United States Patent [19]

Williams

[11] **3,710,184**

[45] **Jan. 9, 1973**

[54] **CIRCUIT ARRANGEMENTS FOR OPERATING ELECTRIC DISCHARGE LAMPS**

[75] Inventor: **Charles Edington Williams**, Stanmore, England

[73] Assignee: **The General Electric Company Limited**, London, England

[22] Filed: **Oct. 22, 1970**

[21] Appl. No.: **82,957**

[30] **Foreign Application Priority Data**

Oct. 30, 1969 Great Britain.....53,305/69

[52] **U.S. Cl.**.....**315/227**, 315/DIG. 5

[51] **Int. Cl.**.....**H05b 37/00**

[58] **Field of Search**.....315/100 U, 207, 227

[56] **References Cited**

UNITED STATES PATENTS

2,130,077 9/1938 Dorgelo.....315/207

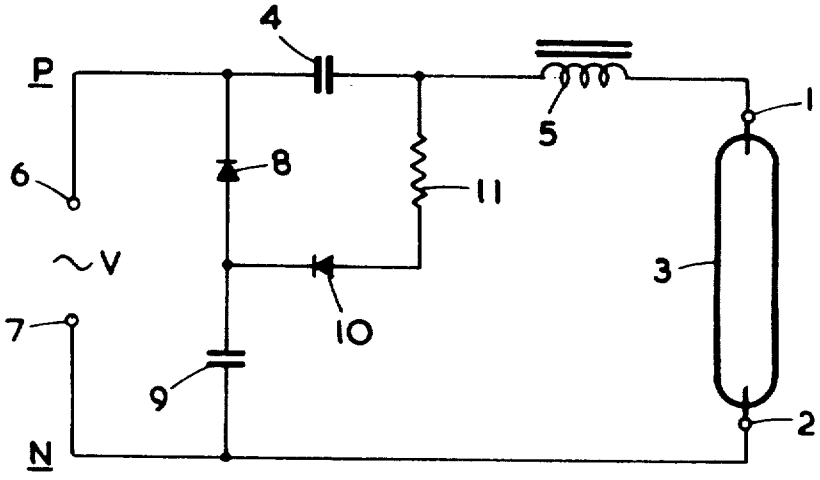
2,575,001 11/1951 Bird.....315/207

Primary Examiner—Roy Lake
Assistant Examiner—Lawrence J. Dahl
Attorney—Kirschstein, Kirschstein, Ottinger & Frank

[57] **ABSTRACT**

A starting circuit arrangement for an electric discharge lamp has a capacitive ballast connected in series with the lamp terminals and the A.C. supply terminals. A charging circuit, which includes one or more diodes, charges the capacitive ballast to twice (or more than twice) the peak voltage of the supply so that three times (or more than three times) the supply voltage is available to start the lamp. In one embodiment the capacitive ballast is divided into two equal parts, each connected to one lamp terminal and each charged to twice the peak voltage of the supply by an associated diode charging circuit, so that five times the peak voltage of the supply is available across the lamp terminals.

