

[54] BURNER CONTROL APPARATUS

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[51] **Int. Cl.**..... F23n 5/12

[58] **Field of Search** 431/78, 80; 317/146

[56] **References Cited**

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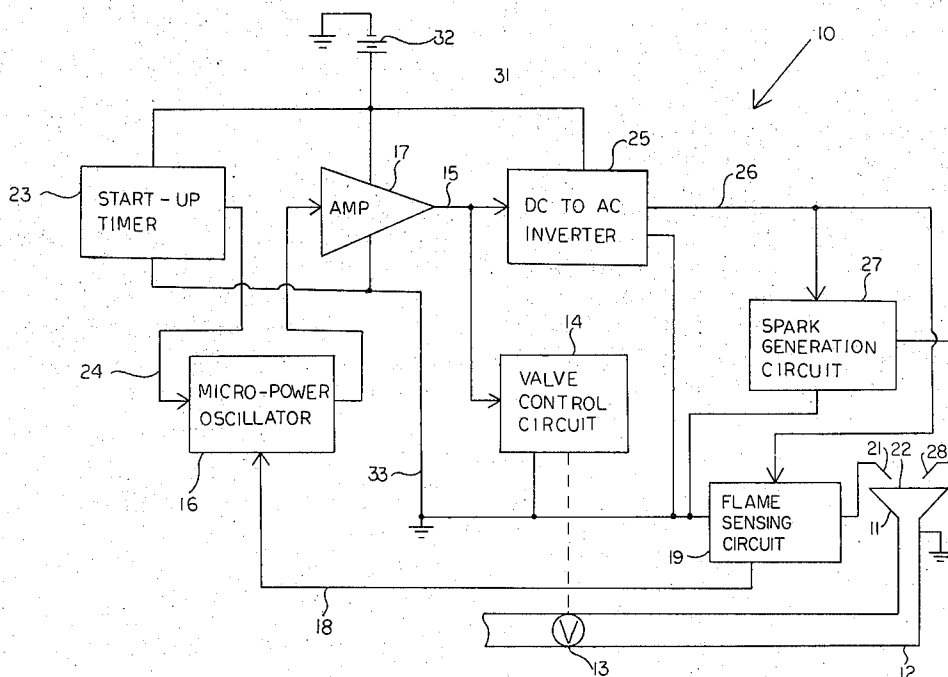
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[57] **ABSTRACT**

Disclosed is a d.c. powered burner control system having a fuel valve controlled by a micro-power oscillator exclusively powered by energy present in electrical current rectified by flame emanating from the burner. A d.c. to a.c. inverter controlled by the oscillator converts the d.c. supply into an a.c. signal applied across a region occupied by flames emanating from the burner which flame rectifies the a.c. signal to thereby produce the negative flame signal required to power the oscillator. Preferably a capacitor stores energy present in the flame rectifier current and provides operating power to the oscillator, the output of which maintains the fuel valve in an open position.

