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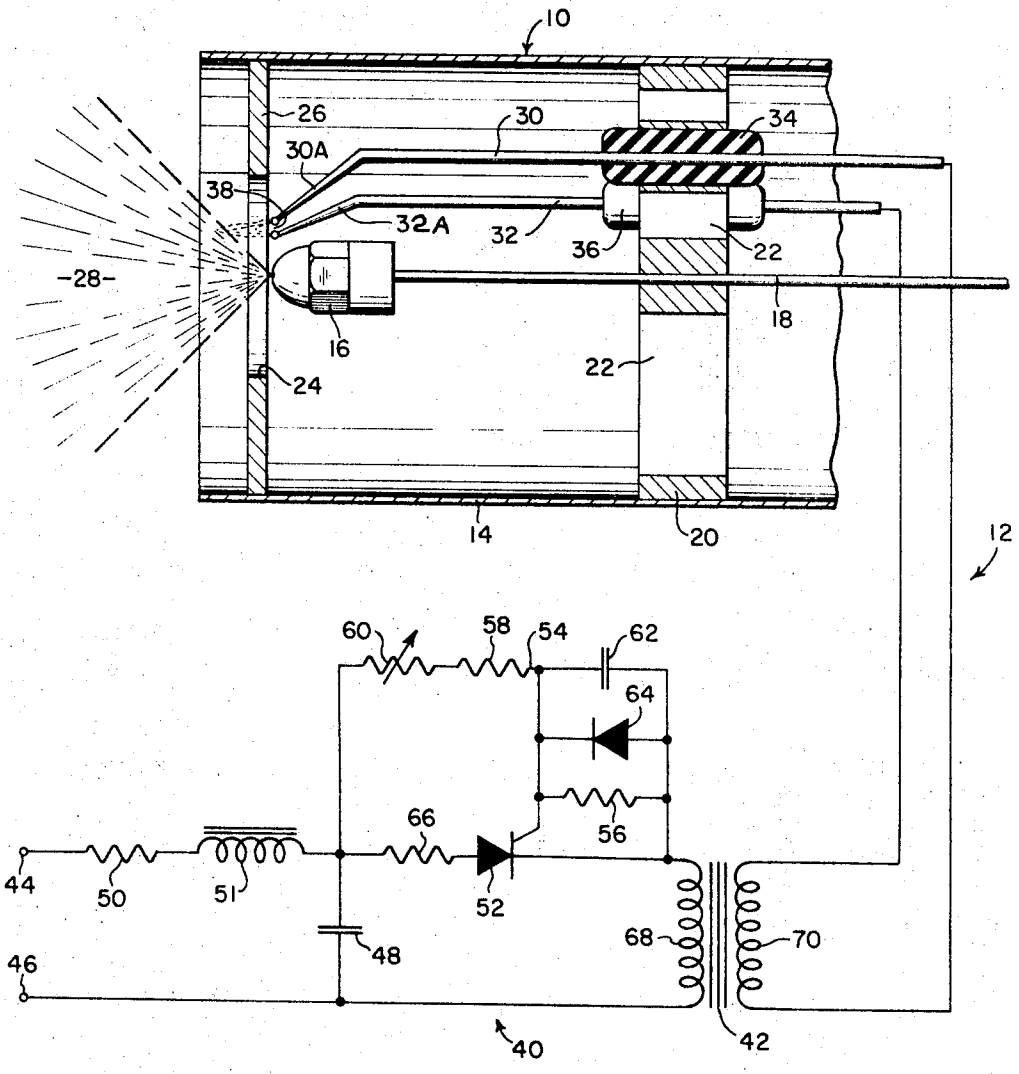

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OIL BURNER SPARK IGNITION SYSTEM

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ABSTRACT OF THE DISCLOSURE

An oil burner ignition system produces a tongue-like configuration of individual sparks extending from a pair of discharge electrodes and into the spray pattern of oil particles produced by the burner nozzle. The system includes a spark generating relaxation oscillator circuit capable of producing individual sparks at a frequency such that subsequent sparks are able to follow the elongating ionized air path established by previous sparks. The oscillator circuit includes a capacitor charged from an AC power source and repetitively discharged during alternate half cycles at rapid intervals through the primary winding of a transformer by means of a controlled rectifier gated in accordance with the capacitor charge level.

The present invention relates to ignition systems for fuel oil burners.

A conventional fuel oil burner includes a nozzle for creating a spray pattern of oil particles in an air stream produced by a blower. In order to ignite the oil particles emerging from the burner nozzle, the traditional method is to mount a pair of spark electrodes upstream in the air stream from the spray pattern and to provide a substantially continuous stream of sparks with a large and expensive transformer coupled to an AC supply. Sparks produced in this manner are capable of forming a tongue-like spark extension in the air stream projecting from the electrodes into the spray pattern.

