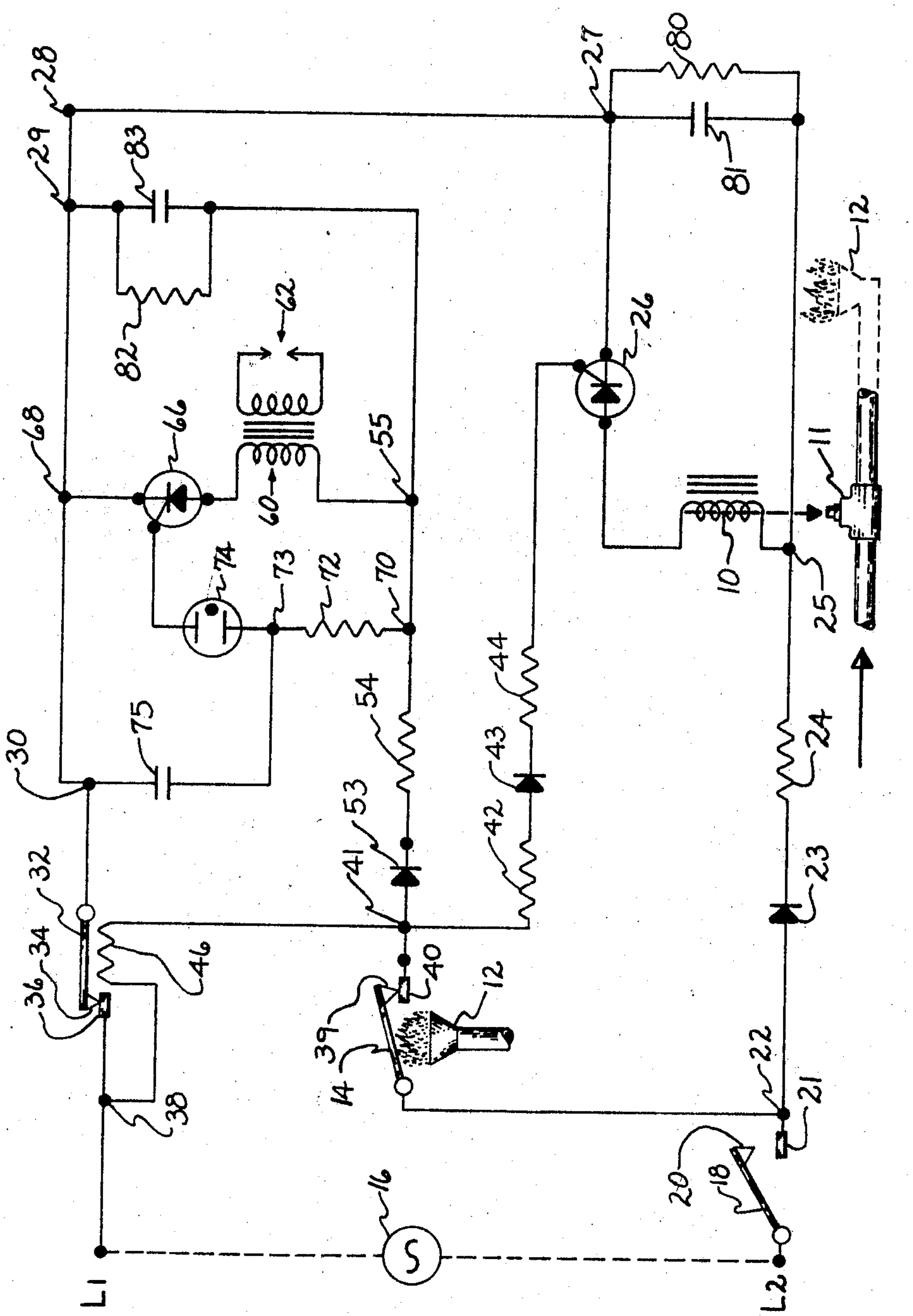
May 27, 1969 M. E. HANTACK 3,446,565

IGNITION SYSTEM

Filed June 27, 1966



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United States Patent Office

3,446,565

Patented May 27, 1969

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3,446,565
IGNITION SYSTEM

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Filed June 27, 1966, Ser. No. 560,607
Int. Cl. F23n 5/00
U.S. Cl. 431—70 10 Claims

ABSTRACT OF THE DISCLOSURE

An electrical system for the ignition of fuel wherein a spark discharge ignition device is deenergized upon ignition of fuel and wherein there is also a decrease in consumption of power from the electrical source upon such ignition.

This invention relates to electrical systems for the ignition of fuel burning devices and the like, and particularly to a gaseous fuel burner.

