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HIGH VOLTAGE SPARK GENERATOR FROM LOW VOLTAGE SUPPLY

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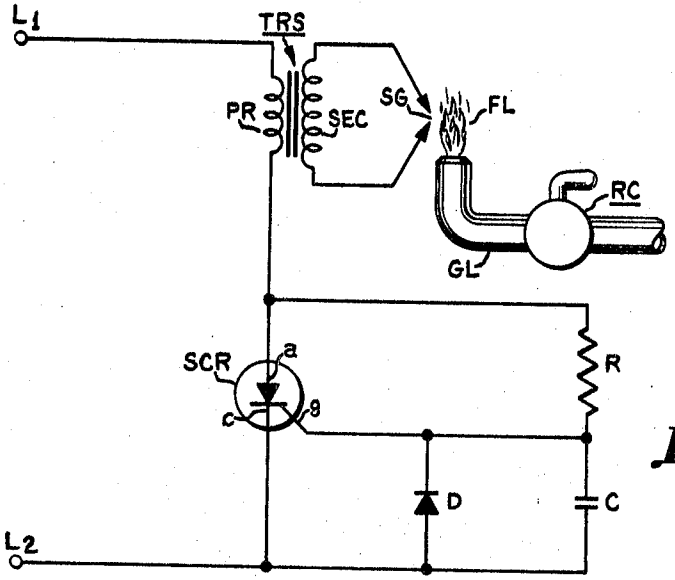


Fig. 1.

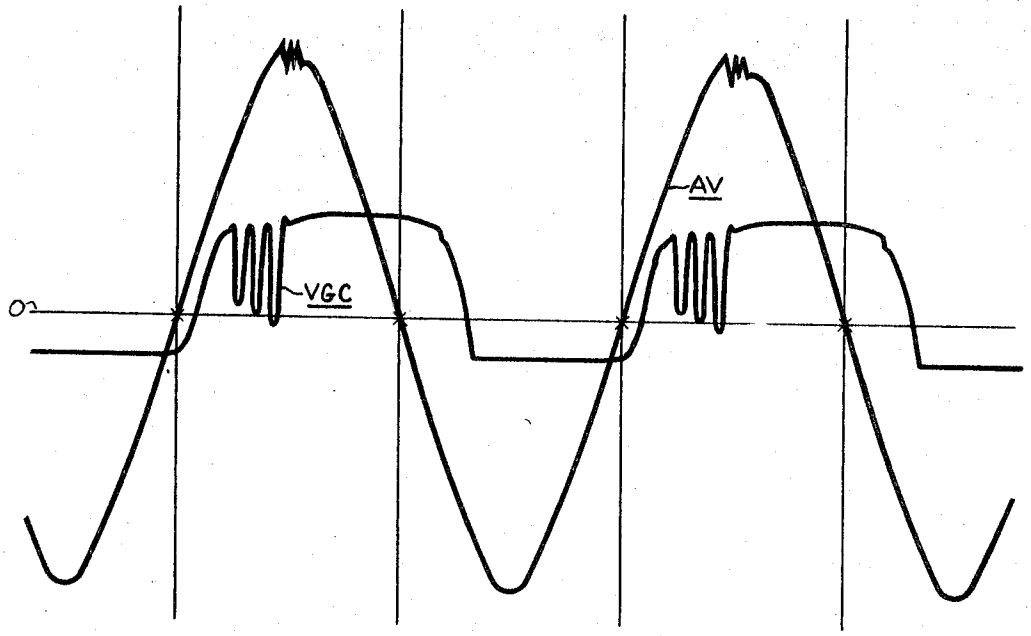


Fig. 2.

