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(72) Inventor: **Slegers, Frans**
c/o Int. Octrooibureau B.V.,
Prof. Holstlaan 6
NL-5656 AA Eindhoven(NL)

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(74) Representative: **Evers, Johannes Hubertus**
Maria et al
INTERNATIONAAL OCTROOIBUREAU B.V.,
Prof. Holstlaan 6
NL-5656 AA Eindhoven (NL)

(71) Applicant: **PHILIPS ELECTRONICS N.V.**
Groenewoudseweg 1
NL-5621 BA Eindhoven(NL)

(54) **High frequency inverter for a discharge lamp with preheatable electrodes.**

(57) The invention relates to a circuit arrangement for high-frequency operation of a discharge lamp (La), comprising

- input terminals (1,2) for connection to a supply voltage source,
- a load branch provided with terminals (H1,H2) for accommodating the discharge lamp and with an electrode heating transformer (L3) provided with a primary winding (P) and secondary windings (Sec1, Sec2), each secondary winding being shunted by a branch comprising an electrode (E11, E12) of the discharge lamp,
- at least one switching element (S1, S2) for generating a high-frequency current through the load branch from a supply voltage delivered by the supply voltage source,
- a control circuit (I) for generating a control

signal for rendering the switching element conducting and non-conducting with high frequency,

- a dimmer circuit (II) coupled to the control circuit for adjusting the frequency of the control signal.

According to the invention, each branch shunting a secondary winding of the transformer also comprises inductive means (L1, L2) and capacitive means (C1, C2) and has a resonance frequency which is different from the resonance frequency of the load branch. It is achieved by this that a discharge lamp operated by means of the circuit arrangement can be dimmed over a wide range with a comparatively long electrode life and only very little blackening at the ends of the discharge vessel.

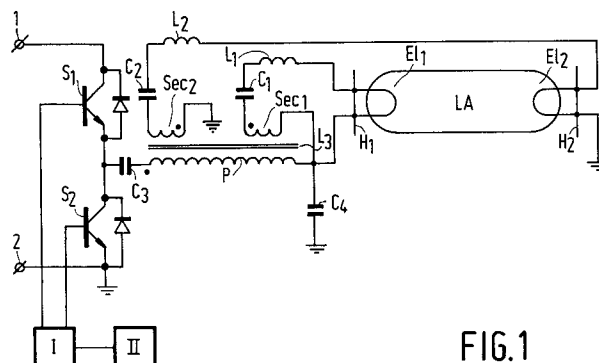


FIG.1

The invention relates to a circuit arrangement for high-frequency operation of a discharge lamp, comprising

- input terminals for connection to a supply voltage source,
- a load branch provided with terminals for accommodating the discharge lamp and with an electrode heating transformer provided with a primary winding and secondary windings, each secondary winding being shunted by a branch comprising an electrode of the discharge lamp,
- at least one switching element for generating a high-frequency current through the load branch from a supply voltage delivered by the supply voltage source,
- a control circuit for generating a control signal for rendering the switching element conducting and non-conducting with high frequency,
- a dimmer circuit coupled to the control circuit for adjusting the frequency of the control signal.

Such a circuit arrangement is known from European Patent 98285. The luminous flux of a discharge lamp operated by means of this known circuit arrangement may be adjusted in that the frequency of the control signal is adjusted. A change in the frequency of the control signal leads to a change in the frequency of the high-frequency current through the load branch, so that the impedance of the load branch and the amplitude of the high-frequency current are also changed. A change in the luminous flux of the discharge lamp may thus be achieved through a change in the frequency of the control signal. In the known circuit arrangement, the electrodes of the discharge lamp are heated during lamp operation both by the high-frequency current flowing through the lamp and by an electrode heating current of the same frequency which flows through the electrodes of the discharge lamp as a result of a potential difference between the ends of the secondary windings of the electrode heating transformer during lamp operation. It is ensured through dimensioning of the known circuit arrangement that the temperature of the lamp electrodes is maintained at a suitable value during a lamp operation in which the discharge lamp achieves the highest adjustable luminous flux as a result of the discharge current and the electrode heating current. Lamp electrode life is comparatively long at this suitable value of the electrode temperature. When the luminous flux of the discharge lamp is reduced by a user by means of the dimmer circuit, however, not only the discharge current through the discharge lamp but also the electrode heating current through the electrodes decreases. The temperature of the electrode as a

result drops further below the suitable value in proportion as the luminous flux of the discharge lamp is reduced further. As a result, lamp electrode life is shortened to a comparatively high degree by dimming of the discharge lamp, while at the same time blackening of the ends of the lamp vessel of the discharge lamp takes place.

