(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 893 943 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
15.02.2006 Bulletin 2006/07

(51) Int Cl.:
H05B 41/392 *(2006.01)*

(21) Application number: **97202310.5**

(22) Date of filing: **24.07.1997**

(54) **Inverter for a gas discharge lamp with stepwise variable frequencies**

Wechselrichter zur Versorgung einer Entladungslampe mit sprunghaft veränderlicher Frequenz

Onduleur à fréquence graduellement variable pour alimenter une lampe à décharge

(84) Designated Contracting States:
AT BE DE ES FI FR GB IE IT NL SE

(43) Date of publication of application:
27.01.1999 Bulletin 1999/04

(73) Proprietor: **F. Verdeyen N.V.**
3400 Landen (BE)

(72) Inventors:
- **Van Tichelen, Paul Jos Luc**
B-3001 Leuven (BE)
- **Weyen, Dominique**
B-3920 Lommel (BE)

(74) Representative: **Eveleens Maarse, Pieter**
Arnold & Siedsma,
Advocaten en Octrooigemachtigden,
Sweelinckplein 1
2517 GK Den Haag (NL)

(56) References cited:

EP-A- 0 066 927	**EP-A- 0 291 223**
EP-A- 0 397 334	**EP-A- 0 633 711**
EP-A- 0 744 883	**EP-A- 0 746 186**
US-A- 4 523 128	**US-A- 5 365 151**
US-A- 5 394 064	**US-A- 5 481 163**

Remarks:
The file contains technical information submitted after the application was filed and not included in this specification

EP 0 893 943 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The invention relates to an inverter for feeding a gas discharge lamp, comprising:

- a direct voltage source;
- at least two switch elements incorporated in a bridge circuit;
- a control circuit for controlling the switch elements so that the bridge circuit continuously generates an alternating voltage;
- at least one ballast inductance connected to one of the output terminals of the bridge circuit; and
- at least one gas discharge lamp connected between the ballast inductance and the other output terminal of the bridge circuit.

[0002] Such an inverter is known from US-A-5 569 984.

[0003] In high-frequency feed of gas discharge lamps, which is per se attractive in respect of the attractive dimensioning of the frequency-dependent components which goes together with high frequencies, it is generally known that acoustic resonances can occur in gas discharge lamps. If they persist for long enough, such acoustic resonances can result in destruction of the lamp or in considerable shortening of the lifespan of the lamp.

[0004] The above mentioned literature reference therefore teaches choosing the power supply frequency of the gas discharge lamp such that at the chosen frequency acoustic resonance is prevented. Once a frequency has been chosen the inverter will continue to operate at the said frequency.

[0005] In order to choose the correct frequency a selection procedure is run during start-up of the lamp. Use is made herein of a parameter of the lamp to be monitored outside the lamp, such as light output and the like, which is used as indicator for the occurrence of acoustic resoance. If this parameter gives an indication for the occurrence of acoustic resonance a following frequency is chosen. After a time this procedure is completed and the feed of the lamp is retained with the chosen frequency wherein no resonance occurs.

[0006] From US-A 5 365 151 is known a similar circuit, wherein the gas discharge lamp is also fed with different frequencies and wherein the frequency of the lamp is changed for instance to vary the light output or the colour of the light generated by the lamp. This relates however to two separate frequencies or a frequency which varies continuously within a frequency range.

[0007] The circuit known from the first literature reference has the drawback that in the course of time, for instance due to thermal phenomena, the properties of the lamp change so that, at a determined power supply frequency wherein initially no acoustic resonance occurred, acoustic resonance can begin to occur after a period of time. This could result in the above stated drawbacks.

[0008] Finally, the journal article "White-Noise Modulation of High-Frequency High-Intensity Discharge Lamp Ballasts" by Laskai et al. describes a circuit wherein the power is modulated continuously in a random distribution in order to prevent inter alia acoustic resonance; stepwise varying of the frequency is not discussed here either.

[0009] EP-A-0 397 334 discloses a inverter for feeding a gas discharge lamp, comprising:

- a direct voltage source;
- at least two switch elements incorporated in a bridge circuit;
- a control circuit for controlling the switch elements so that the bridge circuit continuously generates an alternating voltage;
- at least one ballast inductance connected to one of the output terminals of the bridge circuit; and
- at least one gas discharge lamp connected between the ballast inductance and the other output terminal of the bridge circuit, wherein the control circuit is adapted to apply at its output terminals a control signal to the switch elements of the bridge circuit so that the alternating voltage generated by the bridge circuit changes frequency stepwise in time between at least three frequencies.

