Dec. 8, 1942. R. J. PLEIN ET AL 2,304,200

SAFETY CONTROL MECHANISM FOR FUEL BURNERS

Filed Aug. 20, 1938 5 Sheets-Sheet 1

Fig. 1.

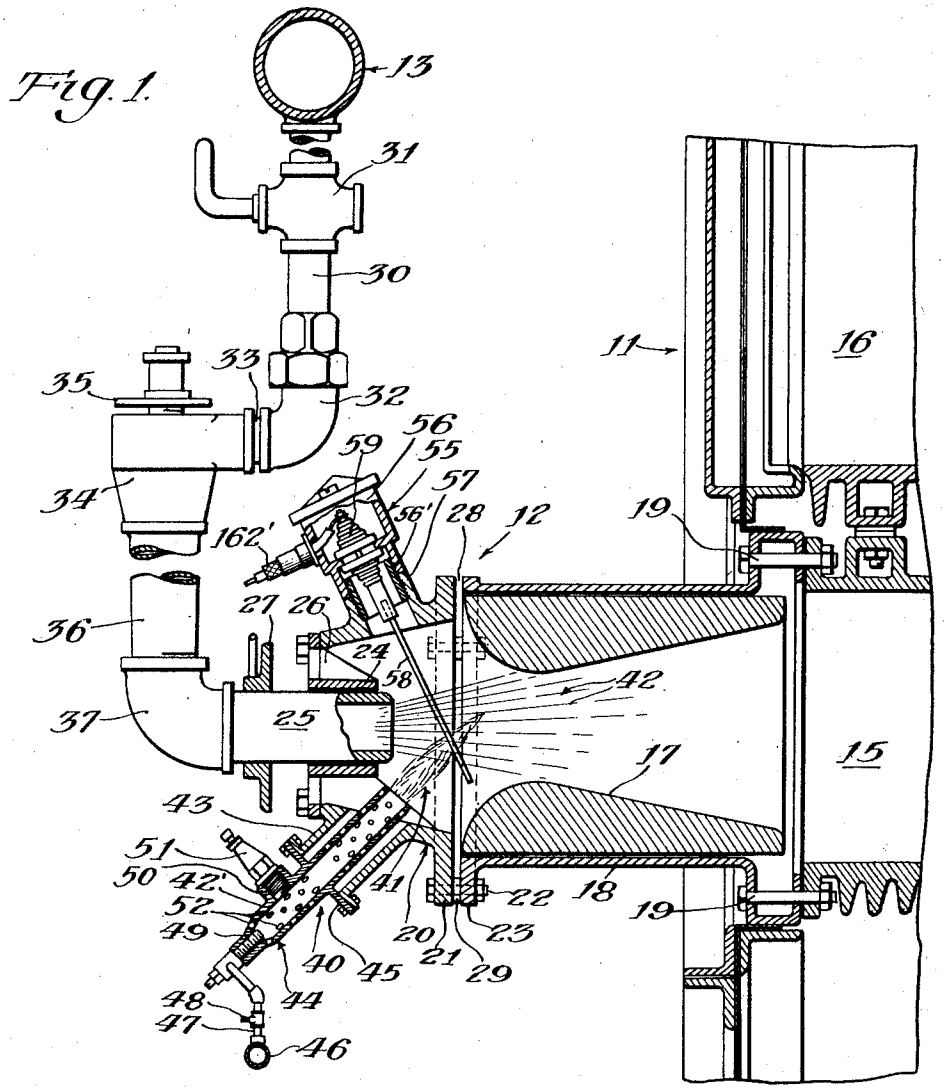
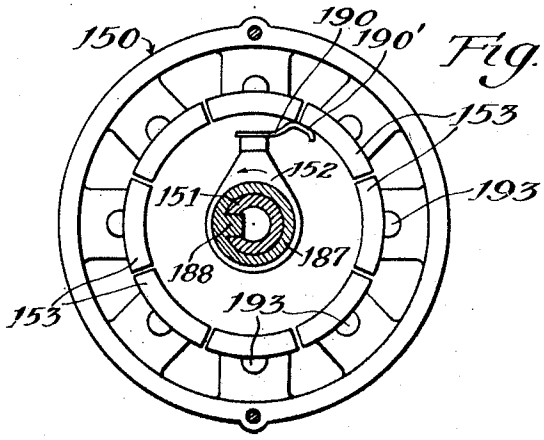


Fig. 2.



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SAFETY CONTROL MECHANISM FOR FUEL BURNERS

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Fig. 3.

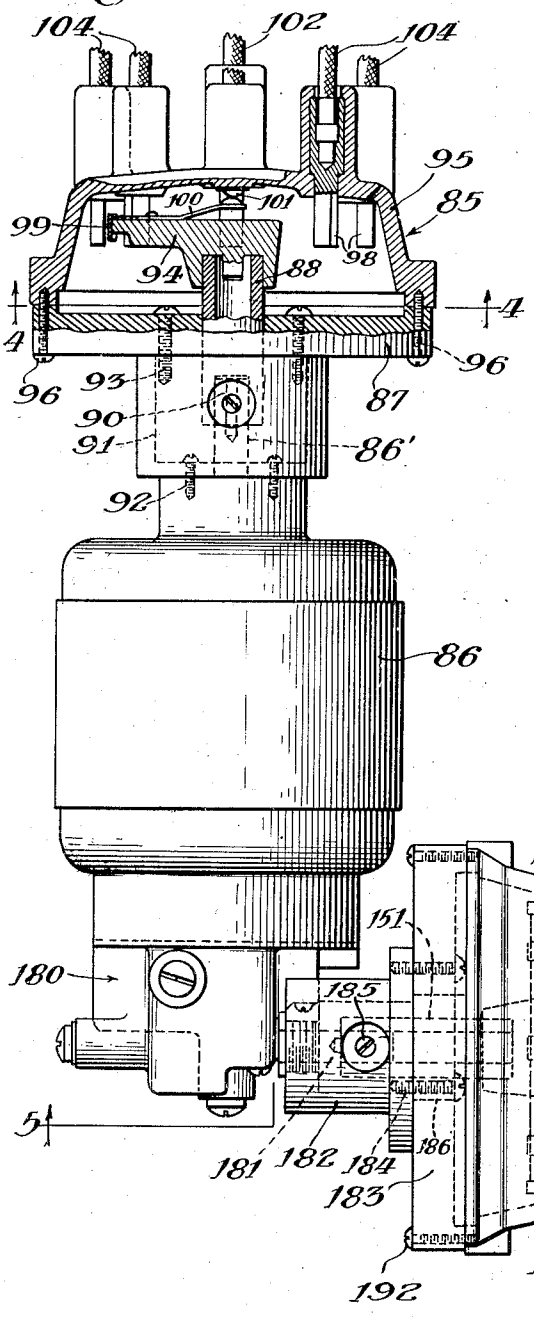
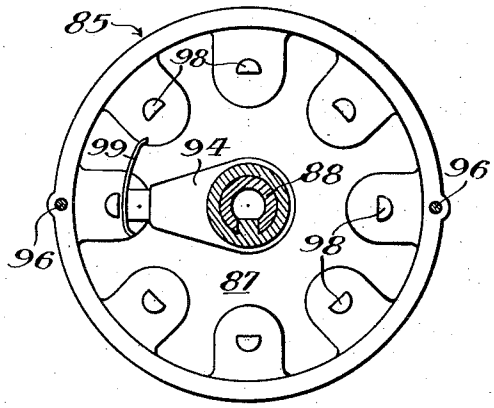


Fig. 4.



