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D. KIND

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LAMP STRIKING ARRANGEMENT

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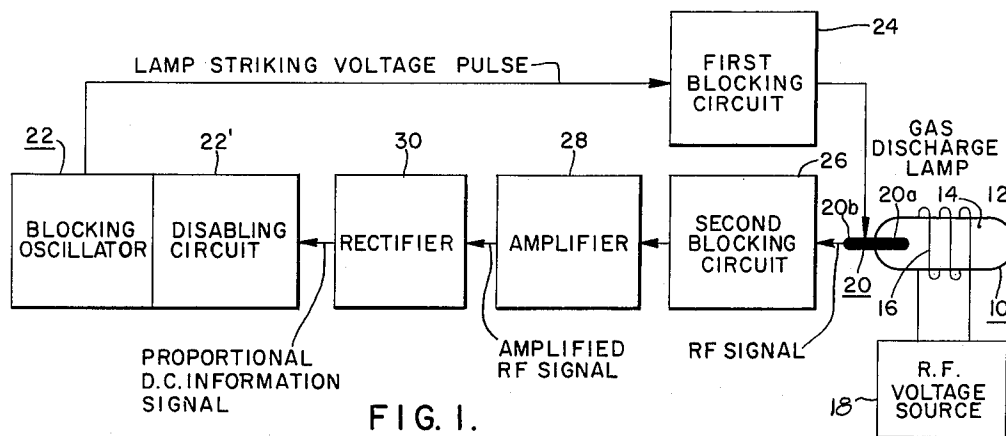


FIG. 1.

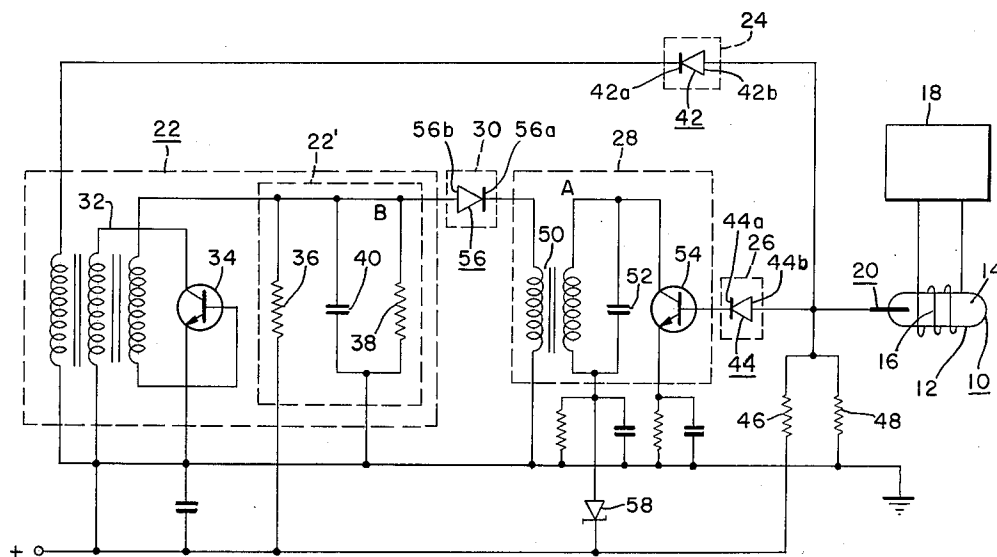


FIG. 2.

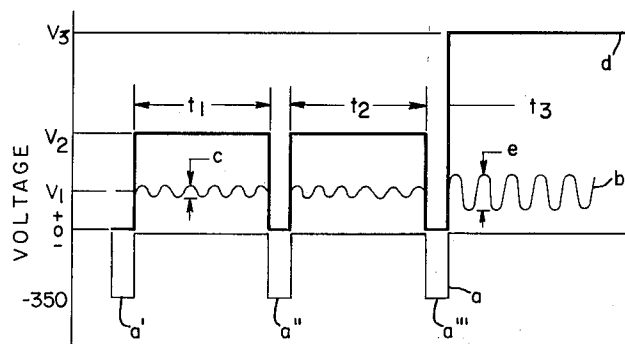


FIG. 3.

DALE KIND
INVENTOR.

BY

Don Finkelstein

AGENT
Albert Rosen
ATTORNEY.

