

Sept. 22, 1970

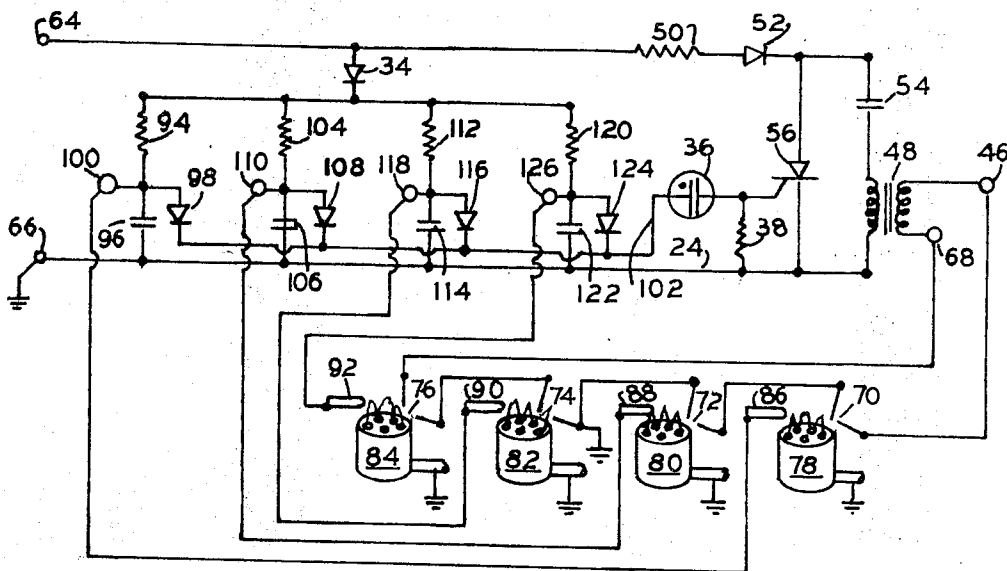
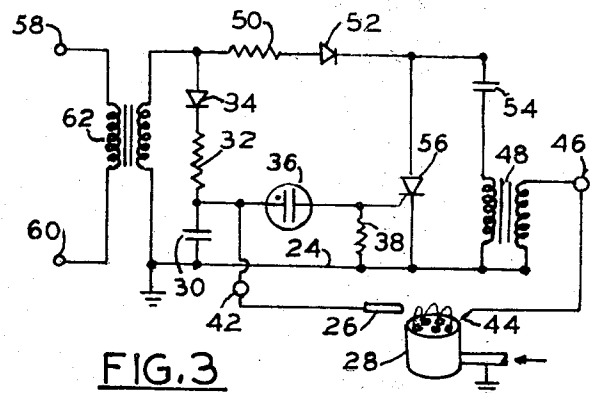
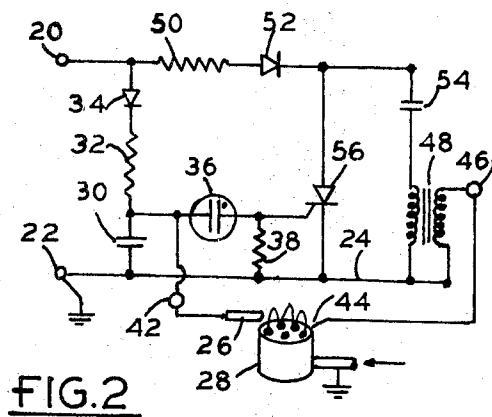
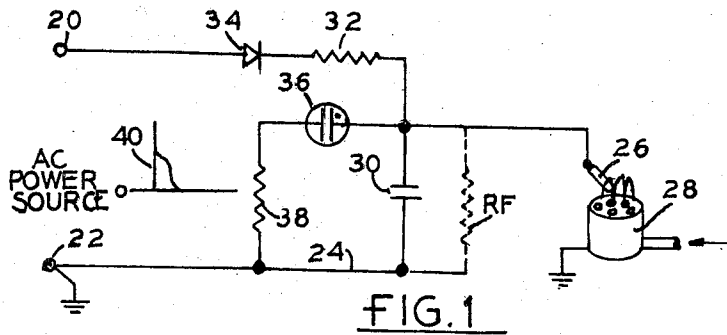
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3,529,910

