(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 May 2010 (14.05.2010)

PCT

(10) International Publication Number
WO 2010/052641 A2

(51) International Patent Classification:
H05B 41/288 (2006.01) *H05B 41/392* (2006.01)

(21) International Application Number:
PCT/IB2009/054877

(22) International Filing Date:
3 November 2009 (03.11.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
08168612.3 7 November 2008 (07.11.2008) EP

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM,

[Continued on next page]

(54) **Title**: PROVIDING POWER TO GAS DISCHARGE LAMP

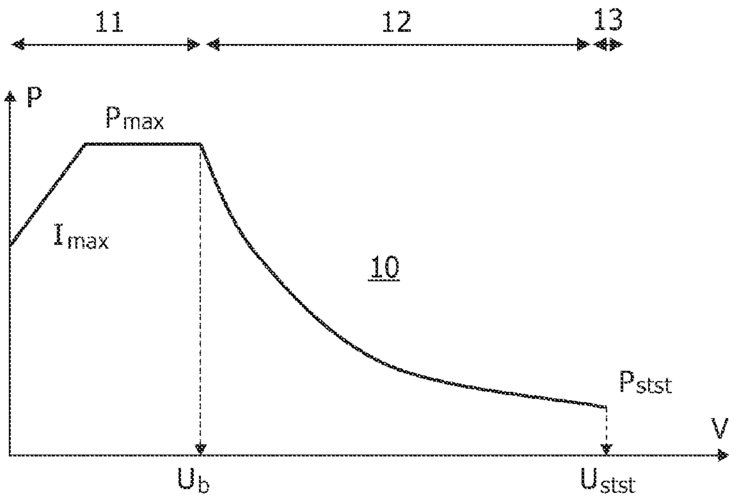

FIG. 1

(57) Abstract: A device (1) for providing an amount of power to a gas discharge lamp (2) comprises a control circuit (3) for controlling a supply circuit (4) for supplying the power according to a power versus voltage graph (10). A calculator (30) calculates a boundary voltage value as a function of a measured voltage value of a voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp (2). A more accurate boundary voltage value results in more stability and in less time required to reach a steady state. The calculator (30) may be arranged for calculating the boundary voltage value as a function of a minimum voltage value of the voltage signal and of a steady state voltage value of the voltage signal. A memory (31) may store voltage values of the voltage signal and a processor (32) may update these voltage values.

WO 2010/052641 A2

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

PROVIDING POWER TO GAS DISCHARGE LAMP

FIELD OF THE INVENTION

The invention relates to a device for providing an amount of power to a gas discharge lamp. The invention also relates to a system comprising a device, to a method, to a computer program product and to a medium.

Examples of such a device are electronic ballasts, and examples of such a system are power supplies, and/or lights comprising gas discharge lamps. The computer program product may be used in a computer, a microcontroller, and analog and/or digital control circuitry etc. As a result, the device can be any kind of control device.

BACKGROUND OF THE INVENTION

US 2005 / 0088114 discloses a discharge lamp lighting device. A discharge bulb ballast has a control circuit that includes a turning point detecting unit for detecting a turning point at which a bulb voltage starts rising after switching on a discharge bulb. Immediately after switching on the discharge bulb, a power control unit carries out control in such a manner that the discharge bulb is supplied with first power. When the turning point detecting unit detects that the voltage of the discharge bulb exceeds the turning point, the power control unit supplies the discharge bulb with second power less than the first power.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved device. It is a further object of the invention to provide a system comprising an improved device, and to provide an improved method, computer program product, and medium.

According to a first aspect of the invention, a device is provided for providing an amount of power to a gas discharge lamp, the device comprising a control circuit for controlling a supply circuit for supplying the power according to a power versus voltage graph, the power versus voltage graph defining a first state for supplying a first amount of power, the power versus voltage graph defining a second state for supplying a second amount of power, the first state ending at a boundary voltage value of a voltage signal and the second state starting at the boundary voltage value, the control circuit comprising a calculator for calculating the boundary voltage value as a function of a measured voltage value of the voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp.

A device provides for example a current signal to a gas discharge lamp. As a result, a voltage signal across the gas discharge lamp will be present. The combination of these current and voltage signals defines an amount of power provided to the gas discharge lamp. The device comprises a control circuit for controlling a supply circuit for supplying the power according to a power versus voltage graph. This power versus voltage graph defines a first state for supplying a first amount of power. This power versus voltage graph defines a second state for supplying a second amount of power. A border between these first and second states is situated at a boundary voltage value of the voltage signal present across the gas discharge lamp, also known as turning point voltage value. The control circuit comprises a calculator for calculating the boundary voltage value as a function of a measured voltage value of the voltage signal that has been measured after a predefined time-interval has elapsed. This predefined time-interval is started at a cold start of the gas discharge lamp.

In Figure 7 of US 2005 / 0088114, a minimum value of the voltage signal is detected. Then, a predefined voltage value is added to said minimum value, to find a turning point voltage value. This is a relatively inaccurate way to find the turning point voltage value. For a particular kind of lamp, the minimum value appears for example one second after a cold start of the lamp. The minimum value itself as well as its moment of appearance may depend on many circumstances, like a lamp temperature at a start and a lamp age. According to the invention, a more accurate way to find the boundary voltage value has been realized by measuring a voltage value of the voltage signal at a fixed moment in time, such as for example, for a particular kind of lamp, five, six or seven seconds after a cold start of the gas discharge lamp, or such as for example, for a more general kind of lamp, any time value between two and ten seconds, and by calculating the boundary voltage value as a function of this measured voltage value. As a result, an improved device has been created.

A further advantage might be that a more accurate boundary voltage value results in more accuracy and in less time required to reach the steady state.

Instead of measuring the voltage value of the voltage signal present across the gas discharge lamp, a voltage value may be measured of another voltage signal derived from said voltage signal present across the gas discharge lamp. Said derivation may for example be done a voltage divider. The function may take this derivation into account and/or may be based on this derivation. Said calculator can be any kind of analog and/or digital machine in hardware and/or software.

