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[54] **COMBUSTION CONTROL CIRCUIT FOR A FUEL BURNER**

[75] Inventor: **Ronald F. Lourigan,** Kenosha, Wis.

[73] Assignee: **Webster Electric Company, Inc.,** Racine, Wis.

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[52] **U.S. Cl.** **307/117,** 431/69, 431/74

[51] **Int. Cl.** **H01h 35/00**

[58] **Field of Search**.......................307/116, 117, 118, 307/119, 112; 431/24, 25, 26, 66, 71, 74, 69, 27

[56] **References Cited**

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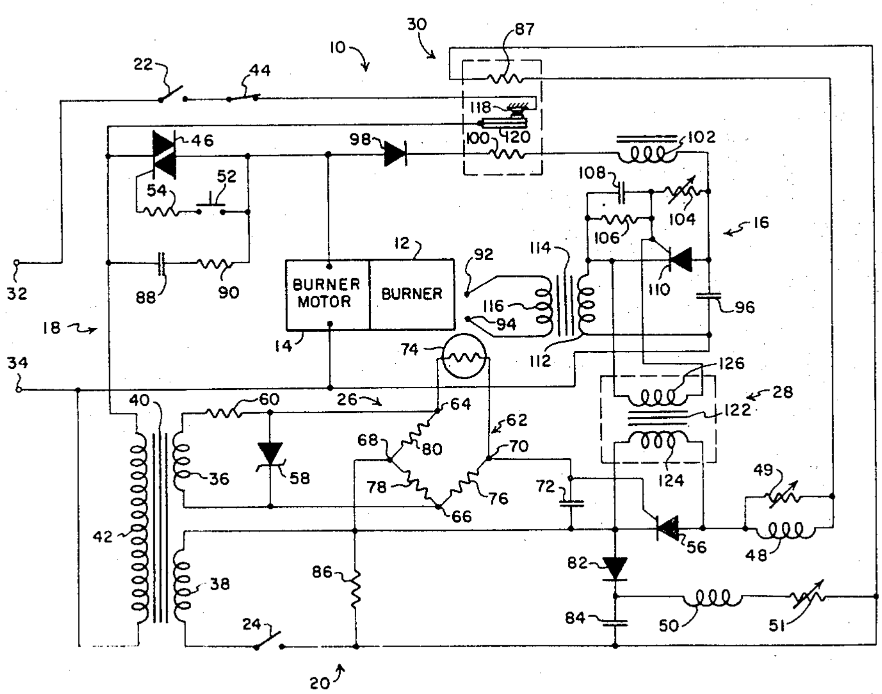
3,463,600	8/1969	Axmark	307/117 X
3,584,988	6/1971	Hirsbrunner et al.	431/66
3,624,407	11/1971	Bauer	307/116

Primary Examiner—Robert K. Schaefer
Assistant Examiner—M. Ginsburg
Attorney—Richard D. Mason et al.

[57] **ABSTRACT**

A combustion control circuit for an oil burner installation includes a triac for controlling the energization of both a burner motor and an ignition circuit. A control circuit carries out a safe start component check and then operates the triac when a thermostat closes and when no flame is detected at the burner. If ignition fails to take place in a trial-for-ignition period of predetermined time, a thermal switch is heated by a heater in the control circuit and opens to shut off the burner motor. However, if ignition takes place, flame is detected within the predetermined period by an improved, positively acting, reliable resistance bridge flame detector circuit. The flame detector circuit serves to render nonconductive a silicon controlled rectifier in the control circuit in order to disconnect the thermal switch heater while maintaining operation of the burner motor. Simultaneously, the ignition circuit is deenergized by a novel ignition disabling circuit connected between the silicon controlled rectifier and the ignition circuit. Failure of the triac in a short circuit condition prevents an unsafe condition due to connection of the thermal switch to the motor and due to the use of a second heater in circuit with the ignition circuit.

