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Strowe

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[54] **ARC LAMP IGNITION AND OPERATING CIRCUIT**

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[73] Assignee: **Streamlight, Inc.,** King of Prussia, Pa.

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[52] **U.S. Cl.** ..... **315/171;** 315/173; 315/241 R

[51] **Int. Cl.²** **H05B 41/00**

[58] **Field of Search** ..... 315/173-174, 315/241 R, DIG. 5

[56] **References Cited**

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3,316,445	4/1967	Ahrons	315/241 R X
3,514,669	5/1970	Helmuth	315/241 R
3,771,014	11/1973	Paget	315/173 X
3,780,342	12/1973	Grimshaw et al.	315/173

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[57] **ABSTRACT**

A circuit for energizing a Xenon arc lamp. A pulse of high potential is applied to the lamp to ionize it and render it conductive. A first capacitor charged to a first voltage less than the high pulse potential discharges current into the lamp after ionization to provide for first stage heating of the electrodes of the lamp. A second capacitor charged to a second potential less than the first and coupled to the lamp through a diode, discharges current into the lamp only after substantial discharge of current from the first capacitor to provide for second stage heating of the electrodes and condition the lamp for continuous conduction. A DC to AC to DC converter is utilized to develop a DC potential which is added to the potential from a battery to provide an operating potential for the continuous operation of the lamp.

6 Claims, 3 Drawing Figures

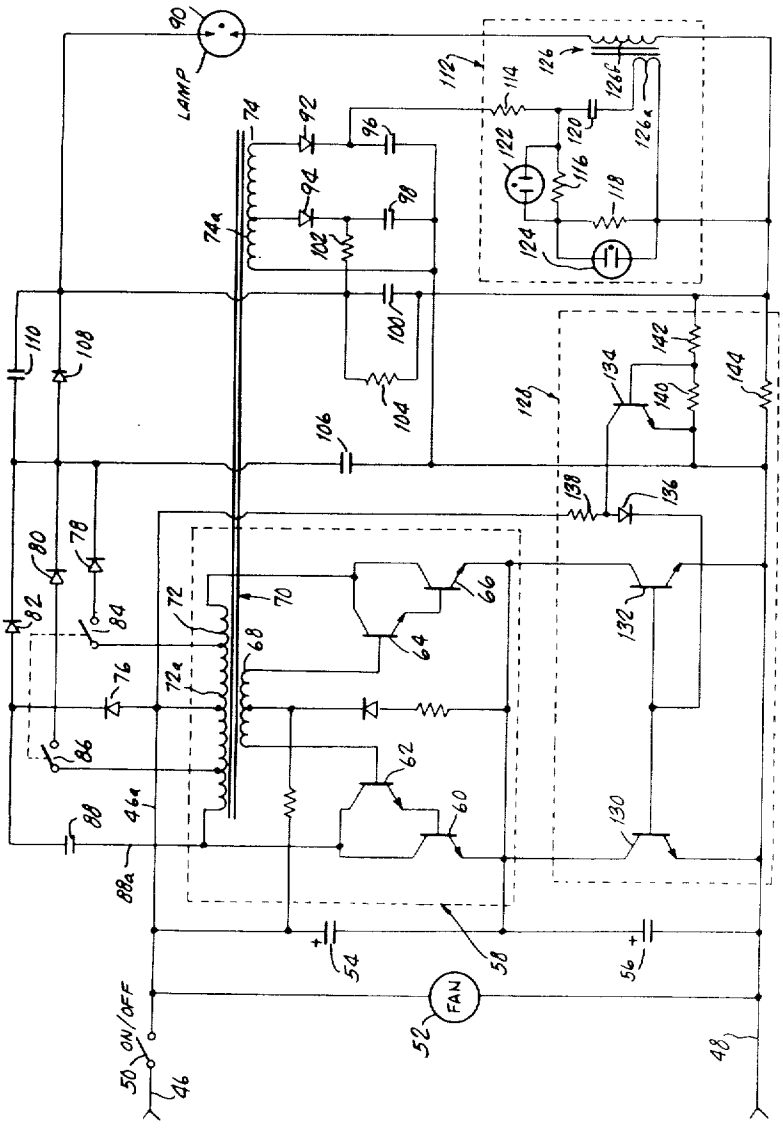
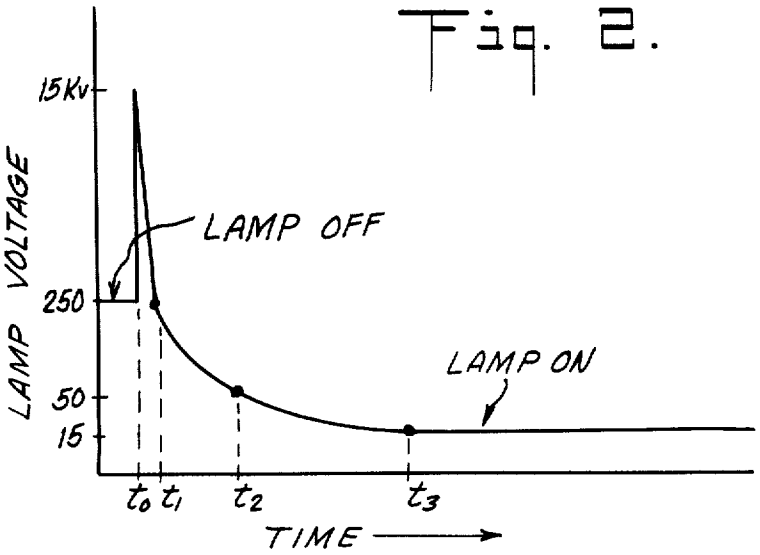