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HIGH VOLTAGE SPARK GENERATOR FROM LOW VOLTAGE SUPPLY

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ABSTRACT OF THE DISCLOSURE

The primary winding of a high turns ratio spark transformer is connected in the anode circuit of a silicon controlled rectifier for energization from a 24 volt, 60 cycle alternating power source. A biasing resistor is connected between the anode and gate electrodes of the rectifier, while a firing capacitor is connected between its gate and cathode electrodes to control the firing angle of the rectifier. Charging of the capacitor through the primary winding and the biasing resistor to a predetermined value fires the rectifier provided a correct phase relationship exists between the biasing voltage signal applied to the gate electrode and the voltage applied across the anode-cathode circuit of the rectifier. A clamping diode connected in parallel with the capacitor (between the gate and cathode of the rectifier) maintains the phase relationship by clamping the biasing voltage signal to a predetermined zero reference level until the applied power causes the anode electrode to become of positive polarity with respect to the cathode electrode. This causes the rectifier to successfully fire through its anode-cathode circuit and, in turn, through the primary winding of the spark transformer. As such successive firing coincides with the near peak of positive polarity of the applied voltage, sufficient transformation is provided by the high voltage transformer (approximately 1 to 90 ratio) to induce approximately 13,500 to 18,000 volts in its secondary winding which is connected across the spark gap. Under such conditions, voltage sparks arc across the spark gap, igniting fuel in the vicinity thereof. This firing sequence is repeated, producing successive sparks across the sparks across the spark gap each positive half cycle of the applied power. By maintaining the gate electrode clamped to substantially zero reference voltage until the applied power becomes of positive polarity the need to match closely the circuit components of the firing circuit with the silicon controlled rectifier used is obviated, while producing a spark adequate to cause combustion at relatively low ambient temperature conditions to —40° F.

The invention involves providing spark generating means and more particularly such means for generating a high voltage spark for igniting gaseous fuels.

Modern heating systems using gaseous fuels are normally controlled by thermostatic means operating at 24 volts alternating current power of 60 cycles per second. In such systems, in order to obtain the high voltage spark necessary to arc across an air gap for igniting the fuel it is often necessary to provide a high voltage spark transformer of substantial size. Additionally, such electric ignition of fuels is often utilized where the fuel burner is not readily accessible, or is difficult to service. For example, where the fuel burner is located on a roof top, or is of the radiant heat type mounted high in the ceiling of a plant or shop, or is "slab mounted" (the heating plant is installed on a concrete slab exterior to the building being heated). For such difficult to reach installations the spark generating means must often function properly

throughout a wide range of ambient temperatures (often from —40° F. to temperatures in excess of 100° F.).

It is, therefore, desirable that such spark generating means be of relatively small size, economical to manufacture and be substantial trouble free under varying conditions of ambient temperature, thereby requiring minimal service while giving dependable operation over a long period (at least through a normal heating season which in northern zones of the United States extends over a period of six to eight months).

It is, therefore, an object of the invention to provide a high voltage spark generator operable from a low voltage supply, which generator is of relatively small size, economical to manufacture and maintain and extremerly reliable throughout a broad range of temperature from below 0° F. to 100° F.

The invention involves providing a silicon controlled rectifier switching circuit in which the rectifier is pulsed to conducting condition successively in coincidence with the near peak of a certain polarity of the voltage applied through the primary of a high voltage sparking generator, which primary is connected in the anode circuit of the rectifier. Means are provided to maintain the rectifier in nonfiring condition until the applied alternating power approaches such peak polarity. Under such conditions, the pulsed conduction of the silicon controlled rectifier occurs substantially in phase with the applied power through the primary winding of the high voltage transformer. This induces sufficient transient pulses therein (due to the fast rise time of the pulses and their coincidence with the applied power) to provide sufficient transformation through the spark transformer to cause a high voltage spark of from 13,500 to 18,000 volts to arc across the spark gap and ignite the fuel.

The coincidence of firing signal and applied power is obtained by means of a clamping diode connected between the gate-cathode electrodes of the silicon controlled rectifier. Clamping of the gate electrode of the silicon controlled rectifier to substantially reference voltage during the negative half cycles of the applied power causes the firing of the controlled rectifier to coincide with the near peak of the positive polarity power appearing across the primary winding. This provides arcing across the spark gap notwithstanding variations in ambient temperature over a tested 100° F. to —40° F. range.

