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SPARK IGNITION AND FLAME SENSING CIRCUIT

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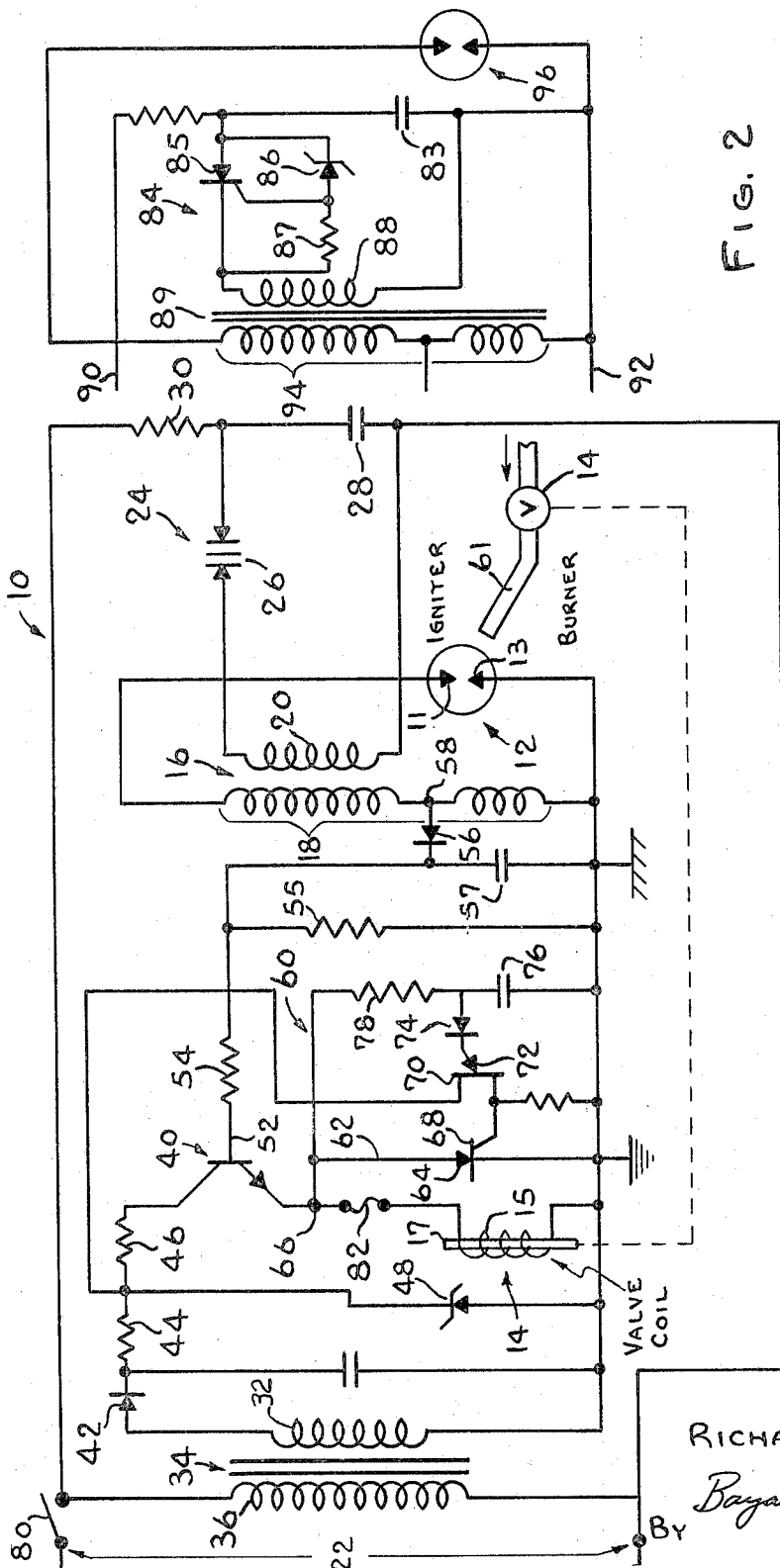


FIG. 1

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SPARK IGNITION AND FLAME SENSING
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This invention relates to ignition and fuel control systems and, more particularly, to an improved flame sensing arrangement therefor.

A general object of this invention is to provide an improved ignition and fuel control system.

Another object of this invention is to provide a simplified and improved flame sensing arrangement for an ignition and fuel supply control system.

A more specific object of this invention is to provide an ignition system containing inherent flame sensing capabilities.