Due to the size, weight, expense and power consumption of conventional spark transformers, it has been proposed to provide solid state ignition of fuel oil burners. Some devices of this type introduced to date have not produced sparks capable of forming into a tongue-like extension, and as a result have required location of the spark electrode tips within the oil spray pattern. This approach is subject to several disadvantages including the fact that when the electrodes are located in the oil path, carbon forms on the electrodes eventually bridging the spark gap and resulting in unreliable ignition. In addition, impinging oil deflected from the spray pattern may reach the combustion area in an unatomized form, resulting in an undesirable smoky fire. Furthermore, interference by the electrodes with the spray pattern can disturb the uniformity of the pattern to such an extent that unstable, lopsided and noisy combustion takes place.

In order to overcome such disadvantages, it has been proposed to produce with a solid state ignition device a low frequency series of individual sparks each having a size and duration capable of being diverted by the air stream into the spray pattern. Devices of this character developed heretofore, however, have been subject to the disadvantages of high power consumption, expense and questionable reliability in operation.

Among the important objects of the present invention are to provide an improved oil burner ignition system characterized by small size, low cost, and reliability; and to provide an improved solid state fuel oil ignition system capable of producing a tongue-like extension of sparks in an air stream.

In brief, an oil burner ignition system constructed in

accordance with the present invention serves to ignite an oil burner of the type producing a spray pattern of oil particles in an air stream. The ignition system includes a pair of spark discharge electrodes having spaced tip portions forming a spark gap and being located upstream in the air stream from the spray pattern and out of the path of the oil particles. In accordance with an important feature of the invention, a relaxation oscillator generates at the spark gap a series of individual sparks at a frequency such that a series of sparks traverse an ionized air path or region and are deflected from the spark gap into the spray pattern for ignition of the oil particles. A first circuit loop of the oscillator circuit includes a pair of power supply terminals adapted to be connected to an AC power source for charging a capacitor in a predetermined polarity during alternate half cycles of the power supply voltage waveform. A second circuit loop includes the primary winding of a transformer and the capacitor, together with the output terminals of a controlled rectifier. A trigger circuit for the rectifier places the rectifier in a conductive condition in response to a predetermined capacitor charge level, and the capacitor discharges in a current pulse through the primary winding thereby to produce a spark at the spark electrodes coupled to the secondary winding of the transformer. The controlled rectifier is returned to a nonconductive condition in response to production of the current pulse whereupon the capacitor recharges and subsequent sparks are produced. Since the system produces a train of individual short duration high frequency sparks rather than low frequency long duration sparks, the circuit design is simplified and the power consumption is significantly reduced.

The invention together with the above and other objects may be better understood from consideration of an illustrative embodiment shown in the accompanying drawing.

The single figure of the drawing includes a somewhat diagrammatic sectional view of a fuel oil burner together with a diagrammatic and schematic illustration of an ignition system for the burner.

Referring now more specifically to the drawing, there is illustrated part of an oil burner **10** equipped with an improved ignition system designated as a whole by the reference numeral **12** and constructed in accordance with the principles of the present invention. In accordance with important features of the present invention, the ignition system **12** is compact in size, light in weight, does not require a substantial amount of power for operation, and in operation serves to produce a series of individual high frequency sparks capable of establishing a deflectable ionized air path to the end that the ignition system **12** does not intrude upon or interfere with the oil particles emitted by the burner **10**.

The burner **10** may be of conventional construction and includes a draft tube **14** within which is centrally disposed a nozzle **16** supplied with pressurized fuel oil from a suitable pump or the like by means of an oil conduit **18**. Air is supplied to the draft tube **14** by a suitable fan or blower (not shown) and moves in a stream through a wall structure **20** defining an array of swirl vanes **22**. The air stream emerges from the burner **10** through an aperture **24** in a choke plate **26**, and the swirl vanes **22** and choke plate **26** combine to impart a turbulent swirling motion to the air stream.

Oil expelled from the nozzle **16** is atomized and forms a spray pattern of oil particles designated by the numeral **28**. In the illustrated arrangement the spray pattern is substantially conical in shape. Interaction between the swirling turbulent air stream and the emerging oil particles in the region of the choke plate **26** causes some divergence of oil particles from the true conical array of particles,

and the actual interface between the spray pattern and the air stream is not well defined and may vary by as much as one-eighth inch or so.