26 Claims, 3 Drawing Figures



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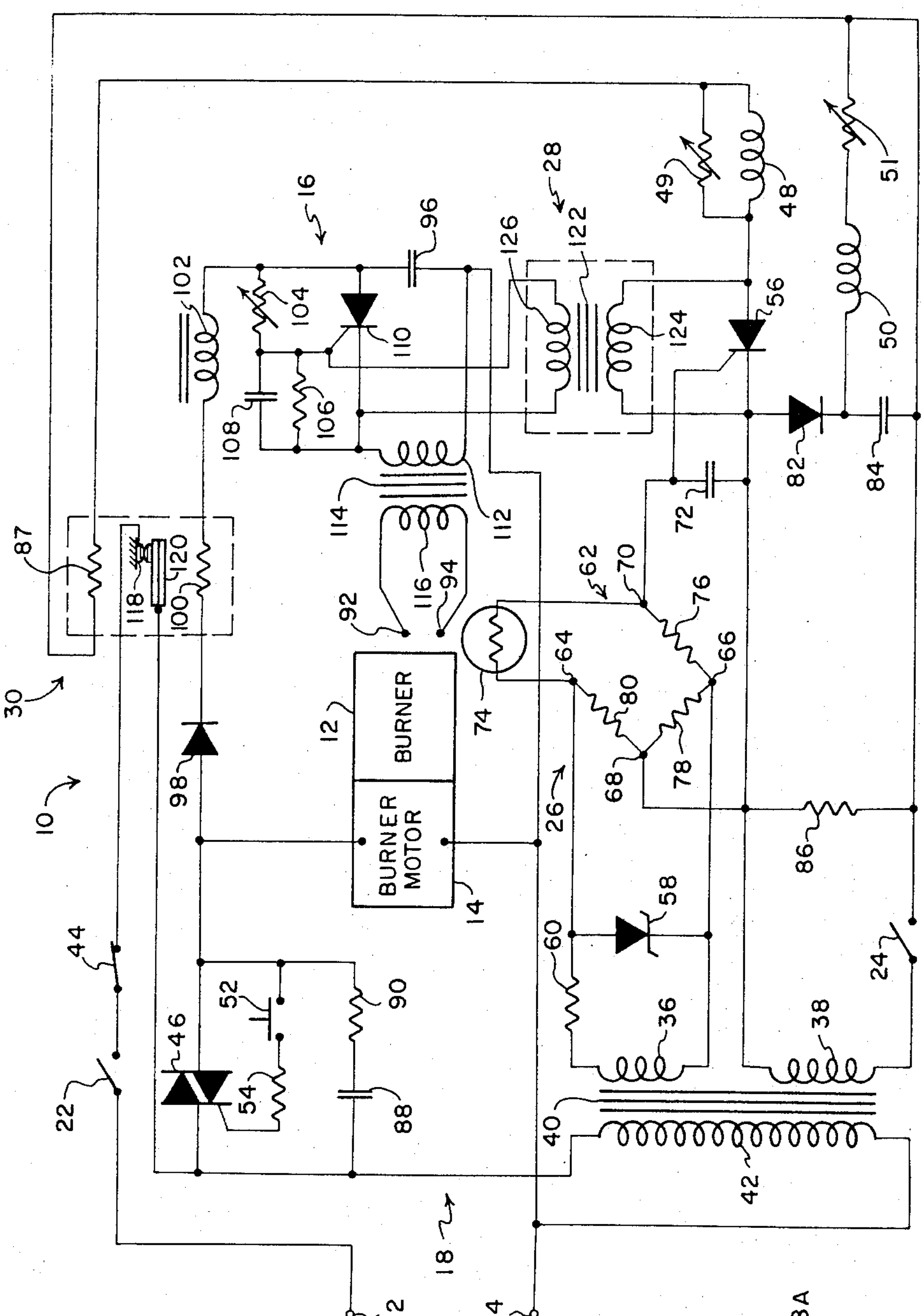

FIG. 1

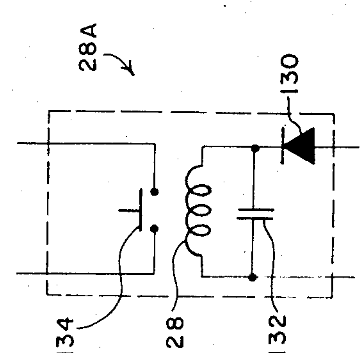

FIG. 2

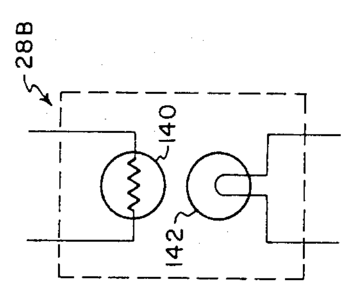

FIG. 3

COMBUSTION CONTROL CIRCUIT FOR A FUEL BURNER

The present invention relates to an improved combustion control circuit for reliably and safely controlling the operation of a fuel burner.

A conventional fuel oil burner heating installation of a type widely used in the past includes an ignition device such as a transformer or other ignitor for igniting fuel at the burner, together with a primary control using two or more relays for operating the burner in response to a thermostat. Upon closing of the thermostat in normal operation, the burner motor and the ignition device are energized during a trial-for-ignition period. If burner flame is detected, the burner motor is continued in operation and, if the installation is of the intermittent ignition type, the ignition device is deenergized. On the other hand, if flame is not detected during the initial period, a thermal delay safety switch shuts down the installation.