More specifically, the invention concerns an arrangement of the above-mentioned type which acts as a safety device for preventing dangerous situations that may develop in the event a component of the electrical installation should fail, including interruption of the power supply or the source of current, fuel flow stoppage, failure to ignite, and flame extinguishment.

These desirable features are provided by the present novel circuitry that also includes an automatic ignition system of the high-voltage spark discharge type that is deenergized upon ignition of fuel so as to increase the operating life of the ignition system, and also provides for a decrease in the consumption of power from the electrical source. This novel circuit eliminates many moving parts, and eliminates radio and television interference and noise.

The present novel ignition system employs a pair of SCR (silicon-controlled rectifiers), each being arranged parallel with respect to each other, in two more or less different circuits, with one SCR being arranged in series with the ignition transformer and the flame responsive switch, and the second being arranged in series with the solenoid of a fuel valve. The silicon-controlled rectifiers, in conjunction with a pair of diodes, change alternating current into controlled pulsating direct current that permits it to work efficiently at different current flow dependent upon the E.M.F. imposed upon the emitter. In particular, by arranging the emitter of the SCR associated with the solenoid whereby its current source is controlled in response to burner flame, the current flow through the solenoid may be adjusted to provide a high flux density for the solenoid valve actuation upon start-up, and low flux density for normal run condition so that the current flow through the solenoid is consequently maintained at the minimum amount required to supply a flux density that will hold the valve in open condition. The entire circuitry employs additional safety devices associated with the two parallel legs thereof to accordingly provide safety features generally considered either desirable or necessary for a system such as described herein.

One object of this invention is to provide for an electric igniting and fuel supply control arrangement for heating systems that require a low current drain after start-up.

Another object of this invention is to provide an electric igniting and fuel supply control arrangement that eliminates many moving parts, and reduces radio and television interference and noise to a minimum.

It is another object of this invention to provide for an arrangement of the type set forth which operates in a maner that the fuel valve is opened simultaneously with

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the activation of the ignition device, so that fuel to the burner is immediately ignited upon flow through the fuel valve.

Still another object of this invention is to provide an ignition and fuel control device which cuts off upon fuel flow stoppage, or flame failure, after one re-ignition attempt.

Other objects of this invention will become apparent to those skilled in the art from the following drawing and specification, which shows one illustrative embodiment of the invention that is also defined and embraced by the annexed claims.

Seen in the present drawing is a schematical representation of the novel ignition control system, wherein conventional circuit components are conventionally illustrated, but arranged in a novel electrical configuration. The system includes a solenoid **10** adapted to actuate a fuel valve **11** that is usually flow connected to a burner as suggested by the numeral **12**. The device includes a flame responsive switch **14** placed in heat-responsive or heat-sensing relationship to the burner, so that the normally closed switch will assume the open position when heated. A source of current, illustrated by numeral **16**, provides electrical conductor lead lines L1 and L2 with a suitable supply of current.

Looking now to the details of the figure, there is seen schematically illustrated therein a thermostat **18** which, in this particular instance, is shown as having a bi-metal strip that may be warped in accordance with the ambient temperature, so as to close contacts **20** and **21** upon heat demand and open contacts **20** and **21** when the desired temperature has been obtained. The fixed contact **21** connects to the junction **22** to provide a source of current along the two indicated electrical paths to form two circuits, the first of which flows through the diode **23**, resistance **24**, and terminal **25** where the current again splits to provide a source along two different paths, one of which supplies the SCR **26** with a current source through the solenoid **10**. The SCR **26** is further connected so as to complete its circuit along the electrical path identified by terminals **27**, **28**, **29**, and **30**, warp safety switch bi-metal portion **32**, movable contact **34**, fixed contact **36**, and terminal portion **38** so as to complete the circuit at L1. Hence, it is now clear that when thermostat **18** demands heat by moving to the closed position (opposite that shown in the figure), current flow is available to the SCR **26**, assuming contacts **34** and **36** of the warp safety switch are closed. With the emitter, or triggering portion, of SCR **26** de-energized, insufficient current will flow along the before-described path to actuate the valve **11** that is controlled by the solenoid **10**.

