CONTROL CIRCUIT FOR GAS BURNER

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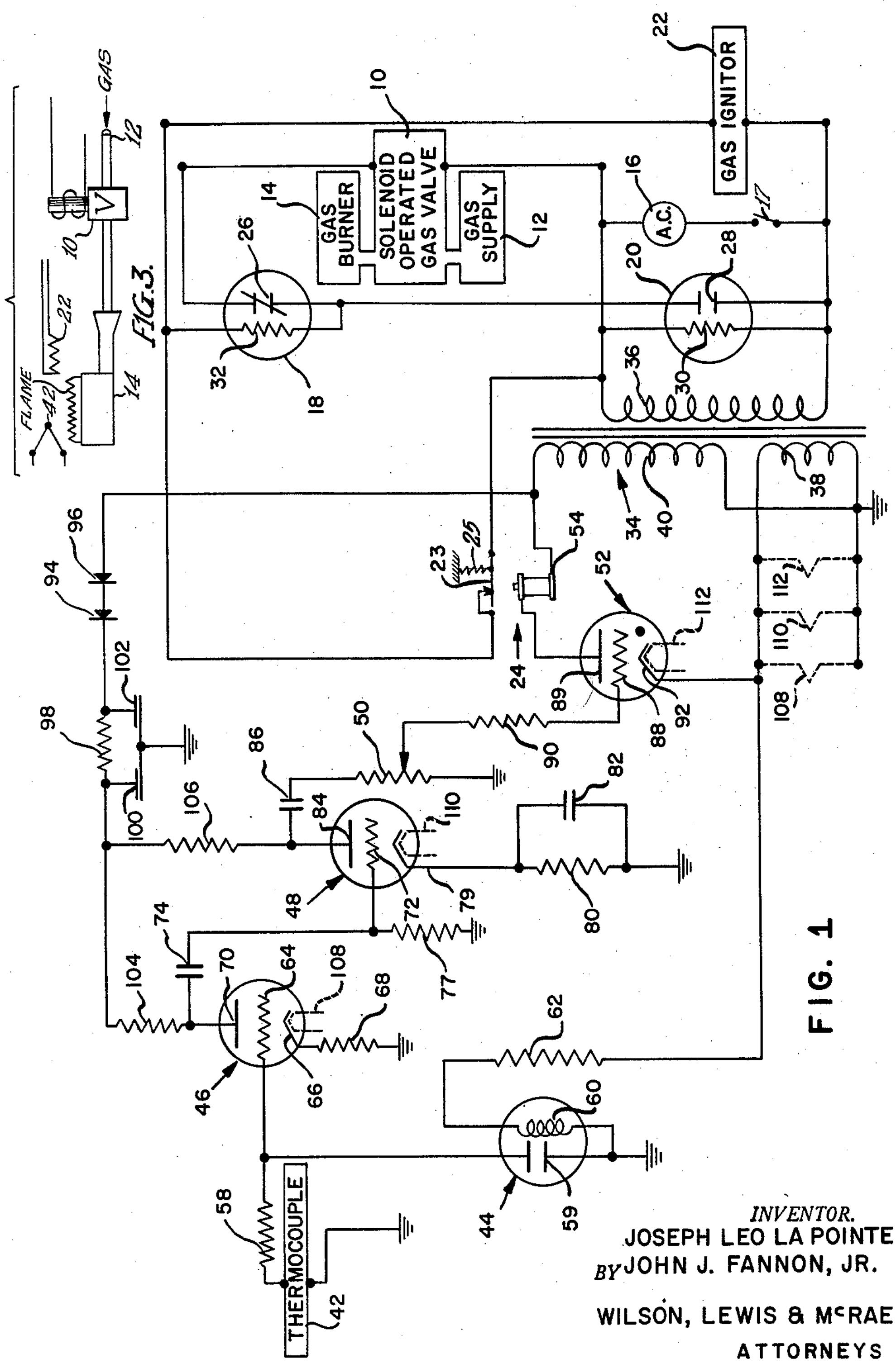

FIG. 3.