17 Claims, 6 Drawing Figures



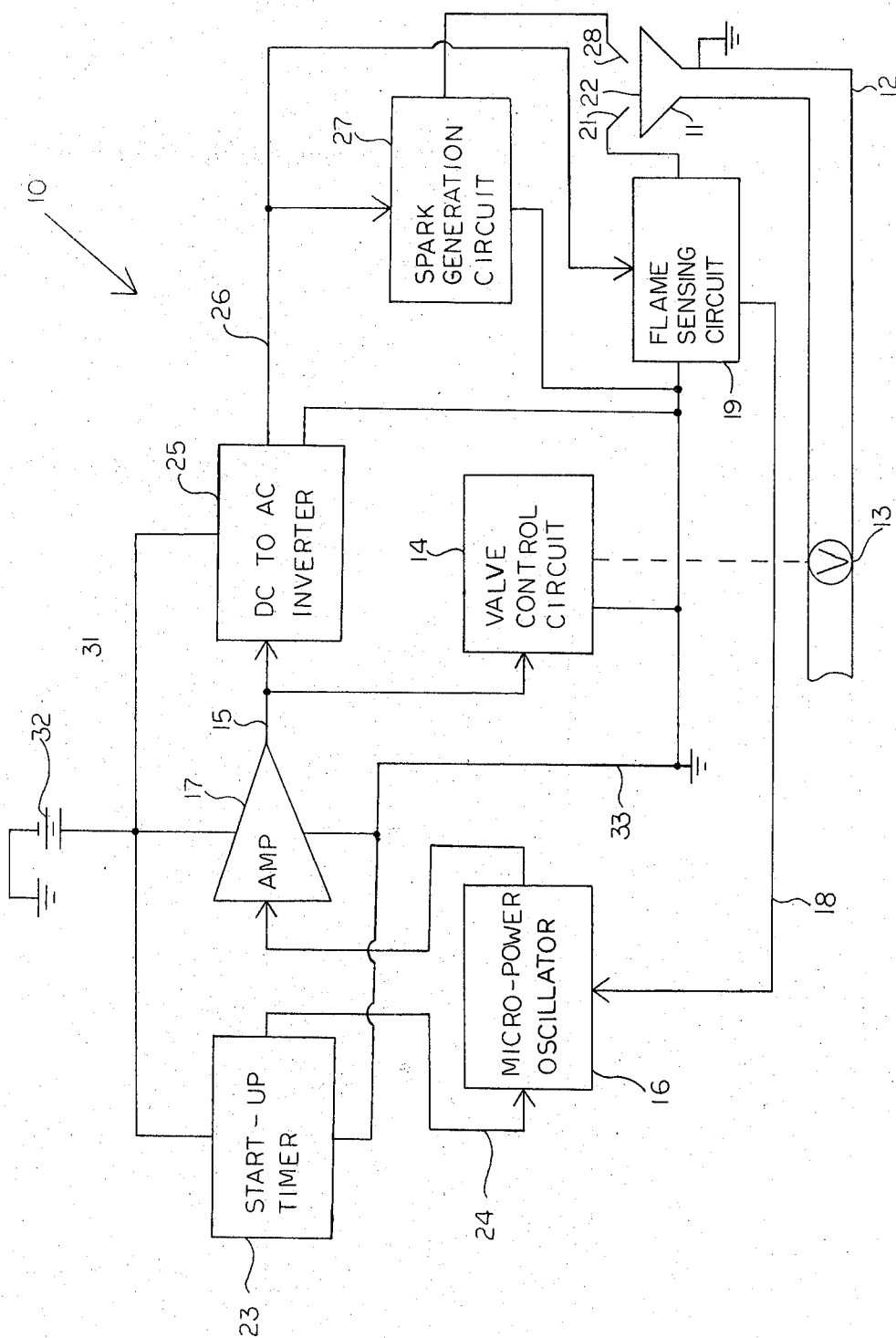


FIG. 1

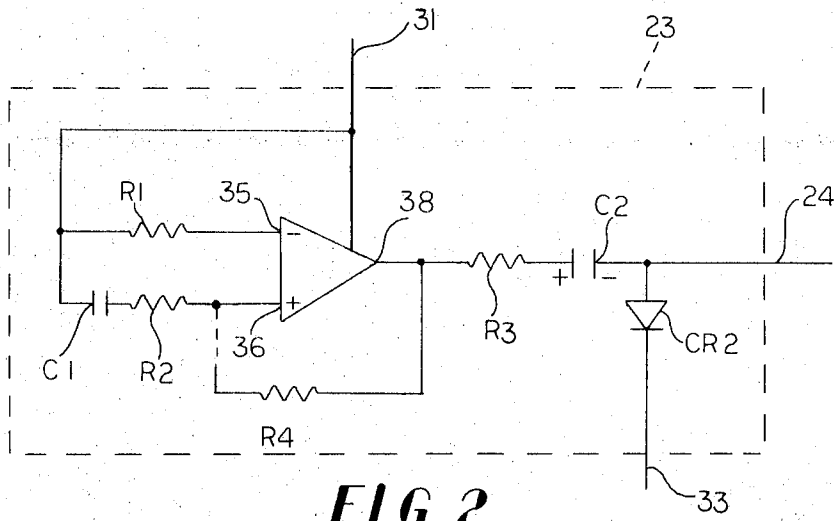


FIG. 2

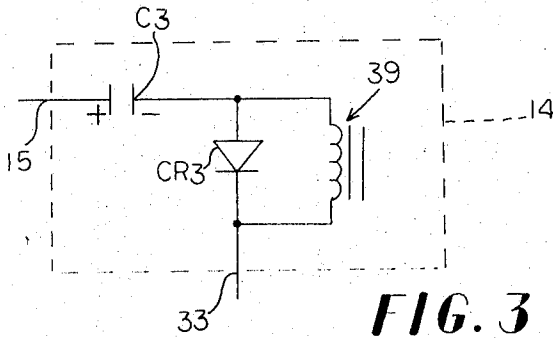


FIG. 3

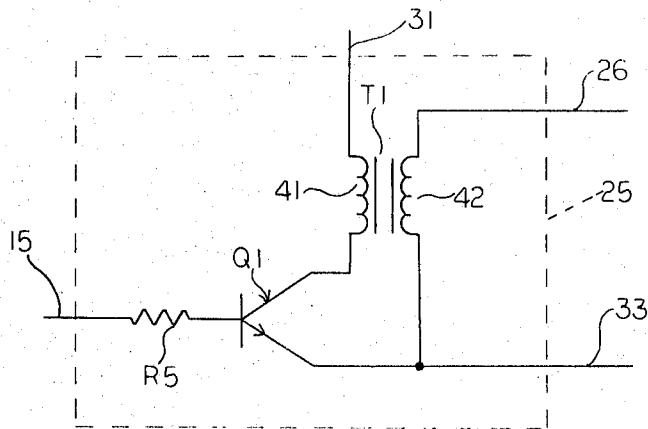


FIG. 4

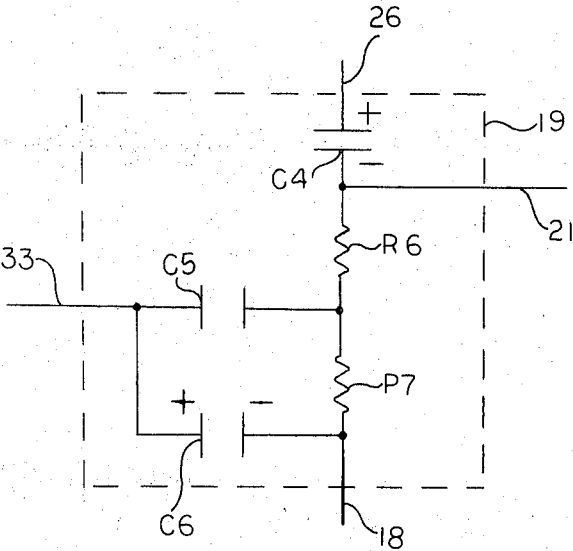


FIG. 5

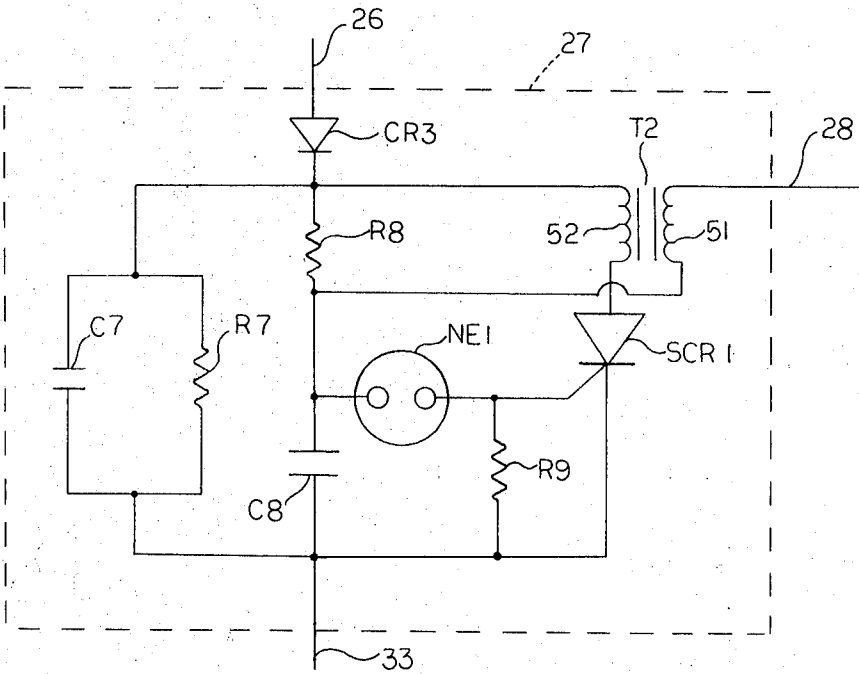


FIG. 6

BURNER CONTROL APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to burner control systems and, more particularly, to fail safe burner control systems.

Extensive efforts have been directed toward the improvement of control systems for fuel burners such as gas and oil burners and the like. Increased system safety and reliability have been primary objectives of such efforts. These objectives, however, generally conflict with an obvious desire to limit the cost and physical size of the systems. Thus system complexity is an important consideration.

Such systems often ignite the fuel with a spark igniter. Interest has recently been directed toward systems that extinguish the spark after ignition to eliminate radio frequency interference. However, circuits to extinguish the spark have greatly added to the complexity of the control circuit. This is particularly true since it is required that if flame is lost for any reason, the system must respond in one of two ways. Either the valve must be closed to stop the flow of fuel, or, as is preferable if heat is still required, the ignition apparatus must be reactivated in an effort to reestablish flame.

