US 20100108658A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2010/0108658 A1

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(43) Pub. Date: May 6, 2010

(54) DUAL VOLTAGE REGULATING SYSTEM FOR ELECTRICAL RESISTANCE HOT SURFACE IGNITERS AND METHODS RELATED THERETO

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(21) Appl. No.: **12/589,253**

(22) Filed: **Oct. 19, 2009**

Related U.S. Application Data

(60) Provisional application No. 61/196,759, filed on Oct. 20, 2008, provisional application No. 61/239,279, filed on Sep. 2, 2009.

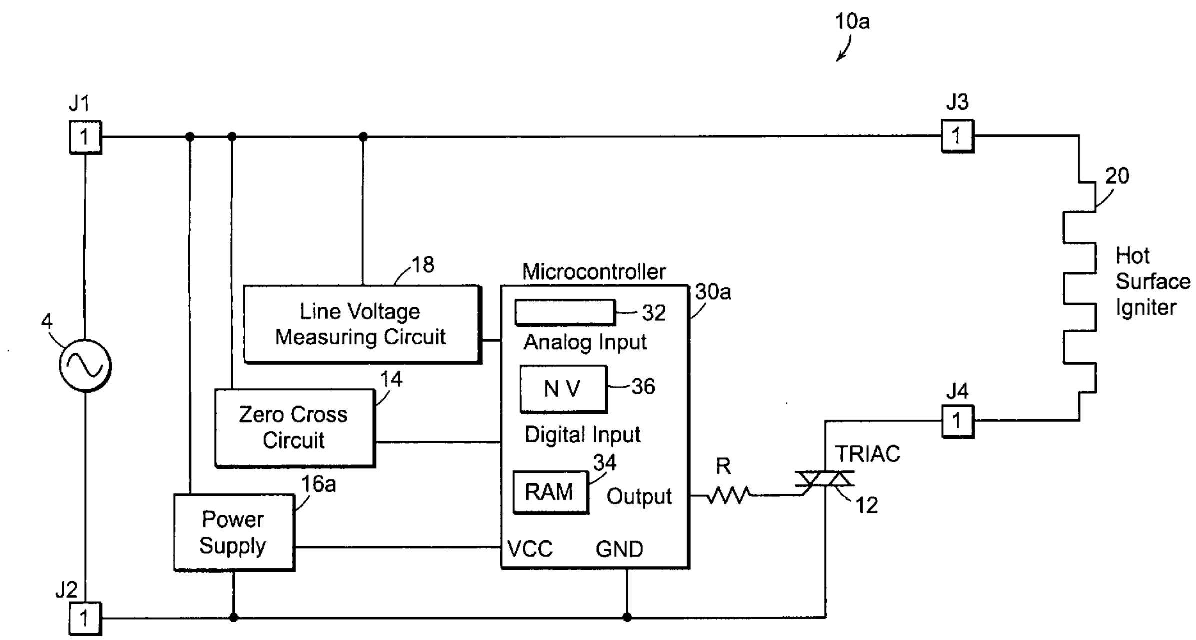
Publication Classification

(51) **Int. Cl.**
F23Q 7/22 (2006.01)

(52) **U.S. Cl.** **219/262**; 219/268

(57) **ABSTRACT**

Systems and methods for energizing a low voltage electrical resistance igniter are disclosed. The systems and methods determine the line voltage into the system and control the voltage being applied to the electrical resistance igniters so a first regulated voltage is applied initially and for a time period and thereafter a second regulated voltage is applied, the second voltage being the operating voltage for the igniter. The systems and methods decrease the amount of time required to heat-up the low voltage electrical resistance igniter to a temperature sufficient to ignite a fuel-air mixture while regulating the output voltage being delivered to the igniters to prevent over voltage damage to the igniters.



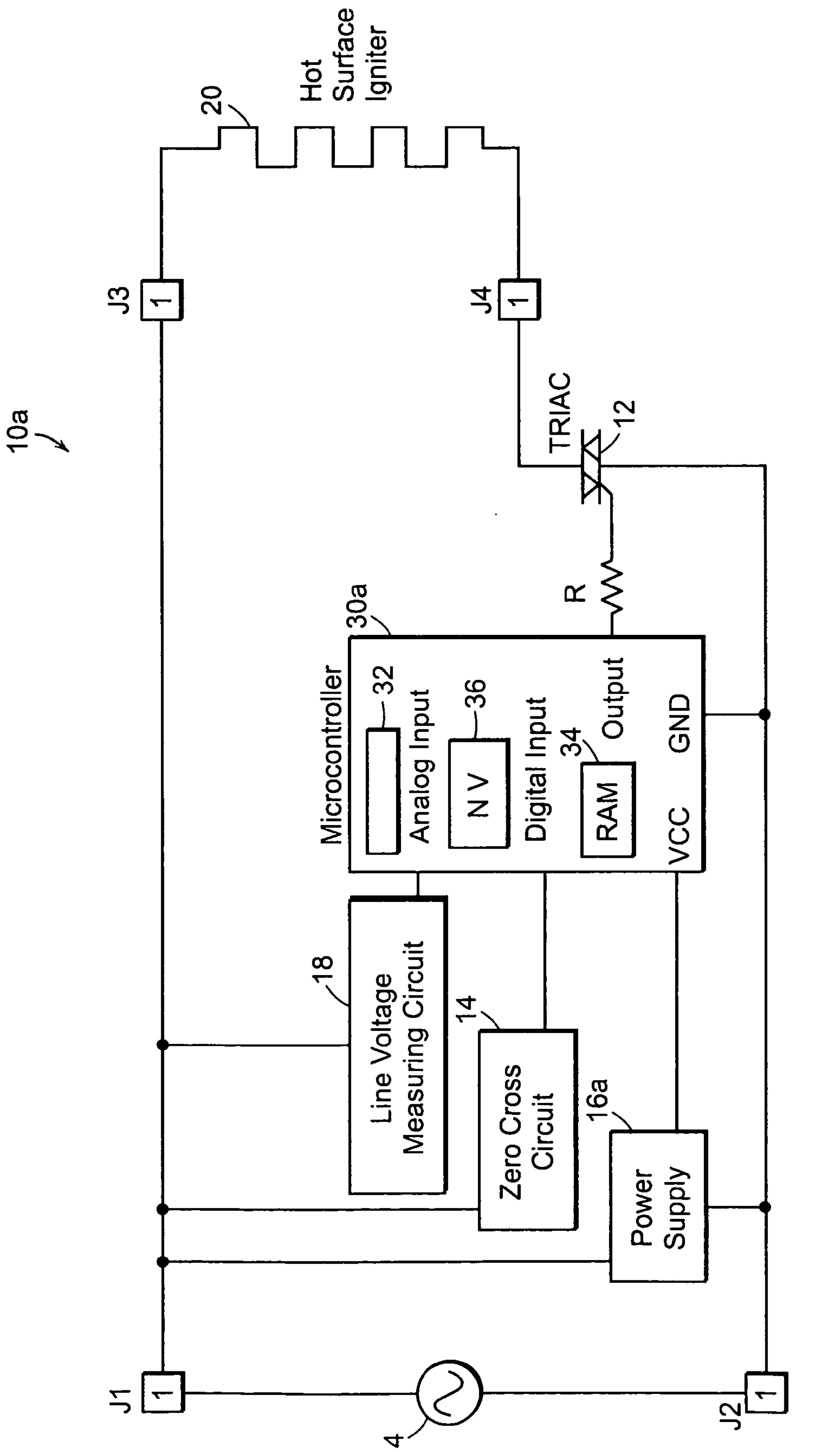

10a
20
Hot Surface Igniter
J3
1
J4
1
TRIAC
12
30a
Microcontroller
32
Analog Input
36
N V
Digital Input
34
RAM
Output
VCC
GND
R
18
Line Voltage Measuring Circuit
14
Zero Cross Circuit
16a
Power Supply
J1
1
J2
1
4