To achieve these and other objects, this invention proposes to utilize the change, or lack of change, in the voltage condition across the spaced electrodes of an igniter as an indication of successful or unsuccessful ignition. More specifically, the voltage necessary to draw an arc at the electrodes will vary depending upon the presence or absence of a flame at the electrodes in that the ionization potential between the electrodes (the potential necessary to arc across the gap) when a flame is present is only one-third to one-half as great as the ionization potential without a flame present. This change in potential is used for the control function. In the illustrated embodiment, the electrodes of a spark igniter are connected in the secondary of a transformer, the transformer being pulsed to obtain a spark across the igniter electrodes. When the ignition and fuel control system is initially energized, the secondary voltage across the igniter electrodes is relatively high and a tapped voltage, which is proportional to the secondary voltage, is applied to open an electromagnetic valve. This establishes a flow of fuel to the burner and when ignition occurs the ionization potential required to produce a spark between the electrodes immediately decreases. Hence the secondary voltage decreases and, correspondingly, the voltage to which the fuel control valve is subjected decreases to a holding value, i.e. to one which is sufficient to hold the valve open but insufficient to open a closed valve. A voltage sensitive circuit capable of removing the voltage from the valve is connected to monitor the voltage on the igniter. If ignition does not occur, or the flame goes out, the higher secondary voltage is impressed on the igniter. The voltage sensitive circuit includes a time delay and if the higher voltage remains on the igniter electrodes for the period of the time delay the voltage on the valve is reduced below its holding voltage and the valve closes. Preferably this is accomplished by shunting the valve coil. At this point flow of fuel is interrupted and the fuel control and ignition circuit is in what is termed a locked-out condition. The circuit can be re-established for normal operation by momentarily breaking the main electric supply circuit.

Other objects and advantages will be pointed out in, or be apparent from, the specification and claims, as will obvious modifications of the embodiments shown in the drawing, in which:

FIG. 1 is a circuit diagram of an ignition and fuel control system embodying this invention; and

FIG. 2 is a view of an alternative pulsing circuit for use in the system.

With particular reference to the drawing, ignition and fuel control circuit 10 includes an igniter 12 having spaced

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electrodes 11 and 13 and a fuel control valve 14. The fuel control valve is electrically energized and is of the electromagnetic type including coil 15 and armature 17 which have been illustrated schematically in FIG. 1. Igniter 12 is connected in the secondary circuit of air core transformer 16 with electrodes 11 and 13 in series with secondary coil 18. Primary coil 20 of the transformer is connected to a suitable electrical source 22 through a pulsing circuit 24. Pulsing circuit 24 includes an electronic switch 26 in series with primary coil 20 and also includes capacitor 28 and resistance 30. Electronic switch 26 can be of any conventional well-known construction, for example a five-layer semiconducting device capable of switching in either direction of current flow and which in one form is identified commercially as a biswitch. Under normal operating conditions this switch will conduct at least once on each half cycle of source 22, and in opposite directions on successive half cycles. Under low voltage conditions it may conduct only on every other half cycle due to the forward and reverse breakdown voltage being somewhat different; this will produce switching in only one direction. In either case the overall system will operate properly as the primary 20 and, correspondingly, secondary coil 18 and igniter 12 will be pulsed to produce ignition.

In the illustrated embodiment coil 15 of the fuel control valve is connected in series with secondary coil 32 of a second transformer 34, the primary coil 36 of which is connected to source 22. Transistor 40 is connected in circuit with valve coil 15 and secondary coil 32, the valve coil and secondary coil being connected in series in the emitter-collector circuit of the transistor.

The output of transformer 34 is converted to D.C. by diode 42 and resistances 44 and 46 and Zener diode 48 act as a voltage regulator. Transistor 40 and valve coil 15 are connected in a circuit commonly referred to as an emitter-follower circuit. More particularly, transistor 40 is normally nonconducting with respect to operation of valve 14 and remains in that nonconductive state until the proper potential appears on base 52. Transistor base 52 is connected to a tap connection 58 in secondary coil 18 through a circuit branch including resistances 54 and 55, diode 56 and capacitor 57. The potential of base 52 corresponds to the voltage in secondary 18 and the potential of base or gate 52 determines the current flow through transistor 40 to valve coil 15, current flow through the valve coil following the base potential. That is, as the gate potential increases the current flow through valve coil 15 increases and, similarly, when it decreases the current flow through valve coil 15 decreases.

