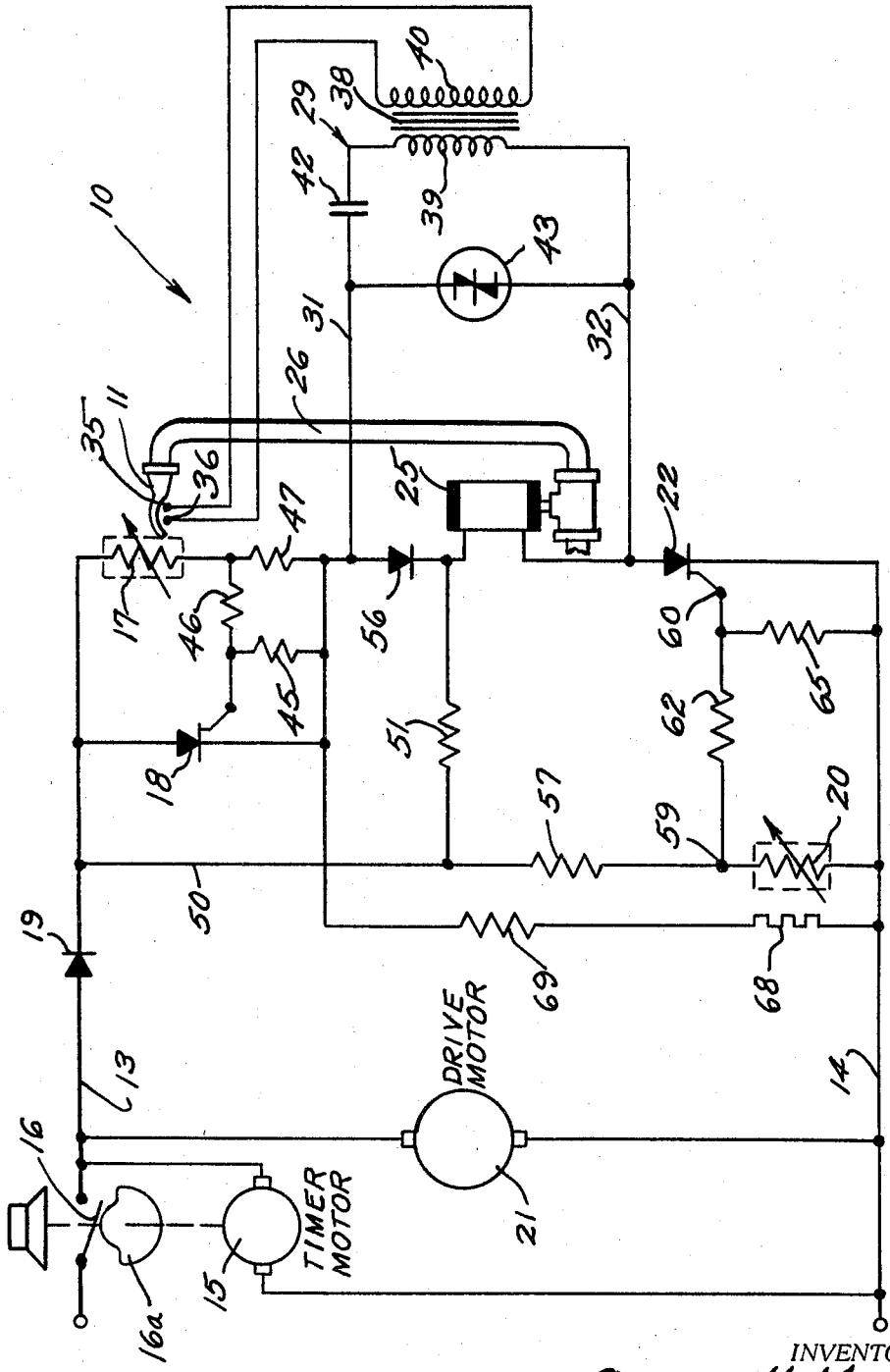
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SOLID STATE IGNITION CIRCUIT FOR FUEL BURNERS

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SOLID STATE IGNITION CIRCUIT FOR FUEL BURNERS

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11 Claims. (Cl. 431—68)

This is a continuation of application Ser. No. 406,399, filed Oct. 26, 1964, and now abandoned.