[0010] In this prior art inverter the frequencies are chosen without any relation to the frequency dependant power supplied to the lamp. This may lead to an uneven distribution of the power-frequency spectrum.

[0011] The object of the present invention is therefore to provide such a circuit, wherein the power frequency-spectrum is more evenly distributed.

[0012] The present invention according to claim 1 provides the feature that the time duration for which a signal of a determined frequency is generated depends on the value of the frequency, and that the time duration for which a high frequency is generated is longer than the time duration wherein a low frequency is generated.

[0013] The present invention will be elucidated hereinbelow with reference to the annexed drawings, in which:

figure 1 shows a schematic diagram of a circuit according to the present invention;
figure 2 shows a view of the sequence of the various frequencies as according to a first embodiment;
figure 3 shows a view corresponding with figure 2 of a second embodiment; and
figure 4 shows a diagram of a voltage source with variable voltage which can be used in the present invention.

[0014] Shown in figure 1 is an inverter 1 which is fed by a direct voltage source 2. This latter is formed for instance by a rectifier, for instance a controllable rectifier which rectifies alternating voltage coming from an alternating voltage mains supply. It is otherwise also possible to make use of a direct voltage mains supply.

[0015] The actual inverter 1 comprises four switch elements 3,4,5,6 which are connected in the form of a bridge. In the present embodiment the switch elements are each formed by bipolar transistors. It will be apparent that it is possible to apply other switch elements such as FETs or other elements designed from semiconductor configurations. A freewheel diode 12 is connected in parallel to each of these elements.

[0016] The lamp circuit is connected to the output terminals 7,8. The lamp circuit is formed by a ballast 9 and by a gas discharge lamp 10. A control circuit 11 is arranged for controlling switch elements 3,4,5,6. The control circuit is formed essentially by for instance a microprocessor which is provided with a suitable drive circuit for driving the control electrodes of the switch elements. Use is preferably made of a micro-controller provided with a sequence counter.

[0017] The control herein is such that the frequency of the signal generated at the output terminals 7,8 is independent of the impedance connected thereto. In this case the ballast coil 9 does not therefore form an implicit part of the oscillator circuit.

[0018] It is thus apparent that the control circuit 11 can fully determine the frequency of the output signal.

[0019] The frequency is herein determined such that it varies stepwise at discrete time intervals.

[0020] Such a configuration is shown for instance in figure 2. Herein during the first time duration from the point in time t_0 to the point in time t_1 the frequency of the oscillator circuit is chosen at F_1, from point in time t_1 to t_2 at F_4, from t_2 to t_3 at F_2 and so on.

[0021] In this embodiment the starting point is six separate frequencies which are stored for instance in the memory of control circuit 11. Thus is avoided that the lamp is operated for such a long period at a particular frequency that acoustic resonance possibly occurring at said frequency results in destruction phenomena; the frequency has already been changed again to another frequency before this is the case.

[0022] It is however possible to make a choice from a larger number of frequencies.

[0023] It is equally unnecessary to cause the frequencies to repeatedly run through a cycle but instead to choose the frequencies in a random sequence.

[0024] In this embodiment a frequency following a first frequency is always chosen which is separated by at least one other frequency. The successive frequencies are thus located relatively far away from each other. Achieved herewith is that if acoustic resonance were to occur at a random frequency the following frequency is located so far away therefrom that it is certain no acoustic resonance will occur at the following frequency.

[0025] In the above stated embodiment the time durations, i.e. the time durations between the points in time t_0, t_1, t_2 and so on are always the same.

[0026] According to another embodiment which is shown in figure 3, the time durations for which a frequency is generated are proportional to the frequency. An attempt is made here to distribute the power frequency spectrum as much as possible; the power fed to the lamp is in any case inversely proportional to the frequency as a result of the presence of the inductance 9.

[0027] According to yet another embodiment the frequency between two successive points in time is modulated to a very slight extent. The danger of acoustic resonance is herein reduced still further.

[0028] In the choice of the frequencies and the time durations a strategy can further be applied which aims at power regulation of the lamp. At nominal voltage gas discharge lamps have a power which gradually varies as a result of ageing processes. By adapting frequency and time duration this phenomenon can be compensated. The frequency and time duration regulation can of course also be used to vary the light output in order to obtain a dimmer operation.