With this arrangement both the igniter and the fuel flow control respond to the same voltage. Valve 14 is normally closed and when ignition voltage is applied to igniter 12 with no flame at the electrodes thereof, a relatively high voltage is required to spark across the gap. A correspondingly high voltage is applied to gate 52 of transistor 40 rendering the transistor conductive to pass a relatively high current sufficient to open valve 14 and initiate fuel flow. A suitable burner 61, illustrated schematically in FIG. 1, receives fuel through the valve and is associated with igniter 12. If ignition takes place a flame occurs at burner 61 and this flame influences the condition between electrodes 11 and 13. More particularly, the flame reduces the resistance of the gap and, correspondingly, the ionization potential between these electrodes, the voltage necessary to arc across the electrodes being one-third to one-half less with a flame present than without a flame. This results in a corresponding reduction in the voltage in secondary coil 18 which also reduces the potential of transistor gate 52 and correspondingly reduces the voltage and current flow to the valve to a holding value.

To protect against creation of a potentially hazardous condition where ignition does not occur or, if having occurred, the flame for some reason is extinguished and re-ignition does not take place immediately, a flame sensing device is generally utilized to close the control valve and discontinue fuel supply. This invention achieves effective flame sensing in a relatively simplified manner by utilizing the change in voltage across the igniter electrodes upon ignition as the flame sensor, or the control parameter, upon which closure of the valve is based. More particularly, a voltage sensitive circuit 60 includes a circuit branch 62 defining a path to ground from junction 66 in the emitter-collector circuit of the transistor and including a silicon control rectifier (SCR) 64 controlling current flow in that path. The SCR is normally nonconductive but when rendered conductive establishes a circuit which shunts valve coil 15 and passes the current to ground removing it from the valve to close the valve. To control closure of the valve in accordance with the condition at igniter 12 the conductive state of silicon control rectifier 64 is controlled in accordance with the voltage appearing on the valve 14 which reflects and is dependent on the voltage in secondary coil 18 and on electrodes 11 and 13. More particularly, gate 68 of the SCR is connected and controlled by unijunction transistor 70 the gate 72 of which is connected through a diode 74 to a capacitor 76. Capacitor 76 is connected through resistance 78 to junction 66 so that the voltage at junction 66 is impressed on capacitor 76. This combination resistance-capacitance provides a time delay in the voltage sensitive circuit as will appear more clearly from the following description. The unijunction transistor 70 is normally nonconductive so that SCR 64 is also normally in a nonconductive state and current flow is through valve coil 15.

The voltage sensitive circuit is designed to be insensitive to the reduced, holding voltage and current flow which occurs as a result of successful ignition. However, should initial ignition fail to occur, or should the flame at burner 61 be extinguished without re-ignition, so that no flame is present at the electrodes then the relatively higher ignition voltage appearing in secondary 18 and on transistor 40 subjects the valve to full opening voltage and current. Voltage sensitive circuit 60 is responsive to this full opening voltage condition and a charge begins to build on capacitor 76. If the condition of full opening voltage on the valve continues for the period of the time delay, thereby indicating no flame at the electrodes, the charge built up on capacitor 76 reaches that necessary to change the conductive state of the unijunction transistor. Unijunction transistor 72 becomes conductive and the necessary potential is impressed on gate 68 of SCR 64 to switch it to a conductive state and thereby establish a shunt circuit to ground around valve coil 15 and the valve closes.

With this arrangement, voltage sensitive circuit 60 responds to the voltage on secondary coil 18, which is reflected in the current flow through transistor 40. Since the voltage condition on the secondary corresponds to the various states and conditions of operation of the igniter, circuit 60 provides effective and simplified control of the fuel supply in accordance with the state of operation of the igniter and, correspondingly, burner 61. To summarize, in response to a pulse at transformer 16 the fuel valve opens and if ignition occurs the voltage in secondary coil 18 is reduced and the valve is subjected to a holding voltage, circuit 60 remains inactive and the valve remains open. If, on the other hand, a proper ignition pulse is generated and there is no spark, or a spark and no flame, the fuel supply valve is initially opened but circuit 60 becomes operative and, if no flame occurs within the designated time delay, the valve is eventually closed. Similarly, if ignition takes place and the flame is subsequently extinguished, without re-igni-

tion, the voltage on the secondary is increased, circuit 60 activated, and the fuel valve is eventually closed. Finally, if the electrodes are short circuited no voltage is generated in the secondary coil and the fuel valve does not open.

After the valve has been shunted and closed through operation of circuit 60 in the manner just discussed, the system is in what is termed a locked-out condition. To return the circuit to a normal condition so that subsequent ignition cycle can take place, a reset switch 80 is provided in the main electrical supply line. By momentarily opening switch 80, the path to ground through SCR 64 is interrupted and the ignition and fuel control circuit is re-established for subsequent ignition.

Fuse 82 is provided in series with valve 14 and should circuit 60 fail to operate and the condition of an open valve without ignition continue the fuse will eventually de-activate the valve by disabling the entire circuit.