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SAFETY CONTROL MECHANISM FOR FUEL BURNERS

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Fig. 5.

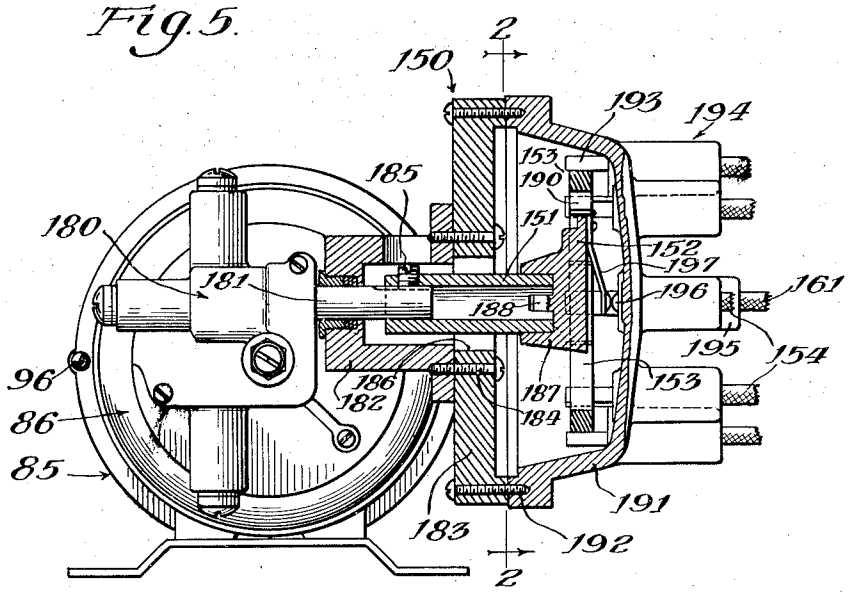
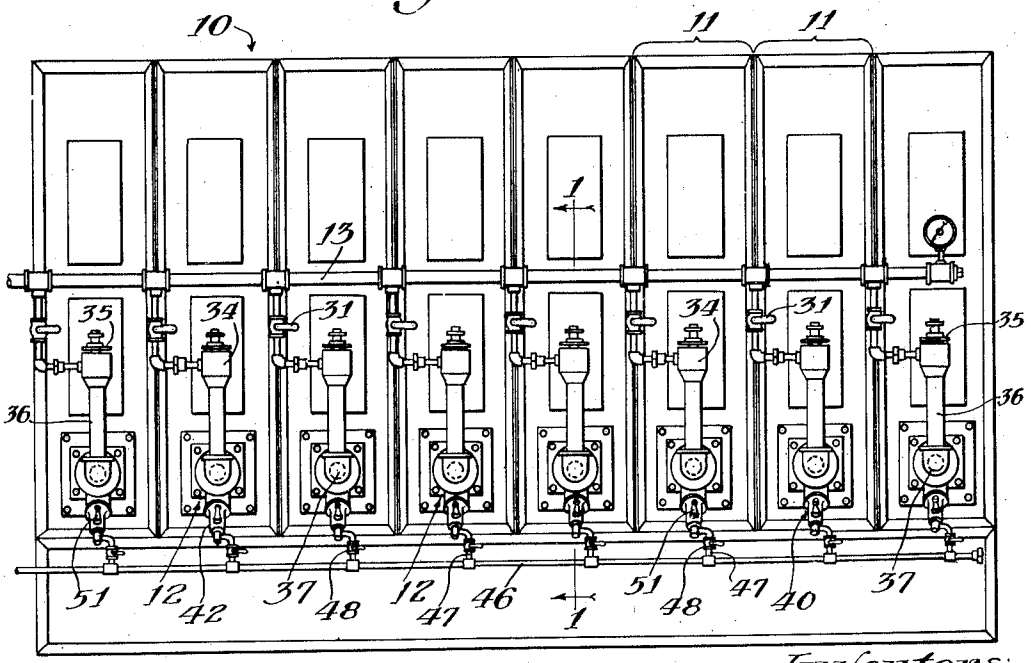


Fig. 6.



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SAFETY CONTROL MECHANISM FOR FUEL BURNERS

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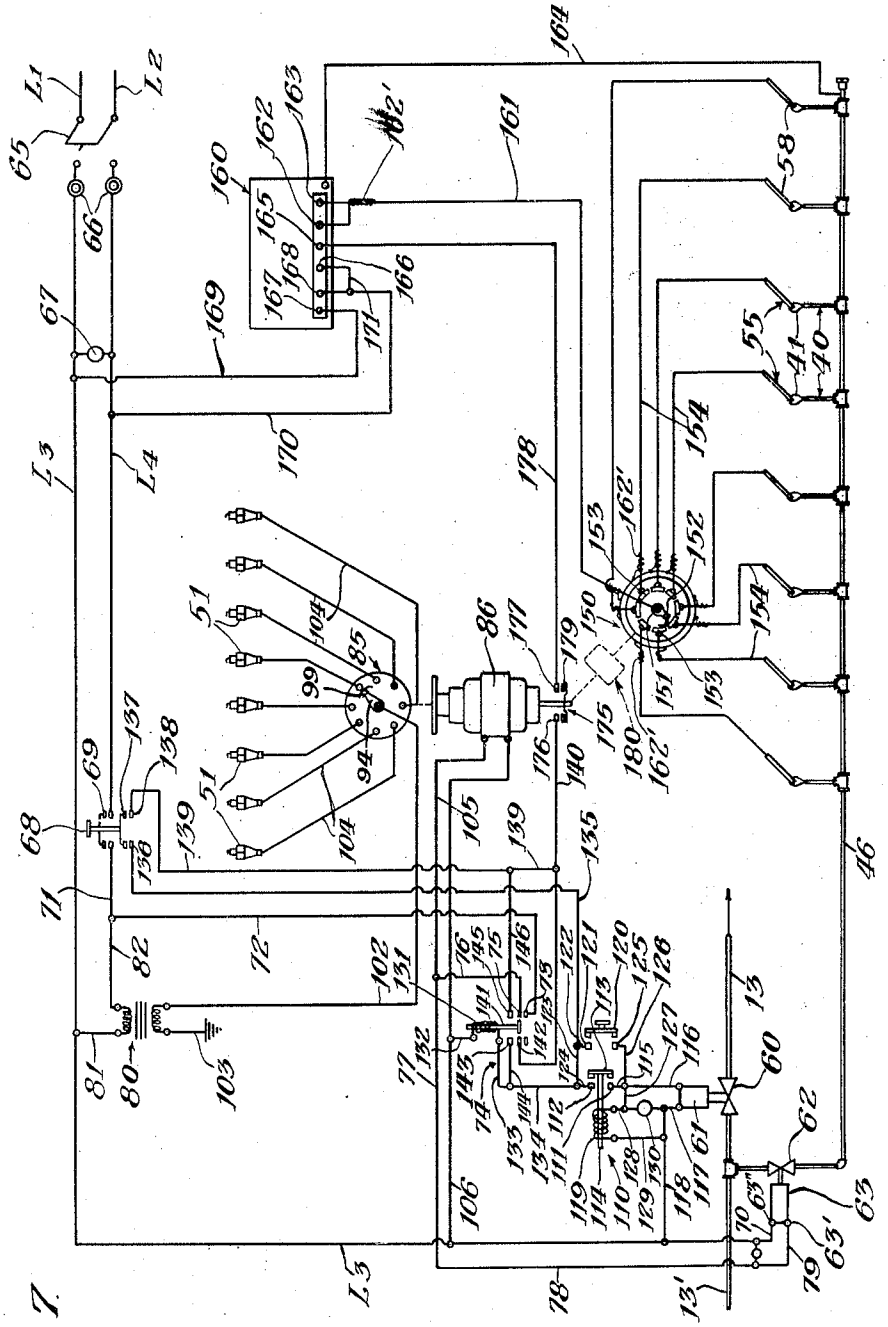


Fig. 7.

