

[72] Inventor **Samuel W. Woolsey**  
**Los Altos, Calif.**  
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 [73] Assignee **Varian Associates**  
**Palo Alto, Calif.**

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*Primary Examiner*—John W. Huckert  
*Assistant Examiner*—R. F. Polissack  
*Attorney*—Stanley Z. Cole

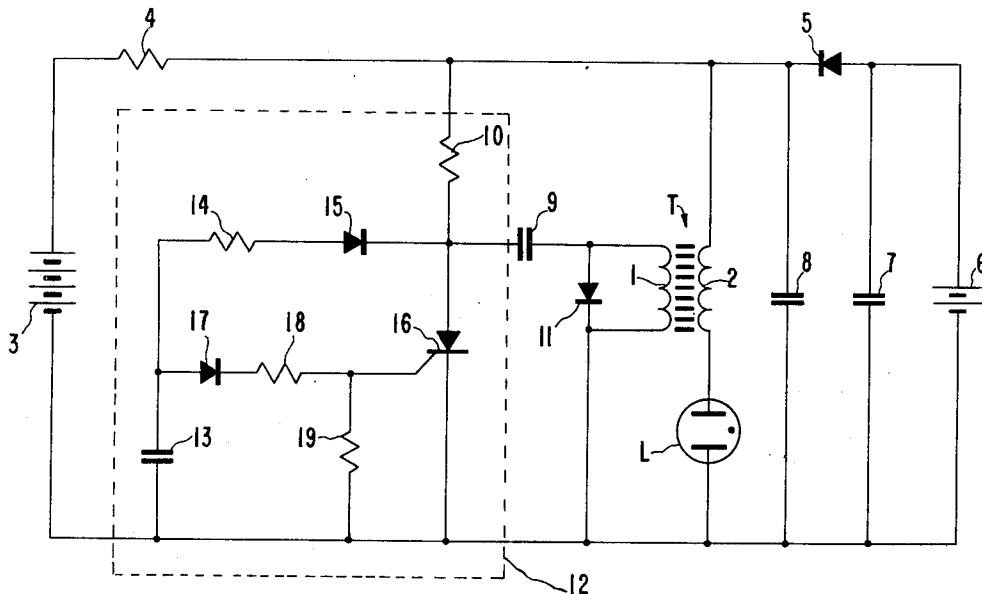
[54] **STARTING AND OPERATING CIRCUIT FOR GAS DISCHARGE LAMPS**  
**9 Claims, 1 Drawing Fig.**

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[56] **References Cited**  
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**ABSTRACT:** A circuit for starting a gas discharge lamp connected across a high voltage direct current source. The circuit comprises a saturable core transformer having primary windings connected in parallel with the lamp, and secondary windings connected in series therewith. A capacitor is connected in series with the primary winding. Switching means are provided for discharging the capacitor through the transformer to breakdown gas in the lamp. Another capacitor is connected across the serially connected secondary windings and lamp to provide a starting current through the lamp once it has become conductive.

An operating circuit is also disclosed comprising a low voltage direct current source connected in parallel with the lamp across the high voltage source with like terminals of the two sources coupled together.





## STARTING AND OPERATING CIRCUIT FOR GAS DISCHARGE LAMPS

### BACKGROUND OF THE INVENTION

This invention relates generally to power supply circuits for gas discharge lamps, and particularly to circuits for starting and operating high intensity short arc lamps.

High intensity short arc lamps typically comprise two electrodes spaced-apart some 4 to 10 mm. from each other to form an arc gap therebetween. The arc gap is located in vacuumtight envelope which confines an ionizable gas under pressure. To ionize the gas and break down the gap required the impression of high voltage thereacross, such as in the range of 5 to 30 KV. Once breakdown occurs, however, the arc gap impedance drops from infinity to a low value such as in the order of a few ohms. At this point only a relatively low voltage is required to cause sufficient current to flow across the arc gap to flash the lamp or to produce continuous luminescence. The ultimate goal thus is to provide a power supply which most efficiently delivers these required voltages to the lamp.

Heretofore power supplies for gas discharge lamps have most frequently employed a spark gap to generate a high voltage, radio frequency pulse in breaking down the lamp. Representative examples of such are disclosed in U.S. Pat. Nos. 3,189,789, 3,250,953 and 3,323,015. Though capable of delivering a large quantity of pulse energy, such pulse of radio frequency. This often creates electromagnetic interferences and interface problems between the lamp and power supply. Too fast a pulse rise time, for example, may lead to excessive voltage buildup between conductive elements of the lamps other than the starting electrodes. This may in turn lead to internal arcing between the anode and reflector or between external envelope members. Furthermore, the repeated impression of high voltage RF energy between the cathode and anode rapidly causes them to erode.