10 Claims, 8 Drawing Figures



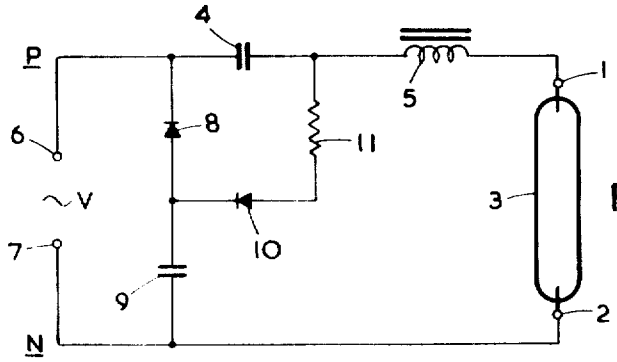


FIG. 1

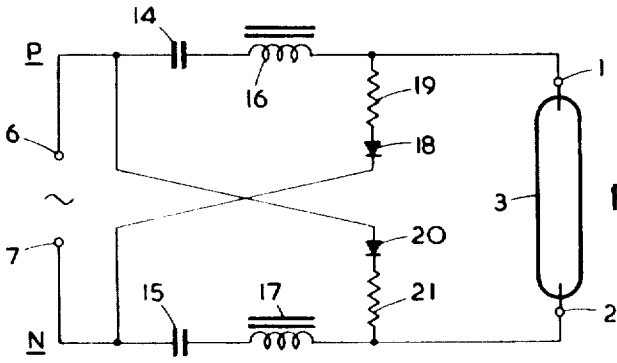


FIG. 2

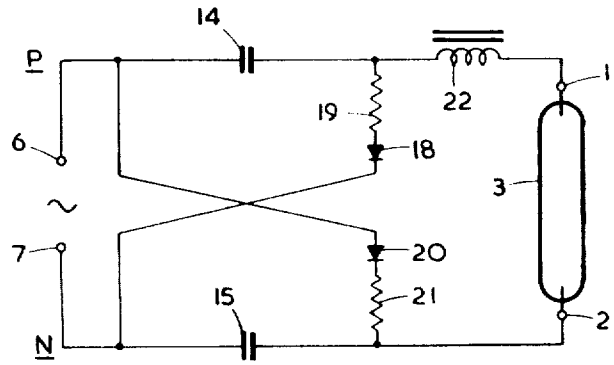


FIG. 3

INVENTOR
CHARLES EDINGTON WILLIAMS
BY
ATTORNEYS

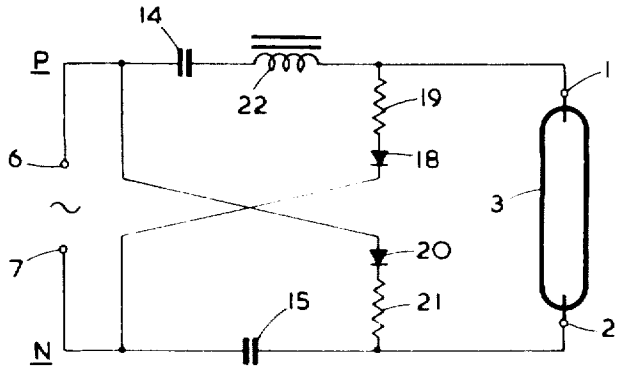


FIG.4

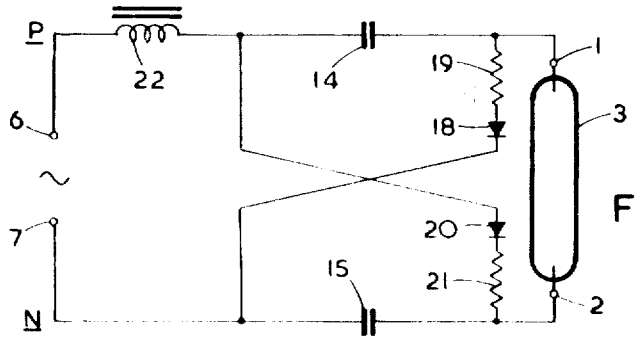


FIG.5

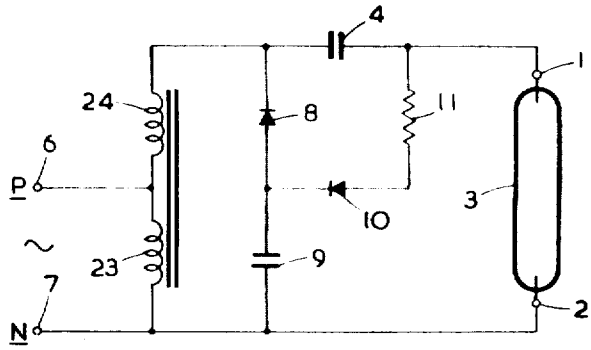


FIG.6

INVENTOR
CHARLES EDINGTON WILLIAMS
BY
ATTORNEYS

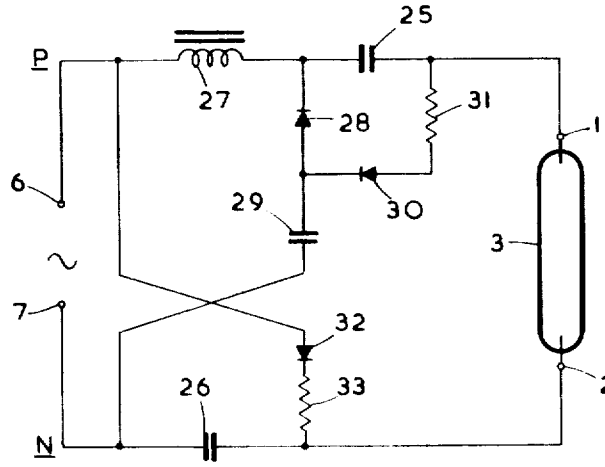


FIG.7

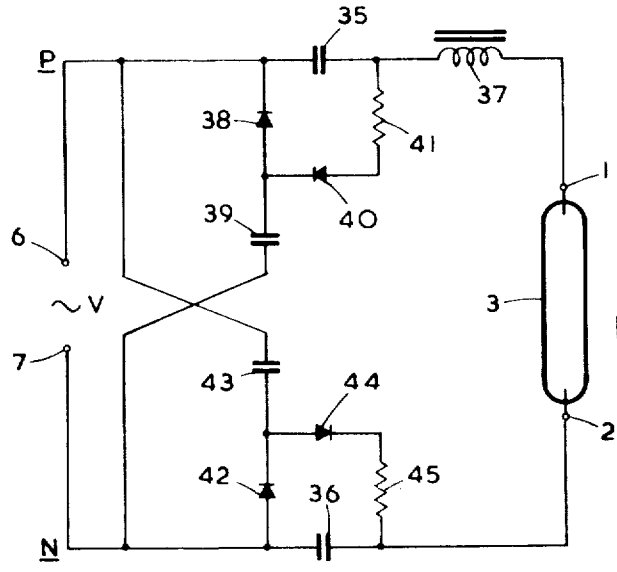


FIG.8

INVENTOR
CHARLES EDINGTON WILLIAMS
BY
ATTORNEYS

CIRCUIT ARRANGEMENTS FOR OPERATING ELECTRIC DISCHARGE LAMPS

This invention relates to circuit arrangement for starting and operating an electric discharge lamp from an alternating current supply, and has an important application to the starting and operating of a low pressure mercury vapor discharge lamp from an alternating current supply of 50 Hz or 60 Hz.

According to the present invention a circuit arrangement for starting an electric discharge lamp from an alternating current supply includes a capacitive ballast connected in series with two lamp terminals between two input terminals for applying the supply voltage across the lamp terminals and the capacitive ballast, and a charging circuit including one or more non-linear circuit elements whereby the capacitive ballast can be charged to substantially twice (or more than twice), the peak voltage of the supply so that a voltage of substantially three times (or more than three times), the peak voltage of the supply can be made available across the lamp terminals to start a lamp.

The capacitive ballast may be divided into two parts each connected between an input terminal and a lamp terminal. Each of the two parts of the capacitive ballast may be provided with an individual charging circuit including a non-linear circuit element.

The circuit arrangement may include inductive ballast which may be provided by a winding of a leakage flux transformer.

In one circuit arrangement in accordance with the invention the capacitive ballast is divided into two substantially equal parts and one part is arranged to be charged to substantially twice the peak voltage of the supply while the second part is arranged to be charged to substantially the peak voltage of the supply, so that a voltage of substantially four times the peak voltage of the supply can be made available across the lamp terminals to start a lamp.

In another circuit arrangement in accordance with the invention the capacitive ballast is divided into two substantially equal parts both of which are arranged to be charged to substantially twice the peak voltage of the supply, so that a voltage of substantially five times the peak voltage of the supply can be made available across the lamp terminals to start a lamp.