FIG. 1

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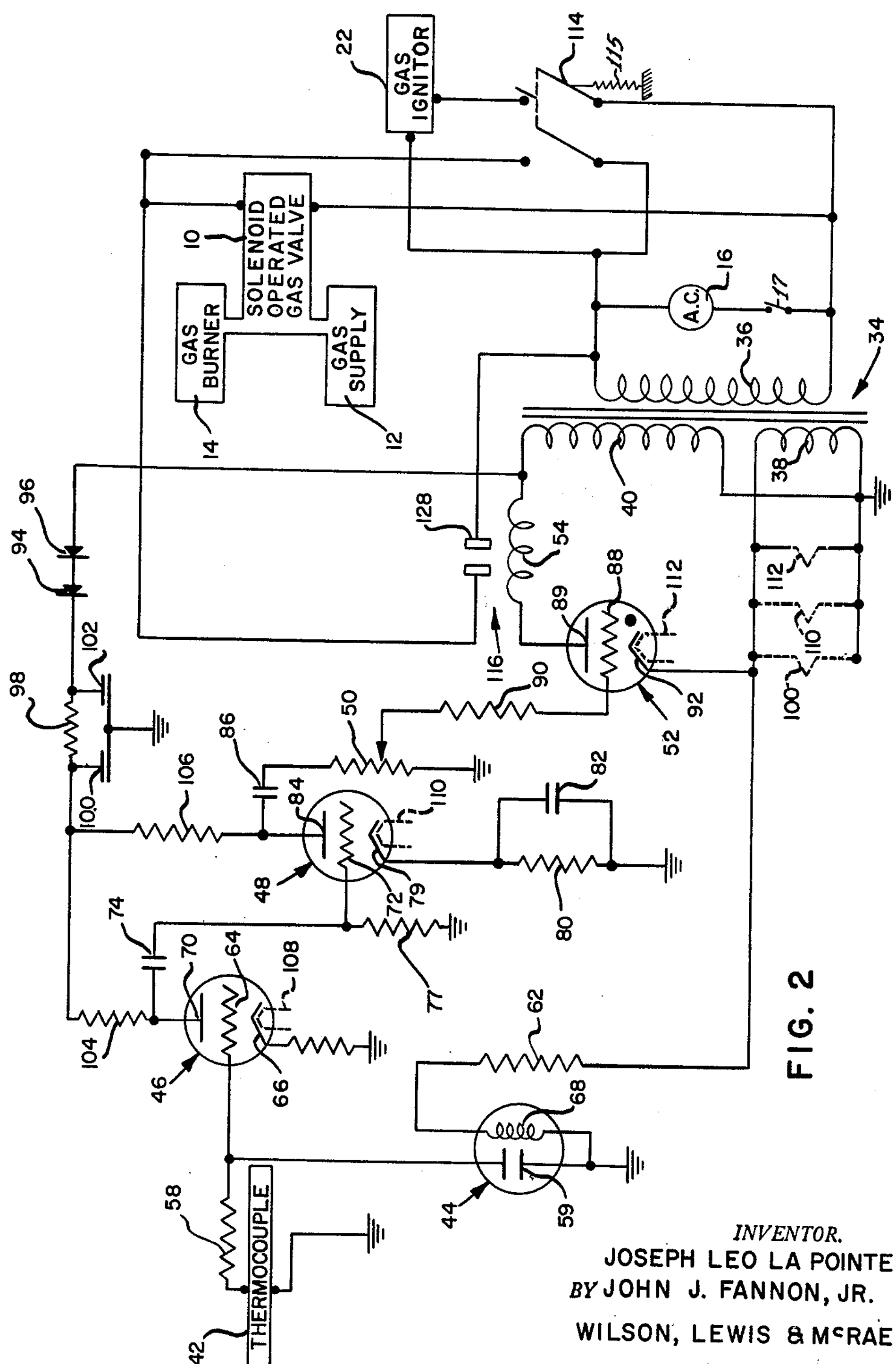

FIG. 2

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CONTROL CIRCUIT FOR GAS BURNER

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This invention relates to a control circuit for a gas burner and more particularly to a control circuit for controlling the fuel supply means to a burner. The control circuit is operative to initiate fuel flow, ignite the fuel and discontinue fuel flow in the event that combustion does not take place.