It therefore is a general object of the present invention to provide an improved circuit for starting a gas discharge lamp, and to provide improved, combined circuits for both starting and operating such lamps.

Another object of the invention is to provide a starting circuit for a gas discharge lamp which does not require the use of RF energy.

Another object of the invention is to provide a starting and operating circuit for a gas discharge lamp which exclusively utilizes solid state components.

Yet another object of the invention is to provide a starting circuit for a gas discharge lamp utilizing only direct current voltage sources.

### SUMMARY OF THE INVENTION

Briefly described, the present invention is a starting and operating circuit for a gas discharge lamp. The starting circuit comprises a high voltage direct current source, a first capacitor connected across the source, a second capacitor, and a transformer having primary windings serially connected to the second capacitor, and secondary windings serially connected through the lamp across the high voltage source. Switching means are provided for connecting the serially connected second capacitor and primary windings across the high voltage source to charge the second capacitor, and for connecting the second capacitor across the primary windings to discharge the second capacitor through the primary windings without discharging the first capacitor other than through the lamp. The operating circuit comprises a low voltage direct current source connected in parallel with the lamp across the high voltage source with like terminals of the sources coupled together. Means are also incorporated to prevent the high voltage source from charging the low voltage source.

### BRIEF DESCRIPTION OF THE DRAWING

The drawing is a schematic diagram of the preferred embodiment of the present invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawing, there is schematically illustrated a high intensity short arc lamp L such as the 150X8P xenon short arc lamp sold by the Eimac Division of Varian Associates. The cathode of lamp L is connected to the negative terminal of high voltage battery 3 whereas the lamp anode is connected to the positive terminal of the high voltage battery through rate limiting resistor 4 and secondary coil 2 of saturable core transformer T. The lamp anode is also connected through diode 5 to the positive terminal of low voltage battery 6 which has its negative terminal connected to the negative terminal of high voltage battery 3. If required a small ballasting resistor, now shown, having a value such as 1 ohm, may be placed in series with battery 6 and lamp L. The battery prefixes "high voltage" and "low voltage" are intended in this application merely to denote relative source strengths and not quantitative values or ranges of values.

Capacitor 7 is connected across low voltage battery 6. Capacitor 8 is connected across high voltage battery 3 in series with resistor 4. Primary coil 1 of transform T is connected in parallel with lamp L with one terminal of coil 1 connected to the negative battery terminals and the other coil terminal connected to the positive battery terminals through capacitor 9 and switching means 12. Diode 11 is connected across coil 1.

Switching means 12 are incorporated into the circuit for discharging capacitor 9 through transformer T. The switching means comprises capacitor 13, resistor 14, zener diode 15 and resistor 10 serially connected across battery 3. Silicon controlled rectifier 16 connects the negative terminal of battery 3 with the connection joining resistor 10 with diode 15. A trigger circuit, comprising four-layer switching diode 17 and resistor 18, connects the gate of rectifier 16 with capacitor 13. Resistor 19 provides a DC path between the gate to ground and the the cathode of lamp L.

When DC voltage is applied from high voltage battery 3, capacitors 8 and 9 charge. When the voltage across capacitor 9 reaches the breakdown voltage of zener diode 15, capacitor 13 charges. When the voltage across capacitor 13 reaches the breakdown voltage of switching diode 17, a trigger voltage is applied to silicon controlled rectifier 16 which goes into conduction and discharges capacitor 9 through primary coil 1 of transformer T. The just described solid state switching means for discharging capacitor 9, as outlined by block 12, is conventional. There are, of course, other well-known switching circuits which could be substituted, if desired.

The discharge of capacitor 9 through coil 1 induces a voltage across coil 2 and lamp L sufficient to ionize gas within the gap between the cathode and anode of the lamp. With the arc gap ionized, lamp L goes into conduction thereby closing the loop consisting of lamp L, secondary coil 2 and capacitor 8. The closing of this loop causes capacitor 8 to discharge through coil 2 and the lamp. Resistor 10 prevents this discharge from passing through switching means 12 itself.

During the time capacitor 8 takes to discharge, sufficient current flows through lamp L to maintain the lamp gas in an ionized state. This will be seen by carefully noting that during this time the polarity of voltage across coil 2 has reversed from that initially induced by the discharge of capacitor 9 through coil 1. This reversal in polarity causes the magnetic flux in transformer T to likewise reverse. Though current flow in coil 2 is limited by its inductance, such current flow is enhanced by that induced by current in primary coil 1 through diode 11 which has been made conductive by this polarity reversal. Though the voltage induced across coil 1 by charged capacitor 8 is greatly stepped down through transformer T, the lack of significant impedance in the coil 1-diode 11 closed loop

nevertheless causes substantial current to flow in coil 1. As the core approaches saturation, the inductance of transformer T drops, thereby enabling the current in the coils to increase rapidly. This is of significant benefit when the lamp is operated in a flashing mode.