This invention relates generally to a control system used in a domestic clothes dryer for igniting and controlling fuel gas therein, and more specifically to a control system which operates without the use of moving contacts or switches.

In control systems of the prior art mechanical switching devices have been provided such as thermalbimetal switching or relay switching to ignite and control fuel gas supplied to a burner. Although these past control systems provide a fundamentally workable means to control a fuel burner in a clothes dryer, there still exists a need for a control system with improved reliability, reduced size having a minimum number of components and a system which is not expensive to manufacture or maintain.

Also in past control systems, the fuel gas is ignited in some instances by a glow-type igniter, which is energized by a mechanical switching device. These glow-type igniters comprise a resistive heating element which generates heat sufficient to ignite fuel when electric current passes therethrough. This type of igniter may be subject to failure because of excessive current flow which can prematurely burn the heating element in two. Other fuel burners are ignited by a maintained pilot light flame in proximity with the main fuel burner. Although this system is not as prone to failure due to burnout of the igniter as is the case with the glow-type igniter, it requires continuous consumption of fuel gas even when the main gas burner is not in operation, thereby reducing the efficiency for the fuel burner.

According to this invention, a control system is provided for a gas burner in a clothes dryer wherein a pair of electronic switching devices are connected in series and have disposed therebetween a solenoid valve which controls the flow of gas to the gas burner. By providing a completely electronic control system the use of mechanically actuated switching devices is eliminated thereby greatly increasing the reliability of such a system. Also, by the use of thermal responsive variable resistors in circuit with such electronic switching devices it is possible to have an igniter and control system which has a high degree of safety and reliability.

It is further controlled by this invention, that the arrangement of components in the igniter and control circuit greatly decrease the number of components necessary to produce reliable control of the flow of fuel gas.

To that end, a thermal responsive variable resistor having a positive temperature coefficient is placed in proximity with the flame from the fuel burner for receiving heat therefrom to vary its resistance value. This thermal responsive variable resistor is then connected in circuit with one of the electronic switching devices to control the conduction thereof which, in turn, controls the initial energization of the solenoid valve and an electronic spark igniter.

A second thermal responsive variable resistor having a negative temperature coefficient is connected in circuit with another electronic switching device for control thereof. This second electronic switching device is used to maintain the solenoid valve in the energized condition during the normal operating cycle of the clothes dryer, and also to deenergize the solenoid valve to prevent gas flow in the event the gas in the gas burner fails to ignite, thereby eliminating a hazardous condition of accumulating gaseous fuel in the treatment zone.

It is therefore an object of the present invention to provide an improved electronic igniter and control system which can be used to control a gas burner adapted to be connected to a clothes dryer.

Another object of the present invention is to provide an igniter and control system which has improved reliability, reduced size and having a minimum number of components and which is not expensive to manufacture or maintain.

Yet another object of the present invention is to provide an electronic igniter and control system which can readily detect the failure of the igniter to ignite a quantity of fuel gas in a predetermined period of time.

Another object of the present invention is to provide a control system which energizes the igniter circuit and the solenoid valve simultaneously at the beginning of a drying cycle and thereafter deenergizes the igniter circuit and reduces the voltage supplied to the solenoid valve to a valve sufficient to maintain the solenoid valve energized.

Still another object of the present invention is to provide an igniter and control system for a fuel burner in a clothes dryer which eliminates mechanically movable switches or relays without loss of function.

Many other and more specific objects, features and advantages which will become more fully apparent to those versed in the art from the following detailed description taken in conjunction with the accompanying drawing which illustrates the preferred embodiment therein.

The single figure is a schematic wiring diagram illustrating the types of solid state devices used and the manner in which they are connected to obtain all the desirable features mentioned hereinabove.

As shown in the drawing

Reference numeral **10** designates generally the igniter and control system which is used to control a fuel burner **11** during the normal drying cycle of a clothes dryer. A pair of input leads **13** and **14** for applying power to the igniter and control circuit **10** can be connected to a suitable timing means, comprising motor **15**, switch **16** and cam **16***a*, to control the operation of the clothes dryer for a predetermined drying cycle. The power received through the timing means passes through the rectifier **19**, thereby changing alternating current to a pulsating DC current which is used for operation of the control system **10**. Because of the resistive value of the thermal responsive variable resistor **17** a solid state switching device such as a silicon controlled rectifier **18** is rendered conductive during the early portion of each positive halfway cycle applied thereto. The resistive value of the thermal responsive variable resistor **20** will render the silicon control rectifier **22** conductive, thereby providing a current energizing path through an electrically energized solenoid valve **25** which, in turn, supplies fuel gas to the burner **11** through fuel feeding means **26**.