In addition, most burner systems must employ fuel supply valves that are controlled by flame sensing mechanisms which automatically interrupt fuel flow in response to a predetermined loss of flame condition. In accordance with the above requirements, circuits have been designed wherein the spark apparatus is responsive to the flame sensor so that when flame is detected the igniter is stopped and upon loss of flame the igniter is activated to reestablish flame. A difficulty encountered with these circuits is their complexity; for example, often a plurality of feedback loops, or the like, is used. A danger in having such a complex system is that failure of one or more circuit components can cause an unsafe condition as, for example, a situation in which the valve remains open but the ignition apparatus is not activated. An explosive amount of fuel may thereby enter the combustion chamber.

Many conventional circuits provide a capacitor flame sensor that is charged by flame rectified current and a valve that opens when the charge on the capacitor exceeds a predetermined minimum. To initiate operation of some circuits of this type, the capacitor is precharged to open the valve and is kept charged by the rectified current if flame is achieved. If no flame is achieved before the capacitor becomes discharged, the valve closes and the system shuts down. The unsafe condition can occur in this circuit, for example, if flame is lost or never established, but a malfunction in the precharging circuit keeps the capacitor charged and thus the valve open. Other problems in circuits of this type result from line powered amplification stages utilized before the low energy flame signal and the valve control circuit responsive thereto. In certain instances, the line power can introduce false signals not distinguishable from the flame signal and therefore effective to cause improper and sometimes dangerous operation. Although relatively complex and expensive fail safe burner control systems eliminating most of these problems have been disclosed, most have not been capable of d.c. powered operation.

The object of this invention, therefore, is to provide a relatively inexpensive, d.c. powered burner control system that automatically activates an igniter to reestablish flame in the event of a loss thereof but that closes a fuel supply valve if a failure to establish flame occurs, either initially or after a loss of flame. It is further desired that the system be fail safe, that is, not subject to unsafe operation in response to either malfunction of any component or group of components or to inadvertently introduced false signals.

SUMMARY OF THE INVENTION

This invention is characterized by the provision of a d.c. powered burner control system having a fuel valve controlled by a micro-power oscillator exclusively powered by energy present in electrical current rectified by flame emanating from the burner. A d.c. to a.c. inverter controlled by the oscillator converts the d.c. supply into an a.c. signal applied across a region occupied by flames emanating from the burner which flame rectifies the a.c. signal to thereby produce the negative flame signal required to power the oscillator. Preferably a capacitor stores energy present in the flame rectified current and provides operating power to the oscillator, the output of which maintains the fuel valve in an open position.

