April 9, 1968 R. J. ZIELINSKI 3,377,125

ELECTRICAL IGNITION SYSTEM FOR GASEOUS FUEL BURNERS AND THE LIKE

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FIG. 1.

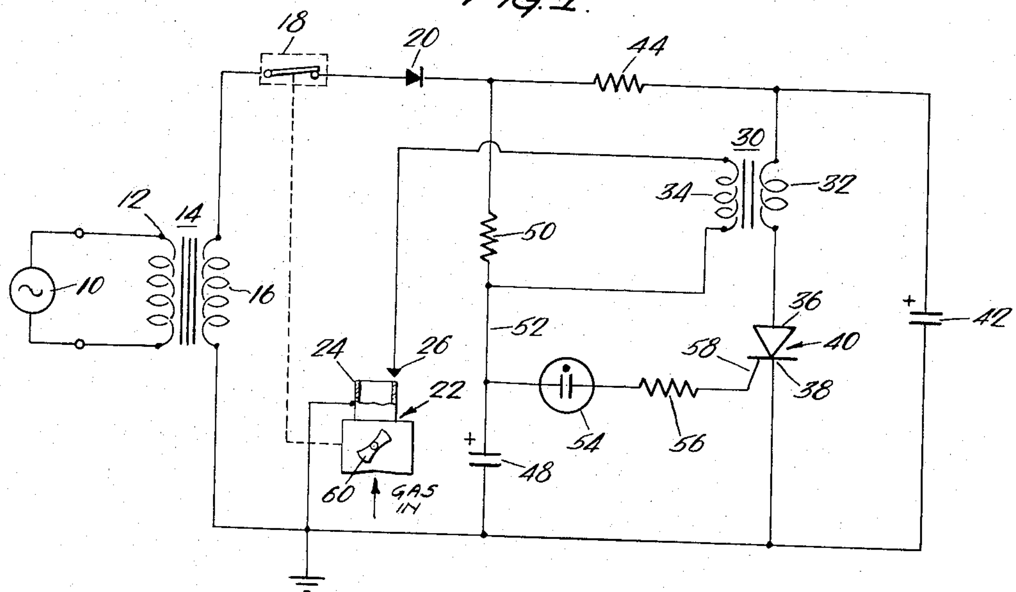
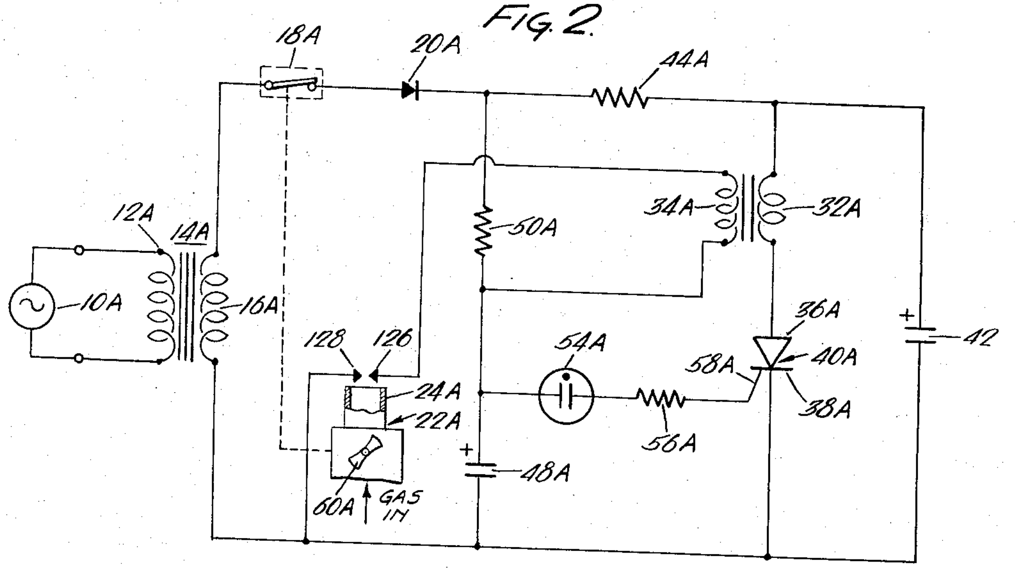


FIG. 2.



