



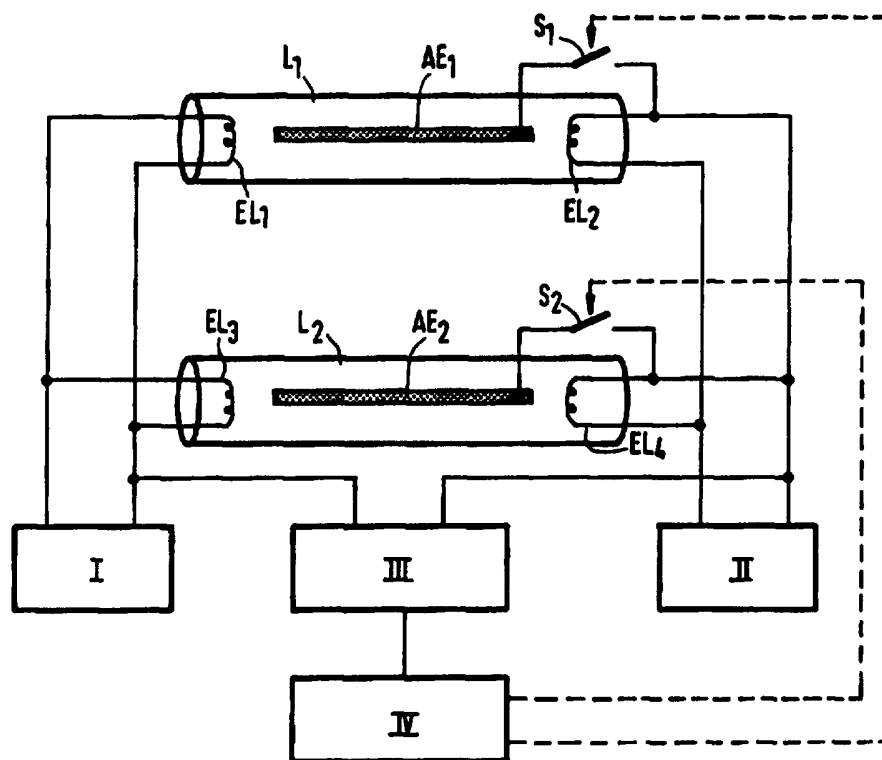
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(21) International Application Number: PCT/IB95/00956 (22) International Filing Date: 2 November 1995 (02.11.95) (30) Priority Data: 94203533.8 5 December 1994 (05.12.94) EP <i>(34) Countries for which the regional or international application was filed:</i> AT et al. (71) Applicant: PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL). (71) Applicant (for SE only): PHILIPS NORDEN AB [SE/SE]; Kottbygatan 5, Kista, S-164 85 Stockholm (SE). (72) Inventors: HILBIG, Rainer; Pirolweg 23, D-52076 Aachen (DE). CHITTKA, Uwe; Dedolphstrasse 8, D-52066 Aachen (DE). POSTMA, Pieter; Markt 52-54, D-52062 Aachen (DE). (74) Agent: EVERS, Johannes, H., M.; Internationaal Octrooibureau B.V., P.O. Box 220, NL-5600 AE Eindhoven (NL).		(81) Designated States: CN, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>Without international search report and to be republished upon receipt of that report.</i>

(54) Title: CIRCUIT ARRANGEMENT FOR ALTERNATINGLY ESTABLISHING AND EXTINGUISHING A DISCHARGE IN EACH OF A PLURALITY OF DISCHARGE PATHS

(57) Abstract

The invention relates to a circuit arrangement for alternately with frequency f establishing and extinguishing a discharge in each of a plurality of discharge paths, each of which is associated with a first electrode situated at a first end of the discharge path and with a second electrode situated at a second end of the discharge path, comprising means for generating operating voltages out of a supply voltage, said operating voltages during operation being present over respective discharge paths and being periodical with frequency f . In accordance with the invention the circuit arrangement is characterized in that the same operating voltage is present over each discharge path, in that during operation each discharge path is associated with an auxiliary electrode situated alongside the discharge path and in that the circuit arrangement further comprises switching means for connecting and disconnecting each of the auxiliary electrodes with frequency f to a terminal of the circuit arrangement to establish an ignition voltage during part of each period between one of the electrodes and the auxiliary electrode associated with the same discharge path. This way it is assured by relative simple means that a discharge is only established in the proper discharge path(s).



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CIRCUIT ARRANGEMENT FOR ALTERNATINGLY ESTABLISHING AND EXTINGUISHING A DISCHARGE IN EACH OF A PLURALITY OF DISCHARGE PATHS

The invention relates to a circuit arrangement for alternatingly with frequency f establishing and extinguishing of a discharge in each of a plurality of discharge paths, each of which is associated with a first electrode situated at a first end of the discharge path and with a second electrode situated at a second end of the discharge path, comprising
5 means for generating operating voltages out of a supply voltage, said operating voltages during operation being present over respective discharge paths and being periodical with frequency f .

The invention also relates to a lighting arrangement comprising a plurality of discharge paths.

