

[54] **BURNER FLAME DETECTION CIRCUIT**

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[56] **References Cited**

**UNITED STATES PATENTS**

|           |         |               |          |
|-----------|---------|---------------|----------|
| 3,610,790 | 10/1971 | Lindberg..... | 431/78 X |
| 3,649,156 | 3/1972  | Conner .....  | 431/78   |
| 3,705,783 | 12/1972 | Warren .....  | 431/78 X |

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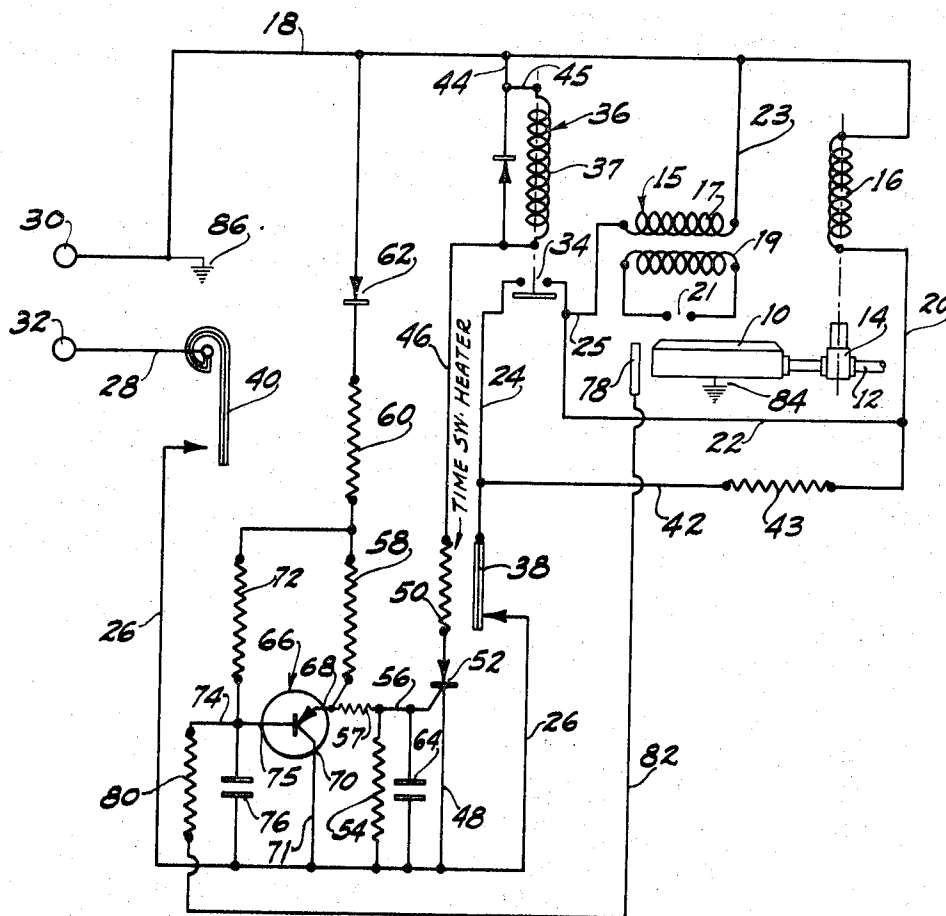
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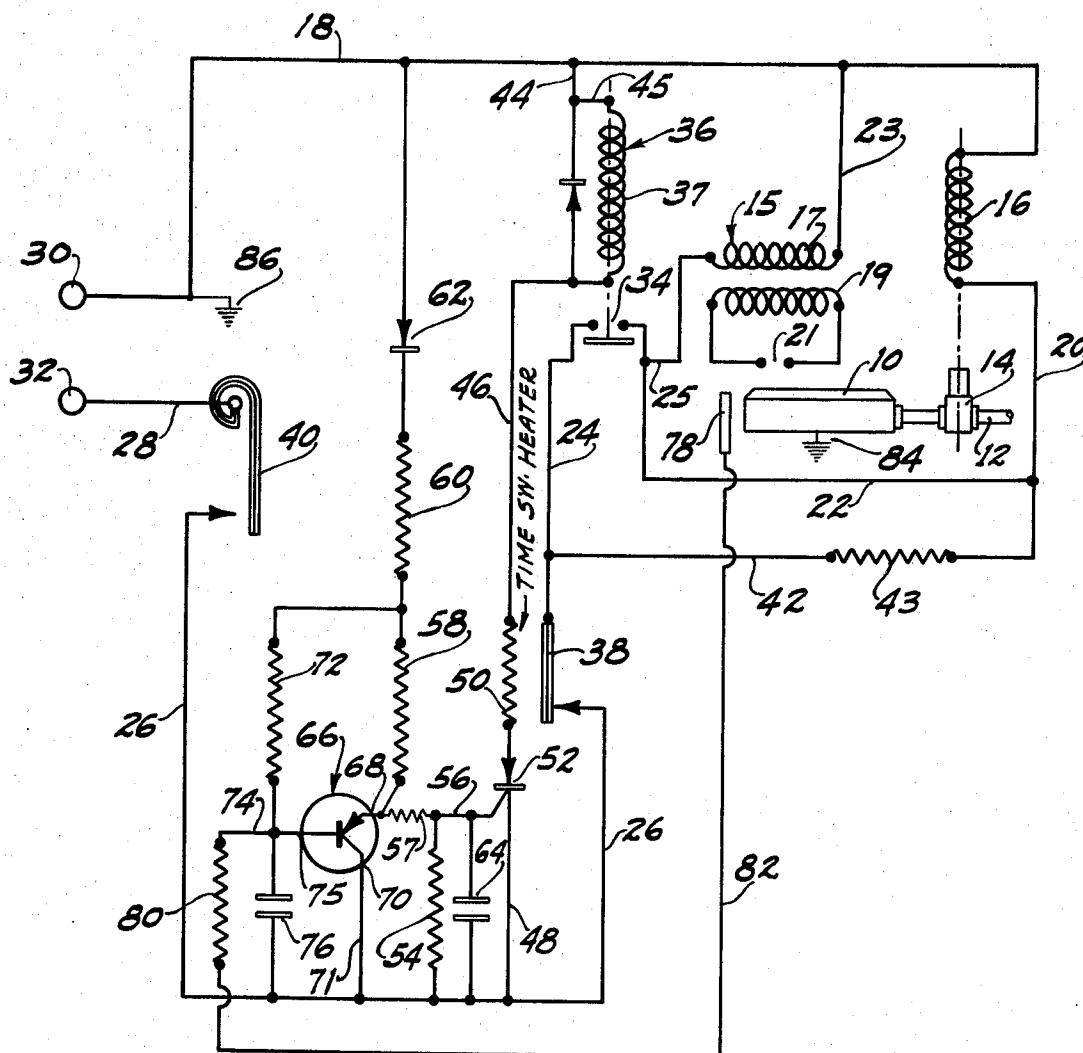
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**ABSTRACT**