According to an embodiment, the device is defined by the calculator being arranged for calculating the boundary voltage value as a function of a minimum voltage value of the voltage signal and as a function of a steady state voltage value of the voltage signal. By calculating the boundary voltage value as a function of said measured voltage value and of said minimum voltage value and said steady state voltage value, an even more accurate boundary voltage value will be determined, owing to the fact that three functions are combined.

Alternatively, only one of the functions of the minimum voltage value of the voltage signal and of the steady state voltage value of the voltage signal may be combined with the function of the measured voltage value of the voltage signal. Preferably, each function may be of the type f (x) = p x + q with p and q being selected per function. In other words, each function f (x) may comprise a term p x + q with p and q being selected per function.

Further alternatively, the boundary voltage value may be calculated as a function of more than one minimum voltage value of the voltage signal. Two or more minimum voltage values of the voltage signal may occur for two or more different situations, such as for example two or more different starting temperatures of the lamp. Each minimum voltage value of the voltage signal may only be a minimum value in a certain time-interval, so the voltage signal may have different minimum values in different time-intervals.

According to an embodiment, the device is defined by the function of the measured voltage value of the voltage signal comprising a first weighting factor, the function of the minimum voltage value of the voltage signal comprising a second weighting factor, and the function of the steady state voltage value of the voltage signal comprising a third weighting factor, a sum of the weighting factors being equal to a predefined value. This way, a most accurate boundary voltage value can be determined.

In case the boundary voltage value is calculated as a function of more than one minimum voltage value of the voltage signal, more than one weighting factor may need to be used, such as for example one weighting factor per minimum voltage value.

According to an embodiment, the device is defined by the first amount of power comprising an increasing amount of power during a first part of the first state while supplying a maximum current to the gas discharge lamp, the first amount of power comprising a maximum amount of power during a second part of the first state, and the second amount of power comprising a decreasing amount of power until the steady state voltage value of the voltage signal has been reached. The increasing amount of power results from increasing voltage values of the voltage signal in combination with the maximum current. The maximum amount of power results from increasing voltage values of the voltage signal in combination with a decreasing current. The decreasing amount of power results from increasing voltage values of the voltage signal in combination with an even more decreasing current.

According to an embodiment, the device is defined by the power versus voltage graph defining a third state for supplying a third amount of power, the third state starting at the steady state voltage value of the voltage signal, the third amount of power comprising a stable amount of power. A stable amount of power is an amount that changes less than for example 1% per second, preferably less than 0.1% per second.

According to an embodiment, the device is defined by the control circuit comprising a memory for storing the measured voltage value of the voltage signal and comprising a processor for updating the measured voltage value stored in the memory. After a start of the gas discharge lamp, a stored measured value is used to calculate a boundary voltage value, and a more recent measured value is used for updating the stored measured value.

According to an embodiment, the device is defined by the control circuit comprising a memory for storing the measured voltage value of the voltage signal and the minimum voltage value of the voltage signal and the steady state voltage value of the voltage signal and comprising a processor for updating the voltage values stored in the memory. After a start of the gas discharge lamp, stored values are used to calculate a boundary voltage value, and more recent values are used for updating the stored values.

According to an embodiment, the device is defined by the device being an electronic ballast for the gas discharge lamp.

According to a second aspect of the invention, a system is provided comprising the device and comprising the supply circuit, in which case the system can be a power supply, and/or comprising the gas discharge lamp, in which case the system can be a light. A combination of a power supply and a light is not to be excluded.

According to a third aspect of the invention, a method is provided for providing an amount of power to a gas discharge lamp, the method comprising a step of controlling a supply of the power according to a power versus voltage graph, the power versus voltage graph defining a first state for supplying a first amount of power, the power versus voltage graph defining a second state for supplying a second amount of power, the first state ending at a boundary voltage value of a voltage signal and the second state starting at the boundary voltage value, the step of controlling comprising a sub-step of calculating the boundary voltage value as a function of a measured voltage value of the voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp.

According to a fourth aspect of the invention, a computer program product is provided for performing the step of the method.

According to a fifth aspect of the invention, a medium is provided for storing and comprising the computer program product.

Embodiments of the system and of the method correspond with the embodiments of the device.

An insight might be that for a power versus voltage graph of a gas discharge lamp, the boundary voltage value should (also) depend on a relatively stable voltage value of the voltage signal.

A basic idea might be that for a power versus voltage graph of a gas discharge lamp, the boundary voltage value is to be calculated as a function of a measured voltage value of the voltage signal that has been measured after a predefined time-interval from a cold start.

A problem to provide an improved device has been solved.

A further advantage might be that a more accurate boundary voltage value results in more accuracy and in less time required to reach the steady state.

These and other aspects of the invention are apparent from and will be elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

Fig. 1 shows a power versus voltage graph,

Fig. 2 shows a system comprising a device,

Fig. 3 shows a control circuit,

Fig. 4 shows a power defining algorithm,
Fig. 5 shows a boundary voltage as a function of a timed voltage,
Fig. 6 shows a voltage as a function of a time for Fig. 5,
Fig. 7 shows a boundary voltage as a function of a minimum voltage,
Fig. 8 shows a voltage as a function of a time for Fig. 7,
Fig. 9 shows a boundary voltage as a function of a steady state voltage,
Fig. 10 shows a voltage as a function of a time for Fig. 9, and
Fig. 11 shows a measured boundary voltage versus a calculated boundary voltage.

DETAILED DESCRIPTION OF EMBODIMENTS

In the Fig. 1, a power versus voltage graph 10 of a gas discharge lamp is shown. The power versus voltage graph 10 defines a first state 11 for supplying a first amount of power. The power versus voltage graph 10 defines a second state 12 for supplying a second amount of power. The first state 11 ends at a boundary voltage value U_b of a voltage signal and the second state 12 starts at the boundary voltage value U_b. The first amount of power comprises an increasing amount of power during a first part of the first state 11 while supplying a maximum current I_{max} to the gas discharge lamp. The first amount of power comprises a maximum amount of power P_{max} during a second part of the first state 11. The second amount of power comprises a decreasing amount of power until a steady state voltage value U_{stst} of the voltage signal has been reached. The power versus voltage graph 10 defines a third state 13 for supplying a third amount of power. The third state 13 starts at the steady state voltage value U_{stst}. The third amount of power comprises a stable amount of power.