A second circuit, including portions of the above described circuit, provides power to the igniter **60** along the path defined by L2, thermostat **18**, terminal **22**, flame responsive switch **14**, terminal **41**, diode **53**, resistor **54**, terminal **70**, terminal **55**, ignition transformer **60**, SCR **66**, terminal **68**, terminal **30**, warp safety switch **32**, and terminal **38** which completes the circuit back to the source at L1. The last-described circuit provides for current flow through the particular circuitry involved when the system is in stand-by condition and the burner accordingly is not burning, but thermostat **18** is calling for heat. This last circuit will also cause the triggering circuits of SCR **26** and **66** to become energized by the following paths of current flow:

With the thermostat **18** and flame responsive switch **14** closed, current is available at terminal **41** where it branches into two different paths, each of which trigger the particular SCR to which it is electrically connected. The SCR **26** that actuates the solenoid **10** is triggered by a first triggering circuit wherein the current flows from terminal **41**, resistor 42, diode 43, and resistor 44 whereupon a triggering current supply is then imposed upon the SCR 26 to allow current to then flow along the first above-described path so as to energize the solenoid 10. The second path of current flow that forms the second triggering circuit from terminal 41 to the SCR 66 is along the path defined by diode 53, resistor 54, terminal 70, resistor 72, terminal 73, neon firing light or bulb 74, and to the emitter of SCR 66 which is triggered, thereby allowing a large flow or surge of current to pass through or along the second flow path that includes the ignition transformer 60.

The design of the neon firing light 74 is conventional and "fires," or becomes highly conductive, only when the voltage applied across its two terminals exceeds a predetermined critical value. The combination of the resistor 72 and the capacitor seen at 75 determine the rapidity or frequency with which the neon firing light produces an E.M.F. upon the emitter of the SCR 66. Each pulsation of current that flows across the firing light produces a large flow of current through the ignition transformer 60, and accordingly each surge of current produces a spark at electrodes 62, which are located adjacent the burner 12 that is desired to be ignited. The resistance 82 and capacitor 83 modify the action of the firing light 74 upon SCR 66 so as to produce a hot spark at the spark gap or electrodes 62.

As will be readily recognized by those skilled in the art, rectified line current from rectifier or diode 53 flows through resistors 54 and 72 to charge capacitor 75 at a rate determined by the time constant of the resistance and capacitance of elements 54, 72, and 75. The E.M.F. across capacitor 75 is applied fully across the neon lamp 74 so that when the capacitor reaches a certain critical value, the gas in the neon lamp will break down and effectively short-circuit the emitter to terminal 73. As a result, strong conduction of SCR 66 will occur through the second described circuit comprised of diode 53, igniter 60, terminals 68 and 30, and to the source through warp safety switch 32. During this process the capacitor 75 is substantially completely discharged, and neon lamp 74 becomes extinguished so that the cycle may again commence with the recharging of capacitor 75. Hence, in this manner, ignition sparks are produced at electrodes 62 at a regularly repeated rate determined by the above time constant.

The heater 46 is in heat transfer relationship with the bi-metal portion of warp switch 32 and is connected to the source through flame-responsive switch 14 and thermostat 18, which provides a series flow path of current along these series connected elements from the source of current 16 as previously detailed.

In operation, and with the ignition system in the illustrated stand-by condition of the figure, the thermostat 18 will be in its normally cold, and hence opened, position so that no current flow occurs across contacts 20 and 21, and accordingly the entire system is shut down and power consumption is zero. At this time the normally closed solenoid actuated valve 11 will be closed and no fuel will be flowing therethrough since solenoid 10 is de-energized. The flame-responsive switch 14 will be in its normally closed or cold position whereby contacts 39 and 40 are closed as illustrated in the drawing since no flame is present at burner 12 at this time. The warp safety switch 32 will be in the closed position since heater 46 is cold or de-energized, and contacts 34 and 36 accordingly are in the illustrated normally closed position. When the environment that is being temperature controlled calls for heat, the thermostat 18 will move to the closed position, whereupon current will flow through solenoid 10 and SCR 26 along the before-described first flow path, while at the same time current flow from terminal 22 through flame-responsive switch 14 will provide the ignition transformer 60 and SCR 66 with a current source. The neon firing light 74 is likewise energized, and begins to trigger the emitter of the SCR 66. Current simultaneously flows from terminal 41 to the emitter of SCR 26, along the above-described first triggering flow path. Since terminal portion 41 is connected to the source of L2, the heater 46 of the safety warp switch 32 begins to heat up and in a very short predetermined interval of time, will cause the bi-metal at 32 to warp the contacts 34 and 36 to the open position, unless some intervening action prohibits this occurrence. Upon SCR 26 being triggered, a sufficient amount of current flows through solenoid 10 to open valve 11, thereby supplying burner 12 with fuel. At this same time SCR 66 is triggered, and firing light 74 causes a saw-toothed wave of current to pass through transformer 60 with sufficient intensity to produce a hot spark at electrode 62, thereby igniting fuel flowing from the burner 12. Upon ignition of fuel at burner 12, the flame responsive switch 14 will begin heating and will soon warp to the open position, thereby discontinuing the flow of current through the movable and fixed contacts 39 and 40 respectively. The flame-responsive switch 14 must open before the safety warp switch 32, in order to prevent shut-down of the system, and this is precisely what will happen under normal conditions of operation, for the reason that the flame-responsive switch 14 is designed with this in mind, whereby it will open prior to the safety warp switch 32 opening. Upon flame-responsive switch 14 opening, the current flow to terminal 41 is discontinued, and accordingly the heater 46 begins to cool, the ignition transformer 60 is de-activated, and the emitter of SCR 26 is de-energized. Hence, it should now be evident that when the flame-responsive switch 14 moves to the open position, the only path of current flow is from L2, then along the path described by solenoid 10, SCR 26, terminal 28, warp safety switch 32, and back to the source at L1. In spite of the emitter of SCR 26 being de-energized, there is still a sufficient amount of rectified current flowing through the solenoid 10 to maintain the solenoid in a sufficient state of magnetism to maintain the valve 11 in the open condition, once it has been opened; although there is insufficient current now flowing to have originally moved the valve from the closed to the open position. Accordingly, there is a negligible current drain from the electrical source as compared to the current requirements for start-up condition. The system will remain in the run condition under normal circumstances until the environment in which thermostat 18 is placed has been suitably warmed up, whereupon the thermostat will again open and return the circuitry to its original stand-by condition.