FIG. 1A

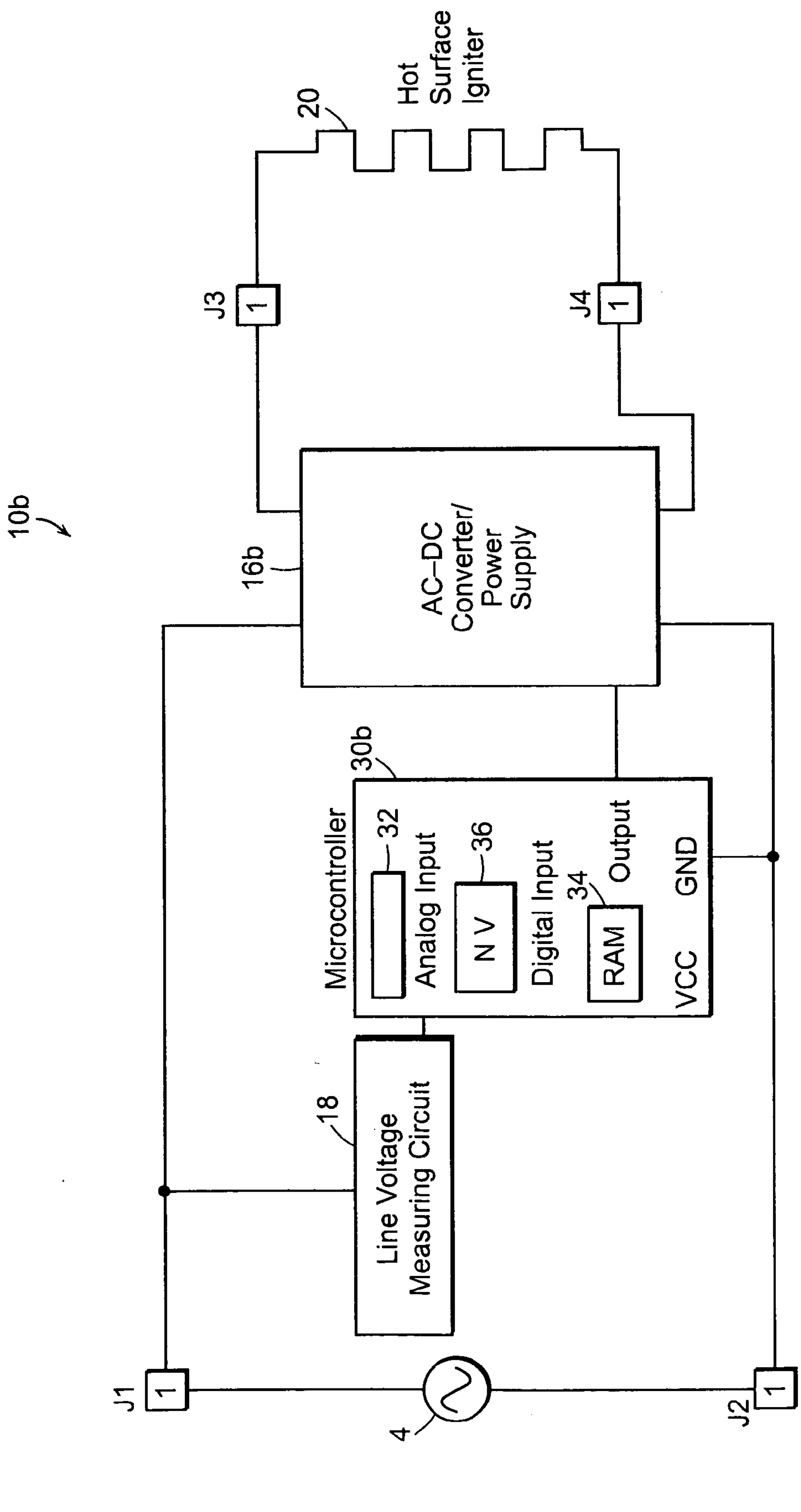

10b
20
Hot Surface Igniter
J3
1
J4
1
16b
AC–DC Converter/ Power Supply
30b
Microcontroller
32
Analog Input
36
N V
Digital Input
34
RAM
Output
VCC
GND
18
Line Voltage Measuring Circuit
J1
1
4
J2
1

FIG. 1B

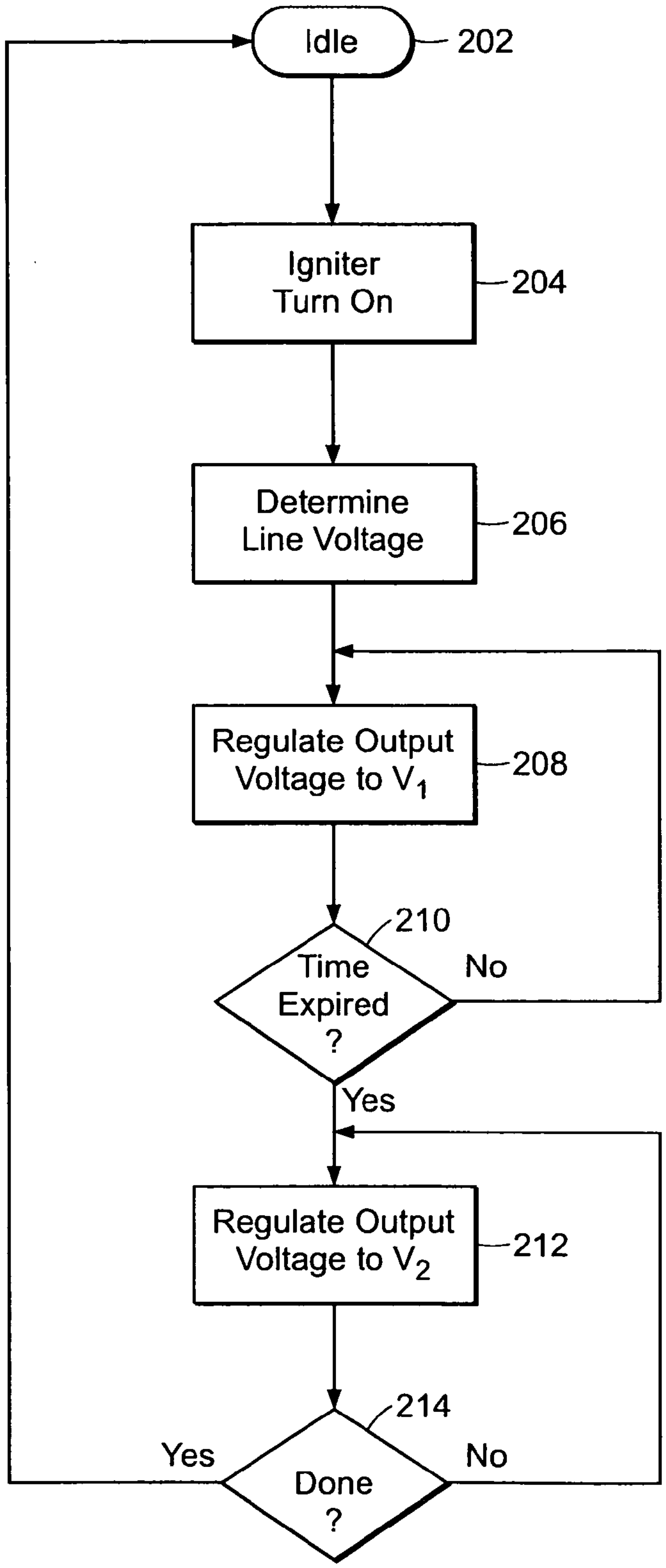

Idle
202
Igniter
Turn On
204
Determine
Line Voltage
206
Regulate Output
Voltage to V_1
208
210
Time
Expired
?
No
Yes
Regulate Output
Voltage to V_2
212
214
Yes
Done
?
No

FIG. 2A

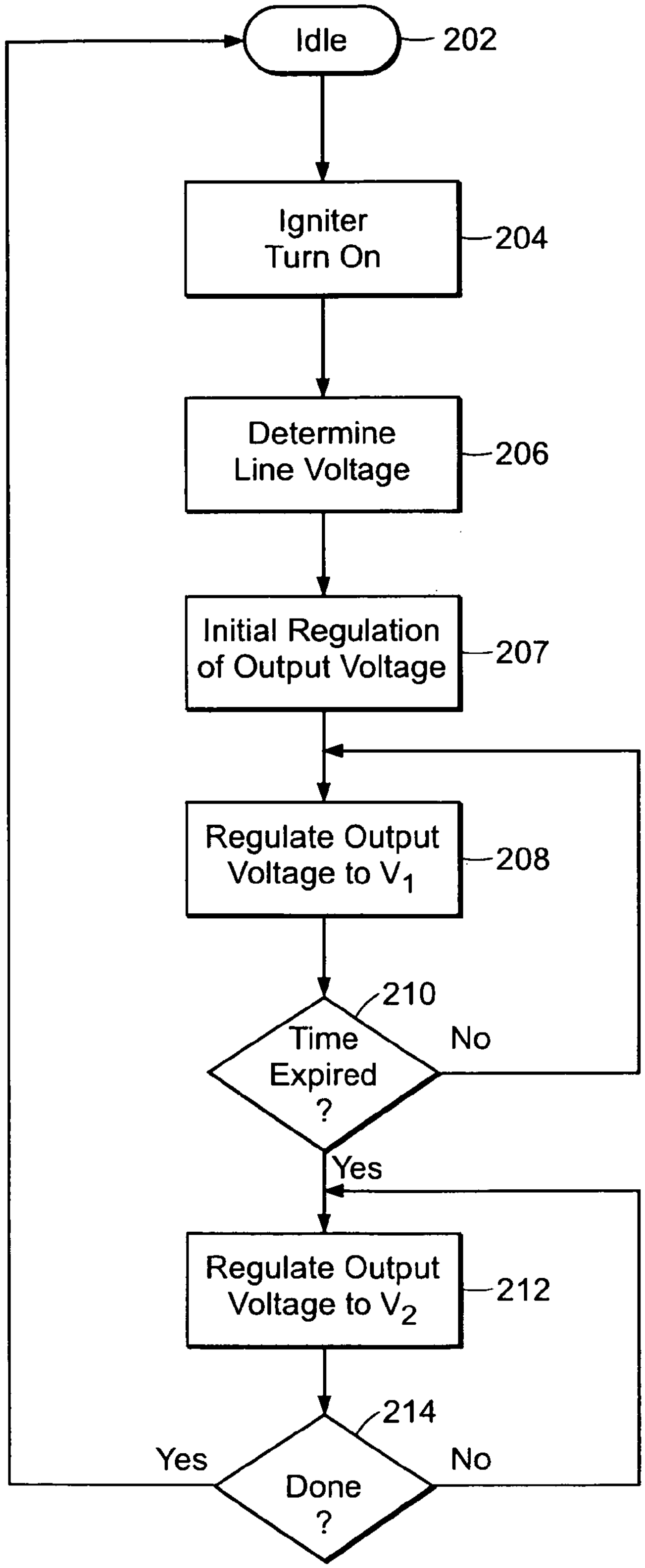

Idle
202
Igniter Turn On
204
Determine Line Voltage
206
Initial Regulation of Output Voltage
207
Regulate Output Voltage to V_1
208
210
Time Expired ?
No
Yes
Regulate Output Voltage to V_2
212
214
Yes
Done ?
No