In the Fig. 2, a system 6 is shown comprising a device 1. The system 6 further comprises a gas discharge lamp 2 connected to a supply circuit 4 for supplying an amount of power according to the power versus voltage graph 10 shown in the Fig. 1. Thereto, the supply circuit 4 supplies for example a current signal to the gas discharge lamp 2, which current signal results in a voltage signal across the gas discharge lamp 2. A combination of these current and voltage signals defines an amount of power. The supply circuit 4 is for example connected to a rectifier 5 for rectifying a mains voltage. Alternatively, a battery may be used. The device 1 comprises a control circuit 3 connected to the gas discharge lamp 2 (in parallel to the supply circuit 4) and for example connected to the rectifier 5 (in parallel to the supply circuit 4). A control output of the control circuit 3 is connected to a control input of the supply circuit 4. Between the gas discharge lamp 2 and the supply circuit 4, or in/near the gas discharge lamp 2, or in/near the supply circuit 4, an ignition circuit may be present (not shown).

In the Fig. 3, the control circuit 3 is shown in greater detail. The control circuit 3 comprises a calculator 30 for calculating the boundary voltage value U_b as a function of a measured voltage value U_T of the voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp 2. According to an option, the calculator 30 may further calculate the boundary voltage value U_b as a function of a minimum voltage value U_{min} of the voltage signal and as a function of a steady state voltage value U_{stst} of the voltage signal. According to a further option, the function of the measured voltage value U_T of the voltage signal comprising a first weighting factor A, the function of the minimum voltage value U_{min} of the voltage signal comprising a second weighting factor B, and the function of the steady state voltage value U_{stst} of the voltage signal comprising a third weighting factor C, a sum of the weighting factors being equal to a predefined value ($A + B + C = D$, D is for example equal to 1, without having excluded other predefined values).

An output of the calculator 30 constitutes the control output of the control circuit 3 and an input of the calculator 30 is for example connected to a processor 32. The processor 32 is connected to a memory 31 and is for example connected to a voltage determining circuit 33 and a feeding circuit 34. The feeding circuit 34 for example feeds the calculator 30, the memory 31, the processor 32 and the voltage determining circuit 33. The voltage determining circuit 33 determines the measured voltage value U_T of the voltage signal by for example measuring this voltage value after a predefined time-interval from a cold start of the gas discharge lamp 2 in response to an instruction from the processor 32. The voltage determining circuit 33 may further determine other voltage values of the voltage signal by for example measuring these voltage values and supplying the measured voltage values to the processor 32 to for example find the minimum voltage value U_{min} of the voltage signal and the steady state voltage value U_{stst} of the voltage signal by for example comparing the measured voltage values with each other. The processor 32 may thereto comprise an analog comparator or comparing function, alternatively this analog comparator or comparing function may be located inside the voltage determining circuit 33 etc. Alternatively, the voltage determining circuit 33 may comprise an analog to digital converter, and the processor 32 may then comprise a digital comparator or comparing function, alternatively this digital comparator or comparing function may be located inside the voltage determining circuit 33 etc. The calculator 30 may form part of the processor 32, or vice versa.

The memory 31 stores the measured voltage value U_T of the voltage signal and the processor 32 updates the measured voltage value U_T stored in the memory 31. The memory 31 may further store the minimum voltage value U_{min} of the voltage signal and the steady state voltage value U_{stst} of the voltage signal and the processor 32 may further update these voltage values stored in the memory 31. After a start of the gas discharge lamp 2, one or more stored values may be used to calculate the boundary voltage value U_b, and one or more recent values may be used for updating the stored values.

The units 30-33 may be hardware units and/or software units and may form part of a computer or a microcontroller or analog and/or digital control circuitry etc.

In the Fig. 4, a power defining algorithm is shown. At a block 40, a measured voltage value U is presented. At a block 41, a (calculated) boundary voltage value U_b is presented. At a block 42, a (measured) steady state voltage value U_{stst} is presented. At blocks 43 and 44 differences are determined, and at a block 45 a division is made such that at the output of the block 45 a normalized voltage value U_{norm} is available:

$U_{norm} = (U-U_{stst}) / (U_b-U_{stst})$. Other ways to normalize the voltage are not to be excluded. This normalized voltage value U_{norm} is offered to a block 46 that for example calculates a polynomial $15\ x^3 + 13\ x^2 + 7\ x + 35$ or any other kind of polynomial. At blocks 47 and 48, a maximum power P_{max} and a minimum power P_{min} are defined, and at a block 49, the information from the blocks 46, 47 and 48 is converted into an output power defined at a block 50 and to be provided to the gas discharge lamp 2. Thereby, according to an embodiment, as long as the calculated polynomial has a value between the maximum power P_{max} and the minimum power P_{min}, this value is offered, if said value is larger than the maximum power P_{max}, this maximum power P_{max} is offered, and if said value is smaller than the minimum power P_{min}, this minimum power P_{min} is offered.

In the Fig. 5, a boundary voltage U_b (V) as a function of the measured voltage U_T (V) is shown. The measured voltage value U_T of the voltage signal is to be measured after a predefined time-interval T from a cold start of the gas discharge lamp 2. The Fig. 6 shows a voltage U (V) as a function of a time t (s) for the Fig. 5. Clearly, after having measured U_T, U_b can be calculated.

In the Fig. 7, a boundary voltage U_b (V) as a function of a minimum voltage U_{min} (V) is shown. The Fig. 8 shows a voltage U (V) as a function of a time t (s) for the Fig. 7. Clearly, after having determined U_{min}, U_b can be calculated.

In the Fig. 9, a boundary voltage U_b (V) as a function of a steady state voltage U_{stst} (V) is shown. The Fig. 10 shows a voltage U (V) as a function of a time t (s) for the Fig. 9. Clearly, after having determined U_{stst}, U_b can be calculated.