The complexity and expense of conventional control systems has made it desirable to provide a safe, economical and reliable combustion control circuit making use of inexpensive solid state components in place of expensive relays, large transformer windings, and the like. Devices of this general class have been proposed, and one example may be found in U. S. Pat. No. 3,624,407 — Bauer. However, solid state devices developed to date have suffered from several disadvantages such as lack of complete safety in operation, unreliability under some circumstances, the need for expensive components, and excessive cost and/or complexity.

Objects of the present invention are to provide an improved combustion control circuit for controlling the operation of a fuel burner installation including a burner motor and an ignition circuit; to provide an improved combustion control circuit having desirable safety features including a novel arrangement for protecting against component failure; to provide an improved combustion control circuit in which the necessity for expensive components is reduced; to provide an improved, highly reliable flame detection circuit for use in a combustion control circuit; and to provide a combustion control circuit having an improved arrangement for discontinuing the operation of the ignition circuit when burner ignition is accomplished.

In brief, the above and other objects and advantages of the invention are realized by the provision of an improved combustion control circuit for an oil burner installation of the type including a burner motor and an ignition circuit. A triac switching device is connected for simultaneously energizing both the burner motor and the ignition circuit. A thermostat is located in the area to be heated by the oil burner installation, and a light sensitive variable resistance flame detector is disposed adjacent the fuel burner. A control circuit operates to place the triac in a conductive condition to energize both the burner motor and the ignition device when the thermostat closes upon demand for heat. When ignition is accomplished, the control circuit operates in response to the flame detector for discontinuing operation of the ignition circuit. On the other hand, if ignition is not accomplished during a predetermined period of time, a thermal delay switch connected to the burner motor prevents further operation of the burner motor upon being heated to a predetermined extent. A first heater in the control circuit operates from the time that the thermostat closes until such time as a flame is detected. A second heater for the thermal switch protects against failure of the triac and heats the thermal switch at all times that the ignition circuit is in operation.

In accordance with another feature of the invention, there is provided a novel flame detection circuit comprising a resistance bridge provided with a regulated operating potential and including a light sensitive variable resistance flame detector in one leg thereof. In the absence of flame the resistance bridge is maintained in an unbalanced condition. Upon the detection of flame, the resistance bridge is moved through the null point to an oppositely unbalanced condition, and the control circuit is operated positively and effectively.

An aspect of the invention resides in a novel circuit for disabling the ignition circuit in response to the detection of flame. In one embodiment, a transformer coupled between a switching device in the control circuit and a controlled conduction device in the ignition circuit enables or prevents operation of the ignition circuit in response to presence or absence of flame. In other embodiments, a relay and a light and light sensitive device are used.

The invention and its objects and advantages may be best understood from consideration of the following detailed description of embodiments of the invention shown in the accompanying drawing, wherein:

FIG. 1 is a schematic and diagrammatic illustration of a combustion control circuit embodying the principles of the present invention; and

FIGS. 2 and 3 are fragmentary schematic illustrations of alternative embodiments of the invention.

With reference now to FIG. 1 of the drawing, there is illustrated a combustion control circuit designated generally by the reference numeral **10** and constructed in accordance with the principles of the present invention. The circuit **10** controls the operation of a typical oil burner installation including a burner **12**, a burner motor **14** and an ignition circuit generally designated by the reference numeral **16**. In normal operation, the burner motor **14** and the ignition circuit **16** are operated upon a demand for heat by a burner circuit generally designated as **18** under the control of a control circuit generally designated as **20**. Demand for heat is signalled in conventional manner by a line voltage thermostat switch **22** or by a low voltage thermostat switch **24** located to sense temperature in a region heated by operation of the burner **12**. In any given installation only one of the switches **22** or **24** is used, the other being replaced by a permanent closed circuit.

Upon closing of the controlling thermostat switch **22** or **24**, fuel at the burner **12** is ignited by the ignition circuit **16** and flame is detected by a flame detection circuit generally designated as **26**. Upon detection of flame, the control circuit **20** serves to continue operation of the burner motor **14** while an ignition disabling circuit generally designated as **28** discontinues further operation of the ignition circuit **16**. Should ignition fail to take place within a predetermined time, a thermal delay device designated as a whole by the reference numeral **30** discontinues operation of the fuel burner installation. In accordance with a feature of the invention, the device **30** also discontinues operation of the installation in the event of certain undesirable malfunctions of components in the circuit **10**.

Referring now in more detail to the construction and operation of the combustion control circuit **10**, the circuit includes a pair of power supply terminals **32** and **34** adapted to be connected to a standard nominal 115 volt, 60 hertz power supply. The control circuit **20** and the flame detection circuit **26** are supplied with operating potential by means of a pair of secondary windings **36** and **38** of a transformer **40** having a primary winding **42** adapted to be coupled to the power supply terminals **32** and **34**. In addition to the line voltage thermostat switch **22** (when used), energization of the burner circuit **18** and the control circuit **20** can be interrupted by a conventional over-temperature limit switch and fan switch **44** and by operation of the thermal switch structure **30**.