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A circuit arrangement as mentioned in the opening paragraph is known from Japanese patent application JP-A-03 222290. The known circuit arrangement is used in combination with two fluorescent lamps. These fluorescent lamps each provide a discharge
15 path and the associated electrodes. The fluorescent lamps are equipped with different luminescent layers. Each of the fluorescent lamps is connected in series with a bipolar transistor to the terminals of a DC voltage source. During lamp operation each of the bipolar transistors is alternatingly rendered conductive and non-conductive with a frequency f by means of signals generated by a signal generator that together with the bipolar transistors
20 forms part of the means for generating operating voltages out of a supply voltage. When one of the bipolar transistors is conducting, the other one is non-conducting. The sum of the duty cycles of both bipolar transistors is 1. By adjusting the duty cycle of one of the bipolar transistors (and thereby correspondingly adjusting the duty cycle of the other transistor) the fractions of time during which the DC voltage is present over each of the lamps can be
25 adjusted. The fraction of time during which the DC voltage is present over one of the lamps determines the shape of the operating voltage over that lamp which in turn influences the light output of that lamp, so that by adjusting the duty cycle of one of the transistors the colour of the light that the two lamps radiate together is adjusted. In case the frequency f is high enough the light radiated by the lamps is perceived by the human eye as light of a

constant colour. During each period associated with frequency f the following sequence is taking place: during a first time interval of the period the transistor in series with one of the lamps is non-conductive while the transistor in series with the other lamp is conductive. The lamp in series with the conductive transistor ignites under the influence of the DC voltage and the installed discharge causes this lamp to radiate light of a first colour point. At the end of the first time interval the conductive transistor becomes non-conductive so that the discharge in the lamp in series with this transistor extinguishes. This transistor remains non-conductive during a second time interval that constitutes the remaining part of the period. The transistor that was non-conductive during the first time interval becomes conductive in the second time interval so that the lamp in series with it ignites under the influence of the DC voltage and the installed discharge causes the lamp to radiate light of a second colour point. Since the operating voltages of the two lamps differ in the known circuit arrangement a transistor is needed in series with each of the lamps. As a result the known circuit arrangement is relatively complicated and expensive.

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The invention aims to provide a circuit arrangement that is relatively simple and cheap.

A circuit arrangement as described in the opening paragraph is therefore characterized according to the invention in that the same operating voltage is present over each discharge path, in that during operation each discharge path is associated with an auxiliary electrode situated alongside the discharge path and in that the circuit arrangement further comprises switching means for connecting and disconnecting each of the auxiliary electrodes with frequency f to a terminal of the circuit arrangement to establish an ignition voltage during part of each period between one of the electrodes and the auxiliary electrode associated with the same discharge path.

The electrodes can be incorporated in lamps suitable to be operated by means of a circuit arrangement according to the invention. The electrodes can also be part of the circuit arrangement. The electrodes can be present in the discharge during operation but it is also possible for the electrodes to be capacitively coupled to the discharge. The auxiliary electrode can be part of a lamp operated by means of the circuit arrangement but can also be part of the circuit arrangement. Each discharge path can be incorporated in a separate

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lampvessel, but it is also possible to incorporate two or more discharge paths in one lampvessel.

During part of its period, the operating voltage present over the discharge paths and between each pair of electrodes has a value high enough to maintain a discharge present in one or more of the discharge paths but not high enough to establish a discharge (ignite the discharge path). During a second part of its period the operating voltage attains a value at which any discharge present in one of the discharge paths extinguishes. When, during a third part of its period, the operating voltage once more attains a value high enough to maintain a discharge, the switching means connect one or more of the auxiliary electrodes to the terminal of the circuit arrangement. The ignition voltage being present between such a connected auxiliary electrode and one of the electrodes associated with the same discharge path causes ignition and the subsequent establishment of a discharge in this discharge path. The switching means together with the auxiliary electrodes thus form simple means for selecting the discharge path(s) in which a discharge is present during a time interval in which the amplitude of the operating voltage has a value that is high enough to maintain a discharge. Since in a circuit arrangement according to the invention the same operating voltage is applied to every discharge path, the circuit arrangement is relatively simple and therefore relatively cheap. In addition to that advantage, during the establishing and extinguishing of discharges in the discharge paths using a circuit arrangement according to the invention only a relatively small amount of power is dissipated.

In a relatively simple construction of a circuit arrangement according to the invention the terminal is at the same potential as one of the electrodes of each discharge path during operation. Since the switching means connect the auxiliary electrode(s) to this terminals, the ignition voltage present between the other electrode associated with the same discharge path and the auxiliary electrode equals the operating voltage.

A DC voltage can be used as an operating voltage. Depending on the plasma comprised in the discharge path(s), however, it can be desirable to use an alternating voltage as the operating voltage. Such an alternating voltage can be a low frequency alternating voltage such as the mains supply voltage with a frequency of 50 or 60 Hz. The alternating voltage can also be a high frequency alternating voltage. It is well known for instance that low pressure mercury lamps can be operated with a high efficacy by means of a high frequency alternating voltage as an operating voltage.

Since each discharge path is not maintaining a discharge during part of each period of the operating voltage, it is often advantageous if the circuit arrangement is

equipped with means for supplying a heating current to the electrodes. In this way it can be prevented that the temperature of the electrodes decreases to a value at which their life time is only very short.