Fig. 2.


15Kv
250
50
15
LAMP VOLTAGE
LAMP OFF
LAMP ON
t_0 t_1 t_2 t_3
TIME

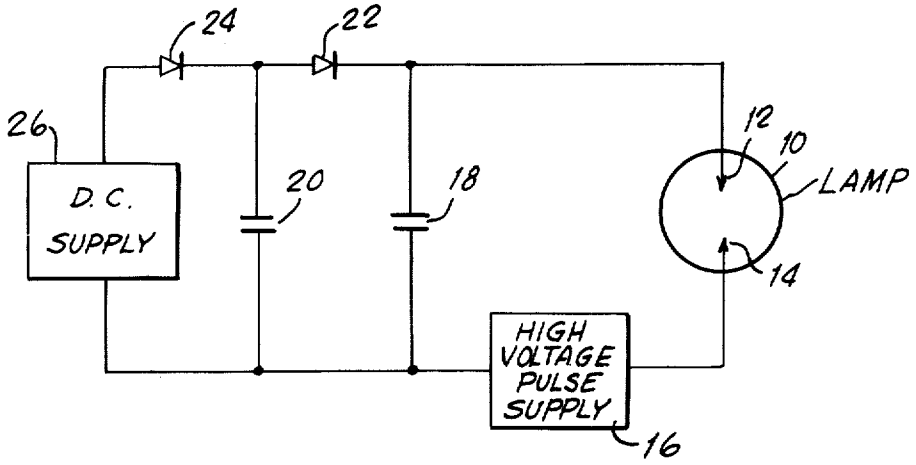

24
22
26
D. C. SUPPLY
20
18
12
10
LAMP
14
HIGH VOLTAGE PULSE SUPPLY
16

Fig. 1.