[0029] It is further possible during start-up of the lamp to chose the collection of frequencies and the associated time durations such that start-up takes place as optimally as possible. The properties of a gas discharge lamp anyway change during start-up as a consequence of the increase in the temperature and the like.

[0030] Finally, it is also possible when a power supply source with a variable voltage is used, as shown in figure 2, to vary the voltage originating therefrom, whereby the power supplied to the lamp can be varied. This power regulation can be combined with variation of the collection of frequencies and variation in the length of the different time durations.

[0031] The adjustable voltage source is supplied by an alternating voltage source 25 and comprises a mains filter 26, a rectifier 27 and a controllable control element, for instance a FET 12, a smoothing choke 13, a diode 14 and a current measuring resistor 15. A control circuit 16 is arranged for control. This can be combined with the control circuit 4 of the foregoing embodiments.

[0032] Such control circuits are per se known, for instance as the commercially available circuit MSC 60028.

[0033] Control circuit 16 is connected to both sides of the current measuring resistor 15. Control circuit 16 is further connected by means of a controllable feedback network 18 to the output terminals. Feedback network 18 comprises a resistance divider comprising two resistors 19,20 and a controllable attenuation network which is connected in parallel to the second resistor 20 and which is formed in the present embodiment by a parallel circuit of four series connections of a resistor 21 and an electronic switch 22.

[0034] By controlling each of the four switches 22 the attenuation and thus the output voltage can therefore be set to 16 different values, this being controllable by control circuit 16. This results in an extensive adjustment option with simple means.

[0035] The values of resistors 19,20,21 are of course chosen so that the output voltage of the circuit can be varied in the vicinity of the nominal voltage, for instance between 350 V and 450 V.

Claims

1. Inverter (1) for feeding a gas discharge lamp (10), comprising:

- a direct voltage source (2);
- at least two switch elements (3-6) incorporated in a bridge circuit;
- a control circuit (11) for controlling the switch elements so that the bridge circuit continuously generates an alternating voltage;
- at least one ballast inductance (9) connected to one of the output terminals (7,8) of the bridge circuit; and
- at least one gas discharge lamp (10) connected between the ballast inductance (9) and the other output terminal (7) of the bridge circuit,
- wherein the control circuit (11) is adapted to apply at its output terminals a control signal to the switch elements (3-6) of the bridge circuit so that the alternating voltage generated by the bridge circuit changes frequency stepwise in time between at least three frequencies, **characterized in that** the time duration for which a signal of a determined frequency is generated depends on the value of the frequency, and that the time duration for which a high frequency is generated is longer than the time duration wherein a low frequency is generated.

2. Inverter (1) as claimed in any of the foregoing claims, **characterized in that** the frequency of the generated alternating voltage is modulated to a slight extent within a time duration with substantially constant frequency, wherein the frequency change is smaller than the difference between frequencies generated during different time durations.

3. Inverter (1) as claimed in any of the foregoing claims, **characterized in that** the generated frequencies are chosen from a collection of discrete frequencies and that frequencies following one another in time are separated by at least one intermediate frequency.

4. Inverter (1) as claimed in any of the foregoing claims, **characterized in that** the voltage generated by the direct voltage source (2) is adjustable.

5. Inverter (1) as claimed in claim 4, **characterized in that** the direct voltage source comprises a regulating circuit to which the output voltage of the circuit is fed via a controllable feedback network.

6. Inverter (1) as claimed in claim 4 or 5, **characterized in that** the voltage generated by the voltage source (2) is controlled for adjustment of the power supplied to the lamp.

7. Inverter (1) as claimed in any of the foregoing claims, **characterized in that** the control circuit (11) is remotely controllable.

8. Inverter (1) as claimed in any of the foregoing claims, **characterized in that** the control circuit (11) is adapted to control the frequency and the time duration of the frequency of the bridge circuit (3-6) in order to adjust herewith the power supplied to the lamp (10).

9. Inverter (1) as claimed in claim 5, 6 or 7, **characterized in that** the control circuit (11) is adapted to choose the frequencies during the start-up phase of the lamp (10) such that the lamp (10) is started up optimally.