As shown on the drawing the electronic switching device in the exemplary embodiment of the present invention are silicon controlled rectifiers but it will be understood that other solid state and thermionic electronic switching devices can be used to obtain the advantages of this invention.

An electronic spark igniter designated generally at **29** has a pair of input leads **31** and **32** connected in parallel with the solenoid valve **25** in such a manner as to receive energizing current simultaneously with the solenoid valve

25 at the beginning of a drying cycle to produce an igniting spark between electrodes 35 and 36 for igniting the fuel gas from burner 11. As long as the solid state devices 18 and 22 are rendered conductive both the solenoid valve 25 and the electronic igniter 29 will be energized.

As further shown on the drawing, the electronic igniter 29 comprises a step-up transformer 38 which has a primary winding 39 and a secondary winding 40. By way of example, the turns ratio between the primary winding 39 and the secondary winding 40 may be approximately 100:1 with the primary winding 39 having 60 turns and the secondary winding 40 having 6000 turns to produce the appropriate step-up ratio. One lead of the primary winding 39 is connected to a capacitor 42 while the other lead thereof is connected to a bidirectional switch 43, which is connected across the leads 31 and 32. The bidirectional switch 43 is preferably a silicon bidirectional avalanche diode or what sometimes is referred to as a five layer diode. However, a unidirectional avalanche diode or what is referred to as a four layer diode may be used equally as well.

At the beginning of a drying cycle, when both the solenoid valve 25 and electronic igniter circuit 29 are energized through silicon control rectifiers 18 and 22, the capacitor 42 will charge through the primary winding 39 of the transformer 38 until the breakover voltage of bidirectional avalanche diode 43 is reached at which time capacitor 42 is rapidly discharged through primary winding 39 causing a rapidly expanding magnetic field therein. The secondary winding 40 receives the rapidly expanding magnetic field from primary 39 in such a manner as to cause a step up voltage sufficient for arcing between the electrodes 35 and 36, which are in proximity with burner 11. This action will ignite fuel gas from burner 11 to provide sufficient heating for the purpose of drying clothes in a predetermined time.

The thermal responsive variable resistor 17 forms a part of voltage divider network further consisting of resistors 45, 46 and 47 located in the gate-to-cathode circuit of the silicon controlled rectifier 18. As mentioned hereinabove, the thermal responsive variable resistor 17 is placed in proximity with the burner 11 for receiving heat therefrom, thereby increasing the resistive value of resistor 17. This action will cause an increased voltage drop to appear across the variable resistor 17 thereby increasing the voltage drop across resistor 45 to a value to render silicon control rectifier 18 nonconductive.

However, when silicon control rectifier 18 is rendered nonconductive it is desired that only the electronic igniter 29 be deenergized and that the solenoid valve 25 remain in the energized state for continually supplying fuel gas to the burner 11 during a period of time sufficient to complete the drying cycle. Solenoid valve 25 is therefore maintained in the energized state by a reduced current flow which passes through the line 50 and the bypass resistor 51. The resistance value of the bypass resistor 51 is high enough to prevent solenoid valve 25 from becoming initially energized by the reduced current flow, however, the resistance value is low enough to maintain the solenoid valve open after it has been energized. This feature will prevent raw fuel gas from being supplied to a hot fuel burner, in the event of a short time interval power failure or if the operator should stop the dryer before the completion of the drying cycle, and again start the drying cycle. If the dryer has been stopped prior to completion of the drying cycle it will not start again until the thermal responsive resistor 17 has cooled sufficiently to decrease its resistive value and render the silicon control rectifier 18 conductive which in turn, will energize the solenoid valve 25 and supply fuel gas to burner 11. Also, the electronic spark igniter 29 is again energized to produce an arc between the electrodes 35 and 36 to ignite the fuel gas. When the thermal responsive resistor 17 is sufficiently heated to increase its resistive value the silicon control rectifier 18 is rendered nonconductive, and the decreased current flow through line 50 and bypass resistor 51 will maintain the solenoid valve 25 energized through silicon control rectifier 22.