There has been a steadily increasing use of natural gas in recent years for many industrial equipments and home appliances. There has always been a safety hazard in the use of gas due to its explosive and poisonous nature. Recently developed apparatus has presented increased dangers in that gas is being used in enclosed housings, such as gas clothes dryers, wherein the frame is not readily visible to the user and which are capable of trapping gas in explosive quantities.

There has been, as a result of the recent technical advances in the use of gas, an aggravated need for means to control gas burners to prevent the flow of gas when the burner is not lit. The present invention provides a control circuit which minimizes the danger of the escape of gas in explosive quantities or in quantities sufficient to be poisonous to human beings.

The control circuit of the present invention may be utilized in such appliances as gas dryers, broilers, refrigerators, roasters, grills, ranges and furnaces. It may also be used for a variety of industrial applications such as industrial ovens, furnaces, die heaters, paint and baking ovens, and infrared space-heating units. When used in industrial applications, it may be readily cycled for repetitive production processes.

One object of the present invention is to provide a control circuit for a gas burner.

Another object is the provision of a control circuit having solenoid-operated valve means to control the flow of gas to a burner.

An additional object is to provide a control circuit having gas igniter means to ignite gas flowing from the burner.

Another object is to provide a control circuit having electronic means responsive to the combustion of gas in a burner to turn off the gas igniter.

A further object is the provision of time delay relay means operative to actuate the solenoid-operated valve means.

Another object is the provision, in the electronic means, of means responsive to failure of combustion of gas in a burner to actuate relay means and shut off the solenoid-operated valve to discontinue flow of gas to the burner.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

In the drawings:

FIGURE 1 is a schematic representation of one embodiment of the present invention;

FIG. 2 is a schematic representation of a second embodiment of the present invention, and

FIG. 3 is a schematic representation of some of the elements shown in FIGS. 1 and 2.

Before explaining the present invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in vairous ways. Also, it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

2

Referring specifically to the drawings, it may be seen that both the FIG. 1 and FIG. 2 embodiments consist of two principal circuits. One circuit, which may be termed Circuit I, comprises means to actuate a gas igniter and to open the gas valve. The other circuit, which may be termed Circuit II, comprises electronic means responsive to the combustion of gas in the burner to control Circuit I. Circuit II is common to both the FIG. 1 and FIG. 2 embodiments and will therefore be described in detail with reference to the FIG. 1 embodiment only.

Circuit I of the FIG. 1 embodiment includes a solenoid-operated gas valve 10 to control the flow of gas from the gas supply 12 to a gas burner 14. Valve 10 is a conventional shut-off valve having a valve element to open or close a port to the flow of gas. The valve element is urged to the closed position by a spring. A solenoid is provided to actuate the valve element to the open position. In operation, energization of the solenoid is effective to open the valve element against the action of the spring and de-energization of the solenoid permits the spring to move the valve element to the closed position. One end of the solenoid in the valve 10 is connected directly to one side of the A.C. input voltage 16. Starting switch 17 is provided to control the application of the input voltage to the circuits. The other end of the solenoid is connected to the opposite side of the A.C. input voltage through the contacts of a pair of time delay relays 18, 20. A gas igniter 22, which is provided to light the gas in the burner 14, is connected between one side of the input voltage 16 and the other side of the input voltage through the normally closed contacts 23 of a relay 24, contacts 23 being biased to the closed position by spring 25.