Start-up of the system is provided by a power supply capacitor that is charged from the d.c. supply and temporarily provides power to the oscillator and accordingly fuel flow to the burner. In one state a sequential switch connects the positive d.c. supply to the end of the supply capacitor opposite to that end connected to the oscillator and thereby allows the supply capacitor to become charged. In a second state, the sequential switch connects circuit common to that opposite end of the supply capacitor so as to induce discharge of operating power into the oscillator. An R.C. timing network controls the state of the sequential switch so as to insure a predetermined charging period for the supply capacitor.

A preferred embodiment of the invention includes a spark generating system for igniting fuel emanating from the burner. The spark ignition system includes a converter that converts the a.c. signal from the inverter into a d.c. ignition supply current that is stored in a storage capacitor and periodically discharged by a trigger circuit into the primary of the spark transformer so as to generate ignition sparks in the secondary circuit thereof. Connected to a spark timing capacitor in the trigger circuit is a leakage circuit including a gap in the region occupied by flame at the burner. The presence of flame completes the leakage circuit so as to prevent buildup of charge in the spark timing capacitor and thereby terminate the generation of sparks.

DESCRIPTION OF THE DRAWINGS

These and other objects and features of the invention will become more apparent upon a perusal of the following description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a block circuit diagram illustrating a preferred embodiment of the invention;

FIG. 2 is a schematic circuit diagram of the start-up timer shown in FIG. 1;

FIG. 3 is a schematic circuit diagram of the valve control circuit shown in FIG. 1;

FIG. 4 is a schematic circuit diagram of the inverter shown in FIG. 1;

FIG. 5 is a schematic circuit diagram of the flame sensor circuit shown in FIG. 1; and

FIG. 6 is a schematic circuit diagram of the spark generation circuit shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 there is schematically shown a burner control system 10 having a conventional fuel burner 11 that is supplied with a suitable fuel, for example, gas, by a fuel line 12 that includes a supply valve 13. Opening and closing of the valve 13 is controlled by a valve control circuit 14 that receives on line 15 an oscillating signal of, for example, 1,000 Hz. provided by a micro-power oscillator 16 requiring, for example, only 5 micro-watts of power and amplified by an amplifier 17. Operating power for the oscillator 16 is provided on line 18 by a flame sensing circuit 19 having a flame electrode 21 mounted in a region 22 occupied by flame emanating from the burner 11. A temporary source of power for initiating operation of the system is provided to the oscillator 16 by a start-up timer 23 on line 24. Also receiving the oscillating signal on line 15 is an inverter 25 that supplies on line 26 an a.c. signal to the flame sensing circuit 19 and to a spark generation circuit 27 having a spark electrode 28 mounted in the region 22. Power is supplied to the start-up timer 23, the amplifier 17, the valve control circuit 14 and the inverter 25 on a line 31 from a positive d.c. power supply 32 of, for example, +12 volts, while all circuit components are tied together by a grounded circuit common line 33.

Referring now to FIG. 2 there is shown a schematic diagram of the start-up timer 23 shown in FIG. 1. A sequential switching operation is provided by a differential current amplifier A1 having one input 35 connected to the power supply line 31 by a resistor R1 and a second input 36 connected thereto by a series combination of a capacitor C1 and a resistor R2. A power supply capacitor C2 has one end connected to both the oscillator 16 by the line 24 and to the circuit common 33 by a blocking diode CR 2. The opposite end of the capacitor C2 is connected to the output 38 of the amplifier A1 by a resistor R3 while another hysteresis introducing resistor R4 couples the amplifier output 38 to the input 36 and insures stable switching operation.