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LAMP STRIKING ARRANGEMENT

Dale Kind, East View, Calif., assignor to Space Technology Laboratories, Inc., Los Angeles, Calif., a corporation of Delaware

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This invention relates to gas discharge lamps and, more particularly, to new and improved methods of and arrangements for automatically striking gas discharge lamps.

Systems utilizing gas discharge lamps are often required to operate continuously without human attention for long periods of time. For example, the gas discharge lamps in automatic clocks, frequency standards, and the like that are utilized in space vehicles not only must be struck automatically upon a signal from a remotely located source but must also be restruck if, because of temporary power failure or other reasons, the lamp should go out.

Starting systems for such lamps utilized in the past have not always proven completely reliable in providing such automatic gas discharge lamp striking and restriking and, further, have often required equipment in addition to the starting circuit itself to provide the automatic restriking characteristic.

This invention overcomes these difficulties by providing an automatic lamp striking and restriking circuit that is free of such additional equipment. This starting circuit is particularly useful in single electrode gas discharge lamps such as, for example, the lamp arrangement described in United States patent "Light Source," Number 2,974,243, Warren A. Morrison, inventor. It is known that gas discharge lamps typically require a comparatively large striking pulse compared with the voltage required to maintain the lamp in the On condition. For example, such lamps generally have an ionizable gas such as rubidium, cesium, sodium, and the like in a transparent, sealed tube member. An RF coil is external to the tube member and, upon receipt of an RF voltage, generates a gas ionization maintaining RF field in regions containing the ionizable gas.

An electrode is often provided in such lamps for ion collection, cooling, and other purposes. The electrode extends through the transparent tube member and is in contact with the ionizable gas. This invention utilizes such an electrode to both strike the lamp and also to determine when the lamp needs to be restruck. The electrode is capacitively coupled to the RF coil and, when the gas is ionized, i.e., when the lamp is not struck, a comparatively small RF potential is generated in the electrode by the RF field. However, when the gas becomes ionized, that is when the lamp has been struck, the RF potential at the electrode increases on the order of one magnitude over the unstruck condition due to the increased capacitive coupling of the electrode to the RF coil through the ionized gas.

According to this invention, a series of lamp striking voltage pulses is impressed upon the electrode while an RF field is generated that is of sufficient magnitude to maintain gas ionization but not sufficient to strike the lamp. The sum of the energy supplied by the voltage pulse and the RF field is sufficient to strike the lamp. The RF signal generated in the electrode is measured between lamp striking voltage pulses and, when the lamp is struck, the

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increased RF signal strength generated in the electrode is detected and in response thereto the transmission of voltage pulses to the electrode is terminated. The starting circuit remains in this condition until the lamp goes out. Under this condition, the RF potential generated in the electrode drops to a comparatively low value and in response to this low value the lamp striking voltage pulses are once again automatically transmitted to the electrode to restrike the lamp.

This invention also provides for blocking the lamp striking voltage pulses from the RF signal detection and measuring circuits so as to provide completely independent operation of the lamp striking voltage pulse generation function and the RF signal intensity detection function.

This system is explained in greater detail in the following description and with reference to the accompanying drawings, wherein similar reference characters indicate similar elements throughout and in which:

FIGURE 1 is a block diagram of an arrangement according to applicant's invention;

FIGURE 2 is a circuit diagram of one embodiment of applicant's arrangement; and

FIGURE 3 is a graph showing the voltage characteristics of the circuit diagram of FIGURE 2.

Referring now to FIGURE 1, there is shown a block diagram illustrating applicant's invention. A gas discharge lamp 10 comprises a transparent, sealed tube member 12 containing therein an ionizable gas 14. An RF coil 16 is wound around a portion of the tube member 12 and, upon application of an RF voltage from RF voltage source 18, generates a gas ionization maintaining RF field in regions containing the ionizable gas 14. An electrode 20 extends through the tube member 12 and has a first portion 20a in contact with the ionizable gas 14 and a second portion 20b external to the tube member 12.