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SAFETY CONTROL MECHANISM FOR FUEL BURNERS

Filed Aug. 20, 1938 5 Sheets-Sheet 5

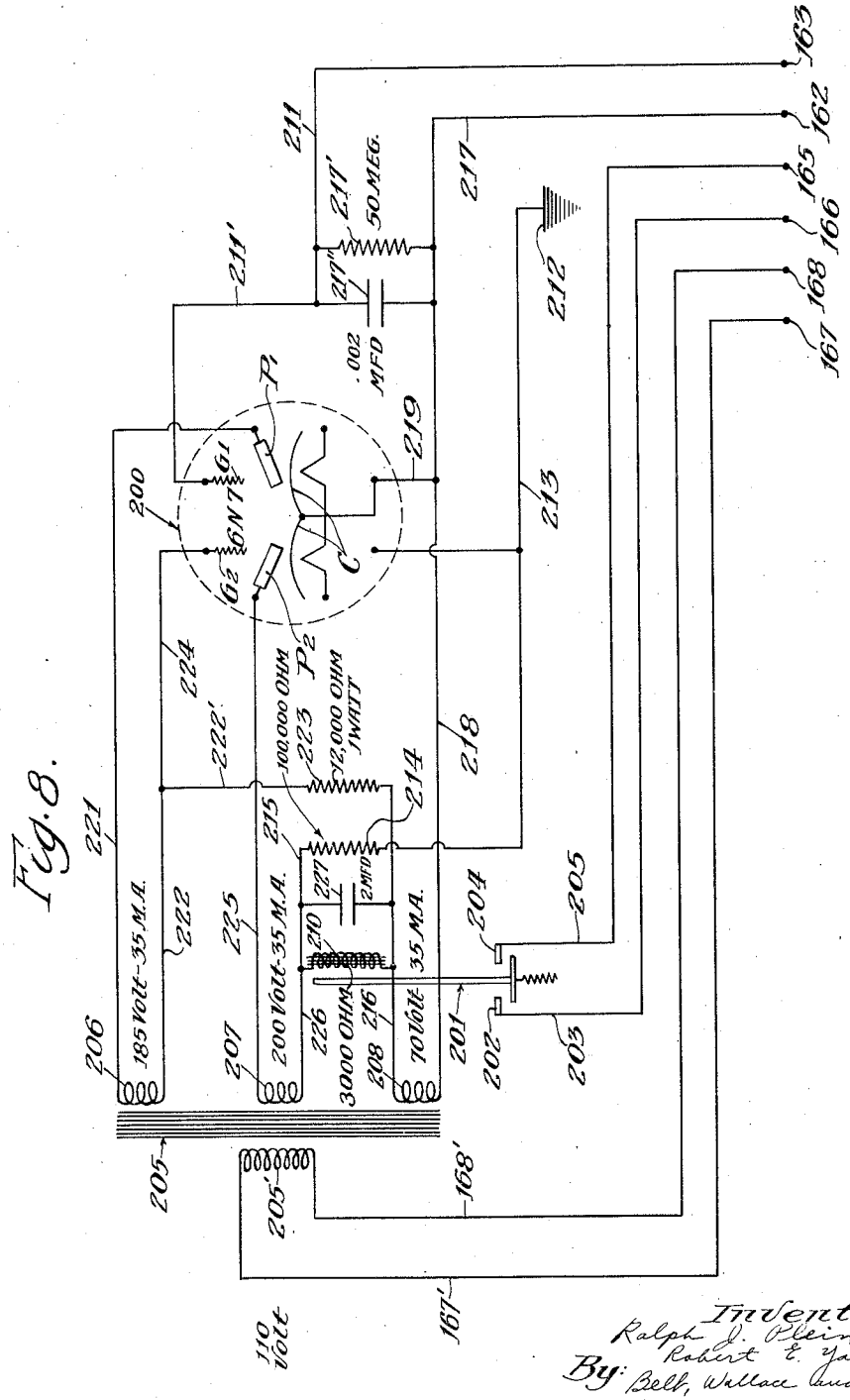


Fig. 8.

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UNITED STATES PATENT OFFICE

2,304,200

SAFETY CONTROL MECHANISM FOR FUEL BURNERS

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Application August 20, 1938, Serial No. 225,996

13 Claims. (Cl. 158—28)

This invention relates generally to fuel burners or heating devices, and more particularly it relates to safety control mechanism for multiple burner installations.

In many industrial drying, baking or heating systems the requisite heat is supplied by a series of individual burner units from which heated air or the heated products of combustion are circulated through the several parts of the system. Such individual burner units must each be equipped with safety control means to insure the desired sequence of operations in starting units and also to cause automatic interruption of the fuel feed upon flame failure in the individual burner unit.

An important object, therefore, of the present invention is to enable a multiple burner installation having a relatively large number of burner units to be controlled by a central control system which is responsive to flame failure in any one of the burner units to shut down the entire multiple burner system.

More specifically, it is an object of the present invention to provide a central safety control system for multiple burner installations which avoids duplication of the more expensive elements of the control apparatus.

A further object is to provide such a multiple burner control system wherein each burner unit of the system acts periodically to govern the fuel supply to the burners.

Another object is to provide a multiple burner system wherein a control impulse the continuity of which governs the operation of all of the burners is made up of a related series of short control impulses originating successively in the different burners of the system only during normal or safe operation of such individual burners.

Other objects and advantages will become apparent from the following description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a fragmental vertical sectional view taken through a fuel burner adapted to be controlled in accordance with the present invention, the view being taken along the line 1—1 of Fig. 6;

Fig. 2 is an enlarged sectional view of the progressive detector switch utilized in our new control system, the view being taken along the line 2—2 of Fig. 5;

Fig. 3 is a view showing the progressive detector switch and the ignition distributor of the present invention, the ignition distributor being shown in central section;

Fig. 4 is a sectional view of the ignition distributor taken along the line 4—4 of Fig. 3;

Fig. 5 is a sectional view of the progressive detector switch taken along the line 5—5 of Fig. 3;

Fig. 6 is a front elevational view showing a battery of eight heaters adapted to be controlled in accordance with the present invention;

Fig. 7 is a diagrammatic view illustrating the control of the multiple heater system of Fig. 6 in accordance with the present invention; and

Fig. 8 is a wiring diagram illustrating a part of the control system of Fig. 7.