The circuit of this invention provides inherent flame sensing utilizing the change in voltage at the igniter as the parameter for flame detection. In a sense the secondary of the igniter transformer acts as the sensor since its voltage condition changes with the condition at the igniter (flame or no flame) and it relates this change to the fuel control valve and voltage sensitive circuit.

It is recognized that changes can be made in pulsing circuit 24 and circuit 60 without departing from the spirit or scope of this invention and therefore it is not intended that this invention be limited to the exact circuitry illustrated. For example, the biswitch pulsing circuit can be replaced by pulsing circuit 84 illustrated in FIG. 2. Only the pulsing and ignition portion of the circuit has been illustrated in FIG. 2 and it will be appreciated that the remainder of the circuit can be the same as that illustrated in FIG. 1. At this point it might also be noted that if it is desired to operate the entire ignition and fuel control system from a lower voltage source the igniter, the pulsing circuit, the pulsed transformer, and the fuel control valve circuit can be operated from a common transformer secondary. Returning now to pulsing circuit 84, this circuit includes capacitor 83, silicon controlled rectifier (SCR) 85, Zener diode 86 and resistance 87 connected in circuit with primary coil 88 of transformer 89. Leads 90 and 92 are connected to a suitable electrical source such as the secondary coil of the transformer mentioned above. Zener diode 86 and resistance 87 are arranged in parallel with SCR 86. When the circuit is activated a charge builds up on capacitor 83 until it reaches the breakdown potential of Zener diode 86 at which point current flows through the Zener and the necessary potential appears at the gate of SCR 85 to render it conductive. The stored charge on the capacitor then passes through the SCR and primary coil 88 and produces a pulsed output in secondary 94 to activate igniter 96.

It will also be appreciated that the circuit of this invention can be applied to either gas or oil systems.

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.

I claim:

1. An ignition and fuel control circuit comprising, in combination,
 - an igniter including spaced electrodes,
 - means applying a voltage to said igniter to operate said igniter, said igniter requiring a first voltage for operation thereof when no flame is present at said electrodes and a second reduced voltage when a flame is present at said electrodes,
 - valve means,
 - means connecting said valve means with said igniter for response to the voltage condition on said igniter,
 - said valve means opening in response to said first

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voltage and remaining open in response to said second voltage,
 and means connected to said valve means and said igniter and responsive to a continued condition of said first voltage on said electrodes to effect a closing of said valve means with a predetermined time delay after opening of said valve means.

2. An ignition and fuel control circuit comprising, in combination,
 a transformer,
 means for pulsing said transformer,
 a spark igniter comprising spaced electrodes connected in the transformer secondary, said igniter requiring a first voltage for operation when no flame is present at said electrodes and a reduced voltage when a flame is present at said electrodes,
 electrically energized valve means,
 means connecting said secondary to said valve means and operative to effect opening of said valve means in response to said first voltage on said electrodes and to maintain said valve means open in response to a subsequent condition of said reduced voltage on said electrodes,
 and a voltage sensitive circuit responsive to a continued condition of said first voltage for a predetermined period of time indicating absence of flame at said electrodes to close said valve.

3. An ignition and fuel control circuit comprising, in combination,
 an igniter including spaced electrodes,
 means for applying a voltage across said electrodes, valve means,
 means connected to said valve means and said electrodes and operative, in response to the voltage across said electrodes, to apply a valve opening voltage to open said valve means,
 and means responsive to the change in voltage across said electrodes due to presence or absence of flame at said igniter and operative in response to continued voltage across said electrodes indicative of absence of flame to close said valve and to continued voltage across said electrodes indicative of presence of flame to maintain the valve open.

4. An ignition and fuel control circuit comprising, in combination,
 a transformer,
 an igniter including spaced electrodes connected in the transformer secondary,
 means connected to and operative to pulse said transformer,
 valve means,
 means operatively connected between said valve means and said transformer secondary and responsive to the voltage in the transformer secondary to open said valve means,
 and means responsive to continued valve opening voltage in said secondary indicative of absence of flame at said electrodes to close said valve means.

5. An ignition and fuel control comprising,
 a transformer having a primary and a secondary, means supplying a pulsed voltage to the primary,
 a spark igniter connected across the secondary and including electrodes spaced by a gap and characterized by the ionization potential of the gap being less when a flame exists between the electrodes than when there is an air gap whereby the secondary voltage drops when a flame exists in the gap,
 electrically operated valve means for supplying fuel to the igniter and requiring a given voltage to open the valve means and a reduced voltage to hold the valve means open,
 means responsive to a voltage in the secondary indicative of an air gap between the electrodes to supply the given voltage to the valve means to open the valve means and to reduce the voltage on the valve means

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to a reduced voltage when the secondary voltage drops in presence of a flame between the electrodes to hold the valve means open,
 and time delay means responsive to application of said given voltage but not to said reduced voltage to reduce the voltage on the valve means below the holding voltage to thereby cause the valve means to close after a predetermined time.