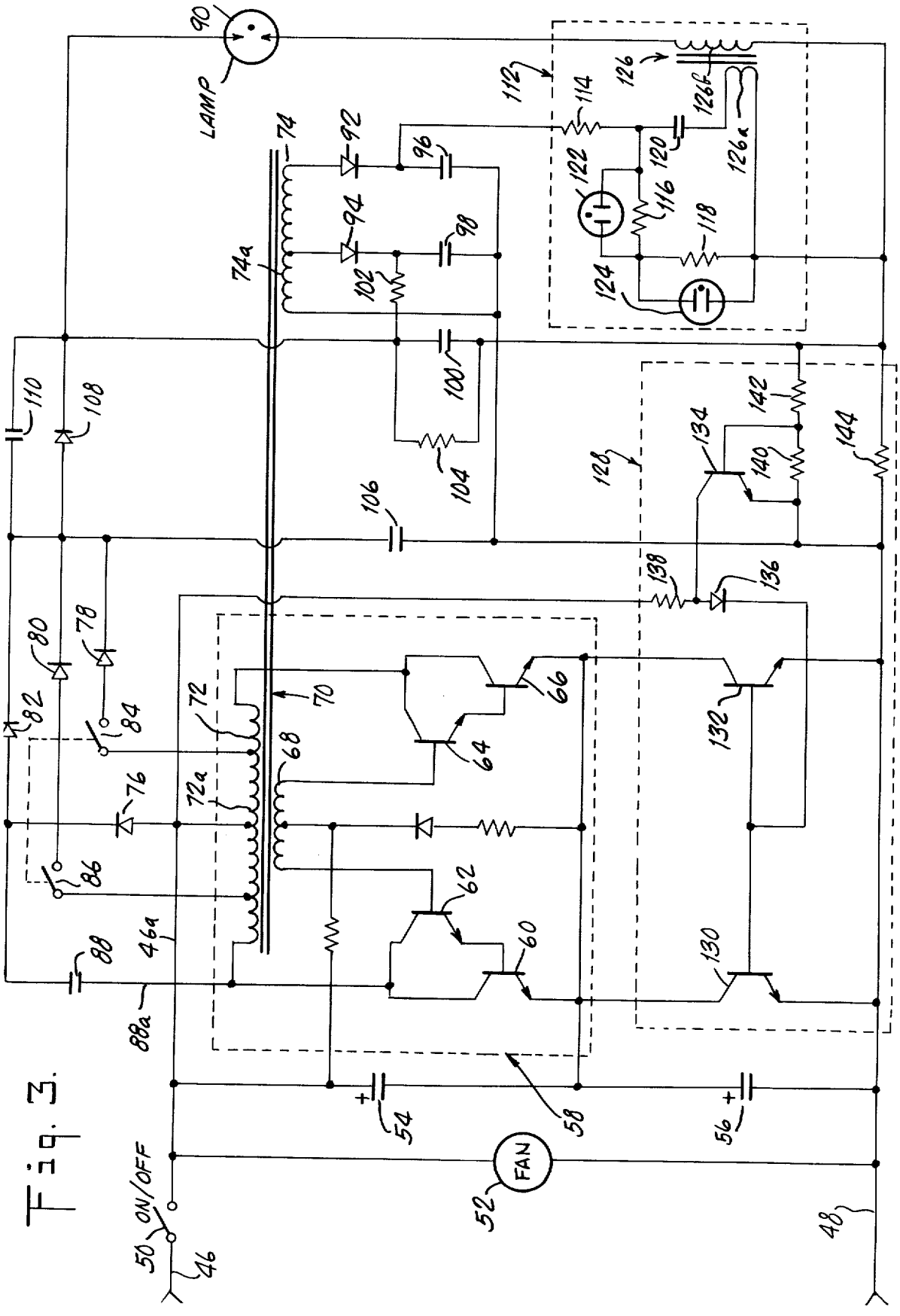

LAMP
90
74
74a
92
94
96
98
102
100
104
106
110
108
112
114
126
126b
126a
122
120
116
118
124
128
134
140
142
144
136
138
132
130
82
80
78
84
86
76
72
72a
68
70
66
64
62
60
88
46a
88a
54
58
56
FAN
52
50
ON/OFF
46
48

Fig. 3.

ARC LAMP IGNITION AND OPERATING CIRCUIT

BACKGROUND AND BRIEF DESCRIPTION OF THE INVENTION

This invention relates to lamp energizing circuits, and more particularly to a circuit for energizing a Xenon arc lamp.

