

Dec. 1, 1970

HANS-JÜRGEN FÄHRNICH

3,544,839

APPARATUS FOR STARTING AND OPERATING ELECTRIC DISCHARGE
LAMPS, MORE PARTICULARLY SUCH LAMPS WITH STARTING
VOLTAGES EXCEEDING 1000 VOLTS

Filed Oct. 11, 1968

2 Sheets-Sheet 1

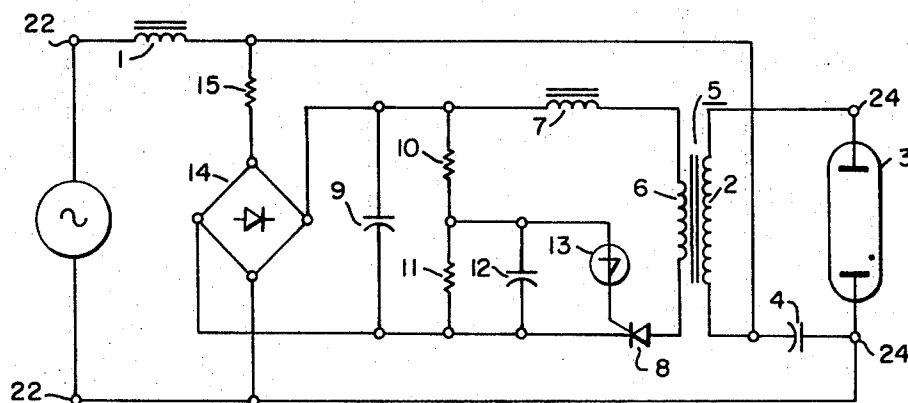


FIG. 1.

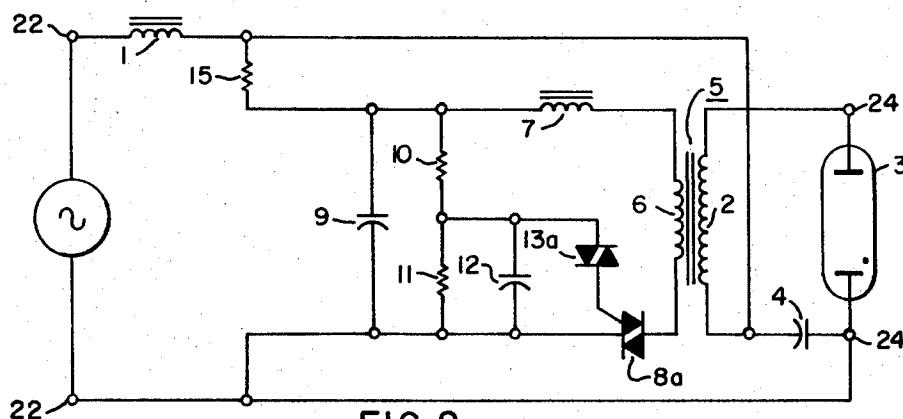


FIG. 2.

WITNESSES:

Bernard R. Giequy
James F. Young

INVENTOR
Hans-Jürgen Fährnich

BY *W. D. Palmer*
ATTORNEY

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2 Sheets-Sheet 2

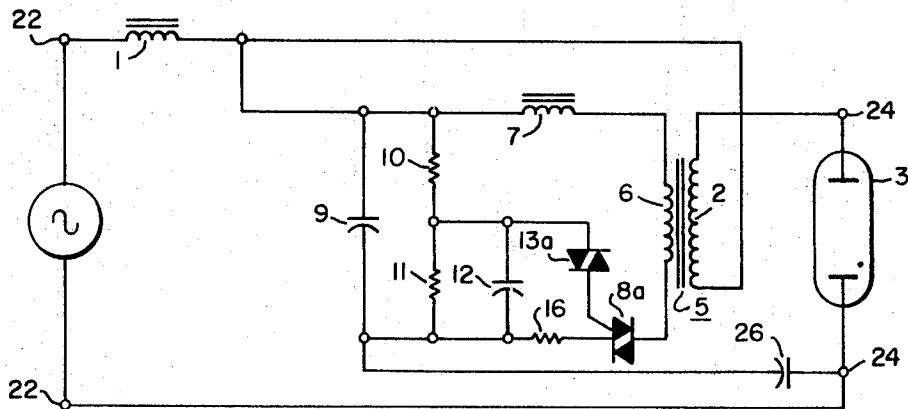


FIG. 3.