A gated, free running, blocking oscillator 22 generates lamp striking voltage pulses which are transmitted to the electrode 20 through first blocking circuit 24. An RF signal is generated within the electrode 20 by the RF field through the capacitive coupling between the RF coil 16 and the electrode 20 and this RF signal is transmitted to a second blocking circuit 26. The RF signal is prevented from being transmitted back to the output of the blocking oscillator 22 by the first blocking circuit 24. The second blocking circuit 26 prevents transmission of both the voltage pulse and the RF signal therethrough for the condition of a voltage pulse being generated by the blocking oscillator 22 and only transmits a signal therethrough between voltage pulses. Therefore, in the preferred embodiment of this invention, the duration of the lamp striking voltage pulse is comparatively short as compared to the time interval between voltage pulses.

During the time interval between lamp striking voltage pulses, the RF signal is transmitted through the second blocking circuit 26 to a tuned amplifier 28. Applicant has found that the tuned amplifier 28 is required when the absolute value of the RF signal strength is comparatively small; however, in many systems the RF signal is of a sufficient magnitude that the tuned amplifier 28 is not needed in the system. The amplified RF signal is transmitted to a rectifier 30 which rectifies the signal to a proportional D.C. information signal. The proportional D.C. information signal is fed into a disabling circuit portion 22' of the blocking oscillator 22 which co-

operates with the blocking oscillator 22 to terminate transmission of the lamp striking voltage pulse to the electrode in response to the magnitude of the D.C. information signal.

In operation, the RF coil 16 is energized by RF voltage source 18 to provide an RF field of gas ionization maintaining strength. This induces an RF signal in the electrode 20 of a predetermined magnitude and, as described above, rectification of the RF signal by the rectifier 30 to a proportional D.C. information signal provides a first predetermined magnitude D.C. information signal. For this condition at the first predetermined magnitude D.C. information signal strength, the gated, free running, blocking oscillator 22 generates lamp striking voltage pulses which are fed to the electrode 20. Since it is generally impractical to predict the exact number of voltage pulses that are required to strike the lamp, the lamp striking voltage pulses continue until the disabling circuit 22 terminates the transmission of the voltage pulses to the electrode. After some unknown number of these voltage pulses the lamp is struck and because of the increased capacitive coupling between the electrode 20 and the coil 16, the RF signal generated in the electrode 20 increases in magnitude. At the termination of the particular voltage pulse that struck the lamp 10, the RF signal generated in the electrode 20 has a second predetermined magnitude greater than the first magnitude and, when this RF signal is rectified by the rectifier 30 to a proportional D.C. information signal, the D.C. information signal has a second predetermined magnitude greater than the first magnitude. The disabling circuit 22 receives this second magnitude D.C. information signal and in response thereto terminates the transmission of the lamp striking voltage pulses to the electrode 20.

The lamp striking circuit remains in this condition, which may be termed a stand-by condition, until the lamp 10 goes out. If the lamp 10 goes out, the RF signal and, consequently, the D.C. information signal return to the first magnitude and the disabling circuit 22' stops the termination of lamp striking voltage pulse transmission and the lamp striking voltage pulses are once again transmitted to the electrode to thereby restrike the lamp.

Referring now to FIGURE 2, there is shown a circuit diagram of one embodiment of applicant's invention. The gated, free running, blocking oscillator 22 is comprised of a transformer 32, transistor 34, resistors 36 and 38, and capacitor 40. The blocking oscillator 22 generates negative valued lamp striking voltage pulses which are transmitted to the electrode 20 through first blocking circuit 24. The first blocking circuit 24 is comprised of a first switching diode 42 having a cathode portion 42a and an anode portion 42b. The cathode portion 42a is coupled to the output of blocking oscillator 22 and the anode portion 42b is coupled to the electrode 20.

An RF field is generated in regions containing the ionizable gas 14 by RF coil 16 and an RF signal is thereby induced in electrode 20. A second blocking circuit 26 comprising a second switching diode 44 having a cathode portion 44a and an anode portion 44b is adapted to receive the RF signal generated in the electrode 20 and transmit the RF signal to the tuned amplifier 28. The anode portion 44b is connected to the electrode 20 and the cathode portion 44a is connected to the input of the amplifier 28. Resistors 46 and 48 maintain second switching diode 44 in a forward biased condition with respect to the amplifier 28 when no negative lamp striking voltage pulse is transmitted through first switching diode 42. For this condition, the RF signal generated in the electrode is transmitted to the tuned amplifier 28 which is comprised of transformer 50, capacitor 52, and transistor 54. The amplified RF signal is transmitted to rectifier 30 which is comprised of rectifier diode 56 having a cathode portion 56a coupled to the output of the tuned amplifier 28 and an anode portion 56b coupled to the input of blocking oscillator 22. Rectifier diode 56 rectifies the RF signal to

a proportional D.C. information signal having a magnitude proportional to the magnitude of the amplified RF signal.

