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STARTER FOR MULTIPLE ELECTRODE LAMPS

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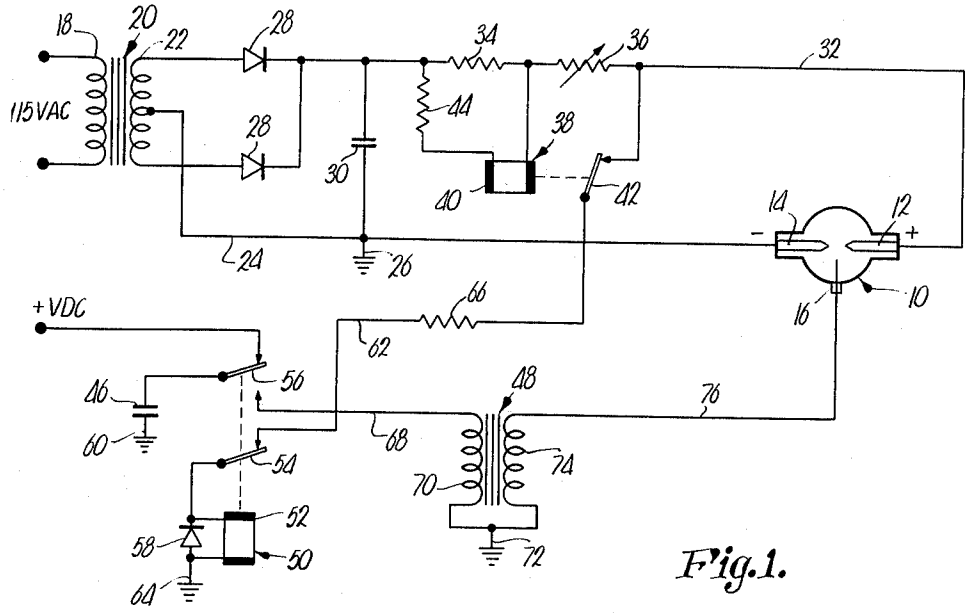


Fig.1.

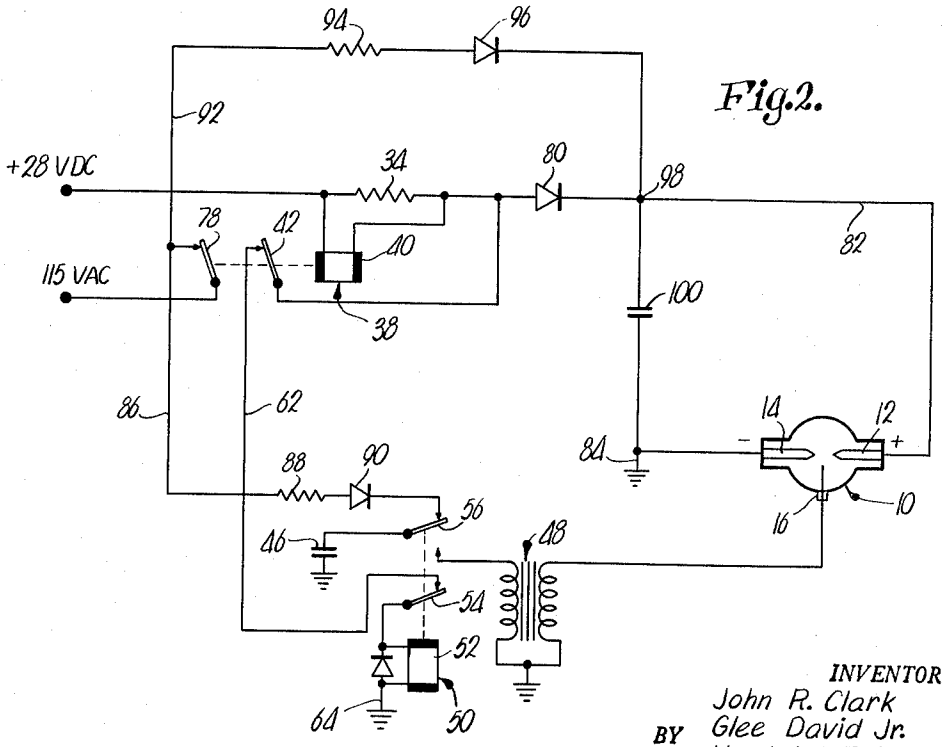


Fig.2.