In the past, a high voltage radio frequency source has been employed for initial breakdown of a Xenon arc lamp in conjunction with a source of relatively high voltage for maintaining current flow through the lamp. The disadvantages of such an ignition system are relatively high cost, radio frequency interference during ignition, shortened lamp life because of the adverse effect of the radio frequency discharge, and inefficient lamp operation due to the difference between the open circuit voltage of the power supply and the operating voltage of the lamp during its steady state operation.

The present invention provides for the ignition and operation of an arc lamp, in particular, through use of a circuit that avoids the above disadvantages. Briefly, a DC to AC to DC converter provides a DC potential which is added to that from a DC potential source (for example, a battery) to provide a potential necessary to provide for continuous operation of an arc lamp. Additionally, the DC to AC conversion permits the development of a high potential pulse which is applied to the lamp to ionize it and render it conductive. A continuous (i.e., over a number of cycles) R.F. frequency signal is thereby avoided. Additionally, capactive storage is employed of DC potentials (less than the high pulse potential) generated by the converter with successive discharging of plural capacitors into the lamp following the application of the high voltage pulse. Such successive discharging of the capacitors provides for successive stages of heating of the electrodes of the lamp, conditioning the lamp for conduction in a steady state mode. If flashing of the lamp is desired, rather than steady state operation, continuous charging and discharging of the capacitors, in combination with successive applications of high potential pulses is employed along with the removal of the steady state operating potential from the converter.

The following patents are representative of the prior art in this field:

U.S. Pat. Nos.: 3,697,805 issued Oct. 10, 1972 — Switsen

3,280,369 issued Oct. 18, 1966 — Baum et al.

3,115,594 issued Dec. 24, 1963 — Mallory

3,066,243 issued Nov. 27, 1962 — Mutschler

2,724,792 issued Nov. 22, 1955 — Nessel

2,575,001 issued Nov. 13, 1951 — Bird

The invention will be more completely understood by reference to the following detailed description, taken in conjunction with the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified circuit diagram of a lamp ignition and operating circuit in accordance with the invention.

FIG. **2** is a graphical representation of lamp voltage versus time for the circuit of FIG. **1**.

FIG. **3** is a detailed schematic circuit diagram of a lamp ignition and operating circuit in accordance with the invention.

DETAILED DESCRIPTION

Referring to FIG. **1** a Xenon arc lamp **10** is shown having electrodes **12** and **14**. A circuit for energizing the lamp includes a high voltage pulse supply **16** shown in block diagram form for generating and applying to the lamp a high voltage pulse in the order of 15 to 35 kilovolts, for example. The circuit also includes a first capacitor **18** charged to an initial potential in the order of 250 volts, for example, and a second capacitor **20** charged to an initial potential of about 50 volts, for example. Diodes **22** and **24** are also included, as well as a DC supply **26**. These diodes prevent the discharge of the capacitors through the DC supply **26**.

In its off state, the potential across the electrodes **12** and **14** of the lamp is equal to the potential across the pre-charged capacitor **18**, e.g., 250 volts. This is shown in waveform diagram of FIG. **2** by the time period preceding the time t_0 (designated "lamp off" in FIG. **2**). At the time that the lamp is to be turned "on", the high voltage pulse supply **16** generates a high potential pulse, e.g., in the order of 15 to 35 kilovolts. This is shown in FIG. **2** as occurring at time t_0. Such a high potential pulse is applied to the electrodes **12** and **14** of the lamp through the capacitor **18** which essentially acts as a bypass during this period of time. Such a high potential applied to the electrodes **12** and **14** of the lamp ionizes the lamp and renders it conductive.

The potential across the electrodes **12** and **14** decays rapidly. This is illustrated in FIG. **2** by the decay of the lamp voltage between the times t_0 and t_1. The time scale has been expanded in FIG. **2**; the decay is virtually instantaneous. At time t_1 the potential across the electrodes **12** and **14** of the lamp is equal to the potential across the pre-charged capacitor **18**. Following the time t_1 the capacitor **18** discharges slowly through the lamp, which is now conductive. The discharge of current from the capacitor **18** is illustrated by that portion of the curve in FIG. **2** between times t_1 and t_2. During this time period the current discharging through the lamp serves to heat the electrodes of the lamp to provide for first stage heating.