In the form chosen for disclosure herein the invention is embodied in a multiple unit burner system 10, which, as illustrated in Fig. 6, comprises a battery of eight similarly formed heater units 11, arranged side by side, and having individual fuel burners 12 constructed as shown in Fig. 1. The burners 12 are supplied from a common fuel source such as a main gas supply line 13 and all the burners are controlled by a common control system such as that illustrated diagrammatically in Fig. 7.

The heater units 11 and their fuel burners 12 may be of any preferred type, such as the gas-fired type illustrated in detail in Fig. 1. In this form each heater 11 has its combustion chamber 15 merging at the rear end of the unit with a return flue or mixing chamber 16, the fuel burners 12 being positioned to discharge the fuel into the forward end of the combustion chamber 15. Each burner 12, as herein shown, is associated with a venturi 17 formed from refractory material within a supporting sleeve 18, and by means of bolts 19 between the sleeve 18 and the wall of the combustion chamber 15, the venturi is secured in an operative relation on the forward end of the combustion chamber.

On the outer end of the Venturi sleeve 18 the various parts of the burner assembly are mounted by means of a hollow mounting casting 20 this casting being in the general form of a truncated cone and having a flange 21 at its larger end through which bolts 22 pass to secure the casting 20 to a flange 23 at the outer end of the Venturi sleeve 18. At its other or outer end the casting 20 has a central sleeve 24 through which a main fuel discharge nozzle 25 projects so as to discharge fuel longitudinally toward the adjacent end of the venturi 17. The sleeve 24 is carried by a spider 26 so as to provide for the entrance of an annular stream of air about the nozzle 25, such air supply being controlled by an adjustable baffle plate 27. Additional air may enter the venturi through an annular slot 28

formed between the flanges 21 and 23 by placing spacer collars 29 on the bolts 22 between said flanges. Gas is supplied to the nozzle 25 by a pipe 30 leading from the common gas line 13, a valve 31 preferably being included in the pipe 30. At its lower end the pipe 30 has an angle 32 which through a pipe 33 discharges the gas into a mixer 34. The mixer 34 has an upper air inlet governed by an adjustable valve plate 35, and the mixture of gas and air is discharged downwardly through the tapered connector 36 and an elbow 37 to the nozzle 25.

In the preferred form shown herein, each burner unit 12 is equipped with means for igniting the fuel flowing from the main fuel nozzles 25, this means being shown herein as comprising an electrically ignited pilot burner 40 which projects it flame, as indicated at 41, laterally into the flame zone 42 of the main fuel nozzle. As herein shown the pilot burner 40 is mounted in an angularly related sleeve 43 formed on the mounting casting 20, the burner 41 comprising a burner tube 44 having a flange 45 intermediate its ends whereby the tube 44 is secured to the flanged outer end of the mounting sleeve 43.

In the present burner installation, fuel gas is supplied to each pilot 40 from a common pilot fuel supply line 46 through individual branch pipes 47, each of which includes a manual valve 48 as shown in Fig. 6.

The pipe 47 is connected to a nozzle 49 which discharges longitudinally into the reduced outer end of the burner sleeve 42'. On the sleeve 42' an internally threaded hub 50 is formed outwardly of the flange 45 to receive a spark plug 51 by means of which the gaseous fuel within the burner sleeve 42' may be ignited. The resulting combustion of the fuel is supported by air which enters through a plurality of small ports 52 formed in the sleeve 42'.

In association with each of the burners 12 of the present illustrative installation, safety means is provided whereby proper operation of the burners is detected and the operation of the burners is automatically suspended upon failure of combustion. Of the many different types of detecting means which may be employed for this purpose, we have shown herein a flame detecting device 55. This particular safety detecting device 55 comprises a hollow mounting member 56 secured by means of a threaded nipple 56' on an angular sleeve 57 on the mounting casting 21 so that an insulated electrode 58 carried by the member 56 projects through the sleeve 57 and into the common zone of the main flame 42 and the pilot flame 41. Preferably the electrode 58 is replaceably mounted in an insulating structure 59 clamped permanently within the mounting member 56. With this construction either flame may serve as an electrical conductor to complete a circuit to ground through the insulated electrode 58, and this circuit may therefore be utilized as a means to detect the presence or absence of the desired flame in the combustion chamber 15.

In carrying out the objectives of the present invention, the main burner fuel line 13 and the pilot fuel line 46 are both fed from a common source 13' (Fig. 7), and each is provided with normally closed valve means whereby to shut off the fuel flow to all of the pilot burners or main burners under the governing action of our novel control system. As indicated in Fig. 7, the main fuel line 13 has a normally closed valve 60 therein adapted to be opened only during energization of its actuating solenoid 61, while the pilot line has a similar valve 62 similarly operated by a solenoid 63.

When a battery of two or more heaters 12 is to be employed, it has heretofore been necessary to duplicate, for each heater, the various ignition and control elements ordinarily used with such individual heaters, while in accordance with the present invention such duplication is avoided except as to the detecting means of the control system and the spark plugs or equivalent means of the ignition system.

Furthermore, the present system is such that opening of the main fuel valve 60 is dependent upon the existence of a pilot flame in each burner 12 of the system, and hence it is impossible for an operator to flood any of the heaters with the large quantities of unignited fuel which would otherwise be supplied to a combustion chamber having a faulty pilot.

To this end the present invention provides for operative interconnection of the various manually operable control elements whereby any particular operation in the burner-starting sequence is rendered dependent upon the actuation of the manual control elements in the proper sequence and is also rendered dependent upon proper functioning of several elements of the apparatus. Thus the electrical power for the various elements herein shown, in Fig. 7, is taken from leads L_1 and L_2 which are connected in series through the such other operative elements, such as relays and control switches, as are to be used in association with the heating system, so that power reaches a main switch 65 only when the preceding electrical elements are properly energized.

Under such conditions, closure of the main switch 65 energizes wires L_3 and L_4, which may include fuses 66; and between the wires L_3 and L_4 an indicator light 67 is preferably connected to indicate visually the presence of power in these leads.

When the indicator light 67 shows the presence of power in leads L_3 and L_4, a manual control element such as push button 68 is depressed to start the pilot burners 40 of the several burners 12. This starting operation includes the opening of the pilot fuel valve 62, which opening is attained through energization of the solenoid 63 thereof. Hence, the actuation of the push button 68 operates to close a normally open switch 69 to connect the lead L_4 to a circuit to one terminal 63' of the solenoid 63, the other terminal 63'' of the solenoid 63 being connected by a wire 70 to the lead L_3. As herein shown, this circuit from the switch 69 comprises wires 71 and 72 to a stationary contact 73 of a magnetic contactor 74, the contact 73 being normally engaged by a movable contact 75 of said contactor. From the contact 75 wires 76, 77, 78 and 79 are connected in series to said terminal 63' of the solenoid 63. Thus when the switch 69 is closed, the pilot valve solenoid 63 is energized and the pilot gas valve 62 is opened so as to start the gas flow to all of the pilot burners 40.