In order to ignite the oil particles in the spray pattern **28**, the ignition system **12** includes a pair of spark discharge electrodes **30** and **32** supported by a pair of insulators **34** and **36** carried by the wall structure **20**. A pair of angularly offset electrode tip portions **30A** and **32A** define a spark gap **38** which may have a length in the neighborhood of one-eighth to three-sixteenth inch. Advantageously, the spark gap **38** defined between the tip portions **30A** and **32A** is spaced sufficiently from the spray pattern **28** so that the electrodes are not contacted by oil particles expelled from the nozzle **16**. For example, the electrode tips **30A** and **32A** may be located one-quarter inch upstream in the moving air stream from the normal boundary of the spray pattern **28** so that disturbances in the spray pattern caused by the turbulent air stream do not result in oil particles striking the electrodes. As a result, the problem of carbon formation on the electrodes is greatly diminished, and since the electrodes do not interfere with the spray pattern, a clean burning, even and quiet combustion condition is maintained.

One important aspect of the present invention resides in the ability of the ignition system **12** to produce a high frequency series of individual sparks at the spark gap **38** in order that a tongue-like extension of sparks is deflected by the moving air stream from the gap **38** and into the spray pattern **28** for the ignition of the oil particles. The system **12** includes a relaxation oscillator circuit generally designated as **40** coupled by means of a transformer **42** to the electrodes **30** and **32** for producing the highly desirable high frequency spark action at the electrodes.

More specifically, the oscillator circuit **40** includes a pair of power supply terminals **44** and **46** adapted to be connected to a standard sixty cycle AC power supply having a rated line voltage in the neighborhood of 120 volts. During alternate half cycles of the voltage waveform when the terminal **44** is positive with respect to the terminal **46**, the oscillator circuit **40** is effective to produce a series of individual sparks at a high frequency. When the terminal **44** becomes positive relative to the terminal **46**, a capacitor **48** is charged by a current flowing in a first circuit loop through a current limiting resistor **50** and an inductor or choke **51**. The capacitor **48** is permitted to become charged due to the initially nonconductive condition of a controlled rectifier **52**.

In order to control discharge of the capacitor **48**, there is provided a trigger circuit **54** coupled between the capacitor and the gate electrode of the controlled rectifier **52** for rendering the controlled rectifier **52** conductive when a predetermined capacitor charge level is attained. The trigger circuit includes a resistor **58** and a variable resistor **60**, the setting of which determines the firing point of the controlled rectifier **52**. A resistor **56** provides stabilizing gate bias on the controlled rectifier for preventing spurious triggering due to internally generated leakage currents. A capacitor **62** provides a slight delay phase shift, and a diode **64** is included to prevent an excessive and possibly damaging voltage drop between the cathode and gate electrodes of the controlled rectifier **52**.

When the controlled rectifier **52** is rendered conductive, the capacitor **48** rapidly discharges in a current pulse through a second circuit loop including the capacitor **48**, a current limiting resistor **66**, the anode-cathode circuit of the controlled rectifier **52** and a primary winding **68** of the transformer **42**. A secondary winding **70** of the transformer **42** is connected to the electrodes **30** and **32** and includes substantially more turns than the primary **68** to provide a high voltage for generation of an arc at the spark gap **38**. The transfer of energy into the spark gap may be substantially improved by choosing the electrical values of the circuit so that resonance takes place at a frequency approximating that of the generated pulse.

Upon discharge of the capacitor to produce a spark, the controlled rectifier **52** is returned to its nonconductive condition in preparation for another cycle of operation. More specifically, when the controlled rectifier **52** becomes conductive, the inductance **51** acts as a choke to prevent rapidly increasing current flow from the power supply terminals **44** and **46**. The collapsing field associated with the primary winding **68** of the transformer **42** imposes a reverse voltage through the capacitor **48** across the anode and cathode of the controlled rectifier **52**, thereby to return it to its nonconductive condition. Preferably the rectifier is subjected to a substantial reverse bias to provide positive turnoff and to increase the frequency of operation. As a result, the capacitor **48** again is permitted to become charged until the trigger circuit **54** again renders the controlled rectifier **52** conductive to produce another spark.

The sparking operation continues repetitively throughout the half cycle of the power supply waveform until the power supply voltage is incapable of charging the capacitor to the extent necessary for operation of the trigger circuit **54**. The oscillator **40** then remains inactive during the following half cycle of reverse polarity and operates once more in the second following half cycle. Since the oscillator is energized directly by an AC supply, rather than by DC, the reverse polarity excursions of the power supply render the controlled rectifier **52** nonconductive in the event that the negative voltage pulse normally turning off the rectifier is interrupted or the like. Thus, the reliability of the circuit is improved because the oscillator is effectively returned to its initial condition prior to each positive excursion of the power supply voltage waveform.