In operation of the circuit **10**, control of the energization of the burner circuit **18** is provided by a gated, bidirectional solid state controlled conduction device **46** in the form of a triac. The output electrodes of triac **46** are in current supplying relation with both the burner motor **14** and with the ignition circuit **16**. Thus triac **46** must be rendered conductive by coupling of its gate electrode to one of its output electrodes in order to bring about operation of the burner circuit **18**.

In FIG. **1** the combustion control circuit **10** is illustrated in its normal, temperature satisfied condition wherein the thermostat switch **22** or **24** is open and wherein the triac **46** is in its high resistance or open circuit condition so that neither the burner motor **14** nor the ignition circuit **16** is energized. When a demand for heat is sensed by closing of the controlling thermostat switch **22** or **24**, a heating cycle is initiated under the control of the control circuit **20**. Upon initiation of this heating cycle, a safe start component check takes place, and assuming the circuit components to be operating properly, the control circuit **20** serves to render the triac **46** conductive thereby simultaneously energizing the burner motor **14** and the ignition circuit **16** throughout a trial-for-ignition period having a duration determined by the operation of the thermal device **30**.

In order to operate the triac **46**, control circuit **20** includes a pair of relay windings **48** and **50**, which windings control a normally open set of relay contacts **52** connected in series with a resistor **54** and with the gate electrode of the triac **46**. Windings **48** and **50** are arranged in known manner relative to contacts **52** through adjustment of variable resistances **49** and **51** respectively so that energization of both windings is necessary to move or pull in the set of contacts from the open to the closed position, while energization of only the winding **50** suffices to hold the contacts in the closed position. Energization of the windings **48** and **50** is controlled by operation of switch **22** or **24**, while energization of winding **48** is further controlled by a gated solid state controlled conduction device **56** in the form of an SCR having its gate electrode controlled by the flame detection circuit **26**.

With reference now to the flame detection circuit **26**, the function of this circuit is to control the condition of the SCR **56** in accordance with the presence or absence of flame at the burner **12**. In accordance with important features of the invention, the circuit **26** carries out a stable and reliable control operation despite such unfavorable factors as supply voltage fluctuations, intermittent or unstable ignition, intermittent extraneous light, or the like.

More specifically, circuit **26** includes a zener diode **58** serving together with a resistor **60** to supply a voltage regulated driving signal to a resistance bridge **62**. Due to the inclusion of diode **58**, the bridge **62** operates substantially independently of supply voltage variations. Bridge **62** includes a pair of input terminals **64** and **66** connected across the zener diode **58** and a pair of output terminals **68** and **70** connected to the gate and cathode electrodes of the SCR **56** and shunted by a capacitor **72**.

One leg of bridge **62** includes a variable resistance photoelectric device **74** disposed adjacent the burner **12**. In the absence of flame the device **74** is in a high resistance condition, and when illuminated by the presence of flame the device **74** assumes a low resistance condition. The remaining three legs of bridge **62** include resistances **76**, **78** and **80** having values such that the bridge **62** is unbalanced in opposite directions when the device **74** is alternatively in its high and low resistance conditions.

The novel flame detection circuit **26** has important advantages in operation because it reliably and positively controls the condition of the SCR **56**. When no flame is present at burner **12**, device **74** is in its high resistance condition and as a result the bridge **62** is unbalanced and bridge terminal **70** is maintained at a positive potential relative to bridge terminal **68**. This potential appears across capacitor **72** in such a way as to maintain the gate electrode of the SCR **56** positive relative to its cathode. Accordingly, the SCR is maintained in condition for conduction of current through its output circuit. When flame is detected the resistance of device **74** drops to a low level and the bridge **62** moves through its null point or balance condition to an oppositely unbalanced condition wherein terminal **70** is negative relative to terminal **68**, thus biasing the gate electrode of the SCR **56** negative relative to its cathode to assure that SCR **56** ceases conduction and remains nonconducting.

Capacitor **72** provides a smoothing or filtering effect which prevents unwanted response of the flame detection circuit to various possible transient effects. Moreover, since the incident light level at device **74** must change substantially enough to change the condition of the bridge from one unbalanced condition to the oppositely unbalanced condition, positive and reliable operation is achieved. Furthermore, stability of operation is aided by the use of the zener diode **58** which provides a regulated driving voltage for the bridge **62** substantially independent of variations in the supply voltage.