In the Fig. 11, a measured boundary voltage $U_{b,m}$ (V) versus a calculated boundary voltage $U_{b,c}$ (V) is shown.

A possible algorithm might be as follows. After the predefined time-interval T, such as for example five, six or seven seconds for a particular kind of gas discharge lamp 2, or such as for example for a more general kind of lamp any time value between two and ten seconds, the voltage value U_T of the voltage signal is to be measured. This measured voltage value U_T of the voltage signal is to be compared with a previous voltage value U_T stored in the memory 31. In response to a first comparison result (non-cold start) the previous voltage value U_T stored in the memory 31 is to be replaced by the measured voltage value U_T of the voltage signal. In response to a different second comparison result (cold start) the previous voltage value U_T stored in the memory 31 is to be replaced by a new voltage value U_T depending on for example the measured voltage value U_T of the voltage signal and one or more, such as for example 20, previously stored voltage values U_T.

After another predefined time-interval, such as for example 120 seconds for a particular kind of gas discharge lamp 2, the steady state voltage value U_{stst} of the voltage signal is to be measured. This steady state voltage value U_{stst} of the voltage signal is to be compared with a previous steady state voltage value U_{stst} stored in the memory 31. In response to a first comparison result the previous steady state voltage value U_{stst} stored in the memory 31 is to be replaced by the measured steady state voltage value U_{stst} of the voltage signal. In response to a different second comparison result the previous steady state voltage value U_{stst} stored in the memory 31 is to be replaced by a new steady state voltage value U_{stst} depending on for example the measured steady state voltage value U_{stst} of the voltage signal and one or more previously stored steady state voltage values U_{stst}. With the updated voltage values, a new boundary voltage value U_b is to be calculated, and the new boundary voltage value U_b and the new steady state voltage value U_{stst} can be used for a next calculation of the amount of power to be provided etc.

Of course, in addition, after having measured / determined one of the voltage values U_T and U_{stst}, a measurement / determination result can be used for updating the (calculated) other one.

After a cold start of an existing particular gas discharge lamp 2, U_T and U_{stst} can be updated. After a non-cold start of the existing particular gas discharge lamp 2, U_T can be kept as it is and U_{stst} can be updated. After a cold start of a novel particular gas discharge lamp 2, U_T and U_{stst} are to be determined. After a non-cold start of the novel particular gas discharge lamp 2, U_T can be kept as it is and U_{stst} can be updated.

Summarizing, a device 1 for providing an amount of power to a gas discharge lamp 2 comprises a control circuit 3 for controlling a supply circuit 4 for supplying the power according to a power versus voltage graph 10. A calculator 30 calculates a boundary voltage value as a function of a measured voltage value of a voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp 2. A more accurate boundary voltage value results in more accuracy and in less time required to reach a steady state. The calculator 30 may be arranged for calculating the boundary voltage value as a function of a minimum voltage value of the voltage signal and of a steady state voltage value of the voltage signal. A memory 31 may store voltage values of the voltage signal and a processor 32 may update these voltage values.

While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. For example, it is possible to operate the invention in an embodiment wherein different parts of the different disclosed embodiments are combined into a new embodiment.

Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. A computer program may be stored / distributed on a suitable medium, such as an optical storage medium or a solid-state medium supplied together with or as part of other hardware, but may also be distributed in other forms, such as via the Internet or other wired or wireless telecommunication systems. Any reference signs in the claims should not be construed as limiting the scope.

CLAIMS:

1. A device (1) for providing an amount of power to a gas discharge lamp (2), the device (1) comprising a control circuit (3) for controlling a supply circuit (4) for supplying the power according to a power versus voltage graph (10), the power versus voltage graph (10) defining a first state (11) for supplying a first amount of power, the power versus voltage graph (10) defining a second state (12) for supplying a second amount of power, the first state (11) ending at a boundary voltage value of a voltage signal and the second state (12) starting at the boundary voltage value, the control circuit (3) comprising a calculator (30) for calculating the boundary voltage value as a function of a measured voltage value of the voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp (2).

2. The device (1) as claimed in claim 1, the calculator (30) being arranged for calculating the boundary voltage value as a function of a minimum voltage value of the voltage signal and as a function of a steady state voltage value of the voltage signal.

3. The device (1) as claimed in claim 2, the function of the measured voltage value of the voltage signal comprising a first weighting factor, the function of the minimum voltage value of the voltage signal comprising a second weighting factor, and the function of the steady state voltage value of the voltage signal comprising a third weighting factor, a sum of the weighting factors being equal to a predefined value.

4. The device (1) as claimed in claim 2, the first amount of power comprising an increasing amount of power during a first part of the first state (11) while supplying a maximum current to the gas discharge lamp (2), the first amount of power comprising a maximum amount of power during a second part of the first state (11), and the second amount of power comprising a decreasing amount of power until the steady state voltage value of the voltage signal has been reached.

5. The device (1) as claimed in claim 2, the power versus voltage graph (10) defining a third state (13) for supplying a third amount of power, the third state (13)

starting at the steady state voltage value of the voltage signal, the third amount of power comprising a stable amount of power.

6. The device (1) as claimed in claim 1, the control circuit (3) comprising a memory (31) for storing the measured voltage value of the voltage signal and comprising a processor (32) for updating the measured voltage value stored in the memory (31).

7. The device (1) as claimed in claim 2, the control circuit (3) comprising a memory (31) for storing the measured voltage value of the voltage signal and the minimum voltage value of the voltage signal and the steady state voltage value of the voltage signal and comprising a processor (32) for updating the voltage values stored in the memory (31).

8. The device (1) as claimed in claim 1, the device (1) being an electronic ballast for the gas discharge lamp (2).

9. A system (6) comprising the device (1) as claimed in claim 1 and comprising the supply circuit (4) and/or comprising the gas discharge lamp (2).