It has been found that a very effective operation resulted in case the amplitude of the operating voltage is substantially square wave modulated. Both the extinguishing as well as the ignition of the discharges take place immediately after the square wave changes from high to low or from low to high respectively. Also the colour of the light radiated by the discharge paths can be easily adjusted in case the time intervals during which the amplitude of the substantially square wave modulation is high are adjustable.

Embodiments of the invention will be illustrated further making use of a drawing. In the drawing

Fig. 1 is a schematic representation of an embodiment of a lighting arrangement according to the invention comprising a circuit arrangement according to the invention;

Fig. 2 shows a schematic representation of a further embodiment of a lighting arrangement according to the invention comprising a circuit arrangement according to the invention;

Fig. 3a shows a schematic representation of an embodiment of a part of the circuit arrangements comprised in the embodiments shown in Fig. 1 and Fig. 2;

Fig. 3b shows a schematic representation of a further embodiment of a part of the circuit arrangements comprised in the embodiments shown in Fig. 1 and Fig. 2;

Fig. 4 shows the shape of the operating voltage present over discharge lamps incorporated in the lighting arrangement shown in Fig. 1, and

Fig. 5 shows the shape of the operating voltage present over discharge paths incorporated in the lighting arrangement shown in Fig. 2.

In Fig. 1 L1 and L2 are discharge lamps. The discharge lamps incorporate different luminescent layers. Discharge lamp L1 is equipped with electrodes E11 and E12 and discharge lamp L2 is equipped with electrodes E13 and E14. A discharge path exists in each discharge lamp between its electrodes. Discharge lamp L1 is also equipped with an auxiliary electrode AE1 consisting of a strip of electrically conductive material attached to the outside

of the lamp vessel of discharge lamp L1. Similarly discharge lamp L2 is equipped with an auxiliary electrode AE2. A switching element S1 connects auxiliary electrode AE1 to electrode E12. A further switching element S2 connects auxiliary electrode AE2 to electrode E14. Circuit parts I and II both constitute means for heating the electrodes. For this purpose
5 output terminals of circuit part I are coupled to electrodes E11 and E13 while output terminals of circuit part II are coupled to electrodes E12 and E14. Circuit part III constitutes means for generating an operating voltage out of a supply voltage. The coupling between circuit part III and a supply voltage source is not shown in Fig. 1. A first output terminal of circuit part III is connected to electrodes E11 and E13. A second output terminal of circuit part III is
10 connected to electrodes E12 and E14. During operation the operating voltage is present between the first and the second output terminal and therefor also between electrodes E11 and E12 and between electrodes E13 and E14. Circuit part III further comprises ballast means (not shown in Fig. 1) such as an inductance to limit the current through discharge lamps L1 and L2. Circuit part IV coupled to circuit part III constitutes a control circuit for generating
15 control signals for rendering switching element S1 and switching element S2 conducting and non-conducting. Output terminals of circuit part IV are therefore coupled to control electrodes of the switching elements S1 and S2. In Fig. 1 this coupling is indicated by means of a dotted line. Circuit part IV together with the switching elements S1 and S2 form in this embodiment the switching means for connecting and disconnecting each of the auxiliary
20 electrodes with frequency f to a terminal of the circuit arrangement to establish an ignition voltage during part of each period between one of the electrodes and the auxiliary electrode associated with the same discharge path. In this embodiment the terminal is the second output terminal of circuit part III. As a result the ignition voltage that is present between the auxiliary electrode and one of the electrodes of the discharge lamp, when its associated
25 switching element is conducting equals the operating voltage.

The lighting arrangement shown in Fig. 1 operates as follows. During operation circuit part III generates an operating voltage shaped as illustrated in Fig. 4. In Fig. 4 along the vertical axis voltage is plotted in arbitrary units. Along the horizontal axis time is plotted in arbitrary units. Fig. 4 shows one period of the operating voltage. As can be
30 seen the operating voltage employed in the embodiment shown in Fig. 1 is a substantially square wave modulated high frequency voltage. Each period of the operating voltage consists of four consecutive time intervals: Δt_1 , Δt_2 , Δt_3 and Δt_4 . These time intervals are indicated in Fig. 4. During the first time interval Δt_1 the amplitude of the operating voltage is substantially zero and consequently none of the two discharge lamps carries a current.