REIGNITE SYSTEM

Filed March 20, 1968

2 Sheets-Sheet 1



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REIGNITE SYSTEM

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2 Sheets-Sheet 2

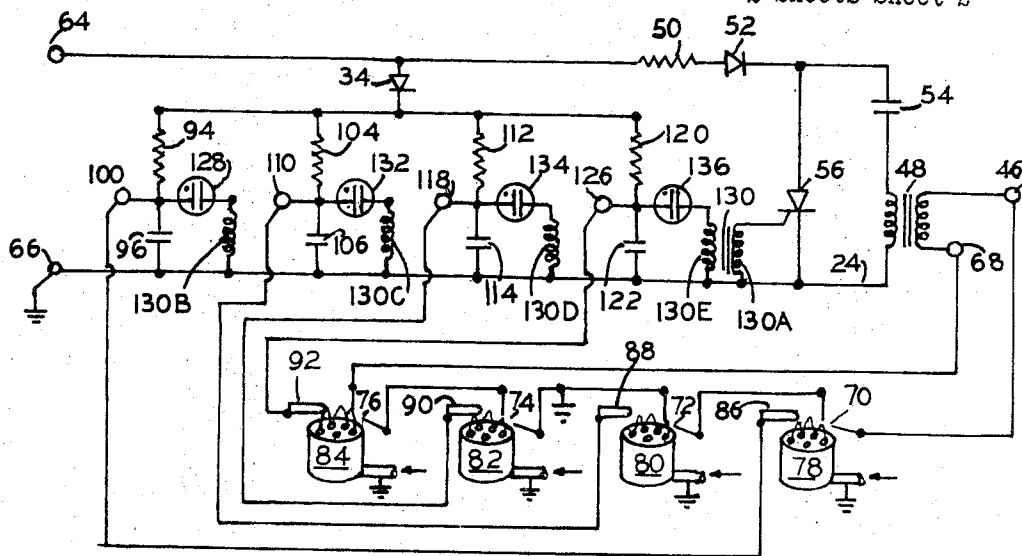


FIG. 5

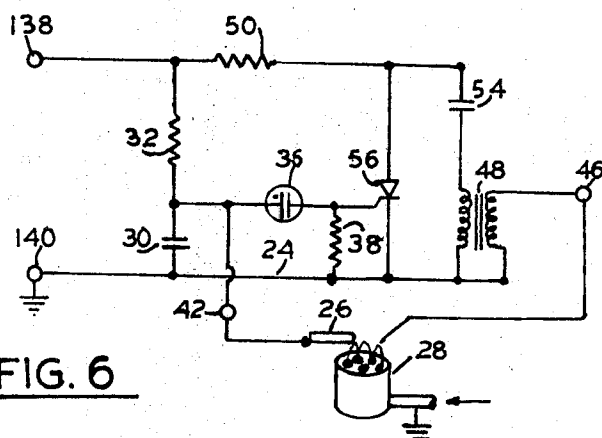


FIG. 6

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3,529,910

REIGNITE SYSTEM

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23 Claims

ABSTRACT OF THE DISCLOSURE

Spark ignition apparatus for the ignition and reignition of a gas pilot or other type of gas burner, employing a capacitive-discharge ignition voltage generator in conjunction with independent electrodes, one for forming a spark gap to the burner and the other for flame sensing, wherein sparks occur in the spark gap in the absence of flame and do not occur when burner flame envelops the tip of the flame sensing electrode. The disclosure includes the ignition and reignition of a plurality of burners.

This invention relates to an improvement in fluid fuel burner systems, and more particularly relates to a burner ignition and burner continuity device employing a high voltage spark at the burner to ignite the fuel or reignite the fuel the instant the burner is extinguished. The gas heating industry has been subjected to the nuisance and aggravation of pilot burners being extinguished for whatever reason, with the attendant inconvenience and lack of heat to the user of the gas burner. Furthermore, when the pilot goes out there is the nuisance of resetting and the expense of a service call for public utilities and others that supply burner service along with fuel. In the majority of burner installations employing a constant burning pilot, a safety means such as a thermocouple or heat sensitive device is located in the pilot flame and connected electrically or mechanically to a fuel valve in the fuel supply, the valve being open and operable so long as the pilot light is functioning, and upon the failure of the pilot light, the valve shuts off the fuel supply to the burner as the burner cools. While such fuel burning systems are well enough protected by thermocouple installations, a reset operation must be made to relight the pilot and bring the thermocouple up to heat so as to generate its holding power upon the main fuel supply valve before the system is again in operation. Since the response time of the thermocouple to the loss of pilot flame is generally in the order of a minute, the annoyance and cost of pilot outages is considerable.

The present invention is directed to overcoming by providing spark ignition to reignite the pilot immediately upon the flame being extinguished.

Accordingly, it is an object of the invention to provide an ignition means to relight a gas pilot or other gas burner the moment the pilot or the burner is extinguished.

Another object of the invention is to reignite the burner by electric spark discharges in response to loss of conductivity of the hot gases of the burner flame.

A further object is to allow sparks to occur only in the absence of flame at the pilot or other burner and to stop them from occurring when flame is present.

Still another object is to provide a common ignition means to relight several pilot or other burners, any one burner having its own means to cause a spark to occur instantly if its flame is extinguished while the fuel is issuing from it, and before the safety device can act to cut off the fuel supply.

A still further object is to provide such an ignition system having an inherently long life and high reliability.

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The above object and other features of the invention will appear more fully hereinafter from the following detailed description when taken in conjunction with the accompanying drawings. It is expressly understood that the drawings are employed for purposes of illustration only and are not designed as a definition of the limits of the invention, reference being had for this purpose to the appended claims.

Referring to the drawings wherein like reference characters indicate like parts:

FIG. 1 is a schematic diagram of a part of the invention.

FIG. 2 is a schematic diagram of the invention designed to operate from 120 v. AC source of power.

FIG. 3 is a schematic diagram of the invention designed to operate from a 24 v. alternating current source of power.

FIG. 4 is a schematic diagram of the invention extended to serve more than one burner.

FIG. 5 is a schematic diagram of a variation of the invention and also extended to serve more than one burner.

FIG. 6 is a schematic diagram of the invention operable from a direct current source of power.