Disabling circuit portion 22', which receives the proportional D.C. information signal, is comprised of the resistors 36 and 38 and the capacitor 40 and co-operates with the blocking oscillator 22 to terminate transmission of lamp striking voltage pulses to the electrode 20 when the magnitude of the proportional D.C. information signal is above a predetermined value, which value is developed across resistor 38.

Resistors 46 and 48, together with the coupling of cathode portion 42a of first switching diode 42 to the positive supply voltage through transformer 32, maintain a reverse bias on first switching diode 42 during nonvoltage pulse generation periods of the blocking oscillator 22.

For the condition of a negative lamp striking pulse being generated, the comparatively small reverse bias maintained across first switching diode 42 is overcome by the negative lamp striking voltage pulse and is transmitted to the electrode. However, the negative lamp striking voltage pulse also reverse biases second switching diode 44 thereby isolating amplifier 28, rectifier 30, and disabling circuit 22' from the voltage pulse. Thus, it may be seen that the single electrode 20 of the gas discharge lamp 10 is uniquely utilized as both a means for striking the lamp and as a source of determining the lamp operational condition by isolating the lamp striking function from the detection of the lamp operating condition.

FIGURE 3 illustrates the waveforms developed in the operation of the embodiment of applicant's invention shown in FIGURE 2. Curve *a* illustrates a typical negative lamp striking voltage pulse developed at the output of blocking oscillator 22. Applicant has found that with such pulses having a duration of approximately four microseconds and a magnitude of approximately minus three hundred and fifty volts at a repetition rate on the order of one thousand pulses per second, lamp striking is obtained. Curve *b* illustrates the voltage obtained at point A on the primary of transformer 50 in the tuned amplifier 28. During the transmission of the first voltage pulse *a'* to the electrode 20, no RF signal is transmitted to the tuned amplifier 28. Operating bias voltage *V*₁ is supplied to the tuned amplifier 28 through Zener diode 58. When the voltage pulse *a'* is over, during time interval *t*₁, the RF signal is transmitted through the second switching diode 44 and has an amplitude *c* for the condition that the lamp 10 is unlit.

Curve *d* illustrates the proportional D.C. information signal obtained at point B at the output of rectifier 30. During the voltage pulse *a'*, no voltage is transmitted through the rectifier diode 56. During time interval *t*₁ a voltage having a first magnitude *V*₂ is developed at point B. Resistor 38 is selected so that disabling circuit 22' does not terminate transmission of lamp striking voltage pulses to the electrode 20 for the condition of the proportional D.C. information signal having a magnitude *V*₂. Since the lamp remains unlit, a second voltage pulse *a''* is transmitted to the electrode 20 and, for example, the lamp may not light after this voltage pulse either. For this condition during time interval *t*₂ after the termination of the second voltage pulse *a''* and before the beginning of the third voltage pulse *a'''*, the voltages at point A and point B are as described above for the time interval *t*₁. After a third lamp striking voltage pulse *a'''*, for example, the lamp may be struck. This ionizes the ionizable gas 14 and the ionization is maintained by the RF field generated by RF coil 16. The increased capacitive coupling between the electrode 20 and the RF coil 16 caused by the ionization of the gas 14 results in an RF signal generated in the electrode 20 having a second magnitude *e* greater than the first magnitude *c*. This increased magnitude *e* is transmitted to the rectifier diode 56 through the amplifier 28 and second blocking circuit 26 where it is rectified to a proportional D.C. informa-

tion signal having a second magnitude V_3 as shown on curve *d*. The voltage V_3 appears at point B and the value of the resistor 38 is selected so that when a voltage of the magnitude V_3 appears at point B the disabling circuit 22' terminates the transmission of the voltage pulses to the electrode 20. As long as a voltage of the magnitude V_3 or greater appears at point B, no voltage pulses will be transmitted to the electrode. If, however, the lamp goes out, the voltage at point B would drop below the value V_3 and voltage pulses would once again be transmitted to the electrode 20 to effect a restriking of the lamp 10.