6. An ignition and fuel control comprising,
 a transformer having a primary and a secondary,
 a spark igniter on the secondary,
 means operative to pulse the primary to spark the igniter,
 an electromagnetic fuel valve,
 means responsive to the secondary voltage incident to sparking the igniter in air to apply a valve opening voltage to the fuel valve,
 means responsive to the secondary voltage incident to sparking the igniter in presence of a flame to reduce the voltage applied to the fuel valve to a holding voltage sufficient to hold the valve open but insufficient to open the valve,
 and means operative within a predetermined time delay after the fuel valve opens in absence of such reduction to a holding voltage to reduce the voltage applied to the fuel valve below that required to hold the valve open.

7. An ignition and fuel control circuit comprising, in combination,
 a transformer,
 means for pulsing said transformer,
 an igniter comprising spaced electrodes connected in series with the transformer secondary,
 electrically energized valve means,
 a source of electrical energy connected to said valve means,
 first means controlling flow of electrical current to said valve means and operative, in response to a predetermined voltage, to pass current corresponding to said predetermined voltage to said valve means to open said valve means,
 means connecting said first means to said secondary to respond to the voltage in said secondary,
 and a voltage sensitive circuit defining a circuit shunting said valve means, said voltage sensitive circuit being normally inactive and operative to respond to a continued voltage condition on said igniter indicating the absence of a flame at said electrodes and activate said shunt circuit to close said valve means a predetermined time after said valve means has opened.

8. The ignition and fuel control circuit of claim 7 wherein said first means is connected to a tap connection in said secondary.

9. The ignition and fuel control circuit of claim 8 wherein said valve means is an electromagnetic type.

10. An ignition and fuel control circuit comprising, in combination,
 an igniter including spaced electrodes,
 means for applying a voltage to said electrodes to operate said igniter, said igniter requiring a first voltage for operation thereof when no flame is present at said electrodes and a second reduced voltage when a flame is present at said electrodes,
 electromagnetic valve means,
 first normally nonconducting means connected to said electrodes and in circuit with and controlling operation of said valve means, said first normally nonconducting means being responsive to the voltage on said electrodes and operative to pass current corresponding to said voltage to operate said valve means,
 and voltage sensitive means connected with said valve means and said igniter and operative in response to a continued condition of said first voltage on said

igniter to reduce the current flow to said valve means below its holding voltage with a predetermined time delay after said valve means has been opened.

11. The ignition and fuel control circuit of claim 10 wherein said first normally nonconducting means comprises transistor means connected with said valve means in an emitter-follower circuit and having the control gate thereof connected to and responding to the voltage on said electrodes. 5

12. The ignition and fuel control circuit of claim 11 wherein said voltage applying means comprises a transformer having the secondary thereof connected to said electrodes and means for pulsing said transformer, and wherein said control gate is connected to said secondary. 10

13. The ignition and fuel control circuit of claim 12 wherein said voltage sensitive means includes means defining a normally nonconducting circuit shunting said valve means, 15

and time delay means connected to said shunt circuit and responsive to a condition of said first voltage at said electrodes and operative to change the conductive state of said shunt circuit with a predetermined time delay after said voltage condition is applied to said first normally nonconducting means. 20

14. The ignition and fuel control circuit of claim 13 including a reset switch connected in circuit with said voltage sensitive means to open the circuit to said voltage sensitive means and re-establish said ignition and fuel control circuit for subsequent ignition. 25

15. The ignition and fuel control circuit of claim 10 including fuse means in series with said valve means. 30

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

a transformer,

means for pulsing the primary of said transformer, an igniter comprising spaced electrodes connected in series with the transformer secondary, said igniter requiring a first voltage for operation thereof when no flame is present at said electrodes and a second reduced voltage when a flame is present at said electrodes,

electromagnetic valve means,

an electrical source,

transistor means connected between said source and valve means in an emitter-follower circuit to control the flow of current to said valve means, the control gate of said transistor means connected to said secondary so that the amount of current passed to said valve means corresponds to the voltage in said secondary,

and voltage sensitive circuit means defining a circuit shunting said valve means and being responsive to a continued condition on said igniter corresponding to said first voltage to activate said shunt circuit and close said valve means with a predetermined time delay after said valve has been opened.

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