When the capacitive ballast is divided into two parts the inductive ballast may be connected in series with one part, or, the inductive ballast may be similarly divided into two parts each connected in series with one part of the capacitive ballast.

The invention will now be described, by way of example, with reference to the drawings filed with the Provisional Specification in which:

FIGS. 1 to 8 are circuit diagrams of eight different circuit arrangements embodying the invention.

Referring in the first instance to FIG. 1, the circuit arrangement includes a pair of lamp terminals 1 and 2 between which a lamp 3 which is to be operated is connected. A ballast consisting of a capacitor 4 and a choke inductance 5 is connected in series with the lamp terminals 1 and 2 with respect to input terminals 6 and 7 which are intended to be connected to an alternating current supply in use of the arrangement to provide the operating current for the lamp. A series combination of a diode 8 and a capacitor 9 is connected across the input terminals 6 and 7 with the cathode of the diode 8 connected to input terminal 6, which constitutes the 'phase' terminal, and the capacitor connected to input terminal 7, which constitutes the 'neutral' terminal. A series combination of a diode 10 and a resistance 11 is is connected in parallel with the diode 8 and the capacitor 4, with the cathode of the diode 10 connected to the junction between the diode 8 and the capacitor 9 and with the resistance 11 connected to the junction between the inductance 5 and the capacitor 4.

In operation of the circuit arrangement of FIG. 1, before the lamp 3 starts, current from the supply flows through the diode 8 and charges capacitor 9 to the peak voltage V of the supply, so that a peak inverse voltage of 2V appears across diode 8. Consequently the ballast capacitor 4 is charged to a peak voltage 2V through the diode 10 and the resistance 11. The lamp terminal 1 is therefore held negative with respect to the phase input terminal 6 by a voltage of substantially 2V. These voltages assume negligible leakage across the capacitors 4 and 9. When the phase terminal 6 is at its maximum negative voltage, the lamp terminal 1 therefore attains a voltage which is substantially 3V negative with respect to the lamp terminal 2 and the lamp 3 lights. After ignition of the lamp 3, the circuit components diode 8, diode 10, capacitor 9 and resistor 11 no longer play an important part in the operation of the circuit arrangement. The resistance 11 is chosen to have a relatively high value so that the current flowing through the diode 10 which is in shunt with the lamp terminals 1 and 2 is small in comparison with the operating current flowing through the lamp 3. Assuming a supply voltage of 240 volts r.m.s. the voltage 3V would have a peak value of substantially 1020 volts which is effective in lighting many types of electric discharge lamp 3.

In one arrangement of the circuit shown in FIG. 1 for operating an 8 foot, 1½ inch diameter, fluorescent lamp from a 240 volt 50 Hz supply, details of the components of the circuit are as follows:

Capacitor 4	7.2 microfarads.
Capacitor 9	1 microfarad.
Inductor 5	0.56 henries.
Resistor 11	22 kilo-ohms.
Diode 8	680 volts, peak inverse voltage rating.

Referring now to FIG. 2, the circuit arrangement includes a pair of lamp terminals 1 and 2 between which is connected the lamp 3 which is to be operated. A ballast consisting of two capacitors 14 and 15 and two choke inductances 16 and 17 is connected in series with the lamp terminals 1 and 2 with respect to input terminals 6 and 7 of an alternating current supply of peak voltage V. The series combination of the capacitor 14 and the inductance 16 is between the phase input terminal 6 and the lamp terminal 1, and is substantially identical to the series combination of the capacitor 15 and the inductance 17, which is between the neutral input terminal 7 and the lamp terminal 2. The ballast is therefore divided into two substantially identical parts. A series combination of a diode 18 and a resistance 19 is connected between the neutral input terminal 7 and the lamp terminal 1, with the cathode of the diode connected to the neutral terminal 7 and the resistance connected to the lamp terminal 1. A similar

series combination of a diode 20 and a resistance 21 is connected between the phase input terminal 6 and the lamp terminal 2, with the anode of the diode connected to the phase terminal 6 and the resistance connected to the lamp terminal 2.