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STARTER FOR MULTIPLE ELECTRODE LAMPS

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This invention relates generally to circuitry for igniting and operating gaseous discharge lamps and, more specifically, to circuitry for providing the necessary starting and operating voltages for gaseous discharge lamps provided with a starting electrode in addition to the normal cathode and anode electrodes.

Gaseous discharge lamps, whether of the mercury vapor or the inert gas type, have certain physical characteristics which make the operation thereof substantially different from the operation of other types of lamps. One salient characteristic is the necessity for applying a very high voltage to the discharge electrodes of the lamp during starting thereof which, subsequent to starting, must be substantially reduced.

Many gaseous discharge lamps are provided with a starting electrode in addition to the normal cathode and anode electrodes to facilitate the application thereto of a high starting voltage and thus the ignition of the lamp.

Recently, xenon gas lamps have become available with a starting electrode in addition to the usual electrodes. These lamps are especially suited for utilization with direct reading oscillographs but, for maximum utility, the problem of starting these lamps has existed heretofore unless relatively heavy and bulky power supplies were utilized. This factor becomes especially important when these oscillographs are to be utilized in aircraft where weight and space is at a premium. Furthermore, the rarefied atmosphere creates an additional problem in that flashover external of the lamp and the power supply components often occurs due to ionization of the rarefied gases. This can only be held at a minimum and thus the operational altitude increased if the high voltage starting circuitry is made as simple as possible to facilitate the insulation thereof and isolation from the low voltage operating circuitry.

It is, therefore, an object of this invention to provide ignition circuitry for a gaseous discharge lamp having a starting electrode as above described, such ignition circuitry being provided with means for repeatedly applying high voltage pulses to the starting electrode until proper ignition occurs.

It is another object of this invention to provide ignition circuitry for a gaseous discharge lamp having a starting electrode as above described, such circuitry being provided with means for automatically rendering the ignition circuit inoperative after proper ignition of the lamp has occurred.

It is still another object of this invention to provide igniting and operating circuitry for a gaseous discharge lamp having a starting electrode wherein isolation of the low voltage operating circuit and the high voltage ignition circuit is achieved.

It is still another object of this invention to provide igniting and operating circuitry for a gaseous discharge lamp enabling operation of the lamp in rarefied atmosphere without external discharge during ignition.

It is yet another object of this invention to provide an ignition circuit for a gaseous discharge lamp utilizing an electro-mechanical actuator coupled with switch structure for cyclically operating the latter to enable a capacitor coupled with the switch structure to be repeatedly charged by a source of electrical energy and discharged through the starting electrode of the lamp thereby providing voltages pulses for effecting ignition thereof.

Other objects will become apparent as the detailed description proceeds.

In the drawing:

FIGURE 1 is a schematic circuit diagram of an embodiment of the present invention especially suited for operation from a 115 volt A.C. power source and a relatively high voltage D.C. power source; and

FIGURE 2 is a schematic circuit diagram showing an embodiment of the present invention especially suited for operation from the power sources which commonly exist on aircraft.

The embodiment of FIG. 1 shows a gaseous discharge lamp generally designated 10, having an anode 12, a cathode 14, and a starting electrode 16. Electrical power for igniting and operating the lamp is obtained from a 115 volt alternating current power source which is impressed across the primary winding 18 of a transformer 20. Secondary winding 22 of transformer 20 is center-tapped, the cathode 14 being connected to the center tap by conductor 24 which is grounded as at 26. Diodes 28 rectify the output from the secondary winding 22 and capacitor 30 filters the rectified output. Conductor 32 from the anode 12 completes the power circuit. The turns ratio of transformer 20 may be such that approximately 50 volts D.C. will be placed across the anode 12 and cathode 14 when no current is being drawn from the transformer secondary. The exact value of this voltage will be dependent upon the particular type of lamp 10 utilized.

In the power circuit described above it may be noted that a pair of series-connected resistors 34 and 36 are interposed in conductor 32. These resistors serve to limit the current in this power circuit after starting of the lamp when current is flowing between the cathode and anode thereof. Resistors 34 and 36 will be of a value depending on the operating current characteristics of the particular lamp utilized, and for this purpose, resistor 36 may be variable as shown in FIG. 1 to allow adjustment of the load current.