As indicated above, upon a demand for heat the operation of the combustion control circuit **10** commences with a safe start component check. When switch **22** or **24** closes, a circuit is completed for energization of the control circuit **20** from the transformer **40**. At this time the triac **46** is rendered conductive only if the components of the flame detection circuit **26** and control circuit **20** are operational. If the photoelectric device **74** provides a false indication of flame, the

SCR **56** is nonconductive and winding **48** cannot be energized to close normally open relay contacts **52**. Similarly if SCR **56** is inoperative and cannot conduct current, winding **48** cannot be energized. The same result follows if because of any other fault the control circuit **20** or flame detector circuit **26** fails to operate.

If all components are operational, closing of the thermostat switch causes both windings **48** and **50** to be energized. More specifically, winding **50** is energized at a continuous DC level by a diode **82** and capacitor **84** connected across secondary winding **38** in parallel with a resistor **86**. Winding **48** is energized simultaneously by current flowing through the conductive SCR **56** and through a resistor **87** associated with the thermal delay circuit **30**.

Simultaneous energization of windings **48** and **50** causes contacts **52** to move to their closed condition thereby gating the triac **46** to its conductive condition. Voltage fluctuations due to the inductive nature of the load and switching transients and the like are shunted by a circuit including a capacitor **88** and resistor **90** providing reliable turn-off of the triac **46**. A further aspect of the safe start component check is that the triac **46** cannot be rendered conductive following a failure of the relay which prevents contacts **52** from closing, or if the triac itself fails in the open circuit condition.

Operation of both the burner motor **14** and the ignition circuit **16** takes place when the triac **46** is rendered conductive. When the burner motor operates, a combustible mixture of fuel and air is emitted at the burner, and is ignited by the ignition circuit **16** to produce a stable burner flame.

Referring more specifically to the structure of the ignition circuit **16**, this circuit may take any desired form, and as illustrated includes a pair of spark electrodes **92** and **94** located in ignition relation to the combustible air - fuel mixture at the burner **12**. Although other types could be used, the ignition circuit **16** is similar to the ignition circuit illustrated and described in detail in U. S. Pat. No. 3,556,706 — Campbell, to which reference may be had for a more complete disclosure. Briefly, the circuit **16** includes a capacitor **96** which charges repetitively during alternate half-cycles of the power supply waveform through a diode rectifier **98**, a resistance **100** associated with the thermal delay circuit **30**, and an inductance **102**. Repeatedly during the half-cycle, as the voltage across the capacitor **96** reaches a predetermined threshold level, a trigger circuit including a pair of voltage divider resistors **104** and **106** and a phase shift capacitor **108** applies an operating voltage to the gate electrode of an ignition circuit SCR **110**. At this point the SCR **110** is placed in a conductive condition and rapidly discharges the capacitor **96** in a pulse or surge through the primary winding **112** of a transformer **114** having a secondary winding **116** connected to the spark gap electrodes **92** and **94**. As a result, during alternate half-cycles of the power supply waveform there are produced adjacent the burner **12** a high frequency series of discrete, high energy ignition sparks.

Following initial energization of the burner motor **14** and ignition circuit **16**, the combustion control circuit carries out a trial-for-ignition operation during a predetermined time period the duration of which is established by operation of the thermal delay device **30**. In normal operation, ignition takes place during this period. If ignition fails to occur, then continued emission of fuel from the burner **12** could create an undesirable and potentially unsafe condition. For this reason, the thermal delay device functions to shut down the burner motor **14** and the combustion control circuit **10** at the end of the trail-for-ignition period if ignition is not detected by the flame detecting circuit **26**.

Proceeding now to a description of the thermal delay device **30**, this device includes a normally closed set of switch contacts **118** controlling current flowing via the triac **46** to the burner motor **14** and ignition circuit **16**. Contacts **118** are controlled by a bimetallic switch actuator **120** which opens the contacts **118** when the actuator is heated to a predetermined extent. Preferably, the contacts are arranged so that they are latched open and cannot reclose until released by a service man or operator. Heating of the actuator **120** is carried out at a relatively high rate of thermal transfer by the resistor **87** in series with the relay winding **48** and the control circuit SCR **56**. Heating at a slower rate is carried out by the resistor **100** in series with the triac **46**. The heat transferred to the actuator **120** by the resistor **87** is such that contacts **118** open in about **30** seconds.

Although the thermal delay device **30** may take various forms, one device highly suitable for the purpose is disclosed in U. S. Pat. application Ser. No. 204,491, filed Dec. 3, 1971, of Donald F. Dalziel and Charles H. Heide. Reference may be had to that application for a further description of the structure and operation of the device **30**.

Throughout the trial-for-ignition period, the heater resistor **87** is energized because it is in series with the relay winding **48**. If ignition fails to occur within the predetermined time, contacts **118** open and deenergize the burner motor **14** and the ignition circuit **16**. The burner installation remains shut down until such time as the cause for ignition failure is corrected and the contacts **118** are reclosed.

