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IGNITION AND FUEL CONTROL CIRCUIT

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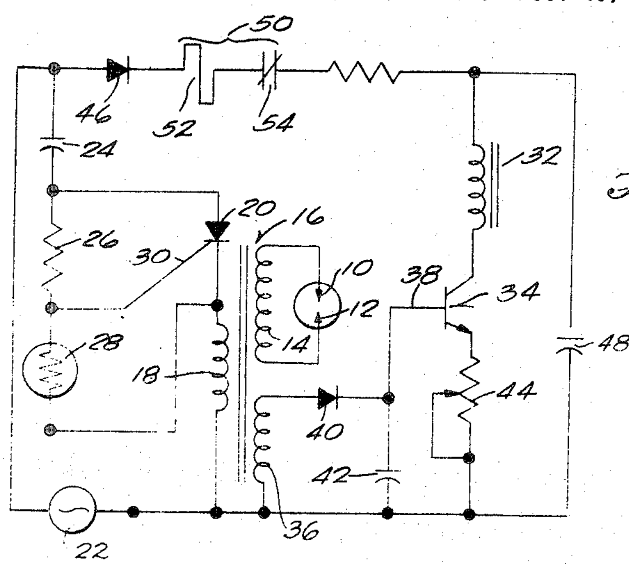

Fig. 1

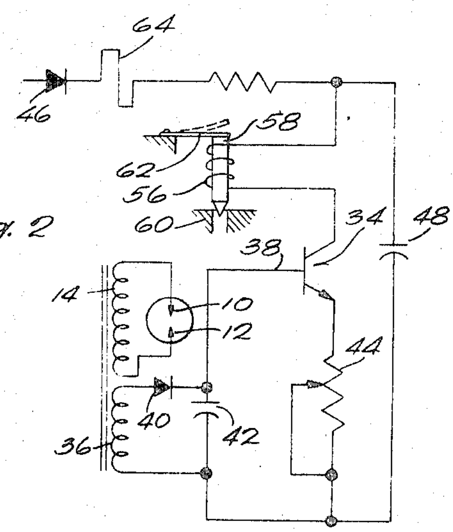

Fig. 2

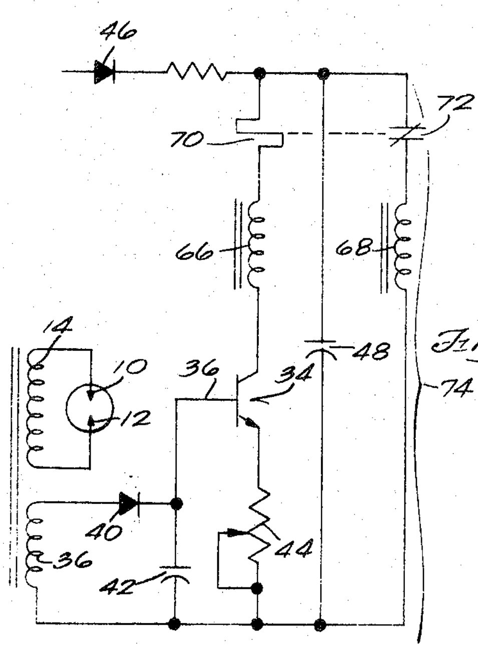

Fig. 3

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IGNITION AND FUEL CONTROL CIRCUIT

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U.S. Cl. 431—66 4 Claims

ABSTRACT OF THE DISCLOSURE

A solenoid operated fuel flow valve is controlled by a voltage responsive circuit element, a transistor, and the circuit element is in turn controlled in accordance with the voltage condition at the electrodes of the ignitor. A heater is connected in series with the valve and is responsive to current in the solenoid. In response to a heater temperature corresponding to a continued high voltage condition at the electrodes, indicating a failure of ignition, the valve is closed to interrupt fuel flow. In one embodiment the heater opens a switch in the valve circuit to close the valve by removing current from the solenoid. In another embodiment the heater actuates a bimetal which moves the valve element into a closed position to interrupt fuel flow. In a still further embodiment two serially arranged, solenoid operated valves are provided. The heater and one valve solenoid are in series with the circuit element in a first circuit. The other valve solenoid is in parallel with the first circuit and has a normally closed series related thermal switch in its circuit, the thermal switch responding to increased heater temperature to open the circuit to the solenoid.

BACKGROUND OF INVENTION

Field of invention

This invention relates to ignition and fuel flow control circuits and, more particularly, to a circuit which will automatically interrupt fuel flow in the event of failure of ignition and/or a malfunction of the ignition system.