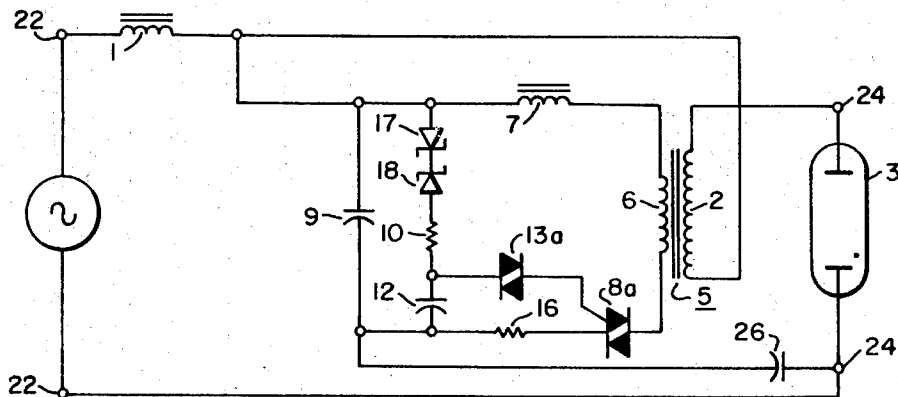


FIG. 4.

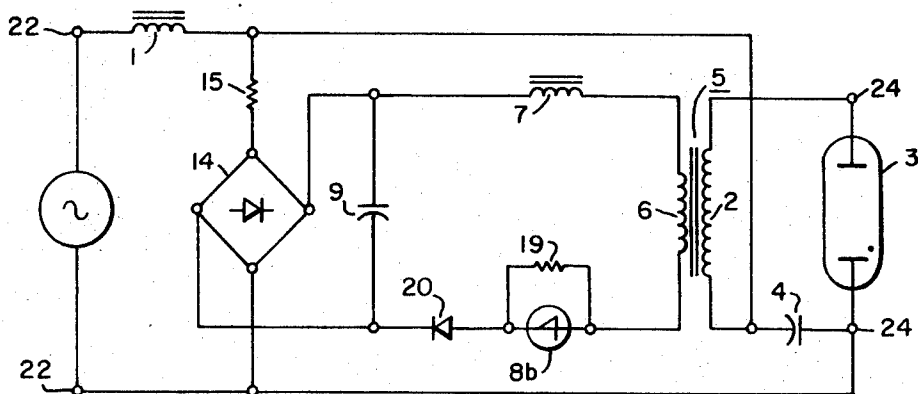


FIG. 5.

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APPARATUS FOR STARTING AND OPERATING ELECTRIC DISCHARGE LAMPS, MORE PARTICULARLY SUCH LAMPS WITH STARTING VOLTAGES EXCEEDING 1000 VOLTS

Hans-Jürgen Fährich, Munich, Germany, assignor to Patent-Treuhand-Gesellschaft für Elektrische Glühlampen m.b.H., Munich, Germany

Filed Oct. 11, 1968, Ser. No. 766,728

Claims priority, application Germany, Oct. 19, 1967, 1,589,306

Int. Cl. H05b 37/00, 39/00

U.S. Cl. 315—200

6 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for operating high-pressure vapor lamps having a high starting voltage comprises an inductive ballast connected in series with the secondary winding of a high frequency transformer. During starting of the lamp, a pulse generating circuit applies high voltage pulses across the lamp and after the lamp is operational, the pulse generating circuit does not operate.