With reference to FIG. 1, terminals 20 and 22 are connected to a 120 v. AC source, terminal 22 being the neutral or grounded line and grounded as shown. Flame sensing electrode 26 is positioned relative to a burner 28 so that flame from the burner will envelop it. Electrode 26 is connected to capacitor 30, the other side of which is connected to ground line 24. The capacitor is also connected through resistor 32 and the cathode and anode of diode 34 to terminal 20, and to one side of the voltage breakdown device 36, whose other side is connected to the ground line 24 through resistor 38.

When power is applied to terminals 20 and 22, capacitor 30 will charge through diode 34 and resistor 32. In the absence of flame at burner 28, electrode 26 has, in effect, an infinite resistance relative to ground and capacitor 30 will charge to the breakdown voltage of the device 36, discharging capacitor 30 through the device 36 and producing a positive pulse of voltage as indicated at 40, across resistor 38, and when the current through device 36 reaches a critical minimum value, the discharge current will be cut off and capacitor 30 will again charge to the firing point of device 36 and another pulse of voltage will occur across resistor 38.

From the foregoing, it will be seen that capacitor 30 will be charged and discharged at a regularly recurring rate which is a combined function of the applied voltage, resistor 32, capacitor 30, and the breakdown and cut-off voltages of device 36. Because of its very low leakage current in the non-conducting state, a neon tube is preferred over semi-conductor devices as a voltage breakdown device.

When the voltage applied to terminals 20 and 22 is from an alternating current source of power, it has a magnitude and polarity which vary sinusoidally, the value of the voltage at any instant being expressed by the term:

$$e = Em \sin 2\pi ft$$

where

e = instantaneous value of the voltage

Em = maximum value of the voltage

f = frequency of the voltage

t = time in seconds from zero time referenced by $2\pi ft = 0$ radius

Using terminal 22 as a zero voltage reference point, terminal 22 will be of positive polarity during the period of time when $2\pi ft$ is between 0 and π radius. It is only during this period, generally referred to as the positive half cycle, and subsequent similar periods, that capacitor

30 can charge because of the unidirectional characteristic of rectifier diode 34.

Capacitor 30 will accumulate a charge over a number of cycles because it cannot discharge on the negative half cycles due to the unidirectional characteristic of diode 34. The time required to charge capacitor 30 to the breakdown voltage of device 36 will be determined by the magnitude of the applied voltage, the breakdown voltage of device 36, and the time constant of resistor 32 and capacitor 30 modified by the effect of charging the capacitor from a rectified sinusoidal voltage, and in the absence of a conductive path from electrode 26 to burner 28 and hence to ground, capacitor 30 will repetitively charge and discharge through device 36 at a rate determined by these factors.

When electrode 26 is enveloped in flame from burner 28 the resulting conductive flame path, having an effective resistance herein designated as RF, is in parallel connection with capacitor 30 thereby altering the condition under which capacitor 30 is charged. Since the voltage available to charge capacitor 30 is the same rectified half wave sinusoidal voltage now reduced in value by the multiplier

$$\frac{RF}{R} 32 \times RF$$

where RF is the effective resistance in ohms of the conductive flame path and R32 is the value in ohms of resistor 32, capacitor 30 can now charge only to a maximum value of

$$Em \times \frac{RF}{R32 \times RF}$$

Resistance 32 can be selected to be greater than the value of RF, by a sufficient margin so that the value to which capacitor 30 charges,

$$Em \times \frac{RF}{R32 \times RF}$$

is less than the breakdown voltage of device 36, thereby preventing the discharge of capacitor 30 through device 36 so long as there is a conductive flame path between electrode 26 and grounded burner 28.

Experiment has shown that for resistance 32 to be sufficiently greater than the flame path RF, the value of resistance 32 should be of the order of 40 megohms or more. With the resistance of resistor 32 of such a high value, the time constant of resistor 32 and capacitor 30 can be undesirably long in those cases where the value of capacitor 30 is 0.1 microfarad as must be the case when device 36 is a neon tube triggering a silicon controlled rectifier with the positive pulse of voltage across resistor 38. Similarly, if capacitor 30 is charged from a direct current source, resistor 32 must be of a similar value. The advantage of charging capacitor 30 with a half wave sinusoidal voltage lies in the shunt effect of the conductive flame path which acts to discharge capacitor 30 during that period when the positive half cycle voltage has decreased to a value lower than the charge accumulated on capacitor 30 and the point on the subsequent cycle when the positive half cycle voltage has reached a value exceeding the charge on capacitor 30. It thus is possible to have a value of about six to ten megohms for resistor 32 and still be assured that the capacitor 30 will not reach the breakdown voltage of device 36, when the latter is a neon tube, and thereby allowing a higher rate of pulses of voltage across resistor 38 in the absence of flame enveloping electrode 26.