Patentansprüche

1. Wechselrichter (1) zur Versorgung einer Gasentladungslampe (10), aufweisend:

- eine Gleichspannungsquelle (2),
- wenigstens zwei in einer Brückenschaltung angeordnete Schaltelemente (3-6),
- eine Steuerschaltung (11) zur Steuerung der Schaltelemente so, dass die Brückenschaltung kontinuierlich eine Wechselspannung erzeugt,
- wenigstens eine mit einem der Ausgangsanschlüsse, (7, 8) der Brückenschaltung verbundene Ballastinduktivität (9), und
- wenigstens eine zwischen die Ballastinduktivität (9) und den anderen Ausgangsanschluss (7) der Brückenschaltung geschaltete Gasentladungslampe (10),
- wobei die Steuerschaltung (11) ausgebildet ist zum Anlegen an ihre Ausganganschlüsse eines Steuersignals zu den Schaltelementen (3-6) der Brückenschaltung, so dass die von der Brückenschaltung erzeugte Wechselspannung die Frequenz schrittweise in der Zeit zwischen wenigstens drei Frequenzen ändert, **dadurch gekennzeichnet, dass** die Zeitdauer, für die ein Signal einer vorbestimmten Frequenz erzeugt wird, vom Wert der Frequenz abhängt, und dass die Zeitdauer, für die eine hohe Frequenz erzeugt wird, länger ist als die Zeitdauer, in der eine niedrige Frequenz erzeugt wird.

2. Wechselrichter (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Frequenz der erzeugten Wechselspannung in einer Zeitdauer mit im Wesentlichen konstanter Frequenz in geringem Ausmaß moduliert wird, wobei die Frequenzänderung kleiner als die Differenz zwischen Frequenzen, die während unterschiedlicher Zeitdauern erzeugt werden, ist.

3. Wechselrichter (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die erzeugten Frequenzen von einer Kollektion diskreter Frequenzen ausgewählt werden, und dass zeitlich aufeinanderfolgende Frequenzen durch wenigstens eine Zwischenfrequenz getrennt sind.

4. Wechselrichter (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die von der Gleichspannungsquelle (2) erzeugte Spannung einstellbar ist.

5. Wechselrichter (1) nach Anspruch 4, **dadurch gekennzeichnet, dass** die Gleichspannungsquelle eine regulierende Schaltung, der die Ausgangsspannung der Schaltung über ein steuerbares Rückkopplungsnetzwerk zugeführt ist, aufweist.

6. Wechselrichter (1) nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** die von der Spannungsquelle (2) erzeugte Spannung zur Einstellung der Leistung, die der Lampe zugeführt wird, gesteuert wird.

7. Wechselrichter (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Steuerschaltung (11) fernsteuerbar ist.

8. Wechselrichter (1) nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Steuerschaltung (11) ausgebildet ist zum Steuern der Frequenz und der Zeitdauer der Frequenz der Brückenschaltung (3-6), um dadurch die der Lampe (10) zugeführte Leistung einzustellen.

9. Wechselrichter (1) nach Anspruch 5, 6 oder 7, **dadurch gekennzeichnet, dass** die Steuerschaltung (11) ausgebildet ist zum Auswählen der Frequenzen während der Einschaltphase der Lampe (10) derart, dass die Lampe (10) optimal eingeschaltet wird.

Revendications

1. Convertisseur (1) pour l'alimentation d'une lampe à décharge à gaz (10), comprenant :

- une source de tension directe (2) ;
- au moins deux éléments de commutation (3-6) incorporés dans un circuit en pont ;
- un circuit de commande (11) pour commander les éléments de commutation de telle sorte que le circuit en pont génère de façon continue une tension alternative ;
- au moins une inductance ballast (9) connectée à l'un des terminaux de sortie (7, 8) du circuit en pont ; et
- au moins une lampe à décharge à gaz (10) connectée entre l'inductance ballast (9) et l'autre terminal de sortie (7) du circuit en pont,
- dans lequel le circuit de commande (11) est adapté pour appliquer au niveau de ses terminaux de sortie un signal de commande aux éléments de commutation (3-6) du circuit en pont, de telle sorte que la tension alternative générée par le circuit en pont change progressivement de fréquence entre au moins trois fréquences, **caractérisé en ce que** la durée pendant laquelle un signal d'une fréquence déterminée est généré dépend de la valeur de la fréquence, et **en ce que** la durée pendant laquelle une haute fréquence est générée est supérieure à la durée pendant laquelle une basse fréquence est générée.

2. Convertisseur (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la fréquence de la tension alternative générée est légèrement modulée dans une durée avec une fréquence essentiellement constante, dans lequel le changement de fréquence est inférieur à la différence entre les fréquences générées pendant différentes durées.

3. Convertisseur (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** les fréquences générées sont sélectionnées parmi une collection de fréquences discrètes et **en ce que** les fréquences se suivant les unes les autres dans le temps sont séparées par au moins une fréquence intermédiaire.