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ELECTRICAL IGNITION SYSTEM FOR GASEOUS FUEL BURNERS AND THE LIKE

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This invention relates to electrical systems for igniting fuels, and particularly to such systems for automatically providing ignition and reignition of a gaseous fuel.

In many applications it is desirable to provide electrical ignition of a gaseous fuel, and to provide for reignition of the fuel should the flame disappear while the supply of gaseous fuel continues. For example, this is desirable in a gas range in which prompt ignition of the flame is desired when the supply of gas is turned on and prompt reignition desired should a flame-out occur for any reason while the supply of gas continues. Electrical systems have been proposed in the prior art which produce ignition sparks between a pair of ignition electrodes when a flame is absent and which include flame-sensing means for discontinuing the ignition sparks when the flame is present and for re-establishing the ignition sparks when the flame is again absent. However such previously-known systems are generally more complex, and hence more expensive and more susceptible to erratic operation, than would be desirable for many purposes.

Accordingly it is an object of my invention to provide a new and useful electrical ignition system for gaseous fuel burners.

Another object is to provide such a system which, once set into operating condition, will ignite a gaseous fuel when the fuel supply is turned on and will automatically reignite the fuel thereafter should the flame become extinguished, so long as the supply of gaseous fuel continues.

It is also an object to provide such a system which requires no special flame-sensing electrodes for detecting the presence or absence of the flame, beyond those utilized for ignition purposes.

In accordance with the invention these and other objects are achieved by the provision of a fuel ignition system which utilizes the same pair of electrode means for both ignition and flame-sensing purposes, one of the electrode means preferably but not necessarily comprising an electrically conductive conduit through which the gas is supplied. The system makes use of an ignition transformer having a primary and a secondary, and relaxation oscillator means for producing a pulse of current through the transformer primary each time a capacitive means in the relaxation oscillator means is charged to a predetermined voltage for which a cycle of operation of the relaxation oscillator means is initiated. The secondary of the transformer is connected in a series circuit with the ignition electrodes, the latter series circuit being connected effectively in parallel with said capacitive means. Each of the above-described pulses through the transformer primary then produces a corresponding voltage pulse in the transformer secondary which is applied to the ignition electrodes to produce ignition sparks in the region in which the gas flame is to be produced. The arrangement is such that in the absence of the flame the above-described cycle of operation occurs and repeats until the ignition sparks have ignited the flame. However, when the flame does occur the resistance between the ignition electrodes is lowered by the presence of the flame bridging the gap between the electrodes. This produces a lowered resistance in parallel with the capacitive means such that the capacitive means is no longer able to charge to the predetermined voltage required to initiate a cycle of operation of

the relaxation oscillator. Accordingly, ignition sparks are inhibited while the flame is present. Should the flame disappear, the above-described lower resistance between the ignition electrodes disappears, the capacitive means is able to charge as it did originally, and the relaxational oscillations and resultant ignition sparks are again produced to reignite the flame automatically.

Accordingly, automatic ignition and reignition are provided in an extremely simple and reliable circuit arrangement which requires no flame-sensing electrodes or probes in addition to the pair of ignition electrodes, one of which as mentioned above may be a metallic conduit through which the gaseous fuel is supplied.