10. A method for providing an amount of power to a gas discharge lamp (2), the method comprising a step of controlling a supply of the power according to a power versus voltage graph (10), the power versus voltage graph (10) defining a first state (11) for supplying a first amount of power, the power versus voltage graph (10) defining a second state (12) for supplying a second amount of power, the first state (11) ending at a boundary voltage value of a voltage signal and the second state (12) starting at the boundary voltage value, the step of controlling comprising a sub-step of calculating the boundary voltage value as a function of a measured voltage value of the voltage signal that has been measured after a predefined time-interval from a cold start of the gas discharge lamp (2).

11. A computer program product for performing the step of the method as claimed in claim 10.

12. A medium for storing and comprising the computer program product as claimed in claim 11.

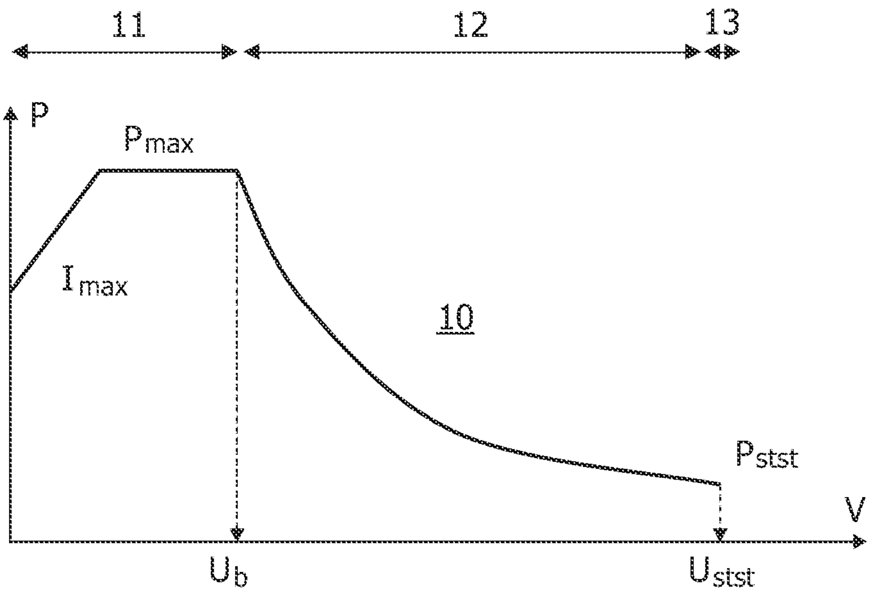

FIG. 1

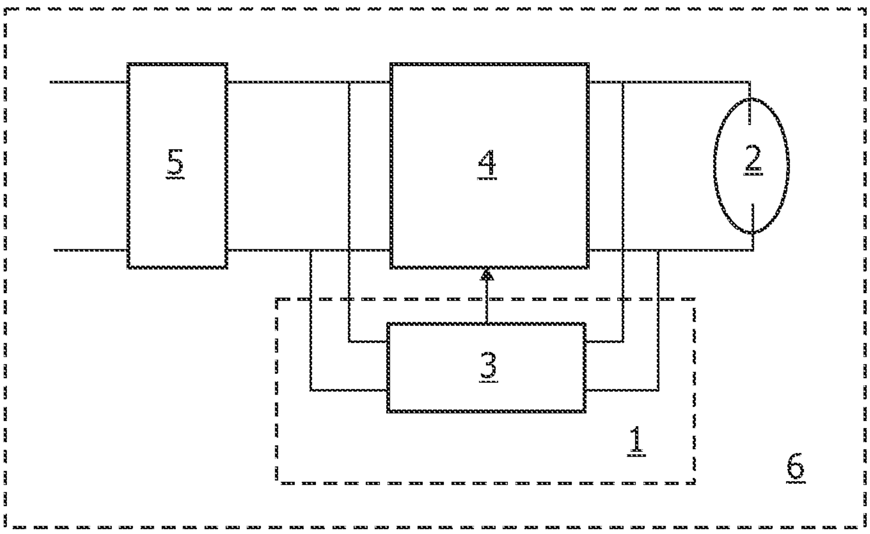

FIG. 2

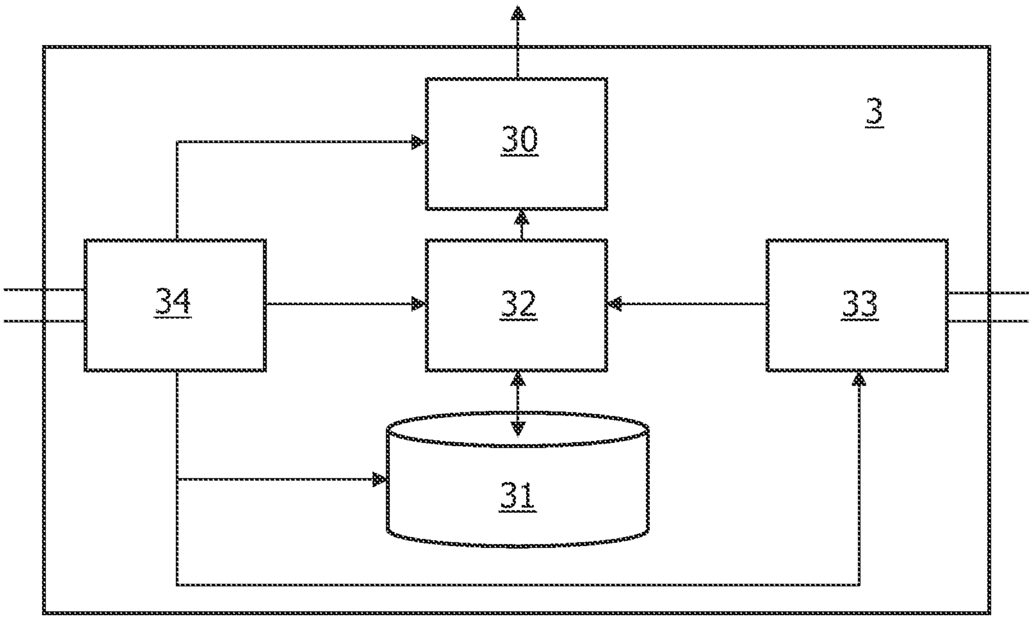

FIG. 3