In FIG. 2, there is shown a schematic diagram of a spark voltage generator having an alternating current source of power connected to terminals 20 and 22, the latter being common ground and connected to line 24. Electrode 26 is positioned relative to grounded burner 28 so as to be enveloped by flame from the burner and is connected to terminal 42. The spark electrode 44 is connected to terminal 46, the latter being connected to

the output winding of spark transformer 48, the other side of which is connected to line 24. Resistor 50, rectifier diode 52 and the primary winding of transformer 48 provide a charging path from terminal 20 through to line 24 for capacitor 54. The anode of silicon controlled rectifier 56 is connected to the cathode of diode 52 and the cathode to line 24. As previously described, diode 34 and resistor 32 provide a charging path for capacitor 30 to line 24 and the junction of resistor 32 and the capacitor 30 is connected to one terminal of breakdown device 36, whose other terminal is connected to resistor 38 and the gate of SCR 56. Terminal 42 is connected to the junction of resistor 32 and capacitor 30.

With power applied to terminals 20 and 22, capacitor 30 will charge, in the absence of flame, at electrode 26 to trigger the gate of SCR 56 periodically, as previously indicated, to produce an output voltage between terminal 46 and ground, causing sparks to occur between electrode 44 and burner 28. If fuel is issuing from burner 28 it will be ignited by the sparks thus produced and flame will occur, thereby enveloping electrode 26 and providing a conductive path to ground so that capacitor 30 will not charge to the breakdown voltage of device 36. Thus no further sparks will be produced. With electrode 26 enveloped in flame there will be some charge lower than the breakdown voltage of device 36 remaining on the capacitor 30 so that when a flame-out occurs capacitor 30 is partially charged and does not have to charge from zero, and consequently the capacitor charge will rapidly rise to that required to fire device 36 into conduction to thereby trigger additional sparks to ignite the fuel, sparks continuing to occur until flame again envelopes electrode 26. Although the arrangement shown in FIG. 2 employs two separate electrodes, electrode 44 for sparking and electrode 26 for sensing flame conductivity, thus slightly complicating the arrangement, and though it would be possible to have terminal 42 connected through the secondary of transformer 48 and there through to electrode 44, capacitor 30 in such an arrangement would act not only as the trigger for neon device 36 but also as a return path for sparks current, thereby eliminating the need for electrode 26. The use of a separate electrode 26 for flame conduction has several advantages, first, it eliminates the possibility of the secondary winding of transformer 48 having an open circuit whereby a DC current resulting from flame conductivity could not flow through it whereas the high voltage current would, in which case the flame conduction would have no effect in causing the sparks to cease and the sparkler would continue to produce sparks in the presence of flame and, second, as described hereinafter it is possible with the arrangement of FIG. 2, with slight modifications, to provide ignition and reignition for several burners using a single spark generator. The first advantage is important in the interest of long term reliability, in that continued sparking without interruption would lead to deterioration of SCR 56 with possible ultimate breakdown whereby no spark or reignition would be available at all.

As will appear hereinafter, it is possible to use a source of direct current rather than alternating current in the above arrangement by applying a suitable magnitude of DC voltage to terminals 20 and 22, terminal 20 being positive, in which rectifier diodes 34 and 52 are not required. However, in this case, because of the steady DC source voltage from terminal 20, resistor 32 would have to be greatly increased in value since capacitor would now be charging from a steady DC voltage rather than the half wave rectified DC pulses obtained when using an alternating current source.

In FIG. 3, there is shown a system which is like that illustrated in FIG. 2, except that it is operated from a 24 v. alternating current source of power and employs a step-up transformer to provide the nominal 120 v. required for operation of the device. The circuit, electrodes and burner comprising items 24 through 56 are the same

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as those described in FIG. 2 in their values and circuit arrangement. The nominal 120 v. AC source of supply is obtained from the secondary winding of step-up transformer 62, the primary winding of which is connected via terminals 58 and 60 to a source of 24 v. AC. The secondary winding is connected to one side of the junction of diode 34 and resistor 50 and the other side to the common ground line 24. Inasmuch as the control circuits in many burner installations are at the 24 v. AC level, this arrangement is adapted to cover those cases. Since normally, a 24 v. control voltage is not grounded, grounding provision is made through common ground line 24. With reference to FIG. 4, there is shown a schematic diagram of a common spark generator arranged to provide ignition at four burners, the spark generator being triggered by one of the four triggering sections each of which is connected to a separate flame rod located at the respective burners. In this arrangement each burner has its own separate fuel control point so that the burners operate independent of each other and each burner is able to initiate sparking if flame is absent while fuel is issuing from the burner. When sparking is initiated by one burner, sparking occurs at all four burners since the spark electrodes are connected in series to the common high voltage source. While this arrangement shows four burners so connected, it is possible to use the same technique for more than four burners depending upon the ability of the spark generator to produce sparks at the series connected electrode pairs.