The just described sequence prevents the transient flow of current through lamp L, provided by the discharge of capacitor 8, from falling below that required to maintain the gas therein ionized. Thus the lamp maintains its conductive state until transformer T saturates at which time the current in lamp L becomes a function of the nominal inductance of coil 2 saturated, and the capacitance of capacitor 8. When the voltage across capacitor 8 drops below that across capacitor 7, diode 5 goes into conduction allowing current to flow therethrough from low voltage battery 6 through coil 2 saturated and lamp L. With this, the lamp goes into continuous conduction. Where the lamp is to be operated in a pulse mode rather than continuously, low voltage diode 5, battery 6 and capacitor 7 may be removed from the circuit.

The actual value of components used in the just described embodiment are given below in Table I:

TABLE I

| Capacitors:         | Value in microfarads      |
|---------------------|---------------------------|
| 7.....              | 5,000.                    |
| 8.....              | 20.                       |
| 9.....              | 4.                        |
| 13.....             | 0.47.                     |
| Resistors:          | Value in thousand ohms    |
| 4.....              | 25.                       |
| 10.....             | 2.2.                      |
| 14.....             | 470.                      |
| 18.....             | .0047.                    |
| 19.....             | 1.                        |
| Batteries:          | Value in volts            |
| 3.....              | 300.                      |
| 6.....              | 30.                       |
| Diodes:             | Type                      |
| 5.....              | IN 1189.                  |
| 11.....             | IN 1203.                  |
| 15.....             | Sarkes Tarzians VR 130.   |
| 16.....             | Motorola MCR 1718-5.      |
| 17.....             | Motorola M4L 3054.        |
| Lamp: L.....        | Type                      |
|                     | Varian Associates 150X8P. |
| Transformer: T..... | Value in Turns            |
|                     | 50-1.                     |

It should be understood that the above-described embodiments are merely illustrative of application of the principals of the invention. Obviously, many modifications may be made in the preferred embodiment without departing from the spirit and scope of the invention as set forth in the following claims:

I claim:

1. A starting circuit for a gas discharge lamp comprising:

A. a high voltage direct current source;

B. a first capacitor connected across said high voltage source;

C. a second capacitor;

D. a transformer having primary windings serially connected to said second capacitor, and secondary windings serially connected to the lamp, said serially connected to

secondary windings and lamp being connected across said high voltage source;

E. switching means connecting said serially connected second capacitor and primary windings across said high voltage source to charge said second capacitor, said means being adapted to connect said second capacitor across said primary windings to discharge said second capacitor through said primary windings, and prevent said first capacitor from discharging through the switch itself prior to discharging through the lamp; and

F. a diode connected across said primary windings.

2. A starting circuit in accordance with claim 1 wherein said switching means comprises a silicon controlled rectifier connected across said serially connected capacitor and primary windings.

3. A starting circuit in accordance with claim 1 wherein said switching means comprises a resistor to prevent said first capacitor from discharging through the switch itself prior to discharging through the lamp.

4. A starting circuit in accordance with claim 1 wherein said transformer has a saturable core.

5. A starting and operating circuit for gas discharge lamp having a starting circuit in accordance with claim 1 combined with an operating circuit for said lamp, said lamp operating circuit comprising:

G. a low voltage direct current source connected in parallel with said lamp and said high voltage direct current source with like terminals of the voltage sources coupled together; said starting and operating circuit further comprising;

H. means to prevent said high voltage direct current source from charging said low voltage direct current source.

6. A starting and operating circuit in accordance with claim 5 wherein said charge preventing means is a diode.

7. A starting and operating circuit in accordance with claim 5 further comprising a third capacitor connected in parallel with said high and low voltage direct current sources with said charge preventing means in series with said third capacitor and said high voltage directed current source.

8. A starting and operating circuit in accordance with claim 5 wherein said lamp operating circuit further comprises:

I. a capacitor connected in parallel with said low voltage direct current and said lamp.

9. Improved circuitry for providing a stepped-up voltage from a high voltage source of direct current across a gas discharge lamp sufficient to ionize the gas therein, and for providing sufficient current through the lamp following said ionization to cause the lamp to flash, said circuitry comprising:

A. a step-up transformer having a saturable core and primary windings connected across said high voltage source through first energy storage means, and secondary windings connected across said high voltage source through said lamp;

B. means for discharging energy stored in said first energy storage means through said primary windings to induce a stepped-up voltage across said serially connected secondary windings and lamp to ionize gas in the lamp and thereby make the lamp conductive, said energy discharging means providing a portion of the connection of said primary windings across said high voltage source; and

C. second energy storage means connected across said high voltage source to store energy for discharge through the lamp when gas therein has been ionized.