Should the flame blow out (and this certainly should rarely happen in a well-designed system), the flame-responsive switch 14 will be cooled and move to the closed position thereby again energizing SCR 26, igniter 60, and warp switch heater 46. The burner 12 normally will re-ignite and the flame will again heat the flame-responsive switch 14 to where it will swing to the open position and interrupt the current flow to the emitter 26, the current flow to the ignition system, and the current flow to the heater 46.

In the unlikely event the burner should fail to re-ignite, the flame responsive switch 14 will accordingly remain in the closed position, whereupon the heater 46 will remain energized, thereby causing the contacts 34 and 36 to open and the entire system to be de-energized and shut down, save the following portion thereof, which includes closed thermostat 18, flame-responsive switch 14, heater 46, and terminal portion 38 connecting these components back to the source of current. Since the remaining portion of the circuit is de-energized, the valve 11 will now return to the closed position, and accordingly shut off the flow of fuel to the burner 12. Since the thermostat is already calling for heat, and heat cannot possibly be provided by the burner, it is highly unlikely that the thermostat can ever again open until the engineer or attendant recognizes and cures the cause of the flame failure, or the failure to re-ignite. In the case of fuel flow stoppage, the action of the ignition safety system will be identical to the before-described condition of flame blow-out.

Upon correction of the cause of the flame failure, the circuit may be returned to stand-by condition by interrupting current flow through the heater **46**, flame responsive switch **14**, and thermostat **18**. This action will permit the warp switch heater to cool, thereby allowing the contacts of the warp switch to again close, whereupon the system is then in the illustrated stand-by condition, with the thermostat **18** calling for heat.

In the particular circuit shown in the drawing, the following values of the various circuit components have been found to provide suitable response rates and ignition spark frequencies:

24	ohms	200
26, 66		MCR 2604–5
42	ohms	1,000
44	do	12,000
54	do	1,000
72	megohms	5.1
75	mfd. @ 200 v. D.C.	0.947
80, 82	megohms	22
81, 83	mfd. @ 250 v. D.C.	20

It will occur to others skilled in the art that various minor changes can be made in the embodiment herein chosen by the inventor to illustrate his novel ignition system. Hence, while this invention has been described in conjunction with the before-mentioned specific or particular embodiment thereof, it should be understood that it may be embodied in many different forms from the above-described without departing from the scope of the invention as defined by the appended claims.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In a fuel burning control system including solenoid operated valve control means for supplying fuel to a burner, and a source of electrical power, the improvement comprising: ignition means associated with a burner and responsive to ignite fuel emanating from the burner when the ignition means is energized; first circuit means for supplying a large current to said valve control means when said igniter is energized and for supplying a small current to said valve control means upon de-energization of said igniter, said first circuit means including an SCR series connected with the solenoid of said valve control means; second circuit means for supplying a current to said igniter; a first triggering circuit for actuating said first circuit means; a second triggering circuit for actuating said second circuit means; said first and second triggering circuits having conduit means connected to the source of power and including means responsive to the burning of fuel to interrupt the power thereto; whereby said igniter is energized upon energization of said valve control means, and de-energized upon the fuel being ignited.