From the above, it is apparent that applicant has invented a new and improved gas discharge lamp striking arrangement.

Those skilled in the art will find many variations and adaptations of applicant's invention. Therefore, the foregoing description of the various embodiments of applicant's invention together with the accompanying drawings are intended to be illustrative and not limiting and the appended claims are intended to cover all variations and adaptations within the true scope and spirit of this invention.

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

1. In a striking circuit for a gas discharge lamp of the kind in which an RF field is generated in regions containing the gas by an RF coil external to the gas and the RF field induces the gas to emit electromagnetic radiation, and in which an electrode is in contact with the gas and capacitively coupled to the RF coil, the improvement comprising, in combination: amplifier means for amplifying an RF signal in the electrode; a gated, free running, blocking oscillator coupled to the electrode for generating therein voltage pulses of a predetermined magnitude and duration at a preselected repetition rate; rectifying means coupled to said amplifier means for rectifying said RF signal to a proportional D.C. information signal; a blocking circuit intermediate the electrode and said amplifier means for blocking said voltage pulses from said amplifier means; means co-operating with said blocking oscillator to transmit said proportional D.C. information signal to said blocking oscillator substantially only during nonpulse producing periods of said oscillator; and disabling circuit means co-operating with said blocking oscillator to terminate said pulse generation in response to the magnitude of said proportional D.C. information signal.

2. The arrangement defined in claim 1, wherein said voltage pulses have a magnitude of approximately minus three hundred and fifty volts and a duration of approximately four microseconds.

3. The arrangement defined in claim 2, wherein the repetition rate of said voltage pulses is approximately one thousand pulses per second.

4. In combination: a gas discharge lamp comprising a sealed, transparent tube member having walls defining a cavity, an ionizable gas contained within said cavity, an RF coil external to said tube member and in RF field generating relationship to said ionizable gas for generating a gas ionization maintaining RF field in regions containing said gas; an electrode coupled to said tube member having a first portion external to said tube member and a second portion in said cavity, said second portion capacitively coupled to said RF coil; an RF generator coupled to said RF coil for generating therein a gas ionization maintaining RF voltage; a gated, free running, blocking oscillator coupled to said first portion of said electrode for generating therein voltage pulses of a predetermined magnitude and duration at a preselected repetition rate whereby said voltage pulses are transmitted to said ionizable gas; amplifier means for amplifying an RF signal generated in said electrode; rectifying means coupled to said amplifier means for rectifying said RF signal

to a proportional D.C. information signal; a blocking circuit intermediate the electrode and said amplifier means for blocking said voltage pulses from said amplifier means; means co-operating with said blocking oscillator to transmit said proportional D.C. information signal to said blocking oscillator substantially only during nonpulse producing periods of said oscillator; and disabling circuit means co-operating with said blocking oscillator to terminate said pulse generation in response to the magnitude of said proportional D.C. information signal.

5. In combination: a gated, free running, blocking oscillator for generating voltage pulses of a predetermined magnitude and duration at a preselected repetition rate and having an On time for a first condition of voltage pulse generation and an Off time for a second condition of nonpulse generation; a source of RF signals coupled to said blocking oscillator for receiving said voltage pulses; means coupled to said source of RF signals for rectifying said RF signals to proportional D.C. information signals; means co-operating with said blocking oscillator for transmitting said D.C. information signal to said blocking oscillator substantially only at said second condition; and means co-operating with said blocking oscillator for preventing transmission of said voltage pulses to said source of RF signals in response to the magnitude of said D.C. information signals.

6. In combination: a gated, free running, blocking oscillator for generating voltage pulses of a predetermined magnitude and duration at a preselected repetition rate and having an On time for a first condition of voltage pulse generation and an Off time for a second condition of nonpulse generation; a source of RF signals coupled to said blocking oscillator for receiving said voltage pulses; amplifier means coupled to said source of RF signals for amplifying said RF signals; rectifier means coupled to said amplifier means for receiving said amplified RF signal and generating a proportional D.C. information signal in response thereto; means co-operating with said blocking oscillator for transmitting said D.C. information signal to said blocking oscillator substantially only at said second condition; and means co-operating with said blocking oscillator for preventing transmission of said voltage pulses to said source of RF signals in response to the magnitude of said D.C. information signals.