An electro-mechanical relay generally designated 38, having a relay coil 40 and a normally closed switch 42, is utilized as an automatic shutoff device for the ignition circuitry to be described hereinafter. The coil 40 is connected across resistor 34. A resistor 44 may be utilized in series with coil 40 to limit the current therethrough in accordance with the operating characteristics of the relay. The contact of switch 42 is connected to conductor 32. It is to be understood that the designation of switch 42 as "normally" closed indicates that the switch is closed when coil 40 is de-energized. Similar nomenclature will be utilized throughout this specification.

The ignition circuitry of FIG. 1 comprises a capacitor 46, an ignition transformer 48, and an electro-mechanical relay generally designated 50. Relay 50 comprises a relay coil 52, a normally closed switch 54, and a single-pole double-throw switch 56 normally closed with its upper contact as shown in FIG. 1. A diode 58 is connected across relay coil 52 and serves as an arc suppressor for eliminating inductive voltage peaks caused by the back E.M.F. of coil 52 during de-energization thereof. It should be understood that the negative electrical side of the positive D.C. potential shown connected to switch 56 is grounded. Therefore, capaictor 46, being grounded at 60, is connected across the D.C. power source when switch 56 is in the normal position as shown.

The operation of the circuitry shown in FIG. 1 will now be explained. It should be understood at the outset that the circuitry as shown will automatically maintain the lamp 10 operative indefinitely. Therefore, a suitable

switch or switches (not shown) would normally be utilized in practice to connect and disconnect the power sources from the circuitry depending on whether or not operation of the lamp 10 is desired.

It may be appreciated that the power circuit commencing with the 115 volt A.C. power source maintains a voltage across anode 12 and cathode 14 at all times through connection therewith by conductors 32 and 24. This voltage, however, is insufficient to ignite the lamp and serves primarily to operate the lamp once ignition has been completed. There is, of course, a certain open circuit voltage that must be maintained across anode 12 and cathode 14 in order for emission therebetween to occur upon application of the ignition voltage to the starting electrode 16. As mentioned above, this open circuit voltage is chosen according to the operating characteristics of the lamp, and the values of resistors 34 and 36 are chosen to provide the proper operating voltage and current after ignition.

A circuit traced from secondary winding 22, along conductor 32, through switch 42, conductor 62, switch 54 and relay coil 52 to ground at 64, indicates that the relay coil 52 will be energized as long as switch 54 is in the closed position. A resistor 66 may be interposed in conductor 62 to control the energizing current in coil 52. However, once coil 52 becomes energized sufficiently to open switch 54, the coil then automatically becomes deenergized and switch 54 is allowed to reclose. Therefore, it may be appreciated that a "buzzer" action is produced in the relay 50. The high inertia of the relay switches 54 and 56 enable the same to move to their energized positions momentarily prior to being returned to their normal positions under the action of the relay springs. The speed of this buzzer action may be controlled by proper relay selection. Furthermore, it has been found that the diode 58 connected across relay coil 52 assists in momentarily holding coil 52 in the energized state after the power circuit thereto is interrupted by the opening of switch 54.

The engagement of switch 56 with its lower contact during momentary energization of relay coil 52 permits the electrical energy stored in capacitor 46 to be transmitted along conductor 68 and through the primary winding 70 of ignition transformer 48. The ground connection 72 completes the circuit from capacitor 46 through primary winding 70. Capacitor 46 is thus alternately charged across the D.C. power source and then discharged through primary winding 70 due to the buzzer action of relay 50.

Since very high voltages relative to the normal operating voltage of lamp 10 are frequently required for ignition, the secondary winding 74 of ignition transformer 48 may be provided with a very large number of turns as compared with the primary winding 70. Ignition transformers having turns ratios enabling the stepping up of a primary winding voltage on the order of 200 volts to secondary winding voltages on the order of 30 kilovolts are conventional items. The pulsed high voltage output of secondary 74 is thus applied to the starting electrode 16 along conductor 76, and an arc is struck from starting electrode 16 to cathode 14 when ignition occurs. The pulses will continue until this ignition occurs, it being apparent that a series of high voltage pulses as provided by the invention assures reliable starting. It should be understood that the polarities of the D.C. power source may be reversed and an arc struck from the starting electrode 16 to the anode 12 with equal effectiveness.

