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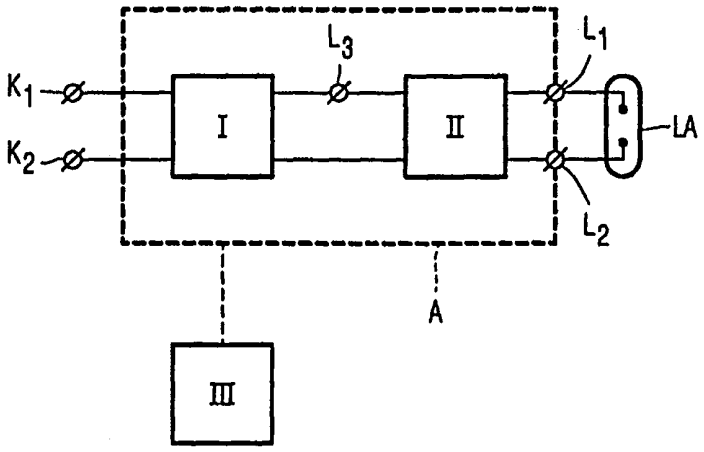

(57) Abstract

The invention is concerned with a circuit arrangement for operating a high pressure discharge lamp comprising input terminals (K1, K2) for connection to a supply voltage source, output terminals for connecting the high pressure discharge lamp, and means, coupled to the input terminals, for supplying an alternating lamp current to the high pressure discharge lamp. The lamp current has per period a mean value Im. According to the invention the lamp current in each period at its start is lowered with respect to the mean value Im so as to allow for stable diffuse attachment on the cathodic phase electrode. The circuit arrangement is in particular suited for operating a lamp in an optical projection system.

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Circuit arrangement.

The invention relates to a circuit arrangement for operating a high pressure discharge lamp having during operation an electrode which is in a cathodic phase, comprising

-input terminals for connection to a supply voltage source,

-output terminals for connecting the high pressure discharge lamp, and

-means, coupled to the input terminals, for supplying an alternating lamp current having successive periods of opposite polarity to the high pressure discharge lamp, the lamp current per period having a mean value Im.

Such a circuit arrangement is known from US 5608294. In the known circuit the lamp current at each period is provided with a superposition of a current pulse in a latter part of each period. In case a high pressure discharge lamp is operated with an AC current, each electrode of the lamp alternatingly functions as a cathode and as an anode during successive periods of the lamp current. During these successive periods the electrode emitting the lamp current is said to be in the cathodic phase and the other electrode to be in the anodic phase respectively. Because the total amount of current through the lamp is increased at the end of each period of the lamp current by means of the current pulse, the temperature of the electrode is sufficiently raised to increase the stability of the discharge arc. Accordingly flickering of the high pressure discharge lamp can be substantially suppressed. Due to its flickering suppression properties the circuit arrangement is in particular suitable for operating a high pressure discharge lamp in a projection system like a projection television apparatus.

Lamps operated with the known circuit arrangement showed to have a continuos increase of the arc voltage over an operating time of several hundred hours, which voltage increase appeared to continue when the lamp was experimentally operated for several thousand hours. As a stable luminous output of the lamp being fairly constant over the life of the lamp is of vital importance for use in a projection system, a continuos arc voltage increase forms a serious draw back in reaching a long lamp live.

The invention aims to provide a circuit arrangement for operating a high pressure discharge lamp in which the mentioned draw back is counter acted.

According to the invention a circuit arrangement mentioned in the opening paragraph is for this purpose characterized in that the lamp current in each period at its start is lowered with respect to the mean value Im so as to allow for stable diffuse attack on the cathodic phase electrode. The arrangement has the advantage that during lamp operation the discharge arc has a soft start each period by diffusely attaching both electrodes resulting in a lower electrode load, so making it possible to operate the lamp without flickering over a long time together with a very significant reduction in occurrence of an increase of the arc voltage.