This generator circuit also obviates the need to closely match the circuit components with the silicon controlled rectifier used. Although the currents and voltages supplied to the rectifier momentarily exceed its rating, the rectifier remains undamaged due to the short duration of its conducting condition relative to its long nonconducting recovery time.

Features and advantages of the invention may be seen from the above, from the following description of the preferred embodiment when considered in conjunction with the drawing and from the appended claims.

In the drawings:

FIG. 1 is a simplified schematic wiring diagram of a high voltage spark generator means embodying the invention; and

FIG. 2 is a diagrammatic representation of oscillograms of a voltage waveform AV appearing across primary winding PR of the transformer TRS of the FIG. 1 circuit, and of the voltage waveform VGC appearing across the gate and cathode electrodes of the rectifier SCR therein.

In the preferred embodiment shown, low voltage alternating power of 25 volts at 60 cycles from any convenient source (not shown) is applied to the circuitry of FIG. 1 over supply lines L1, L2. High voltage spark transformer, generally designated TRS, comprises a primary

winding PR and a secondary winding SEC. A spark gap of approximately .045 inch is provided by two spaced apart electrodes, generally designated SG, connected across secondary winding SEC. Gaseous fuel is shown as being fed through a manual rotocock RC by gas line GL to the area of spark gap SG for ignition thereat; ignited fuel being indicated diagrammatically as a flame designated FL.

Primary winding PR is connected at one side to supply line L1 and on the other side to the anode electrode *a* of a silicon controlled rectifier SCR of the GE C106F type. The cathode electrode *c* of silicon controlled rectifier SCR is connected directly to supply line L2. A firing capacitor C of approximately .047 microfarad is connected between the gate *g* and cathode *c* electrodes of rectifier SCR. A biasing resistor R of approximately 330 kilohms is connected in series between the anode electrode *a* and gate electrodes *g* of rectifier SCR to provide charging current for firing capacitor C. A clamping diode D of the Diodes Inc., 10C1 type is connected across firing capacitor C with its anode tied to the cathode electrode *c* of rectifier SCR, while its cathode electrode is connected to the gate electrode *g* of rectifier SCR. Diode D is selected to clamp the bias signal voltage at electrode *g* of rectifier SCR to a substantially zero voltage reference level during the half cycle of applied power that the anode electrode *a* of rectifier SCR is negative with respect to its cathode electrode *c*.

In one tested embodiment, transformer TRS was constructed of 175 ohms of number 34 wire for primary winding PR and 16,000 turns of number 42 wire for secondary winding SEC, providing "stepped-up" transformation of 1 to 90.

In operation, assume that rotocock RC is manually turned to a position allowing the flow of gaseous fuel to the area of spark gap SG for ignition thereat. Also assume that power is supplied to the circuit of FIGURE 1 at 24 volts, 60 cycles, causing a voltage to appear across primary winding PR of transformer TRS, as is shown by the voltage wave form AV of FIG. 2. As is seen in FIG. 2, each half cycle of applied power is of approximately 8.33 milliseconds duration. During the start of each positive half cycle of the applied voltage (when supply line L1 is positive with respect to supply line L2 FIG. 1), capacitor C charges sufficiently through primary winding PR and biasing resistor R to trigger silicon controlled rectifier SCR to fire through its anode-cathode circuit. Such firing occurs substantially early during the rise of the voltage towards its positive polarity peak, as is shown in FIG. 2 by voltage waveform VGC appearing across the gate-cathode electrodes of rectifier SCR. As rectifier SCR fires, a high inrush of current flows through primary winding PR. The fast rise time of the inrushing current, induces a voltage in secondary winding SEC of transformer TRS, which voltage, however, is of insufficient magnitude to cause arcing across spark gap SG. This flux energy is stored in distributive capacitance of transformer windings SEC.

