grid and cathode becomes sufficiently great to fire the argon lamp 192, as a result of which the capacitor 168 is in effect shorted out by the parallel circuit through the choke coil 178 and the argon lamp. The current then pulses through the choke coil 178 and the grid voltage becomes shifted out of phase and drops from about 160 volts to about 120 volts relative to the cathode. The tube 144 under these conditions ceases to conduct, and the relay coil 146 de-energizes to cause the system to proceed to lockout.

Before presenting a detailed description of the operation of the embodiment of my invention illustrated in the drawings, I will describe the manner in which the flame detector 16 dominates the program control 18. The relay switch 148 within the flame detector 16, when open

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interrupts a lead 194 which supplies current to the relay coil 58 forming part of the program control. So long as the relay switch 148 remains open, the relay 58 is deenergized, and the main burner valve 22 continues in the closed position. Thus, the main burner valve 22 opens only when the gas tube 144 fires to energize the relay 146.

Coming now to the operation, the control system is illustrated in the stand-by position, and is ready to respond to a demand for heat from the thermostat. Upon closing of the thermostatic switch, the timing motor becomes energized and begins to turn the cam shaft 90 slowly through its 30 seconds cycle. After one and one half seconds, the switch S3 closes and after 9½ seconds the cam 120 closes the switch S4. During this 9½ seconds period, the flame detector makes a soft start check. In the event of a short circuit across the burners of resistance comparable to that of the flames, the grid ionizes the gas in the tube 144 which fires, energizing the relay coil 146 which closes the switch 148 thereby energizing the relay coil 58 in the program control 18. The energized coil 58 opens the switch 62 to stop the timing motor. Until such time as the condition is corrected, the programmer will not continue through its cycle. The 9½ seconds period also provides time for a blower (not shown) to purge the combustion zone of any unburned gases. A short circuit of sufficiently low resistance to fire the argon tube 192 will prevent tube 144 from ever firing, as a result of which relay 58 will never actuate. The main burner valve will then not open and the program control will proceed to lock-out.

At the end of this checking period, if conditions are normal, the switch S2 closes and the solenoid valves 26 and 32 in the pilot burner supply pipes open. At the same time, the ignition transformer 80 fires the spark plug 82 and the gas issuing from the pilot burner ignites. If the pilot burners ignite properly, their impinging flames complete the grid circuit of the gas tube 144 and the tube fires, energizing the flame detector relay coil 146. Thus, the main burner valve 22 opens after the pilot burner flames are proved, for the relay coil 146 closes the switch 148 interrupting the leads 46 and 194 which completes the circuit of the relay coil 58 controlling the switches 60 and 62. Although the switch 62 in the timing motor circuit opens, the motor continues to run because the substitute or running circuit through the switch S4 is closed. The duration of the pilot burner proving period is approximately 12 seconds, terminating 22½ seconds after the start of the cycle. During this period, the energized relay coil 58 in the programmer 18 moves the armature seat 104 in the path of travel of the shoulder 112 of cam 110 and the switches S1 and S2 are held open by the surface 116 of that cam.

If the pilot burners fail to ignite during the pilot burner proving period, the gas tube 144 will not fire, and seat 104 of the armature 100 will not move into the path of the shoulder of the cam 110. As a result, the main burner valve 22 will not open for the switch 60 will not close, and the programmer 18 will proceed to lock-out. At the same time switch 86 will close, energizing the alarm.

Assuming that the pilot burners are functioning properly at the end of the pilot burner proving period, the switch S3 opens, closing the ignition pilot burner valve 26, and the grid circuit is completed through the detector pilot burner and main burner flames. At the end of one complete cycle, the surface 124 of cam 120 releases the blade of the switch S4 and the timing motor stops. The cam 110 holds switches S1 and S2 closed and the main burner remains ignited throughout the period of demand for heat. If the main burner fails to ignite, the shutting down of the ignition pilot burner 12 breaks the grid circuit and the system moves to lock-out in the manner described above.