FIG. 2B

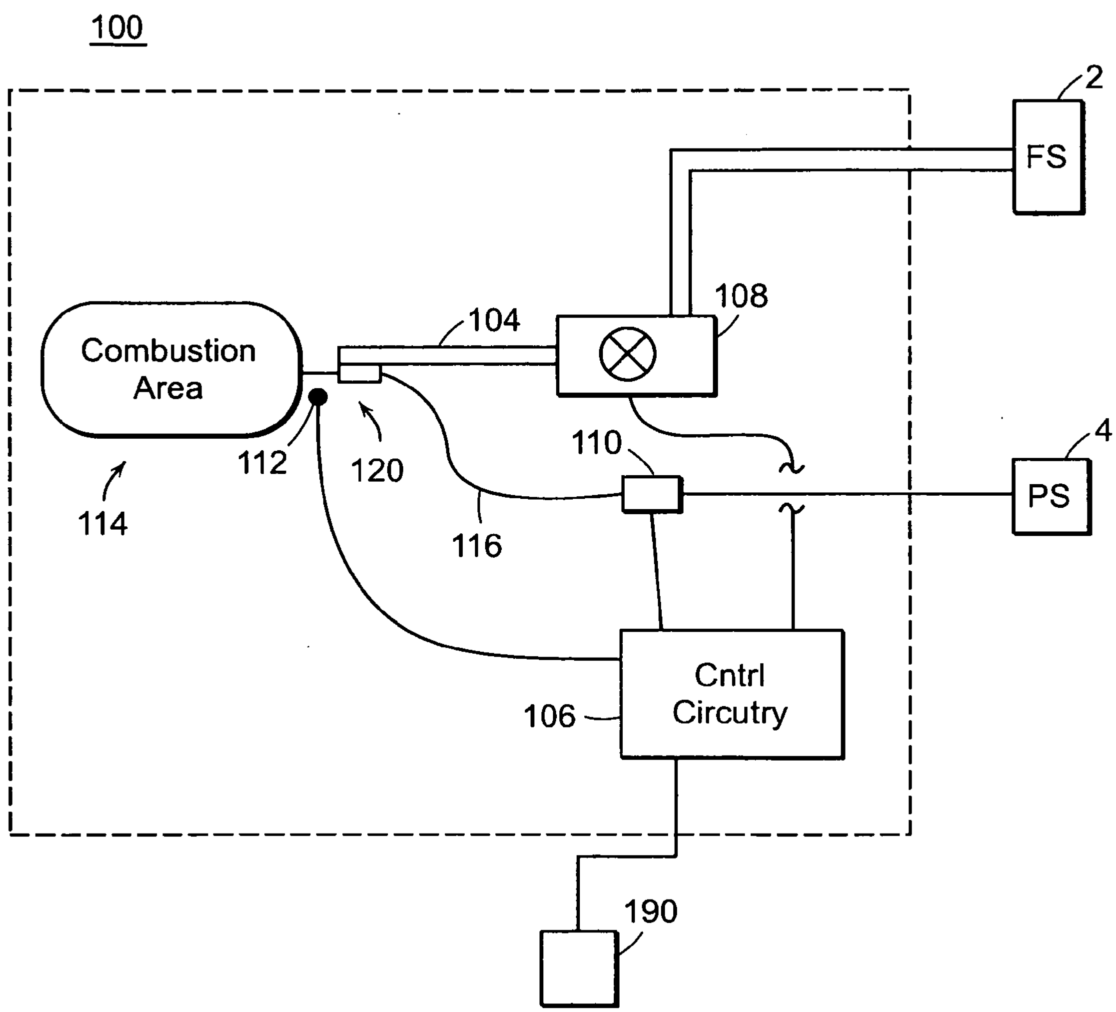

100
2
FS
108
104
Combustion
Area
112
120
110
4
PS
114
116
Cntrl
Circutry
106
190

FIG. 3

DUAL VOLTAGE REGULATING SYSTEM FOR ELECTRICAL RESISTANCE HOT SURFACE IGNITERS AND METHODS RELATED THERETO

[0001] This application claims the benefit of U.S. Provisional Application Ser. No. 61/196,759 filed Oct. 20, 2008, and U.S. Provisional Application Ser. No. 61/239,279 filed Sep. 2, 2009, the teachings of all of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to control systems for fuel burner igniters and more particularly to control systems for electrical resistance-type igniters for fuel burners and methods for controlling the voltage thereto.

BACKGROUND OF THE INVENTION

[0003] There are a number of appliances such as cooking ranges and clothes dryers and heating apparatuses such as boilers and furnaces in which a combustible material, such as a combustible hydrocarbon (e.g., propane, natural gas, oil) is mixed with air (i.e., oxygen) and continuously combusted within the appliance or heating apparatus so as to provide a continuous source of heat energy. This continuous source of heat energy is used for example to cook food, heat water to supply a source of running hot water and heat air or water to heat a structure such as a house.

[0004] Because this mixture of fuel and air (i.e., fuel/air mixture) does not self-ignite when mixed together, an ignition source must be provided to initiate the combustion process and to continue operating until the combustion process is self-sustaining. In the not too distant past, the ignition source was what was commonly referred to as a pilot light in which a very small quantity of the combustible material and air was mixed and continuously combusted even while the heating apparatus or appliance was not in operation. For a number of reasons, the use of a pilot light as an ignition source was done away with and an igniter used instead.

[0005] An igniter is a device that creates the conditions required for ignition of the fuel/air mixture on demand, including spark-type igniters such as piezoelectric igniters and hot surface-type igniters such as silicon carbide hot surface igniters. Spark-type igniters that produce an electrical spark that ignites gas, advantageously provide very rapid ignition, which is to say, ignition within a few seconds. Problems with spark-type igniters, however, include among other things the electronic and physical noise produced by the spark.

[0006] With hot surface igniters, such as the silicon carbide hot surface igniter, the heating tip or element is resistively heated by electricity to the temperature required for the ignition of the fuel/air mixture, thus when the fuel/air mixture flows proximal to the igniter it is ignited. This process is repeated as and when needed to meet the particular operating requirements for the heating apparatus/appliance. Hot-surface-type igniters are advantageous in that they produce negligible noise in comparison to spark-type igniters. Hot surface-type igniters, however, can require significant ignition/warm-up time to resistively heated the resistance igniter sufficiently to a temperature that will ignite the fuel-air mixture (e.g., gas-air). In some applications, this warm-up time can vary between about 15 and about 45 seconds.

[0007] There have been efforts made in the past to develop a robust, low-noise igniter that can ignite gas rapidly, which is to say within a few seconds. There is found in U.S. Pat. No. 4,925,386 a control system for electrical resistance-type igniters, and more specifically for tungsten heater elements embedded in a silicon nitride insulator. The relatively narrow temperature operating range of silicon nitride igniters necessitates such a control system. Indeed, the operating range of silicon nitride igniters must remain between the lowest temperature that will ignite the fuel-air mixture and the temperature at which the igniter fails, i.e., the tungsten heater element breaks down.

[0008] Over time, this narrow range of operating temperatures is further narrowed due to a process referred to as "aging". As the tungsten heater elements are repeatedly heated to relatively high temperatures, the tungsten filaments oxidize or "age". Aging manifests as a cross-sectional change, i.e., decrease, in the tungsten filament. As a result, acceptable operating temperatures routinely decrease and continue to decrease with further aging. The described control system includes a microprocessor and a learning routine to control and modulate a solid-state switching means so that the igniter can be heated rapidly to and maintained at or near a suitable ignition temperature, which is below the maximum operating temperature. Moreover, the described learning routine maintains the temperature of the igniter just above the temperature needed to ignite the gas, to provide quick ignition, while continuously monitoring the maximum allowable temperature to prevent damage to the igniter.

[0009] Similarly, there is found in U.S. Pat. No. 5,725,368 a refined control system that controls the energizing of a silicon nitride igniter that, purportedly, enables ignition within approximately two seconds. The described control system includes a microcomputer in combination with a triac in series with an igniter and a learning routine. The microcomputer determines the level of power to be applied to the igniter as a function of the voltage available to energize the igniter and the resistance of the igniter. The triac delivers time-dependent power to the igniter using an irregular firing sequence.

[0010] There are, however, several shortcomings with these two control systems. First, they are drawn to a specific igniter type that is subject to "aging". As a result, the systems require hardware and software to enable the learning routine. They also continuously maintain the temperature of the igniter slightly above the minimum ignition temperature, e.g., about 1200 degrees Centigrade (° C.).

[0011] There is found in U.S. Pat. No. 7,148,454 systems and methods for energizing an electric resistance igniter by applying line voltage as the input voltage to the electric resistance igniter for a set period of time and then reducing the input voltage to the nominal voltage after the time period time expires. In this way it is described that the electric resistance igniter can be advantageously heated up rapidly as compared to the then typically heat up times of 15-45 seconds and also allow a wider range of igniters to be utilized.

[0012] The described system has been found to work very well with electric resistance igniters that are designed to operate at voltages slightly below the nominal voltage range. For example with a 230 volt supply a 120 to 150 volt hot surface igniter operates very well using the above described system. For low voltage igniters, such as 12 or 24 volt electric resistance igniters for example, when using the such a system the accuracy of the voltage regulation and the overpowering of the igniter to reduce warm up time becomes much more sensitive and thus more difficult to control. Because of this, use of the described system for heating up a low voltage igniter can cause a reduction in igniter reliability and/or actual damage to the igniter element itself. Furthermore the potential for high inrush currents when the low voltage igniters are overpowered with a high supply voltage requires the specification of higher power rated components in the control circuit design which relates to higher system costs.

[0013] Notwithstanding the above described systems, conventional control systems and methods for supplying voltage to low voltage igniters (e.g., typically 12 and 24 volt nominal in US, although this is not limiting), utilize simple voltage transformers (e.g., simple step-down transformers) to supply the operating voltage to the igniter. These transformers take in the supply voltage (typically 100 to 277 volts) and convert it to a lower secondary voltage, which is used to power the low voltage igniter. Because of operational characteristics of the transformers, the secondary voltage varies during normal operation, which voltage variations follow the variance in the typical supply voltage of +10% to −15% of the nominal voltage.