When power is applied to terminals 64 and 66, the latter being grounded, capacitor 54 is charged to the peak value of the line voltage through resistor 50, diode rectifier 52 and the primary winding of spark transformer 48. SCR 56 is connected to discharge capacitor 54 through the primary of transformer 48, when it is triggered by the voltage breakdown device 36 discharging any one of capacitors 122, 114, 106 or 96, connected through diodes 124, 116, 108 and 98 respectively, which provide electrical isolation between the four mentioned capacitors. These capacitors are charged from terminal 64 through diode 34 and respectively through resistors 120, 112, 104 and 94. Terminal 126 at the junction of resistor 120 and capacitor 122 is connected to flame rod 92, the latter being positioned to sense flame at burner 84. Terminal 118 is connected to the junction of resistor 112 and capacitor 114 and to flame rod 90, so positioned as to sense flame at burner 82. Terminal 110 connected to the junction of resistor 104 and capacitor 106 is connected to flame rod 88 in position to sense flame at burner 80. Terminal 100 connected at the junction of resistor 94 and capacitor 96 is connected to flame rod 86 positioned to sense flame from burner 78. The output of spark transformer is connected via terminals 46 and 68 to the series connected sets of electrode pairs 70, 72, 74 and 76, positioned to ignite fuel from burners 78, 80, 82 and 84 respectively. The junction of electrode pairs 72 and 74 is grounded to balance the lines from terminal 46 and 68 to ground. In this arrangement, any one of the flame rods 86, 88, 90 or 92 sensing the absence of flame at its respective burner will allow their respective capacitors 96, 106, 114 or 122, to charge sufficiently to fire device 36 through their respective diodes thereby triggering SCR 56 and causing sparks to occur until flame is again sensed by the appropriate flame rod. For example, when all burners are turned on and burning, and flame at burner 84 is extinguished for whatever reason, the absence of flame at burner 84 is immediately sensed by flame rod 92 to allow capacitor 122 to charge sufficiently to trigger the breakdown device 36. Capacitor 122 discharges through diode 124 through line 102 to breakdown device 36 and the gate-cathode of SCR 56. Sparks will then occur at all four electrode pairs until burner 84 is reignited and flame rod 92 is again enveloped in flames.

The arrangement of FIG. 4 is particularly useful on a multiple burner installation such as certain types of

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boilers, large heating ovens, and furnaces, and gas ranges, having more than one pilot burner.

In FIG. 5, there is shown a circuit for reignition of multiple burners as previously described except that in FIG. 5 the isolation of individual triggering capacitors is provided for by means of pulse transformer 130, the secondary 130A of which is connected between the gate and cathode of SCR 56 and the four primary windings 130B, 130C, 130D and 130E being connected individually in series with a voltage breakdown device across the four respective triggering capacitors. For instance, breakdown device 128 is series connected with transformer primary 130B in parallel with capacitor 96 so that if flame at burner 78 goes out and the absence of flame is sensed by flame rod 86, capacitor 96 will charge to the firing point of the breakdown device 128 and a pulse of current will occur in transformer primary 130B. This pulse of current will induce a voltage in secondary winding 130A thereby triggering SCR 56 into conduction and producing sparks as previously described at all four burners. Similarly, flame rod 88 located at burner 80 will allow capacitor 106 to charge to fire breakdown device 132 to produce a pulse of current in transformer primary 130C thereby producing sparks until flame rod 88 is again enveloped in flame. Absence of flame at flame rod 90 will result in pulses of current in transformer primary 130D and absence of flame at flame rod 92 will result in pulses of current in transformer primary 130E. The arrangement of FIG. 5 has the advantage over FIG. 4 wherein isolation diodes are used, in that a higher degree of reliability may be expected since any component failure in any one triggering section will not affect the triggering of any of the other three sections.

In regard to FIG. 4 or FIG. 5, if one or more of the burners are not needed, the valve which cuts off the fuel to a particular burner can be made to ground the terminal such as 100, 118 or 126 relating to the burner, thus leaving the remaining burners operating in the manner described.

In FIG. 6, there is shown a circuit adapted to operate from a direct current source of power, the circuit being like that of FIG. 2, for the elimination of rectifiers 52 and 34. The operation is otherwise the same as previously described. When direct current power is applied to terminals 138, 140, the latter being grounded, and the former being of positive polarity, capacitor 54 will charge from terminal 138 through resistor 50 and the primary winding of transformer 48, and capacitor 30 will charge from terminal 138 through resistor 32. Since capacitor 30 is charging from a common DC source it will charge much more rapidly than from the previously described rectified AC source and consequently the value of resistor 32 will be made higher to maintain the same sparking rate.

While a single form and variations of the invention have been illustrated and described, it is to be understood that the invention is not limited thereto. As various changes in the construction and arrangement may be made without departing from the spirit of the invention, as will be apparent to those skilled in the art, reference will be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. For the ignition and reignition of a gas pilot burner having a source of fuel, an ignition system having an alternating current source of power comprising a first electrode fixedly positioned relative to the burner to form a spark discharge gap therebetween and so that spark discharges occurring in said gap will ignite fuel issuing from said burner; a second electrode fixedly positioned relative to said burner so as to be enveloped by flame from the burner but not to be in electrical contact with the burner; an ignition circuit comprising a first and a second terminal connected to the source of alternating current, a common ground line connected to said second terminal, a first series circuit disposed between said first terminal

and common ground line and comprising a resistor, the anode and cathode of a first rectifier diode, a first capacitor and the primary winding of a high voltage transformer, the secondary winding of which has one side connected to the common ground line and the other side to a third terminal therethrough connected by a suitable high voltage conductor wire to said first electrode; a second series circuit disposed between said first terminal and common ground line comprising the anode and cathode of a second rectifier diode, a second resistor and a second capacitor, the junction of said second resistor and second capacitor being also connected to the common ground line through the series connection of a voltage breakdown device and the gate and cathode of a silicon controlled rectifier whose anode is connected to the junction of said first diode and first capacitor, and being further connected to a fourth terminal and therethrough by a suitable conductor wire to said second electrode, and a third resistor in parallel connection with the gate and cathode of said silicon controlled rectifier.