The invention has for its object *inter alia* to provide a circuit arrangement by which it is possible to dim a discharge lamp operated by means of the circuit arrangement without the life of the discharge lamp being adversely affected by this.

According to the invention, a circuit arrangement of the kind mentioned in the opening paragraph is for this pulse characterized in that each branch shunting a secondary winding of the transformer comprises inductive means and capacitive means and has a resonance frequency which is different from the resonance frequency of the load branch.

The resonance frequencies of all branches shunting a secondary winding of the transformer are chosen to be either all lower than the resonance frequency of the load branch or all higher than the resonance frequency of the load branch. It is achieved by this that, at operating frequencies between the resonance frequency of the load branch and the resonance frequency of each branch shunting the ends of a secondary winding, a change in the operating frequency results either in an increase in the discharge current and an accompanying decrease in the electrode heating current, or in a decrease in the discharge current and an accompanying increase in the electrode heating current. This means that, provided the circuit arrangement is suitably dimensioned, the luminous flux of the discharge lamp may be adjusted over a wide range, each luminous flux value of the discharge lamp having an accompanying electrode temperature of the discharge lamp of such a value that the electrode life is comparatively long, while in addition blackening of the lamp vessel ends hardly takes place.

An advantageous embodiment of a circuit arrangement according to the invention is characterized in that the load branch comprises an inductive element, in that the resonance frequency of the load branch has a lower value than the resonance frequencies of the branches shunting the secondary windings, and in that the frequency of the high-frequency current through the load branch is higher for each luminous flux value of the lamp which can be set than the resonance frequency of the load branch and lower than the resonance frequencies of the branches shunting the secondary windings of the electrode heating transformer. Since the frequency of the high-frequency current through the load branch is higher than the reso-

nance frequency of the load branch, the load branch acts as an inductive impedance. Depending on the design of the circuit arrangement, this is an important advantage because the life of the switching elements in the circuit arrangement is comparatively long when the load branch is an inductive impedance. In this advantageous embodiment of a circuit arrangement according to the invention, it is profitable to integrate the inductive element and the electrode heating transformer, so that one component performs different functions in the circuit arrangement. Owing to the comparatively small number of components, the circuit is of a comparatively simple construction, and thus more readily manufactured on a large scale.

An embodiment of the invention will be explained with reference to a drawing.

In the drawing, Fig. 1 shows an embodiment of a circuit arrangement according to the invention, and

Fig. 2 shows an electrode heating current as a function of a discharge current through a lamp operated by means of a circuit arrangement as shown in Fig. 1.

In Fig. 1, reference numerals 1 and 2 denote input terminals for connection to a supply voltage source. It is desirable for the circuit arrangement shown in Fig. 1 that the supply voltage source should be a DC voltage source whose anode is connected to terminal 1 and whose cathode is connected to terminal 2. Input terminals 1 and 2 are interconnected by a series circuit of two switching elements S1 and S2. Control electrodes of the switching elements are connected to respective outputs of control circuit I for generating a control signal which is to render the switching elements S1 and S2 alternately conducting and non-conducting with high frequency. An input of control circuit I is connected to an output of dimmer circuit II which adjusts the frequency of the control signal. The load branch in this embodiment is formed by capacitors C1, C2, C3 and C4, transformer L3, coils L1 and L2, terminals H1 and H2 for accommodating a discharge lamp, and the discharge lamp La. The transformer L3 in this embodiment performs the function of electrode heating transformer as well as the function of inductive element. A common junction point of the switching elements S1 and S2 is connected to a first side of capacitor C1. A further side of capacitor C1 is connected to a first end of primary winding P of transformer L3. A further end of primary winding P is connected to a first side of capacitor C4. A further side of capacitor C4 is connected to input terminal 2. The further end of primary winding P is also connected to a first end of electrode E11 of discharge lamp La. Electrode E11 is shunted by a series circuit of coil L1, capacitor C1, and secondary winding Sec1 of

transformer L3. A first end of electrode E12 of the discharge lamp La is connected to input terminal 2. Electrode E12 is shunted by a series circuit of coil L2, capacitor C2, and secondary winding Sec2.

The operation of the circuit arrangement shown in Fig. 1 is as follows.