The subject matter of the invention is an apparatus for starting and operating electric discharge lamps, more particularly A.C. energized high pressure and super-high-pressure lamps with a gas or vapor filling, such as high pressure sodium or mercury vapor lamps with or without additives, with a starting voltage exceeding 1000 volts.

BACKGROUND OF THE INVENTION

In a known apparatus generally of this kind as disclosed in U.S. patent specification 3,310,687, an HF transformer is provided in an HF oscillator circuit including the discharge lamp, and said discharge lamp is arranged in series with the secondary winding of the HF transformer and with the inductive ballast, and the primary winding therein is disposed in a pulse generating circuit which includes at least one starting capacitor and one controlled semiconductor which is controlled by a control circuit.

The circuitry therein is such that components of the pulse generating circuit also form part of the operating circuit. However, this can be undesirable. For example, if the controlled semiconductor of the pulse generating circuit of this prior-art apparatus is included in the operating circuit, then said semiconductor must be rated for the operating current, or additional adjusting means must be provided which render the apparatus more complex and increase the costs thereof. Moreover, the starting apparatus does not switch off subsequent to ignition since if it did, flow of lamp current could not continue.

If the controlled semiconductor of the pulse generating circuit is not provided in the operating circuit but as is additionally also proposed in the indicated shunt connection of the lamp, then there is presented the danger that subsequent to ignition of the lamp the semiconductor may not be closed quickly enough to prevent its shunt effect which in turn could lead to short-circuit of the lamp or at least to arrest the operation of the lamp.

SUMMARY OF THE INVENTION

It is the object of the present invention to overcome the disadvantages of the known apparatus and to provide an apparatus for starting and operating an electric discharge lamp wherein the reliable initiation of the ignition apparatus is achieved at about 80% of the nominal supply voltage, and a reliable disconnection of the ignition apparatus is ensured at about 130% of the nominal operating voltage of the lamp.

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In accordance with the invention this is achieved with an apparatus for starting and operating an electric discharge lamp having a starting voltage which exceeds 1000 volts by designing the control circuit as a bridge control circuitry supplied by the pulse generating circuit, wherein at least one partial branch of said circuitry comprises at least one component, more particularly the semiconductor of the pulse generating circuit, and wherein the control component is included in the branch of the bridge circuit, and at least one component of the pulse generating circuit otherwise separate from the lamp power supply is included in the by-pass circuitry of the discharge lamp, whereby at least one resistor and/or one capacitor is arranged in the by-pass circuit branch, and the pulse generating circuit and the bridge control circuitry are so dimensioned that subsequent to ignition, when changing to lamp operation, both the pulse generating circuit and the bridge control circuitry may automatically be disconnected.

By designing the pulse generating circuit in combination with the bridge control circuitry substantially separate from the power supply, all disadvantages of known circuit arrangements for the controlled semiconductor are avoided and, in addition, this is achieved by suitably dimensioning the individual components, to ensure a perfect functioning and a reliable disconnection of the whole ignition apparatus.

The structure of the bridge control circuitry, the pulse generating circuit, and the by-pass circuit branch may vary within wide limits. For example, the branch of the bridge control circuitry including the semiconductor switch may comprise, apart from the components of the pulse generating circuit, namely, the primary winding and the choke, an additional resistor and possibly, also a pair of bi-directionally connected Zener diodes, while the other branch includes only one resistor with shunt capacitor, or two resistors, or possibly one damping resistor and one capacitor. In this case unilaterally or bilaterally switching trigger diodes are arranged in the bridge circuit in compliance with the selected semiconductor switch.

In one example of automatic control, the bridge control circuitry may even be reduced to a single component, namely, the semiconductor. As a component of the pulse generating circuit for the lamp by-pass circuitry, a surge capacitor is particularly suitable wherein either a load resistor or a further capacitor such as, for example, even the HF short-circuit capacitor is series-connected to said capacitor.