As the transformer flux field starts to collapse, the distributive capacitance discharges through secondary winding SEC to produce voltage spikes (not shown) in primary winding PR of transformer TRS. These voltage spikes are from 150 to 200 volts and drive the anode electrode *a* of the silicon controlled rectifier SCR momentarily sufficiently negative with respect to its cathode electrode *c* to stop conduction of the rectifier. Since the anode electrode *a* of the silicon controlled rectifier SCR is momentarily driven negative to stop conduction for approximately only several hundred microseconds, after which it again becomes positive, rectifier SCR again fires. The above described sequence is, therefore, repeated, producing 4 to 5 successive pulses, as is indicated in waveform VGC during the earily portion of each positive half cycle of the applied voltage. These pulses occur from near the start of the rise of the applied voltage towards its peak of positive polarity and continue to such peak.

The last of these transient pulses occurs substantially within 5° of where the applied voltage attains its peak of positive polarity and is in coincidence phase with such polarity sufficiently to cause (due to its fast rise time and such coincidence) sufficient transformation through transformer TRS to produce high voltage arcing across spark gap SG to ignite the fuel. With such ignition the energy of the collapsing field of winding SEC is dissipated across spark gap SG, preventing the anode electrode *a* of rectifier SCR from again being driven sufficiently negative with respect to its cathode electrode *c* to stop conduction of the rectifier SCR. Thus, rectifier SCR, as is shown by waveform VGC, remains in conducting condition for the remainder of the positive polarity half cycle of the applied power until such applied power starts to decrease to negative polarity. At such time rectifier SCR again ceases to conduct through its anode-cathode circuit.

As the applied voltage enters its half cycle of negative polarity, diode D clamps the voltage applied to gate electrode *g* of rectifier SCR by means of firing capacitor C to below zero reference voltage. Electrode *g* is maintained thereat until the next half cycle of positive polarity of the applied voltage AV starts to rise again towards its positive peak value, as is seen in FIG. 2. At such point, the above sequence of 4 to 5 pulses of conduction of rectifier SCR through primary winding PR again occurs, coinciding with the appearance of a near peak of positive polarity voltage across winding PR to cause again a spark across spark gap SG. Such sparking action is repeated every positive half cycle of the applied voltage.

It may be noted that with the subject arrangement, the lowest cost silicon controlled rectifiers now available may be utilized to provide the required switching action without the need to closely match the electrical characteristics of capacitor C or resistor R therewith. Additionally, in a tested embodiment, good operation was obtained with ambient temperatures as low as −40° F., making the above spark generator applicable to environmental conditions occurring in a variety of areas to provide inexpensive, maintenance free, economical, electrical spark ignition of gaseous fuels without the use of bulky transformers or special wiring arrangements.

As changes can be made in the above described construction and many apparently different embodiments of this invention can be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown on the accompanying drawing be interpreted as illustrative only and not in a limiting sense.

What is claimed is:

1. A high voltage spark generator for providing a spark across a pair of electrodes forming a spark gap for igniting fuel in the vicinity of the gap, said generator comprising:

a spark transformer having primary and secondary windings;

a pair of electrodes spaced apart and connected across said secondary winding of said transformer to provide a predetermined spark gap;

a silicon controlled rectifier having anode, gate and cathode electrodes,

said primary winding being connected in the anode-cathode circuit of said rectifier for energization from a low voltage alternating power source;

a resistor-capacitor timing circuit connected across the anode-cathode electrodes of said silicon controlled rectifier in that named order;

said gate electrode of said rectifier being connected to the junction betwen said resistor and capacitor of said timing circuit for causing application of a firing signal to said silicon controlled rectifier under conditions where said capacitor attains a predetermined charge; and

means for maintaining a predetermined phase relationship between said firing signal and said applied

power for causing successive transient conduction through the anode-cathode circuit of said rectifier and said primary winding of said transformer only when both phases are of a certain polarity simultaneously;

said spark transformer transforming said in phase conduction to provide relatively high voltage arcing across said electrodes during the half cycles of said certain polarity.

2. A spark generator as set forth in claim 1 wherein said means for maintaining a predetermined phase relationship comprises,

a clamping diode interconnected in parallel to said firing capacitor and between said gate-cathode electrodes of said rectifier for maintaining said charge of said capacitor below said predetermined firing charge until said applied alternating source attains said certain polarity causing the firing signal from said capacitor applied to said gate electrode to coincide in phase relationship with the near peak of said certain polarity of said applied power.

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