The time delay relays 18, 20 are of a conventional type in which a heater element is provided to increase to a predetermined temperature in a preselected time. Such relays are operative, at the predetermined temperature, to open or close a set of contacts. The contacts 26, 28 of the relays 18, 20 are, as previously mentioned, arranged in series with the solenoid of the valve 10. Contacts 26 of relay 18 are normally closed and contacts 28 of relay 20 are normally open. Relay 20 permits the circuit to warm up before it is operative to open the gas valve 10. The heater element 30 of the relay 20 is connected directly across the input voltage. Heater element 30 will begin to rise to operating temperature whenever input voltage is applied to the control device. When it reaches its operative temperature, it will close contacts 28 and initiate operation of the burner 14. As will be explained more fully hereinafter, relay 18 is provided with normally closed contacts to be opened to actuate the solenoid valve 10 to the closed position only in the event of failure of the burner to ignite and continue combustion. Therefore, the heater 32 will not normally be connected across input voltage. The heater element 32 of the relay 18 is connected to input voltage on one side through the contacts 23 of relay 24 and on the other side through the contacts of the warm-up relay 20. The heater 32 power supply circuit is normally opened either by the warm-up relay 20 or the relay 24.

The A.C. input voltage 16 of Circuit I is coupled to Circuit II by means of a transformer 34. The transformer 34 is provided with a single primary winding 36 and a pair of secondary windings 38, 40.

Circuit II includes a thermocouple 42 which is located adjacent the burner 14 and acts as a temperature-sensing element. When the burner is lit, a D.C. voltage is generated in the thermocouple 42. The D.C. voltage is chopped by means of a vibrator 44 and amplified in two stages by triodes 46, 48. The signal from the second stage triode 48 is fed through a potentiometer 50 to the grid of a thyratron tube 52. The thyratron will fire when the input signal from the thermocouple 42 reaches a predetermined value. When the thyratron 52 fires, the circuit through the coil 54 of the relay 24 is closed, causing the contacts 23 of the relay to open. Opening of the contacts 23 opens the circuit through the gas igniter 22 and also through the heater 32 of the relay 18.

The temperature-sensing unit 42 is shown as a thermocouple for the purpose of illustration. While the use of the thermocouple is preferred for many applications, other sensing devices such as a photo-cell or a flame detector may be used. The requirements of the sensing device are simply that it generate a signal in response to the burning of gas in the burner 14. The signal may be generated, for example, in response to the temperature of the flame or to the light emitted by the flame.

The polarity of the D.C. signal generated by the thermocouple is important because it is desired to impress a positive signal on the grid of the thyratron 52. The signal from the thermocouple will be inverted twice by the amplifying tubes 46, 48 before it is fed to the thyratron grid and therefore the input to the grid of the first triode 46 should be a positive signal.

The signal generated by the thermocouple 42 is developed across a load resistor 58. The circuit through the thermocouple back to ground is intermittently completed by the closing of contacts 59 of the vibrator 44. The coil 60 of the vibrator is connected through a load resistor 62 to input voltage through the secondary winding 38 of the transformer 34. Operation of the vibrator therefore serves to interrupt the D.C. voltage generated by the thermocouple to provide an amplifiable signal on the grid 64 of the first triode 46. The use of the vibrator 44 permits amplification by an alternating current amplifier to avoid the use of a more expensive and less stable D.C. amplifier.

The cathode 66 of the first triode is connected to ground through a biasing resistor 68. The output from the plate 70 is coupled to the grid 72 of the second triode 48 through a coupling capacitor 74. The signal from the first triode is developed across a load resistor 77. The cathode 79 of the second triode 48 is connected to ground through resistor 80 in parallel with capacitor 82 to provide bias for operation of the tube. The output of the plate 84 is coupled through a capacitor 86 to the grid 88 of the thyratron 52. The output signal is developed across the potentiometer 50 and load resistor 90. The potentiometer 50 is provided as a sensitivity control to permit selection of the minimum burner temperature at which the gas valve 10 is to remain open. The desired temperature may vary considerably with different burners. For instance, the gas valve should be turned off at a relatively high temperature when used in connection with burners located in ovens or furnaces which retain heat long after the burner is out.