In operation of the circuit arrangement of FIG. 2, the two diodes 18 and 20 charge the two parts of the capacitive ballast formed by capacitors 14 and 15, so that before the lamp 3 starts, the lamp terminal 1 attains a negative voltage of 2V whilst the lamp terminal 2 attains a positive voltage of V. The total voltage across the lamp terminals 1 and 2 is therefore equal to 3V and causes the lamp 3 to light. After the lamp has started, the diodes 18 and 20 no longer play an important part in the operation of the circuit arrangement since the resistances 19 and 21, which have relatively high values, prevent the diodes from shunting the lamp 3 and providing an alternative path for the lamp operating current.

The subdivision of the inductive ballast into two parts is not essential, and as shown in FIGS. 3 and 4, a single choke inductance 22 may be used in conjunction with a capacitive ballast divided into two substantially equal parts constituted by capacitors 14 and 15.

With an arrangement having the capacitive ballast in two parts constituted by capacitors 14 and 15 it is not essential that the single choke inductance 22 should be connected between the capacitor 14 and the lamp terminal 1 as shown in FIGS. 3 and 4, and the single choke inductance 22 may be connected between the phase input terminal 6 and the capacitor 14 as shown in FIG. 5.

Moreover, it is not essential that the points in the circuit arrangement to which the series combinations formed by diodes 18 and 20 and resistances 19 and 21 are connected should be those shown in FIG. 2, and the points of connection may be varied as shown in FIGS. 3 and 4. All that is essential is that the components through which charging takes place should be connected on the lamp side of the capacitor being charged. It will be appreciated that the division of the capacitive impedance into two substantially equal parts does not alter the volume of active material involved in the capacitive ballast as a whole, assuming constant dielectric stress. Therefore, with the divided ballast each unit has a capacitance value twice that of the corresponding single unit, but needs a voltage rating of only half that of the corresponding single unit. The total stored energy, which is proportional to the dielectric volume if constant dielectric stress is maintained is for a single unit $\frac{1}{2}CE^2$ and for the divided units $2 \times \frac{1}{2}(2C(E)^2/(2))$ which is also $\frac{1}{2}CE^2$, where E is the peak value of the alternating voltage appearing across a single capacitor.

Turning now to FIG. 6, a primary winding 23 of a leakage flux transformer 24 is connected across the input terminals 6 and 7 of a circuit arrangement identical with FIG. 1, except that the choke inductance 5 has been omitted and the inductive ballst is provided by the secondary winding of the transformer. This circuit arrangement functions in a manner similar to that described with reference to FIG. 1 except the supply voltage is stepped up by the transformer 24 and therefore the arrangement is particularly suitable for operating high voltage discharge lamps. The circuit arrangements of FIGS. 2 to 5 may also be provided with leakage flux transformers, and the choke inductances omitted.

In the circuit arrangements so far described the starting voltage across the lamp terminals 1 and 2 is substantially three times the peak voltage V of the alternating current supply, but in certain circumstances this voltage 3V may not be sufficient to start the lamp. The circuit arrangements shown in FIGS. 7 and 8 provide starting voltages across the lamp terminals 1 and 2 in excess of three times the peak voltage V of the alternating current supply.