Closure of the switch 69 also serves to energize an ignition transformer 80, since one end of the primary winding of the transformer 80 is connected by a wire 81 to lead L_3, while the other end of the primary is connected to the wire 71 by a wire 82. In the system herein shown a single transformer 80 of relatively small size is utilized to energize the spark plugs 51 of all of the burners 12, this end being accomplished by applying the output potential of the single transformer 80, successively, to the several spark plugs in the general manner and by means of apparatus substantially

like that shown and claimed in co-pending application Serial No. 223,658, filed August 8, 1938, now Patent No. 2,212,352, patented August 20, 1940. This apparatus is shown in detail in Figs. 3 and 4 of the drawings, and takes the form of a distributor device 85 mounted on and driven by an electric motor 86. Preferably the distributor device 85 has a mounting plate 87 having an axial sleeve shaft 88 rotatably mounted therein. The sleeve 88 is connected at 90 to the motor shaft 86'. About the lower end of the shaft 89 a housing 91 surrounds the connection 90, the housing 91 being secured to the motor housing by screws 92 and the mounting plate being secured to the housing by screws 93. On the other or upper end of the shaft 88 a radial distributor arm 94 of insulating material is mounted and keyed for rotation with the shaft, the arm 94 having a sleeve portion acting as an external support about the projecting end of the sleeve 88.

A distributor cap 95 which houses the arm 94 is fixed to the mounting plate 87 by screws 96, and in the cap 95 a plurality of insulated contacts 98 are mounted at circumferentially spaced points so as to be successively engaged by a wiper contact 99 mounted on the end of the distributor arm 94. On the upper face of the arm 94 is a spring contact 100 which is located on the axis of the shaft 89 so as to engage a stationary contact 101 on the inner face of the cap 95, and by means of a wire 102 this contact 101 is connected to one side of the secondary coil of the transformer 80. The other end of the transformer secondary is grounded at 103.

Thus when each contact 98 of the distributor 85 is connected to one of the spark plugs 51, as indicated by wires 104 in Fig. 7, rotation of the distributor arm 94 by its motor 86 acts to energize the spark plugs 51 in rapid succession, and each plug is energized once for each revolution of the shaft 89. With the distributor arm 94 rotating at motor speed, a rapid succession of igniting sparks is created at each plug without placing excessive load on the transformer.

As hereinbefore described, the depression of the push button 68 opens the pilot gas valve 62 and energizes the ignition transformer 80; and, in addition, the motor 86 is started so as to cause the spark plugs 51 to be energized in rapid succession and thereby light the pilot burners 40. As shown in Fig. 7, the motor-starting circuit comprises a wire 105 leading from the wire 76 to one of the terminals of the motor 86, and a wire 106 from the other motor terminal to the lead L_3.

When all the pilot burners 40 have been lighted so as to product pilot flames 41, the presence of these flames is detected by the detecting devices 55 so as to condition the apparatus for starting the main flames 42. In attaining this end the magnetic relay or contactor 74 serves as a primary safety device which, until actuated, prevents actuation of the main fuel valve 60, and the contactor 74 is placed under the joint control of all of the detecting devices 55, and also under the control of the motor 86 with the result that unless the motor and all of the pilot burners are operating properly, the main fuel supply to the main burners 25 cannot be turned on. Thus the primary safety control contactor 74 serves as conditioning means for a secondary magnetic contactor 110 which serves as the control means governing the opening and closing of the main gas valve 60. Such actuation of the contactor 74 opens the circuit 73—75 so that there can be no feed of current to the primary of the transformer 80 after the push button 68 has been released, with the result that the ignition means does not operate after such release of the push button. The contactor 110 has normal open stationary switch contacts 111 and 112 adapted to be closed by a bridge contact 113 carried by the armature 114.

The contact 111 is connected by wires 115 and 116 to one terminal of the main valve solenoid 61, while wires 117 and 118, in series, connect the other terminal to the line L_3, so that when the contacts 111 and 112 are bridged and the contact 112 is connected to line L_4, the main fuel valve will be opened. Thus the initial opening of the main fuel valve, as well as the maintenance of this valve in its open position is rendered dependent upon energization of the contact 112 from the line L_4. When the contact 112 is thus energized, as will presently be explained, the coil 119 of the contactor 110 may be energized by momentary closure of a normally open push button switch 120. The switch 120, which forms a shunt circuit around the switch 111—112, has one contact 121 connected by wires 122, 123 and 124 to the contact 112, while its other contact 125 is connected at the junction of wires 115 and 116. From this junction wires 127 and 128 carry the circuit to one end of the coil 119, the other end being connected by a wire 129 to the wire 118. Hence by closure of the push button switch 120 the contactor 110 is energized to close the contacts 111—112 and this closure of contacts 111—112 establishes a holding circuit which maintains the circuit to the main valve solenoid 61 so long as the contact 112 remains energized. The closure of the contacts 111—112 is preferably indicated visually by an indicator light 130 connected across the wires 117—127.

The required energization of the contact 112 is, during normal operation of the system, controlled by the contactor 74, while the contactor 74 is, during such normal burner operation, controlled jointly by all of the detectors 55 and the operation of the motor 86. The initial closure or energization of the contactor 74 must, however, take place under the control and during the depression of the control button 68. To this end, the contactor coil 131 has one of its ends connected by a wire 132 to the wire 106 which connects with lead L_3, while its other end is connected by wires 133, 134, 123 and 135 to a stationary contact 136. A bridge contact or switch member 137 associated with the push button 68 acts to complete a circuit between the contact 136 and a second stationary contact 138 which is connected by a wire 139 to a wire 140. As will be hereinafter explained, this wire 140 is energized from the line L_4 during proper operation of the motor 86 and all of the pilot burners 40, so that under such proper operating conditions, the continued closure of switch 137 energizes the coil 131 of contactor 74 and moves its armature 141 upwardly, as viewed in Fig. 7.

When the contactor 74 is thus energized, a holding circuit from the wire 140 to lead L_3 is established. This is accomplished through a contact 142, carried by the armature 141 in insulated relation to the contact 75, and connected to one end of the wire 140. The contact 142, when the armature 141 is actuated, engages a stationary contact 143 which is connected by a wire 144 to the juncture of wires 133 and 134, thus establishing the desired holding circuit through the wire 133 through the coil 131 and wires 132 and 106 to line L_3.

Closure or energization of the contactor 74 also establishes a running circuit to the motor 86 and

pilot solenoid 63 by engagement of the contact 75 with a contact 145, this contact being connected by a wire 146 to the wire 139. Preferably the arrangement is such that the contact 75 engages the contact 145 substantially simultaneously with or prior to being disengaged from the contact 73, thus insuring that there is no undue interruption in the supply of fuel to the pilot burners or current to the motor 86. This is common practice in the art and may be accomplished, for example, by the use of make-before-break contacts or other equivalent expedients.

As hereinbefore described, each electrode 58 of the detecting devices 55 cooperates with a main flame 42 or a pilot flame 41 to form an electrical control circuit, and in accordance with the present invention the several detecting devices 55 are arranged to cooperate with a central or common control means, such as that which has been described, so that all of the burners 12 cooperate in the exercise of a governing influence on the central control means. To this end, the invention provides means whereby each electrode or detector circuit operates periodically as the ultimate governing control of the burner system, and the several electrode circuits operate in succession to produce a continuous governing action upon the central control means. In the preferred form this cooperative governing action of the detecting means of the several burners is attained through the use of a progressive or cyclic detector switch 150 which places each detector 55 periodically in sole governing control of the central control means. Hence, if any detector circuit during its period of sole governing control indicates the absence of a flame in the associated burner 12, the central control means acts to shut down all of the burners of the system.