The grid circuit of the thyratron must be, of course, biased negatively, when the plate 84 is positive, to a point below the critical bias voltage. The negative biasing voltage is supplied by the secondary transformer winding 38 which connects the cathode 92 to ground. The plate circuit of the thyratron 52 is completed through the transformer secondary winding 40 to ground.

B+ for the triodes 46, 48 is provided by means of the secondary winding 40 of the transformer 34. The A.C. voltage is rectified to pulsating D.C. by means of a pair of rectifiers 94, 96 followed by a filter circuit comprising a resistor 98 and capacitors 100, 102. A load resistor 104, 106 is provided for each of the triode plates. The cathodes of triodes 46, 48 and thyratron 52 are indirectly heated. The filament heaters 108, 110, 112 are supplied with power by the secondary winding 38 of the transformer 34.

As may be readily appreciated, the components of the illustrated circuits, and the specific circuits themselves, may be considerably altered as desired, as for example by substituting transistors for the vacuum tubes. In the circuit shown, the triodes 46, 48 may both be provided in a single envelope, such as, for example, a 12AX7 tube. The thyratron may be a 2D21 tube. The relay 24 is preferably a mercury-type relay. The gas igniter may be any conventional electrically-operated igniter device such as a spark igniter or a glow element igniter.

In operation of the entire control circuit, when the circuit is turned on by closing starting switch 17, power is immediately supplied to the heater of the warm-up relay 20, causing this relay to eventually close and actuate the gas valve 10. The igniter, which has by this time warmed up to operating temperature, will ignite the gas and the burner will be in operation. If ignition does not occur or if the burner goes out after ignition, voltage will not be generated in the thermocouple, the thyratron will not fire, with the consequence that relay 24 will be closed. Closing of the contacts 23 closes the circuit through the heater of the time delay relay 18 and eventually opens the contacts 26 of the relay 18. Opening of the contacts 26 opens the circuit through the solenoid of the valve 10, causing the valve to shut-off and discontinue the flow of gas to the burner. If the burner does ignite and combustion continues, the thermocouple will generate a sufficient voltage to cause the thyratron to fire, maintaining the contacts 23 of the relay 24 open. As a consequence, the time delay relay 18 contacts will remain closed and the valve 10 will remain open to permit the flow of gas to the burner.

In the second embodiment of the present invention as shown in FIG. 2, similar reference numbers have been employed to designate the portions of Circuits I and II which correspond to the circuit elements previously described. Circuit I of FIG. 2 is altered principally in that the time delay relays 18, 20 are omitted. A switch 114 and a normally open relay 116 are provided to substitute therefor.

As in the FIG. 1 embodiment, A.C. voltage 16 is applied across the primary winding 36 of the transformer 34. One side of the solenoid of the gas valve 10 is applied to one side of the input power with the other side being connected to the opposite side of the voltage through the normally open contacts 128 of the relay 116.

The gas igniter 22 has one side directly connected to input voltage, while the other side is connected to input voltage through the switch 114. The switch 114 is a double pole, single throw switch. It is a hold-down switch held in a normally open position by spring means 115. In addition to closing the igniter circuit, switch 114 operates to close a power circuit through the solenoid of the valve 10.