A control system for gas burners operating on a.c. power in which a first circuit including a normally open relay and the heater for a thermal time switch is completed through a normally conducting SCR and a space thermostat and a second circuit including an igniter, a normally closed solenoid fuel valve, and the thermal time switch is completed through the relay contacts and the thermostat. A normally conducting transistor is operative to shunt the gating of the SCR and effect its cutoff, but a capacitor charged through a diode and a high resistance when the thermostat closes cuts off transistor conduction, whereby the SCR conducts. When combustion occurs, the capacitor discharges through burner flame, whereby the transistor again conducts and SCR conduction is cut off. A holding circuit completed through the thermal time switch maintains the solenoid fuel valve open when burner flame appears, but operation of the igniter is cut off.

**8 Claims, 1 Drawing Figure**





### BURNER FLAME DETECTION CIRCUIT

This invention relates to control systems for the safe and automatic operation of fluid fuel burners which include means responsive to the conduction of electrical current through the burner flame to permit the continued supply of fuel to the burner and operative in the absence of such flame to cut off the fuel supply in a predetermined short period of time after supply of fuel to the burner is initiated upon starting burner operation or following a subsequent flame failure once it is established.

An object of the invention is to provide a generally new and improved control system for the safe and automatic operation of gas burners which is reliable, simple, and economical to construct.

A further object is to provide a burner control system including novel and reliable means responsive to the conduction of electrical current through the burner flame to permit a continued supply of fuel to the burner and operative in the absence of flame to cut off the flow of fuel to the burner in a short period of time.

A further object is to provide a control system of this kind in which the flame conduction responsive means is particularly sensitive and responds to very small flow of electrical current through the burner flame.

A further object is to provide a control system of this kind including a thermal time switch operative to provide a trial period in which to establish ignition and in which the flame conduction responsive means renders the thermal time switch inoperative to terminate the trial period.

A further object is to provide a control system of this kind including an igniter, the operation of which is terminated upon the appearance of flame but is re-established substantially instantaneously upon flame failure during operation of the burner.

Further objects and advantages will appear from the following description when read in connection with the accompanying drawing.

The single FIGURE of the drawing is a schematic illustration of a burner control system constructed in accordance with the present invention.

Referring to the drawing, fuel is supplied to a gas burner through a fuel supply conduit 12. A normally closed solenoid valve 14 in conduit 12 having an electromagnetic winding 16 controls the flow of fuel to the burner 10. A first circuit comprising the leads 18, 20, 22, 24, 26, and 28 connects the solenoid winding 16 across a.c. power source terminals 30 and 32 through the normally open contacts 34 of a relay 36 when these contacts are closed. A normally closed bimetal safety switch 38 and a space thermostat 40 are also series connected in this circuit.

A second circuit comprising the leads 18 and 20, a lead 42, and the leads 24, 26, and 28 connects the solenoid winding 16 across the terminals 30 and 32 in series with a current limiting resistor 43, the bimetal safety switch 38, and thermostat 40. The first-described circuit when completed by closure of the thermostat 40 and the relay contacts 34 energizes the solenoid winding 16 sufficiently to effect the opening of valve 14 from its biased closed position. The second-described circuit when completed by closure of the thermostat energizes the solenoid winding 16 only sufficiently to hold valve 14 open once it is opened, but does not energize the winding sufficiently, due to the inclusion of resistor 43, to pull valve 14 open from its closed position.

A spark igniter generally indicated at 15 comprising a voltage step-up transformer having a primary winding 17, a secondary winding 19, and a pair of spaced spark electrodes 21 is operative when energized to ignite the adjacent burner 10. The primary winding 17 of the igniter transformer is connected in parallel with solenoid winding 16 in the first-described circuit by leads 23 and 25 so that the igniter is operative when the relay contacts 34 are closed.

The relay 36 includes an electromagnetic winding 37 which when energized closes relay contacts 34. The relay winding 37 is connected across the power source terminals 30-32 by leads 18, 44, 45, 46, 48, 26, and 28 in series with a safety switch resistance heater 50, an SCR 52, and the thermostat 40. A gating network for SCR 52 comprising a resistor 54 connected between a gate lead 56 and the cathode side of the SCR and resistors 57, 58, and 60 connected in series with a diode 62 between the gate lead 56 and the anode side of the SCR is of such value as to effect conduction of the SCR when thermostat 40 closes. A small capacitance 64 connected in parallel with resistor 54 between the SCR gate lead 56 and the cathode side thereof operates to damp any high frequency pulses which may result from switching at thermostat 40, or from other causes, and which may otherwise momentarily fire the SCR.