The assembly of the inventive apparatus is suitably performed in such manner that the components of the HF circuit, of the pulse generating circuit, as well as of the bridge control circuitry and the by-pass circuit branch constitute one unit which is at least partially embedded in synthetic resin or silicone rubber by casting. On the other hand it might be of special advantage for utilization of the inventive apparatus to assemble the components of the pulse generating circuit without the primary winding with the bridge control circuitry and the by-pass circuit branch into one unit, since said unit may then be exchangeably coupled or decoupled, respectively, to the power supply and to the primary winding of the HF transformer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a circuit diagram of one embodiment of the present apparatus wherein a bridge and a unilateral switch are utilized in the pulse generating circuit;

FIG. 2 is a circuit diagram of an alternative embodiment wherein a bilateral switch is used in the pulse generating circuit;

FIG. 3 is a circuit diagram of yet another alternative embodiment which generally corresponds to FIG. 2 ex-

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cept that the circuit connection for the pulse generating circuit is modified;

FIG. 4 is a circuit diagram of still another alternative embodiment wherein the pulse generating circuit is modified and incorporates Zener diodes as a part of the control; and

FIG. 5 is a circuit diagram of a further alternative embodiment wherein the pulse generating circuit is simplified.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention has been illustrated and described by way of example in the schematic circuit diagrams 1-5.

In FIG. 1, the numeral 3 designates a high pressure or super-high-pressure discharge lamp with a gas or vapor filling, such as a high pressure sodium or mercury vapor lamp, for example, a 400 w. high pressure sodium vapor lamp which, with a supply voltage of approx. 220 v., has an operating voltage of approx. 105 v. and an operating current of about 4 amps, whereas an incipient current flow of about 6 amps is required for approx. 3 minutes. The discharge lamp 3 is disposed in an HF oscillator circuit operated from HF transformer 5; the ignition voltage is about 1-5 kilovolts with approx. 100 kilocycles and about 1 . . . 5 sparks per half cycle of the power supply.

In this arrangement the discharge lamp 3 is in series with choke 1 and secondary winding 2, and the series connection of secondary winding 2 and lamp 3 is parallel to the short-circuit capacitor 4 which has a capacitance of 0.05 . . . 0.25 μ f.

On the primary side of transformer 5, a pulse generating circuit is provided comprising primary winding 6, choke 7, semiconductor switch 8, and surge capacitor 9. A thyristor is included as semiconductor switch 8. The surge capacitor 9 has a capacitance of 0.1 μ f. (0.1 . . . 0.25 μ f.) and is suited for higher impulse currents. Choke 7 is a choke with ferrite core having an inductance which in conjunction with the surge capacitor yields a frequency of about 100 kilocycles. A bridge control circuitry comprises in one of its branches apart from the components forming part of the pulse generating circuit, namely, the thyristor 8, the primary winding 6, the choke 7, in addition the resistor 10, while the other branch includes the resistor 11 with capacitor 12 in shunt connection. Semiconductor 13 is arranged in the bridge and constitutes a unilaterally switching trigger diode across which the capacitor discharges with about 50 nf. at the moment of trigger of the thyristor. The moment of trigger is determined by the voltage divider formed by the two resistors 10, 11. The order of magnitude of the resistors is about 100-200 kilo-ohms.

The surge capacitor 9 constitutes here a component of the pulse generating circuit otherwise separate from the lamp power supply, and is arranged in the by-pass circuitry of the discharge lamp and connected to the bridge rectifier 14 to which a load resistance 15 of about 10 kilo-ohms is series-connected.

FIG. 2 shows as circuit diagram a similar starting and operating apparatus. However, instead of unilaterally switching semiconductor switches there are used bi-laterally switching semiconductor switches 8a. For modulation there is accordingly also applied a bilaterally switching trigger diode 13a. The bridge rectifier 14 of FIG. 1 is omitted.