When the input terminals 1 and 2 are connected to the anode and cathode, respectively, of a DC voltage source, the control circuit I renders the switching elements S1 and S2 conducting and non-conducting with a high frequency f . As a result, a high-frequency current with frequency f flows through the load branch. A high-frequency current with frequency f also flows through the two branches which shunt the secondary windings Sec1 and Sec2 of the transformer L3. When the lowest adjustable frequency of the control signal has been set by means of the dimmer circuit II, the discharge lamp La dissipates approximately its rated power and the luminous flux of the discharge lamp La has the maximum value which can be set. The load branch is so dimensioned that the frequency f has a higher value than the resonance frequency of the load branch, so that the load branch is an inductive impedance at the frequency f . In addition, the branches shunting the secondary windings Sec1 and Sec2 of transformer L3 are so dimensioned that the resonance frequencies of these branches are higher than the frequency f . The impedances of these branches as a result are capacitive. Now when the frequency of the control signal, and thus the frequency f of the high-frequency current in the load branch, is increased through the dimmer circuit II, the impedance of the load branch increases. As a result, the current through the load branch decreases, and accordingly also the current through the discharge lamp La. An increase in the frequency f , however, also leads to a decrease in the impedance of the branches shunting the two secondary windings Sec1 and Sec2. The electrode heating currents flowing through these two branches are increased as a result. Conversely, the currents through the branches shunting the secondary windings Sec1 and Sec2 of the transformer L3 decrease when the discharge current is increased. Thus an increase in the electrode heating current is achieved at a decrease in the discharge current through the lamp such that the temperatures of the electrodes E11 and E12 of the discharge lamp have such a value at every adjustable luminous flux of the discharge lamp that the electrode life is comparatively long and that substantially no blackening occurs at the ends of the discharge vessel.

In Fig. 2, the electrode heating current is plotted on the vertical axis in mA. The discharge current is plotted on the horizontal axis in mA. The discharge lamp for which the relation between dis-

charge current and electrode heating current as shown in Fig. 2 was measured, was a low-pressure mercury discharge lamp of the PL-L type, make Philips, with a power rating of 55 W. The curve K1 shows the measured relation between the discharge current and the electrode heating current. Points A and B on the curve K1 mark the limits of the adjustment range of the discharge current: 50 mA and 600 mA, respectively. Curves K1 and K3 give the empirically determined maximum and minimum values, respectively, of the electrode heating current for each value of the discharge current, at which the electrode life of the discharge lamp is comparatively long. Fig. 2 shows that the electrode heating current lies between the minimum and the maximum value throughout the entire adjustment range of the discharge current.

Claims

1. A circuit arrangement for high-frequency operation of a discharge lamp, comprising

- input terminals for connection to a supply voltage source,
- a load branch provided with terminals for accommodating the discharge lamp and with an electrode heating transformer provided with a primary winding and secondary windings, each secondary winding being shunted by a branch comprising an electrode of the discharge lamp,
- at least one switching element for generating a high-frequency current through the load branch from a supply voltage delivered by the supply voltage source,
- a control circuit for generating a control signal for rendering the switching element conducting and non-conducting with high frequency,
- a dimmer circuit coupled to the control circuit for adjusting the frequency of the control signal,

characterized in that each branch shunting a secondary winding of the transformer comprises inductive means and capacitive means and has a resonance frequency which is different from the resonance frequency of the load branch.

2. A circuit arrangement as claimed in Claim 1, characterized in that the load branch comprises an inductive element, in that the resonance frequency of the load branch has a lower value than the resonance frequencies of the branches shunting the secondary windings, and in that the frequency of the high-frequency current through the load branch is higher for each luminous flux value of the lamp which

can be set than the resonance frequency of the load branch and lower than the resonance frequencies of the branches shunting the secondary windings of the electrode heating transformer.

3. A circuit arrangement as claimed in Claim 2, characterized in that the inductive element and the electrode heating transformer are integrated in one component.