2. For the ignition and reignition of a pilot or other type of fluid fuel burner having a source of fuel, an ignition system having a direct current source of power, comprising a first electrode fixedly positioned relative to the burner to form a spark discharge gap therebetween wherein spark discharges occurring will ignite fuel issuing from the burner, a second electrode fixedly positioned at the burner so as to have its tip enveloped by flame from the burner but not to be in electrical contact with the burner, an ignition circuit comprising a first and a second terminal connected to the positive and negative sides of the source of direct current, a common ground line and grounding connection connected to said second terminal, a first series circuit disposed between said first terminal and common ground line comprising a first resistor a first capacitor and the primary winding of a high voltage transformer whose secondary winding has one side connected to common ground line and the other side to a third terminal therethrough connected by suitable high voltage conductor wire to said first electrode; a second series circuit disposed between said first terminal and common ground line comprising a second resistor and a second capacitor, the junction of said second resistor and second capacitor being also connected to the common ground line through the series connection of a voltage breakdown device and the gate and cathode of a silicon controlled rectifier whose anode is connected to the junction of said first resistor and first capacitor, and being further connected to a fourth terminal and therethrough by a suitable conductor wire to said second electrode, and a third resistor in parallel connection with the gate and the cathode of said silicon controlled rectifier.

3. For the ignition and reignition of a plurality of gas pilot burners, each having its respective source of fuel, an ignition control system comprising a plurality of electrode pairs each forming therebetween a spark discharge gap and each positioned relative to a respective burner so that sparks occurring in said gaps will ignite fuel issuing at their respective burners; a plurality of single electrodes each positioned relative to a respective burner so as to be enveloped by flame from their respective burners; an ignition control circuit having an alternating current source of power one side of which is grounded, comprising a capacitor-discharge type of spark voltage generator whose output transformer has a secondary winding connected to two output terminals and therethrough by suitable high voltage conductors across the plurality of electrode pairs which are series connected; a plurality of like means for causing sparks to occur in the gaps of the series connected electrode pairs dependent upon any one of a plurality of capacitors charging to the breakdown voltage of a plurality of voltage breakdown devices such as neon lamps, in a regularly repetitive fashion, each of said capacitors having disposed across it a respective series connected voltage breakdown device and an input

winding of a transformer, the primary of which is connected to the spark generator; each of said capacitors having connected thereto a terminal for extending connection of each to one of said plurality of single electrodes, whereby spark discharges will occur in all of said gaps when any of said single electrodes is not enveloped by flame from its respective burner, and spark discharges will not occur if every one of said plurality of single electrodes is enveloped by flame from its respective burner.

4. For the ignition and reignition of a plurality of gas pilot burners each having a source of fuel, an ignition control system comprising a plurality of electrode pairs each forming therebetween a spark discharge gap and positioned relative to a respective burner of the plurality of burners so that sparks occurring in said gaps will ignite fuel issuing at their respective burners; a plurality of single electrodes positioned relative to each burner so as to be enveloped by flame from the burner; an ignition control circuit having an alternating current source of power one side of which is grounded and comprising a capacitor-discharge type of spark voltage generator whose output transformer has a secondary winding connected to two output terminals and therethrough by suitable high voltage conductors across the plurality of electrode pairs which are series connected; a plurality of means each including a capacitor for causing sparks to occur in said gaps, each dependent upon its respective capacitors charging to the breakdown voltage of a voltage breakdown device such as a neon lamp, each of said capacitors having a respective diode through which its discharge current through said breakdown must pass thus providing electrical isolation between respective capacitors; each of said capacitors having connected thereto a flame electrode terminal for extending connections from each to a respective one of said plurality of single electrodes, whereby spark discharges will occur when any of said single electrodes is not enveloped by flame from its respective burner, and spark discharges will not occur if everyone of said plurality of single electrodes is enveloped by flame from its respective burner.

5. The ignition control system of claim 4 wherein said source of alternating current power is supplied from the secondary winding of a second transformer whose primary winding is supplied with alternating current power of 30 volts root mean square or less, one side of said secondary winding connected to the burners.

6. The ignition control system of claim 3 wherein said source of alternating current power is supplied from the secondary winding of an input transformer whose primary winding is supplied with alternating current power of 30 volts root mean square or less, one side of said secondary winding connected to the burners.

7. For the ignition and reignition of a gas pilot burner, an electric spark ignition apparatus comprising a source of alternating current power of thirty volts root mean square or less, a spark electrode disposed adjacent the burner to provide a spark discharge gap to the burner wherein the occurrence of sparks will ignite fuel issuing from the burner, a flame electrode positioned at the burner so as to be enveloped in flame when the burner is ignited, an ignition circuit comprising a capacitor-discharge type of spark voltage generator having trigger means to repetitively trigger pulses of spark voltage at the output of said generator, said trigger means connected to said flame electrode and the burner whereby said trigger means is rendered inoperative through the conductivity of the burner flame enveloping said flame electrode, said generator output connected to said spark electrode and the burner, and a step-up transformer having its primary winding connected to said source of power and its secondary winding connected across said generator with one side connected to the burner; whereby said transformer in said circuit provides appropriate operating voltage for said spark voltage generator.