At time t_2 the potential across the electrodes **12** and **14** of the lamp is equal to the potential across the pre-charged capacitor **20** (neglecting the potential drop across the diode **22**). At this time the capacitor **20** discharges through the lamp, as represented by the time period between times t_2 and t_3 in FIG. **2**. The discharge of current from the capacitor **20** provides for second stage heating of the lamp electrodes.

At time t_3 the potential across the electrodes **12** and **14** of the lamp is equal to the potential of the DC supply **26** (neglecting the potential drop across the diodes **22** and **24**). The diodes **22** and **24** are thus rendered conductive and the DC supply **26** supplies current to the lamp to render the lamp "on". This "on" operation of the lamp is designated by "lamp on" in FIG. **2** and is represented by the period of time following time t_3.

It will be noted that the circuit of FIG. **1** utilizes the two capacitors, pre-charged to different potentials, and coupled to the lamp so that a first one of the capacitors (capacitor **18**) discharges current into the lamp, while a second one of the capacitors (capacitor **20**) is coupled to the lamp (by diode **22**) so that it does not discharge current into the lamp only until after substantial discharge of current from the first capacitor.

A circuit embodying the invention of FIG. **1** is shown in FIG. **3**. A DC supply, e.g., a battery (not shown), ap-

pears across conductors **46** and **48.** An ON-OFF switch **50** provides for basic on/off control of the overall lamp control circuit. A fan **52** is energized by the DC supply for the purpose of cooling the lamp. Capacitors **54** and **56** are utilized for the purpose of suppressing oscillations.

The DC supply is coupled to a multivibrator **58** enclosed by dashed lines in FIG. **3.** The multivibrator is conventional in contruction and utilizes a first pair of transistors **60** and **62** connected in "Darlington" configuration in which the gain is equal to the gain of one transistor times the gain of the second transistor. A second Darlington configuration of transistors **64** and **66** is employed in the multivibrator. The multivibrator **58** operates with primary winding **72** and feedback winding **68** of the transformer **70.** This transformer has a secondary winding **74.** The primary winding **72** is coupled to a network consisting of diodes **76, 78, 80** and **82,** ganged-together switches **84** and **86,** and capacitor **88.** This network is utilized for capacitor charging as well as providing an operating potential for the continuous operation of lamp **90,** as will be explained in more detail below. The secondary winding **74** is coupled to a network consisting of diodes **92** and **94,** capacitors **96, 98** and **100,** and resistors **102** and **104** utilized in connection with ignition of the lamp **90** to be explained in more detail below.

In the circuit of FIG. **3,** capacitors **100** and **106** correspond respectively to the capacitors **18** and **20** in the circuit of FIG. **1.** In other words, these capacitors are successively discharged into the lamp **90,** as will be explained in more detail below.

In FIG. **3** diode **108** corresponds to diode **22** in FIG. **1.** A capacitor **110** shunts the diode **108** tp provide for high voltage (starting pulse) bypassing of the diode.

A high voltage pulse supply **112** is included in the circuit of FIG. **3** corresponding to the supply **16** of FIG. **1.** This high voltage pulse supply unit includes resistors **114, 116** and **118,** capacitor **120,** spark gaps **122** and **124,** and a transformer **126** having a primary winding **126*a*** and a secondary winding **126*b*** which is connected in series with the lamp **90.**

Finally, the circuit of FIG. **3** includes a constant current regulator **128** for the purpose of rendering constant the current flow within the lamp **90.** The regulator is conventional and includes transistors **130, 132** and **134,** diode **136,** and resistors **138, 140, 142** and **114.** Of these resistors, the resistor **144** is a ballast resistors having a resistance that is almost negligible, e.g., in the order of 0.10HM.