During the first time interval circuit part IV renders switching element S1 conductive and switching element S2 non-conductive. In the second time interval Δt_2 the operating voltage is a high frequency AC voltage. This high frequency voltage is present between electrodes E11 and E12, between electrodes E13 and E14 and also between auxiliary electrode AE1 and electrode E11. The amplitude of the high frequency voltage is insufficient to establish a discharge in discharge lamp L2. The distance between auxiliary electrode AE1 and electrode E11 is relatively small so that a relatively strong electric field exist in the plasma of discharge lamp L1. As a result of this relatively strong electric field, discharge lamp L1 ignites and a discharge is established between electrodes E11 and E12. This discharge is maintained during the second time interval. Accordingly during the second time interval the lighting arrangement radiates light of a colour associated with the composition of the luminescent layer in discharge lamp L1. At the beginning of the third time interval Δt_3 the discharge in discharge lamp L1 extinguishes since the amplitude of the operating voltage is substantially zero. During the third time interval circuit part IV renders the switching element S2 conductive and switching element S1 non-conductive. During the fourth time interval the operating voltage is again a high frequency voltage with an amplitude substantially equal to the amplitude of the operating voltage during the second time interval. During the fourth time interval the operating voltage is also present between auxiliary electrode AE2 and electrode E13. As a result discharge lamp L2 ignites and a discharge is established between electrodes E13 and E14. This discharge is maintained during the fourth time interval. During the fourth time interval the discharge lamp L1 is not ignited so that during the fourth time interval the lighting arrangement radiates light of a colour associated with the composition of the luminescent layer in discharge lamp L2. The colour of the total amount of light radiated by the lighting arrangement depends on the duration of the second and fourth time intervals. Preferably these durations are adjustable so that via them the colour of the light can be adjusted.

It be mentioned that the lighting arrangement shown in Fig. 1 could also be operated by for instance an operating voltage that is a substantially square wave modulated DC-voltage instead of a substantially square wave modulated high frequency voltage.

In Fig. 2 LV is a tube-shaped transparent lamp vessel. On each side this vessel is closed with a metal lid: E11 and E12. During operation of the lighting arrangement these metal lids function as electrodes. The lamp vessel is filled with a noble gas such as Ar and a small amount of mercury. Around the axis of the lamp vessel three tube-shaped discharge vessels are mounted: DV1, DV2 and DV3. Each of the discharge vessels is opened

on both sides and is equipped with an auxiliary electrode consisting of a strip of electrically conductive material. The inside wall of each of the discharge vessels is covered with a luminescent layer. Each discharge vessel has a different luminescent layer. Preferably the luminescent layers are chosen so that during operation, in case there is a discharge

5 established in the discharge vessel, the respective discharge vessels radiate blue, green and red light. In Fig. 2 the auxiliary electrodes are indicated as AE1, AE2 and AE3. By means of the switches S1, S2 and S3 these auxiliary electrodes are connected with a second output terminal of circuit part III. Circuit part III forms the means for generating an operating voltage out of a supply voltage. During operation this operating voltage is present between a

10 first output terminal and the second output terminal of circuit part III. The first output terminal is connected to electrode E11 and the second output terminal is connected to electrode E12. Circuit part III further comprises ballast means (not shown in Fig. 1) such as an inductance to limit the current through the discharge vessels. Circuit part IV coupled to circuit part III constitutes a control circuit for generating control signals for rendering

15 switching elements S1, S2 and S3 conducting and non-conducting. Output terminals of circuit part IV are therefore coupled to control electrodes of the switching elements S1, S2 and S3. In Fig. 2 this coupling is indicated by means of a dotted line. Circuit part IV together with the switching elements S1, S2 and S3 form in this embodiment the switching means for connecting and disconnecting each of the auxiliary electrodes with frequency f to a terminal

20 of the circuit arrangement to establish an ignition voltage during part of each period between one of the electrodes and the auxiliary electrode associated with the same discharge path. In this embodiment both electrode E11 as well as electrode E12 are associated with each of the three discharge paths defined by the three discharge vessels. Moreover the terminal is the second output terminal of circuit part III. As a result the ignition voltage that is present

25 between the auxiliary electrode and electrode E11, when its associated switching element is conducting equals the operating voltage.

The lighting arrangement shown in Fig. 2 operates as follows. During operation circuit part III generates an operating voltage shaped as illustrated in Fig. 5. In Fig. 5 along the vertical axis voltage is plotted in arbitrary units. Along the horizontal axis

30 time is plotted in arbitrary units. Fig. 5 shows one period of the operating voltage. As can be seen the operating voltage employed in the embodiment shown in Fig. 2 is a substantially square wave modulated high frequency voltage. Each period of the operating voltage consists of six consecutive time intervals: Δt_1 , Δt_2 , Δt_3 , Δt_4 , Δt_5 and Δt_6 . These time intervals are indicated in Fig. 5. During time intervals Δt_1 , Δt_3 and Δt_5 switching elements S1, S2 and

S3 are rendered conductive respectively and remain conductive during the next time interval. When one of the switching elements is rendered conductive, the other switching elements are rendered non-conductive. As a result a discharge is present in discharge vessel DC1 during time interval Δt_2 , in discharge vessel DC2 during time interval Δt_4 and in discharge vessel DC3 during time interval Δt_6 . The duration of these time intervals determines the output of blue, green and red light in one period of the operating voltage and therefor the colour of the light emitted by the lighting arrangement as experienced by the human eye. By adjusting the duration of these time intervals it is possible to adjust the colour of the light radiated by the lighting arrangement.

10 In Fig. 3a circuit part III is formed by terminals K3 and K4, rectifier bridge DB, capacitors C1, C2 and C3, control circuit SC, and-gates N1 and N2, switching elements S4 and S5, ballast means BM and output terminals K1 and K2. Circuit part IV is formed by control pulse generator CPG, means P1 and means P2 and multiplexing switch MS. K3 and K4 are terminals for connection to a low frequency supply voltage SV.