The mean value of the current Im over a period corresponds to the power Pla of the lamp according to the relation Pla=Im*Vla with Vla the lamp voltage. Experiments have learned that preferably the mean value of the current over a fist part of the period Ie is smaller than the value Im and over a second part of the period a mean current value I2 which is larger than Im. This further improves a soft current start at the beginning of each period with a diffuse arc attachment over the first part of the period resulting in a stabilized arc attachment. As a consequence of the current over the second part of the period I2 being larger than Im the need of an additional current pulse near the end of the period is further reduced.

In a preferred embodiment of the arrangement according to the invention the period has a time duration tp and the first part of the period a time duration tl which satisfies the relation $.05 \leq tl/tp \leq .85$. In case of a value of the ratio t1/tp smaller than .05 experiments showed no measurable improvement over the prior art. The upper value of the ratio t1/tp depends on a compromise. For the diffuse stable attachment the ratio should be as long as possible. However as the cathode tends to cool during the cathode phase so the current which is emitted with a diffuse stable attachment tends to lower, this comes in conflict with the need of keeping the lamp operating at the requested power rate. So experimentally it was shown that for an increasing current shape in the first part of the period the ratio should preferably be at most .5. In the situation of a decreasing current during t1 the maximum ratio can be .85. Otherwise it has appeared that for the values of the currents Ie and Im a relation should be hold which reads $.3 \leq Ie/Im \leq .9$ and preferable satisfies $.6 \leq Ie/Im \leq .8$, resulting in a reduced extra load on the electrode in comparison to the prior art. For current values of $Ie > .9Im$ no measurable effects have been found. If Ie becomes too low with respect to Im the value of the mean current in the second part of the period I2 must be chosen so high that there exists a serious risk on occurrence of arc instabilities during the second part of the period resulting in lamp flickering.

In a further preferred embodiment the current at the start of the period is higher than Ie. In this way there is taken into account in an advantageous way that the cathode temperature lowers during the period and thus correspondingly the current value for which a stable diffuse attachment of the arc holds.

Arc stabilization and therethrough reducing lamp flicker is still further promoted with adding to the lamp current an additional current pulse as known from the prior art. Preferably the lamp current is then provided with a pulse of the same polarity at the end of the period with a value I3 satisfying the relation $I3 \leq 2Im$.

The above and further aspects of the invention will be explained in more detail below with reference to a drawing, in which

Fig. 1 shows a schematic scheme of a circuit arrangement according to the invention,

Fig. 2 shows control means of an embodiment of a circuit arrangement according to the invention in accordance with fig 1,

Fig 3 is a graph of a lamp current provided by the arrangement according to fig 1,

Fig 4 to 6 are graphs of the lamp current according to several preferred embodiments of the circuit arrangement.

In fig 1 I are means for generating a controlled dc supply current having input terminals K1,K2 for connecting to a supply voltage source supplying a supply voltage. Output terminals of means I are connected to respective input terminals of a commutator II. The commutator II is provided with output terminals L1,L2 for connecting a high pressure discharge lamp La. III are control means to control the value of the current supplied to the lamp by way of controlling the means I. The means I and the commutator II together constitute means, coupled to the input terminals, for supplying an alternating lamp current having successive periods of opposite polarity, the lamp current per period having a mean value Im.

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

When input terminals K1,K2 are connected to a voltage supply source, means I generate a dc supply current from the supply voltage supplied by the voltage supply source. Commutator II converts this dc current into an alternating current having successive periods of

opposite polarity. By control means III the value of the current thus formed and supplied to the lamp La is controlled such that the lamp current in each period at its start is lowered with respect to the mean value Im so as to allow for stable diffuse attack on the cathodic phase electrode. In a practical realization of the described embodiment the means I are formed by a rectifier bridge followed by a switch mode power circuit, for instance a Buck or down converter. Commutator II preferably comprises a full bridge circuit. Lamp ignition circuitry is preferably incorporated also in the commutator means II.