7. In a striking circuit for a gas discharge lamp of the kind in which an RF field is generated in regions containing the gas by an RF coil external to the gas and the RF field induces the gas to emit electromagnetic radiation, and in which an electrode is in contact with the gas and capacitively coupled to the RF coil, the improvement comprising, in combination: a gated, free running, blocking oscillator coupled to the electrode for generating therein voltage pulses of a predetermined magnitude and duration at a preselected repetition rate and having an On time for the condition of pulse generation and an Off time for the condition of nonpulse generation; means coupled to said electrode and isolated from said voltage pulses for generating a D.C. information signal in response to the presence of an RF signal in said electrode; and means co-operating with said blocking oscillator for transmitting said D.C. information signal to said blocking oscillator during said Off time, whereby pulse generation is terminated for the condition of said D.C. information signal having a magnitude greater than a preselected magnitude.

8. In a striking circuit for a gas discharge lamp of the kind in which an RF field is generated in regions containing the gas by an RF coil external to the gas and the RF field induces the gas to emit electromagnetic radiation, and in which an electrode is in contact with the gas and capacitively coupled to the RF coil, the improvement comprising, in combination: amplifier means having an input portion and an output portion for amplifying RF signals; a gated, free running, blocking oscillator having an input portion and an output portion for generating negative voltage pulses of a predetermined magnitude and

duration at a preselected repetition rate; rectifying means comprising a diode having a cathode portion and an anode portion, said cathode portion coupled to said output portion of said amplifier means and said anode portion coupled to said input portion of said blocking oscillator for rectifying RF signals to a proportional D.C. information signal; a blocking circuit comprising a first switching diode having an anode portion and a cathode portion, said cathode portion coupled to the input of said amplifier means and said anode portion coupled to the electrode for transmitting RF signals from the electrode to said amplifier; means comprising a second switching diode having an anode portion and a cathode portion, said cathode portion coupled to the output of said blocking oscillator and said anode portion coupled to the electrode; disabling circuit means co-operating with said blocking oscillator to terminate said pulse generation for the condition of the magnitude of said proportional D.C. information signal above a preselected level, whereby said blocking circuit is reversed biased with respect to said amplifier during voltage pulse generation thereby blocking said voltage pulse from said input portion of said amplifier means, and said second switching diode is reversed biased with respect to said blocking oscillator during nonpulse generation thereby blocking said RF signal generated in the electrode from the output portion of said blocking oscillator; and means for forward biasing said blocking circuit with respect to said amplifier means during nonpulse generation, thereby permitting transmission of said RF signals from the electrode to said amplifier means during nonpulse generation.

9. The arrangement defined in claim 8, wherein said negative voltage pulses have a magnitude of approximately minus three hundred and fifty volts and a duration of approximately four microseconds at a repetition rate of approximately one thousand pulses per second.

10. In combination: a gated, free running, blocking oscillator for generating voltage pulses of a predetermined magnitude and duration at a preselected repetition rate and having an On time for a first condition of voltage pulse generation and an Off time for a second condition of nonpulse generation; a source of RF signals coupled to said blocking oscillator for receiving said voltage pulses; amplifier means coupled to said source of RF signals for amplifying said RF signals; rectifier means coupled to said amplifier means for receiving said amplified RF signal and generating a proportional D.C. information signal in response thereto; blocking circuit means co-operating with said amplifier means for blocking said voltage pulses from said amplifier means of said first condition of said blocking oscillator; means co-operating with said blocking oscillator for transmitting said D.C. information signal to said blocking oscillator substantially only at said second condition; and means co-operating with said blocking oscillator for preventing transmission of said voltage pulses to said source of RF signals in response to the magnitude of said D.C. information signals.