A PNP transistor 66 connected between the SCR gate lead 56 and the cathode side thereof and having its emitter 68 connected to the gate of the SCR is operative when conducting to shunt the application of a firing signal to SCR 52 through the described gating network and thereby cuts off conduction of the SCR. The transistor 66 is preferably a Darlington amplifier comprising in effect a two-stage transistor amplifier, but for the purpose of simplifying the description and drawing, a single transistor 66 is illustrated. The transistor emitter 68 is also connected to the anode side of the SCR 52 through the resistors 58 and 60 and the diode 62, and the collector 70 is connected to the cathode side of the SCR in parallel with resistor 54 by a lead 71, whereby the emitter 68 is positive with respect to the collector 70 during the conductive half cycle of the SCR 52 and diode 62.

A resistor 72 (in the order of 7 megohms) having much higher resistance than series resistors 58 and 60 is connected at one end to a point between resistors 58 and 60 and at its other end to transistor base lead 74 and effects a lower potential at base 75 than exists at emitter 68, and the transistor is therefore forwardly biased. A capacitor 76 connected between the base lead 74 and the collector side of transistor 66 charges through the high resistance 72, resistor 60, and diode 62 during the conductive half cycles of diode 62. The capacitance of capacitor 76 is such that it requires approximately one second to fully charge it through the high resistance 72. When following closure of thermostat 40 the capacitor 76 becomes fully charged, current ceases to flow through resistor 72 while current continues to flow through resistor 58, so that a higher potential now exists at the transistor base 75 than at the emitter 68. Conduction of the transistor therefore ceases and, as a result, SCR 52 becomes conductive, whereby the relay 36 closes and fuel is supplied to the burner, the igniter becomes operative, and resistance heater 50 is energized.

A conductive probe 78 adjacent the burner 10 is connected to the transistor base lead 74 through a resistor

80 by a lead 82. The probe 78 is arranged adjacent the burner 10 in a position to be impinged by burner flame when the burner is operating normally. The burner is constructed of electrically conductive material and is grounded at 84. The system is also grounded at 86 on the emitter side of the transistor 66, so that when a normal flame exists at the burner 10, a discharge path for capacitor 76 is provided from the transistor base 75 through the probe and burner flame to ground during the non-conductive half cycles of diode 62 when supply terminal 32 is positive. The discharging of capacitor 76 through the burner flame at a greater rate during the non-conductive half cycles of diode 62 than it can be charged through high resistance 72 during the conductive half cycles of the diode will again result in a voltage drop across resistor 72 and re-establish and forward biasing of the transistor 66 and, consequently, the cutoff of SCR 52.

Inasmuch as an intermittent unidirectional current flows through relay winding 37, a diode 88 is connected across the winding in opposed polarity to SCR 52 so as to permit continued current flow through the winding when the SCR cuts off each half cycle. The full filtering effect of an inductance in series with a rectifier is therefore achieved.

### OPERATION

When thermostat 40 closes to start operation of the burner, the transistor 66 is conductive and prevents the gating of SCR 52. The capacitor 76 is, however, now charging through resistors 72 and 60 during the conductive half cycles of diode 62. There being no burner flame at this time to provide a discharge path for capacitor 76 during alternate half cycles, the capacitor becomes fully charged in a short period of time, in the order of one second. When the capacitor 76 is charged, conduction through the transistor 66 is cut off and the SCR 52 becomes conductive.

When SCR 52 conducts the relay 36 is energized and its contacts 34 close, causing the solenoid valve 14 to open to admit fuel to the burner 10. Operation of the spark igniter 15 and energization of the thermal time switch heater 50 also occur when relay contacts 34 close. When the fuel is ignited and flame is established at the burner, capacitor 76 will discharge to ground through the flame during the non-conductive half cycles of diode 62 when terminal 32 is positive with respect to terminal 30 and current will again flow through high resistance 72, which results in the forward biasing and conduction of transistor 66.