8. For the ignition and reignition of a gas pilot burner an electric spark ignition apparatus comprising a source of alternating current power of 30 volts root mean square or less, a spark electrode disposed adjacent the burner to provide a spark discharge gap to the burner wherein the occurrence of sparks will ignite fuel issuing from the burner, a flame electrode positioned at the burner so as to be enveloped in flame when the burner is ignited, an ignition circuit comprising a capacitor-discharge type of spark voltage generator having a trigger capacitor and triggered at regular intervals by the discharge of said trigger capacitor through a voltage breakdown device, charging of said trigger capacitor to the breakdown voltage of said breakdown device responsive only to absence of flame enveloping said flame electrode and a step-up transformer having its primary winding connected to said 30 volts or less source of power and its secondary winding across said voltage generator and one side connected to the burner, whereby said step-up transformer provides appropriate operating voltage for said voltage generator.

9. For the ignition and reignition of a plurality of gas burners, an ignition control system comprising a plurality of series connected electrode pairs each forming therebetween a spark discharge gap and each positioned relative to a respective burner so that sparks occurring in said gaps will ignite gas issuing at their respective burners; a plurality of single electrodes each positioned relative to a respective burner so as to be enveloped by flame from their respective burners; an ignition control circuit having an alternating current source of power one side of which is grounded, comprising a spark voltage generator whose output is connected across the series connection of said plurality of electrode pairs, a plurality of like pulse triggering means each responsive when energized to conductivity from a respective single electrode through flame to its respective burner, each of said triggering means when energized acting on said spark voltage generator whereby said generator will cause sparks to occur in all of said gaps when any of said single electrodes whose respective triggering means is energized is not enveloped by flame from its respective burner, and said generator will not cause sparks to occur in said gaps if every one of said single electrodes whose respective triggering means is energized is enveloped by flame from its respective burner.

10. For the ignition and reignition of a plurality of gas burners, an ignition control system comprising a plurality of series connected electrode pairs each forming therebetween a spark discharge gap and each positioned relative to a respective burner so that sparks occurring in said gaps will ignite gas issuing at their respective burners, a plurality of single electrodes each positioned relative to a respective burner so as to be enveloped by flame from their respective burners, an ignition control circuit having an alternating current source of power of 30 volts root mean square or less comprising a spark voltage generator whose output is connected across the series connection of said plurality of electrode pairs, and whose operating voltage is greater than 30 volts root mean square, a step-up transformer whose primary winding is connected to said source of power and whose secondary is connected to said generator, a plurality of like pulse triggering means each responsive when energized to conductivity from a respective single electrode through flame to its respective burner, each of said triggering means when energized acting on said spark voltage generator whereby said generator will cause sparks to occur in all of said gaps when any of said single electrodes whose respective triggering means is energized is not enveloped by flame from its respective burner, and said generator will not cause sparks to occur in said gaps if every one of said single electrodes whose respective triggering means is energized is enveloped by flame from its respective burner.

11. For the ignition and reignition of a plurality of gas burners, an ignition control system comprising a plurality

of series connected electrode pairs each forming therebetween a spark discharge gap and each positioned relative to a respective burner so that sparks occurring in said gaps will ignite gas issuing at their respective burners; a plurality of single electrodes each positioned relative to a respective burner so as to be enveloped by flame from their respective burners; an ignition control circuit operable from a source of alternating current power of 30 volts root mean square or less, comprising a spark voltage generator whose output is connected across the series connection of said plurality of electrode pairs, a plurality of like pulse triggering means each responsive when energized to conductivity from a respective single electrode through flame to its respective burner, each of said triggering means acting when energized on said spark voltage generator whereby said generator will cause sparks to occur in all of said gaps when any of said single electrodes whose respective triggering means is energized is not enveloped by flame from its respective burner, and said generator will not cause sparks to occur in said gaps if every one of said single electrodes whose respective triggering means is energized is enveloped by flame from its respective burner.

12. For the ignition and reignition of a plurality of gas burners an ignition control system comprising in combination a plurality of electrode means each disposed adjacent a respective burner whereat to provide a spark discharge when energized and to provide means to sense presence of flame enveloping the respective electrode means at its respective burner, an ignition control circuit operable from a source of alternating current power of more than thirty volts root mean square said circuit comprising a capacitor-discharge type of ignition voltage generator having spark voltage triggering means and having connections extending the spark voltage to said plurality of electrode means to simultaneously energize the latter, a plurality of like voltage supplying means each supplying operating voltage upon energization to said triggering means and each having connections extending to a respective electrode means each of said voltage supplying means upon energization responsive to flame enveloping its respective electrode means not to supply operating voltage to said triggering means whereby said generator will energize all of said electrode means when any of them whose respective voltage supplying means is energized is not enveloped by flame from its respective burner, and said generator will not energize any of said electrode means if every one of them whose respective voltage supplying means is energized is enveloped by flame from its respective burner.