To explain the operation of the circuit of FIG. **3,** the DC input applied to the conductors **46** and **48** from a battery, for example, is typically in the order of 12 to 14 volts. This supply potential energizes the multivibrator circuitry of windings **68** and **72** of transformer **70.** Winding **74** is the high voltage secondary winding of the transformer and typically generates an AC potential of around 1000 volts across the entire secondary winding and a potential of about 400 volts across that portion of the secondary winding designated **74*a***. Diodes **92** and **94** serve as rectifiers, while capacitors **96** and **98** serve as filters. The rectified high voltage potential across the entire secondary winding **74** (as rectified by the diode **92**) is applied through resistor **114** to capacitor **120.** The capacitor thus stores thereon a charge or rectified high potential. Resistors **116** and **118** serve as voltage dividers to evenly distribute the potential of capacitor **120** across spark gaps **122** and **124,** so that one spark gap does not prematurely break down before the other. Charge builds up on capacitor **120** until the voltage across the spark gaps is such as to break them down. Such gaps typically break at about 470 volts, e.g., and then present a relatively low impedance which permits the rapid discharging of capacitor **120** through primary winding **126*a***. This discharging causes a high voltage pulse to be generated by the secondary winding **126*b*** which is applied to the lamp **90.** Such a pulse, in the order of 15 to 35 kilovolts, as described above in connection with the circuit of FIG. **1,** is utilized to ionize the lamp **90** and to render it conductive.

As noted above, capacitors **100** and **106** correspond to capacitors **18** and **20** in the circuit of FIG. **1** and are utilized for the purposes of electrode heating as will now be explained. The capacitor **100** is charged to a potential of about 200 to 250 volts, e.g., by the action of resistors **102** and **104** which divide the potential across the secondary winding section **74*a*** (this latter potential is in the order of 400 volts, e.g.). After the lamp **90** has been rendered conductive by action of the high voltage pulse supply unit **112** as just described, the capacitor **100** discharges through the lamp to provide for first stage heating of the lamp electrodes. The discharging of the capacitor **100** continues until the potential across the lamp **90** is equal to the potential drop across the storage capacitor **106** (neglecting the potential drop across conductive diode **108**). At this time the diode **108** is rendered conductive, permitting this latter capacitor to discharge to provide for second stage heating of the electrodes of the lamp. Capacitor **106** is charged to a potential of from about 35 to 50 volts, e.g., as will now be explained.

The charging of the capacitor **106** is provided for by a voltage "tripling" action. In particular, the potential of the source of supply across the conductors **46** and **48** and is added to a part of the potential developed across secondary winding **72.** Tracing the current path, conductor **46** is connected through on/off switch **50** by conductor **46*a*** to the center tap **72*a*** of the transformer primary winding **72.** The potential developed across the left-hand section of that primary winding is added to the supply potential and is coupled by conductor **88*a*** to capacitor **88.** Thus, assuming that the source of supply is 12 volts and that the potential developed across the primary winding half is 12 volts, a total of 24 volts is developed. The capacitor **88** is charged through diode **76** during the conducting period of transistor **60** so that capacitor **88** stores thereon a charge of 12 volts, e.g. During the period when transistor **60** is not conducting and transistor **66** is, the primary winding **72** of transformer **70** connected to wire **88*a*** rises to a potential of 24 volts, e.g. Thus the potential applied to diode **82** is the sum of the voltage of capacitor **88** and the peak voltage of primary winding **72,** roughly three times the initial supply potential across the conductors **46** and **48.** The diode **82** provides for rectification so that only a DC potential is present at the cathode of the diode for charging the capacitor **106** to the potential mentioned above, e.g., 35 to 50 volts.