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Flame failure at the main burner 10 and/or at the detector pilot burner 14 during the normal operating period breaks the grid circuit, and subsequently, the relay coil 58 deenergizes and releases the armature 100. The cam 112 thereupon releases the switches S1 and S2, and switch S2 opens while switch S1 is held closed by the surface 94 of the cam 92. Simultaneously the switch 62 in the timing motor circuit closes and the programmer 18 recycles in an effort to reignite the main burner. If unsuccessful, the programmer moves directly to lock-out.

To recycle the system after correcting the unsafe condition which caused "lock-out," the operator closes the manual reset switch 56, completing a circuit through the closed switch S4 to the timing motor. The operator must hold the switch 56 closed until the blade of switch S1 rides out of the recessed surface 98 and onto the surface 94 of the cam 92. Thereafter the program control 18 will automatically recycle, being driven by the normally operating timing motor.

In summary therefore it will be appreciated that the present invention offers a device comprising in one aspect a burner control apparatus having a first or ignition pilot burner, a second or main burner, and a third or detector pilot burner. The impinging flames of two of the burners are used to complete an electrical circuit and cooperate in combination in a manner whereby the impinging flames of the first and third burners are utilized with means responsive to the impingement to cause the initial flow of fuel to the second burner and having done so, to stop the flow of fuel to the first burner, and using the impinging flames of the second and third burners to maintain the flow of fuel to the second burner.

From the foregoing description those skilled in the art will appreciate that numerous modifications may be made of the illustrated embodiment without departing from the spirit of my invention. Therefore, I do not intend to limit the scope of my invention to the single embodiment illustrated and described, but rather that its breadth be determined by the appended claims and their equivalents.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus of the class described comprising a main burner, a first pilot burner, a second pilot burner adapted to produce a flame impinging upon the flames of the main and first pilot burner, valves controlling the supply of fuel to each of the burners, means responsive to the presence of impinging pilot burners flames for opening the main burner valve, means for closing the first pilot burner valve after the main burner is ignited by the pilot burners, and means responsive to the presence of impinging second pilot burner and main burner flames after the first pilot burner valve is closed for maintaining the main burner valve open.

2. Apparatus of the class described comprising a main burner, a valve controlling the flow of fuel to the main burner, a first pilot burner, a valve controlling the flow of fuel to the first pilot burner, a second pilot burner adapted to produce a flame impinging upon the flames of the first pilot burner and the main burner, a first circuit controlling the first pilot burner valve, means for energizing the first circuit to open the first pilot burner valve, means for igniting the first pilot burner, a second circuit for opening the main burner valve, means responsive to the presence of mutually impinging flames at the pilot burners for energizing the second circuit to open the main burner valve, means for deenergizing the first circuit after the main burner has ignited and means responsive to mutually impinging second and main burner flames for maintaining the second circuit energized.

3. In combination with a main burner, first and second pilot burners adapted to produce flames which mutually impinge within the flame of the main burner, and electrically operated valves controlling the supply

of fuel to each of the burners; a program control comprising electrical circuits for opening each of the electrically operated valves, a first normally open switch in the circuit of the first pilot burner valve, a second normally open switch in the circuits of each of the pilot burner valves, a third normally open switch in the circuit of main burner valve, a timing device responsive to a demand for heat for first closing the first switch, and later closing the second switch to open the pilot burner valves, ignition means responsive to the closing of the first and second switches for igniting the pilot burners, means responsive to the presence of impinging flames at the pilot burners for closing the third switch, said timing device releasing the first switch after the third switch is closed, means responsive to the presence of impinging flames at the main burner and the second pilot burner for holding the third switch closed, and a fourth switch in the circuit of each of the pilot burner valves and the main burner valve, said switch being opened by the timing device in response to failure of the impinging pilot burner flames or the impinging second pilot burner and main burner flames.