[0014] Consequently, the voltage being supplied to the igniter by the transformer will vary as well between +10% to −15% of the nominal supply voltage. That being the case, a low voltage igniter must be designed and specified so that they can function properly to ignite the gaseous fuel (i.e., fuel-air mixture) at the lower secondary voltage level and still operate reliably with reasonable service life at the higher secondary voltage level. As a consequence of these variations in the supply voltage, the time response of the typical low voltage igniter will vary significantly as the secondary voltage varies, with typical warm up times ranging from 3 to 10 seconds depending on the required temperature for ignition of the fuel-air mixture.

[0015] It thus would be desirable to provide a robust control system and methods related thereto for energizing low voltage hot surface-type igniters so as to reduce igniter warm-up time without significantly increasing the risk of igniter failure or significantly reducing operational life of the igniter. It would be particularly desirable to provide such a control system and method that would reduce warm-up times while minimizing the risk of overpowering the igniter such as that cause by the large current inrushes and reducing the need for higher power rated components.

SUMMARY OF THE INVENTION

[0016] The present invention features a control system for a hot-surface-type igniter, the control system comprising a control device that is configured and arranged to continuously monitor the line voltage to the system, and when it is time to ignite the fuel-air mixture, to regulate the voltage being applied to the electrical resistance igniter to a first voltage for a given period of time and upon expiration of the period of time to regulate the voltage being applied to the electrical resistance igniter to a second voltage. The control system also includes a switching means that selectively controls the voltage being applied to the electrical resistance igniter responsive to signals from the control device.

[0017] In more particular embodiments, the first voltage is a voltage level that is higher than the second voltage level and is set so as to cause the igniter to heat up rapidly thereby reducing warm up time so as to be in a set range. In more specific embodiments, the first voltage also is set so as to not significantly reduce operating life of the igniter. In yet further embodiments, the first voltage is set so that the voltage being applied satisfies the following relationship: $V_{1st}=V_{nom}+(V_{nom}\times c)$, where V_{1st} is the first voltage, V_{nom} is the nominal operating voltage of the low voltage igniter and c is a number that satisfies the following relationship $0.1\leqq c\leqq 0.4$. It shall be understood that low voltage igniters, as that term is used in the subject application, shall mean igniters whose nominal operating voltage is about 60 volts or less such as for example, igniters whose nominal operating voltage is about 6 volts, 12 volts, 18 volts, 24 volts, or 60 volts (volts AC or DC).

[0018] In more particular embodiments, the second voltage is lower than the first voltage. In more specific embodiments, the second voltage is at or about the nominal operating voltage specified for the igniter. In yet more specific embodiments, the second voltage is about the nominal operating voltage and in even yet more specific embodiments, the second voltage is essentially the nominal operating voltage of the igniter. In yet further exemplary embodiments, the first and second voltages and the time period are set so that the time to warm the igniter up to the igniter's normal operating temperature for igniting the fuel-air mixture satisfies the following relationship $1\text{ sec}\leqq t_{warmup}\leqq 3\text{ sec}$, less than 4 seconds or less than 5 seconds.

[0019] In more particular embodiment, the control device comprises a microprocessor and the switching device comprises a thyristor or more particularly a triac. The microprocessor is any of a number of microprocessor is known to those skills in the art including a central processing unit (CPU), one or more memories, and an application program for execution in the CPU. In a more specific embodiment the one or more memories comprises two memories; one memory accessed by the CPU and the second nonvolatile type of memory for storing information such as look-up tables for determining the first and second voltages and the on-time time for regulating and applying the regulated first voltage and thereafter controlling application of the second voltage. In further embodiments, the CPU and the one or more memories are disposed on a single chip.

[0020] The thyristor or triac is operably coupled to the control device and the electric resistance igniter so as to be selectively controlled by the control device and so as to selectively control the first and second voltages being applied to the electrical resistance igniter. In more particular embodiments, the thyristor or triac is controlled by the control device so that the first voltage, as described above, is applied for a predetermined period of time and thereafter the control device controls the thyristor or triac so a second voltage corresponding to the another voltage level or the nominal operating voltage is being applied. In a more specific embodiment, the control device controls the thyristor or triac by duty cycling the AC line voltage in half-wave cycle increments. In yet a more specific embodiment, the control device monitors the line voltage and regulates the first and second voltages being applied so that a fairly constant voltage is applied to the electric resistance igniter.

[0021] In yet further embodiments, the control device regulates the voltage being applied to the electrical resistance igniter so that the voltage initially being applied to the electrical resistance igniter is controlled so that the voltage varies as a function of time until it reaches the first voltage and thereafter regulates the voltage so as to be at or about the first voltage until expiration of the period of time. In more particular embodiments, the voltage is controlled so that the voltage varies according to a predetermined algorithm. In an exemplary embodiment, the voltage varies linearly.

[0022] In more specific embodiments, the algorithm is established so as to minimize the inrush current (e.g., peak inrush current) as compared to the inrush current that would occur in the case where voltage being applied initially was applied without such voltage control. In more particular embodiments, the algorithm is established so that the peak inrush current with such control is about at least 30 percent less than the peak inrush current when there is no such voltage control; more specifically is about at least 40 percent less than the peak inrush current when there is no such voltage control; and yet more specifically at least about 50 percent less than the peak inrush current when there is no such voltage control.

[0023] In further embodiments, the power supply or voltage source that supplies the voltage to the thyristor or triac embodies a means for reducing the nominal supply voltage to a lower or third voltage level so as to reduce shock hazards or risks to users, where the third voltage is higher than the first voltage. In particular embodiments, the third voltage is set so that the nominal output voltage of the step down transformer satisfies the following relationship: $V_{3rd}=V_{1st}+(V_{1st}\times c)$, where V_{3rd} is the third voltage, V_{1st} is the first voltage level and c is a number that satisfies the following relationship $0.1\leqq c\leqq 0.4$.

[0024] According to another aspect of the present invention, there is featured a method of controlling energizing of one or more electrical resistance igniters. This method includes providing a first voltage to the electrical resistance igniter for a time period; and thereafter providing a second voltage to the electrical resistance igniter after expiration of the time period. In more particular embodiments, such providing a first voltage includes setting the first voltage so as to be at a voltage that is higher than the second voltage level and also so as to cause the igniter to heat up rapidly thereby reducing warm up time so as to be in a set range. In yet further embodiments, such setting the first voltage includes setting the voltage so as to also be at a voltage that does not significantly reduce operating life of the igniter.

[0025] In further embodiments, such setting the first voltage includes setting the first voltage so that the first voltage satisfies the following relationship: $V_{1st}=V_{nom}+(V_{nom}\times c)$, where V_{1st} is the first voltage, V_{nom} is the nominal operating voltage of the low voltage igniter and c is a number that satisfies the following relationship $0.1\leqq c\leqq 0.4$. It shall be understood that low voltage igniters, as that term is used in the subject application, shall mean igniters whose nominal operating voltage is about 60 volts or less such as for example, igniters whose nominal operating voltage is about 6 volts, 12 volts, 18 volts, 24 volts, or 60 volts (volts AC or DC).

[0026] In more particular embodiments, such providing a second voltage includes setting the second voltage so it is lower than the first voltage. In more specific embodiments, the second voltage is at or about the nominal operating voltage specified for the igniter. In yet more specific embodiments, the second voltage is about the nominal operating voltage and in even yet more specific embodiments, the second voltage is essentially the nominal operating voltage of the igniter. In yet further exemplary embodiments, the first and second voltages and the time period are set so that the time to warm the igniter up to the igniter's normal operating temperature for igniting the fuel-air mixture satisfies the following relationship 1 sec$\leqq t_{warmup}\leqq$3 sec, less than 4 seconds or less than 5 seconds.

[0027] In yet further embodiments, regulating the voltage being applied to the electrical resistance igniter to a first voltage for a given period of time is performed so that the voltage initially being applied to the electrical resistance igniter is controlled so that the voltage varies as a function of time until it reaches V_{1st} and thereafter is regulated so as to be at or about V_{1st} until expiration of the period of time. In more particular embodiments, the voltage is controlled so that the voltage varies according to a predetermined algorithm. In an exemplary embodiment, the voltage varies linearly.

[0028] In more specific embodiments, the algorithm is established so as to minimize the inrush current (e.g., peak inrush current) as compared to the inrush current that would occur in the case where voltage being applied initially was applied without such voltage control. In more particular embodiments, the algorithm is established so that the peak inrush current with such control is about at least 30 percent less than the peak inrush current when there is no such voltage control; more specifically is about at least 40 percent less than the peak inrush current when there is no such voltage control; and yet more specifically at least about 50 percent less than the peak inrush current when there is no such voltage control.

[0029] The control system and method of the present invention provide a robust control system and methodology for energizing one or more hot surface igniters of a type that is not susceptible to significant aging. Furthermore, the control system and method of the present invention provide a control system and methodology that do not maintain the igniter continuously at above an ignition temperature (e.g., 1200 degrees Centigrade) but rather resistively heats the one or more hot surface igniters with a first regulated input voltage for a predetermined time period and thereafter regulates the input line voltage so that a voltage at another voltage level, a nominal operating voltage for the igniter, is applied.

[0030] Also featured is a heating apparatus, the device or an appliance including an igniter control system according to the present invention. Such a heating apparatus, device or appliance further includes mechanisms for controlling and admitting combustion gas in proximity to the igniter.