15 Terminals K3 and K4 are connected to respective input terminals of rectifier bridge DB. A first output terminal of rectifier bridge DB is connected to a second output terminal of rectifier bridge DB by means of capacitor C1, that functions as a buffer capacitor during operation. Capacitor C1 is shunted by a series arrangement of switching elements S4 and S5 and by a series arrangement of capacitor C2 and capacitor C3. A common terminal of switching element S4 and switching element S5 is connected to output terminal K1. A

20 common terminal of capacitor C2 and capacitor C3 is connected to output terminal K2 by means of the ballast means BM. During operation the output terminals K1 and K2 are coupled to the electrodes associated with the discharge paths. A first output terminal of control circuit SC is connected with a first input terminal of and-gate N1. A second output terminal of control circuit SC is connected with a first input terminal of and-gate N2. An

25 output terminal of and-gate N1 is connected to a control electrode of switching element S4. An output terminal of and-gate N2 is connected to a control electrode of switching element S5. A second input terminal of and-gate N1 and a second input terminal of and-gate N2 are connected to an output terminal of control pulse generator CPG. Input terminals of control

30 pulse generator CPG are coupled to the means P1 and the means P2 respectively. The output terminal of control pulse generator CPG is connected to an input terminal of multiplexing switch MS. Output terminals of the multiplexing switch MS are coupled respectively to the switching elements S1 and S2 in case of an embodiment as shown in Fig. 1 and to the switching elements S1, S2 and S3 in case of an embodiment as shown in Fig. 2. This

coupling is indicated in Fig.3 by means of a dotted line.

The circuit parts III and IV in Fig. 3a operate as follows. During operation the low frequency supply voltage delivered by the low frequency supply voltage source SV is rectified by the rectifier bridge DB. As a result a DC voltage is present over capacitor C1. Control circuit SC during operation generates control signals for rendering the switching elements S4 and S5 alternately conductive and non-conductive. When the output terminal of control pulse generator CPG is high, these control signals are coupled via and-gates N1 and N2 to the control electrodes of switching elements S4 and S5 rendering the switching elements S4 and S5 alternately conductive and non-conductive. As a result a discharge current is generated that flows through the ballast means BM and the discharge paths where a discharge is established by means of the auxiliary electrodes. When the output terminal of control pulse generator CPG is low, the voltage at the control electrodes of switching elements S4 and S5 is also low so that both switching elements are non-conductive and no discharge current is generated. The control pulse generator CPG generates at its output terminal a periodical substantially square wave signal having the same frequency as the operating voltage. In case of a lighting arrangement as shown in Fig. 1 each period of the substantially square wave signal comprises two rectangular pulses having a width equal to the duration of time intervals Δt_2 and Δt_4 respectively. In case of a lighting arrangement as shown in Fig. 2 each period of the substantially square wave signal comprises three rectangular pulses having a width equal to the duration of time intervals Δt_2 , Δt_4 and Δt_6 . Means P1 offer a user of the lighting arrangement the possibility to manually adjust the ratio of the widths of the rectangular pulses comprised in a period. Means P2 offer a user of the lighting arrangement the possibility to adjust the sum of the widths of the rectangular pulses comprised in a period. In a lighting arrangement as shown in Fig. 1 the multiplexing switch renders switching element S1 conductive during the first rectangular pulse in each period and renders switching element S2 conductive during the second rectangular pulse in each period. In a lighting arrangement as shown in Fig. 2 switching elements S1, S2 and S3 are respectively rendered conductive by the multiplexing switch MS during the first, second and third rectangular pulse in each period.

In Fig. 3b circuit part IV is identical to the circuit part IV shown in Fig. 3a. The circuit part III is formed by terminals K3 and K4, rectifier bridge DB, capacitor C1, switching element S6 and ballast means BM. K3 and K4 are terminals for connection to a low frequency supply voltage SV. Terminals K3 and K4 are connected to respective input terminals of rectifier bridge DB. A first output terminal of rectifier bridge DB is connected

to a second output terminal of rectifier bridge DB by means of capacitor C1, that functions as a buffer capacitor during operation. A series arrangement of switching element S6 and ballast means BM connects the first output terminal of rectifier bridge DB with output terminal K2. The second output terminal of rectifier bridge DB is connected with output terminal K1. During operation the output terminals K1 and K2 are coupled to the electrodes associated with the discharge paths. A control electrode of switching element S6 is connected to an output terminal of control pulse generator CPG.

The operation of the embodiment of circuit part III and circuit part IV as shown in Fig. 3b is as follows.

10 The control pulse generator CPG generates at its output terminal a periodical substantially square wave signal having the same frequency as the operating voltage. This substantially square wave signal renders the switching element S6 conductive and non-conductive. Thereby an operating voltage that is a substantially square wave modulated DC voltage is generated out of the DC voltage that is present over capacitor C1. This

15 embodiment of circuit part III and circuit part IV is relatively simple and is very suitable to be used in combination with discharge lamps that can be operated by means of a DC discharge current. Apart from the operating voltage being a DC-voltage the remaining part of the operation of the embodiments of circuit parts III and IV shown in Fig. 3b are similar to the embodiments shown in Fig. 3a.