The function of the start-up timer 23 is to activate the control system 10 when operation of the burner 11 is desired. When positive power is applied to the timing circuit 23 on input line 31, the amplifier A1 is turned on providing a positive output at 38 and thereby charging the supply capacitor C2 to the polarity indicated in FIG. 2. During this initial state, the timing capacitor C1 is charging through the resistor R2 providing the predominant input signal current that establishes the desired output at 38 which is on. As the timing capacitor C1 charges, the input current diminishes and after a short period of, for example, 4 seconds, the input current to 36 falls below the input level provided by R1 thereby causing the amplifier output at 38 to switch to an off state. This switching off of the output is equivalent, of course, to tying the positive end of the supply capacitor C2 to circuit common through the resistor R3 and the amplifier A1. Thus from the positive supply

32, the capacitor C2 then provides on line 24 a temporary negative supply required to operate the oscillator 16 the output from which initiates a try for ignition period as described in greater detail below.

Referring now to FIG. 3 there is shown a schematic diagram of the valve control circuit 14 shown in FIG. 1. The oscillating signal provided by the oscillator 16 drives the amplifier 17 alternately between cut-off and saturation producing an oscillating square wave signal of, for example, between zero and +12 volts. This square wave signal on line 15 is applied to one end of a capacitor C3 the other end of which is connected to circuit common 33 by the parallel combination of a diode CR3 and a coil 39 that operates the valve 13 shown in FIG. 1. During half cycles when the square wave amplifier output on line 15 is positive, the capacitor C3 is charged to the polarity indicated in FIG. 3 through the diode CR3 while on alternate half cycles with the output cut off, the diode CR3 blocks and the capacitor C3 is discharged back through the amplifier 17 into the valve coil 39. In this way power is supplied to the valve coil 39 maintaining the valve 13 open. The inductance of the valve coil 39 maintains fly-back current flow through CR3 thereby insuring smooth operation of the valve 13. It will be appreciated that failure of any component in the valve control circuit 14 will prevent the flow of power to the coil 39 and thereby insure fail safe closure of the valve 13.

Referring now to FIG. 4 there is shown a schematic diagram of the inverter circuit 25 shown in FIG. 1. The oscillating square wave provided by the amplifier 17 on line 15 is applied through a resistor R5 to the base of a transistor Q1. A step up transformer T1 has a primary winding 41 with one end connected to the positive supply line 31 and the other end connected to the collector electrode of the transistor Q1. The secondary winding 42 of the transformer T1 has one end connected to the output line 26 and the other end connected to both circuit common 33 and the emitter electrode of the transistor Q1. The square wave input provided by the amplifier 17 on line 15 biases the transistor Q1 on and off producing in the primary winding 41 current pulses synchronized with the output of the oscillator 16. This in turn produces on output line 26 of secondary winding 42 an a.c. signal of, for example, 120 volts and at the frequency of the oscillator 16. As described in greater detail below, this a.c. signal is utilized both to generate ignition sparks for igniting fuel at the burner 11 and to monitor the presence of flame emanating therefrom.

Referring now to FIG. 5 there is shown a schematic diagram of the flame sensing circuit 19 shown in FIG. 1. The output line 26 from the inverter 25 is connected to one end of an energy storage flame capacitor C4 the other end of which is connected to the flame electrode 21 shown in FIG. 1. The other end of the storage capacitor C4 is also connected by resistors R6 and R7 to the input line 18 to the oscillator 16 shown in FIG. 1. A pair of capacitors C5 and C6 together with the resistors R6 and R7 form filter networks between the storage capacitor C4 and circuit common 33.

The a.c. signal provided by the inverter 25 is supplied via line 26 and storage capacitor C4 across the gap between the flame electrode 21 and the grounded fuel burner 11 shown in FIG. 1. According to the well known flame rectification phenomena, flame emanating from the burner 11 in the region 22 rectifies current

flow through that path and results in charging of the storage capacitor C4 to the polarity indicated in FIG. 5. The energy thus stored in the capacitor C4 in response to flame present at the burner 11 provides on line 18 the negative supply required to power the oscillator 16. Resultant output from the oscillator activates the valve control circuit 14 to maintain the valve 13 open as described above and thereby insures the continued flow of fuel to the burner 11.