Upon ignition of the lamp 10 the emission between anode 12 and cathode 14 causes current to flow in conductors 24 and 32 of the power circuit emanating from the 115 volt A.C. source. A voltage drop thus occurs across resistor 34 which energizes relay coil 40. This opens switch 42 and interrupts the circuit through conductor 62 thus disconnecting relay coil 52 from its energizing power source. This automatically terminates the operation of the ignition circuit.

When the present invention was conceived, one contemplated utilization thereof was with xenon lamps in oscillographs in aircraft where the size and weight of components must be kept at a minimum. This created a special problem, however, because of the particular voltages available from air-borne power supplies. It is common in aircraft, particularly military aircraft, to provide a variety of A.C. voltages including the usual 115 volt A.C. supply. However, 28 volts D.C. is the common D.C. supply, and D.C. voltages greater than 28 volts are seldom available. It may be appreciated that this presents a special problem with regard to the operation of xenon or other gaseous discharge lamps because a comparatively high D.C. voltage is not readily available for charging capacitor 46 and then pulsing the primary winding of ignition transformer 48, wherein the pulse is boosted to the very high starting voltages required.

The basic principles of operation of FIG. 2 are essentially identical with that as shown and discussed above for FIG. 1. However, it may be noted that an additional switch 78 is ganged with switch 42 of relay 38 and fewer power supply components are utilized. The transformer 20 and its associated rectifiers 28 and filter capacitor 30 utilized in FIG. 1 are large, heavy components and thus are not readily acceptable for utilization in aircraft if a more lightweight, compact unit of equal effectiveness can be provided.

FIG. 2 overcomes the aforementioned disadvantages in a manner to be now fully described. It should be understood from FIG. 2 that the negative electrical side of the 28 volt D.C. supply is maintained at ground potential along with the return for the 115 volt A.C. supply. Furthermore, the components in FIG. 2 identical in physical characteristics and function to the components in FIG. 1, are designated by reference characters common to the two figures.

The positive 28 volt D.C. supply lead is connected with resistor 34. A circuit traceable from resistor 34 through switching diode 80, conductor 82, anode 12, and cathode 14 to ground at 84 provides the operating voltage and current for lamp 10 after ignition thereof. During ignition however, diode 80 is nonconducting and thus the 28 volt D.C. supply is isolated from the remainder of the circuit.

The additional switch 78 added to relay 38 is connected with the 115 volt A.C. supply lead. Conductor 86 connects the contact of switch 78 to a resistor 88 in series with a diode 90 which is connected to the upper contact of switch 56, said upper contact being engaged by switch 56 when the same is in its normal position. The remainder of the ignition circuitry is identical to that shown and described for FIG. 1.

A conductor 92 connects the contact of switch 78 with a resistor 94 in series with a diode 96 connected to junction point 98. A capacitor 100 is connected from junction point 98 to ground at 84. Conductor 82 from the anode 12 of lamp 10 also is connected with junction point 98.

It may be appreciated that in FIG. 2 the rectifying action of diode 96 provides a path for the flow of unidirectional current from the 115 volt A.C. supply lead along conductor 92, through resistor 94 and diode 96, to junction point 98, and thus across capacitor 100 to ground at 84. Resistor 94 is of a value such that the voltage developed across capacitor 100 equals the proper open circuit supply voltage across anode 12 and cathode 14 for starting thereof when ignition pulses are applied to starting electrode 16. As discussed above, this voltage is generally on the order of 50 volts. The diode 90 also serves to rectify the voltage from the 115 volt A.C. supply and thus enables capacitor 46 to charge when switch 56 is in its normal position.

Resistor 88 may be chosen to provide the proper time

constant for the R.C. combination of resistor 88 and capacitor 46. Electrical power for the energization of relay coil 52 is obtained from the 28 volt D.C. supply lead by circuit traceable through resistor 34, switch 42, conductor 62, switch 54, and relay coil 52 to ground at 64. Therefore, except for the above described re-arrangement of the power sources, the circuit of FIG. 2 during the ignition phase functions in an identical manner to the circuit of FIG. 1.

