

[54] **LOW-VOLTAGE STARTING MEANS FOR ARC LAMP**

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[58] Field of Search.... 315/261, 263, 327, 330-333, 315/335, 357; 313/146, 152

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[57] **ABSTRACT**

A low-voltage power supply can be used to start a gas-filled arc lamp having a movable electrode. To initiate the arc, a solenoid is energized by the low-voltage power supply to drive the movable electrode into contact with another electrode. An inductor is provided in series with the movable electrode. When the solenoid is deenergized, the movable electrode withdraws from contact with the other electrode, and a voltage which is larger than that of the power supply develops across the two electrodes. This difference of potential is attributable to the energy stored in the inductor, and is sufficient to ionize the gas in the gap between the two electrodes. In one embodiment the movable electrode is retractable into an anode electrode structure from which it is electrically insulated. The arc generated in the gap follows the movable electrode until the movable electrode is withdrawn into the anode structure, whereupon the arc jumps to the anode.

22 Claims, 2 Drawing Figures

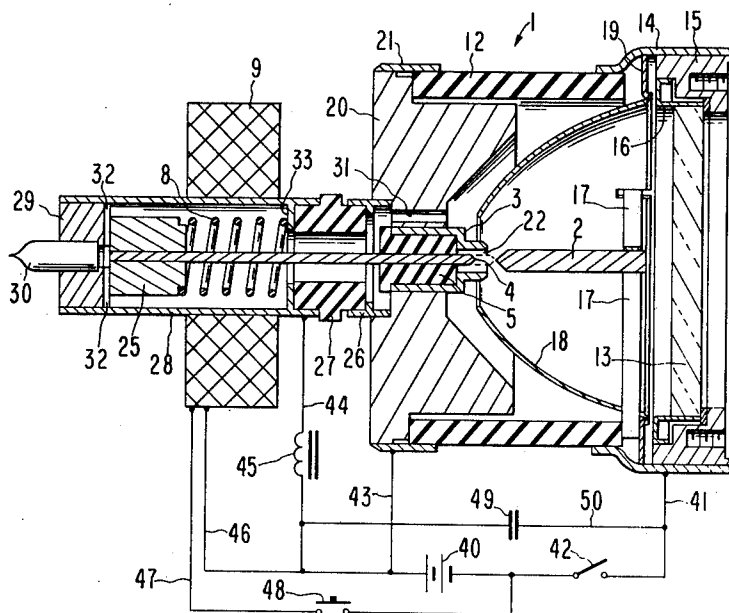


FIG. 1

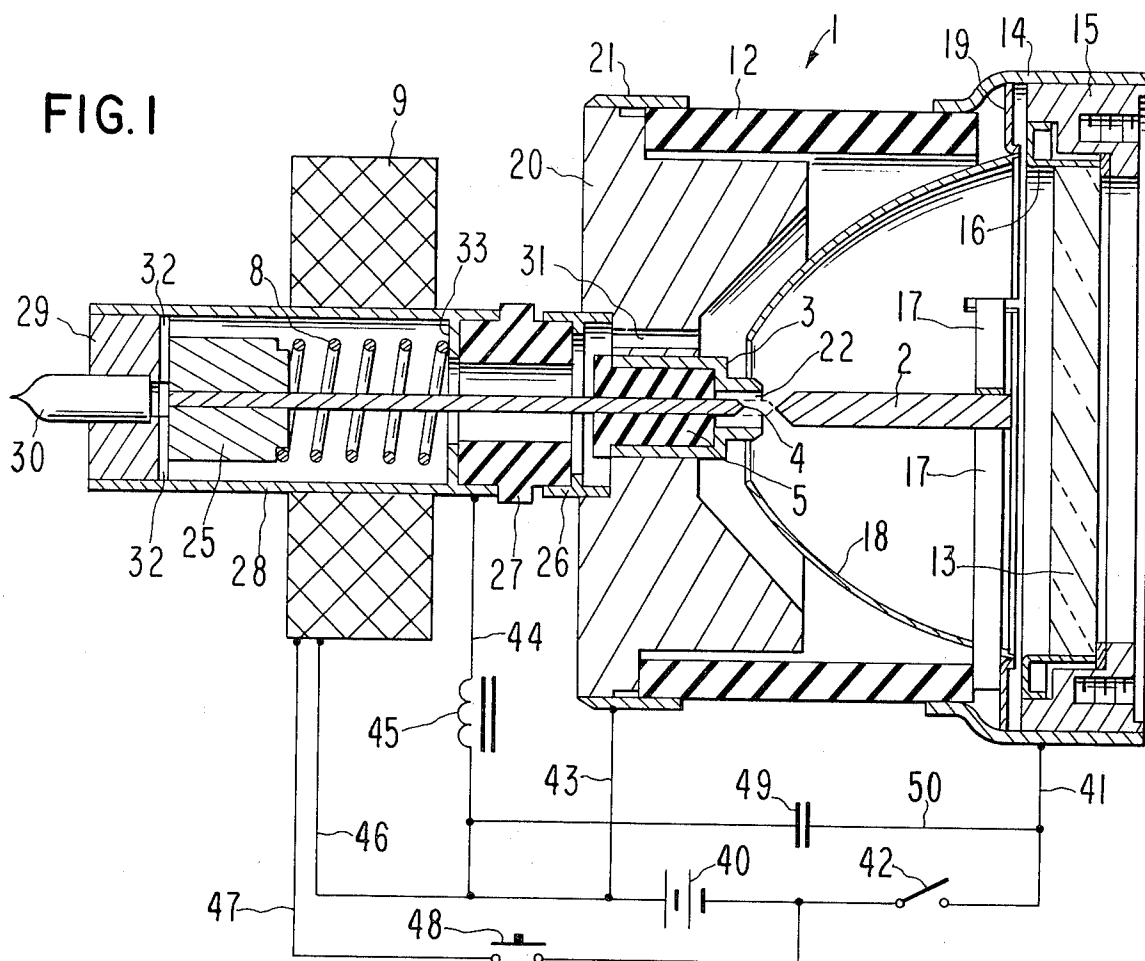
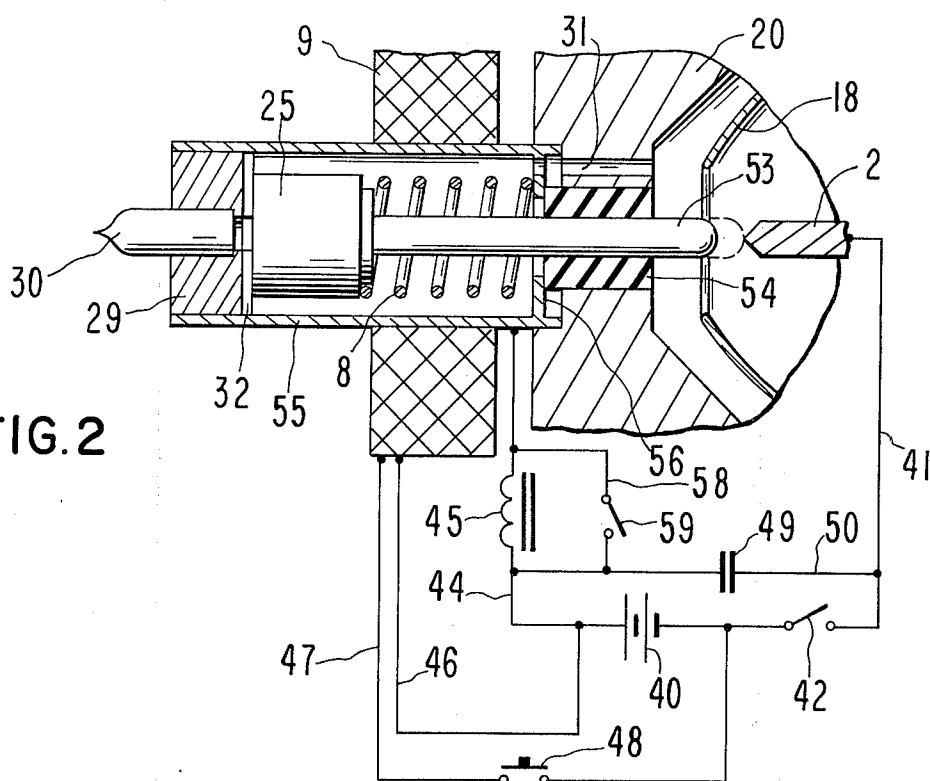


FIG. 2



LOW-VOLTAGE STARTING MEANS FOR ARC LAMP

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention is a further development with respect to gas-filled arc lamps. In particular, an electric circuit is disclosed whereby an arc lamp can be started with a low-voltage power supply.