Description of prior art

The art has recognized the problem of continued fuel flow should ignition fail to occur or, having occurred initially, be interrupted. Such continued fuel flow may increase the difficulty of obtaining ignition and creates a hazardous condition at the burner. Various arrangements have been proposed to interrupt fuel flow should ignition fail to occur. Such prior art arrangements have generally required relatively complex circuit arrangements for sensing the presence, or absence, of a flame and for translating the sensed signal into an operation for interrupting fuel flow. Typical of such arrangements are circuits which require the characteristics of the conductive path provided by a flame between spark electrodes to maintain the fuel flow control open. Another type of spark ignition and fuel flow control is disclosed in Patent 3,291,183 to Richard K. Fairley and assigned to the assignee of this application. This invention is concerned with providing an improved and/or simplified circuit which will automatically interrupt fuel flow should ignition not occur or should there be a malfunction in the ignition system.

SUMMARY OF INVENTION

The operative state of the fuel flow control valve is controlled on the basis of the voltage condition of the ignition means. The ignition means requires a relatively high voltage to produce ignition and the valve will open under an electrical condition corresponding to that relatively high voltage, preferably relatively high current in the electrical operator of the valve. After ignition, and when a flame is present, the ignition means requires only a reduced voltage condition and the valve is capable of remaining open under a reduced electrical condition influenced by the reduced voltage. A valve control is connected in circuit with valve and is responsive to the electrical condition of the valve. The valve control responds to a continued condition of the valve corresponding to the high voltage at the ignition means, indicating failure of ignition, to close the valve and interrupt fuel flow. Preferably, the valve control includes a heater which responds to relatively high current in the valve as a result of the high voltage condition on the ignition means and operates a thermally responsive member to interrupt flow.

DESCRIPTION OF DRAWINGS

FIG. 1 illustrates an ignition and fuel flow control circuit incorporating this invention;

FIG. 2 illustrates an alternative embodiment; and

FIG. 3 illustrates still another embodiment.

DESCRIPTION OF PREFERRED EMBODIMENT

With reference to FIG. 1, the ignition portion of the circuit is shown as including spaced arcing electrodes **10** and **12** connected in the secondary **14** of ignition transforcer **16**. Primary **18** of the transformer is connected to a pulse generating portion of the circuit which periodically applies an electrical pulse to the primary of sufficient magnitude to cause an arc to be drawn across electrodes **10** and **12**. A silicon controlled rectifier (SCR) **20** is in series with the primary and AC source **22**. The SCR together with capacitor **24** and/or resistances **26** and **28** determine the manner in which the transformer is pulsed. Resistance **28** is preferably a thermistor to compensate for variations in triggering voltage of the SCR due to changes in temperature of the SCR.

The manner in which the pulsing portion of the circuit operates is described more completely in the co-pending application of Richard K. Fairley and Reinhold Mueller Ser. No. 694,200, filed Dec. 28, 1967, entitled "Spark Ignition Circuit," and assigned to the assignee of this application. Reliance is placed on that co-pending application should a complete explanation of the advantages and manner of operation of the pulsing circuit become necessary. For purposes of this application a general description should be sufficient.

On each positive half cycle of the electrical supply the SCR will be rendered conductive when a preselected voltage occurs on its gate **30**. The relative values of resistances **26** and **28**, and of capacitor **24**, are selected so that the SCR is triggered to its conductive state near the peak of the positive half cycle. Capacitor **24** is selected so that it charges, and discharges, rapidly and this produces a fast rising, short duration pulse in the primary. This is translated into a high voltage, low energy content spark at the electrode. The SCR returns to its nonconductive state during each positive half cycle and will again be switched "on" in the next positive half cycle when the necessary voltage condition appears at gate **30**.

A burner (not shown) of any conventional construction is associated with the electrodes and delivery of fuel to the burner is controlled by an electrically operated valve. Solenoid **32** of the fuel valve is connected in the fuel flow control portion of the circuit. When the requisite current is in the solenoid the valve opens and fuel is delivered to the burner for ignition. Opening of the valve is coordinated with the operation of the igniter (transformer **16**, the arcing electrodes and the pulsing circuit) so that the valve opens to deliver fuel when sparks are drawn and remains open after ignition to sustain combustion.

More particularly, solenoid **32** is connected in series with transistor **34**, i.e. in the emitter-collector circuit thereof, and with respect to source **22**. Transformer **16** is provided with a tertiary winding **36**. The tertiary winding is inductively related with secondary **14** so that a voltage is induced in the tertiary winding which is proportional to that in the secondary and thus corresponds to the voltage condition at the electrodes. The tertiary winding is arranged so that any influence from primary winding **18** is negligible. The actual construction of the transformer is more completely described in the aforementioned co-pending application and reliance is again placed on that application should a more detailed description of the transformer be required.