[0031] Other aspects and embodiments of the invention are discussed below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] For a fuller understanding of the nature and desired objects of the present invention, reference is made to the following detailed description taken in conjunction with the accompanying drawing figures wherein like reference character denote corresponding parts throughout the several views and wherein:

[0033] FIG. **1**A is a schematic view of one illustrative embodiment of an igniter control system in accordance with the present invention;

[0034] FIG. **1**B is a schematic view of another illustrative embodiment of an igniter control system in accordance with the present invention;

[0035] FIG. **2**A is a flow diagram illustrating one embodiment of a method of energizing an igniter in accordance with the present invention;

[0036] FIG. **2**B is a flow diagram illustrating another embodiment of a method of energizing an igniter in accordance with the present invention; and

[0037] FIG. **3** is a simplified schematic view of an appliance or heating apparatus having an igniter and igniter control system in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0038] Referring now to the various figures of the drawing wherein like reference characters refer to like parts, there is shown in FIG. **1**A a schematic view of one illustrative embodiment of an igniter control system **10***a* according to the present invention that is electrically connected to a low voltage electric surface igniter **20** and an electrical power source **4**. The low voltage electric surface igniter **20** is any of a number of low voltage resistance hot surface igniters, more particularly ceramic type of electric surface igniters, known to those skilled in the art.

[0039] In a particularly illustrative embodiment, the low voltage igniter **20** is a ceramic/intermetallic hot surface igniter such as Norton Mini Igniters® manufactured by St. Gobain Industrial Ceramics Norton Igniter Products. Such an ignition device typically includes a heating element that extends outwardly from an end of the base which it is secured to. This shall be not limiting as the present invention can be used with other types of hot surface igniters as well as other types of ignition devices or igniters, such as for example Norton CRYSTAR Igniters®. In specific exemplary embodiments, the low voltage electric surface igniter **20** is an electrical resistance igniter having a nominal operating voltage of 6 volts, 12 volts, 18 volts, 24 volts, or 60 volts (V) AC or DC, however, it should be recognized that the present invention is not particularly limited to these exemplary nominal operating voltages. For simplicity, reference is made hereinafter to resistance hot surface igniter; however, it shall be understood that this refers to a low voltage resistance hot surface igniter.

[0040] The power source **4** for the resistance hot surface igniter **20** and the control system **10***a* has sufficient capacity to heat-up the heating element of the igniter to the temperature required for ignition of the combustible mixture (i.e., fuel-air mixture) as well as for operation of the various functionalities of the control system. The electrical power source **4** is any of a number of sources of electrical power that are known to those skilled in the art. In an exemplary embodiment, the electrical power source **4** is the electrical wiring of the building or structure in which is located the heating device **100** (FIG. **3**), which electrical wiring is interconnected via a fuse box or the equivalent to the electrical distribution system of an electrical utility. As indicated herein, the operating voltage of such an electrical distribution system can vary over a range of voltages as well as being dependent upon the country or region producing the power.

[0041] The control system **10***a* according to one aspect of the present invention is configured and arranged so as to control the operation, including the energizing, of the electric surface igniter **20**. The control system **10***a* according to the present invention includes a thyristor **12**, zero cross circuitry **14**, a power supply **16***a*, a line voltage measuring apparatus **18** and a microcontroller **30***a*.

[0042] The zero cross circuitry **14** is electrically coupled to the power source **4** to monitor the line voltage from the power source and is operably coupled to the microcontroller **30***a*. The zero cross circuitry **14** is any of a number circuits known to those skilled in the art that is configured and arranged so as to be capable of detecting or determining when the AC line voltage crosses the time axis, in other words passes through zero voltage. The zero cross circuitry **14** also is configured and arranged so as to provide an output signal to the microcontroller **30***a* when the AC line voltage passes through zero voltage. In an exemplary embodiment, the output signals are digital signals.

[0043] Power supply **16***a* is electrically coupled to the power source **4** and to the microcontroller **30***a*. The power supply **16***a* is any of a number of power sources known to those skilled in the art that is configured and arranged to provide the appropriate voltage and current required for operation of the microcontroller **30***a*. In an exemplary embodiment, the power supply **16***a* includes a series connected capacitor and zeiner diode that steps the line voltage down to the operating voltage of the microcontroller **30***a*.

[0044] As described further herein, in more particular embodiments the power supply **16***a* is operated so that the electric surface igniter **20** is initially heated up or energized by a increasingly varying AC voltage to the first voltage over a predetermined time period. Thereafter, the power supply **16***a* is operated so that the electric surface igniter **20** is energized by the first voltage so as to maintain the electric surface igniter **20** at or about a desired operating temperature.

[0045] In further embodiments, the electrical power supply **16***a* or the power source embodies or includes a step down transformer or similar electrical component that steps the voltage down to a voltage having a value less than that being inputted to the transformer. Such a transformer provides a mechanism by which a voltage higher than that used to warm-up the igniter is provided to the circuitry as hereinafter described, but which reduces the voltage to a level that reduces or minimizes shock hazards or risks in the event there is a component failure in the circuitry.

[0046] The line voltage measuring apparatus **18** is electrically coupled to the power source **4** and is operably coupled to the microcontroller **30***a*. The line voltage measuring apparatus **18** includes any of a number of line voltage measuring circuits known to those skilled in the art that is configured and arranged to monitor and determine the line voltage from the power source **4** and to provide output signals representative of the determined line voltage. More particularly, such circuits are configured and arranged so as to be capable of quickly determining the line voltage and providing such output signals to the microcontroller **30***a*. In a more particular embodiment, the line voltage measuring apparatus **18** comprises a conventional resistor divider filter circuit. In an exemplary embodiment, the output signals are analog signals, however, the circuitry can be configured so as to provide digital output signals.

[0047] The microcontroller **30***a* includes a processing unit **32**, random access memory **34**, a nonvolatile memory **36** and an applications program for execution in the processing unit. The applications program includes instructions and criteria for receiving and processing the various signals being inputted to the microcontroller **30***a* from the line voltage measuring apparatus **18** and the zero cross circuit **14** and to provide output control signals to the thyristor **12**, thereby controlling the energizing of the hot surface igniter **20**. It is within the skill of those knowledgeable in the art and thus within the scope of the present invention, for an application specific integrated circuit (ASIC) or other circuitry component(s) to be used in place of the microcontroller **30***b*. The applications program, including instructions and criteria thereof, is discussed below in connection with FIGS. **2**-**3**.

[0048] The processing unit **32** is any of a number of microprocessors known to those skilled in the art for performing functions described herein and operating in the intended environment. In an exemplary embodiment, the processing unit **32** is a Samsung S3C9444 or Microship 12G671. The random access memory (RAM) **34** and the nonvolatile memory **36** are any of a number of such memory devices, memory chips, or the like as is known to those skilled in the art. The nonvolatile memory **36** more particularly can comprise either flash or spindle type of memory. In more particular illustrative embodiments, the nonvolatile memory **36** includes nonvolatile random access memory (NVRAM), read-only memory

(ROM) such as EPPROM. In a particular embodiment, the processing unit **32**, RAM **34** and nonvolatile memory **36** are disposed/arranged so as to be co-located on a single integrated chip. This is not particularly limiting as these components can be configured and arranged in any of a number of ways known to those skilled in the art.

[0049] The thyristor **12** is a rectifier which blocks current in both the forward and reverse directions. In a more specific embodiment, the thyristor **12** is a triac as is known to those skilled in the art that blocks current in either direction until it receives a gate pulse from the microcontroller **30***a*. Upon receiving the gate pulse, current flows through the triac. The thyristor **12** or triac is electrically coupled to the power source **4** and the hot surface igniter **20** so as to control the flow of current from the power source through the hot surface igniter. Thus, in the case where the thyristor **12** or triac is blocking current flow, the hot surface igniter **20** is de-energized. In the case where the thyristor **12** or triac has received a gate pulse, current flows through the hot surface igniter **20** thereby energizing the igniter and causing it to be heated.

[0050] Now referring to FIG. **1**B, the control system **10***b* according to another aspect of the present invention also is configured and arranged so as to control the operation, including the energizing, of the electric surface igniter **20** with DC voltage. The control system **10***b* according to the present invention includes a AC-DC converter or DC Voltage power supply **16***b*, a line voltage measuring apparatus **18** and a microcontroller **30***b*. Reference shall be made to the discussion regarding FIG. **1**A for further details of functionalities and features of the control system not described below.

[0051] The AC-DC converter or DC Voltage power supply is electrically coupled to the power source **4** and to the microcontroller **30***b*. The DC Voltage power supply **16***b* is any of a number of power sources known to those skilled in the art configured and arranged to provide the appropriate DC voltage and current required for energizing electric surface igniter **20** under the control of the microcontroller **30**. In an exemplary embodiment, the DC voltage power supply **16***b* is an AC-DC switching power supply as is known to those skilled in the art, which converts AC voltage and current to DC voltage and current and which is controllable (e.g., by the microcontroller **30***b*) so as to output the first and second voltages.

[0052] As described further herein, in more particular embodiments, the DC Voltage power supply **16***b* is operated so that the electric surface igniter **20** is initially heated up or energized by an increasingly varying DC voltage to the first voltage over a predetermined time period. Thereafter, the DC Voltage power supply **16***b* is operated so that the electric surface igniter **20** is energized by at or about the first voltage so as to maintain the electric surface igniter **20** at or about a desired operating temperature.

[0053] In further embodiments, the DC Voltage power supply **16***b* or the power source embodies or includes a step down transformer or similar electrical component that steps the AC voltage down to an AC voltage having a value less than that being inputted to the transformer. Such a transformer provides a mechanism to reduce the AC voltage to a level that reduces or minimizes shock hazards or risks in the event there is a component failure in the circuitry.

[0054] As described above, the microcontroller **30***b* includes a processing unit **32**, random access memory **34**, a nonvolatile memory **36** and an applications program for execution in the processing unit. The applications program includes instructions and criteria for receiving and processing the various signals being inputted to the microcontroller **30***b* from the line voltage measuring apparatus **18** to provide output control signals to the DC Voltage power supply **16***b*, thereby controlling the energizing of the hot surface igniter **20**. The applications program, including instructions and criteria thereof, is discussed below in connection with FIGS. **2**-**3**.