Disposed between the solenoid valve 25 and the silicon control rectifier 18 is a blocking diode 56 connected to prevent the decreased solenoid valve energizing current from energizing the electronic igniter 29 during the normal burning operation of the burner 11.

The silicon controlled rectifier 22 has connected in the gate circuit thereof a voltage divider network comprising the thermal responsive variable resistor 20, and a resistor 57. Connected between a thermal point 59 and a gate terminal 60 is a current limiting resistor 62, which prevents the gate firing current of silicon control rectifier 22 from exceeding rated capacity. During normal operation, the gate-to-cathode junction of the silicon controlled rectifier 22 may have a temperature rise caused by normal firing current thereby providing a varying voltage drop between the gate and cathode electrodes. The resistor 65, which is connected between the gate and cathode electrodes of silicon control rectifier 22 is provided to substantially maintain this voltage drop constant. The resistor 45 in the gate-to-cathode circuit of the silicon controlled rectifier 18 has the same function as the resistor 65, while the resistor 46 in the gate circuit of silicon controlled rectifier 18 has the same function as the resistor 62.

Another safety feature which the control circuit 10 affords to a domestic clothes dryer is one which prevents fuel flow to the burner 11 should the fuel therein fail to ignite after a predetermined period of time. This safety feature is accomplished by the use of the thermal responsive variable resistor 20, which has a negative temperature coefficient.

When energizing current is applied to the solenoid valve 25 and the igniter circuit 29 from silicon control rectifier 18, current is also applied to a heating element 68 through a resistor 69. The heating element 68 is in proximity with the thermal responsive variable resistor 20 and serves to apply heat thereto to decrease its resistive value.

As the resistance of the thermal responsive resistor 20 decreases the voltage drop thereacross also decreases, thereby decreasing the total voltage drop across the rate and cathode electrodes of the silicon control rectifier 22. When the voltage drop across the thermal responsive resistor 20 has decreased below the critical minimum firing voltage of the silicon control rectifier 22 the control rectifier will be rendered nonconductive thereby deenergizing the solenoid valve 25 and the electronic igniter circuit 29.

By way of example, not by way of limitation, the electric heating element 68 and the resistor 69 may provide a six second initial igniting time upon the expiration of which the resistive value of the thermal responsive resistor 20 would have decreased sufficient to render the silicon control rectifier 22 nonconductive thereby turning off the solenoid valve and breaking the igniter circuit.

Since the fuel gas in the burner 11 has not ignited, the thermal responsive resistor 17 is virtually unaffected and silicon control rectifier 18 will remain conductive to continually apply heating current to the heating element 58 and the resistor 59 until power is removed from the entire control system 10.

Summary of operation

After wet clothes have been placed in a suitable treatment zone the switch 16 is actuated thereby energizing the timing motor 15 and the drive motor 21 with a source of alternating current applied through the rectifier 19, thereby applying a pulsating DC current to the igniter and the control circuit 10.

The solid state electronic switching devices 18 and 22, which can be silicon control rectifiers, are initially in the conductive state by virtue of the resistance value

of the thermal responsive variable resistors **17** and **20**. With both of the switching devices **18** and **22** in the conductive state, energizing current will pass through the solenoid valve **25**, the electronic igniter circuit **29**, and the electric heating element **68**.

If the fuel gas in the burner **11** has ignited within a predetermined period of time the thermal responsive resistor **17** in proximity with the fuel burner **11** for receiving heat therefrom will increase its resistive value to decrease the voltage drop between the gate and cathode electrodes of the silicon control rectifier **18** thereby rendering it nonconductive. This action will deenergize the electronic igniter circuit **29** and remove heating current from the heating element **68**. The solenoid valve **25** is maintained energized by reduced current flow, through the line **50** and the bypass resistor **51**, which is sufficient to maintain the solenoid valve **25** open but not sufficient for initial energization thereof.

A safety feature of the present invention which is of importance is that which deenergizes the solenoid valve **25** after a predetermined time interval should the gas in the burner **11** fail to ignite. This is accomplished by placing the silicon control rectifier **22** in series with the solenoid valve **25** and the igniter circuit **29** for passing energizing current therethrough. It is rendered nonconductive by the thermal responsive variable resistor **20** connected in the cathode to gate circuit. As the temperature of thermal responsive resistor **20** increases, the resistive value thereof decreases, thereby decreasing the voltage between the gate and cathode electrodes below the minimum firing voltage of the silicon control rectifier **22** which, in turn, renders the control rectifier **22** nonconductive.