In normal operation, ignition occurs before opening of the contacts **118** and the control circuit **20** places the combustion control circuit **10** in an operating condition wherein the burner motor **14** is continuously energized and the ignition circuit **16** is disabled. The latter function is carried out by the novel ignition disabling circuit **28**.

More specifically, upon ignition a flame at the burner **12** is detected by the photoelectric flame detecting device **74**. In the manner described above, this results in the SCR **56** being placed in a nonconductive condition. Accordingly, the heater resistor **87** of the thermal delay device is deenergized and actuator **120** is no longer heated by this resistor. Although relay winding **48** is deenergized at this time, contacts **52** remain closed due to the continuing energization of the relay winding **50**. The burner motor **14** continues to operate because the triac **46** is maintained in its conductive condition.

When the control circuit SCR **56** becomes nonconductive, the ignition circuit SCR is disabled by the circuit **28**. Ignition disabling circuit **28** includes a coupling transformer **122** having a primary winding **124** connected to the anode and cathode of the SCR **56** and a secondary winding **126** connected to the gate electrode and cathode of the SCR **110**. When SCR **56** is nonconductive, current flows through the primary winding **124** in half cycles when the ignition circuit **116** would otherwise operate, and the gate electrode and cathode of the SCR **110** are reverse biased. Due to this reverse bias the SCR **110** cannot be rendered conductive and no capacitor discharge takes place to produce ignition sparks. Conversely, when SCR **56** is conductive, it acts as a low resistance shunt of primary **124** to prevent reverse biasing of the ignition circuit SCR **110**.

FIG. 2 illustrates an alternative ignition disabling circuit generally designated as **28A**. In this arrangement a relay winding **128** is energized by a DC potential produced by a diode rectifier **130** and capacitor **132** to close a normally open set of relay contacts **134**. Closing of contacts **134** effectively connects the gate electrode of SCR **110** to its cathode and prevents firing of the SCR **110**. When SCR **56** conducts, it provides a low resistance bypass of the winding **128** and contacts **134** remain open, permitting SCR **110** to operate in its normal fashion in ignition circuit **16**.

FIG. 3 illustrates yet another alternative ignition disabling circuit generally designated as **28B**. In this arrangement a light sensitive resistance **140** is coupled between the gate electrode and cathode of the ignition circuit SCR **110**. A lamp **142** is disposed to illuminate the resistance **140** and is connected across the output electrodes of the SCR **56**. When SCR **56** conducts, it shunts the lamp **142** so that resistance **140** is in its high resistance condition and the ignition circuit operates. When SCR **56** is biased to its nonconductive condition, the lamp **142** is energized to reduce the resistance of the device **142** and disable the ignition circuit.

If at any time during normal operation the burner flame should be extinguished, another trial-for-ignition period is commenced. If flame detecting device **74** does not detect flame, the SCR **56** is operated once again. The ignition circuit **16** operates and the heater resistor **87** is energized until such time as ignition is reestablished, or, alternatively, until the contacts **118** open.

Returning to a description of a heating cycle carried out by the combustion control circuit **10**, after ignition the burner motor **14** continues to operate and the flame at the burner **12** heats the region including the thermostat **22** or **24**. When the demand for heat is satisfied, the triac **46** is rendered nonconductive and the installation returns to its initial temperature satisfied condition.

One important feature of the present invention is that the circuit **10** includes novel structure to prevent against unsafe conditions arising from failure of the triac **46** in a short circuit condition wherein it remains conductive regardless of the control signal applied to its gate electrode. This is a common failure condition of such devices. In prior art units if a controlling triac shorts out, the burner motor is energized without any monitoring by the flame detector, and without control of the thermostat in some cases, giving rise to a highly undesirable and potentially unsafe condition. Thus, in prior circuits it has been necessary to purchase expensive triac devices of a high quality in order to reduce the probability of failure as much as possible.

In the circuit **10**, failure of the triac **46** does not lead to an unsafe condition. Should such a failure occur with a control circuit thermostat **24** in the open position, the burner motor **14** and ignition circuit **16** are energized, and the control circuit **20** exercises no monitoring function. Moreover, the ignition circuit **16** is not disabled by the SCR **56** and the disabling circuit **28** or **28A**. However, the continuously operating ignition circuit **16** draws current through the heater resistor **100** of the thermal delay device **30**. After a period of several minutes or so, the resistor **100** heats the actuator **120** and the contacts **118** open to shut down the installation in a safe condition.