Thus as shown diagrammatically in Fig. 7, the progressive detector switch 150 has a rotatable shaft 151 carrying a wiper arm 152 which establishes contact successively with a plurality of insulated contacts 153. Each contact 153 is connected by a wire 154 to the electrode 58 of one of the detector devices 55 so that when the wiper arm 152 is in engagement with a particular contact 153, a flame from the associated pilot burner 40 (or main burner 25) will establish an electrical circuit from the wiper arm to the connected gas supply lines 13 and 46, these gas lines 13 and 46 being grounded in the control circuit.

The circuit thus established is utilized, in the present instance, to govern the energization of the lead wire 140 and thus control the contactors 74 and 110, and such governing action is attained through a self-restoring relay mechanism indicated at 160. This relay mechanism 160 is preferably constructed as shown in Fig. 8, and in order to attain sensitivity of control this relay mechanism employs a grid-controlled thermionic amplifier tube 200 which operates to control the supply of energizing current to a magnetic relay 201.

With this particular relay, a wire 161 from the wiper arm 152 is connected to terminal 163, while a ground wire 164 from the relay cabinet is connected to the gas supply pipe 46, and these connections act in conjunction with the wiper arm 152 and any one of the detectors 55 with which it is connected to supply control or grid potential to a grid-controlled thermionic amplifier tube 200.

As shown in Fig. 7, terminals 167 and 168 of the relay cabinet are connected by wires 169 and 170 to the leads L_3 and L_4, and the wire 170 has a branch lead 171 to the terminal 166. Thus the terminal 166 is connected to lead L_4 and the contactors 74 and 110 may be energized when a circuit is completed from the wire 140 to the terminal 166.

To this end the relay switch 201 has its one stationary contact 202 connected by a wire 203 to the terminal 166, while its other contact 204 is connected by a wire 205 to a terminal 165, and means is provided forming a circuit connection from the terminal 165 to the wire 140. Preferably this circuit connection includes a normally open centrifugal switch 175 operated by the motor 86. The switch 175 has one contact 176 to which the wire 140 is connected, and a second contact 177 connected by a wire 178 to the terminal 165, and a centrifugally actuated bridging element 179 which operates to connect the contacts 176 and 177 when the motor 86 attains its running speed.

As herein shown, the progressive detector switch 150 is driven from the motor 86, and it is for this reason that the running circuit for the motor is provided through contactor 74. Hence, during closure of the contactor 74 the detector switch 150 is constantly rotated to place the several detector circuits successively in sole controlling relation to the relay 160. Since the absence of a flame in any particular one of the burners 12 acts to break the detector circuit of that burner, the detector switch in its periodic association with this particular burner will fail, during such association, to transmit energizing potential of the required polarity to the grid terminal 163 of the relay 160. When this takes place the circuit is such that no plate current will be fed to the associated relay 201 so that this relay will open and break the circuit between terminals 165 and 166. Thus the holding circuit 178—175—140—142—143—144—133 through the coil 131 of the contactor 74 is broken so that the contactor 74 is released and moves to its open position. This breaks the circuit to contact 112, and hence the holding circuit to the contactor 110 is broken. Hence, the solenoid 61 of the main gas valve 60 is deenergized so as to shut off the flow of the main fuel through the line 13.

This desired functioning of the apparatus is attained through the circuit shown in Fig. 8, which will for present purposes be considered as having its electrode terminal 163 connected through the progressive detector switch 150 to one of electrodes 58. The control tube 200 is herein shown in such a circuit that grounding or improper connection of the electrode 58, or of other sensitive elements of the circuit, will act to cause the relay switch 201 to open, and thereby insure proper shut down of the burner system not only upon flame failure but also upon failure of the safety detector system.

The illustrated tube-circuit of Fig. 8 embodies a transformer 205, the primary 205' of which is connected by wires 167' and 168' across power supply terminals 167 and 168, while three similarly positioned secondary windings 206, 207 and 208 of substantially the output indicated are provided from which the tube 200 is powered. The tube 200 is of the type having two triodes within a single envelope (such as the commercial type 6N7), one triode being used as a primary control or amplifier governing the output of the other triode which energizes the actuating coil 210 of the relay 201. Both triodes of this tube are of the zero bias type wherein current flows in the

plate circuit while there is a zero bias on the grid or a positive bias on the grid, and plate current is cut off only when the grid has a negative bias. Since the tube is herein powered by alternating current, we will describe the operation during the operative cycle of the triodes, that is, during that portion of the current alternation when the plate is positive and the cathode negative.

Broadly considered, the safety circuit of Fig. 8 is such that its elements are normally biased so as to prevent flow of alternating current to the relay **201**, and actuating current for the relay is supplied only when an abnormal biasing of the tube elements is caused by the presence of a flame. Thus the electrode terminal **163** is connected by wires **211** and **211'** to the first grid G_1 so that a circuit formed to the electrode **58** by a flame may serve to complete an energizing circuit to the grid G_1. To this end a circuit from ground, as at **212**, is provided through a wire **213**, a resistor **214** of the order indicated in Fig. 8, a wire **215** to one end of the coil **210**, and a wire **216** to the upper end of the secondary **208**, the lower end of which is connected by wires **218** and **219** to the common cathode C of the tube. This cathode C has a conventional heater circuit not herein shown. The plate P_1 of the first triode is connected by wire **221** to the upper end of the secondary **206**, the lower end being connected by wires **222** and **222'** and a resistor **223** of the order indicated to the wire **216**, thus providing the plate-cathode circuit for the first triode of the tube.

Bearing in mind the similar positioning and winding of the several transformer secondaries, and the fact that for present purposes the description is limited to that portion of the alternating cycle when a positive potential is applied to the plate and a negative potential is applied to the cathode, it will be evident that the bias as between plate P_1 and C will be such as to normally cause current flow in the plate circuit of the first triode. In this connection it will be noted that the shielding terminal **162** is connected to a wire **217** to the cathode circuit at the juncture of wires **218** and **219**, and that the wires **217** and **211** are connected by a resistance **217'** and a parallel capacitance **217''**, these being of the order indicated in Fig. 8. Thus the grid G_1 normally has no power or biasing connection so that current normally flows as above described in the plate circuit of plate P_1. This plate current of the circuit from plate P_1 does not, however, actuate the coil relay **201**, the circuit being around the coil **210** as follows: plate P_1, wire **221**, secondary **206**, wires **222** and **222'**, resistance **223**, wire **216**, secondary **208** and wires **218** and **219** to the common cathode C. In this circuit the secondary **206** supplies a voltage of approximately 185 volts, while secondary **208** supplies a voltage of approximately 70 volts.

The plate current thus flowing in the plate circuit of plate P_1 provides a negative biasing potential for the second triode of the tube **200**, this potential being applied to grid G_2 by a wire **224** tapped into the first plate circuit at the juncture of wires **222** and **222'**.

When this negative bias on the grid G_2 is removed, the circuit from plate P_2 is such as to pass plate current to the relay coil **210** to actuate the relay, this circuit from plate P_2 being provided by a wire **225** to the upper end of the 200 volt secondary **207**, and a wire **226** from the lower end of secondary **207** to the upper end of the relay coil **210**. The lower end of coil **210** has a circuit to the common cathode C through wire **216**, secondary **208** and wires **218** and **219**.