More particularly, the arrangement of the invention preferab'y comprises a silicon controlled rectifier having its anode and cathode elements in a first series circuit with the primary of the ignition transformer. First capacitive means is connected in parallel with this first series circuit, and a source of direct voltage charges the first capacitive means by way of a first resistive means with a first predetermined charging time constant. Second capacitive means is also charged from the direct voltage source, by way of a second resistive means, with a second predetermined charging time constant which is preferably longer than said first predetermined time constant. A gas discharge device is connected in a second series circuit with the gate electrode of the silicon controlled rectifier, and this second series circuit is connected in parallel with the second capacitive means. As a result, in the absence of a flame from the burner, the silicon controlled rectifier is normally non-conductive and the first capacitive means charges rapidly toward the supply voltage. The second capacitive means charges more slowly, until it reaches a predetermined voltage at which the gas discharge device breaks down to pass a pulse of current through the gate electrode of the silicon controlled rectifier, rendering it strongly conductive. As a result of the latter action, the first capacitive means discharges abruptly through the transformer primary to produce a voltage pulse across the transformer secondary and across the ignition electrodes, whereby ignition sparks are produced at the ignition electrode means. This action repeats until the flame is ignited. When the flame bridges the gap between the ignition electrode means, its resistance is sufficiently low, as related to the value of the second resistive means through which the second capacitive means is charged, that the second capacitive means no longer can reach the voltage required to break down the gas discharge device. Accordingly the silicon controlled rectifier, which resumes its non-conductive state after each discharge of the first capacitive means through it, remains non-conductive and no further sparks are produced. Extinction of the flame again permits the gas discharge device to break down and causes the circuit to resume its original operation.

The above-described limiting of the production of ignition sparks to the times when ignition must be provided reduces the electrical current drain and also reduces the noise due to ignition sparks.

Other objects and features of the invention will be more fully understood from a consideration of the following detailed description, taken in connection with the accompanying drawings, in which:

FIGURE 1 is an electrical schematic diagram illustrating one preferred embodiment of the invention, in which an electrically-conductive conduit for the gaseous fuel is utilized as one of the ignition electrode means; and

FIGURE 2 is an electrical schematic diagram of a circuit in accordance with the invention, which is like that shown in FIGURE 1 with the exception that it employs two ignition electrode means separate from the conduit which supplies the gas.

Referring now to the embodiment of the invention shown in detail in FIGURE 1, a source of alternating line voltage **10** is connected to the primary **12** of a line transformer **14**, the secondary **16** of which transformer is grounded at its lower end. The upper end of secondary **16** is connected through a control switch **18** to the anode of a diode rectifier **20**. When switch **18** is open, no voltage reaches diode **20**; however, when switch **18** is closed the voltage at the cathode of diode **20** with respect to ground comprises a series of rectified half-waves of positive voltage. The portion of the circuit thus far described comprises a simple supply source of direct voltage for the system.

Gas burner **22** includes a gas conduit **24** of electrically-conductive material for conducting gaseous fuel to the region in which it is to be burned. The burner may be of any of a variety of types, and may for example comprise a pilot burner, or an oven burner in a gas range, for example.

Mounted adjacent the burner conduit **24** is ignition electrode means **26**, which may be of conventional type for such purposes. Ignition electrode means **26** is positioned so that it will respond to voltages applied in sufficient magnitude between itself and burner conduit **24** to generate ignition sparks for lighting the gas emanating from conduit **24**, and is also positioned so that when the gas has been ignited the resultant flame will contact electrode means **26**. The portion of the circuit now to be described applies voltage pulses between ignition electrode means **26** and conduit **24** when the flame is absent, but not when the flame is present.

To accomplish this, there is provided an ignition transformer **30** having a primary **32** and a secondary **34** electrically insulated from each other. The anode **36** and the cathode **38** of a silicon controlled rectifier **40** are connected in a first series circuit with transformer primary **32**. A first capacitive means **42**, which may be an ordinary electrical capacitor, is connected directly across the above-described first series circuit. The lower end of capacitor **42** is connected to ground and its upper side is connected to the cathode of supply-voltage rectifier **20** by way of first resistive means **44**, which may be an ordinary electrical resistor.

Second capacitive means **48**, which may be an ordinary electrical capacitor, has its lower side connected to ground, the upper side thereof being connected to the cathode of the supply-voltage rectifier **20** by way of resistive means **50**, which may also be an ordinary electrical resistor. The interconnection **52** between the lower end of resistor **50** and the upper side of capacitor **48** is connected to one electrode of a two-electrode gas discharge device **54**, which may be an ordinary glow lamp. The other electrode of gas discharge device **54** is connected by way of a current-limiting resistor **56** to the gate electrode **58** of silicon controlled rectifier **40**.