13. For the ignition and reignition of a plurality of gas burners an ignition control system comprising in combination a plurality of electrode means each disposed adjacent a respective burner whereat to provide a spark discharge when energized and to provide means to sense presence of flame enveloping the respective electrode means at its respective burner, an ignition control circuit operable from a source of alternating current power of thirty volts root means square or less said circuit comprising a capacitor-discharge type of ignition voltage generator having spark voltage triggering means and having connections extending the spark voltage to said plurality of electrode means to simultaneously energize the latter, a plurality of like voltage supply means each supplying operating voltage upon energization to said triggering means and each having connections extending to a respective electrode means each of said voltage supplying means upon energization responsive to flame enveloping its respective electrode means not to supply operating voltage to said triggering means whereby said generator will energize all of said electrode means when any of them whose respective voltage applying means is energized is not enveloped by flame from its respective burner, and said generator will not energize any of said electrode means if every one of them whose respective voltage

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applying means is energized is enveloped by flame from its respective burner.

14. For the ignition and reignition of a gas pilot burner having a source of fuel, a spark ignition apparatus comprising a spark electrode disposed adjacent the burner to provide a spark discharge gap to the burner to ignite gas issuing from the burner, a flame electrode positioned at the burner so as to be enveloped in flame when the burner is ignited, and a spark voltage generator circuit of the capacitor-discharge type having an alternating current source of power, one side of which is connected to the burner, said circuit having operably independent connections extending to said spark electrode and to said flame electrode whereby spark discharges will occur in said gap when said flame electrode is not enveloped in flame, and spark discharges will not occur when the flame electrode is enveloped in burner flame.

15. The ignition apparatus as described in claim 14 wherein said spark and flame electrodes are physically mounted in a common mass of insulator material providing electrical isolation and physical separation of said electrodes whereby the electrodes are operably independent one from the other.

16. For the ignition and reignition of a gas pilot burner having a source of fuel, a spark ignition apparatus comprising a spark electrode disposed adjacent the burner to provide a spark discharge gap to the burner to ignite gas issuing from the burner, a flame electrode positioned at the burner so as to be enveloped in flame when the burner is ignited, and a spark voltage generator circuit of the capacitor-discharge type having an alternating current source of power of thirty volts root mean square or less said circuit including a step-up transformer whose primary winding is connected to said source of power and whose secondary winding supplied a higher operating voltage to the balance of said circuit; and one side of said secondary is connected to the burner, said circuit having operably independent connections extending to said spark electrode and to said flame electrode whereby spark discharges will occur in said gap when said flame electrode is not enveloped in flame, and spark discharges will not occur when the flame electrode is enveloped in burner flame.

17. The ignition apparatus as described in claim 16 wherein said spark and flame electrodes are physically mounted in a common mass of insulator material providing electrical isolation and physical separation of said electrodes, whereby the electrodes are operably independent one from the other.

18. Spark ignition apparatus, for use with a gas pilot burner, to provide spark discharges for igniting gas issuing from the burner, said apparatus comprising a spark electrode disposed adjacent the burner to provide a spark discharge gap to the burner wherein the occurrence of sparks will ignite fuel issuing from the burner, a flame electrode positioned at the burner so as to be enveloped in flame when the burner is ignited, and a capacitor-discharge type of spark voltage generator having a pulse triggering section and operable from a source of alternating current power, said generator providing a periodic output of spark voltage pulses in response to the operation of said triggering section, said output being connected to said spark electrode and the burner and causing spark discharges to occur in said spark gap, said triggering

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section being connected to said flame electrode and the burner thereby to be rendered operative in the absence of flame from the burner and rendered inoperative when burner flame envelopes said flame electrode.

19. The spark ignition apparatus as described in claim 18 wherein said spark and flame electrodes are physically mounted in a common mass of insulator material, said material providing electrical isolation and physical separation whereby the electrodes are operably independent one from the other.

20. The spark ignition apparatus as described in claim 18 wherein the source of alternating current power is supplied from the secondary winding of a transformer, one side of said secondary connected to the burner, and the primary winding of said transformer is supplied with alternating current power of thirty volts root means square or less.

21. Spark ignition apparatus, for use with a gas pilot burner, to provide spark discharges for igniting fuel issuing from the burner, said apparatus comprising a spark electrode disposed adjacent the burner to provide a spark discharge gap to the burner wherein the occurrence of sparks will ignite gas issuing from the burner, a flame electrode positioned at the burner so as to be enveloped in flame when the burner is ignited, and a capacitor-discharge type of spark voltage generator having a pulse triggering section and operable from a source of direct current power the negative side of which is connected to the burner, said generator providing a periodic output of spark voltage pulses in response to the operation of said triggering section, said output being connected to said spark electrode and the burner and causing spark discharges to occur in said spark gap, said triggering section being connected to said flame electrode and the burner thereby to be rendered operative in the absence of flame from the burner and rendered inoperative when burner flame envelopes said flame electrode.

22. The spark ignition apparatus as described in claim 21 wherein said spark and flame electrodes are physically mounted in a common mass of insulator material, said material providing electrical isolation and physical separation whereby the electrodes are operably independent one from the other.

23. For the ignition of a gas pilot burner, a spark ignition apparatus having a source of alternating current power of 30 volts root mean square or less and comprising a spark voltage generator circuit of the capacitor-discharge type and electrode means providing a spark gap and a conductive path through the burner flame to render said generator inoperative when the burner flame envelopes said electrode means, said circuit including a step-up transformer to provide a circuit operating voltage greater than thirty volts root mean square.

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