It should be appreciated that other commonly used temperature responsive devices could be employed for the thermal responsive variable resistor **17** and **20**. For instance, an open-on-rise bimetallic thermostat could be used instead of the variable resistor **17** and a close-on-rise thermostat could be used instead of variable resistor **20**.

Similarly, light sensitive devices could be substituted for elements **17** and **20** if a conventional type of light emitter were substituted for heater **68**.

By way of example, not by way of limitation the heating element **68** and the resistor **69** may be selected to provide a six second initial starting period during which time the fuel gas in burner **11** must ignite and heat the thermal responsive resistor **17** sufficiently to render the silicon control rectifier **18** nonconductive which, in turn, will remove heating current from the heating element **68** and deenergize the electronic igniter circuit **29**. A blocking diode is connected between the solenoid valve **25** and the electronic igniter circuit **29** in such a manner as to prevent the reduced solenoid valve energizing current from passing through the electronic igniter circuit **29** during the remainder of the drying cycle.

Although minor modifications might be suggested by those versed in the art, it should be understood that we wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of our contribution to the art.

What is claimed is:

1. A control system for operation of a fuel burner in a clothes dryer comprising:
- electrically controlled valve means for controlling supply of fuel to the burner,
  - said valve means having a single solenoid,
- circuit means comprising an electrically energized igniter system for igniting fuel supplied to the fuel burner,
- said circuit means connecting said valve means and said igniter system electrically in parallel and to an energizing voltage source, electronic switching means in said circuit means controlling current flow to said valve means and to said igniter system upon initial energization of the control system to cause fuel flow to the fuel burner and ignition thereof at said fuel burner,
- and bypass circuit means in parallel with said electronic switching means having voltage dropping resistance means external of said valve means to supply a reduced voltage from said energizing voltage source to said single solenoid of said valve means,
  - said bypass circuit means being operable to maintain said valve means open when said electronic switching means becomes nonconductive.

2. A control system for operation of a fuel burner in a clothes dryer comprising:
- electrically controlled valve means for controlling supply of fuel to the burner,
- circuit means comprising an electrically energized igniter system for igniting fuel supplied to the fuel burner,
- said circuit means connecting said valve means and said igniter system to an energizing voltage source,
- first and second electronic switching means in said circuit means for controlling current flow to said valve means and to said igniter system upon initial energization of the control system to cause fuel flow to the fuel burner and ignition thereof at said fuel burner,
- means responsive to flame emanating from the fuel burner to render said first electronic switching means nonconductive,
- bypass circuit means in parallel with said first electronic switching means and operable to maintain said valve means open when said first electronic switching means becomes nonconductive,
- and a blocking diode connected between said electrically controlled valve means and said electrically controlled igniter system having a polarity to block current to said igniter system while said valve means is maintained open by current through said bypass means.

3. The system of claim **2** in which said means responsive to flame emanating from the fuel burner is a thermal responsive variable resistor.

4. A control system for operation of a fuel burner comprising:
- electrically controlled valve means for controlling supply of fuel to the burner,
- circuit means comprising an electrically energized igniter system for igniting fuel supplied to the fuel burner,
- electrically energized heating means,
- said circuit means connecting said valve means and said igniter system and said electrically energized heating means to an energizing voltage source,
- first and second electronic switching means in said circuit means for controlling current flow to said valve means and said igniter system and said electrically energized heating means upon initial energization of the control system,
- and a thermal responsive variable resistor in proximity to said electrically energized heating means and connected to said second electronic switching means for rendering said second switching means nonconductive in the event fuel in said burner fails to ignite after a predetermined period of time.

5. A system for controlling the operation of a fuel burner,
- electrically controlled valve means for controlling supply of fuel to the burner,
- circuit means comprising an electrically energized igniter system for igniting fuel supplied to the fuel burner,
- electrically energized heating means,
- said current means connecting said valve means and said igniter system and said electrically energized heating means to an energizing voltage,

first and second electronic switching means in said circuit means for controlling current flow to said valve means and said igniter system and said electrically energized heating means upon initial energization of the control system to cause fuel flow into said fuel burner,

variable resistance means responsive to heat from the fuel burner after the ignition of the fuel flowing therefrom to render said first electronic switching means nonconductive,

and a thermal responsive variable resistor in proximity with said electrically energized heating means and connected to said second electronic switching means for rendering said second switching means nonconductive in the event fuel in said fuel burner fails to ignite after a predetermined period of time.