11. In a striking circuit for a gas discharge lamp of the kind in which an RF field is generated in regions containing the gas by an RF coil external to the gas and the RF field induces the gas to emit electromagnetic radiation, and in which an electrode is in contact with the gas and capacitively coupled to the RF coil, the improvement comprising, in combination: a gated, free running, blocking oscillator for generating lamp striking voltage pulses; means coupled to said blocking oscillator for transmitting said lamp striking voltage pulses to the electrode; amplifier means coupled to said electrode for amplifying RF signals generated in said electrode; blocking circuit means co-operating with said amplifier means for blocking said voltage pulses from said amplifier means; means coupled to the electrode for preventing transmission of the RF signals to said blocking oscillator; rectifier means intermediate said amplifier means and said blocking oscillator for rectifying said amplified RF signal to a proportional D.C.

information signal; and disabling circuit means co-operating with said blocking oscillator for preventing lamp striking pulse generation for the condition of said D.C. information signal having a magnitude greater than a preselected magnitude.

12. In a striking circuit for a gas discharge lamp of the kind in which an RF field is generated in regions containing the gas by an RF coil external to the gate and the RF field induces the gas to emit electromagnetic radiation, and in which an electrode is in contact with the gas and capacitively coupled to the RF coil, the improvement comprising, in combination: a gated, free running, blocking oscillator for generating lamp striking voltage pulses; means coupled to said blocking oscillator for transmitting said lamp striking voltage pulses to the electrode; rectifier means intermediate the electrode means and said blocking oscillator for rectifying said amplified RF signal to a proportional D.C. information signal; blocking circuit means co-operating with said rectifier means for blocking said voltage pulses from said rectifier means; means coupled to the electrode for preventing transmission of the RF signals to said blocking oscillator; and disabling circuit means co-operating said blocking oscillator for preventing lamp striking pulse generation for the condition of said D.C. information signal having a magnitude greater than a preselected magnitude.

13. In combination: a gas discharge lamp comprising a sealed, transparent tube member having walls defining a cavity, an ionizable gas contained within said cavity, an RF coil external to said tube member and in RF field generating relationship to said ionizable gas for generating gas ionization maintaining RF field in regions containing said gas; an electrode coupled to said tube member having a first portion external to said tube member and a second portion in said cavity, said second portion capacitively coupled to said RF coil; an RF generator coupled to said RF coil for generating therein a gas ionization maintaining RF voltage, whereby said RF field induces an RF signal in said electrode, said RF signal having a first magnitude for the condition of said gas not being ionized and a second magnitude for the condition of said gas being ionized and said second magnitude is greater than said first magnitude; a gated, free running, blocking oscillator having an input and an output for generating lamp striking voltage pulses having a preselected magnitude and duration at a preselected repetition rate, said oscillator having an On time for the condition of pulse generation and an Off time for the condition of nonpulse generation, and said Off time is longer than said On time; amplifier means having an input and an output for amplifying said RF signal generated in said electrode; rectifier means for rectifying said amplified RF signal to a proportional D.C. information signal comprising a diode having a cathode portion and an anode portion, said cathode portion coupled to said output of said amplifier and said anode portion coupled to the input of said blocking oscillator; means comprising a first switching diode having a cathode portion and an anode portion, said cathode portion coupled to said output of said blocking oscillator and said anode portion coupled to said first portion of said electrode for transmitting said lamp striking voltage pulses to said electrode; means coupled to said first switching diode for impressing thereon a first reverse bias voltage having a magnitude less than the magnitude of said lamp striking voltage pulse, whereby said RF signal generated in said electrode is blocked from said output of said blocking oscillator; blocking circuit means comprising a second switching diode having an anode portion and a cathode portion, said anode portion coupled to said first portion of said electrode and said cathode portion coupled to said input of said amplifier means whereby said lamp striking voltage pulse reverse biases said second switching diode during said On time of said blocking oscillator to block transmission of said lamp

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striking voltage pulse from said amplifier; means coupled to said blocking circuit for maintaining said second switching diode in a forward biased condition during said Off time of said blocking oscillator whereby said D.C. information signal is transmitted to said blocking oscillator during said Off time of said blocking oscillator; and disabling circuit means co-operating with said blocking oscillator for terminating transmission of said lamp striking voltage pulses to said electrode for the condition of said RF signal having said second magnitude.

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14. The arrangement defined in claim 13, wherein said second magnitude of said RF signal is approximately six times greater than said first magnitude.

15. The arrangement defined in claim 14, wherein said lamp striking voltage pulses have a magnitude of approximately minus three hundred and fifty volts and a duration of approximately four microseconds at a repetition rate of approximately one thousand pulses per second.

No references cited.