2. The system of claim **1**, wherein said second circuit means includes an SCR series connected with an ignition transformer, with said ignition transformer forming a portion of said igniter means; said first and second triggering circuits being connected by circuit means to the emitter of said first and second SCR respectively and to a common terminal; and a flame responsive switch connected between said common terminal and the source of electrical power.

3. The system of claim **2**, and further including a warp safety switch series connected between the source of power and said first and second circuit means; a warp safety switch heater connected between said common terminal and said source of power; whereby failure of said flame responsive switch to be actuated will permit said heater to open said warp safety switch to thereby discontinue the flow of power to said first and second circuit means.

4. The system of claim **2**, and further including a neon firing lamp including circuit means associated with said second triggering circuit and connected to the emitter of said second SCR, and including a source of power, a capacitive means, and a resistive element associated therewith to control the firing rate of said neon lamp; said ignition means including a spark gap associated with said transformer; whereby said second SCR is triggered by said second triggering circuit in response to the firing rate of said neon lamp to thereby apply a suitable voltage to said transformer to produce sparks across the electrodes of the spark gap in order to ignite fuel from a burner.

5. The system of claim **1**, wherein said igniter means includes a transformer having a primary and a secondary with a spark gap electrically connected to said secondary to perform the igniting function of claim **1**; said first and second circuit means each including a SCR and each being connected in parallel between two common terminals and including a thermostat between one said terminal and the source of power and a warp safety switch between the remaining said terminal and the source of power; a flame responsive switch in heat-responsive relationship to the burner to be ignited and located in series with said thermostat and said second circuit means; said first triggering means being in series with said flame responsive switch and connected to the emitter of said first SCR; said second triggering means being connected to the emitter of said second SCR and including a neon firing lamp having capacitive-resistive means associated therewith to cause the lamp to fire at a predetermined rate; and a heater associated with said warp safety switch and including circuit means connecting said heater between said source of power and in series with said flame safety switch.

6. The system of claim **5**, and further including a parallel connected capacitor and resistor connected in parallel with said series connected SCR and solenoid of said first circuit means; and a parallel connected capacitor and resistor connected in parallel to said series connected SCR and ignition transformer of said second circuit means.

7. A control device for igniting and supervising the combustion process of heating systems comprising: a first circuit adapted to be connected to a source of power and including electrical connecting means and series connected thermostat, diode, resistor, fuel valve solenoid, SCR, and a warp safety switch completing the circuit to the source of power; a second circuit connected in series with said thermostat and including series connected flame switch, diode, ignition means, SCR, and with said warp safety switch completing the circuit to the source of power; a common junction in series with said flame-responsive switch having a heater, first triggering circuit, and a second triggering circuit connected thereto; said heater having circuit means connecting to said source of like polarity with respect to said warp safety switch and in heat transfer relationship thereto; said first triggering circuit having circuit means connected to the emitter of said first SCR and including a resistance and a diode; said second triggering circuit having circuit means connected to the emitter of said second SCR and including the diode of the second circuit means and a current interrupting means adapted to cause current to intermittently flow through the last recited SCR to thereby produce a suitable igniting voltage for said ignition means; whereby closing of said thermostat causes energization of said solenoid so as to move a fuel valve to the fuel flow position, and said heater to be energized, and said ignition means to be energized; and, said flame responsive switch to move to the open position upon being heated to thereby discontinue current flow through the heater and ignition means, and to reduce the current flow through the solenoid.

8. The device of claim **7** wherein said ignition means includes a transformer having a primary and a secondary with said primary connected in series with said second SCR, and further including a spark gap operatively associated with said secondary thereof; said current interrupting means including a gaseous discharge device having a pair of electrodes that are highly conductive at a critical value of current applied therebetween and low conductive at values less than the critical value; and timing means associated with said discharge device to cause successive pulses of current above the critical value to be imposed on the plates of said neon tube; whereby said transformer receives successive pulses of current in accordance with the pulse frequency of said gaseous discharge device to thereby cause successive sparks to occur at said spark gap.

9. A fluid fuel burner control system having:

(a) a fuel control valve circuit including: a silicon controlled rectifier and an electromagnetic device having a coil connected in series circuit relationship with said silicon controlled rectifier, a capacitor connected in shunt relationship with the series circuit relationship of said coil and said rectifier; and

(b) means supplying said silicon controlled rectifier with triggering current while the temperature circumambient said burner is below a predetermined value.

10. The fluid fuel burner control system of claim 9 having:

(c) an igniter circuit including: a silicon controlled rectifier, an electromagnetic device having a coil connected in series circuit relationship with said silicon controlled rectifier; and means (b) also supplies triggering current to the rectifier of (c).

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