In Fig. 2, the control means III for controlling means I are shown in more detail. The control means III comprise an input 1 for detecting the arc voltage, for instance the voltage over the terminals L1,L2 connected to the lamp forming a signal representing the arc voltage and further called lamp voltage. Preferably the lamp voltage representing signal is formed by detecting a voltage at a connection point L3, as the thus detected voltage is a dc voltage which will not be disturbed by ignition voltages generated in the lamp ignition circuitry. Control means III further comprises, an input 2 for detecting of the current through inductive means L of the converter forming the switch mode power circuit of the means I, which converter has at least a switch, and an output terminal 3 for switching the switch of the switch mode power circuit periodically in a conducting and a non-conducting state thus controlling the current through the induction means L of the converter. Input 1 is connected to connection pin P1 of a microcontroller MC. A connection pin P3 of the microcontroller is connected to an input 4 of a switching circuit SC. Input 2 is connected to an input 5 of the switching circuit SC, of which an output O is connected to output terminal 3.

The operation of the circuit arrangement shown in Fig. 2 with the converter being a Buck or down converter, is as follows. The microcontroller MC is provided with software containing a matrix of converter peak current values labeled to lamp voltage, time combinations, wherein the time is counted from the start of each period of the lamp current. A thus found converter peak current value is fed to switching circuit SC at input 4 and used as reference for comparison for the detected current at input 2 which is also fed to the switching circuit SC, at input 5. Based on this current values comparison the switching circuit generates a switching off signal at output O, which switches the switch of the down converter in the non-conducting state when the detected current equals the peak current value. As a result the current through the inductive means will decrease. The converter switch is kept in the non-conductive state until the current through the inductive means L becomes zero. On detecting the converter current becoming zero the switching circuit SC generates at its output O a switch on signal that renders the switch of the down converter conductive. The current through the

inductive means L now starts to increase until it reaches the peak current value. Such switching circuit SC is for instance known from WO97/14275. The value of the peak current is refreshed each time the lamp voltage is detected by the control means III.

The detection of the lamp voltage is done with a repetition rate during each period depending on the shape of the current to be realized through the lamp and is controlled by a built in timer of the microcontroller MC. Taking the lamp voltage as lamp parameter for detection has as an advantage that it makes possible to have a wattage control of the lamp inherently incorporated in the microcontroller software. In case the lamp current itself is taken as parameter for detection a wattage control would not only require an additional detection of the lamp voltage, but also an additional control procedure in the microcontroller. The down converter operates in a favourable embodiment at a frequency in the range of 45kHz to 75kHz.

A resulting lamp current as formed in a practical realization of the described practical embodiment of the circuit arrangement according to the invention is shown in the graph of fig.3 for 2 successive periods with opposite polarity. The current is set along the vertical axis in a relative scale. Along the horizontal axis the time is displayed. For a first period B of time duration tp the lamp current has a mean value Im and over a first part of the period with time duration t1 a lower mean value Ie and over a second part of the period a constant current having a mean value I2 being larger than Im. The value of the current at the start of the period I1 allows for a diffuse stable arc attachment and so for a thermionic emission of the emitting electrode of the lamp. In the described embodiment the ratio Ie/Im has a value .9 and the ratio t1/tp a value .5.

In fig 4 is shown the lamp current of an alternative embodiment in which the current over the first part of the period is held constant at a value allowing thermionic emission at the start of the period.

According to a further preferred embodiment the resulting current is shown in fig 5. In this case the current at the start of the period I1 is higher than Ie.

In fig 6 is shown a graph of the current according another preferred embodiment in which the lamp current is provided with a pulse of the same polarity at the end of the period with a value I3. In a practical realization of the described embodiment the value of I3 is 1,6Im.