The tertiary winding is connected to base **38** of the transistor through diode **40** and capacitor **42** so that the potential on the base corresponds to the voltage induced in winding **36** and, in that manner, to the voltage at electrodes **10** and **12**. The voltage at the electrodes is dependent on the operational environment and/or state of the electrodes. Prior to ignition and with no flame present at the electrodes, a relatively high voltage is required to produce a spark at the electrodes. With a flame present, the voltage necessary to arc across the electrodes is reduced. Thus, in one instance a relatively high voltage is impressed on base **38** influencing relatively high current in the emitter-collector circuit of the transistor. After ignition a lesser voltage is impressed on the base and current in the transistor is reduced. Solenoid **32** and transistor **34** are connected to source **22** through diode **46** and capacitor **48**. Variable resistance **44** is provided in the emitter-collector circuit to afford current adjustment and is selected so that under the initial, or high, voltage condition at the electrodes the current in solenoid **32** is sufficient to open the valve. This provides a fuel supply to the electrodes when the arc is drawn. The reduced current condition resulting from ignition and a flame being present at the electrodes (although inadequate to open the valve initially) is sufficient to hold the valve open after it is opened to thereby maintain combustion. Also, if the electrodes are shorted or if the pulsing circuit fails and no ignition pulse is delivered to the electrodes, the valve, being coordinated with the operation at the electrodes, will not open. More particularly, with shorted electrodes the voltage across the electrodes is not great enough to influence sufficiently high current in solenoid to open the valve or hold it open if already open. With no pulse at all no current appears in the solenoid. This prevents delivery of fuel to the burner when conditions are such that ignition cannot take place.

This operation of the fuel valve on the basis of the voltage condition at the electrodes is similiar to the arrangement disclosed in the aforementioned Patent 3,291,-183. As in the arrangement disclosed in that patent, the circuit of this application is capable of closing the fuel valve after it has opened and should ignition fail to have occurred within a prescribed time, or should combustion be interrupted and ignition fail to occur. In FIG. 1 a circuit breaker arrangement **50** is provided in series with solenoid **32** and current in the circuit breaker corresponds to that in the solenoid. Should a continued condition of high current in solenoid **32** persist for a preselected length of time, indicating a high voltage condition at the electrodes and failure of ignition, the circuit breaker will respond by opening the circuit to the solenoid allowing the valve to close and interrupt fuel flow. More specifically, the circuit breaker includes heater **52** and normally closed switch **54** in series with the solenoid. The switch is in heat transfer relation with the heater and will open in response to increased temperature of the heater, due to the high valve opening current condition of the solenoid. Below the high current condition, e.g. the reduced holding current condition, the temperature of the heater is insufficient to open the switch. The time constant (i.e. the time necessary to heat the switch such that it will open) of the circuit breaker is selected to be of sufficient duration to permit ignition to occur under normal conditions of operation before the switch opens.

This circuit arrangement is relatively simple requiring a relatively small number of electrical circuit elements and yet is reliable and coordinates fuel flow control fully with the state of operation of the ignition circuit, and with the secondary voltage, or arcing electrode voltage, as the basic control parameter.

FIG. 2 illustrates an alternative fuel flow control arrangement. Only a portion of the ignition circuit is illustrated, the remainder being identical to FIG. 1, and corresponding circuit elements are identified by the same numeral in FIG. 2 as in FIG. 1. In this alternative solenoid **56** of the fuel control valve is connected in series with and controlled by transistor **34** in the same manner as in FIG. 1. A high voltage condition is required at electrodes **10** and **12** to produce sufficient current in the transistor and the solenoid to open the valve. As illustrated schematically, solenoid **56** is inductively related with valve element **58** of the fuel valve and, in response to the opening current, moves the valve element away from fixed orifice **60** to initiate fuel flow. As the valve element moves away from the orifice it moves against thermal element **62**, preferably a bimetal. The bimetal is in heat transfer relation with heater **64** which is in series with solenoid **56** so that the current in the heater corresponds to that in the solenoid. Under a continued condition of high, opening current in the solenoid and heater, the temperature of the heater is such that it bows the bimetal a sufficient amount to close the valve element on the orifice and interrupt fuel flow. Below that current level, the temperature of the heater, and correspondingly the bimetal, is insufficient to close the valve. Again the time constant of the heater-bimetal arrangement is such that under normal conditions, ignition can occur before fuel flow is interrupted.

In the alternative embodiment of FIG. 3 a fuel flow control system is shown wherein fuel is controlled through two series related valves so that both must be open for fuel to flow to the burner. Again only a portion of the ignition circuit is shown in FIG. 3 as the remainder is identical to that of FIG. 1 and corresponding circuit elements are identified by the same numeral in FIG. 3 as in FIG. 1.