It is critical in carrying out the present invention that the frequency of operation of the relaxation oscillator circuit **40** be sufficient so that a tongue-like extension of spark is created in the air stream at the spark gap **38**. Having reference to the mechanism of the arc in the air stream at the gap **38**, when an arc is struck by an initial high voltage jump across the shortest path between the two spaced electrode tips **30A** and **32A**, the air path traversed by the arc is ionized and consequently exhibits an abrupt drop in impedance. The arc continues over the ionized path, and due to the movement of air through the region of the spark gap the ionized path is displaced downstream and becomes elongated. At some point the combination of decreasing voltage at the spark gap and increasing length of the low impedance ionized air path causes the arc to become extinguished. For a period of time after the arc is extinguished, the ionized region persists adjacent the electrodes. If the subsequent spark is produced soon enough, the arc is reestablished in the region of ionized air remaining from the previous spark. Since the region of ionized air is continually moved downstream, the arc can be extended into the spray pattern **28** to ignite the oil particles even though the electrode tips **30A** and **32A** are located as much as one-quarter inch or more from the spray pattern region.

The frequency of operation is important to carrying out this result. For example, many known solid state ignition devices produce sparks at the rate of one spark during each half cycle of the power supply AC waveform. With such an extended duration of time between sparks, it is impossible for subsequent sparks to produce arcing across the ionized air path established by previous sparks, and the tongue-like spark extension of several individual sparks cannot be achieved.

In conventional oil burner apparatus the velocity of the moving air stream may range from as high as fifty feet per second to a much smaller value. In order to produce the desirable result of the present invention, it is necessary for the frequency of spark production to be no less than about several thousand sparks per second. As a practical matter, it is believed that under ordinary conditions about twenty-five hundred sparks per second is the minimum rate which will produce the desired spark

tongue extension, while a considerably higher frequency is desirable in order to produce sparks having a desirable "hot," "fat" appearance.

Another advantage of the high frequency of operation of the relaxation oscillator circuit **40** is that the cost of the transformer **42** is reduced. More specifically, at a high operating frequency the impedance of the transformer is such that smaller wire and fewer turns can be used than would be required at a lower frequency.

In an oil burner ignition apparatus constructed in accordance with the present invention, the following specific values, dimensions and details of construction produced highly satisfactory results. These specific details of the illustrated embodiment are given by way of example only, and other arrangements may be used as well. The spark gap **38** between the electrode tips **30**A and **32**A had a length of about one-eighth inch, and the gap was spaced about one-quarter inch from the normal position of the spray pattern **28**. The circuit was operated from a standard sixty cycle 120 volt AC power supply, and the controlled rectifier **52** comprised a General Electric Company type C106B1 semiconductor controlled rectifier. The transformer **42** included a ferrite core having a primary winding **68** with 18 turns and a secondary winding **70** with 891 turns. The remaining components of the relaxation oscillator circuit had the following values:

Resistor **50**—70 ohms
Resistor **56**—510 ohms
Resistor **58**—33,000 ohms
Variable resistor **60**—250,000 ohms, maximum
Resistor **66**—1.0 ohms
Capacitor **48**—.68 microfarad
Capacitor **62**—.068 microfarad
Inductance **52**—335 millihenries

It was found that the circuit constructed with these specific components performed in a successful manner and was capable of producing individual sparks at a spark production frequency of about five thousand to about eight thousand sparks per second during the intervals when the oscillator circuit **40** operated. Consequently, a desirable tongue-like extension was produced at the spark gap extending well into the region of the oil particles in the spray pattern **28**.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. An ignition system for use with a fuel oil burner of the type producing a spray pattern of oil particles in an air stream, said system comprising:

a pair of spark discharge electrodes having tip portions spaced apart to form a spark gap;

said tip portions being disposed upstream in said air stream from said spray pattern and out of the path of the oil particles;

an oscillator circuit for producing a series of spark discharges at said spark discharge electrodes and including a pair of power supply terminals adapted to be coupled to an AC voltage source;

a transformer having a secondary winding coupled to said electrodes and having a primary winding;

a capacitor;

a first circuit loop including said power supply terminals for charging said capacitor in accordance with the voltage source;

a second circuit loop including said primary winding and said capacitor;

a controlled rectifier having a pair of output electrodes and a control electrode;

said output electrodes being connected in said second circuit loop for controlling the discharge of said capacitor through said second circuit loop;

a trigger circuit coupled between said capacitor and said control electrode for rendering said controlled conduction device conductive in response to a predetermined capacitor charge level thereby to discharge said capacitor in a current pulse through said second circuit loop to produce an arc at said spark discharge electrodes;

and means responsive to production of the current pulse for returning said controlled rectifier to the nonconductive condition;

said oscillator being constructed and arranged to produce sparks at a rate sufficient to provide a tongue of sparks in said air stream extending into said spray pattern for ignition of said oil particles.

2. The ignition system of claim **1**, the rate of spark production being more than about twenty-five hundred sparks per second during operation of said oscillator.

3. The ignition system of claim **1**, the rate of spark production being in the approximate range of about five thousand to about eight thousand sparks per second during operation of said oscillator.

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