One end of transformer secondary **34** is directly connected to the interconnection **52** between resistor **50** and capacitor **48**, and the upper end of transformer secondary **34** is connected to electrode means **26**.

Preferably the gas supply conduit **24** has a control **60** for turning on and off the supply of gas, which control is linked with switch **18** mechanically or by suitable electric or magnetic means, so that when the gas supply is turned on the switch **18** is closed and when the gas supply is turned off switch **18** is opened automatically.

The time constant for the charging of capacitive means **42** is determined by the product of the resistance of resistor **44** and the capacity of capacitive means **42**, while the time constant for the charging of capacitive means **48** in the absence of flame is the product of the resistance of resistor **50** and the capacity of capacitive means **48**. Preferably the charging time constant for capacitive means **42** is short compared with that for capacitive means **48**.

In operation, before the gas control **60** is turned on the circuit is quiescent and there is no current drain, since

switch **18** is open. When gas control **60** is turned on, gas emanates from conduit **24** and switch **18** is closed to start the operation of the circuitry. At this time both silicon controlled rectifier **40** and gas discharge device **54** are non-conductive. However, the direct voltage produced at the cathode of rectifier **20** then immediately begins to charge capacitor **42** by way of resistor **44**, and to charge capacitor **48** by way of resistor **50**. Because of its shorter time constant, capacitor **42** reaches its nearly fully-charged condition before capacitor **48** does. However, very shortly thereafter capacitor **48** has charged to the point where the voltage which it applies across gas discharge device **54** exceeds the breakdown voltage of the latter device, at which time it ionizes, becomes highly conductive, and passes a strong pulse of current through gate electrode **58** to the grounded cathode of silicon controlled rectifier **40**. This discharges capacitor **48**, so that gas discharge device **54** extinguishes and capacitor **48** recharges in the manner of a relaxation oscillator.

In response to each pulse of current through gate electrode **58**, silicon controlled rectifier **40** becomes highly conductive. Capacitor **42**, which preferably has a relatively large value, then discharges abruptly through transformer primary **32** and silicon controlled rectifier **40**. The resultant pulse of current through transformer primary **32** induces a corresponding strong voltage pulse in transformer secondary **34**, which is applied between electrode means **26** and conduit **24**; it has been found that the frequency components of the transformer-secondary voltage pulse pass readily through capacitor **48** to permit this operation. The resultant voltage pulse between electrode means **26** and conduit **24** is sufficient to produce a spark between them. Upon the above-described discharging of capacitor **42**, the anode voltage of silicon controlled rectifier **40** falls to such a level with respect to its cathode **38** that the silicon controlled rectifier resumes its non-conductive state and capacitor **42** recharges. The above-described cycle repeats itself, producing repetitive sparks between electrode means **26** and conduit **24** until such time as the sparks cause ignition of the gaseous fuel, which normally occurs promptly.

The next feature of operation of the circuit relies upon the fact that the electrical resistance between electrode means **26** and conduit **24** is extremely large in the absence of flame (generally greater than several hundred megohms), but is much smaller (considerably less than 100 megohms) when the gap between electrode means **26** and conduit **24** is bridged by a flame. The exact value of the latter resistance depends to some extent upon a variety of factors including the electrode area and the flame temperature, but may readily be made less than ten megohms. Accordingly, in the original operation of the circuit when the flame is absent, the series circuit through transformer secondary **34**, electrode means **26** and conduit **24** provides no effective shunting of capacitor **48** and no dividing down of the voltage at junction **52**, so that capacitor **48** charges toward substantially the total supply voltage produced at the cathode of rectifier **20**. The latter voltage is sufficient to assure that the voltage on capacitor **48** will rise above the value required to produce breakdown of gaseous discharge device **54** and produce the above-described type of relaxation oscillations by which periodic sparking is produced for ignition purposes.