2. Description of the Prior Art

A gas-filled arc lamp having a typical anode-to-cathode spacing of 0.100 inch requires a high-voltage in the range from 20 to 40 kilovolts to initiate breakdown of the gas in the gap between the cathode and the anode. After an arc has been initiated in the gap, the arc can be maintained at a typical current value of about 50 amperes with a typical difference of potential of about 20 volts between the cathode and the anode. The prior art has attempted to lower the starting voltage by employing a movable electrode so that the lamp can be started across a relatively short gap which is then lengthened to the full operating gap. In this way the starting voltage can be reduced but it remains higher than the running voltage. The prior art has been unable to achieve both starting and running operation with a single low-voltage power supply.

SUMMARY OF THE INVENTION

This invention provides an electric circuit whereby a gas-filled arc lamp can be started with a low-voltage power supply, which may be the same power supply that is used to run the lamp. In one embodiment the anode comprises a hollow structure spaced apart from the cathode within a gas-filled envelope. A stinger electrode is slidably mounted within the anode and is electrically insulated therefrom. To start the lamp, a push-button switch is pressed to energize a solenoid from the low-voltage power supply. The solenoid moves the stinger into contact with the cathode, thereby completing an electric circuit. An inductor is provided in this circuit in series with the stinger and the cathode. The inductor causes the current in the stinger circuit to increase exponentially from zero, when the stinger first contacts the cathode, to its steady state value. The internal resistance in the inductor limits the steady-state current across the stinger-cathode contact to a safe value. Thus, welding of the electrodes and damage to the power supply that might occur in the absence of the inductor are prevented. The push-button can therefore be pressed as long as desired without any damage occurring to the arc lamp. When the solenoid is in the energized state, the stinger is in contact with the cathode and the voltage drop across the gap is zero because the resistance is zero. When the push-button is released, the solenoid will be deenergized, whereupon a mechanical bias will cause separation of the stinger from the cathode. The break in electrical contact between the stinger and the cathode causes an instantaneous difference of potential between the stinger and the cathode which is larger than the power supply voltage. The interelectrode separation can be thought of as a varying resistance which initially starts at zero and approaches infinity. Since the inductor will not allow the current to change instantaneously, current continues to flow as the stinger leaves the cathode. The combination of resistance in the gap region and the continued current flow due to the presence of the inductor result in a dif-

ference in potential between the stinger and cathode. This difference in potential can be much higher than the power supply voltage and is a function of the value of inductance and its internal resistance. If the value of the inductor is sufficiently high, this difference of potential will ionize the gas in the short gap formed as the stinger moves away from the cathode. As the stinger withdraws from the cathode and retracts into the anode structure, the arc generated in the gap follows the stinger. By the time the stinger is completely retracted within the anode structure, the arc has jumped to the anode. Retraction of the stinger into the anode structure thus has the effect of switching the lamp from one mode of operation to another mode of operation, i.e., from the mode of operating on the cathode-stinger-inductor circuit to the mode of operating on the cathode-anode circuit wherein the inductor is shunted out.

It is an object of this invention to provide a compact and lightweight arc lamp system in which the lamp is started with a low-voltage power supply.

It is a further object of this invention to provide an arc lamp system comprising a movable electrode and a stationary electrode, with an inductor disposed in series with the power supply for the electrodes, wherein the lamp can be started by causing the movable electrode to come into contact with the stationary electrode and subsequently retracting the movable electrode from the stationary electrode, whereby a difference of potential sufficiently high to ionize the gas in the gap between the movable and stationary electrodes is generated.

It is also the object of this invention to provide an arc lamp system which is switched from operation on one electric circuit to operation on another electric circuit by the retraction of a movable electrode into a stationary electrode structure.

It is likewise an object of this invention to provide an operating circuit for arc lamps and including inductor means for generating the voltage necessary to initiate the arc discharge in such lamps.