4. In combination with a main burner, first and second pilot burners adapted to produce flames which mutually impinge within the flame of the main burner, and electrically operated valves controlling the supply of fuel to each of the burners; a program control comprising electrical circuits for opening the first and second pilot burner valves and the main burner valve, a timing motor, a circuit for energizing the timing motor, a first normally closed switch controlling each of the valve circuits and the timing motor circuit, a second switch in the circuit of the first pilot burner valve, a third switch controlling each of the pilot burner valves, a fourth switch in the circuit of the main burner valves, means responsive to energization of the timing motor for first closing the second switch and then closing the third switch to open the pilot burner valves, ignition means responsive to the closing of the second and third switches for igniting the pilot burners, means responsive to impinging pilot burner flames for closing the fourth switch to open the main burner valve and holding the third switch closed, means driven by the timing motor for opening the second switch after the fourth switch is closed, means responsive to impinging second pilot burner and main burner flames for holding the third switch closed, and means driven by the timing motor for opening the first switch after the second switch is open if the main burner fails to impinge upon the flame of the second pilot burner.

5. In combination with a main burner, first and second pilot burners adapted to produce flames which mutually impinge within the flame of the main burner, and electrically operated valves controlling the supply of fuel to each of the burners; a program control comprising a timing motor, a first cam driven by the timing motor, means including a switch controlled by the first cam for opening the first and second pilot burner valves a predetermined period after the timing motor is energized, ignition means controlled by the last named means for igniting the pilot burners, means responsive to impinging pilot burner flames for opening the main burner valve, a second cam driven by the timing motor, means controlled by the second cam for closing the first pilot burner valve a predetermined period after the first and second pilot burner valves are opened, means responsive to impinging second pilot burner and main burner flames for maintaining the main burner valve open, and means responsive to the absence of a pair of impinging flames at the burners for closing the valves.

6. Apparatus of the class described comprising first and second gaseous fuel burners, a third gaseous fuel burner for producing a flame which impinges upon the flames of the first and second burners, a control device having means controlling the flow of fuel to said second burner, means responsive to impinging flames of the first and third gaseous fuel burners for placing said control device in a condition effective to flow fuel to said second burner, and further means responsive to impinging flames of the second and third gaseous fuel burners for holding said control device in said effective condition in the absence of impingement between the flames of the first and third burners.

7. Apparatus of the class described comprising first and second gaseous fuel burners, a third gaseous fuel burner for producing a flame which impinges upon the flames of the first and second burners, a control device having means controlling the flow of fuel to said second burner, means responsive to impinging flames of the first and third burners for placing said control device in a condition effective to flow fuel to said second burner, means for shutting down the first burner after the control device has been placed in said effective condition, and means responsive to the impinging flames of the second and third pilot burners for holding said control device in said effective condition in the absence of impingement between the flames of the first and third burners.

8. Apparatus of the class described comprising a main burner, a pair of pilot burners for producing flames which mutually impinge in the flame of the main burner, valves controlling the supply to each of the pilot burners and the main burner, means for opening the valves controlling the supply of fuel to each of the pilot burners, means for igniting the fuel issuing from the pilot burners, means responsive to impinging pilot burner flames for opening the valve controlling the supply of fuel to the main burner, means for closing one of the pilot burner valves a predetermined period of time after each of the pilot burner valves are opened, and means responsive to the impinging flames of the main burner and other pilot burner for maintaining the main burner valve open.

9. Combustion control apparatus comprising a first pilot burner, a second pilot burner adapted to produce a flame impinging with a flame from the first pilot burner thereby creating a first electrical circuit between the first pilot burner and the second pilot burner when said flames impinge, a main burner adapted to produce a flame impinging with a flame from said first pilot burner thereby creating a second electrical circuit between the main burner and the first pilot burner when the said flames impinge, a main valve controlling the flow of fuel to the said main burner and means responsive to said first electrical circuit for opening said main valve, a pilot valve controlling the flow of fuel to said second burner, means for closing the pilot valve a time interval after said main valve is opened, and means responsive to opening of said second electrical circuit for closing said main valve.

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