However, once the flame has appeared the relatively low resistance produced thereby between electrode means **26** and conduit **24** causes a substantial shunting of capacitor **48** and a very substantial reduction or dividing down in the maximum voltage available at junction **52**. In general, if the supply voltage is V_S, the resistance of resistor **50** is R_{50}, and the resistance of the flame R_F, the maximum voltage producible at junction **52** with flame present will be about $V_S R_F/(R_F+R_{50})$. The value of resistor **50** is so chosen in relation to the value of the resistance of the flame that, with the flame present, the voltage at junction **52**, and hence at the upper plate of capacitor **48**, can never reach a value sufficiently high to cause breakdown of gas discharge device **54**, and hence silicon controlled rectifier **40** remains nonconductive and no further sparks are produced while the flame is present. However, when the flame disappears the lowered-resistance effect which it produced also disappears, and the circuit resumes its original operation involving relaxation oscillations causing periodic turning-on of silicon controlled rectifier **40**, periodic pulses through transformer primary **32**, and periodic voltage pulses applied by transformer secondary **34** between electrode **26** and conduit **24**, whereby repetitive ignition sparks are produced to reignite the flame.

The embodiment of the invention illustrated in FIGURE 2 is identical with that shown in FIGURE 1 except for the arrangement of the ignition electrodes, and accordingly corresponding parts are indicated by the same numerals with the suffix A and need not be described again. More particularly, the ground connection in the embodiment of FIGURE 1 to the lower end of the secondary **16** of transformer **14** is omitted and, instead of utilizing an electrode **26** and the conductive conduit **24** for the pair of ignition electrode means as in FIGURE 1, there are provided a pair of opposed electrode means **126** and **128** in addition to and electricaly separate from the gas conduit **24A**. Electrode means **126** and **128** are positioned so that sparks will be produced between them by the voltage applied thereto from transformer secondary **34A**, and so that the gap between the electrode means will be bridged by the flame when present. It will be appreciated that the operation of the circuit of FIGURE 2 will also be the same as that of FIGURE 1, although the particular values of components utilized may differ somewhat to accommodate the usually higher resistance of the flame between the pair of electrode means such as **126** and **128** as compared with the flame resistance normally found to exist between the burner conduit itself and an adjacent electrode.

Without in any way thereby limiting the scope of the invention the following examples of typical component values for the embodiments shown are given in the interest of complete definiteness.

The values for the embodiment of FIGURE 1 may be as follows:

Diode rectifier **20**	Type 1N3194 diode.
Capacitor **48**	0.047 microfarad.
Capacitor **42**	Ten microfarads.
Resistor **50**	22 megohms.
Resistor **44**	1,000 ohms.
Resistor **56**	1,000 ohms.
Silicon controlled rectifier **40**	Type 2N3228 silicon controlled rectifier.
Transformer **14**	1:1 isolating transformer.
Transformer **30**	Commercial pulse transformer suitable for the pulse frequencies involved.
Gaseous discharge device **54**	Type A057B neon glow lamp.

For the embodiment of FIGURE 2, all elements may be the same as specified for the embodiment of FIGURE 1, except as follows:

Capacitor **48A**	microfarad	0.005
Resistor **50A**	megohms	200
Resistor **56A**	ohms	470

With the above-described values for the embodiment of FIGURE 1, the circuit will yield one spark approximately every 0.6 second, and, after a flame has been present and becomes extinguished, periodic sparking will be resumed within about one second.

For the arrangement shown in FIGURE 2 utilizing the values tabulated above, one spark is produced approximately every 2 seconds, and periodic sparking resumed within about two seconds after flame extinction.