Other features of this invention will be apparent from a perusal of the accompanying drawing and description of the preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a cross-sectional view of an arc lamp and a schematic view of an operating circuit embodying this invention; and

FIG. 2 is a partial cross-sectional view showing an arc lamp and operating circuit according to another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1 the arc lamp of this invention comprises a gas-filled hermetically sealed envelope 1, typically containing xenon gas. An elongated metal cathode 2 is mounted at a fixed position within the envelope. A metal anode 3 is provided in the form of a hollow cylindrical structure likewise mounted at a fixed position within the envelope, spaced apart from the cathode. An elongated metal stinger electrode 4 is disposed coaxially within the anode, and is electrically insulated from the anode by an insulating sleeve 5. The stinger is slidably movable within the bore of the insulating sleeve 5 from a retracted position at which the tip of the stinger is completely withdrawn into the cylindrical anode structure (as shown by solid lines) to an ex-

tended position at which the tip of the stinger contacts the tip of the cathode (as shown by broken lines). The stinger is mechanically biased by a metal spring 8 to remain in the retracted position. Movement of the tip of the stinger out of the anode structure into the gap between the anode and the cathode occurs when a solenoid 9 is energized, which counteracts the mechanical bias of spring 8.

The details of the arc lamp comprise a cylindrical ceramic side envelope wall member 12. A transparent window disc 13 is hermetically sealed to the front end of side wall 12 by means of metal rings 14, 15 and 16 all brazed together. Rings 14 and 16 are metallicity bonded to side wall 12 and window 13 respectively. The cathode 2 is bonded to metal support arms 17 which extend radially out through a reflector 18. The wide end of the reflector and the outer ends of the support arms are brazed to a metal support ring 19 which is brazed to ring 14 and forms an electrical lead to the cathode. The rear or base of the envelope comprises a large metal member 20 which serves to conduct heat from anode 3. Base member 20 is brazed to a metal ring 21 which is metallicity bonded to ceramic cylinder 12.

The tubular anode 3 is brazed in a bore in base 20 and the insulating sleeve 5 is metallicity bonded to the anode. The inner end of the anode has an oversize bore 22 through which the stinger 4 passes without contacting the anode, so that the anode and stinger are electrically isolated from each other. The electrical lead path for the anode is formed by ring 21 and base 20.

The outer end of the stinger has an iron core 25 attached thereto for interaction with coil 9 to move the stinger inwardly against the force of spring 8. The outer end of the stinger is hermetically sealed in an envelope comprising metal cylinder 26, ceramic insulating cylinder 27, metal cylinder 28, metal end plug 29, and metal pinch-off tubulation 30, all metallicity bonded together. A bore 31 in base 20 and radial grooves 32 across the inner face of plug 29 are provided to permit pumping and filling the lamp through tubulation 30 before it is pinched off. The metal cylinder 28 is provided with an inwardly projecting lip 33 which engages metal spring 8 to provide an electrical path through the spring and iron core 25 to the stinger 4. The insulating cylinder 27 maintains the stinger 4 insulated from the anode 3.

The starting and operating circuit comprises a low voltage direct current power supply such as a 24-volt battery 40. The negative side of the battery is connected to the cathode 2 by a lead line 41 containing an on-off switch 42. The positive side of the battery is connected to the anode 3 by a lead line 43. The positive side of the battery is also connected to the stinger 4, by a lead line 44. An inductor 45 is connected in series in line 44. The coil 9 is connected across the battery by lead lines 46 and 47, and a push-button switch 48 is connected in line 47. In a preferred arrangement, a capacitor 49 is connected in a line 50 between lead lines 41 and 44. The connection to line 44 is on the battery side of inductor 45.

To start the arc lamp, switch 42 is first closed. Switch 42 functions as a safety switch which must be closed before current can be drawn through the cathode. With switch 42 closed, the gap between the anode and the cathode remains as a break in the cathode circuit. Push-button switch 48 is then pressed to complete the circuit to the solenoid, causing the stinger 4 to move

inwardly against the force of spring 8 until the tip of the stinger 4 makes mechanical and electrical contact with the tip of the cathode 2. When electrical contact between the stinger and the cathode is made, a circuit is thereby completed in which the cathode 2, the stinger 4, inductor 45, and the low-voltage power supply 40 are all in series with each other. With a 24-volt direct current power supply, an inductor rated at 10 millihenries will typically draw a current of about 15 amperes.