A practical embodiment of a circuit arrangement as described herein before has been used for the operation of a high pressure discharge lamp of the type UHP, make Philips. The lamp which had a nominal power consumption of 100 Watt and an electrode distance of only 1.3 mm, was operated with a current according to fig 4. The values of the currents are:

Ie=.93A, Im=1.25A, I2=1.33A. So the ratio Ie/Im is .74. The period duration tp is 5.6ms, according to an operating frequency of the commutator means II of 90Hz, and the ratio t1/tp is .2. As microcontroller MC a P87C749EBP, make Philips has shown to be suitable, programmed to detect twice the lamp voltage during each period. In a further practical embodiment wherein a current pulse according to fig 6 was superimposed on the lamp current during the latter 8 % of each half period, resulting in a current I3 of 1.4*Im flickering could be substantially suppressed.

The lamp voltage is 85V at 100 hours of the lamp life and showed an increase after 500 hours operation to 94V. For comparison an identical lamp was operated on a circuit arrangement according to the prior art. In this case the lamp voltage had increased from 85 V at 100 hours to 110V after only 300 hours of operation.

CLAIMS:

1. Circuit arrangement for operating a high pressure discharge lamp having during operation an electrode which is in a cathodic phase, comprising

-input terminals for connection to a supply voltage source,

-output terminals for connecting the high pressure discharge lamp, and

-means, coupled to the input terminals, for supplying an alternating lamp current having successive periods of opposite polarity to the high pressure discharge lamp, the lamp current per period having a mean value Im, characterized in that the lamp current in each period at its start is lowered with respect to the mean value Im so as to allow for stable diffuse attack on the cathodic phase electrode.

2. Circuit arrangement according to claim 1, characterized in that the lamp current per period has a mean value Im and over a first part of the period a lower mean value Ie and over a second part of the period a mean current I2 being larger than Im.

3. Circuit arrangement according to claim 1 or 2, characterized in that the period has a time tp and the first part of the period a time duration tl which satisfies the relation $.05 \leq tl/tp \leq .85$

4. Circuit arrangement according to claim 1,2 or 3, characterized in that $.3 \leq Ie/Im \leq .9$.

5. Circuit arrangement according to claim 2,3 or 4, characterized in that the current at the start of the period is higher than Ie.

6. Circuit arrangement according to any of the preceding claims, characterized in that the lamp current is provided with a pulse of the same polarity at the end of the period with a value I3 satisfying the relation $I3 \leq 2Im$.