When the negative bias provided on the grid G_2 is removed as will hereinafter be described, the plate P_2 will, during half cycles of the alternating current, be positive, while the cathode C is negative, and hence plate current will flow in the second plate circuit through the relay coil **210**. The relay **201** will therefore be closed. In this action a condenser **227**, of the order indicated, connected across the coil **210** between wires **215** and **216**, acts to smooth out the half cycle rectified current supplied to the coil **210**.

With the circuit thus provided the presence of a flame between the grounded fuel nozzle and the associated electrode **58** serves to apply a negative potential to the grid G_1 so as to stop the flow of plate current in the circuit from plate P_1. Such negative bias of the grid G_1 is caused by the high resistance of the flame in the G_1-cathode circuit, which in combination with the capacitance in the circuit causes the phase relationship in the circuit to grid G_1 to approach a phase opposition relationship. As a result the negative cycle of the alternating current is applied to the grid G_1 at the time the plate P_1 is positive, with the result that no current flows in the circuit of plate P_1.

When a sensitive relay of this character is employed the various wires such as wires **154** and **161** are shielded as indicated fragmentally at **162'** and the shields are connected to terminal **162**. This terminal **162** is connected internally of the relay housing **160** to the cathode element of the amplifier tube by means of a wire **230**. A grounded shielding is also used on all high tension leads which are in close proximity to the detector circuits, such as the wires **104** and **102**, and the lead **102** also has a conventional suppressor associated therewith to prevent undesired feedback currents.

Failure of the flame serves, of course, to remove the negative bias on grid G_1 so that plate current flow is reestablished in the circuit of plate P_1. Such plate current flow instantly applies a negative bias to grid G_2 so as to stop the flow of the energizing current in the circuit of plate P_2 through the relay coil **210**.

With this circuit the various short circuits or grounds which would tend to render the system unsafe act to stop the flow of plate current to the relay coil **210** so as to shut down the burner system. Thus a grounding of the electrode **58**, or any part of the circuit between this electrode and the grid G_1 serves to short out the flame resistance. Since this resistance is vital in producing the phase shifting required to negatively bias the grid G_1, the tube will be so biased as to prevent flow of energizing current to the relay coil **210**.

Similarly, a short between the shielding and the grid G_1, or between the grid G_1 and the cathode, or any part of the circuits associated therewith, serves to short out the capacitance **217''** and thereby disrupt the phase shifting in the circuit to G_1. A similar action results from the grounding of the circuit of grid G_1.

With the release of the main safety contactor **74**, the running circuit to the motor **86** is broken, and the holding circuit through contacts **75—145** to the pilot gas solenoid **63** is broken. Hence, no fuel can flow to either the pilot burners or the main burners of any of the heaters, and the burner system cannot be placed in operation

again until the sequence of manual starting operations is properly performed by the operator.

To insure complete release of the several relays when there is a flame failure in any one of the burners 12, the progressive detector switch 150 is so constructed, and is rotated at such a speed, that each detector circuit remains in sole governing control for a time interval sufficient to permit the requisite releasing movement of the relays in the event that the absence of a flame is detected by the sensing element 55. To this end, the detector switch 150 is driven at a reduced speed from the motor 86 by a conventional speed reduction gearing 180 which has an output shaft 181 as shown in Fig. 5. A housing 182 is mounted in fixed position surrounding the projecting end of the shaft 181, and on the open end of the housing a base plate 183 is secured by screws 184. The drive shaft 151 of the switch 150 is shown in Fig. 5 as being of a hollow form surrounding the shaft 181 and fixed thereto by a set screw 185. On the end of the shaft 151 which projects through an axial opening 186 in the plate 183 the wiper arm 152 is mounted by means of a sleeve 187 and key 188, the arm being formed from an insulating material. At the end thereof the arm 152 has a resilient metallic wiper contact 190 which in the rotation of the arm 152 successively engages the contacts 153. An insulating cover 191 is mounted on the plate 183 by screws 192, and by means of metallic studs 193 projecting inwardly of the cover from individual connecter sockets 194, the arcuately faced metallic contacts 153 are supported for such engagement by the wiper contact 152. The wires 154 are inserted into the connector sockets 194, which are constructed as shown in Fig. 3. A similar connector socket 195 receives the wire 161 to form an electrical path to a central internal contact 196 within the cover 191, and a spring contact 197 connected to the wiper contact 190 engages the contact 196 to complete the circuit to the wiper contact 190.

While the speed of rotation of the detector switch 150 may be varied considerably, it has been found that with the number and type of burners herein shown, and with the contacts of the switch 150 constructed and related as herein shown, the present safety control system will operate to prevent unsafe conditions in all of the burners when the switch 150 is operated at what might be termed a relatively slow speed. Thus the speed reducer 180 is so constructed and related to the motor 86 as to rotate the switch 150 at a speed of approximately ten revolutions per minute (10 R. P. M.). This speed may be varied in accordance with the nature of the burners or the particular installation so that each individual burner is checked by the switch 150 at sufficiently frequent intervals to prevent accumulation of dangerous quantities of unburned fuel in the combustion chambers thereof.

In order that the relays and other operating parts of the present system may be controlled by operating or control currents, applied in accordance with standard practice, thereby to permit the use of relays and other parts of a standard commercial construction, the progressive detector switch 150 is preferably so constructed that during normal operation thereof potential is continuously applied to the grid terminal 163. This end is attained by so constructing and relating the stationary contacts 153 and the wiper contact 190 that between the periods of sole governing control of the successive detector circuits, the two adjacent contacts 153 are simultaneously engaged by the wiper contact 190. The particular construction employed in this connection is best illustrated in Fig. 2 wherein the contacts 153 are shown as being of relatively great arcuate length so as to leave but a slight space between adjacent contacts. With this construction the wiper contact 190 is provided with a contact portion 190' of sufficient length to bridge the slight space between adjacent contacts 153. Hence the wiper contact 190 as it approaches the end of one contact 153 makes circuit with the next contact 153, with the result that the control grid G_1 of the relay mechanism 160 is continually biased in such a manner as to enable the fuel supply to be maintained during the existence of proper combustion conditions in all of the burners 12.

It is, of course, obvious that during those periods in which the wiper contact 190, Figs. 2 and 7, bridges two adjoining segments 153, the effective flame resistance in the flame detecting grid circuit of the tube 200, Fig. 8, may decrease due to the fact that two flame paths are electrically connected in parallel. The apparatus is so designed, however, that such reduction in the effective flame resistance does not affect the bias on the grid G_1 sufficiently to cause any appreciable flow of current through the tube 200 from the cathode C to the plate P_1. Hence, under normal operating conditions, the fuel supply continues uninterruptedly irrespective of the position of the wiper arm 152, Fig. 2, and it is only when there is flame failure or an actual short-circuit, or stoppage of the distributor motor 86, that the system automatically shuts down as above described.

The control circuit herein shown is such that the burner system continues in operation so long as pilot flames exist in all of the combustion chambers, but it will be evident that in some instances the pilot valve 63 might be shut off after the main burners have been started and that the detectors 55 and the progressive detecting switch 150 would continue to act as a safety means to stop the burner system upon failure of the main flame in any one of the burners.

From the foregoing description it will be apparent that the present invention provides a control system for multiple burner installations whereby expensive duplication of control equipment is avoided. Moreover, the present control system is such that completion of the starting operation is dependent upon proper operation of the pilot burners, and hence safety of operation is insured.