CLAIMS:

1. Circuit arrangement for alternatingly with frequency f establishing and extinguishing of a discharge in each of a plurality of discharge paths, each of which is associated with a first electrode situated at a first end of the discharge path and with a second electrode situated at a second end of the discharge path, comprising means for generating
5 operating voltages out of a supply voltage, said operating voltages during operation being present over respective discharge paths and being periodical with frequency f , characterized in that the same operating voltage is present over each discharge path, in that during operation each discharge path is associated with an auxiliary electrode situated alongside the discharge path and in that the circuit arrangement further comprises switching means for
10 connecting and disconnecting each of the auxiliary electrodes with frequency f to a terminal of the circuit arrangement to establish an ignition voltage during part of each period between one of the electrodes and the auxiliary electrode associated with the same discharge path.
2. Circuit arrangement according to claim 1, wherein the terminal is at the same potential during operation as one of the electrodes of each discharge path.
- 15 3. Circuit arrangement according to claim 1 or 2, wherein the operating voltage is an alternating voltage.
4. Circuit arrangement according to one or more of the previous claims, wherein the circuit arrangement is equipped with means for supplying a heating current to the electrodes.
- 20 5. Circuit arrangement according to one or more of the previous claims wherein the amplitude of the operating voltage is substantially square wave modulated.
6. Circuit arrangement according to claim 5 wherein the time intervals during which the amplitude of the substantially square wave modulation is high are adjustable.
- 25 7. Lighting arrangement comprising a plurality of discharge paths and comprising a circuit arrangement according to one or more of the previous claims.

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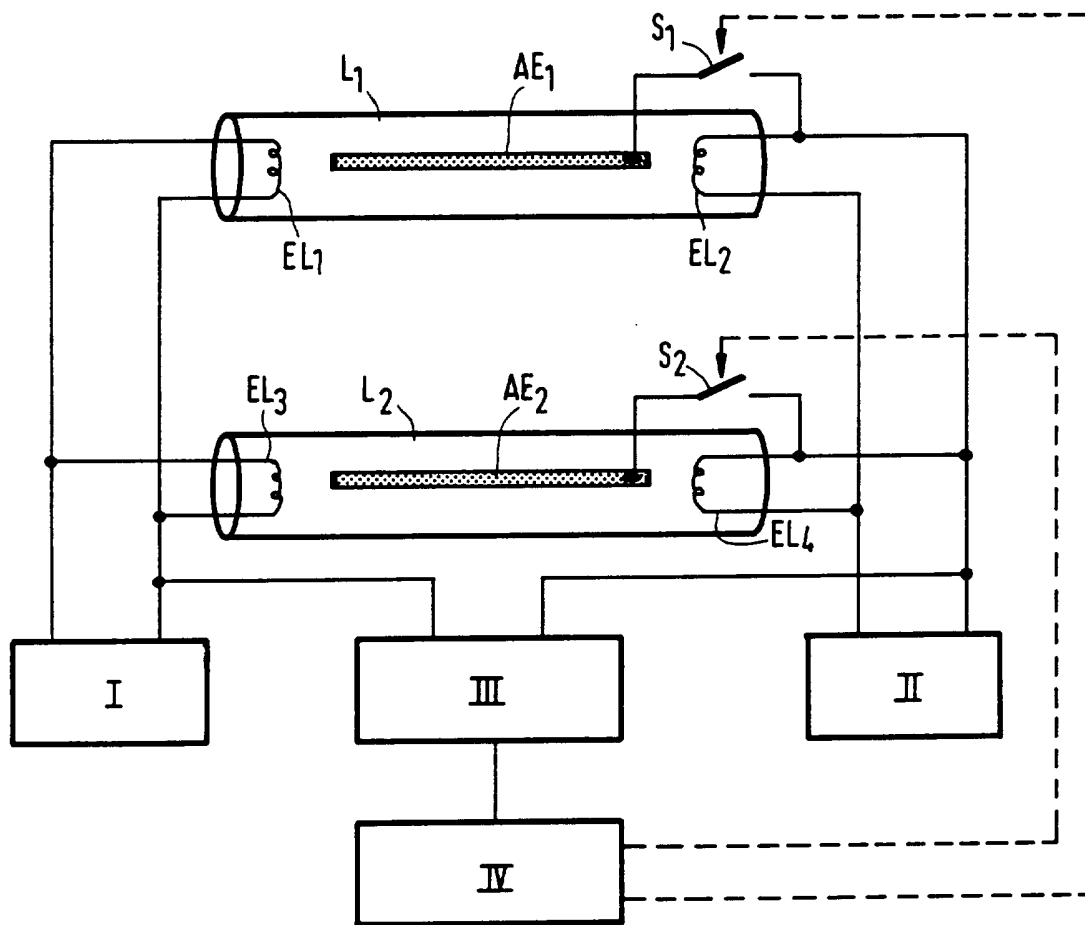