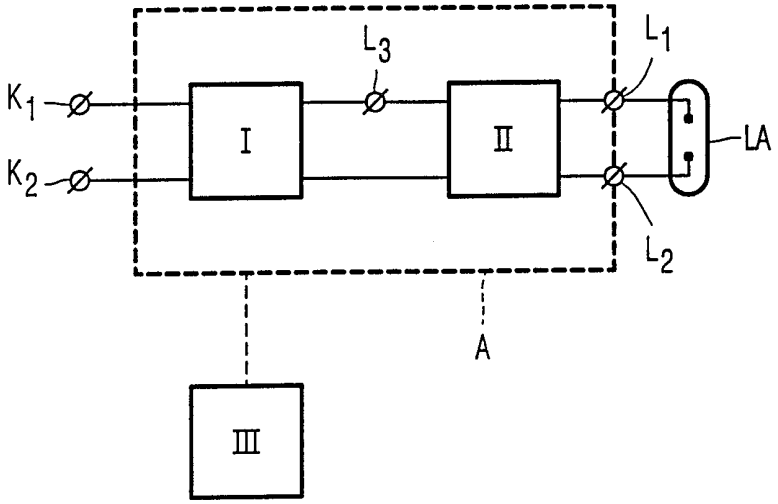

FIG. 1

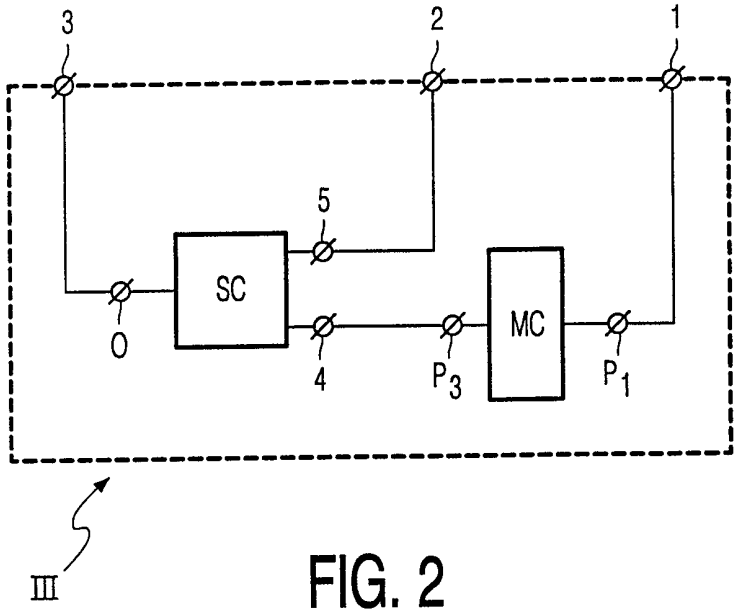

FIG. 2

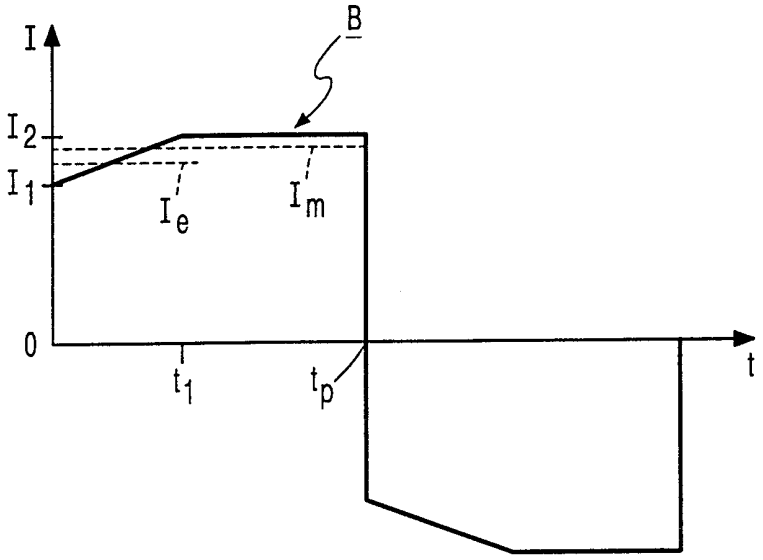

FIG. 3

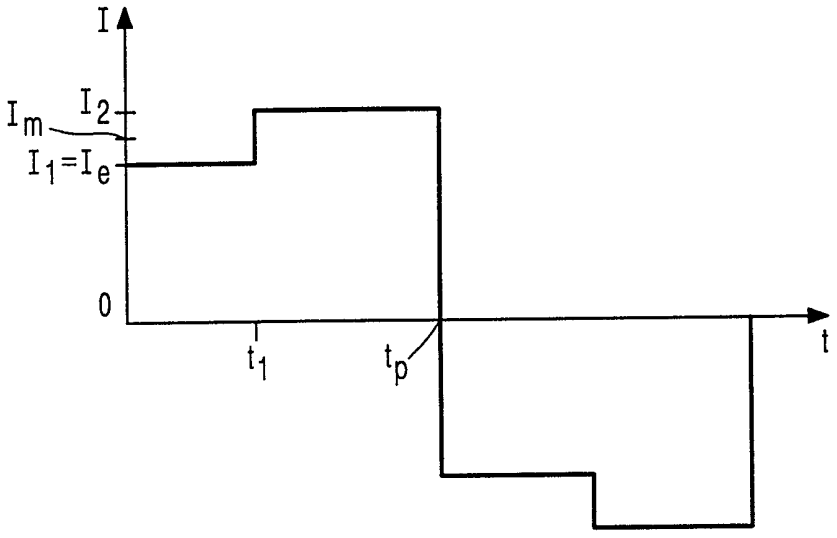

FIG. 4

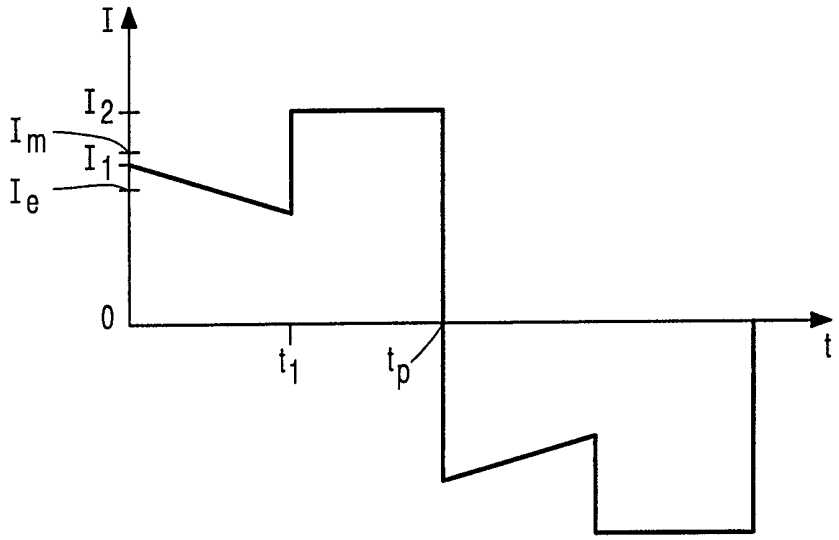

FIG. 5

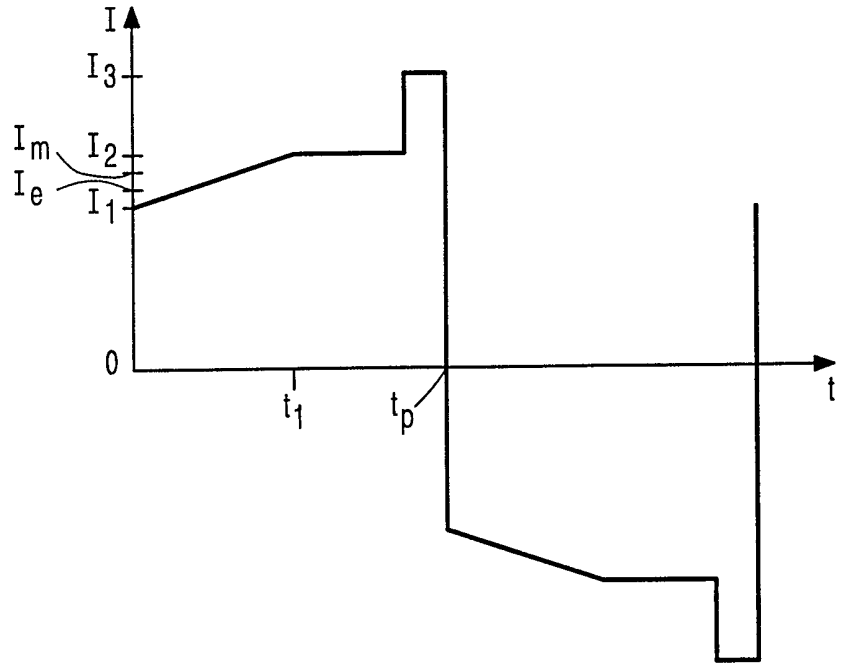

FIG. 6

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H05B41/292

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 44 39 885 A (BOSCH GMBH ROBERT) 9 May 1996 (1996-05-09) column 1, line 52 -column 1, line 57 column 4, line 43 -column 4, line 64; figures 1,2	1-4,6
X	US 5 608 294 A (GANSER HANS G ET AL) 4 March 1997 (1997-03-04) cited in the application column 1, line 24 -column 2, line 53; figure 4	1-4,6
A	DE 44 10 177 A (HELLA KG HUECK & CO) 28 September 1995 (1995-09-28) column 1, line 59 -column 2, line 13; figures 1,2	1

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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