While we have illustrated and described a selected embodiment of our invention it is to be understood that this is capable of variation and modification and we therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes and alterations as fall within the purview of the following claims:

We claim:

1. In a multiple heater system having a plurality of pairs of burners each pair of which includes a main burner and a pilot burner, each pair of burners being associated with a combustion chamber, the combination of a common automatic governing means for starting all of said main burners and for stopping the operation of all of said main and pilot burners, and a sensing device associated with each of said combustion chambers and each operable to detect the presence or failure of a flame in the combustion

chamber with which it is associated, individual detector circuits for each of said sensing devices, a progressive detector switch operable to make circuit with said detector circuits in predetermined timed succession, a motor for actuating said detector switch, a normally open safety switch associated with said motor for closure during operation of said detector switch by said motor, and an energizing circuit through which said common governing means may be actuated to start said main burners, said energizing circuit including said safety switch and being jointly controlled by the progressive action of said detector circuits.

2. In a multiple burner control system for use with a burner system having a plurality of pairs of associated main and pilot burners, a plurality of detector elements adapted for operative individual association with the individual pilot burners of such a multiple burner system, a main control mechanism for starting all of the main burners of such a multiple burner system, an energizing circuit for operating said main control mechanism to start said main burners and including a common lead wire, a normally open safety switch in said common lead, and a progressive detector switch, a motor for driving said progressive detector switch, said motor being operable to close said safety switch during operation of the motor, a plurality of stationary contacts forming part of said detector switch and each having a lead wire connected to one of said detector elements, and a movable contact forming part of said detector switch and connected to said common lead, said movable contact being driven by said motor and being operable in its movement to place said common lead wire successively in circuit with said stationary contacts.

3. In a heating system having a plurality of fuel burners, fuel supply means for said burners, sensing devices each associated with a respective burner for sensing the presence or absence of a flame in such burner, automatic means governing said fuel supply means, sequencing means normally operating to place said automatic means sequentially under the control of said sensing devices, said automatic means responding to a flame failure detected by any of said sensing devices to disable said fuel supply means, and safety means controlling said burners and operatively related to said sequencing means for preventing the admission of fuel to said burners whenever said sequencing means is not operating.

4. In a heating system having a plurality of fuel burners, electrically operated fuel supply means for said burners, sensing devices each associated with a respective burner for detecting the presence or absence of a flame in such burner, automatic means governing said fuel supply means, sequencing means normally operating to place said automatic means sequentially under the control of said sensing devices, said automatic means operating in response to a flame failure detected by any of the sensing devices to interrupt the supply of fuel to said burners, and a centrifugal switch controlled by said sequencing means and effective to prevent said fuel supply means from supplying fuel to said burners when said sequencing means ceases operating.

5. In a multiple heater system having a plurality of fuel burners, sensing devices each associated with a respective burner for detecting lack of combustion of the fuel in such burner, a detector switch comprising a rotary wiper cooperating with a series of arcuately arranged contacts, means for driving said wiper rotatively to successively engage said contacts, means affording a plurality of normally effective detector circuits, each of said circuits including a particular one of said contacts and being controlled by a respective sensing device to become ineffective when such device detects lack of combustion in the associated burner, automatic means governed by said detector switch and responding when said wiper is engaged with a contact included in an ineffective detector circuit to prevent operation of said burners, and a centrifugal safety device operated by the driving means for said distributor switch and effective to prevent operation of said burners when said wiper is rotating at less than a predetermined speed.

6. In a multiple heater system having a plurality of pilot burners and associated main burners, valve means regulating the admission of fuel to said pilot burners, other valve means regulating the admission of fuel to said main burners, electrical ignition means for said pilot burners, a first manually operable means controlling said pilot valve means and said ignition means and effective when operated to cause fuel to be admitted to said pilot burners substantially concurrently with the energization of said ignition means, governing means operatively associated with said pilot burners and effective in response to the establishment of flames in all of such burners to control said pilot valve means for maintaining the supply of fuel to said pilot burners independently of said first manually operable means, said ignition means remaining under the control of said first manually operable means, and a second manually operable means controlling said main valve means.

7. An apparatus as set forth in claim 6, in which said governing means is adapted to prevent said second manually operable means from being effective to admit fuel to the main burners until all of the pilot burners are lighted.

8. In a heating system having a plurality of heaters each embodying a main burner and a pilot burner, a normally closed fuel valve for said pilot burners, a solenoid operating when energized to open said pilot valve, electrical ignition means for said pilot burners, manually controlled switch effective when operated to concurrently energize said pilot valve solenoid and said ignition means, a relay, governing means operatively associated with the pilot burners and responding to the presence of flames in all of such burners to operate said relay, means controlled by said relay and said governing means and effective when said relay is operated to maintain said pilot valve solenoid energized independently of said switch, said ignition means remaining under the control of said switch, and manual means controlled by said governing means and operable when all of said pilot burners are lighted to start the main burners.

9. In a multiple heater system having a plurality of fuel burners, means for supplying fuel to said burners, ignition means operable to light said burners, manually controlled means for concurrently initiating operation of said fuel supply means and said ignition means, and means operatively associated with said burners and responding to the presence of flames in all of the burners to maintain said fuel supply means in operation independently of said manual means, said ignition means remaining under the control of said manual means.

10. In a multiple heater system having a plurality of fuel burners, fuel supply means for said burners, control means effective when operated to maintain said fuel supply means in operation, individual spark ignition devices for said burners, distributor means operable to successively energize said ignition devices, driving means for said distributor means, and safety means governed by said driving means for preventing operation of said control means when said driving means is not in operation.

11. An apparatus as set forth in claim 10, in which said safety means comprises a centrifugal device mechanically connected to said driving means.

12. In a multiple fuel burner system, means for supplying fuel to the burners in the system, manually controlled means for initiating operation of said fuel supply means, electrical means effective when energized to maintain said fuel supply means in operation independently of said manually controlled means, governing means effective when in one condition to establish a holding circuit for maintaining said electrical means energized and when in another condition to interrupt such holding circuit, said electrical means being arranged to remain deenergized following interruption of said holding circuit irrespective of the subsequent condition of said governing means, sensing devices each associated with a respective burner for detecting the presence or absence of a flame in such burner, and a rotary switch operating to place said governing means in controlled relation successively to said sensing devices, said governing means responding to the presence of flames in all of said burners to assume the first-named condition and assuming the second-named condition in response to the absence of a flame detected by a controlling sensing device.

13. In a multiple fuel burner system, means for supplying fuel to the burners in the system, manually controlled means for initiating operation of said fuel supply means, electrical means effective when energized to maintain said fuel supply means in operation independently of said manually controlled means, governing means effective when in one condition to establish a holding circuit for maintaining said electrical means energized and when in another condition to interrupt such holding circuit, sensing devices each associated with a respective burner for detecting the presence or absence of a flame in such burner, a rotary switch operating to place said governing means in controlled relation successively to said sensing devices, said governing means responding to the presence of flames in all of said burners to assume the first-named condition and assuming the second-named condition in response to the absence of a flame detected by a controlling sensing device, and a centrifugal safety device operatively connected to the movable part of said rotary switch and effective in the event said switch ceases operating to deenergize said electrical means.

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