Both of the fuel valves are solenoid operated, their solenoids **66** and **68** being shown in the circuit. One solenoid, **66**, is in series with the transistor and electrical source in the manner discussed in FIG. 1. The other, solenoid **68**, is connected in a circuit branch **74** which, with respect to the source, is in parallel with solenoid **66**. In this embodiment, a heater **70** is connected in series with solenoid **66** and the transistor so that its electrical state is controlled by the transistor and corresponds to that of solenoid **66**. Heater **70** is in heat tranfer relation with a thermal switch **72** in series with solenoid **68** in circuit branch **74**. Thermal switch **72** is normally closed so that solenoid **68** is operated to open its valve immediately upon application of electrical power from the electrical source. However, solenoid **66** cannot open its valve until the ignition transformer is pulsed, thus fuel flow cannot occur until the ignition circuit is energized. Upon the occurrence of the high voltage ignition pulses, solenoid **66** will open its valve and fuel is delivered to the burner. Upon successful ignition, current in the solenoid is reduced but is sufficient to hold the valve open so that combustion is maintained. If the condition of high opening current persists in the solenoid for a prescribed length of time indicating failure of ignition, the high current condition raises the temperature of the heater sufficiently to open switch **72**. This closes the valve associated with solenoid **68** and interrupts fuel flow even though the valve of solenoid **66** remains open, because the two valves are in series. The lower, holding current resulting from successful ignition will not result in the temperature of the thermal switch increasing to the point where it will open. Again in this embodiment as in FIGS. 1 and 2, ignition pulses are required to initiate fuel flow and in the event of a malfunction in the ignition circuit or failure of ignition the flow of fuel to the burner is either not started or interrupted if already started when the failure of ignition or combustion occurs. A sufficient time delay is provided in the automatic fuel interruption mechanism to accommodate the normally expected time lag for ignition.

A conventional switch (not shown) can be connected in the circuit to provide overall control of the circuit. Also, circuit breaker **50** is of the type requiring manual reset once opened so that the circuits do not cycle "on" and "off" when a faulty condition exists, whereas switch **72** is of the type which resets itself when current in heater **70** is interrupted.

Although this invention has been illustrated and described in connection with particular embodiments thereof, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

We claim:

1. An ignition and fuel control circuit comprising, in combination,

ignition means requiring a first voltage for operation thereof when no flame is present at said ignition means and a second reduced voltage when a flame is present at said ignition means,

fuel flow valve means including a movable valve element supported for movement into and out of a position closing said valve means to flow, and electrically operated means operatively associated with said valve element and, when electrically activated, moving said valve element out of said position, said electrically operated means requiring a first current condition to open said valve means to fuel flow and a second reduced current condition to maintain said valve means open to fuel flow,

electrical control means in circuit with said valve means and controlling the electrical condition of said valve means, said electrical control means operatively connected to said ignition means and responding to said first and second voltage conditions to establish, respectively, said first and second current conditions of said valve means,

heater means in series with said valve means and having a current condition therein corresponding generally to the current condition of said valve means,

and thermally responsive means operatively associated with said valve element and in heat transfer relation with said heater means, said thermally responsive means responding to a temperature of said heater means corresponding to a continued condition of said first current condition to engage and positively move said valve element into said closed position.

2. The ignition and fuel flow control circuit of claim **1** wherein

said valve means is a solenoid operated valve,

said electrical control means comprises transistor means,

and said solenoid and heater means are in series with each other and said transistor means.

3. The ignition and fuel flow control circuit of claim **2** wherein said thermally responsive means comprises a bimetal member engageable with said valve element to move said valve into said position when heated by said heater means.

4. An ignition and fuel control circuit comprising, in combination,

ignition means requiring a first voltage for operation thereof when no flame is present at said ignition means and a second reduced voltage when a flame is present at said ignition means,

fuel flow valve means including a movable valve element supported for movement into and out of a position closing said valve means to flow,

electrical control means in circuit with said valve means and controlling the operative condition of said valve means, said electrical control means operatively connected to said ignition means and responding to said first and second voltage conditions to operate said valve means accordingly,

and means including heater means in circuit with said valve means having a current condition therein corresponding to the electrical condition of said valve means and thermally responsive means operatively associated with said movable valve element and in heat transfer relation with said heater means, said thermally responsive means responding to a temperature of said heater means corresponding to a continued condition of said first voltage condition on said valve means to engage and positively move said movable valve element to close said valve means and interrupt fuel flow.

References Cited

UNITED STATES PATENTS

2,869,633	1/1959	Schaaf et al.	431—66
3,151,661	10/1964	Matthews	431—66 X
3,276,507	10/1966	Eldridge et al.	431—69
3,282,324	11/1966	Romanelli	431—24
3,291,183	12/1966	Fairley	431—66
3,393,966	7/1968	Clark	431—24

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307—252, 253; 317—132; 431—69