The circuitry of FIG. 3 conforms to that of FIG. 2. However, in this case the load resistor 15 has been omitted and was replaced by the HF short-circuit capacitor 26 as a series capacitor for the surge capacitor 9 in the by-pass circuit. Since this constitutes a capacitive voltage divider, a capacitance of about 0.2 μ f. will have to be selected in case of an impulse capacitance of 0.1 μ f. for the HF short-circuit capacitor 26. Due to the low-ohmic connection of the primary circuit for higher frequencies it

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is additionally necessary to provide a damping resistance 16 of about 6 ohms.

FIG. 4 shows a further circuitry resembling that of FIG. 3 but wherein the bridge control circuitry for the semiconductor switch has been changed. Resistor 11 is omitted and only capacitor 12 is maintained while a pair of bi-directionally connected Zener diodes 17, 18 have been inserted in the other branch with a Zener voltage of about 180 volts. The resistor 16 has about 5 kilo-ohms.

FIG. 5 shows a circuitry for starting and operating discharge lamps wherein the whole bridge circuitry has been reduced to a single component, namely, the semiconductor switch 8. The semiconductor switch is in this case a four-layer diode automatically switching at about 200 volts. To increase the blocking voltage, a silicon diode 20 is series-connected to said automatically switching four-layer diode, and a resistor 19 is shunted thereto. A load of the four-layer diode in blocking direction is avoided by the structural components 19 and 20. Alternately, the diode 20 may be connected antiparallel to the four-layer diode in which case the resistor 19 may be omitted. The by-pass circuit branch conforms entirely to that of the circuitry of FIG. 1.

Common to all inventive circuit arrangements is that the sparks occur in both half cycles of the power supply and each starting voltage impulse is a damped oscillation. In the circuit arrangements of FIGS. 3 and 4, the HF pulse is followed by an audio-frequency oscillation due to the capacitive voltage divider facilitating ignition of the lamp. The circuit arrangement of FIG. 4 is advantageous in case audio-frequency oscillations with larger amplitudes occur in the low ohmic connection illustrated in the circuit arrangement of FIG. 3.

It is self-evident that a great number of further variations may be disclosed within the scope of the inventive combination of control bridge circuitry, pulse generating circuit and by-pass circuit branch. For example, resistors and capacitors may commonly be connected in series or interconnected; moreover, both the primary winding and the secondary winding of the HF transformer may be included as autotransformer windings in the by-pass circuit.

Upon assembly of the inventive apparatus, care should be taken that the components of the HF circuit together with the pulse generating circuit, and the bridge control circuitry, as well as the by-pass circuit branch, form one unit and are at least partially embedded in synthetic resin or silicone rubber by casting.

For utilization of the inventive apparatus it might on the other hand be of special advantage to assemble the components of the pulse generating circuit without the primary winding, with the bridge control circuitry and the by-pass circuit branch into one unit, since said unit in case of need may exchangeably be coupled and decoupled, respectively, to the power supply and to the primary winding of the HF transformer.

All circuits are provided with input terminals 22 adapted to be connected to the A.C. source and output terminals 24 across which the lamp 3 is connected.

I claim as my invention:

1. An apparatus for starting and operating electric discharge lamps, particularly A.C.-energized high pressure and super-high-pressure lamps with a gas or vapor filling, such as high pressure sodium or mercury vapor discharge lamps, and with a starting voltage exceeding 1000 volts, said apparatus comprising:

- (a) input terminals adapted to be connected to a source of A.C. energizing potential, and output terminals connected to a discharge lamp;
- (b) inductive ballast means having one side thereof connected to one of said input terminals;
- (c) a high-frequency transformer forming a part of a pulse generating circuit and having a primary winding and a secondary winding, one side of said secondary winding of said high-frequency transformer connected to the other side of said inductive ballast