Referring to FIG. 7, the circuit arrangement includes a pair of lamp terminals 1 and 2 between which is connected a lamp 3 which is to be operated. A ballast consisting of two capacitors 25 and 26 and a choke inductance 27 is connected in series with the lamp terminals 1 and 2 with respect to input terminals 6 and 7 of an alternating current supply of peak voltage V. The series combination of the capacitor 25 and the inductance 27 is between the phase input terminal 6 and the lamp terminal 1, and the capacitor 26 is between the neutral input terminal 7 and the lamp input terminal 2. The capacitors 25 and 26 are of substantially equal values. A series combination of a diode 28 and a capacitor 29 is connected between the junction between the inductance 27 and the capacitor 25 and the neutral input terminal 7, with the cathode of the diode connected to the junction between the two components and the capacitor connected to input terminal 7. A series combination of a diode 30 and a resistance 31 is connected in parallel with the diode 28 and the capacitor 25, with the cathode of the diode 30 connected to the junction between the diode 28 and the capacitor 29 and with the resistance 31 connected to the capacitor 25. A series combination of a diode 32 and a resistance 33 is connected between the input terminal 6 and the lamp terminal 2 and with the anode of the diode 32 connected to the input terminal 6 and the resistance 33 connected to the lamp terminal 2.

In operation of the circuit arrangement of FIG. 7, before the lamp 3 starts, current from the supply flows through the diode 28 and charges the capacitor 29 to the peak value V of the supply, so that a peak inverse voltage of 2V appears across the diode 28. Consequently the ballast capacitor 25 is charged to a peak voltage 2V through the diode 30 and the resistance 31. The lamp terminal 1 is therefore held negative with respect to the phase input terminal 6 by a voltage of substantially 2V. At the same time, current from the supply flows through the diode 32 and charges the capacitor 26 to the peak voltage V of the supply. Therefore when the phase terminal 6 is at its maximum negative voltage, the lamp terminal 1 attains a voltage which is substantially 4V negative with respect to the lamp terminal 2 and the lamp 3 starts. After ignition of the lamp 3, the circuit components diode 28, capacitor 29, diode 30, resistance 31, diode 32 and resistance 33 no longer play an important part in the operation of the circuit arrangement. The resistances 31 and 33 are chosen to have relatively high values so that the currents flowing through the diodes 30 and 32 which are in shunt with the lamp terminals 1 and 2 are small compared with the operating current flowing through the lamp 3.

Turning finally to FIG. 8, the circuit arrangement includes a pair of lamp terminals 1 and 2 between which is connected a lamp 3 which is to be operated. A ballast consisting of two capacitors 35 and 36 and a choke inductance 37 is connected in series with the lamp terminals 1 and 2 with respect to input terminals 6 and 7 of an alternating current supply of peak voltage V. The series combination of the capacitor 35 and the inductance 37 is between the phase input terminal 6 and the lamp terminal 1, and the capacitor 36 is between the neutral input terminal 7 and the lamp terminal 2. The capacitors 35 and 36 are of substantially equal values. A series combination of a diode 38 and a capacitor 39 is connected across the input terminals 6 and 7 with the cathode of the diode 38 connected to the phase input terminal 6 and the capacitor connected to the neutral terminal 7. A series combination of a diode 40 and a resistance 41 is connected in parallel with the diode 38 and the capacitor 35, with the cathode of the diode 40 connected to the junction between the diode 38 and the capacitor 39, and with the resistance 41 connected to the junction between the capacitor 35 and the inductance 37. A series combination of a diode 42 and a capacitance 43 is connected across the input terminals 6 and 7 with the anode of the diode 42 connected to the neutral input terminal 7 and the capacitor 43 connected to the phase input terminal 6. A series combination of a diode 44 and a resistance 45 is connected in parallel with the diode 42 and the capacitor 36 with the anode of the diode 44 connected to the junction between the diode 42 and with the capacitor 43 and the resistance 45 connected to the lamp terminal 2.