After electrical contact has been made between the stinger and the cathode, push-button switch 48 is released thereby breaking the solenoid circuit and deenergizing the solenoid. As the solenoid is deenergized, the mechanical bias of spring 8 causes the stinger to retract into the anode structure. In practice, there is no difficulty with respect to the length of time push-button 48 can be pressed. If push-button 48 is not pressed long enough, the solenoid may not remain energized long enough to drive the tip of the stinger all the way to the tip of the cathode. In this case, the operator simply presses the push-button again for a longer time interval. There is no danger to the lamp in keeping the push-button pressed for an extended interval of time, because there is a current-limiting action due to the internal resistance of inductor 45. Inductor 45 also prevents the full current generated by the power supply from surging across the area of contact between the stinger and the cathode. There will therefore be no transfer of large amounts of electric charge across the contacting tips of the electrodes, and consequently pitting or melting of the electrode tips is prevented. When the solenoid is deenergized and the stinger starts to move away from the cathode, the energy stored in the inductor 45 will resist the disruption of the current in the circuit, and a high enough difference of potential will thereby be developed between the tip of the stinger and the tip of the cathode to ionize the gas and start the arc. As the stinger withdraws into the anode structure, the arc initially follows the stinger. Then as the stinger moves into the anode, the arc is transferred to the anode which is connected to the same battery 40 as is the stinger. Thus, the withdrawal of the stinger into the anode structure serves as a switching technique whereby the inductor 45 is switched off by the opening of a lower impedance path comprising the cathode 2, the anode 3, and the power supply 40 in series with each other. Capacitor 49 provides an instantaneous current return path for the inductor circuit when the stinger breaks contact with the cathode. In a particular embodiment, it has been found that the back emf of the inductor 45 did not damage the 24 -volt power supply 40 and/or switch 42. However, a capacitor 49, having a value such as 0.1 microfarad, in parallel across the power supply 40 and switch 42 will provide positive protection against a high-voltage power surge through the power supply and switch.

FIG. 2 shows an embodiment in which the inductive starting concept is applied to a two-electrode structure not employing a separate stinger. FIG. 2 shows only a portion of the arc lamp and it is to be understood that the remaining portion of the lamp is identical to that shown in FIG. 1. The parts shown in FIG. 2 which are the same as those in FIG. 1 are identified by the same reference numbers as used in FIG. 1.

Basically the structure of Fig. 2 differs from FIG. 1 in that a movable anode 53 replaces the stationary anode 3 and movable stinger 4 of FIG. 1. Anode 53 is

slidingly received in a bearing sleeve 54 metallurgically bonded within a central bore in base 54. Sleeve 54 is shown as a ceramic member but it could be metal since there is no need to insulate the anode from base 20. Cathode 2 is insulated from base 20, and thus from anode 53, by means of the ceramic envelope cylinder 12. In FIG. 2 the auxiliary envelope which houses spring 8 and core 25 comprises a single metal cylinder 55 brazed to base 20 and end plug 29. Cylinder 55 has an inwardly extending rim 56 which forms the electrical path to anode 53 through spring 8 and core 25.

The starting and operating circuit in FIG. 2 is basically the same as in FIG. 1 and both utilize inductor 45 for starting. FIG. 2 does not need the separate lead 43 since FIG. 2 does not have a separate stationary anode. The operation of FIG. 2 is similar to FIG. 1 in that switch 42 is first closed, and then switch 48 is closed and reopened. When switch 48 is closed, the solenoid 9 will move the anode 53 from its solid line, operating-gap position, into contact with the cathode 2, as shown in broken lines. When switch 48 is reopened, spring 8 will move the anode 53 back to its solid line position which forms the full operating gap between the cathode and anode. As the anode 53 moves away from the cathode, the stored energy in inductor 45 provides the energy necessary to start the arc. Once started, the arc follows the anode back to the solid line position of the anode for steady state operation. It is desirable to remove the inductor losses from the circuit during steady state operation, and since the inductor is not removed automatically as in FIG. 1, a shunt line 58 and switch 59 are provided. Switch 59 remains open during starting and is closed after steady state operation is achieved.

Since changes could be made in particular details of the embodiment disclosed herein without departing from the scope of the invention, it is intended that the above description and accompanying drawing be interpreted as illustrative only and not as limiting. For example, the preferred arrangement is for electrode 2 to function as the cathode, but the poles of battery 40 could be reversed so that electrode 2 functions as the anode and electrodes 3 and 53 function as the cathode.

What is claimed is:

1. An arc lamp comprising a sealed envelope containing an ionizable gas, a portion of said envelope comprising an optical window, a first stationary electrode and a second stationary electrode mounted in fixed positions in said envelope, said first and second stationary electrodes being spaced apart to form an arc gap therebetween, a stinger electrode movably mounted in said envelope, a contact portion of said stinger electrode being movable between a first position in contact with one of said stationary electrodes and a second position adjacent the surface of the other of said stationary electrodes, said first and second stationary electrodes and said stinger electrode all being mounted to said envelope in electrical isolation from each other.