Should the triac **46** fail with a low voltage thermostat **24** in the closed circuit condition, the circuit **10** operates normally until the thermostat opens. At this time the burner motor **14** continues to operate and the ignition circuit **16** begins to operate. After a delay period, heater resistor **100** heats the actuator **120** and the circuit **10** goes out on safety.

When a line voltage thermostat is used, a potentially unsafe condition exists in prior circuits wherein the thermal switch contacts are located in a low voltage circuit and not in series with the triac. In such an arrangement, should ignition fail to occur or should the flame be extinguished, the burner motor is maintained energized even if no flame is present because the thermal switch contacts are not in circuit with the burner motor. The present invention avoids this unsafe condition because if flame is not present and the thermal switch contacts open, current to the burner motor is positively discontinued without reliance upon the operability of the triac **46**.

Although the present invention has been described with reference to the details of the illustrated embodiments, it should be understood that other modifications and embodiments will be apparent to those skilled in the art. The details of the illustrated embodiments are not intended to limit the scope of the present invention as set forth in the following claims.

What is claimed and desired to be protected by Letters Patent of the United States is:

1. A combustion control circuit for controlling the operation of a fuel burner having a burner motor and an ignition device and comprising:
 - a triac in circuit with both the burner motor and the ignition device;
 - a thermostat;
 - a control circuit for placing the triac in a conductive condition to energize both the burner motor and the ignition device in response to operation of the thermostat;
 - a flame detector coupled to the control circuit for providing a flame indication in response to operation of the burner;
 - means coupled to said control circuit for disabling the ignition device in response to a flame indication;
 - a thermal delay switch for disabling the burner motor in response to being heated to a given extent;
 - a first heater connected in said control circuit for heating said thermal delay switch during the time period beginning with operation of the thermostat and ending with production of a flame indication;
 - and a second heater connected in circuit with the ignition device for heating said thermal delay switch during operation of the ignition device.

2. The combustion control circuit of claim 1, said thermal delay switch being connected in series with said triac.

3. A combustion control circuit for a fuel burner used to heat a space and including a burner motor and an ignition device, said combustion control circuit comprising:

a switching means coupled to both the burner motor and the ignition device and operable to energize the burner motor and ignition device simultaneously;

a flame detector disposed adjacent the fuel burner to provide a flame indication;

a thermostatically controlled switch in the heated space movable to an operating position in response to a demand for heat;

a first control means coupled to said switching means and to said thermostatically controlled switch for operating said switching means in response to movement of said thermostatically controlled switch to the operating position;

a second control means coupled to said ignition device and to said flame detector for discontinuing operation of said ignition device in response to a flame indication;

a thermal delay switch connected to the burner motor for preventing operation of the burner motor in response to being heated to a predetermined extent;

a first heater adjacent said thermal delay switch and connected to said first and second control means for energization during operation of said first control means prior to operation of said second control means; and

a second heater adjacent said thermal delay switch and connected to said ignition device for energization during operation of said ignition device.

4. The combustion control circuit of claim 3, said switching means comprising a triac.

5. The combustion control circuit of claim 4, said thermal delay switch being connected in series with said triac.

6. The combustion control circuit of claim 5, said first control means including relay means having a winding means and having a contact means connected in controlling relation to said triac, and an SCR having output electrodes and a gate electrode, said thermostatically controlled switch being coupled to said output electrodes, and said flame detector being connected to said gate electrode.

7. The combustion control circuit of claim 6, said flame detector comprising a light sensitive variable resistor, a bridge circuit including said detector in one leg, means for driving said bridge with a regulated driving signal, and a capacitor coupled to the bridge output and to the gate electrode of the SCR.

8. The combustion control circuit of claim 5, said second control means comprising a coupling transformer connected between said flame detector and said ignition device.

9. The combustion control circuit of claim 5, said second control means comprising a relay connected between said flame detector and said ignition device.

10. The combustion control circuit of claim 5, said second control means comprising a lamp and light sensitive resistor connected between said flame detector and said ignition device.

11. A combustion control circuit for a fuel burner comprising:

control means for operating the burner in response to energization of the control means;

a controlled conduction device including electrodes forming an output electrode pair and a control electrode pair;

said output electrode pair being coupled to said control means for controlling the energization thereof;

a variable resistance flame detection device disposed in flame sensing relation to the burner;

a resistance bridge having opposed input and output terminals and having one leg including said flame detection device and having three legs including only fixed resistance; and

driving signal means coupled between a source of operating potential and said bridge input terminals;

said bridge output terminals being coupled to said control electrode pair of said controlled conduction device.

12. The combustion control circuit of claim 11, said controlled conductive device comprising an SCR.

13. The combustion control circuit of claim 11, said detection device comprising a photoelectric cell.

14. The combustion control circuit of claim 11, said driving signal means including a zener diode.

15. The combustion control circuit of claim 11, said flame detection device having dark and light resistance conditions, said fixed resistances being chosen so that the bridge is unbalanced in response to the absence of flame and oppositely unbalanced in response to the presence of flame.