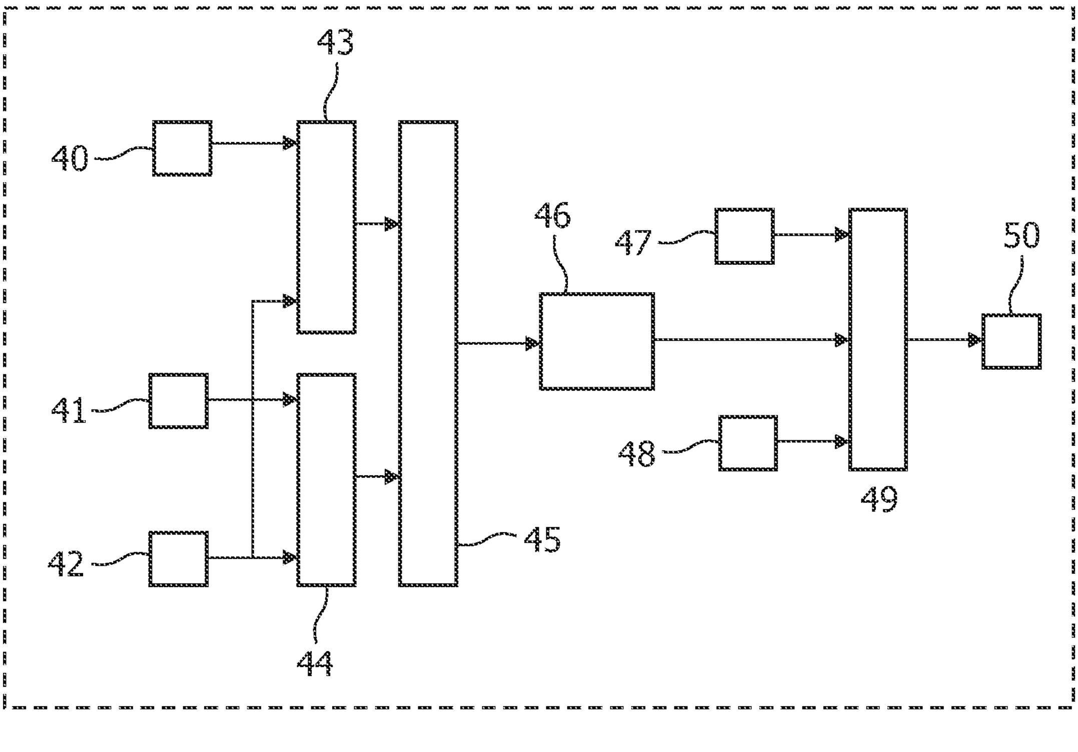

FIG. 4

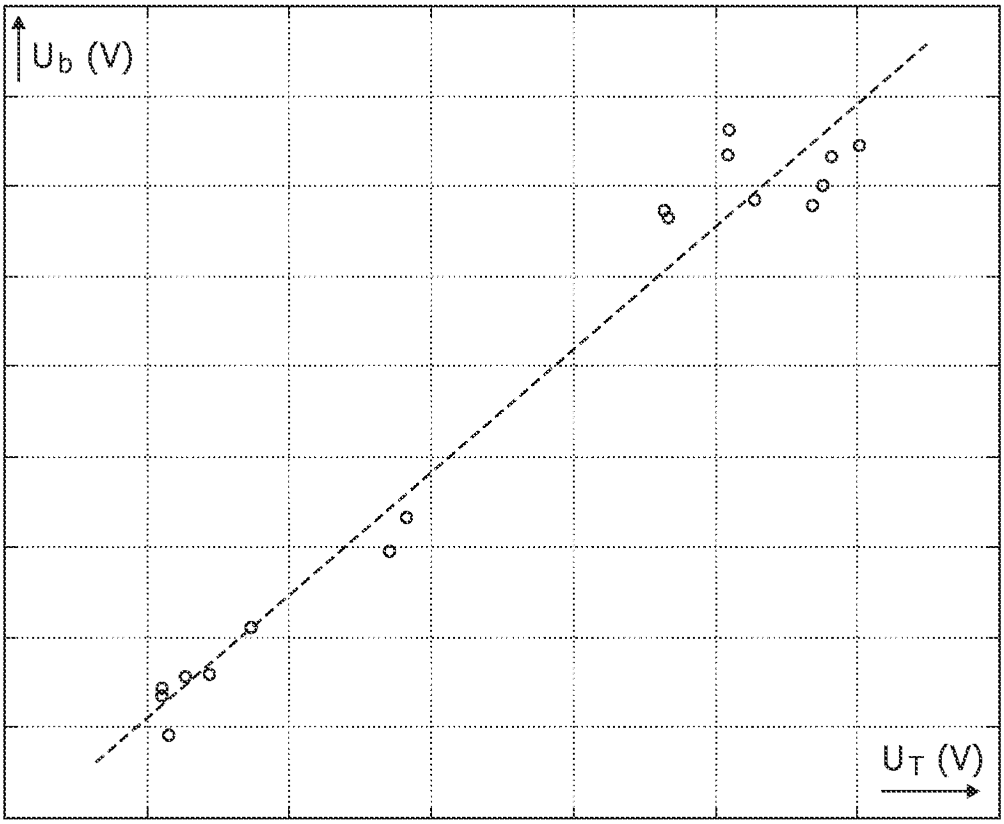

FIG. 5

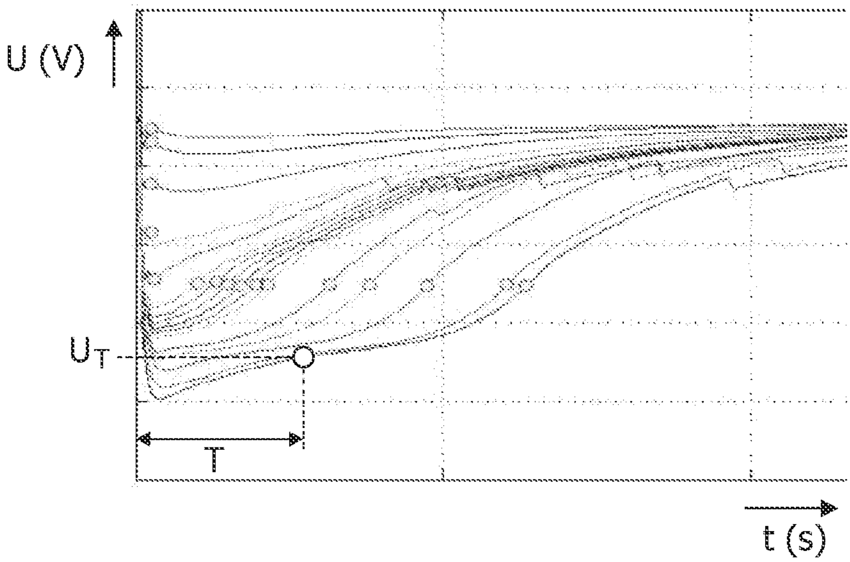

FIG. 6

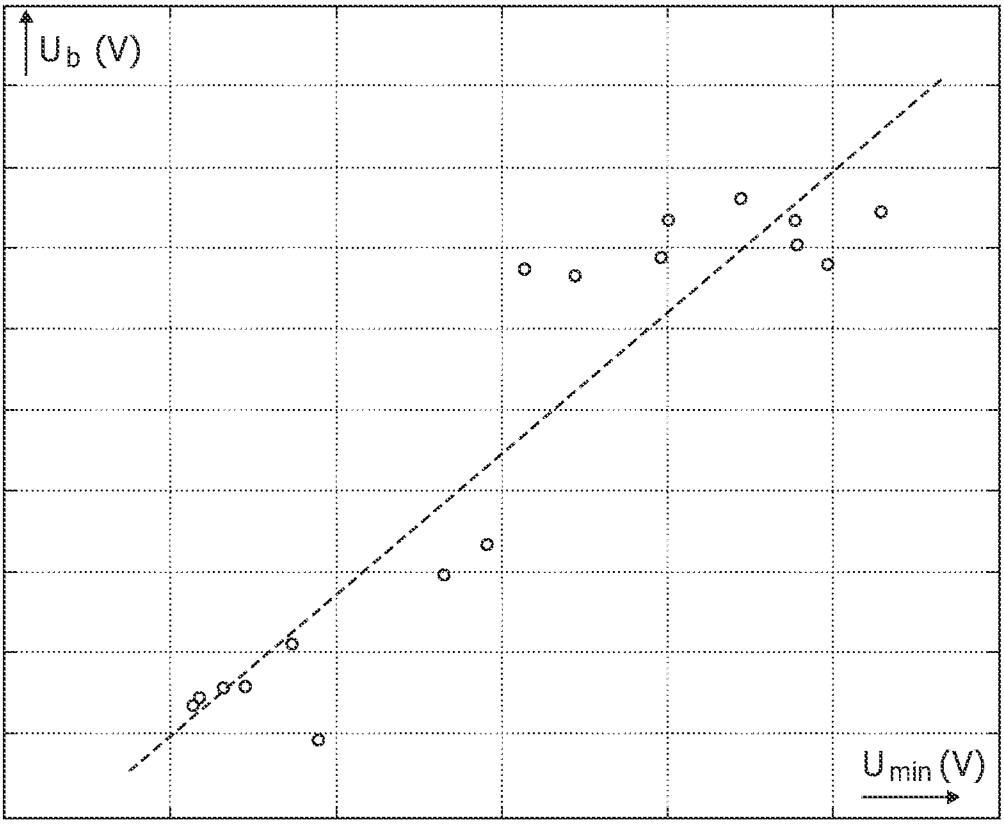

FIG. 7

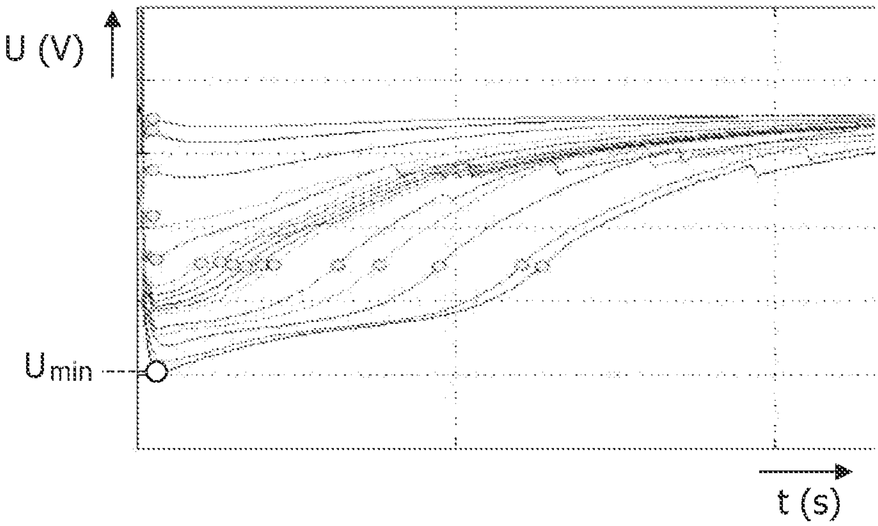

FIG. 8

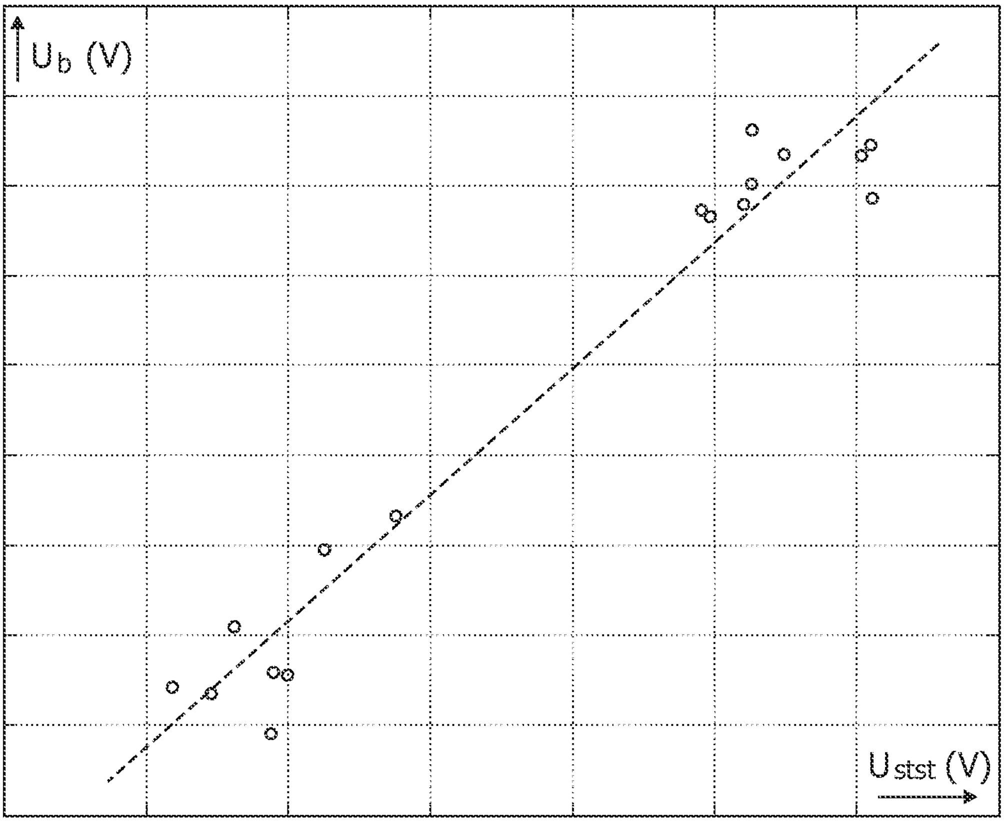

FIG. 9

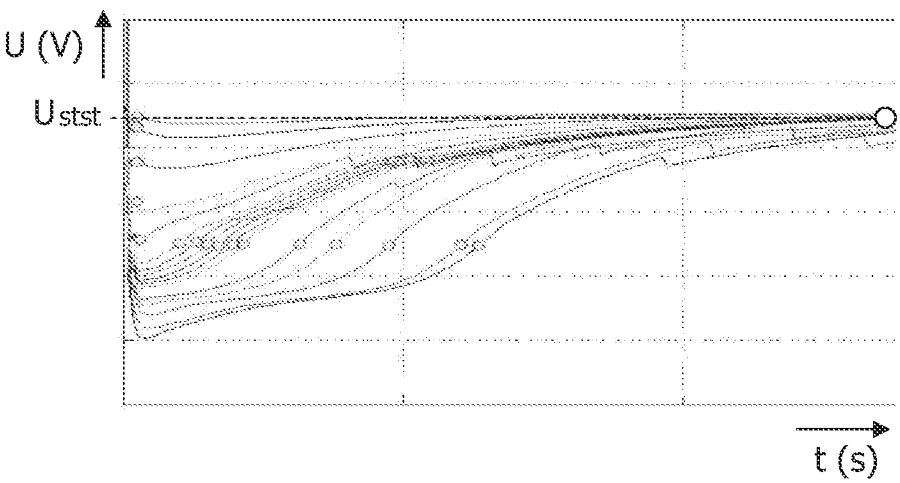

FIG. 10

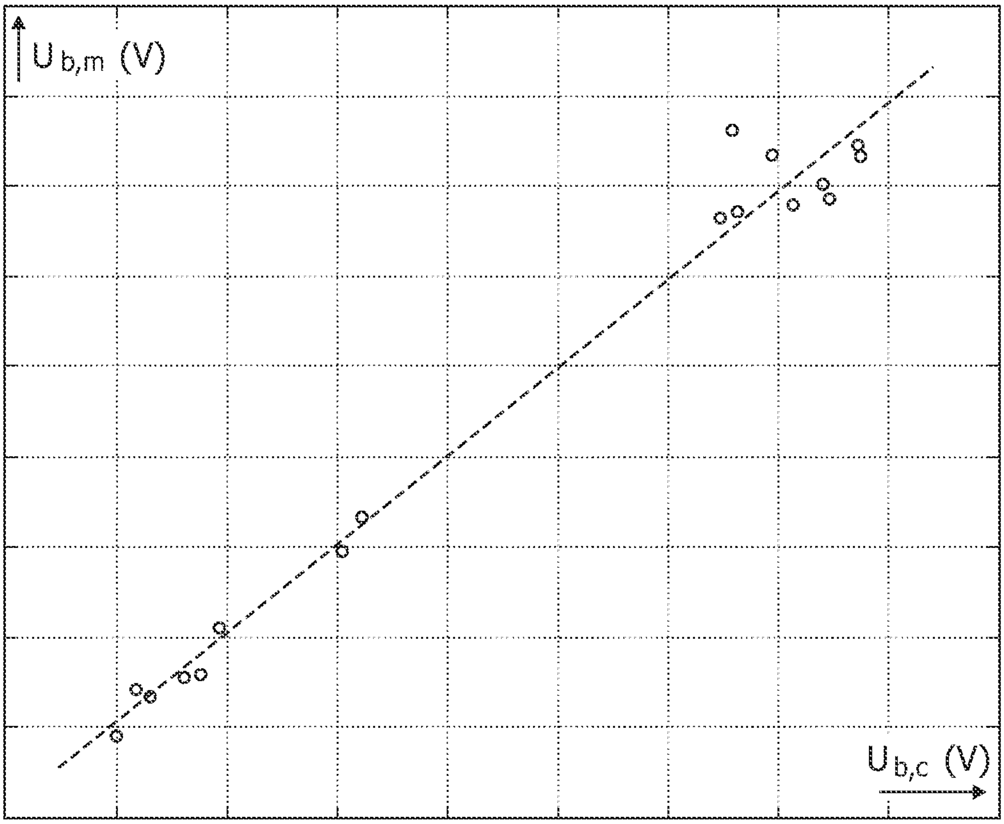

FIG. 11