Illustrated in FIG. 6 is a schematic diagram of the spark generation circuit 27 shown in FIG. 1. Connected in series between the inverter output on line 26 and circuit common 33 is a diode CR3 and the parallel combination of an ignition storage capacitor C7 and a resistor R7. A trigger circuit includes a series combination of a resistor R8 and a capacitor C8 connected in parallel with the storage capacitor C7, and a neon tube NE1 connected between the junction of the resistor R8 and capacitor C8 and gate of a silicon controlled rectifier SCR1. That junction is also connected to the ignition electrode 28 by a secondary winding 51 of an ignition transformer T2 having a primary winding 52 connected in series with the SCR1, across the storage capacitor C7. Another resistor R9 is connected between circuit common 33 and the junction between the neon tube NE1 and the gate electrode of the SCR1.

The a.c. 80 from the inverter 25 is rectified by the diode CR3 resulting in the accumulation of charge by both the ignition storage capacitor C7 and the trigger capacitor C8. Each time the capacitor C8 reaches a given trigger level of, for example, 80 volts, the neon NE1 passes current triggering the SCR1 and rapidly discharging the ignition storage capacitor C7 through the primary winding 52 of the ignition transformer T2. The resultant high current pulses produce voltage spikes in the secondary winding 51 resulting in the generation of sparks across the gap between the spark electrode 28 and the grounded burner 11. These sparks ignite fuel emanating from the burner 11 in the region 22. In the event that ignition is achieved the resultant flame in region 22 completes a circuit between the spark electrode 28 and the grounded burner 11 allowing the trigger capacitor C8 to leak off its charge. This prevents firing of the neon NE1 and thus terminates the generation of additional sparks.

OPERATION OF THE INVENTION

When heat is desired at the burner 11, the start-up timer 23 is activated by completing a circuit to the d.c. power supply 32 via, for example, either a manual or thermostatic switch (not shown). As previously described, activation of the timer 23 produces a starting signal on line 24 that powers the oscillator 16 resulting in an oscillating output that is converted by the amplifier 17 into a square wave signal applied to both the valve control circuit 14 and the inverter 25. That signal activates the valve control circuit to open the valve 13 and initiate the flow of fuel to the burner 11. Simultaneously, the inverter 25 provides an output to the spark generation circuit 27 resulting in the generation of sparks that ignite fuel in the region 22. The presence of flame in the region 22 is detected by the spark circuit 27 which accordingly discontinues the generation of sparks and also by the flame sensing circuit 19 which responds by providing operating power to the oscillator 16 on line 18. This maintains output from the oscillator

16 to the valve control circuit 14 and insures that the valve 13 is maintained in the open position.

Assume, however, that flame is not quickly established in the manner described above. In that case, no energy is stored in the flame sensing circuit 19 for use in powering the oscillator 16. Accordingly, after a short ignition period of for example 10 seconds, the energy available in the power supply capacitor C2 (FIG. 2) will be dissipated and signal output from the oscillator 16 will terminate. The resultant cessation of square wave output from the amplifier 17 deactivates the valve control circuit 14 resulting in closure of the fuel valve 13 and thereby preventing the undesirable emission of unignited fuel from the burner 11. A subsequent try for ignition can be initiated only by opening the circuit between the power supply 32 and the start-up timer 23 to allow discharge of the timing capacitor C1 (FIG. 2). Upon subsequent application of power to the start-up timer 23, the above described operation will be repeated to again try for ignition. It will be noted however that a retry for ignition is not initiated until the timing capacitor C1 charges to a level that switches the amplifier A1 as described above. Thus, a time delay is automatically provided that will allow purging of gas from the region 22 before ignition is attempted.

If flame at the burner 11 is inadvertently extinguished, the system 10 will automatically try for reignition. Cessation of flame in the region 22 stops current leakage from the trigger capacitor C8 (FIG. 6) which therefore quickly charges to trigger the neon NE1 and initiate the generation of sparks in the region 22 as described above. To accommodate this try for reignition, fuel flow through the valve 13 is maintained by the energy stored in the flame capacitor C4 in addition to capacitors C5 and C6 (FIG. 5) which energy continues to power the oscillator 16 for a limited period of for example 5 seconds. If reignition is not attained within that period, however, the energy stored in the capacitors C4, C5 and C6 is dissipated and the valve 13 is closed. Since no energy is then available to any of the capacitors C2, C4, C5 and C6 the system is in lockout condition. Further tries for reignition require opening of the circuit between the supply 32 and the start-up timer 23.