While the invention has been described with particular reference to specific embodiments thereof in the interests of complete definiteness, it may be embodied in any of a large variety of forms differing from those specifically described and shown without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. Gas flame ignition apparatus, comprising:
   a pair of spaced-apart electrode means;
   a transformer having a primary and a secondary;
   relaxation oscillator means, connected to said primary and including capacitive means and means to charge said capacitive means toward a predetermined voltage for producing a pulse of current through said primary each time the voltage across said capacitive means charges to said predetermined voltage; and
   means connecting said secondary and said pair of spark electrode means in common series circuit with each other across said capacitive means, to produce ignition sparks between said pair of spark electrode means in response to pulses of current through said primary and to prevent said voltage from attaining said predetermined value when a flame bridges said pair of spark electrode means, thereby to arrest generation of said sparks whenever said flame is present.

2. Apparatus for igniting gas from a burner, comprising:
   an ignition transformer having a primary and a secondary,
   a first controllable discharge device having a first pair of electrodes connected in a first series circuit with said primary and having a control electrode responsive to a control current through it to render said device conductive between said electrodes of said first pair, said device becoming non-conductive when the voltage between said first pair of electrodes falls below a predetermined minimum level in the absence of said control current;
   first capacitive means connected across said first series circuit;
   means for charging said first capacitive means and for applying a voltage across said first series circuit, whereby a pulse of current from said first capacitive means is passed through said primary whenever said device is rendered conductive;
   second capacitive means;
   means for charging said second capacitive means;
   a voltage breakdown device connected in series with said second capacitive means and said control electrode for discharging said second capacitive means through said control electrode to render said discharge device conductive whenever said second capacitive means charges to a predetermined voltage;
   a pair of ignition electrode means responsive to pulses of voltage applied thereto to produce ignition sparks;
   means connecting said ignition electrode means in series with said secondary, whereby the presence of a flame bridging said ignition electrodes prevents said second capacitive means from charging to said predetermined level and whereby ignition sparks are produced between said ignition electrodes in the absence of said flame.

3. An automatically ignitable and re-ignitable gas burner system, comprising:
   a source of direct voltage;
   first capacitive means;
   an ignition transformer having a primary and a secondary;
   a silicon controlled rectifier;

means connecting said primary in a first series circuit with the anode and cathode elements of said silicon controlled rectifier;

means connecting said first capacitive means in parallel with said first series circuit;

first resistive means connecting said source across said first capacitive means to charge it with a first predetermined charging time constant, whereby said first capacitive means discharges through said primary and said silicon controlled rectifier whenever said silicon controlled rectifier is rendered conductive by current through its gate electrode;

second capacitive means;

second resistive means connecting said source across said second capacitive means to charge it with a second predetermined time constant larger than said first predetermined time constant;

a gas discharge device having a pair of electrodes connected in a second series circuit with the gate and cathode electrodes of said silicon controlled rectifier and responsive to a predetermined voltage applied between said pair of electrodes thereof to break down and become conductive;

means connecting said second series circuit in parallel with said second capacitive means, whereby said gas discharge device breaks down to render said silicon controlled rectifier conductive and to produce a pulse through said primary whenever said second capacitive means is charged to said predetermined voltage;

gas burner means including a pair of spaced-apart ignition electrode means positioned so that electrical discharges between said ignition electrodes will ignite gas from said burner and so that flame from said burner, when ignited, bridges the gap between said ignition electrodes;

means connecting said secondary of said transformer and said pair of ignition electrodes in a third series circuit;

means connecting said third series circuit in parallel with said second capacitive means, whereby pulses of current through said primary produce voltage pulses across said ignition electrodes to produce ignition sparks in the absence of flame bridging said ignition electrodes;

the resistance of said flame to current flowing between said ignition electrodes being sufficiently low to prevent charging of said second capacitive means to said predetermined voltage for which said gas discharge device breaks down.

4. The system of claim **3**, in which said gas burner means comprises an electrically conductive gas conduit from which gas to be burned emanates, and in which one of said ignition electrode means comprises said conduit.

5. The system of claim **3**, in which said means connecting said third series circuit in parallel with said second capacitive means comprises means connecting one end of said third series circuit directly to a point intermediate said second resistive means and one side of said capacitive means, and connecting the other end of said third series circuit directly to the other side of said capacitive means.

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