In operation, manual depression of switch 114 closes power circuits through the igniter 22 and through the solenoid of the valve 10. Gas is thus allowed to flow to the burner 14 from the supply means 12, and is ignited by the igniter. The switch 114 is held down until the gas has burned a sufficient time to raise the temperature of the hot junction of thermocouple 42 to a point where the thermocouple is generating the required signal voltage. The signal voltage is, as in the FIG. 1 embodiment, chopped by vibrator 44, amplified in triodes 46, 48 and fed through the potentiometer 50 to cause the thyratron 52 to fire, completing the circuit through the winding 54 of the relay 116. Completion of this circuit will cause the contacts 128 of the relay 116 to close, thus providing a second power circuit through the solenoid-operated gas valve. At this point, the switch 114 may be released to open one of the circuits through the gas valve and also to open the circuit through the gas igniter. The gas igniter is de-energized at this point for conservation purposes. The contacts 128 will remain closed as long as the thermocouple senses the proper burner operating temperature. In the event that the burner ceases to operate at the proper temperature, the thermocouple will no longer generate the required voltage and the contacts **128** will open, causing the solenoid-operated gas valve to shut off the flow of gas to the burner.

As may be readily appreciated, the control circuits of both the FIG. 1 and FIG. 2 embodiments are effective as safeguards to assure that the gas burner is operating properly when the gas valve is open. The circuit is simple, requiring a minimum number of operating parts and is fail-safe in that the failure of any of the component parts, especially any component located in the path between grid **88** and thermocouple **42**, will operate to discontinue the flow of gas to the burner and require trouble-shooting of the circuit to locate and repair the fault.

Having thus described our invention, we claim:

1. A control circuit for a gas burner comprising means responsive to gas burner operation for generating a signal; amplifier means for said signal; relay means actuable by said amplified signal, said amplifier including an alternating current powered and conducting thyraton; solenoid-operated valve means actuable by said relay means to control the flow of gas to said burner; and igniter means to ignite gas flowing from said burner; said relay means being actuated by said signal to de-activate the igniter subsequent to ignition of the gas.

2. A control circuit for a gas burner comprising temperature-sensing means responsive to a flame occurring during fuel burner operation for generating a signal; amplifier means for said signal; relay means actuable by said amplified signal; solenoid-operated valve means actuable by said relay means to control the flow of gas to said burner; igniter means to ignite gas flowing from said burner; said relay means being actuated by said signal to de-activate the igniter subsequent to ignition of the gas; said amplifier means including a thyratron; and means responsive to a failure in an energized component located in the operative path between the flame and said thyratron for actuating said relay means to close said valve means to provide fail-safe operation during absence of said flame.

3. A control circuit for a gas burner comprising a flame detector responsive to fuel burner operation for generating a signal when a flame is present; amplifier means for said signal; relay means actuable by said amplified signal supplying relay means energizing current only when a flame is present; electrically-operated valve means actuable by said relay means to control the flow of gas to said burner; and igniter means to ignite gas flowing from said burner; said relay means being actuated by said signal to de-activate the igniter subsequent to ignition of the gas.

4. A control circuit for a gas burner comprising electrically-operated valve means to control the flow of gas to a burner; electrically-operated gas igniter means to ignite gas flowing from said burner; flame-sensing means responsive to fuel burner operation for generating a signal whenever a flame is present at said burner; amplifier means for said signal; relay means actuable by said amplified signal to de-activate the igniter means; said relay means including time delay relay means operative, in response to said signal being below a preselected value, to actuate the electrically-operated valve means to shut off the flow of gas to the burner.

5. A control circuit for a gas burner comprising temperature-sensing means responsive to gas burner operation for generating a signal; amplifier means for said signal; a thyratron tube actuated to fire when said signal reaches a predetermined level; relay means controlled by said thyratron tube; solenoid-operated valve means actuable by said relay means to control the flow of gas to said burner; and igniter means to ignite gas flowing from said burner; said relay means being actuated by said thyratron tube to de-activate the igniter subsequent to ignition of the gas.

6. A control circuit for a gas burner comprising means responsive to gas burner operation for generating a signal; amplifier means for said signal; a first normally closed relay actuated to an open position when said signal reaches a predetermined level; said amplifier means including an electronic valve conducting an energizing current to said relay, and including means preventing conduction of said valve when said signal is not generated; a second normally closed time delay relay actuated to open when the contacts of said first relay are closed for a predetermined period of time; solenoid-operated valve means actuable by said second relay to control the flow of gas to said burner; and igniter means to ignite gas flowing from said burner; said igniter means being de-activated by the opening of the contacts of said first relay.