Conductance of transistor 66 shunts the application of a firing signal to SCR 52 and cuts off conduction thereof. Cutoff of SCR 52 de-energizes relay 36 and its contacts 34 reopen, which results in the de-energization of the thermal time switch resistance heater 50 and breaks the pull-in circuit for solenoid valve 16. The spark igniter is also de-energized at this time. The solenoid valve is, however, held open due to the holding circuit, which includes the resistor 43, paralleling the relay contacts 34, so that fuel continues to flow to the burner, which will now continue to operate until thermostat 40 opens.

If, during the start of burner operation, the fuel does not ignite in a predetermined short period of time following the opening of valve 14, the resistance heater 50, in series with relay winding 36, will cause the bimetal safety switch 38 to open, thereby de-energizing

the solenoid winding 16 and cutting off fuel to the burner. The safety switch will remain open under these conditions so long as thermostat 40 remains closed, so that in order to restart, the circuit will have to be opened at the thermostat or other switching point and remain open until bimetal safety switch 38 cools and closes.

If, during normal burner operation, the flame at the burner is extinguished for any reason, the discharge path for capacitor 76 will be broken and the capacitor will again be charged, thereby cutting off conduction of transistor 66 and resulting in re-establishing conduction of SCR 52. When conduction of the SCR is re-established, the resistance heater 50 is again energized and igniter 15 becomes immediately operative. If, under these conditions, flame is again established, the burner will now continue to operate normally until the thermostat opens. If flame is not re-established in a predetermined short period of time under these conditions, the safety switch 38 will open and remain open.

If, during normal burner operation, the electrical power supply fails momentarily, resulting in closure of the solenoid valve 14 and extinguishing of the burner flame, the solenoid will not be reopened upon restoration of electrical power through the holding circuit including resistor 43. Under these conditions, the valve will only be reopened through the pull-in circuit including relay contacts 34 when the relay winding and the series connected safety switch heater 50 are again energized by conduction of SCR 52 and the igniter is operative.

It will be seen that a firing signal is simultaneously applied to the transistor 66 and to the SCR 52 when thermostat 40 closes. Because a short period, in the order of one or two seconds, is required to fully charge capacitor 76 through the high resistance 72, the transistor 66 will be conducting during this short period and will effectively shunt the application of a firing signal to the SCR. However, the pulse applied to the SCR upon closure of the thermostat may cause it to conduct for an instant before conduction through the transistor is effective to shunt out the SCR signal. This frequently results in a momentary closure of relay 36, followed by a reopening of the relay during the short period of conduction of transistor 66, and, then, the reclosing of the relay when capacitor 76 becomes fully charged. While this action would not affect the operation of the system, it would frequently result in the momentary closing and reopening of relay 36 and the solenoid valve 14, with the attending, objectionable, unnecessary sound and wear. The relatively small capacitor 64 connected between the gate lead and the cathode side of SCR 52 precludes this action by shunting this firing pulse to the SCR, which would otherwise occur upon closure of the thermostat. It also precludes the application of a firing pulse to the SCR, which would otherwise occur upon opening of the thermostatic switch 40 at a time when, due to the presence of burner flame and signal conduction therethrough, the transistor 66 and SCR 52 are normally not conducting.

It will be seen that the foregoing system, shown as described, provides for the operation of a conventional spark igniter 15 and a conventional solenoid valve 14 on full wave a.c. supply current under the control of flame responsive means, which due to its simplicity and economy of construction provides only half-wave current to effect a trial period during absence of flame.