Thus, the present invention provides a relatively simple d.c. powered burner control system having the operational features described in the Background presented above. This result is accomplished with a circuit in which malfunctioning components will not cause unsafe operation. Control of the system by the oscillator 16 powered only by the flame sensing circuit 19 or on an inherently time limited basis by the timer 23 further insures safe operation of the valve 13. In addition, the use of an oscillating control signal having a frequency substantially above 60 Hz. reduces the chance of unsafe response to inadvertently introduced false signals.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore, to be understood that within the scope of the appended claims the invention can be practised otherwise than as specifically described.

What is claimed is:

1. Burner control circuit apparatus comprising: valve means for controlling the flow of fuel to a burner;

flame sensor means for providing a source of power in response to the presence of flame at the burner;

oscillator means connected to receive power from said flame sensor means and to produce an oscillating signal in response thereto; and
valve control means for opening said valve in response to said oscillating signal.

2. Apparatus according to claim 1 including electrode means defining a gap in the region occupied by flame generated by the burner, source means for applying an a.c. signal to said electrode means, and wherein said flame sensor means comprises energy storage means connected to said electrode means and adapted to store the energy carried by current rectified by the flame.

3. Apparatus according to claim 2 wherein said energy storage means comprises flame capacitor means connected to be charged by the current rectified by the flame and to supply operating power to said oscillator means.

4. Apparatus according to claim 3 wherein said oscillator means comprises amplifier means for amplifying said oscillating signal.

5. Apparatus according to claim 3 including a d.c. supply means and wherein said source means comprises

an inverter means for producing said a.c. signal from said d.c. supply means.

6. Apparatus according to claim 5 wherein said inverter is controlled by said oscillating signal, and said oscillating signal has a frequency substantially greater than 60 Hz.

7. Apparatus according to claim 6 wherein said inverter means comprises a transformer having a primary winding, and an electronic switch operable to provide power to said primary winding from said d.c. supply means, and wherein said electronic switch means is controlled by said oscillating signal.

8. Apparatus according to claim 6 including a spark generating means for providing sparks to ignite fuel emanating from the burner, said spark generating means comprising a spark transformer and a converter means for converting said a.c. signal into a d.c. ignition supply for said spark transformer.

9. Apparatus according to claim 8 wherein said con-

verter means comprises ignition storage capacitor means for storing electrical energy, and an ignition switching means for discharging said storage capacitor means into the primary winding of said spark transformer.

10. Apparatus according to claim 9 including leakage circuit means for discharging said ignition storage capacitor, said leakage means including an open circuit portion disposed so as to be closed by flame at the burner.

11. Apparatus according to claim 9 wherein said oscillator means is a micro-power oscillator.

12. Apparatus according to claim 1 wherein said oscillator means requires an input signal of a given polarity, and including d.c. power supply of a polarity opposite to said given polarity with respect to circuit common, power supply capacitor means having one end coupled to said oscillator means, sequential switching means operable in a first state to connect said d.c. supply to an opposite end of said supply capacitor means so as to induce charging thereof and operable in a second state to connect said circuit common to said opposite end so as to induce discharge of said supply capacitor means into said load, and switch control means for changing the state of said sequential switching means.

13. Apparatus according to claim 12 wherein said switch control means comprises timing means for maintaining said sequential switching means in said first state for a predetermined charging period.

14. Apparatus according to claim 13 wherein said sequential switching means comprises a differential current amplifier with one input connected to said d.c. supply, a second input connected to said timing means and an output connected to said supply capacitor means.

15. Apparatus according to claim 14 wherein said timing means comprises an R.C. timer.

16. Apparatus according to claim 14 including resistor means connected to said supply capacitor means for controlling the discharge rate into said load.

17. Apparatus according to claim 16 including blocking means for preventing the flow of energy from said supply capacitor to said circuit common with said sequential switching means in said second state.

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