In operation of the circuit arrangement of FIG. 8 before the lamp 3 starts, current from the supply flows through the diode 38 and charges the capacitor 39 to the peak voltage V of the supply voltage, so that a peak inverse voltage of 2V appears across the diode 38. Consequently the ballast capacitor 35 is charged to a peak voltage of 2V through the diode 40 and the resistance 41. The lamp terminal 1 is therefore held negative with respect to the phase input terminal 6 by a voltage of substantially 2V. At the same time current from the supply flows through the diode 42 and charges the capacitor 43 to the peak voltage V of the supply, so that a peak inverse voltage of 2V appears across the diode 42. Consequently the ballast capacitor 36 is charged to a peak voltage of 2V through the diode 44 and the resistance 45. The lamp terminal 2 is therefore held positive with respect to the neutral input terminal 7 by a voltage of substantially 2V. Therefore when the phase terminal is at its maximum negative voltage, the lamp terminal 1 attains a voltage which is substantially 5V negative with respect to the lamp terminal 2 and the lamp 3 starts. After ignition of the lamp 3 the circuit components diode 38, capacitor 39, diode 40, resistance 41, diode 42, capacitor 43, diode 44 and resistance 45 no longer play an important part in the operation of the circuit arrangement. The resistances 41 and 45 are chosen to have relatively high values so that the currents flowing through the diodes 40 and 44 which are in shunt with the lamp terminals 1 and 2 are small in comparison with the operating current flowing through the lamp.

I claim:

1. A circuit arrangement for starting an electric discharge lamp from an alternating current supply comprising:

a. first and second input terminals across which an alternating current supply is connected;

b. first and second lamp terminals across which an electric discharge lamp is connected;

c. first capacitor means connected in series between the first input terminal and the first lamp terminal;

d. a circuit connection between the second input terminal and the second lamp terminal;

e. a charging circuit for the first capacitor means, said charging circuit including a first unilateral impedance device and means connecting one side of said first unilateral impedance device to the side of the first capacitor means which is connected to the first lamp terminal;

f. a second capacitor means and a second unilateral impedance device connected in series between the second and first input terminals in the order stated;

g. means connecting the other side of the first unilateral impedance device to the junction between the second capacitor means and the second unilateral impedance device; and

h. the polarity of the first and second unilateral impedance devices being such that the second capacitor means is charged to at least the peak voltage of the supply and the first capacitor means is charged to at least twice the peak voltage of the supply so that at least three times the peak voltage of the supply is available across the lamp terminals to start the lamp.

2. A circuit arrangement as claimed in claim 1, wherein first and second unilateral impedance devices are diodes.

3. A circuit arrangement as claimed in claim 1, wherein the first unilateral impedance device has a resistance connected in series therewith to prevent the first unilateral impedance device from functioning as a low resistance shunt for the lamp after the lamp has started.

4. A circuit arrangement as claimed in claim 1, including an inductive ballast connected between the first input terminal and the first lamp terminal.

5. A circuit arrangement as claimed in claim 4, wherein the inductive ballast constitutes a winding of a leakage flux transformer.

6. A circuit arrangement for starting an electric discharge lamp from an alternating current supply comprising:

a. first and second input terminals across which an alternating current supply is connected;

b. first and second lamp terminals across which an electric discharge lamp is connected;

c. first capacitor means connected in series between the first input terminal and the first lamp terminal;

d. a charging circuit for the first capacitor means including a first unilateral impedance device connected between the second input terminal and the side of the first capacitor means which is connected to the first lamp terminal;

e. second capacitor means connected in series between the second input terminal and the second lamp terminal;

f. a charging circuit for the second capacitor means including a second unilateral impedance device connected between the first input terminal and the side of the second capacitor means which is connected to the second lamp terminal; and

g. the polarity of the first and second unilateral impedance devices being such that the first capacitor means is charged to at least the peak voltage of the supply is available across the lamp terminals to start the lamp.

7. A circuit arrangement as claimed in claim 6, wherein the first and second unilateral impedance devices are diodes.

8. A circuit arrangement as claimed in claim 6, wherein the first and second unilateral impedance devices in the two charging circuits have respective resistances connected in series therewith to prevent the unilateral impedance devices functioning as low resistance shunts for the lamp after the lamp has started.

9. A circuit arrangement as claimed in claim 6, including an inductive ballast connected between the first input terminal and the first lamp terminal.

10. A circuit arrangement as claimed in claim 6, including an inductive ballast divided into a first part connected between the first input terminal and the first lamp terminal and a second part connected between the second input terminal and the second lamp terminal.

* * * * *