We claim:

1. In a burner control system, an a.c. power source, a burner ignition means, a biased closed solenoid fuel valve having a winding, a normally closed bimetal safety switch, a space thermostat, and a relay having a winding and normally open contacts; circuit connections connecting said solenoid winding in series with said safety switch across said power source through said relay contacts and said thermostat when they are closed, and circuit connections connecting said solenoid winding and said safety switch across said power source through said thermostat independent of said relay contacts; a resistance heater operative when energized to heat said bimetal safety switch and open it in a predetermined short period of time, and unidirectional, signal-controlled, solid state switching means; circuit connections connecting said relay winding, said resistance heater, and said solid state switching means across said power source; gating means operative to apply a firing signal to said solid state switching means thereby to effect half-wave energization of said relay winding and said resistance heater; and means including transistor amplifying means responsive to burner flame conduction to shunt said SCR gating means when combustion occurs.

2. The system claimed in claim 1 in which said circuit connections connecting said solenoid winding and said safety switch across said power source independently of said relay contacts includes a current limiting resistor, which current limiting resistor has a value which permits sufficient energization of said solenoid winding to hold said solenoid valve open but prevents sufficient energization thereof to pull said valve open against its closing bias.

3. A burner control system operating on an a. c. power source comprising; a burner, a spark igniter, a normally closed solenoid valve having a winding, a current limiting resistor, a normally closed bimetal safety switch, a space thermostat, and a relay having a winding and normally open contacts; circuit connections connecting said spark igniter in series with said safety switch across said power source through said relay contacts and said thermostat when they are closed, circuit connections connecting said solenoid winding in parallel with said spark igniter and in series with said safety switch across said power source through said relay contacts and said thermostat when they are closed, and circuit connections connecting said solenoid winding, said current limiting resistor, and said safety switch across said power source and through said thermostat independently of said relay contacts; a resistance heater operative when energized for a predetermined short period to open said safety switch, and signal controlled solid state switching means; circuit connections connecting said relay winding, said switching means, and said resistance heater across said power source through said thermostat, gating means operative to apply a firing signal to said switching means to effect conduction thereof, and controlled solid state switching means responsive to signal conduction through burner flame, 60

when it appears, to shunt said gating means, whereby energization of said resistance heater and said igniter is cut off substantially instantaneously upon the appearance of burner flame and whereby said igniter is rendered operative substantially instantaneously upon a subsequent loss of burner flame so as to be operative during the predetermined period required to open said safety switch following loss of flame.

4. In a burner control system operating on an a.c. power source, a burner, electrically operated fuel supply means, ignition means, a space thermostat, and a normally closed thermal time switch; first circuit means controlled by said thermostat series connecting said fuel supply means and said thermal time switch across said power source; a resistance heater operative when energized for a short period to open said thermal time switch, and an SCR; second circuit means controlled by said thermostat series connecting said SCR and said resistance heater across said power source, gating means for said SCR including relatively low resistance means connecting the control electrode of said SCR with the anode side thereof; PNP transistor means connected between said SCR control electrode and the cathode side thereof and being so arranged and operative when conducting to shunt said SCR gating means and cut off conduction; means forward biasing said transistor means comprising relatively high resistance means connecting the base of said transistor means to the anode side of said SCR and a capacitor connected between said base and the cathode side of said SCR; said forward biasing means including diode means of SCR polarity in series with said high resistance means and operative to effect the full charging of said capacitor during the conductive half cycles thereof thereby to reverse bias and cut off conduction of said transistor means; and circuit means including an air gap arranged to be bridged by burner flame connecting said transistor base to ground thereby to provide a discharge path for said capacitor during the non-conductive half cycles of said diode when burner flame is present.

5. The control system claimed in claim 4 which further includes relay means operative to connect said ignition means across said power source when said SCR is conducting in the absence of burner flame.

6. The control system claimed in claim 4 in which the relative values of said capacitor and said high resistance means are such as to require a plurality of conductive half cycles to fully charge said capacitor.

7. The control system claimed in claim 4 which includes relay means in said second circuit means operative to complete said first circuit means when said SCR is conducting.

8. The control system claimed in claim 4 which includes a small capacitor connected between said SCR control electrode and the cathode side thereof operative to prevent the application of a firing pulse to said SCR upon the closure or the opening of said thermostat.

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