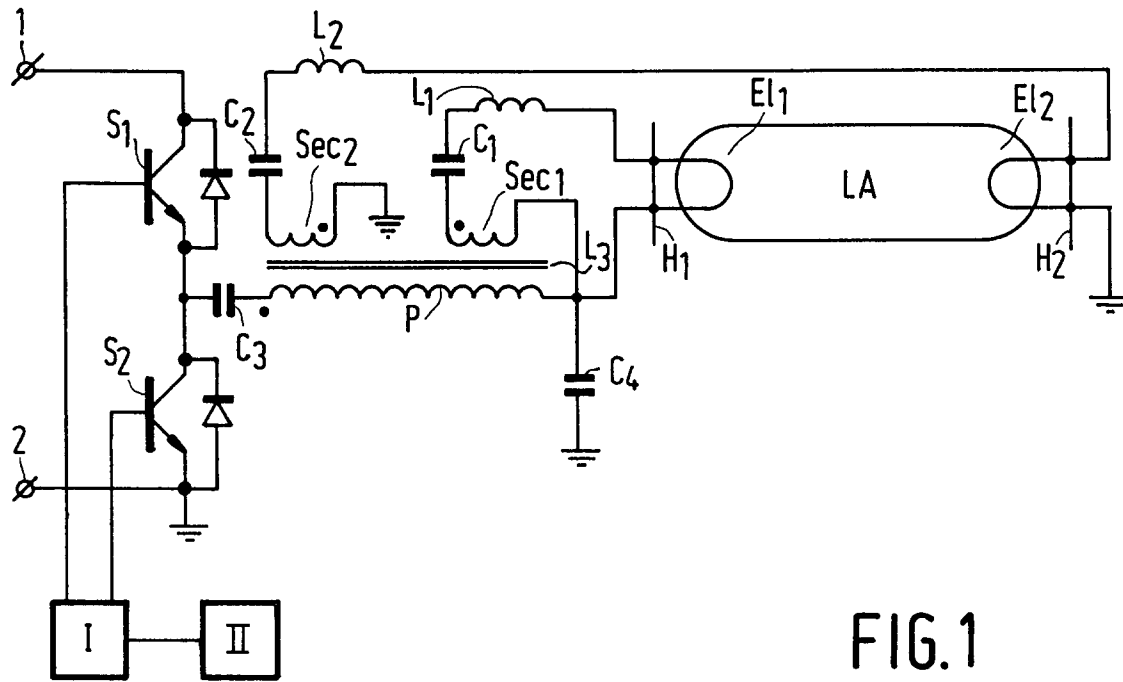


FIG.1

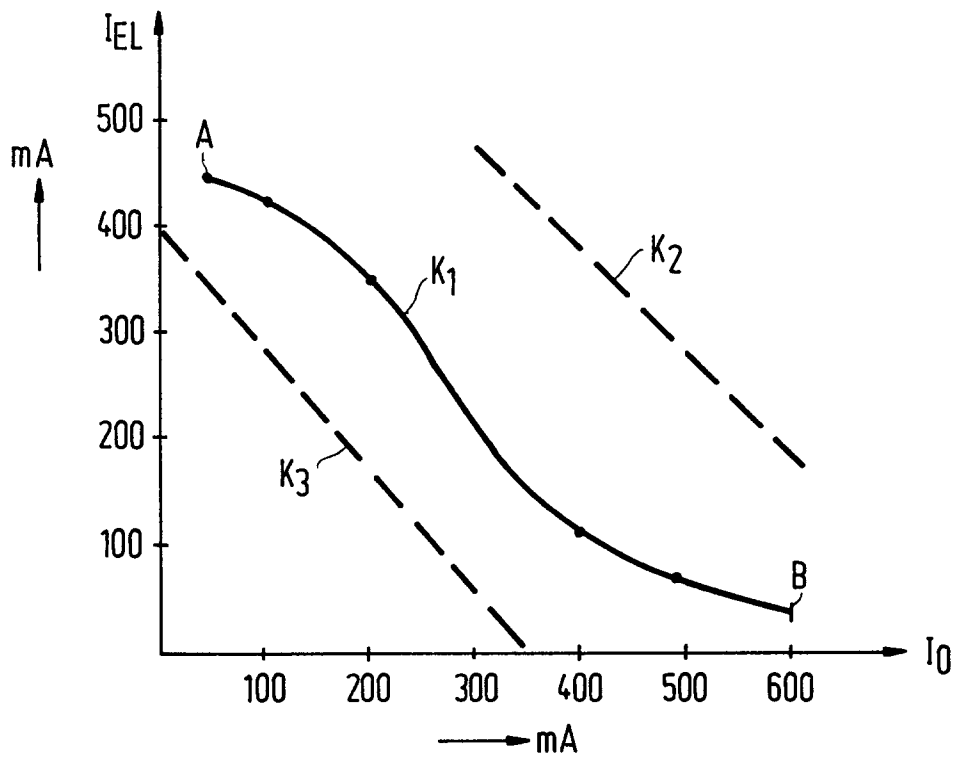


FIG.2



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 93 20 3448

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y	US-A-4 682 080 (OGAWA) * column 7, line 3 - column 8, line 2; figures 6,7 *	1-3	H05B41/29
Y	DE-A-31 40 175 (LICENTIA) * page 8, line 10 - page 8, line 15; figures 2,3 *	1-3	
A,P	WO-A-93 01694 (ROBERT BOSCH) * abstract * * page 9, line 14 - page 9, line 20; figure 1 *	1	
A	US-A-4 686 427 (BURKE) * column 1, line 41 - column 1, line 55; figure 4 *	1,3	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			H05B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 15 April 1994	Examiner Speiser, P
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