The continuous operation of the lamp **90** is provided for by the DC source of supply connected to the conductors **46** and **48** in conjunction with the additional potential generated by the multivibrator **58** including transformer **70** as rectified by diodes **78** and **80.** While the source of DC supply may be in the order of 12 to 14 volts, and the lamp **90** operates continuously at such a voltage, because of the potential drop across the vari-

ous diodes in the system (for example, diode **108**) an additional voltage beyond that supplied by the DC source of supply is needed to run the lamp. The transformer primary winding **72** is connected to diodes **78** and **80** through switches **84** and **86** which are ganged together. These switches are closed when it is desired to operate the lamp **90** continuously. The diodes **78** and **80** provide for full wave rectification of the potential developed across the tapped transformer primary winding **72**. The full wave rectified signal is applied through diode **108** to the lamp for the continuous operation of the lamp once it has been ignited. As noted above the constant current regulator **128** serves to regulate the current through the lamp so that it is constant. The transistors **130** and **132** of this constant current regulator control the applied voltage to the multivibrator **58** for this purpose.

As was noted above, the circuit of FIG. **3** is unique in providing for the ignition and operation of lamp **90**. By use of the "add on" technique by which a potential is developed which is added on to the potential of the DC supply, smaller components can be employed. Thus the multivibrator **58** including transformer **70** can be of less capacity than would be required if these components provided the entire operating potential of the lamp.

If it is desired to operate the lamp **90** in a "flasher" mode, i.e., the lamp **90** is not operated continuously but rather intermittently, the ganged-together switches **84** and **86** are moved to the open positions. In this configuration the lamp **90** is not supplied with an operating potential needed for continuous operation. The capacitor **120** successively charges and discharges providing for successive high voltage pulses to ionize and render conductive the lamp **90**. The capacitors **100** and **106** successively charge and discharge to provide for electrode heating and flashing of the lamp in conjunction with the high voltage pulsing. For a representative circuit configuration as shown in FIG. **3**, the flash rate is approximately one flash of the lamp per second.

The invention described above is susceptible of modification. Accordingly, the invention should be taken to be defined by the following claims.

What I claim is:

1. In a circuit for energizing a Xenon arc lamp including means for applying a pulse of high voltage to the lamp to ionize it and render it conductive, the improvement for discharging current into the lamp to heat the electrodes thereof comprising first capacitor means coupled to the lamp and charged to a first voltage less than that of said high voltage for discharging current into said lamp to provide for first stage heating of said electrodes, second capacitor means, charging means for charging said second capacitor means to a second voltage less than said first voltage but substantially higher than the normal operating potential of said lamp for discharging current into said lamp sufficient to provide for second stage heating of said electrodes, and means for coupling said second capacitor means to said lamp for discharging current into said lamp only after substantial discharge of current from said first capacitor means to provide for said second stage heating of said electrodes resulting in enabling the arc lamp to sustain electron conduction.

2. A circuit according to claim **1**, including means for supplying an operating potential to said lamp for continuous energization thereof and continuous light output therefrom.

3. A circuit according to claim **1**, including means for successively charging said first and second capacitor means which successively discharge into said lamp for providing successive flashes of light output from said lamp.

4. A circuit according to claim **2**, including means for removing said operating potential from said lamp and means for successively charging said first and second capacitor means which successively discharge into said lamp for providing successive flashes of light output from said lamp.

5. A circuit for energizing a Xenon arc lamp from a source of DC potential comprising:

a. multivibrator means coupled to said source for developing an AC potential and including transformer means having low potential and high potential winding means,

b. means coupled to said high potential winding means for applying a high potential pulse to said lamp to ionize it and render to conductive,

c. first capacitor means charged by said high potential winding means to a first voltage for discharging current into said lamp to provide for first stage heating of the electrodes of said lamp,

d. second capacitor means charged by said low potential winding means to a second voltage less than said first voltage,

e. coupling means for coupling said second capacitor means to said lamp for discharging current into said lamp only after substantial discharge of current from said first capacitor means to provide for second stage heating of said electrodes resulting in enabling said arc lamp to sustain conduction,

f. rectifying means,

g. said low potential winding means including a section thereof coupled to said source of DC source potential and to said rectifying means for adding said DC source potential to the rectified AC potential generated by said winding section to produce a combined potential which is applied to said lamp for its continuous operation.

6. A circuit according to claim **5** including switch means for inhibiting the application of said combined potential to said lamp to permit the successive flashing of the lamp by successive ones of said high potential pulse and successive charging and discharging of said first and second capacitor means.

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