Once ignition of the lamp 10 is achieved, it is requisite that the power source for the operation of the cathode-anode emission be transferred from the 115 volt A.C. source to the lower 28 volt D.C. source. This transfer is achieved in part by fixing the ohmic value of resistor 94 high relative to the ohmic value of resistor 34. Therefore, the comparatively heavy current demanded by the cathode-anode circuit of lamp 10 after starting occurs tends to load the 28 volt D.C. supply. Diode 80 is thus placed in the conductive state and the voltage drop across resistor 34 energizes coil 40 of relay 38 to thereby open switch 78 and disconnect the 115 volt A.C. lead from the circuitry. This actuation of switch 78 along with switch 42 (as above described for FIG. 1) thus terminates the operation of the ignition and the cathode-anode starting voltage circuitry.

It may be readily appreciated by those skilled in the art that fixing the ohmic value of resistor 94 relatively high as compared with the value of resistor 34 is realizable due to the difference in the voltages of the A.C. and the D.C. supplies and the difference in the functions of the circuits associated with the two resistors. Capacitor 100, of course, has no effect on the operation of the lamp 10 once ignition is achieved because the capacitor presents an essentially open circuit to the D.C. supply.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A circuit for igniting and operating a continuous arc lamp provided with a starting electrode in addition to the normal discharge electrodes comprising:
- first unidirectional electric current supply means having an output voltage under load at least equal to the voltage required for continuous operation of said discharge electrodes;
- first circuit means for coupling said discharge electrodes with said first supply means;
- electrically responsive switching means coupled with said first circuit means and responsive to current flow therein resulting from starting of said lamp;
- second unidirectional electric current supply means separate from said first supply means;
- switch structure;
- electrical energy storing means coupled with said switch structure;
- means coupling said switch structure and storing means with said second supply means;
- second circuit means for coupling said starting electrode with said switch structure, the latter having a normal, first switch position permitting electrical energy from said second supply means to flow into said storing means and a second switch position permitting electrical energy to flow from said storing means to the starting electrode;
- electrically responsive actuator means coupled with said switch structure for cyclically operating the latter to repeatedly place said switch structure in said second position momentarily and then return the same to said normal position; and
- means electrically coupling said actuator means with said first supply means and said electrically responsive switching means, the latter interrupting current flow from said first supply means to said actuator means when current flows in said first circuit means, whereby the starting electrode is pulsed with electrical energy until current flows between the discharge electrodes and hence in said first circuit means.

2. The invention of claim 1, said second circuit means including transformer means for increasing the voltage level of the electrical energy from said storing means.

3. The invention of claim 1, said storing means comprising a capacitor.

4. The invention of claim 1, said actuator means comprising an electro-mechanical relay including a relay coil having an armature coupled with said switch structure and a normally closed switch series connected therewith, said switch opening upon energization of said coil to interrupt current flow through said coil, whereby the latter is alternately energized and de-energized to cyclically operate said switch structure.

5. A circuit for igniting and operating a continuous arc lamp provided with a starting electrode in addition to the normal discharge electrodes comprising:
- first unidirectional electric current supply means having an output voltage under load at least equal to the voltage required for continuous operation of said discharge electrodes;
- first circuit means for coupling said discharge electrodes with said first supply means;
- electrically responsive switching means coupled with said first circuit means and responsive to current flow therein resulting from starting of said lamp;
- second unidirectional electric current supply means separate from said first supply means;
- switch structure;
- a capacitor coupled with said switch structure;
- means coupling said switch structure and capacitor with said second supply means;
- second circuit means for coupling said starting electrode with said switch structure, the latter having a normal, first switch position permitting electrical energy from said second supply means to charge said capacitor and a second switch position permitting electrical energy to discharge from said capacitor and flow to the starting electrode, said second circuit means including transformer means for increasing the voltage level of the electrical energy from said capacitor during discharge thereof;
- actuator means comprising an electro-mechanical relay including a relay coil, an armature for said coil, and a normally closed switch operably coupled with said armature and series-connected with said coil, the switch opening upon energization of said coil to interrupt current flow through said coil, whereby the latter is alternately energized and de-energized to cyclically operate said armature, the armature being mechanically coupled with said switch structure to repeatedly place said switch structure in said second position momentarily and then return the same to said normal position in sequence corresponding, respectively, to the energization and de-energization of said coil; and
- means electrically coupling said relay coil with said first supply means and said electrically responsive switching means, the latter interrupting current flow from said first supply means to said relay coil when current flows in said first circuit means, whereby the starting electrode is pulsed with electrical energy until current flows between the discharge electrodes and hence in said first circuit means.