16. A combustion control circuit for controlling a fuel burner installation including a burner motor and an ignition circuit of the type including an ignition circuit gated device periodically rendered conductive by a gating signal to create a burner ignition condition, said combustion control circuit including:

motor start means and motor hold means coupled to the burner motor for sequentially initiating and then maintaining operation of the burner motor;

a normally conductive controlled conduction device including electrodes forming an output electrode pair and a control electrode pair;

said output electrode pair being coupled to said motor start means for controlling the energization thereof;

a variable resistance flame detection device disposed in flame sensing relation to the burner;

a resistance bridge having opposed input and output terminals and having one leg including said flame detection device; and

driving signal means coupled between a source of operating potential and said bridge input terminals;

said bridge output terminals being coupled to said control electrode pair of said controlled conduction device for rendering said controlled conduction device nonconductive in response to detection of flame to disable said motor start means;

and an ignition disabling circuit coupled between said output electrode pair and the ignition circuit gated device for disabling the gated device in response to detection of flame.

17. A combustion control circuit for a fuel burner installation of the type including a burner motor and an ignition circuit having an active element, said combustion control circuit comprising in combination:

a triac having a gate electrode and having output electrodes connected in current supplying relation between a power source and both said motor and said ignition circuit;

a thermal switch connected in current supplying relation with the motor;

a flame sensitive variable resistance device adjacent the burner;

a bridge circuit including said device in one leg;

means for driving said bridge with a regulated voltage;

a capacitor connected to said bridge for storing a potential corresponding to the balance condition of the bridge;

a controlled conduction device having a control electrode coupled to said capacitor for conduction in response to the absence of flame and for nonconduction in response to the absence of flame;

a relay having pull-in winding means and hold winding means and having a normally open set of contacts coupled to the gate electrode of said triac;

means including a thermostat for energizing said hold winding means and said controlled conduction device in response to a demand for heat;

said pull-in winding means being connected for energization by said controlling conduction device;

an ignition disabling means coupled between said controlled conduction device and the ignition circuit active element for disabling the active element in response to nonconduction of said controlled conduction device;

a first heater for said thermal switch connected in circuit with said pull-in winding means; and

a second heater for said thermal switch connected in circuit with said ignition circuit.

18. The circuit of claim 17, said thermal switch being in series with said triac.

19. The circuit of claim 17, said controlled conduction device comprising an SCR.

20. The circuit of claim 17, said thermostat being in series with said triac.

21. The circuit of claim 17, said thermostat being connected in current supplying relation to said pull-in winding means and said hold winding means.

22. The circuit of claim 17, said disabling means comprising a transformer.

23. The circuit of claim 17, said disabling means comprising a relay.

24. The circuit of claim 17, said disabling means comprising a lamp and a light sensitive resistance.

25. A combustion control circuit for a fuel burner and for an ignition circuit including an ignition circuit SCR and including a gating circuit for periodically applying a gating signal to the cathode and gate electrodes of the ignition circuit SCR for producing an ignition condition, said combustion control circuit comprising:

control means for operating the burner in response to energization of the control means;

a solid state controlled conduction device having a control electrode and having output electrodes coupled to said control means for controlling the energization thereof;

a flame detection circuit coupled to the control electrode of said solid state controlled conductive device for rendering said device nonconductive in response to detection of burner flame; and

an ignition disabling circuit coupled between said solid state controlled conduction device and said ignition circuit;

said disabling circuit including a transformer having one winding connected across the output electrodes of the solid state controlled conduction device and having another winding connected across the cathode and gate electrodes of the ignition circuit SCR to reverse bias the ignition circuit SCR in response to nonconduction of said solid state controlled conductive device.

A combustion control circuit for a fuel burner and for an ignition circuit including an ignition circuit SCR and including a gating circuit for periodically applying a gating signal to the cathode and gate electrodes of the ignition circuit SCR for producing an ignition condition, said combustion control circuit comprising;

control means for operating the burner in response to energization of the control means;

a solid state controlled conduction device having output electrodes coupled to said control means for controlling the energization thereof;

a flame detection circuit coupled to the control electrode of said solid state controlled conduction device for rendering said device nonconductive in response to detection of burner flame; and

an ignition disabling circuit between said solid state controlled conduction device and said ignition circuit;

said disabling circuit including a lamp connected across the output electrodes of the solid state controlled conduction device and a light sensitive resistance connected across the cathode and gate electrodes of the ignition circuit SCR to prevent gating of the ignition circuit SCR in response to nonconduction of said solid state controlled conduction device.

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