[0055] As indicated above, reference should be made to the above discussion regarding FIG. **1**A for further details regarding the processing unit **32**, the random access memory (RAM) **34** and the nonvolatile memory **36**. As also indicated above, it is within the scope of the present invention for an ASIC or other circuitry to be used in place of the microcontroller **30***b*.

[0056] The operation of the igniter control system **10***a, b* is best understood from the following discussion and with reference to FIGS. **2**A, B. Reference also should be made to FIGS. **1**A, B and the foregoing discussion for features and functionalities of the control system not otherwise provided or discussed hereinafter. As noted above, the following also describes the functions as well as the instructions and criteria of the applications program that is being executed in the processor **32** of the microcontroller **30***a,b*.

[0057] As more particularly described below in connection with FIG. **3**, the igniter control system **10***a, b* of either embodiment is operated so the hot surface igniter **20** is de-energized during those times when heat energy is not to be produced by the appliance or heating device **100** (FIG. **3**). As such, during such non-heat producing times the igniter control system **10***a, b* is in an idle state, step **202**. It also is within the scope of the present invention for the igniter to be de-energized and thus returned to the idle state after the fuel-air mixture is self-sustaining. In a more particular embodiment, the igniter control system **10***a, b* is configured and arranged so as to the powered down when in the idle state.

[0058] When heat energy is to be produced by the appliance or heating device **100**, an input signal is provided to the microcontroller **30***a, b* of the igniter control system **10***a, b*; such a signal corresponds to a signal to energize the one or more hot surface igniters **20** of the heating device, step **204**. Alternatively, in the case where the igniter control system **10***a, b* is powered down in the idle state, such a signal can be manifested by restoring power to the control system.

[0059] Following receipt of this signal, the microcontroller **30***a, b* outputs a signal (e.g., a gate pulse) to the triac or thyristor **12** to fire the thyristor so that AC current from the power source **4** flows through the one or more hot surface igniters **20** or the DC Voltage power supply **16***b* is energized so that DC current flows through the one or more hot surface igniters **20**. More particularly, the microcontroller **30***a, b* controls the DC Voltage power supply **16***b* or the triac or thyristor **12** so that such current flows continuously and so a first regulated voltage is supplied to the hot surface igniter(s) **20**, step **206**. The first regulated voltage typically produces an over voltage condition, that is the voltage developed across the hot surface igniter (s) **20** is more than nominal operating voltage for the igniter(s). Consequently, the hot surface igniter(s) **20** heats faster to a given temperature and also will produce more heat energy in the igniter(s).

[0060] As indicated above, the line voltage measuring apparatus **18** monitors the line voltage of the power source **4** and provides output signals representative of the line voltage to the microcontroller **30***a, b*. After receiving such an energizing signal, the microcontroller **30***a, b* processes the output signals from the line voltage measuring apparatus **18** to determine the amplitude of the line voltage, step **206**. In the United States where the specified line voltage is 220 VAC, the nominal line voltage typically ranges between about 208 VAC and about 240 VAC. In Europe and other parts of the world where the specified line voltage is 230 VAC, the nominal line voltage typically ranges between about 220 VAC and about 240 VAC. Thus, line voltage variance universally can range anywhere between about 176 VAC and about 264 VAC. In the United States, there are cases where other nominal line voltage is found; in one case the nominal line voltage is 120 VAC, which ranges between 102 VAC and 132 VAC and in another case the nominal line voltage is 24 VAC, which ranges between 20 VAC and 26 VAC.

[0061] The microcontroller **30***a, b* evaluates the determined or measured line voltage and the microprocessor **32** controls the DC Voltage power supply **16***b* or the triac or thyristor **12** to regulate the voltage being applied or delivered to the hot surface igniter(s) **20** to maintain the voltage about a first voltage for the igniter, step **208**. In more particular embodiments, the first voltage is a voltage that is higher than the second regulated voltage and is set so as cause the igniter to heat up rapidly thereby reducing warm up time so as to be in a set range. In further embodiments, the second voltage also is less than the DC voltage outputted by the DC Voltage Power supply **16***b* or in the case of application of AC voltage, the power supply **16***a* and/or the power source **4**. This includes the case where the power supply **16***a* includes or embodies a mechanism that steps down the voltage. In more specific embodiments, the first voltage also is set so as to not significantly reduce operating life of the igniter.

[0062] As shown in FIG. **2**B, in further embodiments the microcontroller **30***a, b* controls the DC Voltage power supply **16***b* or the triac or thyristor **12** so as to minimize the inrush current by controlling the DC or AC voltage being initially applied to the hot surface igniter (s) **20**. More specifically, the voltage being initially applied is controlled so that the voltage varies as a function of time until it reaches the first regulated voltage (V_{1st}), step **207** and thereafter the voltage is regulated so as to be at or about V_{1st} until expiration of a period of time, step **208**. In more particular embodiments, the voltage is controlled so that the voltage varies according to a predetermined algorithm. In an exemplary embodiment, the voltage varies linearly.

[0063] In more specific embodiments, the algorithm is established so as to minimize the inrush current (e.g., peak inrush current) as compared to the inrush current that would occur if the case where voltage being applied initially was applied without such voltage control. In more particular embodiments, the algorithm is established so that the peak inrush current with such control is about at least 30 percent less than the peak inrush current when there is no such voltage control, more specifically, is about at least 40 percent less than the peak inrush current when there is no such voltage control; and yet more specifically at least about 50 percent less than the peak inrush current when there is no such voltage control. The specific algorithm controlling the voltage is selected so that the hot surface igniter (s) **20** still will heat faster to a given temperature and produce more heat energy in the igniter(s) while minimizing the peak inrush current during such heating.

[0064] In yet further embodiments, the first voltage is set so that the voltage being applied satisfies the following relationship: $V_{st}=V_{nom}+(V_{nom}\times c)$, where V_{1st} is the first voltage, V. is the nominal operating voltage of the low voltage igniter and c is a number that satisfies the following relationship $0.1\leqq c\leqq 0.4$. It shall be understood that low voltage igniters, as that term is used in the subject application, shall mean igniters whose nominal operating voltage is about 60 volts or less such as for example, igniters whose nominal operating voltage is about 6 volts, 12 volts, 18 volts, 24 volts, or 60 volts.

[0065] In an exemplary embodiment and where AC voltage is being applied, the microprocessor **32** controls the triac or thyristor **12** so as to regulate the voltage being applied to the igniter by duty cycling the AC line voltage in half-wave cycle increments. More particularly, the microprocessor **32** uses the output signals from the zero cross circuitry **14** to control the operation of the triac or thyristor **12** in these half-wave cycle increments. In more specific embodiment's, the regulation method being implemented by the microprocessor **32** regulates the voltage being applied by duty cycling the AC line voltage in half-wave cycle increments with a period of about 50 half-wave cycles that are divided further into sub-periods of about 5 half-wave cycles each to minimize flickering.

[0066] The following example illustrates the application of this regulation method in the case where a nominal voltage of 150 VAC is being applied to a hot surface igniter(s). If it is determined that 32 out of the 50 half-wave cycles are needed to regulate the voltage being applied so as to maintain a 150 VAC nominal voltage, then the half-cycles will be distributed in the sub-periods as follows: eight of the 10 sub-periods in the duty cycle would have three half-wave cycles (8×3=24) and the remaining two sub-periods would have four half-wave cycles (2×4=8). Assuming that the two sub-periods with four half-wave cycles are the first and second sub-periods (SP-**1** and SP-**2**, respectively), the microprocessor **32** regulates output voltage to the hot surface igniter(s) by turning on the triac or thyristor **12** for four half-wave cycles and turning it off for one half-wave cycle during the first sub-period (SP-**1**); turning it on for another four half-wave cycles (SP-**2**); turning it off for one half-wave cycle; turning it on for three half-wave cycles (SP-**3**); and so forth to the tenth sub-period (SP-**10**).

[0067] In more particular embodiments, the nonvolatile memory **36** includes a look-up table that associates line voltage from the power source with the number of half-wave cycles needed to regulate the voltage being applied to the hot surface igniter **20** so the voltage being applied is maintained at or about the first voltage. Those skilled in the art can appreciate that the period of the half-wave cycle, the number of sub-periods, and/or the number of half-wave cycles per sub-period can be modified from that described herein and such modification is within the scope and spirit of the present invention.

[0068] In similar embodiments and in the case where DC voltage is applied to the igniter(s) **20**, the nonvolatile memory **36** includes a look-up table that associates line AC voltage with a DC voltage to be outputted by the DC Voltage power supply **16***b*. In this way, the microcontroller **30***b* of the igniter control system **10***b* is configurable so as to energize the hot surface igniter(s) **20** with DC voltage.

[0069] In further embodiments, the microcontroller **30***a* evaluates the determined or measured line voltage and periodically makes adjustments to the duty cycle so that the second regulated voltage being applied to the hot surface igniter **20** is being maintained so that the hot surface igniter maintains a fairly consistent temperature. More particularly, the microprocessor **32** compares the newly determined or measured line voltage with the look-up table and determines the number of half-wave cycles needed to regulate the voltage being applied to the hot surface igniter **20** so the voltage being applied is maintained at or about the nominal operating voltage for the igniter. Similarly, in the case where the control system **10***b* is configured to apply DC voltage to the igniter, the nonvolatile memory **36** includes a look-up table that associates line AC voltage with a DC voltage to be outputted by the DC Voltage power supply **16***b*. In this way, the microcontroller **30***b* of the igniter control system **10***b* is configurable to regulate the DC voltage being applied to the hot surface igniter **20** so it is maintained at or about the second regulated voltage and/or nominal operating voltage for the igniter.