6. A circuit for igniting and operating a gaseous discharge lamp provided with a starting electrode in addition to the normal discharge electrodes comprising:
- first unidirectional electric current supply means having an output voltage under load equal to the required operating voltage for said discharge electrodes;
- first circuit means for coupling said discharge electrodes with said first supply means;
- means interposed in said first circuit means for preventing current flow from said first supply means to said discharge electrodes until the flow of current between said discharge electrodes commences;

electrically responsive switching means responsive to current flow in said first circuit means and coupled therewith;

second unidirectional electric current supply means having an output voltage higher than the output voltage of said first supply means, said second supply means being separate therefrom;

second circuit means for coupling said discharge electrodes with said second supply means;

switch structure;

a capacitor coupled with said switch structure;

means coupling said switch structure and capacitor with said second supply means;

third circuit means for coupling said starting electrode with said switch structure, the latter having a normal, first switch position permitting electrical energy from said second supply means to charge said capacitor and a second switch position permitting electrical energy to discharge from said capacitor and flow to the starting electrode, said third circuit means including transformer means for increasing the voltage level of the electrical energy from said capacitor during discharge thereof;

actuator means comprising an electro-mechanical relay including a relay coil, an armature for said coil, and a normally closed switch operably coupled with said armature and series-connected with said coil, the switch opening upon energization of said coil to interrupt current flow through said coil, whereby the latter is alternately energized and de-energized to cyclically operate said armature, the armature being mechanically coupled with said switch structure to repeatedly place said switch structure in said second position momentarily and then return the same to said normal position in sequence corresponding, respectively, to the energization and de-energization of said coil; and

means electrically coupling said relay coil with said first supply means and said electrically responsive switching means, the latter including first switching means for interrupting current flow from said first supply means to said relay coil when current flows in said first circuit means, and second switching means electrically independent from said first switching means and interposed in said second circuit means for interrupting current flow in said second circuit means when current flows in said first circuit means, whereby the starting electrode is pulsed with electrical energy until current flows between the discharge electrodes and hence in said first circuit means, and whereby said second supply means is disconnected from said discharge electrodes after current flow therebetween commences.

7. The invention of claim 6, said means preventing current flow in said first circuit means comprising a diode disposed to block current flow from said second supply means to said first supply means.

8. The invention of claim 6, said electrically responsive switching means comprising a second electromechanical relay.

9. A circuit for igniting and operating a continuous arc lamp provided with a starting electrode in addition to the normal discharge electrodes comprising:

first unidirectional current supply means for operating said lamp after starting of the latter, and having an output voltage under load at least equal to the voltage required for continuous operation of said discharge electrodes;

first circuit means for coupling said discharge electrodes with said first supply means;

second unidirectional electric current supply means for furnishing electrical power to said lamp during starting thereof, said second supply means being separate from said first supply means and having an output voltage higher than the output voltage of the first supply means;

second circuit means for coupling said discharge electrodes with said second supply means;

electrically responsive lamp starting means coupled with said second supply means for producing high voltage ignition pulses;

electrically responsive switching means coupled with said first and said second circuit means for interrupting the electrical continuity of the second circuit means in response to current flow in said first circuit means resulting from starting of said lamp;

electrically operated means coupled with said switching means and said starting means for operating the latter to effect repetitive production of said pulses, said switching means being operable to interrupt current flow to said electrically operated means to cease said pulse production when current flows in said first circuit means; and

third circuit means for coupling said starting electrode with the output of said starting means, whereby the starting electrode is pulsed with electrical energy until current flows between the discharge electrodes and hence in said first circuit means, thereby causing disconnection of the second supply means from the discharge electrodes and termination of operation of said starting means.

10. The invention of claim 9, wherein is provided means interposed in said first circuit means for preventing current flow from said first supply means to said discharge electrodes until the flow of current between said discharge electrodes commences.

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