4. Convertisseur (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la tension générée par la source de tension directe (2) est réglable.

5. Convertisseur (1) selon la revendication 4, **caractérisé en ce que** la source de tension directe comprend un circuit de régulation alimenté par la tension de sortie du circuit via un réseau de rétroaction commandable.

6. Convertisseur (1) selon la revendication 4 ou 5, **caractérisé en ce que** la tension générée par la source de tension (2) est commandée pour le réglage de la puissance fournie à la lampe.

7. Convertisseur (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le circuit de commande (11) est commandable à distance.

8. Convertisseur (1) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le circuit de commande (11) est adapté pour commander la fréquence et la durée de la fréquence du circuit en pont (3-6) afin de régler avec ceci la puissance fournie à la lampe (10).

9. Convertisseur (1) selon la revendication 5, 6 ou 7, **caractérisé en ce que** le circuit de commande (11) est adapté pour sélectionner les fréquences lors de la phase de mise en marche de la lampe (10), de telle sorte que la lampe (10) est mise en marche de façon optimale.

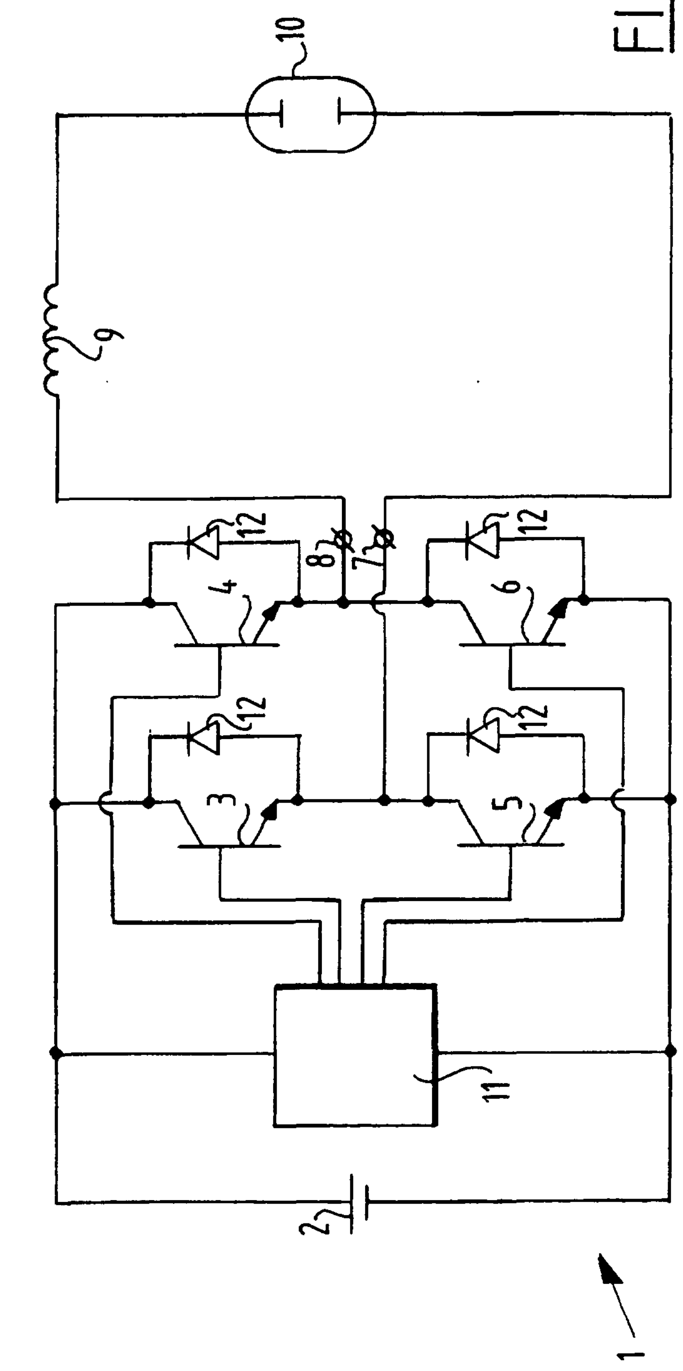

FIG.1

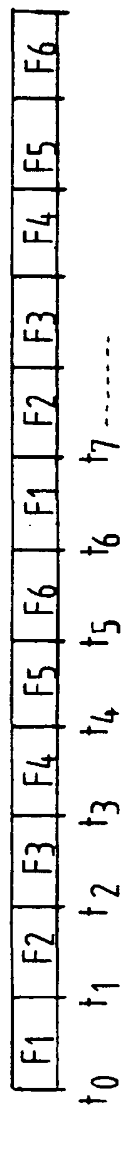

FIG.2

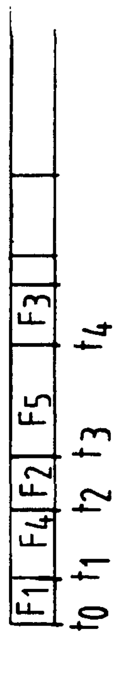

FIG.3

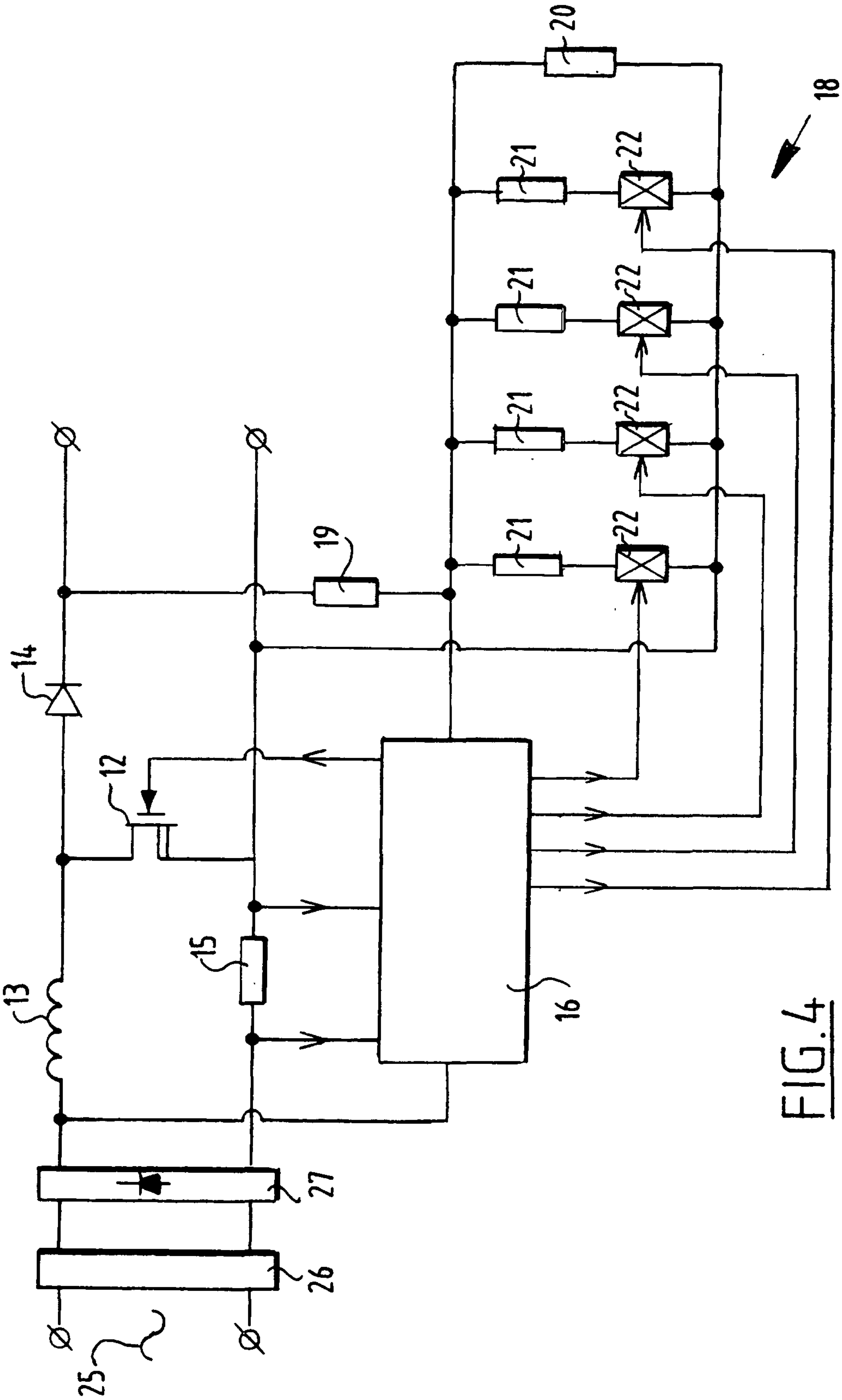

FIG. 4