FIG.1

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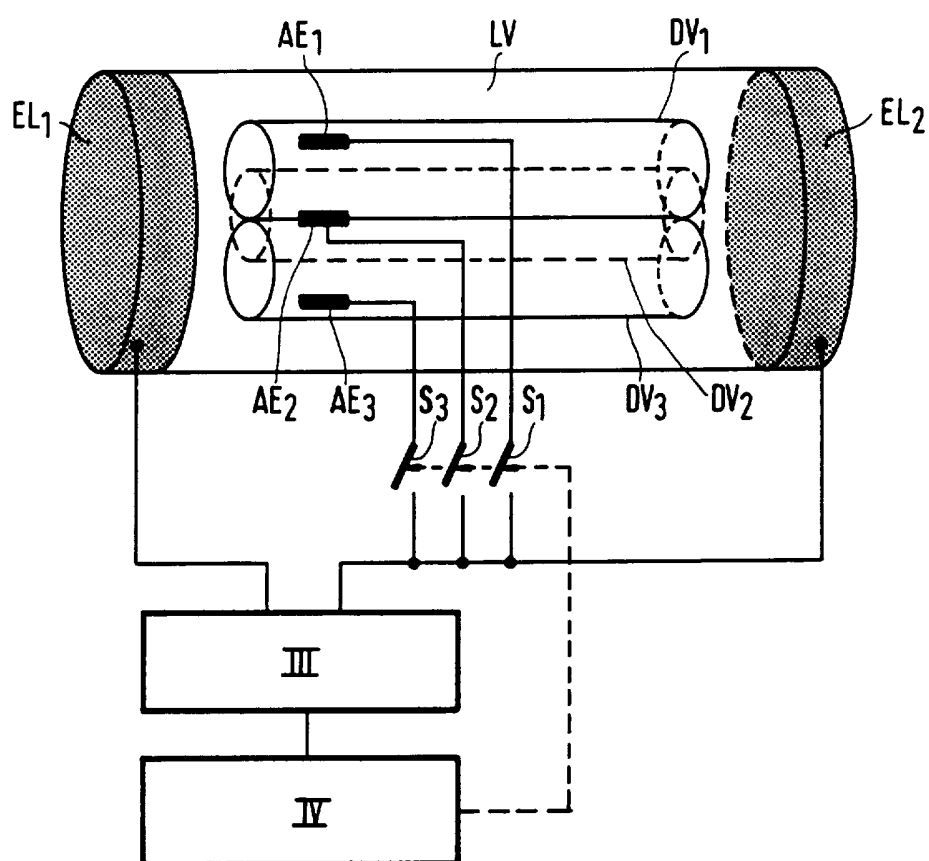


FIG. 2

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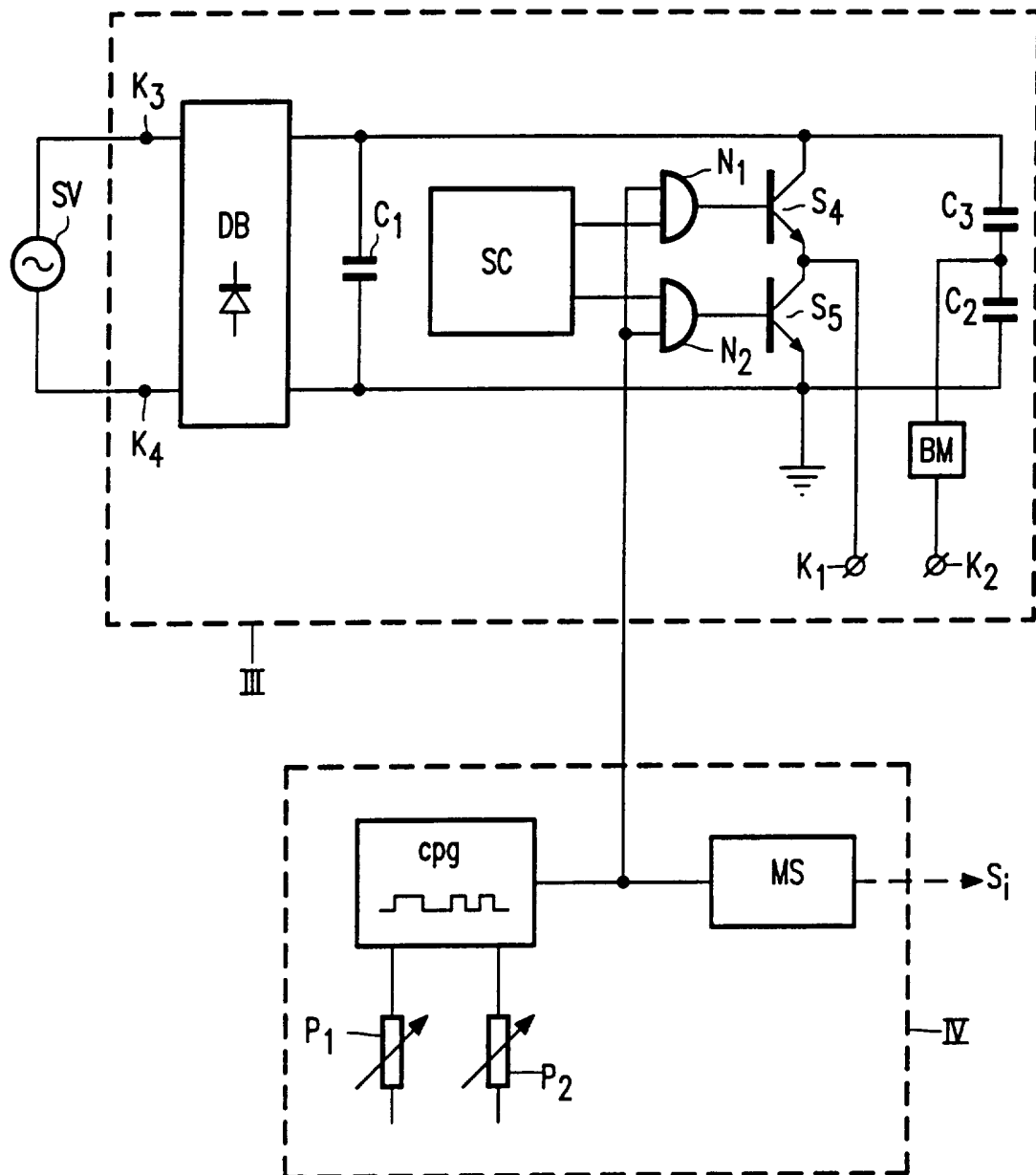