[0070] In further embodiments, the look up table further includes an on-time for applying the first regulated voltage to the hot surface igniter **20**. In particular embodiments, a time period is set equal to the on-time and the processor **32** continuously determines if this time has expired, step **210**. If it is determined that the time period has not expired (NO, step **210**), then the microcontroller **30***a, b*, more particularly the processor **32**, controls the DC voltage power supply **16***b* (DC voltage) or the triac or thyristor **12** (AC voltage) so that the first regulated voltage continues to be applied or delivered to the hot surface igniter(s) **20**, step **208**. If it is determined that the time period has expired (YES, step **210**), then the microcontroller **30***a, b* or the processor **32** thereof controls the DC Voltage power supply **16***b* or the triac or thyristor **12** to regulate the voltage being applied by either of the DC Voltage power supply **16***b* (DC voltage) or the triac or thyristor (AC voltage), step **212** to a second regulated voltage.

[0071] As indicated above, it is within the scope of the present invention to further regulate the AC/DC voltage as it is being initially applied to the igniter (Step **207**). In this case, in yet a further embodiment the determined on-time for applying the first regulated voltage is determined so as to include the time taking initially to increase the voltage from zero volts to the first voltage/first regulated voltage.

[0072] After the first regulated voltage on-time has expired (YES, step **210**), the microprocessor **32** controls the DC Voltage power supply **16***b* (DC voltage) or the triac or thyristor **12** (AC voltage) so as to regulate the voltage (AC or DC) being applied or delivered to the hot surface igniter(s) **20** to maintain the voltage at or about the second regulated voltage to the igniter, Step **212**. As described above, in an exemplary embodiment, the microprocessor **32** controls the triac or thyristor **12** so as to regulate the voltage being applied as the second regulated voltage by duty cycling the AC line voltage in half-wave cycle increments.

[0073] In more particular embodiments, the second regulated voltage is lower than the first regulated voltage. In more specific embodiments, the second regulated voltage is regulated so as to be at or about the nominal operating voltage specified for the hot surface igniter **20**. In yet more specific embodiments, the second regulated voltage is regulated so as to be about the nominal operating voltage of the hot surface igniter **20**, and in even yet more specific embodiments, the second regulated voltage is regulated so as to be essentially the nominal operating voltage of the hot surface igniter.

[0074] In more particular embodiments, the nonvolatile memory **36** further includes in the look-up table an association of line voltage from the power source with the number of half-wave cycles needed to regulate the voltage being applied to the hot surface igniter **20** so the applied voltage is maintained at or about the second regulated voltage. Those skilled in the art can appreciate that the period of the half-wave cycle, the number of sub-periods, and/or the number of half-wave cycles per sub-period can be modified from that described herein and such modification is within the scope and spirit of the present invention. As also described above, in further embodiments, the microcontroller **30***a* evaluates the determined or measured line voltage and periodically make adjustments to the duty cycle so that the voltage being applied to the hot surface igniter **20** is maintained so that the hot surface igniter maintains a fairly consistent temperature.

[0075] In similar embodiments and in the case where DC voltage is applied to the igniter(s) **20**, the nonvolatile memory **36** includes a look-up table that associates line AC voltage with a DC voltage to be outputted by the DC Voltage power supply **16***b*. In this way, the microcontroller **30***b* of the igniter control system **10***b* is configurable so as to energize the hot surface igniter(s) **20** with DC voltage.

[0076] Once the microprocessor **32** has initiated the application of the second regulated voltage to the igniter **20** (Step **212**), the microprocessor **32** continuously determines if the energization cycle of the hot surface igniter **20** is complete or done, step **214**. Typically, the microprocessor **32** receives an input signal from an external sensor or switch indicating that the heating process should be terminated or that a stable combustion process has been established within a heating device such that an ignition source is no longer required. If it is determined that the energization cycle is complete (YES, step **214**), then the microprocessor **32** provides the appropriate outputs that block current flow through the triac or thyristor **12** or causes the DC Voltage power supply **16***b* to discontinue outputting DC voltage and continues to control the system to the idle condition (step **202**). If it is determined that the energy station cycle is not complete (NO, step **214**), then the microprocessor **32** continues to regulate the second regulated voltage being applied to the hot surface igniter (step **212**).

[0077] The igniter control system **10***a, b* according to the present invention yields a control system that allows a low voltage hot surface igniter(s) **20** to be heated up more quickly and thus shorten the ignition time for the heating device or apparatus. This control system, after a predetermined time period has expired, also reduces the regulated voltage being applied thereafter so the hot surface igniter maintains a fairly consistent operating temperature and so as to not unduly shorten the operational life of the hot surface igniter(s). In further embodiments, such a control system includes a mechanism for controlling the voltage being initially applied so as to minimize inrush current to the igniter. In further embodiments, the methodology for regulating the voltage also yields a method that provides the least amount of electrical emissions, such that a line filter need not be provided, thereby reducing hardware requirements as well as associated costs, such as for manufacturing.

[0078] Now referring to FIG. **3**, there is shown a simplified schematic view of a heating device **100**, comprising one of an appliance or a heating apparatus, having a hot surface igniter **20** and a igniter control system **10** in accordance with the methodology and devices of the present invention. In this regard, it shall be understood that the igniter control system is being referred to in connection with FIG. **3** using reference numeral **10**, however, it shall be understood that such a control system **10** includes any of the control systems described herein and is not limited to the control systems **10***a, b* specifically illustrated herein. The heating device **100** being illustrated is described hereinafter as being used with a gaseous hydrocarbon (such as natural gas, propane) as the material to be combusted therein to produce the heat energy. This shall not be construed as a limitation as the materials used for combustion are not limited to gaseous hydrocarbons but also include combustible liquid hydrocarbons and other gases (e.g., hydrogen) and liquids that continuously combust once they are ignited.

[0079] Such a heating device includes an igniter device **20**, a burner tube **104**, device control circuitry **106**, a fuel admission valve **108** and the igniter control system **10**. The device control circuitry **106** is electrically interconnected to the fuel admission valve **108** and the igniter control system so each can be selectively operated to produce heat energy as hereinafter described. The fuel admission valve **108** is fluidly interconnected using piping or tubing to a source **2** of a combustible material, the fuel for the heating device **100**. In the illustrated embodiment, the piping or tubing is interconnected to a source of a gaseous hydrocarbon such as natural gas or propane. The fuel source can be one of an external tank or an underground natural gas piping system as is known to those skilled in the art.

[0080] The control circuitry **106** is electrical interconnected to an external switch device **190** that provides the appropriate signals to the control circuitry for appropriate operation of the heating device **100**. For example, if the heating device **100** is a furnace to heat a building structure or a hot water heater then the external switch device **190** is a thermostat as is known to those skilled in the art that senses a bulk temperature within the building structure or the hot water in the tank. Based on the sensed temperatures the thermostat outputs signals to the control circuitry **106** to turn the furnace or hot water is heater on and off. If the heating device **100** is a heating appliance such as a stove, then the external switch device **190** typically is a mechanical and/or electronic type of switch. The switch outputs signals to the control device by which a user can turn the heating device **100** (e.g., stove burner, oven) on and off and also regulate or adjust the amount of heat energy to be developed by the heating device.

[0081] In use, the control circuitry **106** receives a signal from the eternal switch device **190** calling for the heating device **100** (e.g., stove burner, oven, hot water heater, furnace, etc) to be turned on. In response to such a signal, the control circuitry **106** provides a signal to the igniter control system **10** to energize the hot surface igniter(s) **20**, and thereby cause electricity to flow through the heating element of the igniter (s) **20** to heat the heating element to the desired temperatures for causing a fuel/air mixture to ignite. These processes for energizing and heating of the igniter are as described above in connection with FIGS. **2**A, B. After the igniter heating element is heated to the desired temperature, the control circuitry **106** actuates the fuel admission valve **108** so that fuel flows through the burner tube **104** to the igniter heating element. As is known in the art, air is mixed with the fuel that is presented to the igniter heating element so that a combustible mixture is thereby created and ignited by the igniter heating element. This ignited fuel/air mixture is passed to the combustion area **114** so that useable heat energy can be extracted and used for the intended purpose of the heating device (e.g., to heat food or water). Although a single burner tube **104** is illustrated, and as is known to those skilled in the art, the heating device **100** can be configured with a plurality or a multiplicity or more of burner tubes to generate a desired heat output and with one or more fuel admission valves **108**. Typically, however, one of the plurality or multiplicity or more of burner tubes is arranged with hot surface igniter **20**.

[0082] A sensor **112** is typically located proximal the hot surface igniter for use in determining the presence of continuous combustion of the fuel/air mixture. In one embodiment, the sensor **112** is a thermopile type of sensor that senses the temperature of the area in which the fuel/air mixture is being combusted. In another embodiment, the sensor **112** is configured and arranged to as to embody the flame rectification method or technique. The sensor **112** is interconnected to the control circuitry **106** so that if the sensor does not output, for example, a signal to the control circuitry indicating the safe and continuous ignition of the fuel/air mixture within a preset period of time, the control circuitry shuts the fuel admission valve **108**. As is known to those skilled in the art, in certain applications the control circuitry **106** also can be configured and arranged to repeat this attempt to ignite the fuel/air mixture to start the heating process for the heating device **100** or appliance one or more times. Typically, the electrical power to the hot surface igniter **20** also is terminated in such cases.

[0083] When the heating function is completed, the control circuitry **106** again receives a signal from the external switch device **190** calling for the heating device to be turned off. In response to such a signal, the control circuitry **106** closes the fuel admission valve **108** to cut off the flow of fuel, thereby stopping the combustion process. In addition, and as indicated above, the igniter control system would be placed in the idle or standby condition (step **202**, FIGS. **2**A, B) at least one heating function is completed.

[0084] Although a number of embodiments of the present invention have been described, it will become obvious to those of ordinary skill in the art that other embodiments to and/or modifications, combinations, and substitutions of the present invention are possible, all of which are within the scope and spirit of the disclosed invention.