7. A control circuit for a gas burner comprising solenoid-operated valve means to control the flow of gas to a burner; electrically-operated gas igniter means to ignite gas flowing from said burner; switch means to close a first power circuit through said valve means to actuate the valve means to the open position and to close a power circuit through the igniter means to energize said igniter means; temperature-sensing means responsive to gas burner operation for generating a signal; amplifier means for said signal; a normally open relay actuable by said amplified signal to the closed position; said relay being operative to complete a second power circuit through said solenoid-operated valve means to hold said valve in the open position during burner operation; said switch means adapted to be opened after said second power circuit is closed to open the power circuit through the igniter and to open the first power circuit through the solenoid-operated valve means and permit the valve means to be controlled by the gas burner operating conditions.

8. A control circuit for a gas burner comprising solenoid-operated valve means to control the flow of gas to a burner; electrically-operated gas igniter means to ignite gas flowing from said burner; switch means to close a first power circuit through said valve means to actuate the valve means to the open position; said switch means operative to simultaneously close a power circuit through the igniter means to energize said igniter means; temperature-sensing means responsive to gas burner operation for generating a signal; amplifier means for said signal; a thyratron tube actuated to fire when said signal reaches a predetermined level; a normally open relay actuated, upon the firing of said thyratron, to the closed position; said relay being operative to complete a second power circuit through said solenoid-operated valve means to hold said valve in the open position during burner operation; said switch means adapted to be opened after said second power circuit is closed to open the power circuit through the igniter and to open the first power circuit to the solenoid-operated valve means to permit the valve means to be controlled by gas burner operating conditions.

9. An apparatus for controlling ignition of a burner, comprising a plurality of components including an alternating current transformer having a primary coil and a secondary coil, an igniter positioned adjacent said burner and adapted to be supplied with current to ignite said burner, a thyratron, said secondary coil providing alternating current power to said thyratron, a solenoid operated fuel valve for controlling flow of fuel to said burner, the solenoid of said fuel valve being electrically connected in a valve energizing circuit in parallel with said primary coil, a sensing element adapted to be positioned adjacent the burner to sense the presence of a flame and to produce a voltage pulse when said flame is present, a grid protecting resistance in series with said sensing element, said sensing element being electrically connected to the grid of said thyratron for controlling by said voltage pulses by voltage amplitude grid control the conduction

of said thyratron, a relay energized by said thyratron when the sensing element responsive to the presence of a flame causes said thyratron to conduct only upon the presence of a flame by increasing the positive potential on said grid, switch means in said igniter circuit opened by said relay when energized for cutting off the power to the igniter when the thyratron is energized when a flame is present and closed by said relay when de-energized for automatically applying power to said igniter when the thyratron is de-energized when a flame is absent, thermal time delay switch means including a heater element and a normally closed switch adapted to be opened by energizing said heater element for a predetermined period of time, said normally closed switch being in the valve energizing circuit so that opening said normally closed switch closes said valve, switch means in the energizing circuit of said heater element closed by said relay when de-energized so that the normally closed switch is opened to de-energize the solenoid and to close said fuel valve in the event that the burner either does not initially ignite or does not re-ignite within a predetermined period of time, and means responsive to a failure in a component energized by one of said coils and located in the operative path between the flame and the grid for de-energizing said relay to provide fail-safe operation during absence of said flame.

10. A control circuit for a gas burner comprising means responsive to gas burning operation for generating a signal; amplifier means for said signal, said amplifier means including a thyratron; relay means actuatable by said amplified signal; solenoid-operated valve means actuatable by said relay means to control the flow of gas to said burner; and means responsive to a failure in an energized component located in the operative path between the flame and said thyratron for actuating said relay means, and means responsive to the last mentioned actuation of said relay means for closing said valve means to provide fail-safe operation during absence of said flame.

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