FIG. 3A

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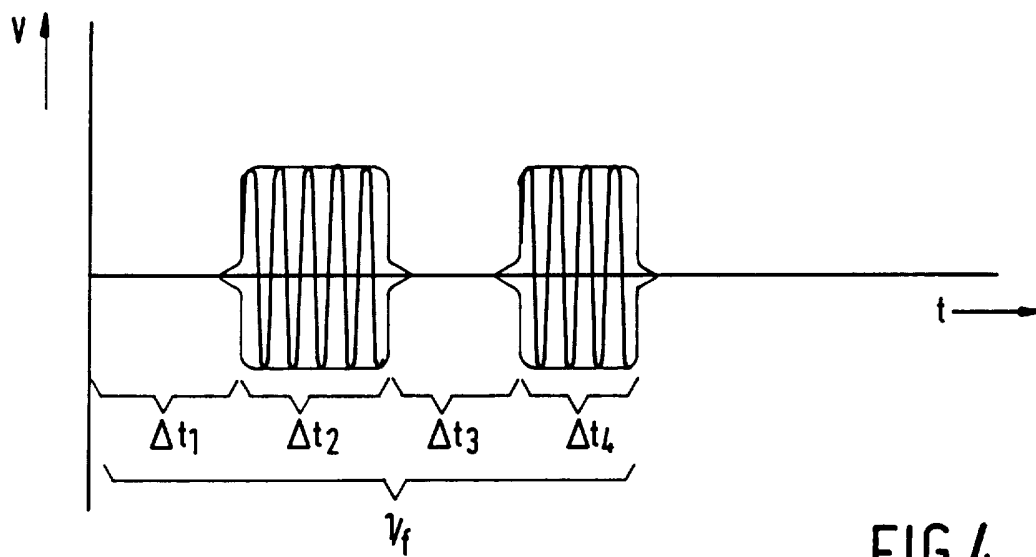


FIG. 4

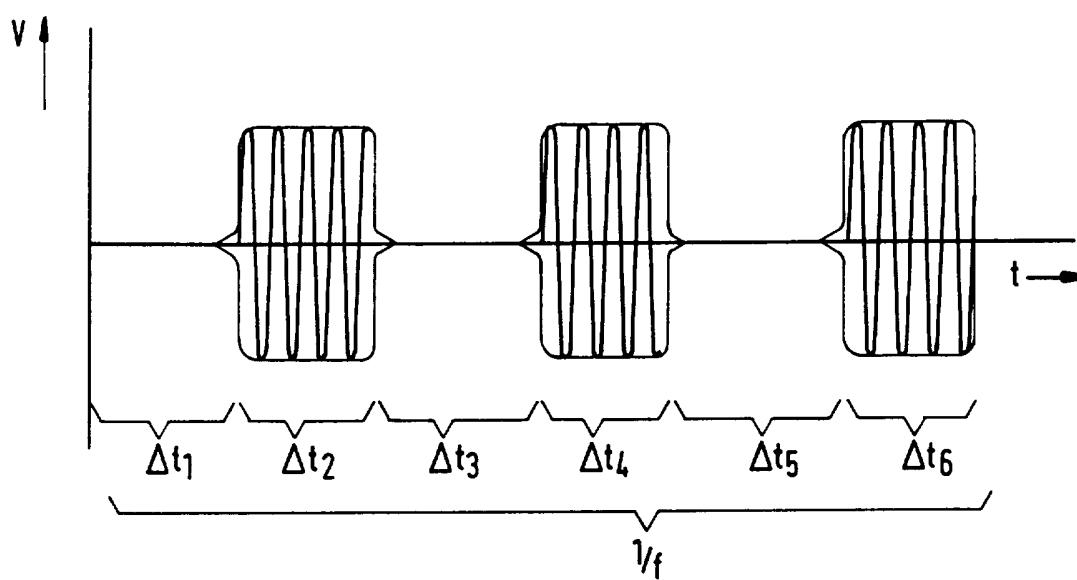


FIG. 5