INCORPORATION BY REFERENCE

[0085] All patents, published patent applications and other references disclosed herein are hereby expressly incorporated by reference in their entireties by reference.

EQUIVALENTS

[0086] Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents of the specific embodiments of the invention described herein. Such equivalents are intended to be encompassed by the following claims.

1. A control system to control energizing one or more low voltage electrical resistance igniters from an electrical power source, the control system comprising:

a switch operably connected between the electrical power source and the one or more low voltage electrical resistance igniters;

a control device operably coupled to the switch;

wherein the control device is configured and arranged to selectively control the switch and thereby the application of voltage(s) to the one or more electrical resistance igniters;

wherein the control device is configured and arranged so that a first voltage is applied initially to the igniter and is applied for a predetermined on time period and so thereafter a second voltage is applied to the igniter; and wherein the first voltage is regulated so it is less than output voltage of the electrical power source and higher than the second voltage

2. The control system of claim **1**, wherein the first voltage is regulated for a predetermined time period to be at or about a predetermined voltage and wherein the second voltage is regulated so as to correspond to a voltage level of about a nominal operating voltage of the one or more electrical resistance igniters.

3. The control system of claim **1**, wherein the first voltage is regulated so that the voltage being applied satisfies the following relationship:

$$V_{1st}=V_{nom}+(V_{nom}\times c),$$

where V_{1st} is the first voltage, V_{nom} is the nominal operating voltage of the low voltage igniter and c is a number that satisfies the following relationship $0.1\leqq c\leqq 0.4$.

4. The control system of claim **1**, further comprising a voltage measuring device, the voltage measuring device being operably coupled to the electrical power source so as to measure an output voltage of the power source and being operably coupled to the control device so as to provide an output of the measured output voltage to the control device; and

wherein the control device is configured and arranged to control the process for applying the first and second voltages based on the measured output voltage.

5. The control system of claim **1**, wherein the control device is configured and arranged so as to provide a fairly constant voltage as one of the first regulated voltage and the second regulated voltage.

6. The control system of claim **4**, wherein the control device is configured and arranged to regulate the second voltage so as to provide a fairly constant voltage based on the measured output voltage.

7. The control system of claim **4**, further comprising a storage device in which is stored a time period for applying the first regulated voltage; and wherein the control device is configured and arranged to select the time period for controlling the extent of time the first regulated voltage is being applied.

8. The control system of claim **6**, wherein the control device is configured and arranged to selectively operate a switch so as to regulate each of the first regulated voltage and the second regulated voltage.

9. The control system of claim **1**, wherein the switch is triac.

10. The control system of claim **9**, wherein the control device is configured and arranged to selectively operate the triac so as to regulate the first regulated voltage and the second regulated voltage by duty cycling the power source output voltage in half-wave cycle increments.

11. The control system of claim **1**, wherein the control device includes a microprocessor and an applications program for execution on the microprocessor, the applications program including instructions and criteria for controlling the functionality of the control device and the switch.

12. The control system of claim **1**, wherein the control device is further configured and arranged so the output voltage of the electrical power source is controlled to vary the voltage as a function of time over a predetermined period until the voltage reaches the first voltage.

13. The control system of claim **1**, wherein the control device is further configured and arranged so the output voltage of the electrical power source is controlled so as to control inrush current over a predetermined period until the voltage reaches the first voltage.

14. The control system of claim **1**, wherein the output voltage is a DC voltage.

15. A control system to control energizing one or more low voltage electrical resistance igniters from an electrical power source, the control system comprising:

a switch operably connected between the electrical power source and the one or more low voltage electrical resistance igniters;

a microprocessor operably coupled to the switch;

a voltage measuring device, the voltage measuring device being operably coupled to the electrical power source so as to measure an output voltage of the power source and being operably coupled to the microprocessor so as to provide an output of the measured output voltage to the microprocessor;

a program for execution in the microprocessor, the program including instructions and criteria for controlling the operations and functions of the microprocessor and the functionality of the switch; and

wherein the program includes instructions and criteria for:

controlling the switch and thereby application of a voltage to the one or more electric resistance igniters,

controlling the switch so a first regulated voltage is applied initially and so the first regulated voltage is applied for a predetermined time period,

controlling the switch so a second regulated voltage is applied after expiration of the time period, and

regulating the first regulated voltage so it is less than an output voltage of the electrical power source and higher than the second voltage

16. The control system of claim **15**, wherein the first voltage is regulated for a predetermined time period so as to be at or about a predetermined voltage and wherein the second voltage s regulated so as to correspond to a voltage level of about a nominal operating voltage of the one or more electrical resistance igniters.

17. The control system of claim **15**, wherein said regulating includes regulating the second regulated voltage so that the voltage being applied to the igniter satisfies the following relationship:

$$V_{1st}=V_{nom}+(V_{nom}\times c),$$

where V_{1st} is the first voltage, V_{nom}, is the nominal operating voltage of the low voltage igniter and c is a number that satisfies the following relationship $0.1\leqq c\leqq 0.4$.

18. The control system of claim **15**, wherein the program includes instructions in criteria for regulating the second regulated voltage so a fairly constant voltage is applied to the one or more electrical resistance igniters.

19. The control system of claim **18**, wherein the program includes instructions in criteria for regulating the second voltage so a fairly constant voltage is applied to the one or more electrical resistance igniters based on the measured output voltage.

20. The control system of claim **18**, further comprising a storage device in which is stored output voltages and voltage application time periods; and wherein the program includes instructions in criteria for selecting one of the stored multiplicity of time period values as the on time period based on the measured output voltage.

21. The control system of claim **15**, wherein the program includes instructions in criteria for selectively operating the switch so as to regulate the first regulated voltage and the second regulated voltage.

22. The control system of claim **15**, wherein the switch is triac.

23. The control system of claim **22**, wherein the program includes instructions in criteria for selectively operating the triac so as to regulate the first regulated voltage and the second regulated voltage by duty cycling the power source output voltage in half-wave cycle increments.

24. The control system of claim **15**, wherein the control device is further configured and arranged so the output voltage of the electrical power source is controlled to vary the voltage as a function of time over a predetermined period until the voltage reaches the first voltage.

25. The control system of claim **15**, wherein the control device is further configured and arranged so the output voltage of the electrical power source is controlled so as to control inrush current over a predetermined period until the voltage reaches the first voltage.

26. The control system of claim **15**, wherein the output voltage is a DC voltage.

27. A control system to control energizing one or more low voltage electrical resistance igniters from an electrical power source, the control system comprising:

a triac operably connected between the electrical power source and the one or more low voltage electrical resistance igniters;

a microprocessor operably coupled to the triac;

a voltage measuring device, the voltage measuring device being operably coupled to the electrical power source so as to measure an output voltage of the power source and being operably coupled to the microprocessor so as to provide an output of the measured output voltage to the microprocessor;

a storage device operably coupled to the microprocessor and in which is stored a multiplicity of time period values for applying the first regulated voltage and criterion for operating the triac so as provide the desired second regulated voltage output;

a program for execution in the microprocessor, the program including instructions and criteria for controlling the operations and functions of the microprocessor and the functionality of the triac; and

wherein the program includes instructions and criteria for:

controlling the triac and thereby application of first and second regulated voltages to the one or more electric resistance igniters,

controlling the triac so a first regulated voltage is applied initially and so the first voltage is applied for a predetermined time period, where the first regulated voltage is less than full line voltage from the power source and larger than the second regulated voltage,

controlling the triac so the voltage being applied thereafter is a second voltage, the second voltage being a nominal operating voltage of the one or more electrical resistance igniters,

determining the predetermined time period based in one of stored multiplicity of time period values based on the measured output voltage.

28. A method for controlling energizing a low voltage electrical resistance igniter by a power source, the controlling method comprising the steps of:

applying a first regulated voltage to the electric resistance igniter for a predetermined time period; and

applying a second regulated voltage to the low voltage electric resistance igniter thereafter.

29. The method of claim **28**, further comprising the steps of:

measuring output voltage of the power source; and

determining a predetermined time period based on the measured output voltage.

30. The method of claim **29**, wherein said measuring is performed when the first regulated voltage is initially applied to the electric resistance igniter.

31. The method of claim **28**, further comprising the steps of:

measuring output voltage of the power source;

determining a predetermined time period based on the measured output voltage; and

wherein said determining includes selecting one of a multiplicity of time period values as the predetermined time period based on the measured output voltage.

32. The method of claim **31**, wherein said measuring is performed when the first regulated voltage is initially applied to the electric resistance igniter.

33. The method of claim **28**, wherein said regulating a second regulated voltage includes substantially constant voltage to the electric resistance igniter.

34. The method of claim **33**, wherein said regulating includes regulating a substantially constant voltage based on the measured output voltage of the power source.

35. The method of claim **33**, wherein said regulating the first regulated voltage and regulating the second regulated voltage includes duty cycling AC line voltage from the power source in half-wave cycle increments.

36. The method of claim **28**, further comprising the steps of:

operably coupling a switch between the power source and the electrical resistance igniter so the switch selectively controls voltage being applied to the electrical resistance igniter; and

wherein said applying a second voltage includes selectively controlling the switch so a substantially above constant voltage is applied to the electric resistance igniter.

37. The method of claim **28**, wherein said applying a first regulated voltage to the electric resistance igniter for a predetermined time period further includes applying a first regulated voltage to the electric resistance igniter that is controlled to vary the voltage as a function of time over another predetermined period until the voltage reaches the first voltage.

38. The method of claim **28**, wherein said applying a first regulated voltage to the electric resistance igniter for a predetermined time period further includes applying a first regulated voltage to the electric resistance igniter that is controlled so as to control inrush current over another predetermined period until the voltage reaches the first voltage.

39. The control system of claim **28**, wherein the first and second regulated voltages is a DC voltage.

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