6. The system of claim **5** in which said first and second electronic switching means are silicon controlled rectifiers.

7. A control system for operation of a fuel burner comprising:

electrically controlled valve means for controlling supply of fuel to the burner,

circuit means comprising an electrically energized igniter system for igniting fuel supplied to the fuel burner,

said electrically energized igniter system consisting of a step up transformer having primary and secondary windings,

a charging capacitor in circuit with said primary winding,

solid state switching means in circuit with said primary winding and said charging capacitor for discharging said capacitor through said primary thereby causing an increased voltage in said secondary winding, and electrode means connected to said secondary winding for dissipation of said increased voltage in the form of an arc,

electrically energized heating means,

said circuit means connecting said valve means and said igniter system and said electrically energized heating means to an energizing voltage,

first and second electronic switching means in said circuit means for controlling current flow to said valve means and said ignition system and said electrically energized heating means upon initial energization of the control system,

a first thermal responsive variable resistor in circuit with said first electronic switching means and in proximity with said fuel burner for receiving heat therefrom thereby increasing its resistive value a sufficient amount to render said first electronic switching means nonconductive,

bypass circuit means in parallel with said first electronic switching means and operable to maintain said valve means open when said first electronic switching means becomes nonconductive,

and a second thermal responsive variable resistor in circuit with said second electronic switching means and in proximity with said electrically energized heating means for receiving heat therefrom thereby decreasing its resistive value a sufficient amount to render said second electronic switching means nonconductive in the event fuel in the fuel burner fails to ignite after a predetermined period of time.

8. The system of claim **7** in which said first thermal responsive variable resistor has a positive temperature coefficient, and said second thermal responsive variable resistor has a negative coefficient.

9. A control system for operation of a fuel burner comprising:

fuel regulating means for controlling supply of fuel to the burner,

igniter means for igniting fuel supplied to the burner,

said igniter means consisting of a step up transformer having primary and secondary windings,

a charging capacitor in circuit with said primary winding,

solid state switching means in circuit with said primary winding and said charging capacitor for discharging said capacitor through said primary winding thereby causing an increased voltage in said secondary winding,

an electrode means connected to said secondary winding for dissipation of said increased voltage in the form of an arc,

electrically energized heating means,

circuit means connecting said fuel regulating means and said igniter means and said electrically energized heating means to an energizing voltage,

first and second electronic switching means in said circuit means for controlling said fuel regulating means and said igniter means and said electrically energized heating means upon initial energization of the control system,

a first thermal responsive variable resistor in circuit with said first electronic switching means and in proximity with said fuel burner for receiving heat therefrom thereby increasing its resistance value a sufficient amount to render said first electronic switching means nonconductive,

bypass circuit means connected in parallel with said first electronic switching means to maintain said fuel regulating means operable after initial operation thereof when said first electronic switching means is nonconductive,

and a second thermal responsive variable resistor in circuit with said second electronic switching means and in proximity with said electrically energized heating means for receiving heat therefrom thereby decreasing its resistance value a sufficient amount to render said second electronic switching means nonconductive in the event fuel in the fuel burner fails to ignite.

10. A control system for operation of a fuel burner comprising:

electrically controlled valve means for controlling supply of fuel to the burner,

and an electrically energized igniter circuit connected electrically in parallel with said valve means,

a source of power having first and second terminals,

first switch means connecting one end of said valve means and said igniter circuit to said first terminal,

second switch means connecting the other end of said valve means and said igniter circuit to said second terminal,

said first and second switch means controlling current flow to said valve means and said igniter circuit upon initial energization of the control system,

and thermal responsive means connected to said second switch means for rendering said second switch means nonconductive in the event fuel in said burner fails to ignite after a predetermined period of time.

11. The system of claim **10** further including a blocking diode connected between said electrically controlled valve means and said igniter circuit having a polarity to block current to said igniter circuit while said valve means is maintained open by said second switch means after the fuel in said burner has ignited.

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