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means, the other side of said secondary winding of said high-frequency transformer connected to one of said output terminals, the other of said output terminals connected to the other of said input terminals, and a high-frequency by pass-capacitor connected across said one side of the secondary winding of said high-frequency transformer and said other of said output terminals; and

(d) a high-frequency pulse generating circuit having an input connected across said other side of said inductive ballast means and said other output terminal, said pulse generating circuit comprising:

- (1) said primary winding of said high-frequency transformer,
- (2) a choke connected in series with said primary winding of said high-frequency transformer,
- (3) a primary semiconductor switching means having an output terminal connected in series with said primary winding of said high-frequency transformer, and
- (4) a voltage-responsive triggering circuit having an input connected across the other side of said inductive ballast means and said other output terminal, said triggering circuit also connected to said series-connected choke and said primary winding and to the input terminal of said primary semiconductor switching means, said voltage-responsive triggering circuit having an output lead connecting to said primary semiconductor switching means to control the switching thereof, the voltage developed at the input of said triggering circuit being sufficient to actuate same to generate triggering pulses for actuating said primary semiconductor switching means and generate lamp starting pulses to initiate operation of said lamp, and the voltage developed across the input of said triggering circuit being insufficient to actuate said triggering circuit after operation of said lamp is initiated.

2. The apparatus as specified in claim 1, wherein said primary semiconductor switching means is gate controlled, and said triggering circuit comprises: a rectifier bridge and a resistor connected in series across the input thereof, a surge capacitor and two series-connected resistors connected in parallel across the output of said rectifier bridge, a unilaterally switching diode connected between the midpoint of said series-connected resistors and the gate of said primary semiconductor switching means, and a capacitor connected between the midpoint of said series-connected resistors and the input to said semiconductor means.

3. The apparatus as specified in claim 1, wherein said primary semiconductor switching means is an A.C. switch and is gate controlled, and said triggering circuit comprises: a resistor and series-connected capacitor connected across the input thereof, a pair of resistors connected in

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series across said series-connected capacitor, a surge capacitor connected in parallel with said series-connected resistors, a bilateral diode means having an input connected to the midpoint of said series-connected resistors and an output connected to the gate of said primary semiconductor switching means, and a capacitor connected between the midpoint of said series-connected resistors and the input terminal of said primary semiconductor switching means.

4. The apparatus as specified in claim 1 wherein said primary semiconductor switching means is an A.C. switch and is gate controlled, and said triggering circuit comprises: surge capacitor connected in series with said high-frequency by-pass capacitor, a pair of resistors connected in series across said surge capacitor a bilateral diode means having an input connected to the midpoint of said series-connected resistors and an output connected to the gate of said primary semiconductor switching means, and a capacitor connected between the midpoint of said series-connected resistors and the input terminal of said A.C. switching means through an additional resistor.

5. The apparatus as specified in claim 1, wherein said primary semiconductor switching means is an A.C. switch and is gate controlled, and said triggering circuit comprises: a surge capacitor connected in series with said high-frequency by-pass capacitor, a pair of bi-directionally connected Zener diodes together with a shunting resistor and a shunting capacitor connected in series in the respective named order across said surge capacitor, a bilateral diode means having an input terminal connected between said shunting resistor and said shunting capacitor and an output terminal connected to the gate of said primary semiconductor switching means, and an additional resistor connected between said shunting capacitor and the input terminal of said primary semiconductor switching means.

6. The apparatus as specified in claim 1, wherein said triggering circuit comprises: a resistor and series-connected rectifying bridge connected across the input thereof, a surge capacitor connected across the output of said rectifying bridge, one side of said surge capacitor connected to said choke, the other side of said surge capacitor connected through a diode to the input terminal of said primary semiconductor switching means, and a resistor shunting said primary semiconductor switching means.

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JOHN W. HUCKERT, Primary Examiner

R. F. POLISSACK, Assistant Examiner

U.S. Cl. X.R.

315—174, 206, 246, 241, 242