2. The arc lamp of claim 1 wherein one of said stationary electrodes comprises a hollow structure and wherein said stinger electrode is mounted within said hollow structure.

3. The arc lamp of claim 2 wherein said first stationary electrode is elongate, said second stationary electrode comprises a hollow cylindrical structure, and said stinger electrode is an elongate structure receivable within said hollow cylindrical structure.

4. The arc lamp of claim 3 wherein said first and second stationary electrodes are electrically isolated from each other by a hollow cylindrical ceramic member.

5. The arc lamp of claim 4 wherein said first and second stationary electrodes are substantially coaxial with said cylindrical ceramic member.

6. The arc lamp of claim 3 wherein said second stationary electrode and said stinger electrode are electrically isolated from each other by an insulating sleeve member disposed therebetween.

7. The arc lamp of claim 3 wherein said first stationary electrode is mounted adjacent said optical window.

8. An arc lamp system comprising a sealed envelope containing an ionizable gas, a portion of said envelope comprising an optical window, a first stationary electrode and a second stationary electrode mounted in fixed positions in said envelope, said first and second stationary electrodes being spaced apart to form an arc gap therebetween, a stinger electrode movably mounted in said envelope, means for moving said stinger electrode from a first position in contact with one of said stationary electrodes to a second position adjacent the surface of the other of said stationary electrodes, a power supply, first means for electrically connecting one terminal of said power supply to said one of said stationary electrodes, second means for electrically connecting the other terminal of said power supply to said other stationary electrode, and third means for electrically connecting said other terminal of said power supply to said stinger electrode, said third means comprising an inductor.

9. The system of claim 8 wherein said means for moving said stinger comprises electromagnetic means.

10. The system of claim 9 wherein said electromagnetic stinger moving means comprises a solenoid coil electrically connectable to said power supply.

11. The system of claim 8 further comprising switch means in series with said power supply, and a capacitor connected in parallel across said power supply and said switch means.

12. The system of claim 8 wherein said first stationary electrode is a cathode.

13. The system of claim 8 wherein said second stationary electrode comprises a hollow structure, and wherein said stinger electrode is mounted within and electrically isolated from said hollow structure.

14. The system of claim 8 wherein a first electrical circuit from said one terminal to said other terminal of said power supply can be completed via said third means when said stinger electrode is in said first position, and wherein a second electrical circuit from said one terminal to said other terminal can be completed via said second means when said stinger electrode is in said second position, the movement of said stinger electrode from said first position to said second position causing said power supply to be switched from said first electrical circuit to said second electrical circuit.

15. A circuit network for a gas discharge device, said network comprising a first electrode, a second electrode, said first and second electrodes being spaced apart to form a discharge gap therebetween, a stinger electrode, means for moving said stinger electrode from a first position in contact with said first electrode to a second position adjacent said second electrode, a power supply, a first lead for electrically connecting one terminal of said power supply to said first electrode, a second lead for electrically connecting the

other terminal of said power supply to said second electrode, and a third lead for electrically connecting said other terminal of said power supply to said stinger electrode, said second electrode and said stinger electrode being electrically isolated from each other.

16. The network of claim 15 further comprising an inductor connected in series between said power supply and said stinger electrode.

17. The network of claim 16 further comprising switch means in series with said power supply, and capacitor connected in parallel across said power supply and said switch means.

18. The network of claim 15 wherein said means for moving said stinger electrode comprises a solenoid coil and switch means for connecting said coil to said power supply.

19. An arc lamp system comprising a sealed envelope containing an ionizable gas, a plurality of electrodes mounted within said envelope, means for moving a first one of said electrodes from a first position in contact with a second one of said electrodes to a second position

tion spaced apart from said second electrode, means for initiating an electric arc within said envelope in an electric arc circuit, said arc initiating means comprising a direct current power supply and an inductor, and means for electrically removing said inductor from said arc circuit after said arc has been created and is being maintained by said power supply.

20. The system of claim 19 wherein said means for removing said inductor from said arc circuit comprises switch means in shunt with said inductor.

21. The system of claim 19 wherein said means for removing said inductor from said arc circuit comprises a third electrode, said third electrode being disposed so that said arc circuit comprises said third electrode after said arc has been created and is being maintained.

22. The system of claim 21 wherein said third electrode comprises a hollow structure, and wherein said first electrode is mounted within and is electrically isolated from said third electrode.

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